LBNL-41432
Appendices

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

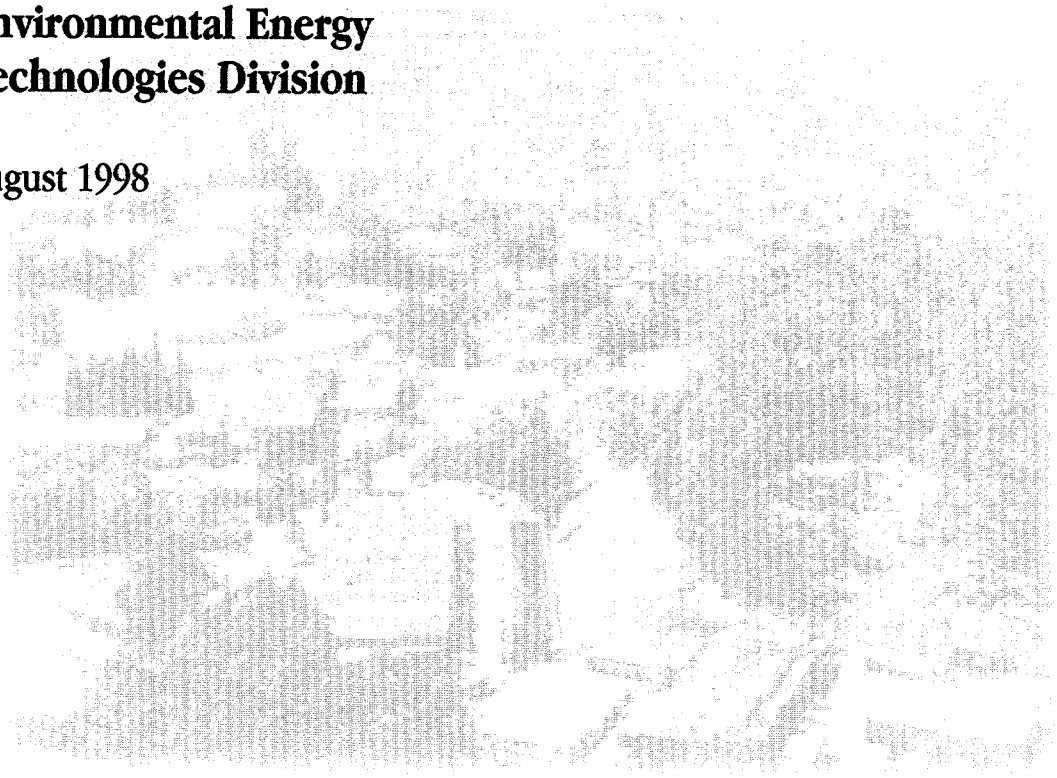
Energy-Efficiency and Renewable Energy Options for Risk Management and Insurance Loss Reduction: An Inventory of Technologies, Research Capabilities, and Research Facilities at the U.S. Department of Energy's National Laboratories

Technical Appendices

Edward Vine, Evan Mills, and Allan Chen

Environmental Energy Technologies Division

August 1998



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Technical Appendices

Edward Vine, Evan Mills, and Allan Chen

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Berkeley, CA 94720 USA

August 1998

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TECHNICAL APPENDICES

Appendix A. Survey Questionnaire and Instructions

Appendix B. Explanations of Insurance Terms and Coverage

Appendix C. National Laboratory Projects

Appendix A

Survey Questionnaire and Instructions

National Laboratory Inventory Survey

(FILL THIS OUT ON THE WEB:

http://eande.lbl.gov/CBS/Climate-Insurance/welcome.html.)

Laboratory name: Division/Department: Division/Dept. WWW link(s):	Contact: Mailing address: Phone/fax: Email:

Technology Studied

A. Description

B. Avoided Insurance Losses

C. Resources

1. Research capabilities and skills
2. Research facilities
3. Selected Publications
4. Standards/guidelines/protocols/software tools
5. WWW links

D. Demonstration Projects

E. International Activities

F. Future Projects

G. Collaborations with Insurance Industry

National Laboratory Inventory Survey

Instructions

This survey is designed to obtain information on technologies and projects that reduce insurance losses while saving energy, improving indoor air quality, or providing renewable energy and which are funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). These instructions provide guidelines for completion of the survey.

Please fill out the survey on the WWW at:
http://eetd.lbl.gov/CBS/Climate-Insurance/welcome.html.

Otherwise complete this form an a file and send the file via email or on a diskette to Ed Vine (elvine@lbl.gov).

Contact Information

Enter the name of the national laboratory and the division or department. Enter the name, address, telephone number, FAX number, and electronic mail (email) address for the person to be contacted for additional information. Provide links to the World Wide Web (WWW) to your division or department where available.

Sector

The questionnaire is divided into four sectors: buildings, industry, utility and transportation. Provide information for each sector where possible.

A. Technology/Project Description

In a few sentences, describe each energy-efficiency, indoor environmental quality, or renewable energy technology or project that is being researched (or recently developed) in your division (or department). Answer all of the questions below for each technology (one technology per page).

B. Avoided Insurance Losses

If available, estimate the amount of insurance losses avoided (or potentially avoidable) due to the technology being studied. Please provide your assumptions and any references to publications used in documenting your estimation.

C. Resources

For each technology, describe the following:

1. Research capabilities and skills associated with the technology, including those internal to your department as well as those external to your department.

2. Energy-related research facilities (if any).

3. Selected publications (list/reference and send with your response).

4. Energy-related standards/guidelines/protocols/software tools developed as part of the research project (e.g., ASHRAE indoor air quality standards, DOE energy building standards, geographic information systems that identify areas of maximum insurance losses, DOE energy measurement and verification protocols, WINDOW 4.1, NFRC window labels)

5. WWW links to the technology project.

D. Demonstration Projects

Describe any projects demonstrating the use of the technology.

E. International Activities

Describe research activities related to this technology that are being conducted by your organization outside the U.S.

F. Future Projects

Describe any future <u>funded</u> work related to this technology which you are planning to undertake. Do NOT describe your "wish list."

G. Collaborations with insurance industry

Describe any collaborative projects with the insurance industry related to this technology.

Appendix B

Explanation of Insurance Terms and Coverage

EXPLANATIONS OF INSURANCE TERMS AND COVERAGES[1]

Commercial Lines

1. BOILER AND MACHINERY COVERAGE

This form of insurance provides important mechanical breakdown coverage generally not available under any other insurance policy. A Boiler and Machinery policy can protect an insured against the effects of catastrophic property loss, such as steam boiler explosion or an expensive breakdown of machinery and equipment. But it's not just the physical damage caused by the explosion or breakdown that's of concern. While repairs are being made, valuable time and profits are lost. Business Interruption coverage protects against this. Often Extra Expense coverage is required to keep the business in operation regardless of cost. Refrigeration Interruption insurance protects against spoilage as the result of a breakdown. Many times these business interruption, extra expense and spoilage losses can be much more extensive than the damage to the equipment itself.

Equally important is the very valuable inspection service that Boiler and Machinery insurance can provide. Not only does this service satisfy most jurisdictional inspection requirements, but it also can benefit the insured by providing sound loss control recommendations that can help assure efficient operation and longer equipment life.

Virtually every commercial business has some type of Boiler and Machinery insurance exposure. Keep in mind that mechanical breakdown coverage encompasses much more than just boilers and pressure vessels. It also can include refrigeration equipment, air conditioning equipment, various types of piping, turbines, engines, pumps, compressors, blowers, gearing, shafting, electric motors, generators, transformers and assorted other types of mechanical and electrical equipment. In fact, many policies are written for insureds who do not own or operate boilers or pressure vessels, but yet have sizable mechanical and electrical exposures.

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[1]Many of these insurance terms and coverage are taken from "The Complete Glossary of Insurance Coverage Explanations" found on the World Wide Web page: http://www.lcgroup.com/explanations.

2. BUILDER'S RISK

Builder's risk insurance indemnifies for loss of or damage to a building under construction. Insurance is normally written for a specified amount on the building and applies only in the course of construction. Coverage customarily includes fire, extended coverage, vandalism, and malicious mischief. Builders risk coverage can be extended to a "special" form as well. The builder's risk policy also may include coverage for items in transit to the construction site (up to a certain percentage of value) and items stored at the site.

3. BUSINESS INTERRUPTION COVERAGE

This form of insurance provides loss of income coverage for a business by replacing the businesses' operating income during the period when damage to the premises or other property prevents income from being earned. It is by means of the business' operating income that the business meets its expenses of payroll, light, heat, advertising, telephone service, etc., and from which the business profit is derived. If a business interruption occurs and the business has to close for several months or operate at a reduced pace because of fire or other perils covered by Earnings insurance, this income will cease or be reduced. The business interruptions are due to fire, lightning, water damage, etc. If the business interruption is due to an interruption in "incoming services" (e.g., electricity and gas), then this is classified as service interruption.

For the purpose of this insurance coverage, "earnings" are defined as the actual loss sustained by the insured as a direct result of business interruption necessitated by damage or destruction of real or personal property. The damage or loss must be caused by the insured perils. Furthermore, "business income" is defined as the sum of total net profit, payroll expense, taxes, interest, rents, and all other operating expenses earned by the business. The amount of coverage the Earnings insurance provides is established on the basis of either the amount of insurance or actual loss sustained for each 30-day period of necessary business interruption caused by damage or loss from covered perils. There are several ways to set up Business Interruption depending upon the particular business: monthly limitations, coinsurance, maximum time period to be paid, etc. In addition to Earnings insurance, it is also advisable to carry Extra Expense insurance.

3.1. EXTRA EXPENSE COVERAGE

If a building was rendered untenable by fire or any other insured peril, it would probably be necessary to secure other quarters to continue business operations. However, the use of such buildings would undoubtedly involve many extra

expenses, such as rent, installation of telephones, etc. Extra Expense insurance covers such expenditures over and above normal monthly expenses.

3.2. CONSEQUENTIAL LOSS OR DAMAGE/CONTINGENT BUSINESS INTERRUPTION

Consequential loss or damage -- as opposed to direct loss or damage -- is indirect loss or damage resulting from loss or damage caused by a covered peril, such as fire or windstorm. In the case of loss caused where windstorm is a covered peril, if a tree is blown down and cuts electricity used to power a freezer and the food in the freezer spoils and if the insurance policy extends coverage for consequential loss or damage, then the food spoilage would be a covered loss. Business Interruption insurance extends consequential loss or damage coverage for such items as extra expenses, rental value, profits and commissions, etc.

4. COMMERCIAL PROPERTY INSURANCE

Commercial property insurance policies provide indemnification to the policyholder for direct damage to insured structures and business personal property (Lecomte 1998). Direct damage to insured structures and business personal property includes payment for the repair or replacement of the damaged property.

5. COMPLETED OPERATIONS LIABILITY COVERAGE

This form of liability insurance provides coverage for bodily injury and property damage rising from completed or abandoned operations, provided the incident occurs away from premises owned or rented by the insured. Operations are deemed completed at the earliest of the following items: (1) when all operations to be performed by or on behalf of the insured under contract have been completed; (2) when all operations to be performed by or on behalf of the insured at the site of the operations have been completed; and (3) when the portion of work out of which injury or damage rises has been put to its intended use by a party other than the contractor or subcontractor.

6. COMPREHENSIVE GENERAL LIABILITY COVERAGE

Under this form of insurance and regarding a covered occurrence[1], the company will pay all sums the insured becomes legally obligated to pay as damages due to bodily injury and property damage. The insurance company has the right to defend any suit against the insured seeking damages on account of such bodily injury or property damage, even if any of the allegations of suit are groundless, false or fraudulent, and to make such investigation and settlement of any claim or suit as it deems expedient. However, the company is not obligated to pay any claim or judgement or to defend any suit after applicable limit of the company's liability has been exhausted by payments of judgements or settlements. Comprehensive general liability provides coverage for damages incurred by third parties (individuals, companies, firms, corporations, etc.) when the insured is legally liable, but does not cover property damage in commercial buildings to the insured (see Commercial Property Insurance).

7. CONTRACTOR'S LIABILITY COVERAGE

7.1. Premises/Operations

The "premises" portion of liability insurance provides for payment on behalf of all sums the business is legally obligated to pay as damages resulting from bodily injury and/or property damage caused by an insured peril and rising out of the ownership, maintenance, or use of premises and operations in progress.

The "operations" portion of liability insurance covers operations in progress and is intended for situations where principal business operations are performed away from the business' premises.

7.2. Completed Operations

This portion of liability insurance provides coverage for possible liability for bodily injury and/or property damage after work is complete and employees have left the job site.

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[1] Occurrence means an accident, including continuous or repeated exposure to conditions, which results in bodily injury or property damage neither expected nor intended from the standpoint of the insured.

8. PRODUCT LIABILITY

Product liability is the liability for bodily injury or property damage incurred by a merchant or manufacturer as a consequence of some defect in the product sold or manufactured, or the liability incurred by a contractor after he has completed a job as a result of improperly performed work.

9. PROFESSIONAL LIABILITY

Errors and omissions insurance is coverage for liability resulting from errors or omissions in the performance of professional duties. This is applicable as a general rule to professional business activities such as banking, accounting, law, insurance and real estate.

10. SERVICE INTERRUPTION

Similar to business interruption coverage, this form of insurance provides loss of income coverage for a business by replacing operating income during the period when damage to the premises or other property prevents income from being earned. It is by means of the operating income that a business meets its expenses of payroll, light, heat, advertising, telephone service, etc., and from which a profit is derived. If business interruption is suffered and one has to close for several months or operate at a reduced pace because of fire or other perils, this income will cease or be reduced. The service interruption is due to an interruption in "incoming services" (e.g., electricity and gas). If the interruptions are due to fire, lightning, water damage, etc., then this is covered under Business Interruption.

11. WORKERS COMPENSATION

Workers compensation insurance protects the domestic employee and the employer from the expenses and liabilities associated with a work-related accident. The legal requirements for obtaining this insurance vary widely from state to state, with wages paid or hours worked usually the defining item, not job description.

1. HOMEOWNERS INSURANCE

Homeowners policies are based on a standard form. All homeowners policies cover two important areas: property and liability. In insurance terms this means that the homeowners policy has two basic components. It covers the homeowners structures and possessions - property insurance - and it furnishes protection against personal liability. Personal liability, as its name implies, means the homeowner is legally obligated to pay money to another person for actions caused by the homeowners, the homeowners family, or the homeowners property. That liability extends to medical payments to others for injuries caused by the homeowners or the homeowners family.

Homeowners insurance usually covers damage to both structures and personal property caused by: (1) fire or lightning, (2) windstorm or hail, (3) explosions, (4) riot or civil commotion, (5) aircraft, (6) vehicles, (7) smoke, (8) theft or vandalism (sometimes called malicious mischief), (9) falling objects, (10) weight of ice, snow or sleet, and (11) freezing of a plumbing, heating, air conditioning or other such household system.

Most catastrophes are covered; for example, wind damage from hurricanes and tornadoes come under the windstorm peril and so are included. Flood and earthquake damage, however, are not covered by a standard policy. There may be exclusions spelled out in the homeowners policy such as neglect, intentional loss, "earth movement," general power failure and even damage caused by war.

Appendix C

National Laboratory Projects

Introduction

Each investigator completed the survey form contained in Appendix A. Some comments on the survey fields are warranted:

1. If a research project was being conducted by two laboratories, the names of both laboratories and the respective contact information were listed.

2. The research projects were categorized into one of four sectors: buildings, industry, utility and transportation. Due to resource limits, we did not collect information on transportation projects. Also, while some projects could be classified under more than one category, we used only one category per project for the project description. Those projects affecting the supply or delivery of energy (e.g., advanced batteries, flywheels, wind, etc.) were placed in the "utility" sector; these kinds of projects could affect insurance losses in the buildings and industrial sectors as well.

3. International activities had to be specific international projects.

4. Future projects had to be specific, near-term projects, rather than wish lists.

5. The Research Agenda items had to specifically target the reduction of insurance losses or risk management.

TABLE C-1. LIST OF PROJECTS

Project Number	Project Title	Page Number
ANL-1	Ceramicrete phosphate ceramic	C-1
ANL-2	Recovering zinc from galvanized steel	C-4
ANL-3	Advanced batteries	C-7
ANL-4	Flywheel energy storage	C-10
ANL-5	Fuel cells	C-13
ANL/ORNL-1	Composite wall systems	C-16
BNL-1	Fan atomized burner and flame quality indicator	C-19
BNL-2	Duct audits	C-22
BNL-3	Software for improving oil-fired heating system venting performance	C-25
BNL-4	Training and certification of oil-fired heating system service personnel	C-28
INEEL-1	Fuel cells	C-30
INEEL-2	Demand-controlled ventilation system	C-33
INEEL-3	Software tools for flywheel design	C-35
INEEL-4	Intelligent air quality monitoring technologies	C-37
LBNL-1	Energy-efficient halogen torchiere replacements	C-39
LBNL-2	Energy-efficient windows	C-42
LBNL-3	Ultraviolet water purification	C-45
LBNL-4	Aerosol-based duct sealing technology	C-48
LBNL-5	Building commissioning	C-51
LBNL-6	Building code compliance	C-55
LBNL-7	Light surfaces and urban trees	C-58
LBNL-8	Geographic information systems for targeting loss-prevention measures	C-61

Project Number	Project Title	Page Number
LBNL-9	Measurement and verification protocols	C-63
LBNL-10	Indoor pollutant source reduction	C-66
LBNL-11	Air jacket for spray booths	C-70
LBNL-12	High-efficiency sulfur lamp uplighter	C-73
LBNL-13	Hydronic radiant cooling	C-75
LBNL-14	Technology for cleanrooms	C-78
LBNL-15	Indoor air quality-related illnesses	C-82
LBNL-16	Mitigating urban heat catastrophes	C-85
LBNL-17	Carbon monoxide sensors	C-87
LBNL-18	Environmental tobacco smoke	C-90
LBNL-19	Radon resistant housing	C-93
LBNL-20	Radon insurance	C-96
LBNL-21	Energy management and control systems	C-99
LBNL-22	Integrated information technology	C-103
LBNL-23	Fuel cells	C-106
LBNL-24	Reducing aerosol deposition on electronic circuits	C-110
LBNL-25	Appliance and lighting standards	C-114
LBNL-26	Motor systems and controls	C-118
LBNL-27	Infrared thermography	C-121
LBNL-28	Daylighting	C-124
LBNL-29	Advanced batteries	C-128
LBNL-30	Cool storage systems	C-131
LLNL-1	Flywheels	C-134
LLNL-2	Zinc-air fuel cells	C-137
NREL-1	Passive solar energy systems	C-140

Project Number	Project Title	Page Number
NREL-2	Parabolic troughs for solar electric power	C-144
NREL-3	Building integrated photovoltaics	C-146
NREL-4	Solar heat and buildings technologies	C-149
NREL-5	Stand-alone photovoltaic systems	C-152
NREL-6	Dispatchable photovoltaic peak-shaving and uninterruptible power supply systems	C-155
NREL-7	Small wind turbine systems	C-158
ORNL-1	Natural refrigerants in air-conditioning and refrigeration equipment	C-161
ORNL-2	Superconducting transformers	C-164
ORNL-3	CFC-free thermal insulation	C-168
ORNL-4	Explosion prevention technology	C-171
ORNL-5	Wind resistant building envelopes	C-174
ORNL-6	Durable roof coating materials	C-176
ORNL-7	Hybrid lighting	C-178
ORNL-8	Cool storage systems	C-181
ORNL-9	High-efficiency clothes washers	C-184
ORNL-10	Building commissioning	C-186
ORNL-11	Refractories in glass production furnaces	C-190
ORNL-12	Recovery boilers in pulp and paper mills	C-193
ORNL-13	Geographic information systems for targeting loss-prevention measures	C-196
ORNL-14	Efficient motor-driven systems	C-201
ORNL-15	Flywheels	C-204
ORNL/NREL-1	Electricity from wood removed from forests to reduce fuel buildup	C-206
ORNL/NREL-2	Advanced desiccant air-conditioning technology	C-209

Project Number	Project Title	Page Number
PNNL-1	Tools for building code development and compliance	C-213
PNNL-2	Microtechnology-based absorption heat pump	C-218
PNNL-3	Building commissioning	C-220
SNL-1	Renewable energy projects	C-224
SNL-2	Solar thermal heat	C-227
SNL-3	Architectural and infrastructure surety	C-229
SNL-4	Photovoltaic systems	C-233
SNL/NREL-1	Solar dish engine systems	C-236

Laboratory Identification Number: ANL-1
Laboratory Name:
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Industrial Technology Development Center
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Div./Dept. WWW link(s):
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630/252-5230
Sector:
Industry

I. **Technology Studied:**
Ceramicrete Phosphate Ceramic

A. **Description:**
Manufactured like concrete, this phosphate ceramic material can stabilize combustion products and low-level radioactive wastes. Ceramicrete is made at room temperature by a process that is very similar to concrete mixing. It is formed by mixing metal oxides, such as magnesium oxide (a very common and low-cost powder used in the ceramic industry) and soluble phosphate powders (common, low-cost materials such as those used in detergents, fertilizers, and fire retardants) with water. These three ingredients react quickly to form a ceramic that is similar in composition to dental cement. The process is not energy intensive and is economical. The setting times are short.
Ceramicrete has a very low porosity and a compressive strength higher than that of concrete. It was originally developed to effectively treat hazardous materials prior to long-term disposal, including radioactive and mixed wastes, and conversion of common wastes into commercial and industrial products for various markets.

B. **Avoided Insurance Losses:**
Ceramicrete can encapsulate nonhazardous wastes, such as ash, wood, tires, and Styrofoam, to create materials for a variety of commercial and industrial products. Examples include fire proof construction products (bricks, blocks, roofing, tiles), structural materials requiring high compressive strength, and sealants and coatings. Ceramicrete also can be sprayed into the space between wall joists to create extremely fire-resistant insulation. Thus, avoided insurance losses include product liability and

property insurance to reduce fire hazards. Environmental liability insurance claims may be avoided as a result of treating hazardous materials prior to disposal.

C. **Resources**

i. **Research capabilities and skills:**
Equipment needed is conventional and readily available, and training required for operations is simple. Technology has been developed for heavy metals stabilization and cesium stabilization, and must be tested for radioactive species.

ii. **Research facilities:**
1. Double Planetary Mixer (for 55 gallon drums)
2. Feeder-Hopper system
3. Water Line

iii. **Selected Publications:**
1. Wagh, A., S. Jeong, and D. Singh, "Stabilization of Contaminated Soil and Wastewater with Chemically Bonded Phosphate Ceramics," Presented at the Waste Management Annual Meeting Tucson, AZ, March 2-6, 1997
2. Jeong, S., A. Wagh, and D. Singh, "Chemically Bonded Phosphate Ceramics for Stabilizing Low-Level Radioactive Wastes," Presented at the American Ceramic Society, Indianapolis, IN, April 14-17, 1997.

iv. **Standards/guidelines/protocols/software tools:**
1. "Toxicity Characteristic Leaching Procedure," as described in U.S. EPA Method 1311.
2. UL Thermal Resistivity tests relating to industrial and residential insulation standards.

v. **WWW links:**
http://www.anl.gov/LabDB/Current/Int/H589-text.001.html

D. **Demonstration Projects:**
The Quick Win Project at Argonne-West: contaminated light bulbs and other lead contaminated debris were treated during Fiscal Year 1997. Funded by the U.S. Department of Energy's Mixed Waste Focus Area (MWFA).

E. **International Activities:**
None currently.

F. **Future Projects:**
Continued development of the Ceramicrete process, leveraged with two industrial firms and the U.S. Department of Energy's Mixed Waste Focus Area (MWFA).

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Identify waste streams (industrial, government, or residential) which the insurance industry would want to dispose of for risk management and

convert them into a fire proof drywall or an insulation with a very high "R" value for an economical cost.

Laboratory Identification Number: ANL-2

Laboratory Name:
Argonne National Laboratory

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ANL, 9700 South Cass Avenue, ITD-900, Argonne, IL 60439-4832

Fax:
630/252-5230

Sector:
Industry

I. **Technology Studied:**
Recovering Zinc from Galvanized Scrap

A. **Description:**
Half of the steel produced in the United States is derived from scrap. With zinc-coated galvanized scrap increasing fivefold since 1980, steelmakers are feeling the effect of increased contaminant loads on their operations. The greatest concerns are the cost of treatment before disposal of waste products, and the water associated with remelting zinc-coated scrap. An economical process is needed to strip and recover the zinc from scrap to prepare it for steelmaking.

The energy benefits to the steelmaking industry from such a process are estimated to be $140 million per year (compared with using non-scrap sources of iron). Environmental compliance costs would be mitigated by about $150 million per year. Foreign exchange could also benefit by some $170 million per year, through reductions in zinc imports.

The process consists of dissolving the zinc coating from scrap in a hot, caustic solution and recovering the zinc from the solution electrolytically. The zinc-bearing scrap is charged in an electrolytic cell containing a 7090 degrees C sodium hydroxide solution. Applying an electric potential dissolves the zinc into the hot caustic. Clean scrap is removed, rinsed, and recycled. The electrolyte is then pumped into a second cell, where the zinc is electrolytically removed from the solution. The zinc can be sold to refiners for purification and resale.

B. **Avoided Insurance Losses:**
Health and liability costs would be reduced by making the workplace safer (zinc is isolated from the clean scrap) and by reducing the amount of time people are in contact with heavy metals and caustic solutions.

C. **Resources**

i. **Research capabilities and skills:**

1. Electrochemical expertise relating to metals
2. Electroplating
3. Separation Science

ii. **Research facilities:**

1. Stripping facilities that contain caustic solutions
2. 400 gallon tank to perform electrolytic stripping tests

iii. **Selected Publications:**

1. Dedek, F., E. Daniels, and W. Morgan, "Recycling Galvanised Steel: Operating Experience and Benefits," Presented at the International Symposium - World Zinc '93, October 10-13, 1993.
2. Dedek, F., E. Daniels, and W. Morgan, "Benefits of Recycling Galvanised Steel Scrap for Recovery of High-Quality Steel and Zinc Metal," Presented in the Proceedings, Minerals, Metals, and the Environment Conference, 1992, (The Institute of Mining and Metallurgy: London).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.es.anl.gov/htmls/zinc.html

D. **Demonstration Projects:**
A rotary dezincing reactor for treatment of 1,500 tons of stamping plant scrap was operated between October, 1996 and September, 1997 in East Chicago, Indiana.

E. **International Activities:**
None currently.

F. **Future Projects:**
Plans are to provide 1,500 tons of dezinced scrap for a melt test to determine the environmental impact of dezinced scrap on furnace operations. If testing is successful, detailed engineering will begin on a 200,000-ton/year dezincing demonstration plant. Plants like this one could be used for future commercial operations.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
The cost to develop a full-scale demonstration plant is approximately $16.8 million. Collaborations are needed to focus on the applied science as well as worker conditions (which could be hazardous). Developing an environmental recycling process that decreases the amount of work days lost per year would be beneficial to all parties, including the insurance industry. Thus, a consortium of industrial firms, the insurance industry, and the national laboratories could be developed.

Laboratory Identification Number: ANL-3

Laboratory Name:
Argonne National Laboratory

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Sector:
Utilities

I. **Technology Studied:**
Advanced Batteries

A. **Description:**
Research is being conducted on advanced battery technology, with particular emphasis on the processing and characterization of novel electrode materials for rechargeable lithium batteries (lithium aluminum and lithium polymer) and on the development of the high-temperature sodium/metal chloride battery system. Compared with present-day technology, this new battery could provide up to five times as much energy and operate ten times longer.

B. **Avoided Insurance Losses:**
Back up battery systems, which could power industrial plants, could provide an uninterruptible power supply for the plant. They could also provide an uninterruptible power supply for equipment, such as computers. Eliminating very short power outages will save the insurance industry money by reducing service interruptions when power service is disrupted.

C. **Resources**

i. **Research capabilities and skills:**

1. Specialties include solid-state chemistry, with an emphasis on structure/property relationships in inorganic materials and a knowledge of transition-metal oxide intercalation compounds, particularly oxides of vanadium, manganese, and nickel.

2. Molten salt chemistry.

3. Testing and evaluation of these systems under various cycling profiles (e.g., constant current, constant power, current interrupt, dynamic stress test, peak power, and specialized cycles), as well as the development of boxes/purification systems, power supplies/cyclers, data acquisition and control systems, and other test apparatus.

4. Neutron diffraction analysis is being used to investigate the crystal structure of nickel/metal hydride cells while they undergo electrochemical cycling.

ii. **Research facilities:**
Battery Analysis and Diagnostic Laboratory (a designated user facility since 1976).

iii. **Selected Publications:**

1. Kaun., T. et al., "High Temperature Lithium/Sulfide Batteries," *Electrochimica Acta* Vol. 38, No. 9, pp. 1269-1287, 1993.

2. Kaun, T. et al., "Development of Prototype Sealed Bipolar Lithium/Sulfide Cells," Proceedings of the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA August 4-9, 1991, Vol. 3, page 417.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.cmt.anl.gov/brochure/brochurebattery.html

D. **Demonstration Projects:**
The first lithium-polymer cell was developed and demonstrated in a collaborative effort involving CMT, Hydro-Quebec, and 3M Corporation.

E. **International Activities:**
Ongoing collaborative research with the Minnesota Mining and Manufacturing

Company (3M) and Hydro-Qubec of Canada.

F. **Future Projects:**
The Division is also developing lithium-polymer batteries, which show considerable potential for meeting the demanding performance requirements of electric vehicles and operate at low temperature (below 100 degrees Celsius). They are assembled from lithium-polymer sandwiches that are extremely thin, sometimes less than a few thousandths of an inch. The battery's flexible, multilaminate structure makes possible very high power and energy densities. The use of a solid polymer as the electrolyte is particularly advantageous because it does not leak, corrode components, or emit dangerous gases.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
The insurance industry, industrial manufacturers, professional trade associations and the national laboratories could collaboratively develop the lithium-polymer batteries.

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Sector:
Utilities

I. **Technology Studied:**
Flywheel energy storage

A. **Description:**
A flywheel power quality unit can be installed between the power source and a manufacturing facility, providing clean, uninterrupted power to the equipment in the facility. The flywheel operates continuously, storing a relatively small amount of energy which can be used when the electrical power is lost for a short period of time (seconds or minutes).

Recent advances in the development of very low friction bearings and high-strength fiber composite rotor materials has revived interest in flywheel energy storage. A rotating permanent-magnet bearing assembly can be stably levitated above a stator component composed of high critical temperature-Tc superconductor (HTS) elements, without the need for position sensors and the elaborate feedback control systems required for conventional active electromagnetic bearings. Significant advances have been made at Argonne in developing very low friction magnetic bearings based on the unique levitation

characteristics of HTS materials. Major accomplishments include an order of magnitude scale-up in HTS magnetic bearing size and demonstration of friction coefficients (æ < 10-6) more than 3 orders of magnitude better than the best commercial bearings. Potential applications for high-Tc superconducting magnetic bearings range from spacecraft gyroscopes to rotating electrical machinery to energy storage flywheels. Flywheels offer an attractive alternative to batteries in the development of zero-emission automotive power systems.

B. **Avoided Insurance Losses:**
On a larger scale, these advances enable superconducting bearing/flywheel systems, which can be used for electric utility load leveling and for diurnal energy storage with high energy densities.

Use of a flywheel energy storage system as a power quality unit can prevent damage from short-term loss of electrical power. Many businesses and industries are sensitive to loss of electrical power, even for a fraction of a second. A flywheel power quality unit can maintain consistent, uninterrupted power to the building and manufacturing equipment. If the power disruption is for a longer period of time, the flywheel power quality unit can provide power to allow a controlled shutdown of equipment.

C. **Resources**

i. **Research capabilities and skills:**

1. Expertise in how to store and disperse energy through high temperature ceramic research applications.

2. Expertise in fabricating experimental superconducting devices.

ii. **Research facilities:**

1. Two vacuum-chamber apparatuses have been developed at ANL to test the rotational losses of HTS bearings. One is a glass bell-jar test chamber with an oil-diffusion pump. This apparatus is capable of testing bearings with rotating mass up to ~1 kg. The second apparatus is a stainless steel chamber with a turbomolecular vacuum pump capable of testing rotating masses of 100 kg. We have identified several design improvements to further reduce loss, and we expect to test these designs in rotors of increasing size.

2. Safely enclosed underground area to actively test rotating flywheels.

1. **Selected Publications:**
None currently.

2. **Standards/guidelines/protocols/software tools:**

None currently.

3. **WWW links:**
   http://www.et.anl.gov/ct/ctSA-Magnetic.html

3. **Demonstration Projects:**
   A collaborative effort with Commonwealth Research Corporation is in progress to demonstrate that low loss HTS bearings can be scaled up to sizes of interest for flywheel energy storage applications.

4. **International Activities:**
   None currently.

5. **Future Projects:**
   The continued development of manufacturing flywheels, the improved safety considerations pertaining to operating a flywheel, and the continued development of a more efficient energy storage and transfer system.

6. **Collaborations with Insurance Industry:**
   None currently.

7. **Research Agenda:**
   Nothing submitted.

Laboratory Identification Number: ANL-5

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Sector:
Utilities

I. **Technology Studied:**
Fuel Cells

A. **Description:**
Fuel cells can convert the chemical energy of nonpetroleum fuels such as hydrogen, methanol, or ethanol to electricity with little or no pollution and with greater efficiency than heat engines. Fuel cells can provide clean, reliable power to building facilities of widely varying sizes, from residences to commercial and industrial facilties, in addition to their applications in the transportation sector.

We are conducting R&D on a solid oxide fuel cell and a molten carbonate fuel cell, both of which are targeted for use as small power plants in utility applications such as hospitals.

For the solid oxide fuel cell, we are developing new electrodes, electrolytes, interconnect materials, and processing techniques to reduce the operating temperature from the present 1000 degrees Centigrade to 800 degrees Centigrade, or even lower. We have also developed glass and glass/ceramic materials to seal

along the edges of each cell and between the gas supply manifold and fuel cell stack. These sealants are able to seal different cell components and withstand the requisite cell operating temperatures and gas compositions.

In the present molten carbonate fuel cells, the nickel oxide cathodes limit cell lifetime because of cathode dissolution and migration to the nickel anode. We have developed lithium ferrate and lithium cobaltate cathodes that are expected to yield the long cell lifetimes (over 40,000 hours) needed for utility applications.

In addition, advanced cell designs are being developed for higher power density and lower cost. The power density is being increased through use of multiple gas manifolding, pressurized operation, and design optimization. The cost is being reduced through eliminating complex and expensive stamped metal parts that currently form the gas flow channels, the electrode supports, and the current collectors for each cell.

B. **Avoided Insurance Losses:**
Continous, reliable power supply to commercial buildings, which require electricity to perform their functions, so that service interruptions are reduced. For example, a fuel cell source is a mini-utility which can supply electricity for patient care even when the hospital loses power. This means the life support mechanisms will remain on and loss of life and service interruptions can be reduced.

C. **Resources**

i. **Research capabilities and skills:**

1. Expertise in molten chemistry, catalysts, membrane research, and electrochemistry.

2. Researchers can develop computer and/or physical models to evaluate a component of the fuel cell or an entire fuel cell system.

ii. **Research facilities:**

1. Fuel Cell testing facility

2. Synchrotron X-ray facility to study anode reactions in real time.

3. X-ray spectroscopic facilities.

iii. **Selected Publications:**

1. Ahmed, S., R. Kumar, and M. Krumpelt, "Development of a Catalytic Partial Oxidation Reformer for Methanol Used in Fuel Cell Propulsion Systems," Presented at the 1994 Fuel Cell Seminar, November 28-December 1, 1994, San Diego, CA.

2. Krumpelt, M., R. Kumar, and K.M. Myles, "Fundamentals of Fuel Cell System Integration," *Journal of Power Sources*, 49, p. 37, 1994.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.cmt.anl.gov/brochure/brochurebattery.html

D. **Demonstration Projects:**
Demonstrated the fuel cell-powered bus as a transportation alternative. Some of this research is currently sponspored by the Partnership for New Generation Vehicles (PNGV), which is sponsored by the US Department of Commerce.

E. **International Activities:**
None currently.

F. **Future Projects:**
Future projects are targeted to reducing operating temperatures. At these lower temperatures, manufacturing costs would be reduced, operating efficiency increased, and cell durability improved.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Work with insurance companies to develop longer lasting fuel cells to guarantee a continuous supply of electric power to industry, when the utility company cannot provide this service.

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Sector:
Buildings

I. **Technology Studied:**
Composite Wall Systems

A. **Description:**
The Composite Wall System involves rigid board insulation and reinforced gypsum board to encase lead-posioning hazards in masonary structures while providing substantial increases in insulation. The wall's R value increases by R12.

B. **Avoided Insurance Losses:**
Lead poisioning is a major public health hazard. Building owners are liable for damages to the health of their residents. This technology provides a low-cost solution to lead-poisioning hazards, thus reducing liability exposures (environmental liability).

C. **Resources**

i. **Research capabilities and skills:**
This work is in collaboration with Oak Ridge National Laboratory. Architects, engineers and an economist are participating.

ii. **Research facilities:**

1. Envelope research facility at Oak Ridge National Laboratory.

2. A majority of the research is performed in the field.

iii. **Selected Publications:**

1. Cavallo, J. and B. Wendt, "New Wall System Keeps the Lead Out and the Heat In," *Home Energy Magazine*, Nov./Dec. 1997, pp 7 - 8.

2. Cavallo, J.and B. Wendt, "Encasing Lead Hazards and Adding Energy Efficiency in Low-Income Housing," in "Selected Readings from the Affordable Comfort Conference," April, 1997, pp. 71-74.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://buildings.dis.anl.gov/eber.html
http://buildings.dis.anl.gov/eber/cha-wall/wallsystem.html

D. **Demonstration Projects:**
We have demonstrated this technology twice with the Chicago Housing Authority (CHA). At 626 West Jackson Street in Chicago, we demonstrated the wall system and conducted destructive tests to probe the integrity of the wall's strength. At Brooks Homes. a CHA development, we demonstrated the wall system in a typical residence. The unit is currently occupied.

E. **International Activities:**
None currently.

F. **Future Projects:**
We intend to test the energy efficiency of this wall unit in a 5-unit public housing row house.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Investigate the performance of the composite wall system in basements with high moisture problems, a concern for the insurance industry. Current technology

(gypsum board) does not resist water damage.

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Sector:
Buildings

I. **Technology Studied:**
Fan Atomized Burner and Flame Quality Indicator

A. **Description:**
Laboratory and field research on innovative oil-fired combustion systems, heat exchanger fouling and corrosion. Two major outgrowths of this research are the Fan Atomized Burner (FAB) and the Flame Quality Indicator (FQI). The FAB has the potential for improved heating equipment efficiency and cleaner (low emission) combustion. The FQI allows for continual monitoring of the combustion process eliminating the potential formation of soot and the danger of combustion puff-back.

B. **Avoided Insurance Losses:**
Improving oil-fired combustion systems, including the reduction of fouling and corrosion of heat exchangers, could result in the reduction of insurance losses, especially property and life.

A recent report by Hall (see below) provides some quantification of these

insurance losses. The following data apply to all BNL research: see BNL-2, BNL-3, BNL-4.

The data contained in Tables 11, 12, and 13 for liquid fueled Central and Water heater applications was summed for the years 1980 through 1994. This information was then evaluated using the results for the Total Change 1980-94 contained at the bottom of Table 1 assuming that the liquid fuel research conducted at BNL accounted for about 10% of the change over the 15 year period.

The estimated reduction in fires is 6.5%. This is estimated to have resulted in 11 fewer deaths and 64 fewer injuries. In the first category, namely deaths, the current recommendations by the insurance industry are for life insurance coverage of 6 to 10 times the person's annual earnings. Assuming an average annual earnings of $25,000 for the individual and an average life policy at 8 times this value, the insurance loss for this life would be $200,000. The avoided insurance loss for 11 fewer deaths could then be estimated as $2,200,000. Assuming that covered injury costs per individual amount to $20,000, then 64 fewer injuries result in an avoided insurance loss of $1,280,000. In terms of dollar savings the only direct information available in the above report is an estimate of home heating property damage. Here the avoided insurance loss is estimated to be $20,500,000 with inflation taken into account.

Source: Hall, J.R., "U.S. Home Heating Fire Patterns and Trends Through 1994" (Oct. 1996). The author is part of the Fire Analysis and Research Division of the National Fire Protection Association (NFPA).

C. **Resources**

i. **Research capabilities and skills:**
Full and part-time staff consisting of scientists and engineers whose responsibilities include basic research, applied laboratory and field data collection, and analysis.

ii. **Research facilities:**
Extensive laboratory facilities and instrumentation dedicated to combustion, efficiency, and emission testing of heating equipment.

iii. **Selected Publications:**

1. Butcher, T., "Advanced Oil Burner for Residential Heating - Development Report," BNL Report 62077, July 1995.

2. Butcher, T. and W.L. Litzke, "Condensing Economizers for Efficiency Improvement and Emissions Control in Industrial Boilers," BNL Report 62939, March 1996.

3. Butcher, T., Y. Celebi, L. Fisher, B. Kamath, "Development of an Air-Atomized Oil Burner," BNL Report 63135, May 1996.

4. **Standards/guidelines/protocols/software tools:**
None currently.

5. **WWW links:**
http://www.bnl.gov/DAS/eecd.html

iv. **Demonstration Projects:**
Pre-production demonstration of UL approved Pioneer Burner (using FAB technology) by Heatwise Inc of Middle Island, NewYork. The field demonstration is currently planned for 100 homes during the 1997/1998 heating season within the New York area.

v. **International Activities:**
None currently.

vi. **Future Projects:**
Continuation of the above described projects.

vii. **Collaborations with Insurance Industry:**
None currently.

viii. **Research Agenda:**

1. The impact, in terms of real insurance loss, of training and service on residential safety related to heating equipment and thermal distribution systems.

2. Safety of venting related to combustion-driven equipment in residences.

3. Fuel storage, filling and location within residences for fire protection and environmental impact.

4. Materials studies of corrosion resistance in fuel storage, heat exchangers, and venting systems for appliances fired with liquid fuels.

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Sector:
Buildings

I. **Technology Studied:**
Duct Audits

A. **Description:**
This work includes field research using energy audit techniques on forced-air duct system performance and the support of the development of ASHRAE Standard 152P in terms of the performance of ducted and hydronic systems. The performance of the duct system has a direct impact on overall heating equipment performance and an indirect effect on indoor air quality. A poor performing duct system, one that leaks, can result in low overall building HVAC efficiency, poor combustion with soot formation and/or improper air balance in the building which can lead to local depressurization and contaminant circulation.

B. **Avoided Insurance Losses:**
Avoided losses span the health, life, property, and property liability insurance markets. By reducing the likelihood of unintended home depressurization, improved duct performance can avoid fires caused by furnace flame roll-out and carbon monoxide deaths. By reducing heat losses into attic spaces, the system can

also help prevent ice dams.

C. **Resources**

i. **Research capabilities and skills:**
Full and part-time staff consisting of scientists and engineers whose responsibilities include basic research, applied laboratory and field data collection, and analysis.

ii. **Research facilities:**
Extensive laboratory facilities and instrumentation dedicated to combustion, efficiency, and emission testing of heating equipment.

iii. **Selected Publications:**

1. Andrews, J.W., "Field Comparison of Design and Diagnostic Pathways for Duct Efficiency Evaluation," BNL Report 632=174, June 1996.

2. Andrews, J.W., "Design Predictions and Diagnostic Test Methods for Hydronic Heating Systems in ASHRAE Standard 152P," BNL Report 63200, April 1996.

iv. **Standards/guidelines/protocols/software tools:**
Proposed ASHRAE Standard SPC 152P, Method of Test for Determining the Steady-State and Seasonal Efficiencies of Residential Thermal Distribution Systems.

v. **WWW links:**
http://www.bnl.gov/DAS/eecd.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
Continuation of the above described projects.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**

1. The impact, in terms of real insurance loss, of training and service on residential safety related to heating equipment and thermal distribution systems.

2. Safety of venting related to combustion-driven equipment in residences.

3. Fuel storage, filling and location within residences for fire protection and environmental impact.

4. Materials studies of corrosion resistance in fuel storage, heat exchangers, and venting systems for appliances fired with liquid fuels.

Laboratory Identification Number: BNL-3

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Sector:
Buildings

I. **Technology Studied:**
Software for Improving Oil-Fired Heating System Venting Performance

A. **Description:**
Technical support of National Fire Protection Association (NFPA) in terms of standards and venting recommendations for high efficiency oil-fired heating systems. Development of Oil Heat Vent Analysis Program (OHVAP) for the analysis of venting systems. The understanding of how a vent system performs has resulted in a plan for periodic inspection and diagnosis of the operating performance over time. This understanding with both mandated text changes and venting recommendations has been incorporated in the flue gas venting and fire safety considerations of NFPA 31.

B. **Avoided Insurance Losses:**
Improving the venting of high efficiency oil-fired heating systems will result in the reduction of health insurance claims, especially those related to carbon monoxide, and to the reduction of property losses as a result of fires.

C. **Resources**

i. **Research capabilities and skills:**
Full and part-time staff consisting of scientists and engineers whose responsibilities include basic research, applied laboratory and field data collection, and analysis.

ii. **Research facilities:**
Extensive laboratory facilities and instrumentation dedicated to combustion, efficiency, and emission testing of heating equipment.

iii. **Selected Publications:**
Krajewski, R.F. and J.J. Strasser, "Oil Heat Vent Analysis Program Users Manual and Engineering Report," BNL Report 63668, November 1996.

iv. **Standards/guidelines/protocols/software tools:**

1. National Fire Protection Association (NFPA) Standard 31, Standard for the Installation of Oil-Burning Equipment, 1997 Edition.

2. Oil Heat Vent Analysis Program (OHVAP) Version 3.1.

v. **WWW links:**
http://www.bnl.gov/DAS/eecd.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
Continuation of the above described projects.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**

1. The impact, in terms of real insurance loss, of training and service on residential safety related to heating equipment and thermal distribution systems.

2. Safety of venting related to combustion-driven equipment in residences.

3. Fuel storage, filling and location within residences for fire protection and environmental impact.

4. Materials studies of corrosion resistance in fuel storage, heat exchangers, and venting systems for appliances fired with liquid fuels.

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Sector:
Buildings

I. **Technology Studied:**
Training and Certification of Oil-Fired Heating System Service Personnel

A. **Description:**
Technical support for the implementation and servicing of high efficiency oil-fired heating systems. Regular and timely communication with industry to discuss the results of and direction of current research and emerging technologies has resulted in the appropriate application of these technologies in the field. As part of this activity the preparation of training literature, and the training, testing, and certification of service personnel has aided in the safe long-term operation of oil-fired heating equipment.

B. **Avoided Insurance Losses:**
Improving the efficiency, venting, and distribution of oil-fired heating systems will result in the reduction of health insurance losses (e.g., carbon monoxide and smoke) and property losses (e.g., from fires).

C. **Resources**

i. **Research capabilities and skills:**
Full and part-time staff consisting of scientists and engineers whose responsibilities include basic research, applied laboratory and field data collection, and analysis.

ii. **Research facilities:**
Extensive laboratory facilities and instrumentation dedicated to combustion, efficiency, and emission testing of heating equipment.

iii. **Selected Publications:**
McDonald, R.J., Proceedings of the 1996 Oil Heat Technology Conference and Workshop (March 28-29, 1996), BNL Report 52506, July 1996.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.bnl.gov/DAS/eecd.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
Continuation of the above described projects.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**

1. The impact, in terms of real insurance loss, of training and service on residential safety related to heating equipment and thermal distribution systems.

2. Safety of venting related to combustion-driven equipment in residences.

3. Fuel storage, filling and location within residences for fire protection and environmental impact.

4. Materials studies of corrosion resistance in fuel storage, heat exchangers, and venting systems for appliances fired with liquid fuels.

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Sector:
Utilities

I. **Technology Studied:**
Fuel Cells

A. **Description:**
Fuel cells can convert the chemical energy of nonpetroleum fuels such as hydrogen, methanol, or ethanol to electricity with little or no pollution and with greater efficiency than heat engines. Fuel cells can provide clean, reliable power to building facilities of widely varying sizes, from residences to commercial and industrial facilties, in addition to their applications in the transportation sector.

INEEL's program develops new materials and low cost fabrication technologies for fuel cells. New materials developed have included various nickel aluminide intermetallic composites (for bi-polar plates) and electronically conductive ceramics. Fabrication techniques have included plasma spraying of protective coatings (metals, ceramics, intermetallics) and electrolytes (zirconia), and powder metallurgy/combustion synthesis of nicel aluminide structures. Emphasis has been placed on high temperature Solid Oxide Fuel Cell (SOFC) technology.

Materials and fabrication techniques have been developed that could be

commercially used at low cost. Enhanced electrochemical performance of fuel cell power plants will be realized due to designs that greatly reduce internal resistance losses. The nickel aluminum bi-polar plate has been found to be catalytic towards internal reforming of hydrocarbon fuels, such that the SOFC can directly utilize fuels such as methane, diesel fuel, unleaded gasoline, methanol, etc.

This work will be helpful for dispersed power users (factories, commercial buildings, neighborhoods, military bases).

B. **Avoided Insurance Losses:**
Fuel cells can be used to reduce service interruptions when power service is disrupted.

C. **Resources**

i. **Research capabilities and skills:**
The Energy Storage Technologies Laboratory is supported by material and chemical science groups.

ii. **Research facilities:**
In the Energy Storage Technologies Laboratory, controlled tests examine the performance of energy storage devices (e.g., fuel cells). The National Institute of Standards and Technology's Calibration Laboratory at INEEL supports the Energy Storage Laboratory; this facility calibrates test equipment within the Energy Storage Laboratory.

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.inel.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: INEEL-2

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Sector:
Buildings

I. **Technology Studied:**
Demand-Controlled Ventilation System

A. **Description:**
Indoor air quality is a growing concern to commercial/industrial building owners and occupants. Complying with the existing standard for indoor air quality is energy intensive with high operational and first costs. An integrated indoor air quality monitoring and control system reduces ventilation rates with resulting energy and equipment savings. The demand control ventilation system (DCVS) is a system of hardware, software, sensors, and controls that can be interfaced with existing and future HVAC systems. The DCVS should be able to provide peak load power reduction in commercial and industrial buildings from reduced HVAC requirements, and reduced new construction costs because systems can be sized for lower ventilation rates.

B. **Avoided Insurance Losses:**
Reduce health insurance and workers compensation claims related to illnesses resulting from poor indoor air quality.

C. **Resources**

i. **Research capabilities and skills:**

ii. **Research facilities:**

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.inel.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Utilities

I. **Technology Studied:**
Software Tools for Flywheel Design

A. **Description:**
Flywheels for stationary and electric/hybrid vehicle applications are costly to prototype and test, yet are an attractive form of energy storage. Software tools for modeling and analysis of flywheel systems allow designs to be optimized prior to prototype development, saving time and money. This software contains a finite element model for structural analysis and consideration of the properties of materials. It also contains design optimization tools that use the model to automate changes in design variables, allow the visualization of the design, and optimize the design subject to structural analysis variables.

The flywheel market has many applications and will result in peak energy savings.

B. **Avoided Insurance Losses:**

Because it is an uninterruptible power supply, service interruption losses will be reduced when power service is disrupted.

C. **Resources**

i. **Research capabilities and skills:**

ii. **Research facilities:**

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.inel.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Intelligent Air Quality Monitoring Technologies

A. **Description:**
The primary objective of this program is the development of integrated embedded sensor system networks for simultaneous measurement of chemical constituents, normally or abnormally, present in air handling and ventilation systems within office buildings, research laboratories, industrial workplaces, public transportation, and other facilities.

The measurement of normal and abnormal constituents will enable timely identification and correction of potential conditions adverse to human health and safety, resulting from the inadvertent, accidental, or intentional introduction of toxic or hazardous materials into human occupied areas. The integrated sensor systems contain several individual sensors that detect different categories of compounds of importance to air quality, such as acids, bases, allergens, halocarbons, hydrocarbons, oxidants, reductants, toxins, permanent gases, and chemical and biological weapon materials.

The various types of sensors include tin oxide solid state detectors, electrochemical sensors, acoustic wave sensors, photoionization sensors, etc. and are incorporated into small compact systems applicable for placement within ventilation and air handling systems throughout a facility. The data produced by the sensors will be integrated and used as input data for a neural network analysis package. The neural network package is trained to assimilate the data from the sensors to assess and identify normal and abnormal air quality.

B. **Avoided Insurance Losses:**
This technology should help reduce insurance losses related to indoor environmental quality within office buildings, research laboratories, industrial workplaces and other public facilities. The following types of insurance losses will be reduced: workers compensation, professional liability, product liability, comprehensive general liability, and contractors liability. This is a growing area for commercial insurers, and it is also applicable to self-insured entities as a loss control technique.

C. **Resources**

i. **Research capabilities and skills:**

ii. **Research facilities:**

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.inel.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Energy-Efficient Halogen Torchiere Replacements

A. **Description:**
Halogen torchieres account for about 10% of residential lighting use in the United States. Current halogen floor lamps are extremely energy-intensive (300 Watts) and also operate at very high temperatures (~1000 F) creating a significant fire hazard in homes). According to the U.S. Consumer Products Safety Commission, they are one of the primary causes of lighting-related fires in homes.

The LBNL Lighting Systems Research Group has developed a safer, energy-efficient torchiere as a replacement for the halogen floor lamp based on compact fluorescent technology. This replacement lamp consumes only 60-80 Watts (over 70% energy savings) to provide the same amount of light output, and operates at significantly lower temperatures (only 100 F) eliminating the risk of fire hazards). It has been estimated that if current halogen torchieres were replaced by CFL torchieres in the US, annual energy savings would be 9.5 TWh, or about two

times the amount of electricity produced in one year by a 1,000 MW power plant.

B. **Avoided Insurance Losses:**
According to the U.S. Consumer Products Safety Commission, halogen torchieres are one of the primary causes of lighting-related fires in homes (232 fires have been reported since 1991). About 100 fires occurred at U.S. colleges and universities in 1996 and 1997. Fire insurance losses related to lighting in U.S. homes run about $100 million annually (U.S. Consumer Products Safety Commission, "1994 Residential Fire Loss Estimates," Washington, DC.). Also, 11 deaths have been attributed to fires from halogen torchieres (Wall Street Journal, 1997). Product liability claims against halogen torchiere manufacturers (already quite numerous) could be avoided through the use of CFL alternatives.

C. **Resources**

i. **Research capabilities and skills:**
Knowledge of material and lighting properties of various light sources. Ability to identify novel and appropriate efficient light sources, develop prototype fixtures, measure fixture lumen output and distribution (swing-arm gonio-photometer), temperatures (bulb) and to analyze energy input and output requirements for lamps and fixtures. Ability to design prototype fixtures to optimize light output and minimize energy inputs. Also ability to gather in-use data from ongoing demonstrations in the field.

ii. **Research facilities:**
LBNL lighting laboratory. Also extensive contacts with major lighting producers who can transform prototypes into commercially available products.

iii. **Selected Publications:**
General descriptions

Center for Building Science Newsletter (http://eande.lbl.gov/CBS/NEWSLETTER/NL12/torchieres.html),

Lighting Systems Research Group torchiere work (http://eande.lbl.gov/BTP/torchiere.html).

More detailed description

Siminovitch, M. J. and Page, E.R., "Energy Efficient Alternatives to Halogen Torchieres," Submitted to Illuminating Engineering Society's Annual Conference, August, 1997.

iv. **Standards/guidelines/protocols/software tools:**
Efficient lighting fixture accepted as an EPA Energy Star Label product.

v. **WWW links:**

http://eetd.lbl.gov/BTP/lsr.html
http://eff.nutek.se/IAEEL/IAEEL.html

D. **Demonstration Projects:**
The Lighting Systems Research Group worked with a major lighting fixture manufacturer and Stanford University to place 500 torchieres, whose design is based on the photometric and optic experiments done at LBNL, in undergraduate dormitories in April 1997. The Stanford Housing Energy Conservation Center plans to study the impact of the torchiere swap on energy consumption. The school hopes to replace all halogen torchieres with an energy-efficient design by the start of the next academic year. An LBNL research group member has also worked with Harvard University to test the potential for energy savings with CFL torchieres there. LBNL is assisting with demonstrations at Northeastern University.

E. **International Activities:**
Data on torchiere penetration and fire incidences in other countries are being collected.

F. **Future Projects:**
Future research efforts for this technology are focusing on (a) the development of cheaper prototypes, (b) development of dimming mechanisms, (c) design, modeling, and possible prototype development of asymmetric reflectors to be used in the lamps, and (d) support for market transformation efforts to increase the rate of penetration of the technology into the consumer lighting market.

G. **Collaborations with Insurance Industry:**
LBNL conducted a demonstration project and training workshop at Northeastern University with Arkwright Mutual Insurance Company and is planning to conduct similar workshops at other universities with Arkwright.

H. **Research Agenda:**

1. Conduct focused surveys to more precisely determine the national sales of fire-hazardous torchiere fixtures, and to pinpoint the types of buildings in which they are installed.

2. Develop more affordable prototypes.

3. Develop dimming mechanisms.

4. Design, model, and develop prototypes of asymmetric reflectors to be used in the fixtures.

5. Support market transformation efforts to increase the rate of penetration of the technology into the consumer lighting market.

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Sector:
Buildings

I. **Technology Studied:**
Energy-Efficient Windows

A. **Description:**
Energy-efficient windows reduce unwanted heat transfer in both summer and winter. Coatings on glass, invisible to the human eye, can reduce solar heat gains and/or long-wave radiant heat transfer. Insulating frames and spacers can reduce conduction and thermal bridges through window edges.

B. **Avoided Insurance Losses:**
Energy-efficient windows reduce exposure to property losses for residences and businesses and increase safety, because they can: (1) reduce glass breakage in fires, (2) minimize forced entry, (3) lead to reduced furnace ontime, reducing the potential for fires from faulty HVAC systems, (4) minimize fading of materials in the home, (5) reduce ultraviolet radiation transmission, which could have positive benefits for human health and fading of furniture, and (6) reduce shattering-related losses resulting from windstorms or earthquakes. Professional liability

losses are also reduced.

C. **Resources**

i. **Research capabilities and skills:**
International experts in window heat transfer and optics. Research staff maintains ongoing ties to national and international glass and window industry R&D and applications teams.

ii. **Research facilities:**

1. Infrared (IR) laboratory: unique facility to measure the surface temperatures of window products.

2. MoWitt laboratory: measures field performance of window by measuring heat flow through two side-by-side window samples.

3. Coating laboratory: facility to manufacture and analyze coatings.

4. Optics laboratory: custom devices are developed to measure optical properties of glazings.

iii. **Selected Publications:**

1. Sullivan, R., B. Chin, D. Arasteh, and S. Selkowitz, "RESFEN: A Residential Fenestration Performance Design Tool," *ASHRAE Transactions* 22(1) (1992).

2. Sullivan, R., D. Arasteh, K. Papamichael, and S. Selkowitz. "An Appoach for Evaluating the Thermal Comfort Effects of Nonresidential Building Fenestration Systems," International Symposium on Advanced Comfort Systems for the Work Environment, May 1-3, 1988.

3. Reilly, S., S. Selkowitz, and F. Winkelmann, "Optical Properties Database For High Performance Glazings," IEA Task XII report, 1992.

4. Sullivan, R., E.S. Lee, and S. Selkowitz, "A Method of Optimizing Solar Control and Daylighting Performance in Commercial Office Buildings," Proceedings of the ASHRAE/DOE/BTECC Conference on the Thermal Performance of the Exterior Envelopes of Buildings V, Clearwater Beach, FL (1992).

iv. **Standards/guidelines/protocols/software tools:**
Technical Leaders of the National Fenestration Rating Council's efforts to develop and implement a fair, accurate, and credible rating and labeling system for the thermal performance of windows. Developers of the

WINDOW and THERM software used to model the thermal and optical performance of windows.

v. **WWW links:**
http://windows.lbl.gov

D. **Demonstration Projects:**
None currently. We are working with the window industry to demonstrate the energy-savings potential and benefits of advanced window products in lab and field projects. We are presently focusing on spectrally selective low-e windows in cooling-dominated climates.

E. **International Activities:**
Active in IEA (International Energy Agency) and ISO (International Standard Organization) committees on window and glass. Maintain contacts with international public and private R&D labs.

F. **Future Projects:**

1. Development and analysis of optically switchable (electrochromic) glazings.
2. Development of highly insulating glazings and window systems.
3. Rating, labeling, and standards activities
4. Increasing the market acceptance of efficient windows.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**

1. Document the insurance benefits of energy-efficient windows.
2. Develop fire ratings, tests, procedures, software, and labels for energy-efficient windows.
3. Educate the insurance industry about energy-efficient windows.

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Sector:
Buildings

I. **Technology Studied:**
Ultraviolet Water Purification

A. **Description:**
The UV Water Purifier (or UV Waterworks) is a small, simple, inexpensive device that uses ultraviolet light to quickly and cheaply disinfect water from the viruses and bacteria that cause cholera, typhoid, dysentery and other deadly diarrheal diseases. Such diseases annually kill an estimated four million children under the age of five and make adults sick enough to lose billions of hours of work productivity and income. The disinfection process is highly energy-efficient and uses approximately 6,000 times less primary energy than the standard alternative--boiling water over a cookstove. It is particularly relevant for developing country applications in communities that do not have adequate water purification facilities.

Unlike other ultraviolet-based water purifiers, UV Waterworks does not require pressurized water-delivery systems. It is designed to rely on gravity for water

flow which means it can be used with any source of water, and needs electricity only for the UV light (40 watts), which means it can be powered by a car-battery or a small (2 square meter) solar panel. The end result is that UV Waterworks offers the first practical means of providing communities in developing nations with readily accessible supplies of safe drinking water. Running on a car battery if necessary, one unit can provide drinking water for a community of 1,000 people. Each unit should cost about $600 retail.

B. **Avoided Insurance Losses:**
UV Waterworks is over 99.99% effective in eliminating waterborne pathogenic bacteria and viruses and producing potable water. Tremendous savings are possible in health insurance losses from UV Waterworks. Water-borne diseases currently kill an estimated four million children under the age of five annually and make adults sick enough to lose billions of hours of work productivity and income. This product could also potentially benefit tourists in developing countries by ensuring potable drinking water and reducing tourist health risks and related insurance claims. Finally, were UV Waterworks to become used as a special disaster-relief technology to produce emergency potable water in US disaster situations, this could shorten periods of business interruption for affected communities (an insurance cost) and reduce health care costs by ensuring adequate clean water supply.

C. **Resources**

i. **Research capabilities and skills:**
Ability to develop prototype UV Waterworks systems and measure system effectiveness, cost, and energy use. LBNL has invented and designed current prototypes, and in 1996 the LBNL principal investigator for this reasearch received both the *Discover Magazine* award for technological innovation and the *Popular Science* award for scientific innovation.

ii. **Research facilities:**
LBNL has dedicated research facilities for improving the UV Waterworks system design and operation, and the project team is now working in the laboratory to significantly lower the system cost without compromising performance.

iii. **Selected Publications:**

1. Gadgil, A. G. and L. J. Shown, "To Drink Without Risk: The Use of Ultraviolet Light to Disinfect Drinking Water in Developing Countries, " LBNL summary article (1995), http://eande.lbl.gov/CBS/archive/uv/drink.html

2. Gadgil, A., "UV Waterworks Specs Sheet (1996)" http://eande.lbl.gov/CBS/archive/uv/specs.html

3. Whitelaw, K., "20 Ways to Save the World," *U.S. News and World Report.* p. 69, Dec. 30, 1996.

4. Ruther, C., "Brighter Light Better Water," *Environmental Health Perspecives*, Vol. 104, No. 10, pp. 1046-1048 (Oct. 1996).

iv. **Standards/guidelines/protocols/software tools:**
Not applicable.

v. **WWW links:**
http://eetd.lbl.gov/CBS/archive/uv/index.html

D. **Demonstration Projects:**
Demonstration projects of the technology are currently underway in South Africa, Mexico, and India.

E. **International Activities:**
In India, Urminus Industries Ltd. of Bombay has taken up the manufacture of UV devices of LBNL design. UV Waterworks units are now being field-tested at one site in South Africa. For all countries except India, the technology has been licensed to Water Health International of Napa, California. A second project has been proposed for areas in South Africa.

F. **Future Projects:**
Future projects will focus on (1) completion of field trials in South Africa, and (2) evaluation of the technology for use in US disaster recovery situations to provide drinking water when piped water supplies are tainted.

G. **Collaborations with Insurance Industry:**
A current collaboration with the insurance industry exists. In a Memorandum of Understanding (MOU) between the U.S. Department of Energy (DOE) and the insurance industry's Institute for Business and Home Safety (IBHS), the two organizations have agreed to cooperate to seek the use of technologies and practices that make buildings and power systems more immune to damages caused by natural hazards. The use of UV Waterworks in the wake of disasters is specifically identified in the MOU as a technology which IBHS and DOE will seek to make widely available in U.S. disaster response operations and will collaborate to encourage the manufacture and use of UV Waterworks for disaster recovery.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Aerosol-Based Duct Sealing Technology

A. **Description:**
Duct systems in houses and offices typically leak 15-30% of the air passing through them. This air leakage impacts safety, energy use, indoor air quality, personal comfort, and the environment. Aerosol sealing is a new technology for internally sealing air leaks in heating and cooling ducts. This technology blows aerosolized adhesive particles into the duct system and deposits them exclusively at the leakage sites, sealing the leaks without depositing on duct surfaces. This technology significantly reduces the cost of insulation retrofits in a home since it reduces labor cost.

B. **Avoided Insurance Losses:**
Avoided losses span the health, life, property, and liability insurance markets. By reducing the likelihood of unintended home depressurization, duct sealing can avoid fires caused by furnace flame roll-out and carbon monoxide deaths. By

reducing heat losses into attic spaces, the system can also help prevent ice dams. This may also reduce product liability and professional liability exposures resulting from improper product installation or building design.

C. **Resources**

i. **Research capabilities and skills:**
Capabilities of developing and testing various duct sealing technologies and measuring impact on air flow, efficiency, and indoor air quality.

ii. **Research facilities:**
Duct research laboratory with technologies for air flow and pressure measurement.

iii. **Selected Publications:**
Trade Publications

1. "Aerosol-Based Duct Sealing Technology," *Center for Building Science News*, Winter 1995, p.8.

2. "Fix a Flat for Ducts," *Popular Science*, March 1996, p.28.

3. "Sticky Little Particles Find Their Way into Duct Leaks and Seal Them Tight," *Fine Homebuilding*, July 1996, pp.38.

4. "Fix-a-Flat for Ducts," *Home Energy*, Vol.12, No. 4, July/Aug. 1995, p.5.

5. "Quick Aerosol Duct Sealing Process Ready for Market," *ENEWS*, No.8, Nov./Dec. 1994, p.1.

6. "Aerosol Technology Seals Ducts Quickly," *Technology Report*, June 1995, p.9.

7. "New Technology Blows Duct Leaks Away," *TOOLS of the TRADE*, Spring 1996, p.12.

8. "New Technology Could Lower Duct Sealing Costs," *Thermal Distribution Update*, Jan. 1995, p.1.

Technical Publications

9. Jump, D.A., I.S. Walker and M.P. Modera, "Field Measurements of Efficiency and Duct Retrofit Effectiveness in Residential Forced-Air Distribution Systems," *Proceedings of ACEEE Summer Study*, Pacific Grove, CA, August 1996, Lawrence Berkeley Laboratory Report, LBL-38537.

10. Modera, M.P., D.J. Dickerhoff, O. Nilssen, H. Duquette, and J.

Geyselaers, "Residential Field Testing of an Aerosol-Based Technology for Sealing Ductwork," *Proceedings of ACEEE Summer Study*, Pacific Grove, CA, August 1996, Lawrence Berkeley Laboratory Report, LBL-38554.

11. Carrie, F.R. and M.P. Modera, "Reducing the Permeability of Residential Duct Systems," Presented at the 16th AIVC Conference, Palm Springs, CA, September 1995.

12. Modera, M.P., "Particle Deposition in a Two-Dimensional Slot from a Transverse Stream," Lawrence Berkeley Laboratory Report LBL-34829. Presented at the 12th Annual Meeting, American Association for Aerosol Research, Oak Brook, Illinois, October 1993.

iv. **Standards/guidelines/protocols/software tools:**
In process of passing UL 181 test protocol.

v. **WWW links:**
http://epb1.lbl.gov/aerosol/page0.htm

D. **Demonstration Projects:**
The technology is now in a commercial phase. Earlier demonstration projects were completed in hundreds of homes nation-wide through the distribution of the technology to utility companies and other housing contractors.

E. **International Activities:**
None currently.

F. **Future Projects:**
Working on developing and applying aerosol-based duct sealing technology to commercial buildings where ducts tend to be larger in both size and length.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Building Commissioning

A. **Description:**
Building commissioning is a process by which a building's energy service systems are tested and calibrated to advance the building system from static installation to full working order. This procedure is *not* normally carried out by today's building professionals, the result of which is frequent underattainment of energy savings and equipment performance problems.

B. **Avoided Insurance Losses:**
Examples of avoided insurance losses include the following: (1) improved indoor air quality, leading to reduced health claims and improved labor productivity; (2) fewer system and equipment design and failure claims; (3) reduced property damages related to avoided equipment failures; and (4) reduced professional liability claims for all participants in the design/build community (e.g., architects and engineers).

C. **Resources**

i. **Research capabilities and skills:**

1. Evaluations of the costs and benefits of commissioning using energy simulations and case study data.

2. Developed information systems for building performance assurance and commissioning

ii. **Research facilities:**
Advanced data visualization tools, database systems, and data collection gateways.

iii. **Selected Publications:**

1. Hitchcock, R. and J. Thorpe, (Video), "Building Performance Assurance Program: Life-Cycle Information Systems," Lawrence Berkeley National Laboratory, Berkeley, CA.

2. Piette, M.A., "Commissioning Tools for Building Life-Cycle Performance Assurance," LBNL Report 38979, Lawrence Berkeley National Laboratory, Berkeley, CA. Presented at the 4th National Conference on Building Commissioning, 1996.

3. Piette, M. A., R. Diamond, B. Nordman, O. de Buen, J.P. Harris, K. Heinemeier and K. Janda, "Final Report on the Energy Edge Impact Evaluation of 28 New, Low-Energy Commercial Buildings," Report to the Bonneville Power Administration, LBL-33708, Lawrence Berkeley National Laboratory, Berkeley, CA, February, 1994.

4. Piette, M.A. and B. Nordman, "Costs and Benefits of Utility Funded Commissioning of Energy-Efficiency Measures in 16 Buildings," *ASHRAE Transactions*, Atlanta, GA, Vol. 102, Pt 1. Feb. 1996, (LBNL-37823, Lawrence Berkeley National Laboratory, Berkeley, CA).

5. Selkowitz, S. "Interoperable, Life-cycle Tools for Assuring Building Performance: An Overview of a Commercial Building Initiative." LBNL-40833. Lawrence Berkeley National Laboratory, Berkeley, CA. Presented at the U.S. Green Buildings Council's Third Annual Conference, Nov. 1996, San Diego, CA.

iv. **Standards/guidelines/protocols/software tools:**

1. "Model Commissioning Plan and Guide Specifications, Version 2.0," Sponsored by the US Department of Energy, 1977.

2. "HVAC Systems Commissioning Manual-1st edition," Sheet Metal and Air Conditioning Contractors' National Association inc. (SMACNA), 1994.

3. Heinz, John A., Rick Casault and Phoebe Caner, "The Building Commissioning Handbook," The Association of Higher Education Facilities Officers (APPA), 1996.

4. "The HVAC Commissioning Process," ASHRAE Guideline 1-1989R, final draft, 1996.

5. The U.S. EPA Energy Star Buildings Program requires building commissioning.

v. **WWW links:**
http://eetd.lbl.gov/CBS/BPA/BPA.html
http://www.lbl.gov/~olken/RBO/rbo.html
http://eetd.lbl.gov/EA/BEA/Diag/diagnostics.html

D. **Demonstration Projects:**

1. Building Life Cycle Information systems (BLISS). BLISS is intended to provide a distributed computing environment for managing, archiving, and providing access to the wide variety of data and information generated across the complete life-cycle of a building project.

2. A multi-year project is underway to develop and apply technology to improve building operation and maintenance (one facet of commissioning). This project is sponsored by the California Institute of Energy Efficiency (CIEE). An interdisciplinary team has been gathered to: assess the current state of performance technology, develop an appropriate information gathering and diagnosis capability, and test this new diagnostic system in real buildings.

E. **International Activities:**
None currently.

F. **Future Projects:**
Working with industry groups to further define the scope of building commissioning.

Continued work on improving commissioning test procedures and tools.

G. **Collaborations with Insurance Industry:**
Active discussions with the two largest U.S. providers of professional liability insurance for architects and engineers.

H. **Research Agenda:**

Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Building Code Compliance

A. **Description:**
Enforcing state building energy codes is one of the most promising approaches to making sure that energy is used efficiently in residential and nonresidential buildings. However, not all builders construct homes that meet energy codes (where they exist). In this project, we examined studies of building compliance in two regions of the U.S. (the Pacific Northwest and California) and found a high number of violations in plans, in the field, and in attainment of energy savings targets.

B. **Avoided Insurance Losses:**
We do not have data relating insurance losses to noncompliance with building codes. Noncompliance with thermal codes can be expected to reduce insurance losses involving fire, freezing, and moisture damage in the building envelope. It can also reduce health, liability, and workers compensation exposures resulting

from poor indoor air quality issues.

C. **Resources**

i. **Research capabilities and skills:**
LBNL's Environment Energy Technologies Division houses a diverse group of scientists known for their expertise in the building sciences and energy policy.

ii. **Research facilities:**
LBNL has developed extensive computer programs to model the behavior of buildings under different compliance regimes: e.g., DOE-2, PEAR, REM, COMMEND, and the Home Energy Saver.

iii. **Selected Publications:**

1. Vine, E., "Residential Building Code Compliance: Implications for Evaluating the Performance of Utility Residential New Construction Programs," *Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings*, Vol. 3 pp. 161-168, Pacific Grove, CA.

2. Vine, E., "Residential Building Code Compliance: Recent Findings and Implications," Center for Building Science, Winter 1997, p. 6 (http://eetd.lbl.gov/CBS/NEWSLETTER/NL13/code.html).

iv. **Standards/guidelines/protocols/software tools:**
For building code development, LBNL has assisted the technical committees of the Association of Heating, Refrigerating and Equipment (ASHRAE).

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL13/code.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
LBNL has conducted code compliance studies in China and building code development in ASEAN economies.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently. We are discussing a possible collaboration with the insurance industry's Institute for Business and Home Safety (IBHS) and insurance companies.

H. **Research Agenda:**
Nothing submitted

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Sector:
Buildings

I. **Technology Studied:**
Light Surfaces and Urban Trees

A. **Description:**
The relative darkness of urban landscapes and absence of trees causes cities to be hotter than surrounding countrysides. Elevated temperatures in urban "heat islands" increase cooling energy use and accelerate the formation of urban smog. A strategy of reroofing residences and pavements with solar reflective materials and planting shade trees can reduce air conditioning use, cool the urban heat island and lower smog, which forms more readily at higher air temperatures. Recent research suggests that by adopting these strategies, Los Angeles could directly lower air conditioning bills by $100 million, cool the air in the LA basin, saving another $70 million from indirect cooling effects, and reduce smog exceedance of federal air standards by 10 per cent (worth about $360 million).

B. **Avoided Insurance Losses:**
Avoided insurance losses include: (1) cool roofing materials buffer interiors

against extreme high temperature episodes (a precursor of urban heat deaths and hospitalization); (2) less air-conditioning use during peak power periods lessens the risk of power failures; (3) less energy use for air conditioning will reduce emissions from power plants and less emissions lowers health insurance claims from respiratory diseases; (4) less property damage from roofs (if new roofs (with light surfaces) are installed, then wind damage should be less than if old roofs were still in place); and (5) health benefits from reduced smog. Also, there are indications that the increased use of urban trees creates a buffer that reduces the likelihood of flash floods from storms, reducing losses for businesses and commercial insurers (but not for residences).

C. **Resources**

i. **Research capabilities and skills:**
Measuring roof reflectivity and interior temperatures at a variety of field sites, including residences, schools, commercial buildings; computer modeling of climate and air quality modeling of the effects of large-scale changes in solar reflectivity of urban areas.

ii. **Research facilities:**
Facilities for studying the solar reflectivity of building and paving materials.

iii. **Selected Publications:**

1. Akbari, H., R. Levinson and P. Berdahl. 1996. "ASTM Standards for Measuring Solar Reflectance and Infrared Emittance of Construction Materials and Comparing their Steady-State Surface Temperature," *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings*, Vol.1, p.1, Pacific Grove, CA. Also, Report No. LBL-38676, Lawrence Berkeley National Laboratory.

2. Rosenfeld, A.H., J.J. Romm, H. Akbari and A. C. Lloyd. 1997. "Painting the Town White—and Green," *Technology Review*, February/March, p.53-59.

3. Rosenfeld, A.H., J.J. Romm, H. Akbari, M. Pomerantz and H. Taha. 1996. "Policies to Reduce Heat Islands: Magnitudes of Benefits and Incentives to Achieve Them," *Proceedings of the 1996 ACEEE Summer Study ono Energy Efficiency in Buildings*, Vol. 9, p. 177, Pacific Grove, CA. Also, Report No. LBL-38679, LBNL, Lawrence Berkeley National Laboratory.

4. **Standards/guidelines/protocols/software tools:**
In the process of developing "coolness" labels for roofing materials and ASTM standards for measuring solar reflectance of building

materials; working with air quality districts to develop emissions trading credits for cool roofs and shade trees.

5. **WWW links:**
   http://eetd.lbl.gov/EA/BEA/HIP/himain.html

iv. **Demonstration Projects:**
Effectiveness of cool building materials has been demonstrated through direct measurements of residences and school buildings in Sacramento. Southern California Gas Company's new Energy Resources Center in Downey, California uses these measures to demonstrate their energy-saving ability. Three commercial building demonstrations in Gilroy, San Jose, and Davis.

v. **International Activities:**
None currently.

vi. **Future Projects:**
Future efforts are focusing on working with roofing material manufacturers to adopt coolness labels, and to develop a new generation of cooler roofing and paving materials. Other efforts are focused on ASTM standards for measuring solar reflectivity, and working with air quality districts to develop incentives for using cool roofing and paving materials, and planting shade trees.

vii. **Collaborations with Insurance Industry:**
None currently.

viii. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Geographic Information Systems for Targeting Loss-Prevention Measures

A. **Description:**
Researchers use geographic information systems (GIS) to combine different types of data in order to understand the variability in the ownership and use of energy-using technologies. GIS can disaggregate data according to different levels: ZIP code locations, census tracts, census divisions, cities, counties, states, utility service territories, climate zone, etc. With this capability, a researcher can determine, for example, how many households in a region own a particular appliance or building technology (such as energy-efficient windows), and how many will buy replacements or new units in the next year.

B. **Avoided Insurance Losses:**
GIS technologies can help insurers analyze policyholder data bases, assess geographic concentrations, and assess risk profiles in personal and commercial insurance lines. Examples include risk of water pipe damage, ice dam formation,

and insufficiently insulated roofs.

C. **Resources**

i. **Research capabilities and skills:**
LBNL Energy Analysis staff have expertise in using GIS software to develop simulation models that can analyze the energy impacts, performance, and market distribution of greenhouse gas-reducing, energy-efficient technologies and practices. The staff is also able to conduct environmental risk assessments using GIS.

ii. **Research facilities:**
The GIS Lab consists of SUN workstations, including a SPARC 20 and SPARC 1, as well as a Calcomp 9500 digitizer, and several types of GIS software, primarily ARC/View, ARC/Info and Earth Resources Data Analysis System. ARC/Info is a vector-based GIS program produced by the Environmental Systems Research Institute; the ERDAS is a raster-based system.

iii. **Selected Publications:**
Center for Building Science News, Spring 95, p.7. The Geographic Information Systems Laboratory (see Web site below).

iv. **Standards/guidelines/protocols/software tools:**
ARC/View, ARC/Info and Earth Resources Data Analysis System

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL6/GIS.html

D. **Demonstration Projects:**
Energy Analysis staff are using GIS for targeted marketing of energy-efficient residential products as part of a project funded by the U.S. Environmental Protection Agency. This project is helping the EPA design effective energy-efficiency programs.

E. **International Activities:**
None currently

F. **Future Projects:**
Analysis of regional impacts of possible uptdates to energy-efficiency standards for residential water heaters.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Measurement & Verification Protocols

A. **Description:**
Standard measurement and verification (M&V) protocols will provide a uniform method of determining how much energy is saved by energy efficiency measures. M&V protocols are necessary because pay-for performance arrangements have become more common in contracts between providers of energy-efficiency services and their customers. Many of these arrangements involve third-party financing and periodic payment streams that are tied to some verified energy savings. LBNL is involved with other national laboratories and many other organizations in assisting the U.S. Department of Energy in designing and implementing the International Performance Measurement and Verification Protocol.

B. **Avoided Insurance Losses:**

M&V provides an industry standard to measure building performance and a basis for insurers to underwrite specialty line coverages. Examples of avoided insurance losses include the following: (1) improved indoor air quality, leading to reduced health claims and improved labor productivity; (2) fewer system and equipment design and failure claims; (3) reduced property damages related to avoided equipment failures; and (4) reduced professional liability claims for all participants in the design/build community (e.g., architects and engineers).

C. **Resources**

i. **Research capabilities and skills:**
Researchers at LBNL's Applications Team sit on working groups and committees of all three organizations that are developing M&V protocols, and are providing input and expertise as these protocols evolve.

ii. **Research facilities:**
Not applicable.

iii. **Selected Publications:**

1. Haberl, J., J. Athar, M. Abbas, D. Claridge, and M. MacDonald, "Comparing Monitoring Protocols for Energy Retrofits," ASHRAE Transactions Symposium Paper, 98 (1): 1081-1096, January 1992.

2. Kats, G., A. Rosenfeld, T. McIntosh, and S. McGaraghan. 1996. "Energy Efficiency as a Commodity: The Emergence of an Efficiency Secondary Market for Savings in Commercial Buildings," Proceedings of the 1996 ACEEE Summer Study, Vol. 5, pp. 111-122. American Council for an Energy-Efficient Economy, Washington, D.C.

3. Kromer, J.S. and S. Schiller, "National Measurement and Verification Protocols," Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency, American Council for an Energy-Efficient Economy, Berkeley, CA.

4. U.S. Department of Energy, *International Performance Measurement and Verification Protocol*, 1998. U.S. Department of Energy, Washington, D.C. (see WWW links)

iv. **Standards/guidelines/protocols/software tools:**

1. "International Performance Measurement and Verification Protocol," U.S. Department of Energy (see Web address below)

2. "GPC-14 Guideline for Measuring Demand and Energy Savings,"

American Society of Heating, Refrigeration and Air Conditioning Engineers (see Web address below).

3. "Measurement & Verification Guidelines," Federal Energy Management Program (FEMP) (see Web address below).

v. **WWW links:**
IMPVP: http://www.ipmvp.org
ASHRAE: http://www.ashrae.org
FEMP: http://www.eren.doe.gov [Building Systems and Community Programs]

D. **Demonstration Projects:**
The Federal Energy Management Program has awarded Energy Service Performance Contracts to six firms that are providing energy efficiency services to federal facilities. They will use FEMP's M&V protocols to measure energy savings.

E. **International Activities:**
The International Performance Measurement and Verification Protocol has been translated into seven languages (Czech, French, Hungarian, Polish, Portuguese, Russian, and Spanish) for implementation internationally.

F. **Future Projects:**
Work groups developing the protocols are developing methods for quantifying costs and benefits of incremental M&V work. M&V methods defined in protocol documents will need to be tested and updated to ensure that they are repeatable. Industry will provide case studies, application guides, and documentation of results and costs. The protocols will continue to evolve as the energy efficiency industry grows.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Indoor Pollutant Source Reduction

A. **Description:**
Reducing the strength of indoor pollutant sources is commonly the best (i.e., the simplest, most effective and economical) method to reduce indoor air pollution. Illustrative measures for reducing source strength include the following:

1. improved selection of building furnishings (e.g., carpets, paneling)
2. selection of low emission paints and coatings for use in the building
3. reduction of biological aerosols by controlling moisture condensation and humidity
4. establishing separately exhausted zones for indoor smoking
5. eliminating or reducing the use of insecticides and fungicides inside

building

6. ensuring adequate isolation of fresh air intakes for the building ventilation from nearby pollutant-laden exhaust air-streams

7. measures to reduce or eliminate the entry of radon-bearing soil gas into the occupied space

8. eliminating the use of unvented kerosene space-heaters.

Each of these measures has detailed technical specifications for implementation.

B. **Avoided Insurance Losses:**

1. Worker's Compensation: Workers can claim worker's compensation if their health is adversely affected by exposure to airborne pollutants at the workplace.

2. Health insurance: Claims for medical treatment will arise for adverse health effects arising from exposure to airborne allergens, toxics and irritants, chemical sensitivities, sickness from exposure to legionella and other pathogens.

3. Professional Liability: The designers, architects, building contractors and interior decorators can be held liable for sickness arising from sick-building-syndrome (SBS). In that case, they will make claims from their insurance carriers for professional liability.

4. Commercial General Liability: The owners and operators of the commercial building having SBS may end up paying compensation for employee health damages to companies renting these premises or directly to employees working there. In that case, they will make claims under commercial general liability.

5. Completed Operations Liability: When the building is designed, built, commissioned and handed over to the operator-owner, the original builders continue to have liability protection should any problems arise. In case of an building with SBS, they will make claims to the insurer under the completed operations liability.

6. Contractor's Liability: SBS problems with a newly completed building could also lead to claims from the contractors who worked on the building, since they may have to pay for either the health care costs or for the necessary repairs and replacement/renovations of building components to remove the cause SBS complaints.

C. **Resources**

i. **Research capabilities and skills:**

1. In-depth knowledge of indoor air pollutants and their sources.
2. Sophisticated and sensitive laboratory capabilities to analyze indoor air samples and quantify the potential of emission-source (e.g., paints, carpets) for their emission characteristics.
3. A thorough understanding of mechanical ventilation systems and their operations and control.
4. Knowledge of entry and control methods for indoor radon.
5. Expertise in measuring fresh air supply rates and pollutant removal rates in commercial buildings under complex conditions.
6. Expertise in collecting air samples.
7. Thorough knowledge of measurement and characterization of indoor aerosols, volatile organics, and other pollutants.

ii. **Research facilities:**
Air-chemistry laboratory facility, fully instrumented room size stainless-steel lined emissions chamber, mechanical ventilation diagnosis equipment and laboratory, ducts laboratory, computational and modeling research facilities, radon research laboratory, full-sized experimental facility for interzonal air and pollutant transport under a variety of indoor environmental conditions.

iii. **Selected Publications:**

1. Chen, A. and E. Vine, "The Costs of Indoor Air Quality Illnesses: An Insurance Loss Reduction Perspective" (draft report), LBNL report.
2. Daisey, J. M., A. T. Hodgson, W. J. Fisk, M. J. Mendell, and J. Ten Brinke, "Volatile Organic Compounds in Twelve California Office Buildings: Classes, Concentrations and Sources," *Atmospheric Environment*, 28:3557-3562. 1994.
3. Fisk, W. J., M. J. Mendell, J. M. Daisey, D. Faulkner, A. T. Hodgson, M. Nematollahi, and J. Macher, "Phase I of the California Healthy Buildings Study: A Summary," *Indoor Air*, 3(4): 246-254, 1993.
4. Fisk, J. W., A. T. Hodgson, J. M. Macher, M. J. Mendell, J. M. Daisey, and D. Faulkner, "Hypothesis-Based Research on the Causes of Sick Building Symptoms: A Design for Phases 2 and 3

of the California Healthy Buildings Study," Report LBL-33434, Lawrence Berkeley Laboratory, 1992.

5. Hodgson, A. T., "A Review and a Limited Comparison of Methods for Measuring Total Organic Compounds in Indoor Air," *Indoor Air* 5(4):247-257, 1995.

6. Mendell, J. M., W. J. Fisk, J. A. Deddens, W. G. Seavey et al., "Elevated Symptoms Prevalence Associated with Ventilation Type in Office Buildings," *Epidemiology*, 7(6): 583-589, 1996.

iv. **Standards/guidelines/protocols/software tools:**
Guidelines and recommended practice protocols exist for many of the items discussed in part 1 above. For example, visit the web site of Occupational Safety and Health Administration at http://www.osha-slc.gov.

v. **WWW links:**
http://eetd.lbl.gov/IEP/IEP.html
http://eetd.lbl.gov/CBS
http://www.osha-slc.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
LBNL's Indoor Environment Program continues to work on projects to characterize and reduce indoor air pollutant sources, and entry and fate of outdoor pollutants (e.g., outdoor ozone, aerosols) into buildings.

G. **Collaborations with Insurance Industry:**
LBNL's Center for Building Science has recently completed a study on the the costs of indoor air quality illnesses with significant input from the insurance industry. LBNL is also working with the U.S. Department of Energy in establishing an insurance industry advisory group for improvements to the International Performance Measurement and Verification Protocols.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Industry

I. **Technology Studied:**
Air Jacket for Spray Booths

A. **Description:**
Air Jacket is a lightweight vest intended for use by workers in spray-booths and walk-in fume hoods. Estimated production cost is $200. The device removes a shortcoming in standard spray-booths: a back-eddy develops in front of the worker standing in the face of the spray-booth that draws the pollutants (e.g., paint fumes) into his/her breathing zone. The Air Jacket expels a small stream of air away from the worker's chest, removing this eddy. Under laboratory conditions, use of the Air Jacket reduces the pollutant concentrations in the breathing zone by factors between 100 and 800. This reduction is so large that use of Air Jacket may allow some reduction in the face velocity of the spray booth while simultaneously reducing the worker's exposure to paint fumes. Reduced face velocity translates into reduced make-up air and reduced energy use to condition this air. These savings are estimated to be worth about $1000 annually

per Air Jacket per shift in Chicago (from reduced winter heating) and Los Angeles (from reduced summer cooling), if the face velocity is reduced by 50%. Also, with reduced exhaust air, the concentration of pollutants in the exhaust increases, making it less expensive to clean up the exhaust in those areas (e.g., L.A.) where such scrubbing is required by air quality management districts.

B. **Avoided Insurance Losses:**
Exposure to paint fumes can have adverse health effects, which may lead to worker's disability and claims for worker's compensation insurance. Adverse health effects of exposure to paint fumes will also lead to higher claims from the health insurance provider for treatment of the health effects.

C. **Resources**

i. **Research capabilities and skills:**
In-depth knowledge of indoor air pollutants and their sources. Sophisticated and sensitive laboratory capabilities to analyze indoor air samples and potential emission-source (e.g., paints, carpets) for their emission characteristics. A thorough understanding of mechanical ventilation systems and their operations and control. Expertise in measuring fresh air supply rates and pollutant removal rates in commercial buildings under complex conditions. Expertise in collecting air samples. Thorough knowledge of measurement and characterization of indoor aerosols.

ii. **Research facilities:**
Air-chemistry laboratory facility, fully instrumented room-size stainless-steel lined emissions chamber, mechanical ventilation diagnosis equipment and laboratory, ducts laboratory, computational and modeling research facilities, full-sized experimental facility for interzonal air and pollutant transport under a variety of indoor environmental conditions.

iii. **Selected Publications:**
Gadgil, A. J., D. Faulkner, and W.J. Fisk, "Reduced Worker Exposure and Improved Energy-efficiency in Industrial Fume-hoods using an Airvest", Proceedings, IAQ'92: Environments for People, pp. 293-300. October 19-21, 1992, San Francisco, CA. Proceedings published by ASHRAE, Atlanta GA. Lawrence Berkeley Laboratory Report LBL-32244 (1992).

iv. **Standards/guidelines/protocols/software tools:**
Occupational Health and Safety Agency (OSHA) and the relevant State authorities (e.g., Cal-OSHA in California) have standards and guidelines on the minimum face velocity of fume hoods. These guidelines will need to be revised downwards to capture the energy (and cost) benefits of using Air Jackets. Capturing the health benefits alone (from reduced exposure to paint fumes) will not need any such changes in the guidelines.

v. **WWW links:**
http://www.lbl.gov/Tech-Transfer/techs/lbnl832.html
http://www.osha-slc.gov

D. **Demonstration Projects:**
For 1996-1998, South Coast Air Quality Management District (SCAQMD) and California Institute for Energy Efficiency (CIEE) have jointly funded a demonstration / field-test of Air Jacket technology in a few spray booths (at LBNL and in two California paint shops). This research effort, led by LBNL, is underway.

E. **International Activities:**
None currently.

F. **Future Projects:**
See demonstration project description above.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
High-Efficiency Sulfur Lamp Uplighter

A. **Description:**
Sulfur lamps have been used to light outdoor applications for several years since they have much higher efficiencies than regular incandescent lamps. The high efficiency uplighter technology developed by LBNL in conjuction with Cooper Lighting allows for the use of sulfur lamps for indoor applications in commercial buildings. The name of the sulfur lamp is called Solar 1000.

B. **Avoided Insurance Losses:**
The sulfur lamp technology requires fewer fixtures thereby reducing the chances of product malfunction. The lamps also generally have easier access since they are an uplight technology, hence improved worker safety during fixture maintenance and lamp replacement. Safety is also increased in outdoor environments with poorly lit areas. Because these lamps do not use mercury, insurance claims related to the handling of mercury are avoided.

C. **Resources**

i. **Research capabilities and skills:**
Knowledge of material and lighting properties of various light sources. Ability to identify novel and appropriate efficient light sources, develop prototype fixtures, measure fixture lumen output and distribution (swing-arm gonio-photometer), temperatures (bulb) and to analyze energy input and output requirements for lamps and fixtures. Ability to design prototype fixtures to optimize light output and minimize energy inputs. Also ability to gather in-use data from ongoing demonstrations in the field. Also, an ability to optimize reflector geometries.

ii. **Research facilities:**
LBNL lighting laboratory. Also extensive contacts with major lighting producers who can transform prototypes into commercially available products.

iii. **Selected Publications:**
Yarris, L., "A Sulfur Lamp and Fixture Demonstration at SMUD," Center for Building Science, Spring 1997, p. 4 (http://eetd.lbl.gov/CBS/NEWSLETTER/NL14/Sulfur.html).

iv. **Standards/guidelines/protocols/software tools:**
LBNL used the ASAP Computer program as a software tool for ray tracing in developing the reflectors.

v. **WWW links:**
http://eetd.lbl.gov/BTP/uplighter.html

http://eetd.lbl.gov/CBS/NEWSLETTER/NL14/Sulfur.html

D. **Demonstration Projects:**
In November of 1996, two kiosks, each containing just one 1000-watt sulfur lamp, were installed in the lobby of the headquarters of the Sacramento Municipal Utility District (SMUD).

E. **International Activities:**
None currently

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Hydronic Radiant Cooling

A. **Description:**
Hydronic radiant cooling (HRC) systems are air-and-water systems that separate the tasks of ventilation and thermal space conditioning. HRC systems rely on radiation from a cooled surface to provide sensible cooling, and use air distribution to fulfill ventilation requirements and control indoor humidity. Most radiant cooling systems use water as a transport medium to connect the interior radiant surface with an exterior heat sink. Thanks to the thermal properties of water, HRC systems can remove a given amount of thermal energy using less than 25% of the fan energy than would be otherwise necessary, shift the peak cooling load to later in the day, and interface more easily with thermal energy storage systems.

B. **Avoided Insurance Losses:**
HRC systems reduce the risk of service interruption losses resulting from service

disruptions from power failures (especially during peak energy demand periods, by reducing the cooling load from air conditioning demand). HRC systems also reduce indoor air quality claims by improving the quality of the indoor environment, since they can be designed to supply only outside air to the building. By avoiding the supply of recirculated air, HRC systems reduce the risk of pollutant distribution throughout the building, as well as comfort complaints related to draft.

C. **Resources**

i. **Research capabilities and skills:**
Computer modeling and characterization of building designs with hydronic radiant cooling systems.

ii. **Research facilities:**
Not applicable.

iii. **Selected Publications:**

1. Feustel, H., "Hydronic Radiant Cooling Systems," *Center for Building Science News*, LBNL, p.5, 1994.

2. Feustel, H., "Hydronic Radiant Cooling Overview and Preliminary Performance Assessment," Report LBL-33194, LBNL, Berkeley, CA (1993).

3. Stetiu, C. and H. Feustel, "Development of a Model to Simulate the Performance of Hydronic Radiant Coolong Ceilings," Report LBL-36636, LBNL, Berkeley (1995).

iv. **Standards/guidelines/protocols/software tools:**
RADCOOL, a program using the Simulation Problem Analysis and Research Kernel, was designed and implemented by LBNL researchers for modeling hydronic radiant cooling systems.

v. **WWW links:**
http://epb1.lbl.gov/thermal

D. **Demonstration Projects:**

1. Office Building European Headquarters of DOW Chemicals, Horgen, Switzerland.

   Reference: Corina Stetiu, H.E. Feustel, and F.C. Winkelmann, "Development of a Model to Simulate the Performance of Hydronic Radiant Cooling Ceilings." *ASHRAE Trans.* (101) (2) 1995, 730-743; also Report LBNL-36636, Berkeley, CA (1995).

2. Office Building Kaiser Center, Oakland, CA.

   Reference: Helmut E. Feustel, C. Stetiu, R. Meierhans and U. Schultz, "Hydronic Radiant Cooling - A Case Study," *Proc. Healthy Buildings '94*, Budapest, Hungary, 1994.

3. Museum Kunsthaus Bregenz, Bregenz, Austria

   Reference: http://www.idiom.com/~ies/bregenz.html

4. Office Building Vorarlberger Nachrichten, Feldkirchen, Austria.

   Reference: http://www.idiom.com/~ies/vorarl.html

E. **International Activities:**
None currently.

F. **Future Projects:**
Evaluate the performance of an HRC system installed in a retail store in Utah.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Technology for Cleanrooms

A. **Description:**
LBNL is conducting research on energy efficiency in laboratory type buildings, with a focus on an important subgroup, cleanrooms. To date, the project has identified current energy use and savings potential, developed an online design guide, and developed a research agenda for focused technology development and for improving our understanding of the market. This work is being conducted for the California Institute for Energy Efficiency. Key activities in this project are:

1. LBNL is working on technology for "Improved Fume Hood Containment". This is anticipated to both improve containment and reduce energy use.

2. The implementation of "Building Life-cycle Information Systems" is

expected to help insure the intended performance of the facility is fully achieved in operations. These methods could be equally effective in reducing risk and improving performance.

3. "Improved Laboratory Airflow Design Methods" (including models) being developed by LBNL and partners will improve both performance and predictability of laboratory air systems.

4. "A Laboratory Performance Information Database" is being developed by LBNL and UC Berkeley. This benchmarking activity is expected to provide feedback on actual laboratory system performance and operations. Intended for designers, this could also be useful in establishing a baseline for risk assessment.

5. A "Benchmarking" activity is planned for manufacturing-scale cleanrooms, so that cleanrooms can be compared with one another.

6. "Optimized Design for Cleanrooms" is being pursued through the development of design tools and systems-oriented design methods.

7. LBNL researchers have tested demand-controlled filtration (DCF) as an energy-efficient strategy to control particles in cleanrooms, which are used extensively in the manufacturing of integrated circuits, in the biological and pharmaceutical industries, and in medical facilities. In normal practice, particle concentrations are kept low by circulating air through high-efficiency particulate air (HEPA) filters at a very high rate. The combined effect of high recirculation and a high pressure drop through HEPA filters produces higher power costs per unit floor area to operate the cleanroom than to ventilate a commercial building. DCF controls the particle concentration in a room by changing the recirculation flow rate based on the real-time measurement of particle concentrations. As the measured particle concentration rises above a threshold, the speed of the recirculation fan increases. As the concentration falls below the limit, the fan speed falls with it. Lower average fan speed reduces fan motor energy consumption. DCF is used to save energy, not improve indoor air quality. However, DCF can be used to maintain good quality indoor air at lower energy consumption. Acceptability of this strategy to the clean room industry has not been tested.

For the US EPA, LBNL is disseminating information on energy-efficiency opportunities in semiconductor cleanrooms through participation in a US EPA-organized workshop (held in November 1997), literature compilation and annotation, and establishing a website on cleanroom energy efficiency.

B. **Avoided Insurance Losses:**
By reducing indoor air particle counts, air is kept very clean and contaminants are

kept to a minimum, so that workers compensation and health insurance claims are reduced, and labor productivity is increased. As an energy-saving strategy, DCF may reduce peak power load and the possibility of power failures, reducing service interruption insurance claims. It also has the potential to reduce fires, reducing property damage.

C. **Resources**

i. **Research capabilities and skills:**
Evaluation of optimal designs for clean room facilities and commercial buildings through field testing and monitoring.

ii. **Research facilities:**
Not applicable.

iii. **Selected Publications:**

1. Faulkner, D., W. Fisk and J. Walton, "Energy Management in Semiconductor Cleanrooms," *Journal of the Institute of Environmental Sciences*, November-December 1996.

2. Mills, E., G. Bell, D. Sartor, A. Chen, D. Avery, M. Siminovitch, S. Greenberg, G. Marton, A. de Almeida, L.E. Lock, "Energy Efficiency in California Laboratory-type Facilities." LBNL Report no. 39061. Lawrence Berkeley National Laboratory, Berkeley, CA (1996).

3. Busch, J., "An Assessment of HVAC Energy Savings Potential in a Semiconductor Cleanroom Facility," LBNL Report no. 41356 .Lawrence Berkeley National Laboratory, Berkeley, CA (1998).

4. Bell, G., E. Mills, D. Sartor, D. Avery, M. Siminovitch, and M. Piette, "A Design Guide for Energy-efficient Research Laboratories," LBNL pub 777. Revised online edition January 1998: http://eetd.lbl.gov/CBS/Ateam/R-LabDG.

iv. **Standards/guidelines/protocols/software tools:**
"A Design Guide for Energy-efficient Research Laboratories" provides a compendium of advanced design and commissioning information for research-scale laboratory-type facilities. It has been incorporated into bid requirements for the procurement of new laboratories.

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL11/cleanrooms.html

http://www.lbl.gov:80/Science-Articles/Archive/cleanroom-energy.html

http://eetd.lbl.gov/CBS/Ateam/R-LabDG

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
The insurance industry is concerned about the potential for contamination in cleanrooms, and any capability of mitigating or minimizing such an event. Contamination may be the result of a fire or an unexpected release of particulates or gases. The resulting property damage and loss of production is a concern to the insurance industry. Thus, there is a need to evaluate designs, control logic, and the capabilities and reliability of HVAC and/or smoke control systems in these rooms.

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Sector:
Buildings

I. **Technology Studied:**
Indoor Air Quality-Related Illnesses

A. **Description:**
Current research evidence suggests there are at least four major links between health and productivity, and the quality of the indoor environment. These links involve infectious disease, allergies and asthma, acute sick building health symptoms, and direct impacts of indoor environments on worker performance. Recent research has estimated that improving indoor air quality (IAQ) by decreasing indoor pollutant concentrations and improving occupant comfort through practical changes in building design, operations and maintenance could save the U.S. a minimum of $29 billion per year. These savings could come from reduced health care costs and improved employee productivity. LBNL has an extensive research and development program in examining these issues and links.

B. **Avoided Insurance Losses:**
Fewer health problems caused by indoor air quality-related factors could reduce health insurance costs. The decrease in litigation from acute building-related IAQ problems could reduce the costs of commercial liability coverage for building owners and operators, and professional liability for architects, engineers and other construction industry professionals. This is a growing area for commercial insurers, and it is also applicable to self-insured entities.

C. **Resources**

i. **Research capabilities and skills:**
Indoor Environment Program researchers at Berkeley Lab have conducted large-scale studies of office workers' symptoms in commercial office buildings; other capabilities include field measurement of indoor pollutants, and assessment of potential building IAQ problems and approaches to mitigation.

ii. **Research facilities:**
Indoor Environment Program researchers use single and multi-room environmental chamber facilities as controlled indoor environments to study the behavior of a variety of indoor pollutants ranging from cigarette smoke to volatile organic compounds (VOCs) from new carpets. The program also has laboratories and extensive instrumentation for indoor pollutant and ventilation rate measurements.

iii. **Selected Publications:**

1. Fisk, W., M. Mendell, J. Daisey, D. Faulkner, A. Hodgson, M. Nematollahi, and J. Macher, "Phase 1 of the California Healthy Building Study: A Summary," *Indoor Air* 3(4): 246-254 (1993).

2. Fisk, W. and A. Rosenfeld, "Estimates of Improved Productivity and Health from Better Indoor Environments," *Indoor Air*, Vol. 7, pp 158-172 (1997).

3. Chen, A. and E. Vine, The Costs of Indoor Air Quality Illnesses: An Insurance Loss Reduction Perspective," (Draft), LBNL, Berkeley, CA, 1997.

iv. **Standards/guidelines/protocols/software tools:**
There are many standards and guidelines that pertain to indoor air quality: e.g., minimum ventilation standards, thermal comfort standards, smoking ordinances, etc. The ASHRAE minimum ventilation standard, Standard 62-1989 ("Ventilation for Acceptable Indoor Air Quality") receives the most attention. The terms of insurance contracts might specify that a

building be operated in a manner consistent with these standards.

The U.S. Department of Energy is also working with the insurance community in developing indoor air quality protocols as part of the International Performance Measurement and Verification Protocol (see WWW link below).

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL2/HealthyBuildings.html <br?
http://www.ipmvp.org

D. **Demonstration Projects:**
The California Healthy Buildings Study is an example of a large-scale field study of symptoms of sick building syndrome in office workers. Workers in 29 study spaces within 12 San Francisco Bay area office buildings filled out questionnaires on their symptoms. The buildings and ventilation systems were characterized and a variety of IAQ measurements were completed. LBNL researchers looked for correlations between the symptoms the 880 respondents reported and building and indoor air quality factors such as the type of ventilation in the building or the concentrations of volatile organic compounds.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
LBNL is working with the insurance industry to obtain better estimates of the costs of indoor air quality illnesses.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Mitigating Urban Heat Catastrophes

A. **Description:**
A number of studies have compared ambient climate conditions to mortality during heat storms and found that there exists a heat-index threshold above which deaths increase rapidly. The duration, high humidity, high minimum temperatures, and low wind speeds all contribute to increased mortality, and a time lag exists between the peaks in the heat index and deaths. The mortality pattern appears to correlate with the thermal response of different building types to a heat storm, as well as to current conditions in the U.S. housing stock.

We have conducted a study of building conditions during the Chicago heat storm of 1995, in which the number of deaths increased by more than 700 in five days. The study suggests some strategies for preventing excessive heating within buildings during heat storms.

B. **Avoided Insurance Losses:**
Reduction in the number of heat-related injuries and deaths during heat storms, leading to reduced health insurance costs. According to one recent study, there have been an estimated 5,324 excess deaths during 12 U.S. heat storms in past years (of which 739 occurred during the Chicago heat storm of 1995) (Whitman 1997).

C. **Resources**

i. **Research capabilities and skills:**
Modeling of conditions such as temperature and humidity within a variety of building types during urban heat storms using DOE-2 simulation software.

ii. **Research facilities:**
Not applicable

iii. **Selected Publications:**

1. Huang, J., "Urban Heat Catastrophes: The Summer 1995 Chicago Heat Wave," *Center for Building Science News*, Fall 1996, p. 5, 7. (see http://eande.lbl.gov/CBS/NEWSLETTER/NL12/heat.html)

2. Whitman, S., "Mortality in Chicago Attributed to the July 1995 Heat Wave," *J. of Public Health* Sept. 1997.

iv. **Standards/guidelines/protocols/software tools:**
DOE-2 simulation software used to model the conditions within buildings during urban heat storms.

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL12/heat.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Carbon Monoxide Sensors

A. **Description:**
Each year, about 1,500 deaths result from carbon monoxide (CO) poisonings. Of these up to 1,000 are from CO emissions caused by such sources as malfunctioning, incorrectly installed or misused combustion appliances (e.g., furnaces and gas ranges), outdoor appliances (e.g., barbecues used indoors), automobiles and generators used indoors. CO from vented combustion appliances can enter a home through a cracked heat exchanger, a blocked vent, or by appliance "backdrafting." Backdrafting is a reversal of the normal appliance ventilation flow; outside air is pulled through the appliance vent and hot combustion gases flow into the indoor environment.

Carbon monoxide is also the most toxic chemical agent in the workplace. It is estimated that about one million workers are exposed occupationally at high levels. The use of propane-powered forklifts indoors has been identified as a

major contributor to occupational CO exposure. Finally, CO from automobiles idling in closed attached garages can enter the home through a doorway and other leaks.

Little is known about how widespread are the risks of CO poisoning in homes in the U.S., in part because of the lack of an inexpensive quantitative CO sensor. Investigators at Berkeley Lab, working with the Quantum Group, have developed a simple passive CO sampler that uses a new and sensitive accurate sensor. This device could be sent to thousands of homes or commercial sites for measuring CO concentrations in the air. The sampler has also been configured to to be used as an occupational dosimeter. The passive CO reduces the cost of CO measurement exposure surveys by reducing the need for expensive, complex testing equipment.

B. **Avoided Insurance Losses:**
Reduction in injuries and deaths caused by carbon monoxide gas with corresponding reduction in health insurance costs. These exposures occur when faulty space heaters and other appliances vent into homes and other enclosed spaces, as well as from occupational exposures. This is also a product liability issue for the malfunctioning of space heaters and other appliances.

C. **Resources**

i. **Research capabilities and skills:**

1. Carbon monoxide sensor design, prototyping and field-testing expertise

2. Large-scale field surveys to characterise the distribution and magnitude of CO hazard in residential and commercial structures

ii. **Research facilities:**
LBNL's Indoor Environment Program has an Environmental Chamber for testing and calibrating sensors and and studying the effects of indoor pollutants under controlled conditions.

iii. **Selected Publications:**

1. Apte, M., "A population-based exposure assessment methodology for carbon monoxide: Development of a carbon monoxide passive sampler and occupational dosimeter," Doctoral thesis, Report no. LBNL-40838, Lawrence Berkeley National Laboratory (1997).

2. Chen, A., "An Inexpensive CO Passive Sampler," *Center for Building Science News*, Spring 1995. p 6. (see http://eande.lbl.gov/CBS/NEWSLETTER/NL6/CO.html).

3. Traynor, G., M. Apte, R. Diamond, and A. Woods, "A Carbon Monoxide Passive Sampler: Research and Development Needs,"

Report LBL-26880, Lawrence Berkeley National Laboratory (1991).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL6/CO.html

D. **Demonstration Projects:**
The prototype sampler has been tested extensively in residential and occupational environments and in controlled laboratory conditions. These tests have demonstrated the viability of the passive sampler.

E. **International Activities:**
None currently.

F. **Future Projects:**
Developing the LBNL/QFI CO Occupational Dosimeter for commercialization. The market will be industrial hygienists for use in measuring CO exposures in industry.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
To the extent that blame can be placed upon an individual or institution for health effects due to CO exposure, liability may exist. Risks of such liability can be mitigated through proactive attempts to understand and remedy the causes of CO exposure. In order to do this, it is necessary to fully understand the nature of CO exposures and how they are distributed in the population. The LBNL/QGI CO Passive Samplers and Occupational Dosimeters are designed to quantify, with accuracy and low cost, the distribution of CO exposures in a population. A survey of CO exposures, with appropriate questionnaires, should be used to develop data bases relating CO exposure levels to demographic, geographic, and CO exposure source parameters. This data base can then be used to identify high-risk populations and the high-risk sources of exposure. Once identified, these risks can be reduced through appropriate mitigation of the sources.

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Sector:
Buildings

I. **Technology Studied:**
Environmental Tobacco Smoke

A. **Description:**
Researchers at Berkeley Lab's Indoor Environment Program study the behavior of environmental tobacco smoke (ETS) in the indoor environment, and develop more accurate and effective methods of measuring ETS concentrations and exposures. ETS consists of particles and gases with some 400 identified components.

B. **Avoided Insurance Losses:**
Reduced health problems caused by non-smokers' passive exposure to tobacco smoke in indoor environments, and corresponding reduction in health insurance costs.

C. **Resources**

i. **Research capabilities and skills:**

1. Identification and measurement of the components of environmental tobacco smoke under controlled environmental conditions as well as in field conditions.

2. Development of better methods of measuring exposures to ETS as a complex mixture.

3. Development and testing of methods to control or reduce ETS in the indoor environment.

ii. **Research facilities:**
Indoor Environment Program researchers use a facility called the Environmental Chamber as a controlled indoor environment to study the behavior of a variety of indoor pollutants including environmental tobacco smoke.

iii. **Selected Publications:**

1. Van Loy, M., J. Daisey and W. Nazaroff, "Implications of nicotine sorption on indoor surfaces on its use as a marker for environmental tobacco smoke," presented at the Air & Waste Management Association/EPA Symposium: Engineering Solutions to IAQ Problems, Research Triangle Park, North Carolina, July 21-23, 1997.

2. Van Loy, M., V. Lee, L. Gundel, J. Daisey, R. Sextro, and W. Nazaroff, "Dynamic Behavior of Semivolatile Organic Compounds in Indoor Air. 1. Nicotine in a Stainless Steel Chamber," *Environmental Science & Technology*, v. 31, no. 9, 2554-2561 (1997).

3. Van Loy, M., W. Nazaroff and J. Daisey, "Sorptive interactions of gas-phase environmental tobacco smoke components with carpet," Paper No. 97-MP3.05, presented at the Air & Waste Management Association's 90th Annual Meeting, June 8-13, Toronto (1997).

4. Hodgson, A., J. Daisey, K. Mahanama, and J. Ten Brinke, L. Alevantis, "Use of Volatile Tracers to Determine the Contribution of Environmental Tobacco Smoke to Concentrations of Volatile Organic Compunds in Smoking Environments," *Environment International*, v. 22, no. 3, 295-307 (1996).

5. Kariyawasam, R., K. Mahanama and J. Daisey, "Volatile N-Nitrosamines in Environmental Tobacco Smoke: Sampling, Analysis, Emission Factors, and Indoor Air Exposures,"

Environmental Science & Technology, v.3 0 no.5, 1477-1484 (1996).

6. Gundel, L., K. Mahanama, and J. Dasey, "Semi-volatile and particulate polycyclic aromatic hydrocarbons in environmental tobacco smoke: Cleanup, speciation and emission factors." *Environmnetal Science & Technology*, 29:1607-1614 (1995).

7. Daisey, J., K. Mahanama, A. Hodgson, "Toxic Volatile Organic Compounds in Environmental Tobacco Smoke: Emission Factors for Modeling Exposures of California Populations," LBNL-36379. Lawrence Berkeley National Laboratory, Berkeley (1994).

8. Xu, M., M. Nematollahi, R. Sextro, A. Gadgil and W. Nazeroff, "Deposition of tobacco smoke particles in a low ventilation room," *Aerosol Science and Technology*, 20: 194-206 (1994).

iv. **Standards/guidelines/protocols/software tools:**
Draft ASTM Standard D 5075-90a: ASTM standard method for sampling nocotine and 3-ethenylpyridine (another ETS tracer).

v. **WWW links:**
http://eetd.lbl.gov/IEP

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
Funding has been secured for a new ETS research project in FY 1998.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Radon Resistant Housing

A. **Description:**
Radon is a naturally occurring radioactive gas that is found in high concentrations in soil gas and gets drawn into homes through small cracks and openings (e.g., in the foundation slab footer joint). The U.S. Environmental Protection Agency (USEPA) recommends taking remedial action to reduce radon entry for homes with indoor annual average radon levels above 4 pCi/l. About 5% of the US homes (and the same proportion of new construction) have indoor radon levels above this amount. A conventional radon mitigation system for a single-family house, using a 50 or 90 W exhaust fan, costs approximately $1,200 to install and $70 to $100 per year to operate. Scientists at LBNL have designed and field tested a method to substantially reduce radon entry into new houses through inexpensive modifications to the foundations and the use of low-power (e.g., 10W) fans. Relative to the current practice, the new radon mitigation technology saves about

$60 per year in energy costs. The method is applicable only to new housing. In regions of the country with a high proportion of high-radon houses, it would be desirable to build new homes incorporating this technology.

B. **Avoided Insurance Losses:**

1. Radon is responsible for about 12,000 deaths annually in the U.S. (mainly from at-home exposures leading to lung cancers).

2. A reduction in life insurance losses is expected.

3. For rental units, radon resistant housing may reduce the liability of the real estate owner from exposing the tenants to high levels of indoor radon. Thus general liability insurance benefits should occur.

4. For developers and builders, radon resistant housing may reduce their professional liability from exposing the purchasers of the housing to high levels of indoor radon.

5. Radon resistant housing may also substantially reduce the risk of radon-induced lung cancer among the home occupants. However, the cancer appears after a long exposure period (tens of years) which is much longer than the average time between changes in home ownership. Thus, health benefits may likely accrue to a succession of occupants in the radon-resistant home, unless an occupant stays in the same home for several decades. Thus, health insurance benefits appear very small or negligible.

C. **Resources**

i. **Research capabilities and skills:**
LBNL has substantial research experience in indoor radon: its indoor entry pathways and technologies for its detection and mitigation.

ii. **Research facilities:**
LBNL has substantial research facilities (on and off site) and instrumentation for conducting research on indoor radon.

iii. **Selected Publications:**

1. Nero, A., S. Leiden, D. Nolan, P. Price, S. Rein, K. Revzan, H. Wollenberg, and A. Gadgil, "Statistically Based Methodology for Mapping Radon "Actual" Concentrations: the Case of Minnesota," *Rad. Prot. Dosim.*, Vol. 56, pp. 215-219 (1994). Also in Proceedings, First International Workshop on Indoor Radon Remedial Action, Rimini, Italy, 1993. Lawrence Berkeley Laboratory Report LBL-34317.

2. Nero, A., A. Gadgil, W. Nazaroff, and K. Revzan, "Indoor Radon

and Decay Products: Concentrations, Causes, and Control Strategies," Lawrence Berkeley Laboratory Report LBL-27798, September 1989. Also published as DOE/OHER Technical Report DOE/ER-0480P (November 1990).

3. Riley, W., W. Fisk, and A. Gadgil, "Potential Energy Use, Energy Cost, and CO2 Emissions Associated with Radon Mitigation by Sub-slab Ventilation in the USA: A Brief Summary," presented at the International Symposium on the Natural Radiation Environment VI (NRE-VI), Montreal, Canada June 5-9, 1995.

4. Fisk, W., R. Prill, J. Wooley, Y. Bonnefous, A. Gadgil, and W. Riley, "New Methods of Energy Efficient Radon Mitigation," *Health Physics*, Vol. 68, No. 5, pp. 689-698 (May 1995). Also, Lawrence Berkeley Laboratory Report LBL-36519.

5. Nero, T. and P. Price, "The High-Radon Project," Center for Building Science, Fall 1996, p. 4 (http://eetd.lbl.gov/CBS/NEWSLETTER/NL12/radon.html).

iv. **Standards/guidelines/protocols/software tools:**
The USEPA has a toll free hot-line number for information, guidelines and protocols for indoor radon levels, including methods of measurements, and existing mitigation technologies: 1-800-SOS-RADON.

v. **WWW links:**
http://eetd.lbl.gov/IEP

http://eetd.lbl.gov/CBS/NEWSLETTER/NL12/radon.html

http://eetd.lbl.gov/IEP/high-radon/hr.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Radon Insurance

A. **Description:**
About 5% of the homes in the U.S. exceed the recommended U.S. Environmental Protection Agency (USEPA) action guideline for annual average indoor radon concentration of 4 pCi/liter. Owing to the growing public awareness of health risk from indoor radon exposure, many home buyers now insist on pre-testing a home for radon before purchase and price negotiations. Generally such pre-testing is conducted on a short-term basis, and owing to poor correlation between the results of short and long-term (more accurate) tests, decisions often are taken based on incorrect information (both false positive, and false negative). If a house is presumed to have indoor radon levels above the EPA action guideline, a radon mitigation system is installed (installation cost about $2,000) and must be continuously operated (operating energy cost about $200 annually). An insurance plan for indoor radon will let home sellers and buyers purchase "radon insurance"

for a modest amount (say, $300), following which the house will have a long-term test conducted for radon. The 5% of the homes found to be in need of radon mitigation will receive it, and others will receive a clean bill of (radon-free) health. Each hundred such sales will generate a revenue of $30,000, and the 5 home installations will cost $10,000. In addition, there will be testing costs for all the 100 homes ($2,000) plus the usual overheads of marketing and administration costs. Since about 2 million homes are sold in the US annually, the potential annual revenue can be significant, $600 million (at $300 per home sold).

However, much like incidence of auto theft, the rate of occurrence of high indoor radon is locality dependent, and thus the rates should be locality dependent too. Lawrence Berkeley National Laboratory (LBNL) has conducted extensive research in predicting the distribution (mean and standard deviation) of indoor radon concentrations by county across the continental U.S. This methodology is based on extracting relevant predictive parameters from geologic and soil characteristics, airborne observations of soil-surface uranium concentrations, and the typically sparse statistical data that already exist from state radon surveys. As radon incidence data from insurance sales and subsequent testing becomes available, the model has the capacity to refine its estimates continually.

B. **Avoided Insurance Losses:**
Health and life losses are reduced. This technology describes a new insurance opportunity, not a way to avoid losses. For information on avoided insurance losses due to radon, see case study LBNL-19.

C. **Resources**

i. **Research capabilities and skills:**
LBNL's Indoor Environment Program (IEP) has research capabilities and skills needed in statistical analysis of multiple sparse data sources for predicting the distribution of indoor radon incidence. LBNL's Radon Group is one of the oldest of its kind in the U.S.

ii. **Research facilities:**
LBNL's IEP has data sources, computing power and statistical knowledge to undertake this research further. No specialized research facilities are needed.

iii. **Selected Publications:**

1. Nero, A., S. Leiden, D. Nolan, P. Price, S. Rein, K. Revzan, H. Wollenberg, and A. Gadgil, "Statistically Based Methodology for Mapping Radon "Actual" Concentrations: the Case of Minnesota," *Rad. Prot. Dosim.*, Vol. 56, pp. 215-219 (1994). Lawrence Berkeley Laboratory Report LBL-34317.

2. Price, P., "Predictions and Maps of County Mean Indoor Radon

Concentrations in the mid-Atlantic States," *Health Physics*, Vol. 72, No. 6, pp. 893-906, June 1997.

3. Nero, T. and P. Price, "The High-Radon Project," Center for Building Science, Fall 1996, p. 4 (http://eetd.lbl.gov/CBS/NEWSLETTER/NL12/radon.html).

iv. **Standards/guidelines/protocols/software tools:**
The USEPA has a toll free hot-line number for information, guidelines and protocols for indoor radon levels, including methods of measurements, and existing mitigation technologies: 1-800-SOS-RADON.

v. **WWW links:**
http://eetd.lbl.gov/IEP

http://eetd.lbl.gov/CBS/NEWSLETTER/NL12/radon.html

http://eetd.lbl.gov/IEP/high-radon/hr.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Energy Management and Control Systems

A. **Description:**
As building codes and standards are tightened to require higher levels of performance, managers and owners need effective ways of monitoring comfort levels, indoor air quality, energy use and other factors that are regulated by buildings systems. Energy management and control systems (EMCSs) (also known as building management systems or building automation systems) are a common-practice technology for operations and control functions, and they are now installed in almost all large commercial buildings. EMCSs control energy use, building comfort and other factors, but there is a large range in their features from building to building, and their sophistication and capabilities vary widely. With additional adaptation, the EMCS could be a useful tool to optimize the factors that affect the energy use and productivity of employees in commercial buildings.

B. **Avoided Insurance Losses:**
An EMCS can improve a building's fire safety when integrated with fire/life/safety equipment. EMCS are typically connected to security systems, thereby reducing the chance of theft of equipment, and leading to reductions in professional and general liability costs. They also improve ventilation and comfort within the building. Improved indoor environmental conditions that result may reduce building-related health problems and their corresponding health insurance costs. The EMCS can also optimize the system to reduce the impacts of service interruptions if known ahead of time.

C. **Resources**

i. **Research capabilities and skills:**

1. Experience in field-testing and evaluating existing energy management and control systems in a large number of commercial buildings.

2. Design and testing of more effective integrated EMCS systems for different types of buildings incorporating the most advanced technologies available on the market.

3. Testing and demonstration of systems incorporating prototype technologies.

ii. **Research facilities:**
Not applicable.

iii. **Selected Publications:**

1. Sebald, A. and M. Piette, "Diagnostics for Building Commissioning and Operation," LBNL Report 40512, Lawrence Berkeley National Laboratory, 1997.

2. Heinemeier, K., H. Akbari, and S. Kromer, "Measuring Savings in Energy Savings Performance Contracts Using In-Place Energy Management Systems—A Case Study," Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, August 25 - 31, 1996. Washington D.C.: American Council for an Energy-Efficient Economy.

3. Heinemeier, K., H. Akbari, S. Kromer, "Monitoring Savings in Energy Savings Performance Contracts Using Energy Management and Control Systems," *ASHRAE Transactions*, American Society of Heating, Ventilating, and Air-Conditioning Engineers, Vol 102 Part 1; pp 1-14 (1996).

4. Heinemeier, K., "The Use of Energy Management and Control

Systems to Monitor the Energy Performance of Commercial Buildings," LBL-36119, Lawrence Berkeley National Laboratory (1994); also in Proceedings of the ACEEE 1992 Summer Study on Energy Efficiency in Buildings, August 30 - September 5, 1992. Washington D.C.: American Council for an Energy-Efficient Economy.

5. Heinemeier, K. and H. Akbari, "Proposed Guidelines for Using Energy Management and Control Systems for Performance Monitoring," Proceedings of the ACEEE 1992 Summer Study on Energy Efficiency in Buildings, August 30 - September 5, 1992. Washington D.C.: American Council for an Energy-Efficient Economy.

iv. **Standards/guidelines/protocols/software tools:**
"Energy Management Control Systems: Best Practices," U.S. Environmental Protection Agency and Portland Energy Conservation, Inc., 1997.

v. **WWW links:**
http://eetd.lbl.gov/CBS/NEWSLETTER/NL3/EMCS.html
http://eetd.lbl.gov/CBS/NEWSLETTER/NL13/Hammer.html

D. **Demonstration Projects:**
An energy-efficient retrofit at 450 Golden Gate, a federal building in San Francisco, uses an energy management and control system, with a BACnet-based (Building Automation Control network) protocol, for monitoring and controlling lighting, HVAC, and metering systems. Interconnecting of multiple control systems in the Federal Building will help its operators provide the optimum level of lighting, heating, air conditioning, and other energy-consuming services. LBNL is evaluating the energy savings of the new control system.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

itor and optimize the operation of whole building systems.

International Activities:

None currently.

Future Projects:
The BLISS software development projects are the ongoing focus of the Building Performance Assurance project.

Collaborations with Insurance Industry:
None currently.

Research Agenda:
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Integrated Information Technology

A. **Description:**
Despite significant advances in building technology and the promulgation of tighter building codes, buildings consume one third of all energy in the U.S. at an annual cost of $200 billion. Commercial buildings alone consume about 15% of all energy at a cost of $85 billion annually. Half of this consumption is wasted, compared to what is cost-effectively achievable. Poorly operating buildings can also be the source of health problems, and loss of employee productivity—at an annual costs of tens to hundreds of billions of dollars more to the economy. Assuring achievable building performance should be a priority in an increasingly competitive world. This goal requires a careful examination of the process by which buildings are designed, built, commissioned, and operated. By taking a life-cycle perspective on how information is managed in the building sector, we can develop integrated information technology (IIT) that can help buildings achieve

their performance potentials.

The Building Performance Assurance (BPA) project addresss these challenges. BPA's long-term goal is to provide building decision-makers with the information and tools needed to cost-effectively assure the desired performance of buildings, as specified by principal stakeholders, across the complete life cycle of a building project. The key elements of IIT are software tools; processes such as building commissioning protocols; data; and systems, for example a new generation of energy management and control systems. These elements will collect, document and communicate important information about the building's design, the state of its operations, and its intended and actual performance. These tools will also allow their users to detect and diagnose discrepancies between intended and actual performance, and feed lessons back to building designers about design and operations problems.

B. **Avoided Insurance Losses:**
These technologies can reduce professional liability exposure to architects and engineers and improve indoor air quality conditions. A recent study by an insurance company found that the most common type of professional liability claim among architects and engineers is HVAC claims related to poor information transfer from the building designer to the building owners and operators concerning design intent. As a result, buildings do not operate properly—they are not as healthy, comfortable or productive as possible. An integrated information system that transfers design intent and operating specifications from designer to builder to building owner and operator can reduce substantially problems in building operation that could cause poor indoor environmental quality leading to health and liability insurance claims.

C. **Resources**

i. **Research capabilities and skills:**

1. Expertise in developing software for building design and energy simulation, as demonstrated by LBNL's previous work creating DOE-2, RADIANCE, THERM and many other software programs for better building design.

2. Ability to develop and field-test innovative, energy-efficient whole building systems, such as the one at the Federal Building, 450 Golden Gate in San Francisco.

ii. **Research facilities:**
Not applicable

iii. **Selected Publications:**
In addition to the publications listed below, several brochures, briefs and a video are available from the Building Performance Assurance Project.

1. Hitchcock, R., S. Selkowitz, M. Piette, K. Papamichael and F. Olken, "Building Performance Assurance Through Improved Life-Cycle Information Management and Interoperable Computer Tools," presented at the Fifth national Conference on Building Commissioning (1997).

2. Selkowitz, S., "Interoperable Life-Cycle Tools for Assuring Building Performance: An Overview of a Commercial Building Initiative," presented at the U.S. Green Buildings Conference, San Diego (1996).

3. Meyers, S., E. Mills, A. Chen, A. and L. Demsetz, "Building Data Visualization for Diagnostics," *ASHRAE Journal*, June 1996.

iv. **Standards/guidelines/protocols/software tools:**
A suite of prototype software tools called the Building Lifecycle Information Support System (BLISS) is currently in development. These tools will include a design intent tool, a chiller commissioning toolkit, remote building monitoring and operations software, and a performance evaluation and tracking tool.

v. **WWW links:**
http://eetd.lbl.gov/CBS/BPA
http://www.lbl.gov/~olken/RBO

D. **Demonstration Projects:**
The 450 Golden Gate project demonstrates elements of an integrated BACnet-based system to monitor and optimize the operation of whole building systems.

E. **International Activities:**
None currently.

F. **Future Projects:**
The BLISS software development projects are the ongoing focus of the Building Performance Assurance project.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Utilities

I. **Technology Studied:**
Fuel cells

A. **Description:**
Fuel cells can convert the chemical energy of nonpetroleum fuels such as hydrogen, methanol, or ethanol to electricity with little or no pollution and with greater efficiency than heat engines. Fuel cells can provide clean, reliable power to building facilities of widely varying sizes, from residences to commercial and industrial facilties, in addition to their applications in the transportation sector.

The fuel cell research at LBNL is carried out in the Environmental Energy Technologies Division, and the Materials Science Division. The research centers on electrocatalysts for use with CO-containing hydrogen fuel, and organic fuels such as methanol.

B. **Avoided Insurance Losses:**
By providing backup power, service interruptions can be reduced when power

service is interrupted. Efficient stationary power sources such as fuel cells can also reduce the vulnerability of commercial and industrial facilities to equipment damage and productivity loss from power failures. For example, voltage excursion on the line can be damped out by the fuel cell.

C. **Resources**

i. **Research capabilities and skills:**
Various surface-science and related techniques are applied to develop a thorough understanding of how the electrocatalysts function, as an aid to the development of new, highly-active electrocatalysts. The techniques used include LEIS, LEED, PBD, nuclear magnetic resonance (NMR), and a number of others. In addition, electrodes and cells are fabricated and tested to evaluate the efficacy of new electrocatalysts and electrode structures.

ii. **Research facilities:**
A wide range of facilities for electrochemical studies and materials characterization is available, including high-resolution electron microscopy, scanning tunneling microscopy, synchrotron X-ray source, NMR, inert-atmosphere boxes, computer-controlled cell cycling equipment, electrochemical impedance spectroscopy, FTIR spectroscopy, photothermal deflection spectroscopy, ellipsometry, porous electrode preparation facilities, and others.

iii. **Selected Publications:**

1. Adler, T., F. McLarnon, and E. Cairns, "Rechargeable zinc cell with alkaline electrolyte which inhibits shape change in zinc electrode," U.S. Patent #5,453,336 (1995); continuation-in-part of U.S. Patent No. 5,302,475.

2. Adler T., R. Plivelich, F. McLarnon, and E. Cairns, "Zinc electrodes," Proc. Symp. on the Science of Advanced Batteries 1995. D.A. Scherson, ed., pp. 100-106, Case Western Reserve University, Cleveland, OH.

3. Brisard, G., J.Rudnicki, F. McLarnon, and E. Cairns, "Application of probe beam deflection to study the electrooxidation of copper in alkaline media," *Electrochim. Acta* 40:859 (1995).

4. Deng Z., J. Spear, J. Rudnicki, F. McLarnon, and E. Cairns, "Infrared-photothermal deflection spectroscopy: a new probe for the investigation of electrochemical interfaces," Paper no. 669 presented at the 187th Meeting of the Electrochemical Society, Reno, NV, May 1995.

5. Plivelich, R., F. McLarnon, and E. Cairns, "Degradation mechanisms of nickel oxide electrodes in zinc/nickel oxide cells with low-zinc-solubility electrolytes," *J. Appl. Electrochem.* 25:433 (1995).

6. Rauhe, B., F.McLarnon, and E. Cairns, "Direct anodic oxidation of methanol on supported platinum/ ruthenium catalyst in aqueous cesium carbonate," *J. Electrochem. Soc.*142:1073 (1995).

7. Ridgway, P., F. McLarnon, and E. Cairns, "Sodium/phosphorous-sulfur cells: Part I - cell performance," *J. Electrochem. Soc.* 143:406 (1996).

8. Ridgway, P., F. McLarnon, and E. Cairns, "Sodium/phosphorous-sulfur cells: Part II - phase equilibria," *J. Electrochem. Soc.* 143:412 (1995).

9. Striebel, K., F. McLarnon, and E. Cairns, "Steady-state model for an oxygen fuel cell electrode with an aqueous carbonate electrolyte," *Ind. & Engin. Chem. Res.* 34:3632 (1995).

10. Taucher, W., T. Adler, F. McLarnon, and E. Cairns, "Development of Lightweight Nickel Electrodes for Zinc/Nickel Oxide Cells," *J. Power Sources* 58:93 (1996).

iv. **Standards/guidelines/protocols/software tools:**
Not applicable.

v. **WWW links:**
http://eetd.lbl.gov/BERC/ejc.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Fuel cell systems for individual buildings will need to be inexpensive and reliable. Current fuel cells that operate below about 200 °C need pure hydrogen as the fuel, which is very expensive, and requires special fuel processing equipment, if the supplied fuel is not already purified hydrogen. Additional research is necessary to

provide electrocatalysts that will accommodate impure hydrogen, or (better yet) utilize a liquid fuel such as methanol. Research on inexpensive, highly active electrocatalysts and electrolytes is also needed in order to improve the fuel flexibility and reduce the costs of fuel cells for buildings.

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Sector:
Buildings

I. **Technology Studied:**
Reducing Aerosol Deposition on Electronic Circuits

A. **Description:**
Indoor air is commonly loaded with many pollutants, some of them gases, others particles. Ordinarily, tens or hundreds of thousand particles are floating in each cubic foot of indoor air. The concentrations of these indoor aerosols are highly variable as a function of the time of the day, season, and geographic location, as well as specific building characteristics. Most of the particles have diameters of less than 10 microns (for comparison, human hair diameters range from 80 to 250 microns). The coarser of these particles (diameters 1-20 microns) are commonly produced from mechanical wear and abrasion. The finer particles (diameters of less than 1 micron) are commonly produced from gas-to-particle conversions, combustion processes, and evaporation of solute-containing spray and mist. Many of the fine particles can be hygroscopic (e.g., Ammonium Sulfate produced from interaction of NOx and combustion products of sulfur containing fuel), and can

deliquesce into liquid form when exposed to high humidity. With deliquescence, the electrical resistance of aerosol particles can drop by several orders of magnitude, turning them from insulators to conductors.

These particles deposit on various indoor surfaces. There are a number of mechanisms controlling the deposition process. Gravitational settling is the dominant mechanism for particles with diameter range of 2-20 microns. Diffusion, electrophoresis and thermophoresis are the dominant mechanisms for fine particles (diameters smaller than 1 micron).

Modern business increasingly depends on electronic communication. Electronic circuit features continue to decrease, concurrent with higher densities of devices on circuit surfaces, and smaller inter-conductor spacing on the circuits. These circuits are exposed to indoor air, and aerosol particles deposit on them also, with the deposition often accelerated by the electric fields on the circuits. The electric fields cause preferential deposition on conducting traces on the circuits, and on the legs of electronic components. While the former are commonly protected with an insulating varnish, the latter are exposed to the pollutant-bearing indoor air which is also used to cool the electronic circuitry.

During a high humidity episode, the deposited particles can deliquesce and short-circuit the adjacent conductors that they may bridge, thus provoking functional failure of the electronic circuit.

The US telephone system uses large banks of expensive (about $5000 each) circuit boards in its switching offices to route telephone calls. There are about 16,000 switching offices in the country. The cost of repairing and replacing failed circuit boards in these offices is about $1 billion annually. Of these, about 20% of the failures (amounting to $200 million annually) are attributed to damage caused by indoor airborne pollutants (mostly aerosol particles) depositing on the electronic circuits. So, we estimate that the damage to all the commercial activities in the US from this cause must be of the order of a billion dollars.

LBNL has undertaken experimental research to understand mechanism and rates of particle deposition on electronic circuits, and determine ways to reduce that deposition (and thus the attendant failures). We understand some of the technology options to reduce the soiling rates of electronic circuits indoors. This is an active area of research, and LBNL may find additional (or more effective) technology options in the future.

B. **Avoided Insurance Losses:**

This type of technology provides a new loss control method for specialty insurers underwriting HPR (Highly Protected Risks) programs for Electronic Communication and Electronic Data Program exposures, High Technology Manufacturing Facilities, and Communication Systems to reduce the risk of loss in several areas. These areas include business interruption and Comprehensive

General Liability, particularly for businesses that depend vitally on electronic communications (e.g., travel agents).

Furthermore, there may be some liability to which the phone or communication companies are exposed when their communication equipment failure leads to loss of business for their customers. This may be relevant to coverage under Comprehensive General Liability and Business Interruption.

C. **Resources**

i. **Research capabilities and skills:**
LBNL has research capabilities and skills to undertake technical research and testing of deposition of indoor aerosols on electronic circuits and the resultant degradation in their performance. LBNL can also provide general technical guidance on common methods to reduce such losses, and specific technical guidance to reduce these losses at particular building sites. LBNL also has developed (but not yet tested) simple modifications to electronic circuit fabrication that will likely result in lower susceptibility to soiling and resulting performance degradation.

ii. **Research facilities:**
LBNL has experimental facilities and advanced instrumentation to undertake research on this topic, and also theoretical and analytical understanding of aerosol transport and deposition processes in buildings.

iii. **Selected Publications:**

1. Weschler, C. and H.Shields, "The Impact of Ventilation and Indoor Air Quality on Electronic Equipment," *ASHRAE Trans.*, Vol. 97, p. 455-463 (1991).

2. Litvak, A., A. Gadgil and W. Fisk, "Hygroscopic Fine Mode Particle Deposition on Electronic Circuits and Resulting Degradation of Circuit Performance," Report LBNL-41315, Lawrence Berkeley National Laboratory (1998).

3. Burnett, W., F. Sandroff and S. D'Egidio, "Circuit Failure due to Fine Mode Particulate Air Pollution," Proceedings of the ISTFA '92, Los Angeles, CA, October 1992, pp. 329-333.

4. Nazaroff, W., A. Gadgil and C. Weschler, "Critique of the use of Deposition Velocity in Modeling Indoor Air Quality," American Society for Testing and Materials STP 1205, N.L. Nagda (ed.), Philadelphia, pp. 81-104 (1993).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://eetd.lbl.gov/IEP

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
We have collaboration on this research topic with a French academic and the government research institute of "Laboratory of Building Science" in Lyon.

F. **Future Projects:**
LBNL expects to continue this research with DOE support at a modest level in the future.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Appliance and lighting standards

A. **Description:**
The Technology and Marketing Assessment Group (TMA) at LBNL has primary responsibility for analyzing and reporting on the impacts and savings potential of energy-efficiency performance standards on a range of products including: home appliances and equipment; office equipment; plumbing products; electric motors; and commercial, industrial, and residential lighting.

B. **Avoided Insurance Losses:**
Technology assessment and engineering design analysis of new appliance technology can ensure that appliances operate safely as well as efficiently. For example, electronic ignition devices in stoves reduce fire hazards from pilot lights, and sealed combustion equipment improves indoor air quality and fire safety. Appliance standards can lead to safer appliances that reduce environmental impacts, resulting in a possible reduction of liability claims.

C. **Resources**

i. **Research capabilities and skills:**
The Technology and Marketing Group's expertise extends from new technology assessment, to detailed demand modeling, to cost-benefit assessments, to product penetrations and distributional analyses using Geographic Information Systems (GIS).

Other areas of expertise include:

1. Cost-benefit analyses (with consumer, manufacturer, government, and environmental perspectives)
2. Technology assessment and engineering design option analyses
3. Residential and commercial energy modeling and forecasting
4. Subpopulation analyses (including use of GIS)
5. Market analyses (including use of GIS)
6. Analysis of potential for harmonization of efficiency standards, regionally and internationally

ii. **Research facilities:**
Not applicable

iii. **Selected Publications:**

1. Biermayer, P., "Analysis of Clothes Washer Design Options for Their Energy and Water Saving Potential," International Appliance Technical Conference, Columbus, OH, May 12-14, 1997.
2. Greening, L., A. Sanstad, and J. McMahon, "Effects of Appliance Standards on Product Price and Attributes: An Hedonic Pricing Model," *Journal of Regulatory Economics*, Vol. 11, No. 2, pp 181-194 (1997).
3. McMahon, J., S. Pickle, I. Turiel, P. Chan, T. Chan, and C. Webber, "Assessing Federal Appliance and Lighting Performance Standards," in Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, Vol. 9, August 25 - 31, 1996, Washington, DC, American Council for an Energy-Efficient Economy.
4. Rosenquist, G., "Opportunities for Improving the Energy Efficiency of Window-Type Room Air Conditioners," in Proceedings of the ACEEE 1996 Summer Study on Energy

Efficiency in Buildings, Vol. 1, August 25 - 31, 1996, Washington, DC, American Council for an Energy-Efficient Economy.

5. Turiel, I. and S. Hakim, "Consensus Efficiency Standards for Refrigerators and Freezers-Providing Engineering/Economic Analyses to Aid the Process," in Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, Vol. 9, August 25 - 31, 1996, Washington, DC, American Council for an Energy-Efficient Economy.

6. Lutz, J., X. Liu, J. McMahon, C. Dunham, L. Shown, and Q. McGrue, "Modeling Patterns of Hot Water Use in Households," LBNL Report 37805, Lawrence Berkeley National Laboratory, Berkeley, CA (1996).

iv. **Standards/guidelines/protocols/software tools:**
In 1978 the Department of Energy (DOE) was authorized to set mandatory energy efficiency standards for 13 household appliances and products under the National Energy Conservation and Policy Act (NECPA). In 1987 the NECPA was amended and updated by the National Appliance Energy Conservation Act (NAECA). NAECA superseded existing state requirements and actually set the first national efficiency standards for home appliances, as well as a schedule for regular updates, currently specified to 2012.

Today, NAECA, its updates, and the Energy Policy Act of 1992 (EPAct), are at the heart of energy efficiency advances in residential appliances and lighting. Office equipment, plumbing products, and small electric motors are also now covered under EPAct. These Federally mandated efficiency standards not only benefit consumers and the environment by saving energy, they also help make American appliance manufacturers more competitive in the global market place. The analysis for these standards was conducted at LBNL.

v. **WWW links:**
http://eetd.lbl.gov/EA/ECP/ECP.html
http://eetd.lbl.gov/EA/ECP/aps.html

D. **Demonstration Projects:**
In addition to the work for the U.S. Department of Energy on appliance standards, TMA has also performed the following:

1. An analysis of, and report on, advanced technologies for energy efficiency as required by the U.S. Congress.

2. An assessment of highest appliance and home product efficiencies for ACT2, a PG&E energy-efficiency project.

3. A commercial building end-use intensity analysis for the Electric Power Research Institute (EPRI).

4. Assessments of market penetration for residential products for the U.S. Environmental Protection Agency.

5. An assessment of energy-efficient product procurement for the federal government under the Federal Energy Management Program (FEMP).

E. **International Activities:**

1. An assessment of the range of international efforts at residential and commercial appliance efficiency standards for the International Energy Agency.

2. Assistance to foreign governments, including: Australia, China, Colombia, the European Union, Ghana, Mexico, the Russian Federation, Thailand.

F. **Future Projects:**
Work for the U.S. Department of Energy on appliance standards continues, as do efforts to help other nations develop national appliance standards programs.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Motor systems and controls

A. **Description:**
Motor systems are the single largest user of energy in commercial and industrial settings. Research at LBNL ranges from standards, to assessments of conservation potential, to development to practical demonstration projects as part of the USDOE In-House Energy Management Program. High-efficiency units will run cooler, which offers a modest benefit in terms of fire risk; they also last longer, reducing lost productivity. Variable Frequency Drives (VFDs) offer significant energy savings opportunities, and are valuable in smoke purging and pressurization of interior spaces during fires. VFDs allow "overspeed" operation, which can increase flow rates for smoke purging by 10-20% and maybe more for brief periods. In industrial applications, VFDs can be utilized to control the force, pressure, or torque on any dangerous process and can be programmed with shutoff points corresponding to failure modes. Such shutoffs may exist anyway in

the system, but VFD adds valuable redundancy and can be easier to tune. Another benefit is "braking": ordinary motors coast to a stop (w/o VFD), whereas with VFD the process can be forced to a very rapid stop. In commercial applications, one cause of failure in three-phase motors is "single-phasing", i.e. when one phase is lost due to blown fuse, distribution problem, etc. An ordinary motor will be damaged/destroyed, whereas a VFD will avoid damage to the motor: at light loads, the motor will run continuously (avoiding loss of production), and at heavier loads, the VFD will trip, protecting itself and the motor.

B. **Avoided Insurance Losses:**
Reduced unscheduled downtime (i.e., business interruption) due to greater system reliability. Lower losses result in equipment running cooler and reduces the risk of fire. Reduction of noise levels reduces potential health impacts on workers in the area. This technology reduces the following insurance losses: Comprehensive General Liability (by reduced number of fires), Health/Life (smoke purging/fire damage reduction), Workers Compensation (industrial safety benefits), and Boiler & Machinery (prevention of single-phasing).

C. **Resources**

i. **Research capabilities and skills:**
Expertise in the design, commissioning, and economic analysis of efficient motor systems and controls.

ii. **Research facilities:**
No fixed facility. LBNL has extensive experience in instrumentation for field measurements in different facilities.

iii. **Selected Publications:**

1. de Almeida, A., and S. Greenberg, "Energy Efficient Technologies: Electric Motor Systems Efficiency," in *CRC Handbook of Energy Efficiency*, Frank Kreith and Ronald West, eds. CRC Press, Boca Raton, 1997.

2. Greenberg, S., "Electric Motor and Belt Retrofits: Measured Savings and Lessons Learned," in Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings, 4.145 - 4.151.

3. de Almeida, A., and S. Greenberg, "Technology Assessment: Energy Efficient Belt Transmissions," *Energy and Buildings* 22:245-253 (1995). Elsevier Science, New York.

4. Meyers, S., P. Monahan, P. Lewis, S. Greenberg, and S. Nadel, "Electric Motor Systems in Developing Countries: Opportunities for Efficiency Improvement," Report No. 34412. Lawrence Berkeley National Laboratory, Berkeley, CA., 1993.

5. Nadel, S., M. Shepard, S. Greenberg, G. Katz, and A. de Almeida, *Energy-Efficient Motor Systems: A Handbook on Technology, Programs, and Policy Opportunities*, ACEEE, Washington, D.C., 1991.

6. de Almeida, A., S. Greenberg, and C. Blumstein, "Demand-Side Management Opportunities Through the Use of Energy-Efficient Motor Systems," *IEEE Transactions on Power Systems*, PWRS-5 #3 (August 1990) 852-861.

7. Greenberg, S., A. de Almeida, J. Harris, and H. Akbari, "Technology Assessment: Adjustable-Speed Motors and Motor Drives," Report No. 25080, Lawrence Berkeley National Laboratory, Berkeley, CA, 1988.

iv. **Standards/guidelines/protocols/software tools:**
Assistance with development of standards for developing countries; review of DOE's MotorMaster data base.

v. **WWW links:**
http://eetd.lbl.gov/CBS/Ateam/Ateam.html

D. **Demonstration Projects:**
Retrofits of over 150 motor systems throughout Lawrence Berkeley National Laboratory, as well as other sites.

E. **International Activities:**
Estimates of motor conservation potential and assistance with standards development.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Infrared Thermography

A. **Description:**
Infrared (IR) cameras make it possible to identify heat losses, and associated energy liabilities as well as safety risks. Insurance companies have used IR cameras for some time and report detecting dangerously worn refractory in steel furnaces, heat leaks in boiler doors, leaks in district heating lines, leaking refrigerants which can lead to food or pharmeceutical spoilage in commercial food refrigeration systems, and leakages in chiller systems than can cause water damage. High-accuracy temperature measurements make quantitative IR thermography useful for a variety of research efforts related to heat flows.

B. **Avoided Insurance Losses:**
Business interruption (due to leaking refrigerants), Homeowners or Comprehensive General Liability (avoided fires and moisture damage from condensation).

C. **Resources**

i. **Research capabilities and skills:**
In addition to field surveys, infrared thermography is being used in the laboratory to acquire experimental data useful for validating computer simulations.

ii. **Research facilities:**
The Infrared Thermography Facility at LBNL has been developed to aid solving technical problems related to heat transfer in building envelope components such as windows and insulation.

iii. **Selected Publications:**

1. Griffith, B., D. Turler, and D. Arasteh, "Surface Temperatures of Insulated Glazing Units: Infrared Thermography Laboratory Measurements," LBNL Report 38117, Lawrence Berkeley National Laboratory, Berkeley, CA. Also, contained in *ASHRAE Transactions* 102 (2):479-488, and presented at 1996 ASHRAE Summer Meeting in San Antonio, TX.

2. Turler, D., B. Griffith, and D. Arasteh, "Laboratory Procedures for Using Infrared Thermography to Validate Heat Transfer Models", in R.S. Graves and R. R. Zarr. Eds. *Insulation Materials: Testing and Applications: Third Volume*, ASTM STP 1320, American Society of Testing and Materials, 1997.

iv. **Standards/guidelines/protocols/software tools:**

1. ASTM standards -- developing draft standards for the use of IR thermography in laboratory thermal test chambers

2. NFRC window labels -- technical research related to rating condensation resistance

3. Software tools -- Window 4.1 and THERM 1.0; Development and validation of Window 5.0 and THERM 2.0

v. **WWW links:**
http://windows.lbl.gov
http://windows.lbl.gov/irlab

D. **Demonstration Projects:**
A range of laboratory-based tests are conducted on an ongoing basis on a variety of building technologies, including window systems and insulation systems. Primary use of data is for validating computer simulations of heat flows.

E. **International Activities:**

Joint US/Canada project related to condensation resistance of windows. Inter-laboratory comparisons of thermographic data and different simulation tools.

F. **Future Projects:**
Numerous experiments on window specimens aimed at mapping local temperature and surface heat transfer coefficients.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
The insurance industry could benefit from special-purpose simulation tools that predict heat flows and air movements in the built environment. For example, insurers could predict the likelihood of the building thermal envelope experiencing water damage from ice dams or window and sheathing condensation. Simulation programs always need to be validated with careful experimental measurements. Our research facility could be used to help test the accuracy of any computer programs developed to assist insurers assessment of risk due to thermal phenomena. Our facility is also involved in developing improved input parameters to help thermal simulations be more realistic.

Infrared thermography is already used in the insurance industry for qualitative surveys. Our research uses thermal imagers extensively for mapping actual temperatures and, as a result, we have developed methods for performing quantitative infrared thermography. Our expertise and facility could be used to help develop more accurate and reliable procedures for conducting infrared surveys for new or existing loss prevention efforts.

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Sector:
Buildings

I. **Technology Studied:**
Daylighting

A. **Description:**
Lighting is one of the largest electrical loads in commercial buildings. The use of daylighting as a source of illumination can displace up to 70% of the lighting energy requirements in a typical office building. Bringing daylight into the office space also has other benefits: a number of studies suggest that office workers in daylit offices are more productive and take fewer sick days off.

Researchers at Berkeley Lab have tested innovative daylighting design concepts such as light shelves and light pipes, which bring light to interior spaces from the outside using reflective films and glass.

Essential to creating a productive, healthy, energy-efficient luminous environment is the ability to predict the quality and quantity of daylight from a building's design. Researchers at Berkeley Lab have developed a number of software tools

that can help designers with this task, including SUPERLITE and ADELINE (see below, under standards, softeware tools, etc.). Researchers have used these tools, plus physical testing facilities such as the Building Technology Program's sky simulator and its bidirectional radiometric scanner, to study and refine the daylighting environment of various building designs.

B. **Avoided Insurance Losses:**
Daylighting may lead to increased productivity and reduced sickness from building-related ailments, resulting in a corresponding reduction in professional liability and health insurance claims. Incorporating daylighting into a buildings lighting strategy helps ensure that at least some natural light is available during power failures, with corresponding safety benefits and reduced service interruptions. As we transition from a society dominated by localized electric lights to fewer centralized lamps integrated with daylighting systems, daylighting will reduce by a factor of 3 or more the amount of electrical wiring needed to light those areas. Less wiring should translate into less electrical and fire hazards.

C. **Resources**

i. **Research capabilities and skills:**
Researchers in the Building Technologies Program are experienced in:

1. Developing and testing new technologies to improve building daylighting, such as light shelves and pipes.

2. Designing energy-efficient lighting systems for buildings, including daylighting as a component.

3. Evaluating the energy-savings of these designs.

They have developed computer simulation software tools for modeling the lighting environment of building designs, and used this software to evaluate commercial and residential building plans. Scientists in the Program also have extensive experience in field testing and evaluating advanced, energy-efficient building lighting systems.

ii. **Research facilities:**
Research facilities relevant to daylighting include the sky simulator and the bidirectional radiometric scanner.

1. The *sky simulator* is a 24-foot-diameter dome that researchers use to measure the illuminance levels in building models fitted with various daylighting systems. By testing these models, they can determine how well a building design or daylighting technology permits light to enter under conditions of varying time of day and season, building orientation, or geographic location.

2. The *bidirectional radiometric scanner* is a tool for accurately measuring the solar heat gain of any window system, which can include shades, blinds, drapes, and a variety of glazings, tints, coatings, and glass thicknesses. Scientists in the Building Technologies Program developed this device to improve research on window systems and to develop a universal rating system for solar heat gain from windows.

iii. **Selected Publications:**

1. Beltran L., E. Lee, and S. Selkowitz, "Advanced Optical Daylighting Systems: Light Shelves and Light Pipes," presented at the 1996 IESNA Annual Conference, August 4-7, 1996, Cleveland, Ohio. Report No. LBL-38133, Lawrence Berkeley National Laboratory, Berkeley, CA.

2. Lee, E., L. Beltran, and S. Selkowitz, "Demonstration of a Light-Redirecting Skylight System at the Palm Springs Chamber of Commerce," presented at the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, August 25-31, 1996, Asilomar, Pacific Grove, CA. Report No. LBL-38131, Lawrence Berkeley National Laboratory, Berkeley, CA.

3. Hitchcock, R., "Advancing Lighting and Daylighting Simulation: The Transition from Analysis to Design Aid Tools," presented at the IBPSA (International Building Performance Simulation Association) Fourth International Conference, August 14-16, 1995, Madison, WI. Report No. LBL-37285, Lawrence Berkeley National Laboratory, Berkeley, CA.

iv. **Standards/guidelines/protocols/software tools:**
The National Fenestration Ratings Council has established a voluntary energy performance rating system for windows and related products such as skylights and doors. An NFRC label tells designers, specifiers and the general public about the energy efficiency of a window product. Berkeley Lab provides technical assitance to the NFRC's testing efforts.

Software tools relevant to daylighting developed by Berkeley Lab's Building Technologies Program include ADELINE, SUPERLITE, RADIANCE:

1. ADELINE (Advanced Day and Electric Lighting Lighting Integrated New Environment) integrates a three-dimensional CAD modeling program with two lighting analysis tools, SUPERLITE and RADIANCE.

2. SUPERLITE is a lighting analysis program designed to predict the

interior illuminance in complex building spaces from daylighting and electric lighting sources.

3. RADIANCE is an advanced ray-tracing system for designing and visualizing arbitrarily complex spaces with daylighting and electric light sources.

v. **WWW links:**
http://windows.lbl.gov/
http://eetd.lbl.gov/btp/pub/designguide/
http://radsite.lbl.gov/adeline/HOME.html
http://radsite.lbl.gov/radiance/HOME.html
http://eetd.lbl.gov/BTP/WDG/SUPERLITE/superlite2.html

D. **Demonstration Projects:**
A recent demonstration of an advanced system to redirect daylight to interior spaces using light shelves at the Palm Springs Chamber of Commerce is described in Lee et al. (1996) (see Publications).

E. **International Activities:**
None currently.

F. **Future Projects:**
Several research projects are described on the Building Technologies Program's windows and daylighting Web site, http://windows.lbl.gov/.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Utilities

I. **Technology Studied:**
Advanced Batteries

A. **Description:**
Advanced batteries are in great demand because of many current and potential applications such as electric vehicles, hybrid vehicles, stationary energy storage, and portable electronic devices. Existing batteries do not store enough energy per unit weight or volume, and are generally too expensive. Some of them are environmentally hazardous.

The advanced battery research at LBNL is carried out in the Environmental Energy Technologies Division, and the Materials Science Division. The research is broad-based, and includes both exploratory work, and applied investigations focused on specific materials and problems. The main area of investigation is rechargeable lithium cells of high specific energy, using environmentally benign materials.

B. **Avoided Insurance Losses:**
By providing backup power, service interruptions can be reduced when power service is interrupted.

Efficient stationary power sources such as batteries can also reduce the vulnerability of commercial and industrial facilities to equipment damage and productivity loss from power failures. For example, voltage excursion on the line can be damped out by the battery.

C. **Resources**

i. **Research capabilities and skills:**
Various techniques are developed and applied to achieve a thorough understanding of how the electrode materials function, as an aid to the development of new, highly-energetic, environmentally-benign electrode materials. The techniques used include X-ray absorption spectroscopies with Sycchrotron radiation, LEIS, LEED, probe-beam deflection, photothermal deflection spectroscopy, spectroscopic ellipsometry, nuclear magnetic resonance(NMR), and a number of other techniques. In addition, electrodes and cells are fabricated and tested to evaluate the efficacy of new electrode materials, new electrode structures, and new electrolytes.

ii. **Research facilities:**
A wide range of facilities for electrochemical studies and materials characterization is available, including high-resolution electron microscopy, scanning tunneling microscopy, synchrotron X-ray source, NMR, inert-atmosphere boxes, computer-controlled cell cycling equipment, electrochemical impedance spectroscopy, FTIR spectroscopy, photothermal deflection spectroscopy, ellipsometry, porous electrode preparation facilities, and others.

iii. **Selected Publications:**

1. Adler, T., F. McLarnon, and E. Cairns, "Rechargeable zinc cell with alkaline electrolyte which inhibits shape change in zinc electrode," U.S. Patent #5,453,336 (1995); continuation-in-part of U.S. Patent No. 5,302,475.

2. Plivelich, R., F. McLarnon, and E. Cairns, "Degradation mechanisms of nickel oxide electrodes in zinc/nickel oxide cells with low-zinc-solubility electrolytes," *J. Appl.Electrochem.* 25:433 (1995).

3. Taucher, W., T. Adler, F. McLarnon, and E. Cairns, "Development of Lightweight Nickel Electrodes for Zinc/Nickel Oxide Cells," *J. Power Sources* 58:93 (1996).

4. Wen, S., T. Richardson, L. Ma, K. Striebel, P. Ross, E. Cairns, "FTIR Spectroscopy of Metal Oxide Insertion Electrodes: Capacity Fading in Secondary Li/LiMn2O4 Cells", *J. Electrochem. Soc.*, 143, No. 5, pp. L136-L138, (1996).

5. Richardson, T., S. Wen, K. Striebel, P. Ross, and E. Cairns, "FTIR Spectroscopy of Metal Oxide Insertion Materials: Analysis of LixMn2O4 Spinel Electrodes," *Materials Research Bulletin*, 32, 609 (1997).

6. Cairns, E., "Overview of the Current Status and Problems for Rechargeable Batteries," *Progress in Batteries & Battery Materials*, 16:237 (1997).

7. Striebel, K., S. Wen, D. Ghantous, and E. Cairns, "Novel Nanodisperse Composite Cathode for Rechargeable Lithium/Polymer Batteries", *J. Electrochem. Soc.*, 144, 1680 (1997).

8. Lee, C-K., K. Striebel, F. McLarnon, and E. Cairns, "Thermal Treatment of La0.6Ca0.4CoO3 Perovskite Oxides for Bifunctional Air Electrodes", *J. Electrochem. Soc.*, 144, 3801, (1997).

iv. **Standards/guidelines/protocols/software tools:**
Not applicable.

v. **WWW links:**
http://eetd.lbl.gov/BERC/ejc.html

D. **Demonstration Projects:**
LBNL has licensed new Li battery technology to a start-up company, which is developing hardware and a market for the new cells.

E. **International Activities:**
None currently

F. **Future Projects:**
LBNL is developing new cells that offer much higher specific energy than any other cells available. An example of such a cell is Li/polymer/S, which has a theoretical specific energy of 2600 Wh/kg, compared to less than 1000 Wh/kg for existing Li ion or Li/polymer cells.

G. **Collaborations with Insurance Industry:**
None currently

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Cool storage systems

A. **Description:**
Cool storage systems are being used primarily in commercial buildings to shift the cooling load of a building to offpeak periods during the day. Simply put, stored water is chilled or frozen during offpeak periods (usually at night) by one or more chillers, and the stored "cool" is used to supplement the cooling need of the building the next day. This reduces onpeak electrical demand which must be met by the electrical utility and reduces air-conditioning operating costs to the building owner/operator by reducing costs associated with the demand component and on-peak energy costs of the electrical utility tariff. Cool storage systems may number about 1500 in the U.S., and the cool storage industry is probably about $30 million annually.

B. **Avoided Insurance Losses:**
One advantage of cool storage is its ability to provide air conditioning (partially

or wholly) to a building based on the "coolth" which has been stored from the previous off-peak period (usually the previous night). This means that if a building's chiller or refrigeration system were to fail (i.e., service interruption), the storage system could provide probably 8 - 10 hours of air conditioning without chiller operation, and this would provide time for the chiller to be repaired or for alternative cooling arrangements to be completed. There would be little to no loss of utility of the building and any losses associated with building operation might be reduced. The stored water can also be used for firefighting.

C. **Resources**

i. **Research capabilities and skills:**
System studies, performance analysis, and simulation tools.

ii. **Research facilities:**

iii. **Selected Publications:**

1. Piette, M., "Analysis of a Commercial Ice-Storage System: Design Principles and Measured Performance", *Energy and Buildings*, 14(4):337-350 (1990).

2. Piette, M., "An International Comparison of Diurnal Thermal Storage System Performance: Lessons from CADDET," Proceedings of the ACEEE 1990 Summer Study on Energy Efficiency In Buildings, August, 1990.

3. Piette, M., "Learning from Experience with Thermal Storage: Managing Electric Loads in Buildings," CADDET Analyses Series, No. 4, International Energy Agency, Center for the Analysis and Dissemination of Demonstrated Energy Technologies, Sittard, The Netherlands, July 1990. ISBN 90-72647-14-9.

4. Piette, M., E. Wyatt, and J. Harris, "Technology Assessment: Thermal Cool Storage in Commercial Buildings," Jan. 1988, LBL Report No. 2552,. Lawrence Berkeley National Laboratory, Berkeley, CA.

iv. **Standards/guidelines/protocols/software tools:**
Cool Storage Design Tools are available from ASHRAE and the Electric Power Research Institute (EPRI).

Information on cool storage systems is available through the University of Wisconsin's Thermal Storage Advisory Research Center.

v. **WWW links:**

D. **Demonstration Projects:**
There are cool storage projects in nearly every state; contacts with local utility would help to identify sites to visit.

E. **International Activities:**
Cool storage projects have been studied under Annexes of the International Energy Agency with the U.S. DOE as a partner; cool storage systems are also in most major industrialized countries.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Utilities

I. **Technology Studied:**
Flywheels

A. **Description:**
A flywheel power quality unit can be installed between the power source and a manufacturing facility, providing clean, uninterrupted power to the equipment in the facility. The flywheel operates continuously, storing a relatively small amount of energy which can be used when the electrical power is lost for a short period of time (seconds or minutes).

In this project, the flywheels are high efficiency electromechanical batteries using Halbach array permanent magnets and magnetic bearings with advanced controls to respond to fraction of a cycle outages. Laboratory prototype units are in the 0.5 kilowatt-hour energy storage range with 50 kilowatt power capability.

B. **Avoided Insurance Losses:**
Use of a flywheel energy storage system as a power quality unit can prevent damage from short-term loss of electrical power. Many businesses and industries

are sensitive to loss of electrical power, even for a fraction of a second. A flywheel power quality unit can maintain consistent, uninterrupted power to the building and manufacturing equipment. If the power disruption is for a longer period of time, the flywheel power quality unit can provide power to allow a controlled shutdown of equipment.

C. **Resources**

i. **Research capabilities and skills:**
Complete flywheel systems, systems analysis, rotor dynamic analysis, carbon composite rotor design and fabrication, magnetic bearing development, high efficiency power conditioning and controls, and lightweight containment development.

ii. **Research facilities:**

1. Laboratory capable of testing full-scale, uncontained flywheel systems, electrical loads of up to 100 kW available

2. Multiple gas gun and x-ray facilities for containment development

iii. **Selected Publications:**

1. Post, R., D. Ryutov, J. Smith, and L. Tung, "Research on Ambient-Temperature Passive Magnetic Bearings at LLNL," August 21-22, 1997, Proceedings of the Mag '97 Industrial Conference and Exhibition on Magnetic Bearings.

2. R. Post, T. Fowler, and S. Post, "A High Efficiency Electromechanical Battery," Proceedings of the I.E.E.E., 81:462 (1993).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www-energy.llnl.gov/docs/index.html

D. **Demonstration Projects:**
A flywheel energy storage system is operational in the LLNL Flywheel Lab and at Trinity Flywheel Power Company (LLNL's licensee), 674-D Preston Ave., Livermore, CA 94550.

E. **International Activities:**
None currently.

F. **Future Projects:**
Demonstrations in both stationary and mobile applications are planned with

industrial partners.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Utilities

I. **Technology Studied:**
Zinc-Air Fuel Cell

A. **Description:**
Lawrence Livermore National Laboratory (LLNL) is developing a refuelable zinc-air fuel cell (ZAFC) technology with an industrial partner for application in the utility sector. The device will be useful in energy storage, peak demand leveling and ennhancing power quality. The technology combines zinc pellets and atmospheric oxygen to produce electricity and an aqueous suspension of zinc oxide which is then pumped out and replaced with new zinc pellets, and the zinc oxide solution is electrically regenerated. The system possesses rapid refueling rates and high energy densities, potentially up to 4 - 5 times higher than that of lead acid batteries. These fuel cells can be used in buildings to provide power.

B. **Avoided Insurance Losses:**
Fuel cells can provide power to a building when power service is interrupted, thus reducing insurance losses due to service interruptions.

C. **Resources**

i. **Research capabilities and skills:**
Electrochemical engineering of flow systems, electrochemistry, and engineering prototyping. LabView: a sophisticated process controler software that controls the charging and discharging of the ZAFC.

ii. **Research facilities:**
Not applicable.

iii. **Selected Publications:**

1. Tokarz, F., J. Smith, J. Cooper, D. Bender, and S. Aceves, "A Concept Electric Vehicle Using Zinc Air and Flywheel Batteries," UCRL-JC-121700, October 1995.

2. Tokarz, F., J. Smith, J. Cooper, D. Bender, and S. Aceves, "A Zinc Air Battery and Flywheel Zero Emission Vehicle," UCRL-JC-121727, October 1995.

3. Cooper, J., L. Keene, J. Noring, A. Maimoni and K. Peterman, "Regenerative Zinc Air and Zinc Ferricyanide Batteries for Stationary Power Applications," UCRL-JC-117248, May 1994.

4. Cooper, J., D. Fleming, D. Hargrove, R. Koopman, and K. Peterman, "A Refuelable Zinc Air Battery for Fleet Electric Vehicle Propulsion," UCRL-JC-120308, April 1995.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.llnl.gov/str/10.95.html

http://www.llnl.gov/tid/lof/lof_home.html

D. **Demonstration Projects:**
LLNL has performed a demonstration of the ZAFC on a Santa Barbara bus. Several 6-cell ZAFC units have been built and demonstrated.

E. **International Activities:**
Commerical partners are interested in applications for the ZAFC worldwide. It has been evaluated as a potential useful technology for remote power energy systems.

F. **Future Projects:**
The development and demonstration of the ZAFCs will be expanded to mobile applications (i.e., light-duty vehicles, including buses) and smaller stationary

products, like gensets.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Passive Solar Energy Systems

A. **Description:**
In the most narrow sense, a passive system is defined as one that can provide heating, cooling and lighting with minimal need for mechanical devices or purchased energy. In a more practical sense, passive solar buildings (sometimes called bioclimatic buildings) are designed to be well adapted to the climates in which they are constructed. In cold climates the emphasis is on insulation, and keeping heat inside the building by collecting and storing solar energy. In hot climates the emphasis is on keeping the interior cool by avoiding excess solar loads beyond those required for daylighting, minimizing internal gains, utilizing non-mechanical methods of heat dissipation such as natural ventilation, and thermal storage mass. Moderate or mixed climates require systems engineered to admit solar energy during cold periods, and reject solar heat gain during warm periods. Because of the benefits of thermal storage mass, passive solar buildings are often constructed of more durable disaster resistant materials such as concrete and masonry. These buildings are also disaster resistant because they will neither

freeze nor become seriously overheated in a power outage. Passive solar buildings do not require specialized component technology. However, they do require specialized computerized design optimization technology to properly match the building to the climate.

B. **Avoided Insurance Losses:**
Unknown at this time. No formal studies have been done, but the potential is estimated to be very large. For example, all concrete passive solar houses built by Tierra Designs in Colorado, with design optimization by NREL, are essentially flood and fire proof, and have an earthquake seizmic zone-4 rating. The houses will neither freeze nor seriously overheat even in a protracted power outage.

C. **Resources**

i. **Research capabilities and skills:**
The Buildings and Thermal Systems Center at the National Renewable Energy Laboratory has extensive capabilities in the following areas:

1. experimental design, energy analysis, applied math
2. data collection and field monitoring
3. building physics and thermal science,
4. computer programming and modeling
5. creation of computerized design and analysis tools
6. policy analysis and evaluation
7. economic analysis and market analysis
8. daylighting, indoor air quality, HVAC systems
9. residential and commercial buildings
10. new materials and component development
11. photovoltaics integrated with buildings

ii. **Research facilities:**

1. Thermal Test Facility with a variety of thermal science labs
2. Large scale environmental chamber
3. Flow visualization lab
4. Wind tunnel

5. HVAC testing lab
6. Solar thermal outdoor test lab
7. Photovoltaics outdoor test lab
8. Air quality field test lab
9. Tracer gas field test lab

iii. **Selected Publications:**
Judkoff, R., J Thornton, et al., "Disaster: Reduce the Risk of Insurance Loss with Renewable Energy Technologies," NREL BR-330-22820, May 1997, NREL, Golden CO.

iv. **Standards/guidelines/protocols/software tools:**

1. The Energy-10 (E-10) computerized building energy design tool
2. The SERIRES computerized building energy analysis tool
3. The BESTEST method for validating building energy software models.

v. **WWW links:**
http://www.nrel.gov

D. **Demonstration Projects:**

1. Exemplary Buildings Project. In this DOE project, building owners and architects and engineers cooperatively design buildings that use 70% less energy than the applicable thermal code (e.g., for residential buildings, the code is the Model Energy Code or ASHRAE 90.1; for nonresidential buildings, the code is ASHRAE 90.2). NREL conducts building simulations at the pre-design stage to model the low-energy buildings.
2. Building America Project. In this DOE project, production builders of residential buildings and their suppliers try to design and market energy-efficient buildings. NREL conducts building simulations.

For both of these programs, see the following Web site:
http://www.eren.doe.gov/overview/budget/budget6.html

E. **International Activities:**
Research projects in this field are being conducted with the International Energy Agency.

F. **Future Projects:**

1. Determination of the statistically determinate value in avoided insurance claim costs for each passive solar strategy and combination of strategies.

2. Determination of the health benefits of daylighting.

3. Determination of the productivity benefits of daylighting in schools, offices, and retail buildings.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: NREL-2

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Sector:
Utilities

I. **Technology Studied:**
Parabolic Troughs for Solar Electric Power

A. **Description:**
Large solar thermal electric power technology ranging in size from 15 to 200 MW. Use parabolic trough solar collectors to collect solar energy to run conventional power plant and generate electricity.

B. **Avoided Insurance Losses:**
The solar field is like a 30 year fuel supply on-site. This solar electricity can provide power to a building when power service is interrupted, thus reducing insurance losses due to service interruptions.

C. **Resources**

i. **Research capabilities and skills:**
The SunLab (NREL and Sandia National Laboratories) has the following capabilities:

1. optical material research and testing
2. systems analysis (performance and financial modelling)
3. solar resource assessment
4. manufacturing assistance
5. operations and maintenance support

ii. **Research facilities:**
Both laboratories have collector testing facilities.

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.nrel.gov

D. **Demonstration Projects:**
SEGS I-IX commercial plants located in California Mojave desert. 354 MW of installed capacity.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: NREL-3

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Sector:
Utilities

I. **Technology Studied:**
Building Integrated Photovoltaics

A. **Description:**
State-of-the-art building integrated photovoltaic (BIPV) technologies are multi-functional building products that generate electricity and perform as part of the building envelope. Roofing materials and facade system are commercially available today. BIPV roofing materials include tiles, shingles, skylights, and metal-standing seam products. For facades, designers can select from curtain wall products, spandrel panels, awnings, canopies, and glazing. These products are available from a variety of manufacturers who also prove turn-key systems. These systems are used in both residential and commercial buildings (e.g., 4 Times Square in New York City).

Additionally, new BIPV product development is underway within the PV:BONUS TWO Program. PV:BONUS is a DOE Office of Utility Technology sponsored program to develop technologies and to foster business arrangements

that integrate photovoltaics or hybrid products into buildings cost-effectively. The ultimate goal is market demonstrations of commercially viable products that lead to manufacturer commitments to pursue production and sales.

B. **Avoided Insurance Losses:**
BIPV applications reduce insurance losses related to service interruptions as a result of power failures.

When tested for performance and safety, PV flat-plate modules must pass the IEEE Standard 1262 hail test which includes meeting the ASTM E-1038-93 standard test adapted from a JPL test. These tests have also been adopted by Underwriters Laboratory (UL) in their UL-1703 standards on PV module and panel safety testing. We do not yet know whether the panel performance is superior to ordinary roofing. If so, there would be a differential benefit in cases where the panels covered a significant portion of the roof area.

C. **Resources**

i. **Research capabilities and skills:**
Working in close collaboration with our customers and stakeholders, we analyze technical, environmental, market, policy, and resource topics to support informed decisions on the role of renewable energy and energy efficiency technologies. In addition, we support the Federal Energy Management Program by helping federal facility managers identify and implement the best, most cost-effective energy efficiency and renewable energy projects.

ii. **Research facilities:**
NREL has a variety of facilities and activities researching renewable energy technologies.

iii. **Selected Publications:**
"Solar Electric Buildings: An Overview of Today's Applications," DOE/GO 10097-357 DE97000101

iv. **Standards/guidelines/protocols/software tools:**
Guidelines are under development relative to BIPV.

v. **WWW links:**
http://www.nrel.gov

D. **Demonstration Projects:**
The Thoreau Center BIPV skylight glazing system at the Golden Gate National Recreation Center, San Francisco, CA.

E. **International Activities:**

The International Energy Agency (IEA) Photovoltaic Powers Systems (PVPS) Implementing Agreement, Task VII on Photovoltaics in the Built Environment provides an international forum for experts in the field of PV architecture and engineering to share experiences, coordinate and promote the development and use of PV systems in buildings and non-building structures (e.g. PV street furniture-bus shelters, street lights etc.). NREL participates in this forum as the Subtask 3 (Non-technical Barriers) Leader.

F. **Future Projects:**
Current work is underway to provide a source book of architectural guidelines for the integration of BIPV systems into buildings. This source book will include information on building codes and standards issues relative to BIPV.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Photovoltaic (PV) flat-plate modules, when tested for performance and safety, must pass the IEEE Standard 1262 hail test which includes meeting the ASTM E-1038-93 standard test adapted from a JPL test. These tests have also been adopted by Underwriters Laboratory (UL) in their UL-1703 standards on PV module and panel safety testing. A research project is needed to determine whether the PV panel performance is superior to ordinary roofing. If so, there would be a differential benefit in cases where the panels covered a significant portion of the roof area.

Laboratory Identification Number: NREL-4

Laboratory Name:
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Sector:
Utilities

I. **Technology Studied:**
Solar Heat and Buildings Technologies

A. **Description:**
The Solar Heat and Buildings Technologies Program conducts research and development and market development activities relating to solar thermal technologies for building applications (e.g., water heating and space conditioning (e.g., solar absorption cooling)), and photovoltaics for building applications.

B. **Avoided Insurance Losses:**
When service is interrupted, building occupants can turn to solar heating and cooling and building technologies and reduce business interruptions. In addition, when combustion appliances are used less often, indoor air quality will improve and the risk of fire will be reduced.

C. **Resources**

i. **Research capabilities and skills:**

1. Heat transfer
2. Solar system design and systems analysis
3. Computer modelling
4. Solar system, subsystem and components testing and evaluation.

ii. **Research facilities:**
The Laboratory has a state-of-the-art array of laboratories, testing and evaluation facilities relating to its missions.

iii. **Selected Publications:**
The Laboratory has a wealth of publications--most of which are accessible through the Internet at http://www.nrel.gov/about.html

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.nrel.gov/about.html

D. **Demonstration Projects:**

1. Solar system at the California Correctional Institute at Tehachapi for providing domestic hot water for a 5000-inmate state prison.
2. Solar sytem at the Jefferson County Detention Facility (Golden, CO) for providing domestic hot water for a 500-inmate county jail.
3. Solar ventilation air preheating system at the Federal Express Distribution Center in Littleton, CO.
4. Solar system for providing domestic hot water for the EPA's headquarters complex in Washington, DC.
5. There are nearly a million solar thermal systems in homes, businesses and government facilities in the United States.
6. Solar absorption cooling at the U.S. Army's Yuma Proving Grounds near Yuma, AZ.
7. Solar absorption cooling for a commercial building in Sacramento, CA, operated by Bergquam Energy Systems.

E. **International Activities:**
None currently.

F. **Future Projects:**

1. R&D to reduce the installed costs of solar systems for water heating by about 50%.

2. R&D targeted at reducing the costs and improving the performance of solar system components.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
For solar water heaters (operating at temperatures of no higher than 200 °F), the major issues relating to insurance loss reduction are losses due to fire, wind, hail, leaks and vandalism. Accordingly, the following research needs to be conducted:

1. Identify low-cost, durable structural materials for use in fabricating the structural components of solar collectors: materials that are resistant to hurricane-level wind loads and associated vibration.

2. Develop mounting structures for installing solar collectors on roofs or on the ground: structural systems that are resistant to hurricane-level wind loads and associated vibration.

3. Develop glazing materials that have transmittances of at least 0.90 and are resistant to hail damage.

4. Develop fittings and connectors for connecting solar collectors to the piping that are leak proof and are resistant to stagnant conditions and thermal cycling.

The above research relates to hail and wind; fire is not an issue of any significance. For roof-mounted collectors, developing glazings that are highly resistant to hail would go a long way towards addressing the issue of vandalism.

Laboratory Identification Number: NREL-5

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Sector:
Utilities

I. **Technology Studied:**
Stand-Alone Photovoltaic Systems

A. **Description:**
Photovoltaic (PV) systems are typically stand-alone (typically less than 10 kWp), utility-independent, electrical generators. PV systems can be connected to the utility grid to augment local power, but should disaster strike and the conventional utility grid fail, a PV system can continue to deliver power.

Because PV systems are modular, they can be tailored to a wide range of electrical loads, sites, and applications. They systems are relatively lightweight, which allows them to be mounted on mobile units that can be deployed rapidly and moved easily to meet changing situations. PV systems are highly cost-effective, low maintenance, silent and emit no radio frequency interference that can block or garble critical communications connections.

Grid-independent PV systems are the most cost-effective source of power when extending transmission lines is prohibitively expensive (remote installations) or difficult (some urban sites), when line-maintenance costs are high (extreme winter weather, heavily treed areas), or when the demand is so small that the potential

revenue doesn't justify the cost of providing service.

B. **Avoided Insurance Losses:**
Stand-alone, utility independent, PV systems offer a high degree of reliability for powering critical climate and environmental sensing and monitoring instruments, lighting and traffic control equipment, water pumps and purifiers, and communication systems. These systems can be used in hazard mitigation, response and recovery applications. They can also improve underwriting, claims management, catastrophe response and recovery, and reduce business and service interruption losses for homes and small businesses in communities. They can be used to replace diesel generators following disasters and to power critical systems following disasters. And they can be used to power insurance catastrophe offices to power laptop computers, cellular phones, and other office equipment.

C. **Resources**

i. **Research capabilities and skills:**

ii. **Research facilities:**

iii. **Selected Publications:**

1. Judkoff, R., J. Thornton, N. Strawn, C. Gay, and P. Torcellini, "Disaster! Reduce the Risk of Insurance Loss with Renewable Energy Technologies," NREL/BR-330-22820, Revised May 1997.

2. National Renewable Energy Laboratory, "Photovoltaics: Advancing Toward the Millenium," DOE/GO-10095-241, May 1996.

3. National Renewable Energy Laboratory, "Tapping into the Sun: Today's Applications of Photovoltaic Technology," DOE/CH10093-203-Rev.1, Revised April 1995.

4. National Renewable Energy Laboratory, "Photovoltaics for Municipal Planners," NREL/TP-411-5450, April 1993.

5. National Renewable Energy Laboratory, "Solar Electric Buildings: An Overview of Today's Applications," DOE/GO-10097-357, Revised Feb. 1997.

iv. **Standards/guidelines/protocols/software tools:**

v. **WWW links:**
http://www.nrel.gov

D. **Demonstration Projects:**
Projects are widely available in the United States. See publications list.

E. **International Activities:**
Projects are widely available internationally. In addition to the industrially developed world, countries that are most active in installing PV systems are Brazil, China, India, Indonesia, Mexico, Russia and South Africa.

F. **Future Projects:**

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: NREL-6

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Sector:
Utilities

I. **Technology Studied:**
Dispatchable Photovoltaic Peak-Shaving and Uninterruptible Power Supply Systems

A. **Description:**
The objectives of this project are: (1) to perform economic and technical analyses of photovoltaic (PV) applications on commercial buildings in the U.S., using building load and other data supplied by twelve cooperating utilities; (2) to assist the State of Delaware, and up to two other states upon request, in identifying high value PV applications on public buildings; (3) to identify PV value analysis refinements including emergency power service in light of an emerging competitive electricity market; (4) conduct analyses of international PV building applications to provide peak-shaving and emergency power functions (1997).

B. **Avoided Insurance Losses:**
Dispatchable photovoltaic systems can reduce insurance losses from service interruptions when power service is disrupted. They also offer a high degree of reliability for powering critical emergency equipment following disasters.

C. **Resources**

i. **Research capabilities and skills:**
Computer models have been developed to predict economic performance and energy generation capacity of PV arrays as a peak demand and uninterruptible power supply (UPS) technology. The Center for Energy and Environmental Policy also has connections to the solar engineering research institute on campus, the Institute of Energy Conversion (IEC).

ii. **Research facilities:**
CEEP has a computer laboratory and PV experimental facility (Solar One) which it jointly uses with the IEC. There is a PV manufacturing facility close by (Newark, DE).

iii. **Selected Publications:**

1. Byrne, J., Y. Wang, K. Boo and J. Song, "The Economic Viability of Dispatchable Peak Shaving PV Systems in Commercial Buildings of Korea," *Proceedings of the International Solar Energy Society 1997 Solar World Congress* (1997).

2. Byrne, J., S. Letendre, L. Agbemabiese, D. Redlin, and R. Nigro, "Commercial Building Integrated Photovoltaics: Market and Policy Implications," *Proceedings of the 26th IEEE Photovoltaic Specialists Conference*, Anaheim, CA (1997).

3. Byrne, J., L. Agbemabiese, and D. Redlin, "Evaluating the Additional Value of Emergency Power Applications in Dispatchable PV Peak Shaving Systems," report submitted to the National Renewable Energy Laboratory, prepared by the Center for Energy and Environmental Policy, University of Delaware, Newark, DE (1997).

4. Byrne, J., S. Letendre, Y. Wang, R. Nigro and W. Ferguson, "Building Load Analysis of Dispatchable Peak-Shaving Photovoltaic Systems: A Regional Analysis of Technical and Economic Potential," *Proceedings of the American Solar Energy Society Solar 97 Conference* (1997).

5. Nigro, R., W. Ferguson and J. Byrne, "The Development of a Dispatchable PV Peak Shaving System," *Proceedings of the First International Conference on Solar Electric Buildings* (1996).

6. Byrne, J., S. Letendre, C. Govindarajalu, Y. Wang, and R. Nigro, "Evaluating the Economics of Photovoltaics in Demand-Side Management Role," *Energy Policy*, Vol. 24, No. 2 (1996).

7. Center for Energy and Environmental Policy (CEEP), "PV Planner: A Spreadsheet Analytical Tool for Grid-Connected Application" (1996).

8. Byrne, J., R. Nigro and Y. Wang, "Photovoltaic Technology as a Dispatchable, Peak-Shaving Option," *Public Utilities Fortnightly* (1995).

iv. **Standards/guidelines/protocols/software tools:**
PV-Planner, a Spreadsheet Analytical Tool for Grid-Connected Applications. It evaluates the economic potential for utility and customer applications of photovoltaic (PV) technologies to serve distributed, peak-shaving and demand-side generation needs under a variety of policy, technical and financial conditions. A manual has been prepared to guide users in the application of PV-Planner.

v. **WWW links:**
http://www.udel.edu/ceep

D. **Demonstration Projects:**
A DPV-PS system has been operating for over four years on Delmarva's Northern Division General Office located in Newark, Delaware. In addition, four DPV-PS systems have been installed at the following locations: a retail store in Green Bay, WI; the State Office Building in Wilmington, DE; Delmarva's Conowingo District Office in Northeast MD; and a manufacturing facility in Aberdeen, NC. The DPV-PS system at the State Office Building in Wilmington has been designed to serve uninterruptible power supply needs in addition to peak-shaving. It is being monitored at this time and an evaluation of the system's performance will be reported in 1998.

E. **International Activities:**
Applications to meet peak-shaving and emergency power needs have been conducted for commercial buildings in Korea, China and Japan.

F. **Future Projects:**
Continue current project. New project has started to evaluate CO2 reduction potential through the application of PVs on U.S. public buildings.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: NREL-7

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Sector:
Utilities

I. **Technology Studied:**
Small Wind Turbine System

A. **Description:**
Small wind turbine systems can be stand-alone, utility independent, electrical generators. Small wind turbine systems can be connected to the utility grid to augment local power and improve the power quality, but should disaster strike and the conventional utility grid fail, a small wind turbine system can continue to deliver power as long as the wind is blowing. Storage media such as batteries may be added to the system to overcome the intermittency of the wind by providing stored power.

Because small wind systems come in a variety of sizes and electrical output configurations, they can be tailored to a wide range of electrical loads, sites and applications. Small wind systems are highly cost-effective, low maintenance, and highly reliable and as a result are often sited remotely.

Grid-independent wind systems are the most cost-effective source of power when extending transmission and distribution lines is prohibitively expensive (remote

installations) or difficult (some urban sites), when line- maintenance costs are high (extreme weather conditions), or when the demand is so small that the potential revenue from extending a transmission or distribution line doesn't justify the cost of providing utility grid service.

B. **Avoided Insurance Losses:**
Stand-alone, utility independent, small wind turbine systems offer a high degree of reliability for powering remote locations with AC or DC power, water pumps, and communication systems. They reduce losses from service and business interruptions when the grid utility grid service is interrupted. They can also be used to power emergency equipment following disasters.

C. **Resources**

i. **Research capabilities and skills:**
NREL has subcontractgs to design, build and test advanced small wind turbines (Bergey Windpower, WindLite Company, World Power Technologies). NREL is also involved with research for large and small wind turbines in a variety of areas including aerodynamics, blade development, variable speed, flexible structure designs, materials, power electronics, controls, acoustics, testing, turbulence, small wind power application development, etc.

ii. **Research facilities:**
NREL's National Wind Technology Center in Golden, Colorado

iii. **Selected Publications:**

1. McGowan, J., J. Manwell, C. Avelar, "Status and Modeling Improvements of Hybrid Wind/PV/Diesel Power Systems for Brazilian Applications," *AWEA Windpower '97 proceedings*, page 201 (1997).

2. Barley, D.; D. Lew, L. Flowers, "Sizing Wind/Photovoltaics Hybrids for Households in Inner Mongolia," *AWEA Windpower '97 proceedings*, page 211 (1997).

3. Forsyth, T., "An Introduction to the Small Wind Turbine Project," *AWEA Windpower '97 proceedings*, page 231 (1997).

4. "Small Wind Energy Systems for the Homeowner," DOE/GO-10097-374, FS135, January 1997.

5. Clark, R., "Performance of small wind-electric systems for water pumping," *AWEA Windpower '94 proceedings*, page 627-634 (1994).

6. Wade, J.E.; Walker, S.N.; Baker, R.W; "Integration of Wind

Energy into the Electrical Utility System: An Overview of the Issues." DOE/BP/63406-11. Washington D.C.: U.S. Department of Energy (1994).

iv. **Standards/guidelines/protocols/software tools:**

1. HYBRID2 - The Hybrid System Simulation Model, version 1.0, June 1996, NREL/TP-440-21272.

2. IEC 1400-2 Wind turbine generator systems - Part 2: Safety of small wind turbines

v. **WWW links:**
http://www.nrel.gov
http://www.eren.doe.gov

D. **Demonstration Projects:**
Projects are widely available in the United States; contact U.S. small wind turbine manufacturers.

E. **International Activities:**
Projects are widely available internationally. In addition to the industrially developed world, countries that are most active in installing small wind turbine systems are: Mexico, Brazil, Indonesia, China, Chile, and Russia.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Natural Refrigerants in Air Conditioning and Refrigeration Equipment

A. **Description:**
The choice to move toward hydrofluorocarbons (HFCs) rather than "natural" refrigerants in the U.S. is strongly influenced by regulatory and legal obstacles rather than technical factors. Natural fluids, such as ammonia and hydrocarbon refrigerants, are being developed in Europe for commercial and residential use but the general consensus among heating, ventilation, air-conditioning and refrigeration (HVAC/R) professionals in the U.S. and Japan is that these fluids will not be used as refrigerants in U.S. and Japanese markets for the forseeable future.

ORNL conducts integrated assessments in evaluating the environmental benefits of natural refrigerants and their liabilities. This type of analysis benefits insurance companies and others by providing them information about what they are gaining and what they are losing by choosing, or not choosing, natural refrigerants for various applications.

B. **Avoided Insurance Losses:**
The U.S. and Japanese opinion is that natural refrigerants that are toxic and/or flammable pose a significant risk of liability which is not balanced by their desireable environmental properties. Inadvertant releases of these chemicals could result in asphyxiations, fires, or explosions, resulting in insurance losses. Information from this project reduces product liability exposure for malfunctioning equipment, property losses from fire hazards, and decreases environmental hazards.

C. **Resources**

i. **Research capabilities and skills:**
Whole-building energy analysis and systems integration, building HVAC/R equipment and envelope research, alternative refrigerants development and testing, and modeling and analytical capabilities.

ii. **Research facilities:**
Roof Climate simulator, large-scale wall calibrated hot box, HVAC system and appliance enviromental chambers, heat exchanger test facility/calorimenter, water-to-water heat pump refrigeration and air condtioning equimpent test loops, absorption heat and mass transfer loops, instrumented desiccant A/C system test loop, and corrosion test laboratory.

iii. **Selected Publications:**

1. Sand, J., S. Fischer, and V. Baxter, "Energy and Global Warming Impacts of HFC Refrigerants and Emerging Technologies," prepared for the U.S. Department of Energy (1997), available from ORNL.

2. Fairchild, P. and V. Baxter, "Ammonia Usage in Vapor Compression for Refrigeration and Air Conditioning in the United States," Workshop Proceedings Compression Systems with Natural Working Fluids.IEA Report No. HPP-AN22-1, Trondheim, Norway, October 1995.

iv. **Standards/guidelines/protocols/software tools:**

1. Uniform Mechanical Code
2. Uniform Fire Code
3. U.S. Occupational Safety and Health Adminstration Process Safety Management Standard
4. ASHRAE-15 Safety Code

5. American National Standards Institute, Inc.: ANSI/IIR-2, "Equipment Design, and Installation of Ammonia Mechanical Refrigeration Systems."

6. Southern Building Code Congress International (SBCCI) Standard Building Code.

7. Building Officials and Code Administrators (BOCA) National Building Code.

8. National Fire Prevention Association/American National Standards Institute: NFPA/ANSI 58-1989, Standard for the storage and handling of liquified petroleum gases.

9. Underwriters Laboratories: Standard UL 1995, Heating Cooling Equipment

10. Underwriters Laboratories: UL 25, Standard for meters for flammable and combustible liquids and LP gas.

11. National Fire Prevention Association: NFPA 325, Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.

12. National Fire Prevention Association: NFPA 49, Hazardous Chemical Data

13. National Fire Prevention Association: NFPA 30, Flammable and Combustible Liquids Code

v. **WWW links:**
http:/www.ornl.gov/ORNL/Enegy_Eff/btc.html

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
U.S. contributer to the International Energy Agency's Annex 22, "Vapor Compression Systems Using Natural Refrigerants."

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Utilities

I. **Technology Studied:**
Superconducting Transformers

A. **Description:**
To help U.S. industry develop high-temperature superconductivity (HTS) technology, the U.S. Department of Energy (DOE) created the Superconductivity for Electric Systems Program in 1988. Industry, in turn, is developing and commercializing electric power applications of HTS. The program combines the entrepreneurial drive of high-tech companies with the vast technological resources of DOE's national laboratories. Program activities are organized into three categories: basic research in wire and systems technologies, and applied research. Researchers in wire technology are developing HTS wire capable of carrying large currents in magnetic fields, including new "second generation" wires based on YBaCuO. Researchers, including industry partners, in systems technology are developing long-length wires and prototype components that will be integrated into complete systems. Applied research is supported through the Superconductivity Partnership Initiative (SPI) and other device-specific projects.

The SPI is designed to accelerate the introduction of HTS electric power devices to the marketplace. Teams consisting of researchers, manufacturers, systems integrators, and end users are currently designing an HTS generator, motor, and cable. SPI teams recently demonstrated a successful fault-current limiter, motor, and power cable. Other activities include a second power cable project and a transformer project. Superconducting transformers will replace oil-filled transformers.

B. **Avoided Insurance Losses:**
By replacing oil-filled transformers with superconducting transformers, there will be less liability concerns with the handling and leakage of oil, as well as problems with transformers that are cooled with oil.

Businesses may experience fewer power interruptions in the future with superconducting transformers because there may be a lower probability of interrupted service with the elimination of the conventional paper-and-oil insulation system. Conventional transformers experience loss of service life when overloaded for even short periods of high electricity demand. In some cases, the result is a fire and destruction of the transformer. "Supertransformers" are expected to be completely fireproof, as they will be cooled with benign nitrogen or helium gas.

C. **Resources**

i. **Research capabilities and skills:**
Materials synthesis and properties of HTS; cryogenics research and development; superconductor stability and alternating current losses; electric machines and drives laboratory; and cable testing.

ii. **Research facilities:**

1. Physical properties measurements laboratories
2. High temperature superconductivity materials laboratory
3. Pulsed laser and electron beam deposition facilities
4. Superconducting cable test facility
5. Cryogenic dielectrics research laboratory
6. High temperature materials laboratory

iii. **Selected Publications:**

1. Mehta, S., N. Aversa, and M. Walker, "Transforming Transformers," *IEEE Spectrum*, 34(7):43-49 (1997). Other superconductivity articles appear in pp. 18-42.

2. Matzdorf, C., J. Daley, and R. George, "Superconductivity - an electrical efficiency resource for the 21st Century," *Sustainable Energy Industry Journal*, Issue 3, 2(1):12-13 (1997).

3. Yurek, G., "Superconductors: The Growth of a New Industry," *Superconductor Industry*, Spring 1997.

4. Daley, J. and C. Platt, "The DOE's Superconductivity Partnerships," *Superconductor Industry*, Spring 1997.

5. Hawsey, R. and D. Peterson, "Coated Conductors: The Next Generation of High-Tc Wires," *Superconductor Industry*, Fall 1996.

6. Sweet, W., "Power and Energy," *IEEE Spectrum*, 34(1):38-42 (1997).

7. Blaugher, R., "Superconducting Electric Power Applications," *Adv. Cryo. Eng.*, L. Summers, ed., Vol. 2, pp. 883-898, Plenum Press, NY, 1996.

8. Sweet, W., "Superconductors Heat Up," *Mech. Eng.*, 118(6):58-64 (1996).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.ornl.gov/HTSC/htsc.html

http://www.eren.doe.gov/superconductivity/

D. **Demonstration Projects:**

1. Fault current controller, Lockheed Martin Corporation

2. Transmission cable, Pirelli Corporation

3. Transmission cable, Southwire Company

4. Power transformer, Waukesha Electric Systems

5. Electric motor, Rockwell Automation

E. **International Activities:**
Implementing Agreement for a Cooperative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector, International Energy Agency.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
CFC-Free Thermal Insulation

A. **Description:**
Advanced thermal insulations are being developed for use in appliances and building envelopes. These include evacuated panel superinsulations, non-HCFC-blown plastic foam insulations, and insulations for retrofit of existing cavity walls. A consumer-oriented Fact Sheet on insulation has been developed and published.

B. **Avoided Insurance Losses:**
The replacement of chlorofluorocarbons (CFCs) by advanced thermal insulation will reduce potential liability claims related to the handling and/or leakage of CFCs in buildings, as well as any health claims related to poor indoor air quality. Workers compensation claims and professional liability claims will be reduced.

C. **Resources**

i. **Research capabilities and skills:**
Knowledge of physics of heat and mass flow through insulation materials. Thermal measurements; mathematical/computer modeling.

ii. **Research facilities:**

1. Heat flow meter apparatuses
2. Apparatuses for measuring total hemispherical emittance, air-flow permeability through permeable insulations, coefficients of gas diffusion through closed-cell foams, permeance of gases through plastic films
3. Equipment for producing prototype evacuated panel insulations
4. Air-jet grinding mill

iii. **Selected Publications:**

1. DOE Insulation Fact Sheet (see http://www.ornl.gov/roofs+walls)
2. Wilkes, K., D. Yarbrough, and F. Weaver, "Aging of Polyurethane Foam Insulation in Simulated Refrigerator Walls," International Conference on Ozone Protection Technologies, pp. 253-262, November 1997.

iv. **Standards/guidelines/protocols/software tools:**

1. ASTM C 1114, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus
2. ASTM C 1303, Standard Test Method for Estimating the Long-Term Change in the Thermal Resistance of Unfaced Rigid Closed Cell Plastic Foams by Slicing and Scaling Under Controlled Laboratory Conditions

v. **WWW links:**

1. http://www.ms.ornl.gov/cimtech.html
2. http://www.ornl.gov/roofs+walls
3. http://www/eren.doe.gov

D. **Demonstration Projects:**
Demonstration of foam-in-place retrofit insulation for existing cavity walls being performed under subcontract with Steven Winter Associates.

E. **International Activities:**

None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Industry

I. **Technology Studied:**
Explosion Prevention Technology

A. **Description:**
The world-wide metals casting industry (including aluminum, steel, etc.) encounter metal-water explosive events ranging from minor pops to devastating explosions which can lead to loss of lives, serious injuries, significant downtimes, and widespread destruction of plant and equipment. Based primarily on empirical tests conducted over the past 50 years, the aluminum industry has found that certain organic coatings, when applied to vulnerable water-covered surfaces, would tend to prevent the onset of melt-water explosions. As a result, it is common practice in the aluminum industry to coat sensitive locations in the casting pit with coatings such as Tarset Standard (a coal-tar epoxy which has been the most popular paint) or others such as Wisechem (a solid epoxy). Currently, due to environmental and other reasons, the Tarset Standard is no longer available on the market. Despite 50 years of empirical testing, the industry does not have an understanding on why certain paints provide protection, or under what conditions

they will not provide protection.

A cooperative research and development agreement (CRADA) was initiated between Oak Ridge National Laboratory (ORNL) and The Aluminum Association to evaluate: (1) why certain coatings prevent explosions; (2) under what conditions, and to what extent, will these coatings provide such protection; and (3) if it is possible to develop a physics-based, environmentally-friendly, lower-cost alternative to the present approach, whereby pit walls are coated with toxic coatings that need periodic inspection.

The technology developed at ORNL has the potential for dispensing with the use of coatings for sensitive surfaces. Energy savings will be achieved by avoiding energy expenditures in manufacturing and application of coatings. Furthermore, by reducing explosions, this technology will also save energy used in the rebuilding of the infrastructure after an explosion.

B. **Avoided Insurance Losses:**
The aluminum industry has experienced over 1,000 explosions in the past 10 years, of which about 400 resulted during casting operations. Prevention of explosions that can lead to loss of lives, serious injuries, significant downtimes, and widespread destruction of plant and equipment. By reducing the risk of fire hazard and property damage as well as injury to people, this technology reduces the general liability exposure and product liability claims.

C. **Resources**

i. **Research capabilities and skills:**
ORNL possesses considerable skills and capabilities (developed over 40 years) for investigating fundamental and practically focused phenomena related to complex interactions between thermal-hydraulics, chemistry and material sciences that are relevant to answering the key questions in this research project.

ii. **Research facilities:**
The steam explosion triggering studies (SETS) facility was developed to provide a means for testing various coated and uncoated surfaces for their ability to prevent or initiate steam explosions. This facility permits (at vastly reduced cost) the study of the initiation process without attendant safety issues involved with conventional means.

iii. **Selected Publications:**

1. Taleyarkhan, R., V. Georgevich, and L. Nelson, "Fundamental Experimentation and Theoretical Modeling for Prevention of Molten Aluminum-Water Steam Explosions in Casting Pits," *Light*

Metal Age Journal, pp. 26-35, June 1997.

2. Taleyarkhan, R., "Fundamental Insights & Novel Technology for Melt-Water Explosion Prevention - A Project Overview," *Journal of Metals*, forthcoming, 1998.

3. Taleyarkhan, R., S. Kim, and K. Gulec, "Fundamental Insights on Impact of Non-Condensible Gas Evolution from Coating Pyrolysis & Intentional Injection on Molten-Metal Water Explosion Onset," Amercian Foundrymen's Society, 1998 Casting Congress, Atlanta, GA May 1998 (submitted).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.ornl.gov

D. **Demonstration Projects:**
The SETS facility has been used for demonstrating effectiveness of various coatings and explosion prevention measures. Live demonstrations are held with industry partners about once every 6 months.

E. **International Activities:**
The current partnership with The Aluminum Association involves aluminum producers from all over the world.

F. **Future Projects:**
A continuation of the existing CRADA with The Aluminum Association is planned to investigate the impact of curing times for various coatings currently used in casting pits, as well as to investigate impacts of bare spots and intentional gas injection in field tests.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
The current research work related to explosion prevention in the aluminum industry has broad applications for other industries also, since the fundamental mechanisms involved in vapor explosion onset and prevention are very similar. Specifically, the technology and insights developed may be useful for prevention of vapor explosions in the steel, magnesium and pulp/paper industries. The implementation of prevention technologies could possibly allow these industries to obtain reasonably cost-effective insurance coverage from their insurance companies.

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Sector:
Buildings

I. **Technology Studied:**
Wind Resistant Building Envelopes

A. **Description:**
This project is a Cooperative Research and Development Agreement (CRADA) with the Roofing Industry Committee on Wind Issues (RICOWI) to investigate the durablity of residential and commercial roofing systems after a major wind event strikes the continental U.S. Eighty industry roofing professonals will assess failure mechanisms of roofing systems after a 95+ miles per hour (mph) hurricane strikes and will determine whether energy-efficient roofing is more or less durable than roofing that is less energy efficient (i.e., does energy efficiency compromise durability?).

B. **Avoided Insurance Losses:**
This technology reduces property losses to residences and businesses. The Institute for Business and Home Safety (formerly known as the Insurance Institute for Property Loss Reduction, IIPLR) estimates $10 billion per year lost due to major wind storms. A significant percentage (1/3?) could be saved if roofs are

improved such that they would continue to protect contents from damage.

C. **Resources**

i. **Research capabilities and skills:**
The CRADA has enlisted 80 top U.S. roofing profesionals ranging from contractors, roofing consultants, systems and material suppliers and academia to participate in the data gathering exercises.

ii. **Research facilities:**
This project is a field survey; no in-house research facilities are being used.

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
A data base of field observations will be created after field investigations are completed.

v. **WWW links:**
None currently.

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
Members of the Institute for Business and Home Safety, State Farm Insurance, Chubb Insurance, and several insurance "consultants" are members of our investigative teams.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Durable Roof Coating Materials

A. **Description:**
This project is a Cooperative Research and Development Agreement (CRADA) with the Roof Coatings Manufacturers Association to measure energy efficiency and durability of roof coating materials. Twenty-four different roof coatings have been applied to several different roofing membranes and exposed to East Tennessee weather. This project will continuously measure energy flow through the roof systems and will periodically measure surface properties. The measured data will then be used as input for subsequent modelling activities regarding the energy efficiency of roof coatings and their impact on membrane service life.

B. **Avoided Insurance Losses:**
Light-colored roof coatings will decrease membrane temperatures, and it is anticipated that this decrease will increase membrane life, leading to longer lasting roofs, and resulting in reduced insurance losses due to business interruptions from installing a new roof. Light-colored coatings used in urban

areas may also lead to reductions in air temperatures resulting in improved air quality and reducing the frequencies of urban heat catastrophes.

C. **Resources**

i. **Research capabilities and skills:**
Staff members have been involved in the development of in-situ experiments on roofing systems for over 15 years. These experts are very familiar with energy modelling of roof systems as well as whole building modelling.

ii. **Research facilities:**
The Roof Thermal Research Apparatus (RTRA) at ORNL is utilized to expose samples of roof coatings to the environment and to simulate actual applications. The RTRA has substantial data acquisition capabilities, including energy, temperature, load, and meteorological sensors.

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
Modifications to "STAR" (Simple Thermal Analysis of Roofs) will be incorporated to deal with time dependence of surface properties.

v. **WWW links:**
None currently.

D. **Demonstration Projects:**
Demonstration buildings on the ORNL campus and a reroofing demonstration project in southwest Virginia incorporate light-colored roofing materials.

E. **International Activities:**
None currently.

F. **Future Projects:**
A similar project examining light-colored single-ply membranes is planned for FY 98.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Hybrid Lighting

A. **Description:**
Lighting is one of the largest electrical loads in commercial buildings. The use of daylighting as a source of illumination can displace up to 70% of the lighting energy requirements in a typical office building. Bringing daylight into the office space also has other benefits: several studies suggest that office workers in daylit offices are more productive and take fewer sick days off.

Hybrid lighting combines natural daylighting and electric lighting into integrated "hybrid" lighting systems that better utilize sunlight during mid-day peak loading periods.

B. **Avoided Insurance Losses:**
Daylighting may lead to increased productivity and reduced sickness from building-related ailments, resulting in a corresponding reduction in professional liability, workers compensation, and health insurance claims due to poor indoor environment. Incorporating daylighting into a buildings lighting strategy helps

ensure that at least some natural light is available during power service failures, with corresponding safety benefits and reduced service interruptions. As we transition from a society dominated by localized electric lights to fewer centralized lamps integrated with daylighting systems, hybrid lighting will reduce by a factor of 3 or more the amount of electrical wiring needed to light those areas. Less wiring should translate into less electrical and fire hazards.

C. **Resources**

i. **Research capabilities and skills:**
Optical materials, thin films & coating, optical system design, advanced manufacturing processes, sensors ans controls, sunlight collection and tracking, etc.

ii. **Research facilities:**

1. ORNL: optical materials & characterization labs, fiber optics R&D labs, Center of Manufacturing Technology, sensors/controls labs, etc.

2. LBNL: lighting research labs

3. Industry/university labs

iii. **Selected Publications:**
None currently.

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.ornl.gov
http://eande.lbl.gov/BTP

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Analysis of the amount of electrical wiring reduced by the use of hybrid lighting

(i.e., fewer centralized lamps integrated with passive day/sunlight systems), and an analysis of the relationship between reduced wiring and frequency of electrical and fire hazards.

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Sector:
Buildings

I. **Technology Studied:**
Cool Storage Systems

A. **Description:**
Cool storage systems are being used primarily in commercial buildings to shift the cooling load of a building to offpeak periods during the day. Simply put, stored water is chilled or frozen during offpeak periods (usually at night) by one or more chillers, and the stored "cool" is used to supplement the cooling need of the building the next day. This reduces onpeak electrical demand which must be met by the electrical utility and reduces air-conditioning operating costs to the building owner/operator by reducing costs associated with the demand component and on-peak energy costs of the electrical utility tariff. Cool storage systems may number about 1500 in the U.S., and the cool storage industry is probably about $30 million annually.

B. **Avoided Insurance Losses:**
One advantage of cool storage is its ability to provide air conditioning (partially or wholly) to a building based on the "coolth" which has been stored from the previous off-peak period (usually the previous night). This means that if a

building's chiller or refrigeration system were to fail (i.e., service interruption), the storage system could provide probably 8 - 10 hours of air conditioning without chiller operation, and this would provide time for the chiller to be repaired or for alternative cooling arrangements to be completed. There would be little to no loss of utility of the building and any losses associated with building operation might be avoided. The stored water can also be used for firefighting.

C. **Resources**

i. **Research capabilities and skills:**
System studies and detailed risk analyses.

ii. **Research facilities:**
ORNL has a cool storage test facility.

iii. **Selected Publications:**
Tomlinson, J. and L. Jennings, "Ice Storage Rooftop Retrofit for Rooftop Air Conditioning," Oak Ridge National Laboratory Report ORNL/CON-451, Sept. 1997.

iv. **Standards/guidelines/protocols/software tools:**
Cool Storage Design Tools are available from ASHRAE and the Electric Power Research Institute (EPRI).

Information on cool storage systems is available through the University of Wisconsin's Thermal Storage Advisory Research Center.

v. **WWW links:**
http://www.ornl.gov

D. **Demonstration Projects:**
There are cool storage projects in nearly every state; contacts with local utility would help to identify sites to visit.

E. **International Activities:**
Cool storage projects have been studied under Annexes of the International Energy Agency with the U.S. DOE as a partner; cool storage systems are also in most major industrialized countries.

F. **Future Projects:**
Assistance to energy services companies (ESCOs) to make information on cool storage available, so that ESCOs can make informed decisions regarding implementation of cool storage.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
High-Efficiency Clothes Washers

A. **Description:**
Appliances and fixtures that use very small amounts of water have been developed and are being commercialized. In particular, high-efficiency clothes washers that tumble clothing about a horizontal axis have been shown to require 40% less water than does the conventional vertical axis type washer. Based on the U.S. average of 416 wash loads per year per machine and an average water savings of 15 gallons per load, a household will save more than 6,000 gallons of drinking water annually, the water supplier will need to provide less water, and there will be a reduced impact on sewage treatment systems in a community where these high-efficiency appliances are prevalent.

B. **Avoided Insurance Losses:**
By reducing the amount of waste water needed to be treated by a community's water treatment facility, high-efficiency clothes washers reduce the risk that drinking water produced from treated waste water will not be safe particularly in

cases where the sewage treatment plant is at capacity and further loads on the plant are passed into a nearby river or stream and could affect downstream communities. The fact that these washers require less water may also be important in locations where fresh water is from surface reservoirs or aquifers which are at the limits of acceptable drawdown. Saltwater intrusion in fresh water supplies or simply the unavailability of water from seasonal droughts may present risks to insurers which could be avoided through implementation of water conserving technologies such as the h-axis clothes washer.

C. **Resources**

i. **Research capabilities and skills:**
ORNL is engaged in several field studies of h-axis, high-efficiency clothes washers and has developed special instrumentation, which can be used by utilities, and others interested in further field evaluation projects.

ii. **Research facilities:**
None at ORNL, but A. D. Little (Cambridge, MA) has done clothes washer laboratory testing according to DOE Test Procedures.

iii. **Selected Publications:**
Tomlinson, J. and D. Rizy, "Bern Clothes Washer Study," draft report prepared by Oak Ridge National Laboratory, forthcoming.

iv. **Standards/guidelines/protocols/software tools:**
Clothes Washer Test Protocol and DOE Test Procedure in Code of Federal Regulations

v. **WWW links:**
http://www.energystar.gov

D. **Demonstration Projects:**
Bern, Kansas in which entire community replaced existing clothes washers with h-axis model; Seattle Water Department; and Pacific Gas and Electric Company.

E. **International Activities:**
Some in individual European countries where h-axis washers are commonplace.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: ORNL-10

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Sector:
Buildings

I. **Technology Studied:**
Building Commissioning

A. **Description:**
Ideally, commissioning is a systematic process (beginning in the design phase, lasting at least one year after project close-out, and including the training of operating staff) of ensuring, through documented verification, that all building systems perform interactively according to the documented design intent and the owner's operational needs. Commissioning does not have to be linked to new installations and capital improvements. Existing equipment can be commissioned to ensure that it operates optimally and meets the building owner's and occupant's current needs.

B. **Avoided Insurance Losses:**
Building commissioning will help reduce insurance losses filed under workers compensation, professional liability insurance, product liability insurance, and

commercial property insurance.

Building commissioning can help avoid insurance losses in more than one way. First, it provides documented verification of a building's performance and operation. Commissioning process can include testing of outside-air flow rates, a primary factor affecting indoor air quality. If an existing building has deficiencies, the commissioning authority also records the repairs made. Commissioning should be repeated throughout the life of a building, and performance documentation should be updated regularly. This documentation provides owners (and design professionals if they remain involved in the commissioning process over time) with a record of building performance that can be used as evidence in the event of a lawsuit.

Commissioning also helps prevent many indoor air quality problems through its focus on training building operators in the proper maintenance of building systems. Properly run and maintained HVAC systems, with clean coils and air intakes and regularly-changed filters, are less likely to contribute to indoor air quality problems. In addition, trained operators can spot potential air quality and ventilation problems before they develop.

C. **Resources**

i. **Research capabilities and skills:**

1. Policy development and collaboration to promote the adoption of building commissioning practices throughout the United States.

2. Market research and informational material development, including developing, implementing and analyzing market research surveys and developing information materials for distribution to all segments of the potential and existing commissioning market.

3. Developing protocols, guidelines and specifications that can be used to define and standardize commissioning processes.

4. Commissioning implementation and pilot research projects.

5. Professional commissioning training/workshops.

ii. **Research facilities:**
Case study database, library of commissioning publications and tools.

iii. **Selected Publications:**

1. Bonneville Power Administration/PECI, *Building Commissioning Guidelines*, PECI, Portland, OR., 1992.

2. Florida Power & Light/PECI, *Commissioning for Better Buildings*, PECI, Portland, OR., 1996.

3. Oregon Office of Energy/PECI, *Commissioning for Better Buildings in Oregon*, PECI, Portland, OR., 1997.

4. USDOE/PECI, *Model Commissioning Plan and Guide Specifications*, PECI, Portland, OR., 1997.

5. PECI, *Proceedings of the National Conferences on Building Commissioning*, PECI, Portland, OR., 1993-1997.

iv. **Standards/guidelines/protocols/software tools:**
Commissioning Existing Buildings, sponsored by USDOE (ORNL), expected to be completed in Spring 1998.

v. **WWW links:**
http://www.peci.org
http://www.ornl.gov

D. **Demonstration Projects:**
Under a joint DOE/EPA grant, PECI demonstrated that significant savings can be obtained through tuning up (commissioning) existing buildings. The demonstration involved performing and evaluating the tune-up process on five existing commercial buildings located across the United States.

PECI is leading a project for the USDOE Seattle Regional Support Office that involves commissioning and tuning the HVAC and control systems in a 152,000 sf GSA-owned, historic federal office building in Seattle, Washington. PECI developed boilerplate commissioning plans and procedures for this project that can be applied to future projects. Due to the positive results of these commissioning efforts, PECI will commission two additional existing GSA buildings in the Northwest.

PECI assessed and commissioned the Chattanooga State Office Building in Tennessee to demonstrate the benefits of existing building commissioning for the state. Based on the results of this demonstration, Tennessee has asked PECI to develop a program for tuning up 135 existing state facilities.

PECI led a project for Southern California Edison to identify whether common building commissioning practices can be improved. The project involved surveys of commissioning service providers, on-site assessments of over 50 buildings, and the commissioning of seven buildings. The project was a groundbreaking effort to obtain data regarding the costs and savings attributable to commissioning commercial buildings.

E. **International Activities:**
None currently.

F. **Future Projects:**
PECI is currently writing a guideline—sponsored by ORNL—for commissioning existing buildings. The guideline is expected to be completed in Spring 1998.

G. **Collaborations with Insurance Industry:**
PECI conducted a telephone survey and two focused discussion groups with DPIC policyholders to assess policyholder knowledge of and attitudes regarding building commissioning.

In addition, DPIC was one of a group of sponsors (including USDOE FEMP) of PECI's 1996-97 commissioning case study collection, database development and analysis, and resulting marketing brochure, "What Can Commissioning Do for Your Building?". PECI and DPIC are currently collaborating on a paper for the 1998 ACEEE Summer Study on commissioning as a loss prevention strategy.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Industry

I. **Technology Studied:**
Refractories in Glass Production Furnaces

A. **Description:**
Glass manufacturers are being challenged more than ever to improve designs of existing and future glass production furnaces in order to maximize production while minimizing the output of environmental pollutants and emissions. This can be achieved through optimum engineering design of furnaces and the refractory superstructures comprising them. A primary factor limiting this is the availability of engineering data which describes the high temperature deformation of these or alternative refractory materials.

This project is performing high temperature mechanical tests on candidate refractory materials for glass production furnaces. The data will be used by designers of glass furnaces to optimize their furnace designs.

The high temperature mechanical performance of competing refractory materials are being generated to 1700°C. Commercially available refractories are being

tested including silica, alumina, mullite, alumina-silicate-zirconia. Chosen stresses and temperatures bracket those which the refractory superstructures are subjected to during furnace operation. The generated data meet two objectives: allows the identification of superior refractory grades to occur and generates engineering data for design purposes.

B. **Avoided Insurance Losses:**
Oxy-fuels fired furnaces are much more cost effective than conventional or electric furnaces. In addition NOx emissions are an order of magnitude less and the output of particulates is also much lower. However, these furnaces operate at much higher temperatures and experience higher rates of creep and corrosion. Improved refractories which are creep and corrosion resistant will enable designers to optimize furnace superstructures for maximum service life, energy-efficient operation, reduced emissions, and minimized down time, thereby avoiding business interruptions (typical downtime for specialty, fiber and container glass ranges from 1-2 months). Product liability and professional liability insurance losses will also be reduced.

C. **Resources**

i. **Research capabilities and skills:**

1. Expertise in high temperature mechanical testing and analysis of ceramic and refractory materials, and creep analysis.

2. Researchers have capabilities and experience in applied mechanical testing, finite element analysis, fractography and failure analysis, and probabilistic design of ceramic and brittle materials.

ii. **Research facilities:**

1. Refractory creep testing facilities to 1700°C

2. Modulus of elasticity and extensometry capabilities to 1700°C

3. Catholuminescence imaging (via subcontract with UM-Rolla)

iii. **Selected Publications:**
Presentation: "High Temperature Mechanical Properties and Corrosion Resistance of Refractories," 2nd Industrial Energy Efficiency Expo, Arlington, Virginia, February 27, 1997

iv. **Standards/guidelines/protocols/software tools:**
None.

v. **WWW links:**

http://www.ornl.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Industry

I. **Technology Studied:**
Recovery Boilers in Pulp and Paper Mills

A. **Description:**
Black liquor recovery boilers are essential components of kraft pulp and paper mills because they are a crucial part of the system used to recover the pulping chemicals required in the kraft pulping process. In addition, the steam produced by these boilers is used to generate a significant portion of the electrical power used in the mill. Recovery boilers require the largest capital investment of any individual component of a paper mill, and these boilers are a major source of material problems in a mill. The walls and floors of these boilers are constructed of tube panels that circulate high pressure water. Molten salts (smelt) are present on the floor of recovery boilers, and leakage of water into the boiler can result in a violent explosion when the leaked water instantly vaporizes upon contacting the molten smelt. Tube leaks, sometimes leading to such explosions, have occurred with some regularity in the paper industry.

Because corrosion of the conventionally-used carbon steel tubing was found to be

excessive in the lower section of recovery boilers, use of stainless steel/carbon steel co-extruded tubing was adopted for boiler walls to lessen corrosion and reduce the likelihood of smelt/water explosions. Eventually, this co-extruded or composite (as it is known in the industry) tubing was selected for use as a portion or all of the floor of recovery boilers, particularly those operating at pressures greater than 6.2 MPa (900 psi), because of the corrosion problems encountered in carbon steel floor tubes.

However, cracking into, or through, the stainless steel outer layer of this composite tubing was subsequently encountered. Almost without exception in sloped-floor boilers, cracks have first been seen in wall tubes that form the openings for removal of the molten salts (smelt spout openings). Subsequently, cracks have been found in floor tube membranes and eventually in floor tubes themselves in both sloped-floor and flat-floor types of boilers.

Since neither the cause of the cracking nor an effective solution has been identified, this program was established to develop a thorough understanding of the degradation that occurs in the composite tubing used for walls and floors. This is being accomplished through a program that includes collection and review of technical reports, examination of unexposed and cracked tubes from boiler floors, collection and analysis of smelt samples, collection and tabulation of temperature data, measurement of residual stresses in as-produced, as-formed, and exposed composite tubing, computer modeling to predict residual stresses under operating conditions, and operation of laboratory tests to study corrosion, stress corrosion cracking, and thermal fatigue. From this work it is anticipated that alternate materials or operating procedures will be identified, and these will be tested in recovery boilers.

B. **Avoided Insurance Losses:**

The financial cost to paper companies resulting from recovery boiler material problems is enormous due to maintenance costs and the value of lost production (i.e., business interruption). Identification of alternate materials, process changes and/or modifications of operating conditions should lessen or eliminate the financial burden. In addition improved materials and operating procedures will lessen the potential for explosions and the attendant liabilities.

C. **Resources**

i. **Research capabilities and skills:**

ii. **Research facilities:**

1. Transmissions electron microscopy facilities
2. Neutron and X-ray residual stress facilities

3. Parallel computing facilities for finate element modeling
4. Thermal mechanical fatigue facilities
5. Corrosion laboratory

iii. **Selected Publications:**
Keiser, J. R., B. Taljat, X.-L. Wang, P. J. Maziasz, C. R. Hubbard, R. W. Swindeman, D. L. Singbeil, and R. Prescott, "Analysis of Composite Tube Cracking in Recovery Boiler Floors," *Proceeding of 1996 TAPPI Engineering Conference*, 693 (1996).

iv. **Standards/guidelines/protocols/software tools:**
None.

v. **WWW links:**

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently

F. **Future Projects:**
None currently

G. **Collaborations with Insurance Industry:**
None currently

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: ORNL-13

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Sector:
Buildings

I. **Technology Studied:**
Geographic Information Systems for Targeting Loss-Prevention Measures

A. **Description:**
Geographic Information Systems (GIS) can be applied to a wide range of database development and subsequent data analysis problems. In particular, GIS provides the ability to overlay two or more different types of data on top of one another to measure the spatial coincidence as well as the spatial and temporal spread of different phenomena. Additional benefits of automated GIS are the ability to zoom into different parts of a region to abstract data, and the ability to aggregate data to support analysis at more than one level of spatial resolution. Primary and secondary sources of GIS data are as diverse as satellite imagery, global

positional tracking systems (GPS) and aerial photography, as well as electronic and paper maps at various levels of resolution and coverage. By embedding GIS functions within Spatial Decision Support Systems that tie geographic data to problem-specific analytical tools, rapid "what if" analyses can be carried out within highly visual software environments.

B. **Avoided Insurance Losses:**
GIS technologies can help insurers analyze policyholder data bases, assess geographic concentrations, and assess risk profiles in personal and commercial insurance lines. Examples include risk of water pipe damage, ice dam formation, and insufficiently insulated roofs.

C. **Resources**

i. **Research capabilities and skills:**
ORNL has extensive experience with GIS for many purposes, including applications in transportation systems, in air, ground, and water quality-based environmental impacts studies, climate studies, land use mapping and monitoring, emergency planning and management, and facilities research. The laboratory has been involved in GIS development and applications for over 25 years. A recently published book on the history of GIS has a chapter devoted exclusively to summarizing ORNL's GIS capabilities and contributions over a quarter century. ORNL staff are also active in the development of spatial data standards. This includes work on spatial data transfer protocols for real time, "intelligent" transportation systems. ORNL is also an actively participating member in the University Consortium for Geographic Information Science. Considerable on-site expertise exists in the design and manipulation of large, multi-attribute, spatial data bases, notably for use by federal government agencies. This expertise includes the development of point, line, and area-based data sets in land use, transportation, and in air quality and water quality studies. ORNL has also developed a wide variety of administrative and jurisdictional boundary data sets. For a number of years, ORNL staff have played a key role in assisting the US Department of Transportation in the design, development, and use of its multi-modal network, facility, and boundary-based National Transportation Atlas database Applications of GIS cover a wide range of policy-relevant studies. This includes widely disseminated research findings into, among other things, the environmental effects of acid precipitation, coastal land cover change for the Chesapeake Bay, projected water consumption by energy facilities in the Ohio River Basin, global airlift scheduling for military contingencies,

mapping the re-designation of the National Highway System, and the areal extent and potential ecological impacts of deforestation in the Amazon basin (see publications).

ii. **Research facilities:**
GIS research and development activities are carried out by different groups located within the Energy, Computational Physics and Engineering, and Environmental Sciences Divisions at ORNL. Each group has laboratory as well as office space dedicated to GIS hardware and software operations. Hardware platforms include SUN SPARC and Apple workstations and Windows-based PCs. Various devices for printing and plotting color maps, both large and small, are available. Various commercial GIS softwares are in use (e.g. ARC/Info, Intergraph, MapInfo, GisPlus/Transcad, AutoCAD). ORNL staff also develop in-house GIS code when required for project specific applications, working with both vector - and raster-based systems.

iii. **Selected Publications:**

1. Dale, V.H., F. Southworth, R.V. O'Neill, A Rosen and R. Frohn (1993), "Simulating spatial patterns of land use change in Rondonia, Brazil." *Lectures on Mathematics in The Life Sciences*, Vol 23:29-55.

2. Dobson, J.E. and R.C. Durfee (1997), "A Quarter Century of GIS at Oak Ridge National Laboratory," Chapter 13 in *The History of Geographic Information Systems: Perspectives from the Pioneers*. Foresman, T.W. (Ed.), Prentice Hall, New Jersey.

3. Dobson, J,.E. (1993), "A Conceptual Framework for Integrating Remote Sensing, GIS, and Geography," *Photogrammetric Engineering and Remote Sensing* 59(10): 1491-1496.

4. Dobson, J.E. (1991), "Coastal Watch - Detecting Change in Coastal Wetlands," *Geo Info Systems* 1: 36-40.

5. Dobson, J.E., R.M. Rush, and R.W. Peplies (1990), "Forest Blowdown and Lake Acidification," *Annals of the Association of American Geographers* 80(3):343-361.

6. Durfee, R.C., R.A. McCord, and J.K. Thomas (1992), "GIS Applications in Environmental Restoration at Federal Facilities," *1993 International GIS Sourcebook*, Fort Collins, CO: GIS

World.Inc.

7. Huntsaker, C.T. and D.A. Levine (1995), "Hierarchical Approaches to the Study of Water Quality in Rivers," *BioScience* 45:193-203.

8. O'Neill, R.V., C.T. Huntsaker et al. (1997). "Monitoring Environmental Quality at the Landscape Scale," *BioScience* 47:513-519.

9. Southworth.F. (1997). *Development of Data and Analysis Tools in Support of A National Intermodal Network Analysis Capability.* Bureau of Transportation Statistics, U.S. Department of Transportation, Washington D.C. January, 1997. (Also accessible at www.bts.gov/gis/reference/develop/develop.html).

10. Southworth, F., D. Xiong and D. Middendorf (1997), "Development of Analytic Intermodal Freight Networks for Use Within a GIS, *Proceedings of the GIS-T 97 Symposium.* American Association of State Highway and Transportation Officials Conference, pp. 201-218.

11. Xiong, D. and S. Gordon, (1995), "Data Structure and Information Coding for ITS Locational Referencing," *Proceedings of the GIS-T 95 Symposium*, American Association of State Highway and Transportation Officials Conference, p. 165-177.

iv. **Standards/guidelines/protocols/software tools:**
None.

v. **WWW links:**
A number of ORNL-developed world wide web sites now display GIS products. For example:

1. The Carbon Dioxide Information Analysis Center site at http://cdiac.esd.ornl.gov/cdiac/about/intro.html

2. The National Intelligent Transportation Systems Architecture Deployment site at http://itsdeployment.ed.ornl.gov

D. **Demonstration Projects:**
None currently.

E. **International Activities:**

None currently.

F. **Future Projects:**
Many projects; contact Frank Southworth for details.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Industry

I. **Technology Studied:**
Efficient Motor-Driven Systems

A. **Description:**
Motor-driven applications represent the largest industrial use of electricity. In the United States, there is an installed base of some 20 million industrial motors and drives. Many opportunities exist for efficiency improvements such as energy efficient motors, adjustable speed drives, and process optimization. The largest potential for improvement is in the systems approach where the components are selected to optimize performance with respect to the system delivery need.

Performance validation for projects performed by industry and projects completed by ORNL have demonstrated energy reductions of 40% and more. In some cases, the savings are obtained with no capital expenditure. In all cases the payback period is less than two years and is frequently less than one year.

Many other benefits accrue from energy efficiency gains. Productivity increases have been noted, and equipment reliability increases because the wasted energy,

which caused excessive wear in the machinery, is used productively. Thus less maintenance is required and unscheduled downtime (i.e., business interruption) is avoided. In addition, noise level decreases in work areas have been noted. These decreases have resulted in areas no longer requiring ear protection for workers.

B. **Avoided Insurance Losses:**
Reduced unscheduled downtime (i.e., business interruption) due to greater system reliability. Lower losses result in equipment running cooler and reduces the risk of fire. Reduction of noise levels reduces potential health impacts on workers in the area. Thus, this technology reduces the following insurance losses: Comprehensive General Liability (by reduced number of fires), Health/Life (smoke purging/fire damage reduction), Workers Compensation (industrial safety benefits), and Boiler & Machinery (prevention of single-phasing).

C. **Resources**

i. **Research capabilities and skills:**
Expertise in identifying energy-efficiency opportunities and teaching industrial personnel how to identify those opportunities. Expertise in advanced motors, drives, and pumps.

ii. **Research facilities:**
Motor testing laboratory (NAVLAP) accredited for motor tests up to 500 horsepower. Power electronics laboratory for development of advanced power electronics and motors.

iii. **Selected Publications:**
None.

iv. **Standards/guidelines/protocols/software tools:**
Pump system prescreening tools to prioritize systems that merit further analysis. ORMEL software to estimate motor efficiency and load while in service. Pump system analysis tool to determine if pump system should be improved. Training courses in pump system optimization.

v. **WWW links:**

D. **Demonstration Projects:**
Currently managing 30 Showcase demonstration projects throughout the country.

E. **International Activities:**
Pump system training completed for New Zealand. Training sessions being scheduled in South Africa and the Phillippines.

F. **Future Projects:**
Additional Showcase projects will be initiated.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
To achieve more efficient operation of motor-driven systems in industry, the insurance industry could support a training initiative and development of system diagnostic and analysis tools that would assist industrial personnel in evaluating their systems and taking cost-effective steps to improve them. Training of design and operating personnel is critical. However, the training presented to each group is different. The insurance industry could develop an approved training course for system designers and one for operators. The training could then be offered to industrial plants and as improvements are made premiums could be reduced. The insurance industry could also establish, in conjunction with appropriate technical organizations, minimum efficiency standards that would qualify reduced premiums.

Coupled with training, advanced system diagnostic and analysis tools will permit personnel to determine how efficiently their motor-driven systems are operating. To be useful these tools must be non-intrusive and be capable of performing their analysis function without disrupting the operation of the machinery.

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Sector:
Utilities

I. **Technology Studied:**
Flywheels

A. **Description:**
A flywheel power quality unit can be installed between the power source and a manufacturing facility, providing clean, uninterrupted power to the equipment in the facility. The flywheel operates continuously, storing a relatively small amount of energy which can be used when the electrical power is lost for a short period of time (seconds or minutes).

B. **Avoided Insurance Losses:**
Use of a flywheel energy storage system as a power quality unit can reduce business interruption losses and prevent damage from short-term loss of electrical power. Many businesses and industries are sensitive to loss of electrical power, even for a fraction of a second. A flywheel power quality unit can maintain consistent, uninterrupted power to the building and manufacturing equipment. If the power disruption is for a longer period of time, the flywheel power quality unit can provide power to allow a controlled shutdown of equipment.

C. **Resources**

i. **Research capabilities and skills:**
As the result of extensive development programs involving high speed rotating equipment, ORNL researchers have analytical and hardware experience in all aspects of flywheel energy storage technology. These technologies include composite materials, bearings, motor/generators, power electronics, rotor dynamics, vacuum technology, and systems integration.

ii. **Research facilities:**
Test facilities are available for safely testing large flywheels.

iii. **Selected Publications:**

iv. **Standards/guidelines/protocols/software tools:**

v. **WWW links:**

D. **Demonstration Projects:**

E. **International Activities:**

F. **Future Projects:**

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: ORNL/NREL-1

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Oak Ridge National Laboratory and National Renewable Energy Laboratory

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Sector:
Utilities

I. **Technology Studied:**
Electricity from Wood Removed from Forests to Reduce Fuel Buildup

A. **Description:**
Fire suppression has resulted in a buildup of highly flammable material (small trees, dead trees, and litter) in forests of the Sierra Nevada and Rocky Mountains. This material increases the likelihood of catastrophic fires in these areas where many homes are being built at the urban/forests interface. Flash floods in watersheds denuded of vegetation as a consequence of fire present another equally threatening risk.

This flammable material could be removed from the forests at a cost of $40 to $70/dry ton, but there is no current market for it in the forest industry sector.

However, it does have energy value. The National Renewable Energy Laboratory is investigating technologies which could use this material to produce electricity and ethanol. Oak Ridge National Laboratory is investigating the environmental consequences of removing this material from the woods. Besides reducing the environmental risks associated with fires and floods following fires, the removal of this material will have direct effects on the ecosystems and hydrology of the forest lands. More open forests will transpire less water, and snow pack conditions will change. These might increase water flows and reduce downstream drought risks. The objective of the ORNL and NREL efforts is to develop environmentally and socially acceptable means of using forest thinnings to produce ethanol and electricity while reducing fire risks.

B. **Avoided Insurance Losses:**
This technology will reduce claims related to fire, flood, and fire fighting, as well as claims related to reduced water quality or drought.

C. **Resources**

i. **Research capabilities and skills:**
NREL and ORNL lead DOE's bioenergy programs in transportation fuels and power. NREL has significant expertise in bioenergy conversion processes and has supported resource assessments in western forest regions. ORNL has experience in the integrated economic and environmental assessment of biomass resources and a long history of research in forest hydrology. Both institutions have developed working relations with the U.S. Forest Service, state and local agencies, and community groups concerned with fire problems in the West.

ii. **Research facilities:**
The Alternative Fuels User Facility at NREL includes a pilot plant for evaluating biofuels technologies and supporting laboratory facilities. ORNL and NREL have Geographic Information System facilities for doing spatial analyses.

iii. **Selected Publications:**
Graham, R., D. Huff, M. Kauffman, D. Lynch, J.Sheehan, W. Shepperd and C. Troendle. 1998. "Bioenergy and watershed restoration in the mountainous regions of the West: What are the environmental/community issues?" *Proceedings of Bioenergy '98. The Eighth National Bioenergy Conference.* Oct 4-8, Madison WI.

iv. **Standards/guidelines/protocols/software tools:**

v. **WWW links:**
http://www.ornl.esd.gov/bfdp
http://www.biofuels.nrel.gov

D. **Demonstration Projects:**
NREL and ORNL are involved with partnerships that are developing large-scale forest fuel reduction projects, most notably the Quincy Library Group in California and the Front Range Forest Health Partnership in Colorado. They are also involved in bioenergy demonstration projects sponsored by DOE and others at various locations across the country.

E. **International Activities:**
ORNL and NREL represent DOE in International Energy Agency bioenergy activities that target the use of small diameter trees for energy and fuels.

F. **Future Projects:**
NREL and ORNL are participants in proposals to the California Energy Commission to evaluate the costs and benefits of a California bioenergy industry using wood removed in forest fuel reduction projects.

G. **Collaborations with Insurance Industry:**
Through the Front Range Forest Health Partnership, NREL has provided assistance to the Wildfire Advisory Board at the Insurance Institute for Property Loss Reduction.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: ORNL/NREL-2

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Sector:
Buildings

I. **Technology Studied:**
Advanced Desiccant Air Conditioning Technology

A. **Description:**
Increased volumes of ventilation air mandated by provisions of ASHRAE Standard 62-1989, "Ventilation for Acceptable Air Quality," and recognition by the HVAC community that design "dew point" data is just as important as design dry bulb temperatures for estimating building loads have dramatically increased building latent (moisture removal) design loads and highlighted the limitations of refrigeration-based air conditioning equipment. Conventional, vapor-compression based air-conditioning equipment is poorly suited to handling this increased latent load. To dehumidify air, this equipment must first cool it below its dew point

resulting in air saturated with moisture at a temperature too cool for human comfort. Reheating this air to make it more comfortable implies an additional use of energy.

Conventional air-conditioning equipment cycles on and off in response to room temperatures, so the dehumidification and air movement it provides stops when the thermostat is satisfied. Allowing the system fans to run when the refrigeration equipment shuts down results in the introduction of unconditioned air into the building envelope and re-entrainment of moisture on the coil and in the condensate drain pan.

With desiccant air-conditioning equipment, the moisture (latent load) in outdoor ventilation air is removed by a desiccant material in a dehumidifier, and then the temperature (sensible load) of the dried process air is reduced to desired comfort conditions by conventional air-conditioning approaches, such as direct expansion refrigeration or chilled water cooling coils. The latent and sensible loads are handled separately and more efficiently in this approach.

Desiccant systems offer significant potential for energy savings (0.1 – 0.4 quads) and reduced consumption of fossil fuels. The electric consumption is small, and the source of thermal energy necessary to regenerate the desiccant can be diverse (i.e., solar, waste heat, natural gas. etc.).

Economic benefits of desiccant-based air conditioning equipment result from reduced initial costs of building air-conditioning systems because of the conventional tonnage displaced by desiccant capacity, from the energy cost savings resulting from the substitution of gas or waste heat for electricity normally used to handle air-conditioning loads during peak-demand periods, and from more efficient removal of moisture from the air.

Indoor air environmental quality also benefits from separating and individually controlling the building's latent and sensible loads. This approach assures the building occupants that the humidity can be maintained in the optimal 40-60% relative humidity range where mold, virus, bacterial and mildew growth are minimized, and the risk of respiratory infections are diminished.

B. **Avoided Insurance Losses:**
Mainstream acceptance and application of desiccant-based air-conditioning systems could be expected to reduce insurance losses in several ways:

1. Reduced necessity for frequent refurbishing and redecorating building interiors due to reduced mold, mildew, fungi, and bacteria growth on carpets, ceiling tiles, walls, etc.

2. Reduced incidence of "Sick Building Syndrome" in commercial and governmental buildings which would be expected to increase worker

productivity, decrease absenteeism, and result in fewer health insurance claims (i.e., less Workers Compensation and life insurance claims).

3. Reduced liability for building owners and designers due to a safer, healthier, and more comfortable indoor environment for the building occupants.

C. **Resources**

i. **Research capabilities and skills:**
Whole-building and building equipment energy analysis and systems integration, highly instrumented/versatile building HVAC/R equipment and envelope research, alternative refrigerants development and testing, expertise in alternative technologies for air-conditioning and refrigeration applications including desiccants, and modeling and analytical capabilities.

ii. **Research facilities:**
HVAC system and appliance environmental chambers, absorption heat and mass transfer loops, roof climate simulator, large scale wall calibrated hot box, heat exchanger test facility/calorimeter, water-to-water heat pump refrigeration and air-conditioning test loops.

iii. **Selected Publications:**

1. Arthur D. Little, Inc., "Desiccant Cooling Market Assessment," December 1993, U. S. Department of Energy, Reference 66111, Final Report.
<liPesaran, A., T. Penney, and A. Czanderna, *Desiccant Cooling: State-of-the-Art Assessment*, October 1992, NREL/TP-254-4147.

2. Engelhard/ICC and Carrier Corporation, "Desiccant Air Conditioning Product Development: Phase I," February 24, 1997, Final Report, ORNL Sub. 86X-ST535V.

3. Slayzak, S., A. Pesaran, and C.Hancock, *Experimental Evaluation of Commercial Desiccant Dehumidifier Wheels*, May 1996, NREL/TP-471-2116.

4. SEMCO and Trane, *Active Desiccant Based Preconditioning Market Analysis and Product Development: Phase I, Report 2*, December 1997. Oak Ridge National Laboratory, Oak Ridge, TN.

iv. **Standards/guidelines/protocols/software tools:**

1. ASHRAE Standard 139P - "Method of Testing for Rating Desiccant Dehumidifiers Utilizing Heat for the Regenerative

Process," Approved for publication by the ASHRAE Board of Directors – January 21, 1998.

2. ARI (Air-conditioning and Refrigeration Institute) Standard 940P, "Desiccant Dehumidification Components," Being acted on in ARI's Desiccant Cooling and Dehumidification Equipment Section's Engineering Committee.

v. **WWW links:**
http://www.ornl.gov/ORNL/Energy_eff/btc.html
http://www.nrel.gov/desiccantcool

D. **Demonstration Projects:**

1. Wendy's Quick Service Restaurant – Palm Harbor Shopping Center - Tampa, FL.

2. Regal/Cobb Multiplex Movie Theater – Sarasota, FL

3. Applebee's sit-down restaurant – Landsdale, PA

E. **International Activities:**
None currently.

F. **Future Projects:**
The Tampa Bay Technical High School – Hillsboro County Public School System, Tampa, FL.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

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Sector:
Buildings

I. **Technology Studied:**
Tools for Building Code Development and Compliance

A. **Description:**
Pacific Northwest National Laboratory (PNNL) provides technical support to the US Department of Energy (DOE) for the complex process of implementing building codes at the state and local levels. PNNL works in partnership with the building industry, state and local governments, and other federal agencies to:

1. help States upgrade their building energy codes and standards, based on a voluntarily achieved consensus among building code organizations;
2. help States update and implement their building energy codes;
3. promulgate energy standards for Federal buildings; and
4. help the US Department of Housing and Urban Development administer energy efficient residential loan programs.

The goal of the DOE/PNNL activities is to make energy code compliance easy. MECcheckTM compliance materials are being used by over 17 states and federal agencies to demonstrate compliance with the Model Energy Code (a residential energy code). A training packet based on the MECcheckTM materials has been produced and has been widely used in training for code officials, builders, state energy office personnel, and industry.

PNNL has also demonstrated strength and leadership in the nonresidential building energy codes industry. PNNL has established a training curriculum for ASHRAE 90.1.

II. **Avoided Insurance Losses:**

We do not have data relating insurance losses to noncompliance with building codes. Noncompliance with thermal codes can be expected to lead to insurance losses involving fire, freeze, and moisture damage in the building envelope as well as health-related claims (life in some cases) related to unintended problems with indoor air quality (reducing Workers Compensation claims). Affects both residential and commercial sectors.

III. **Resources**

i. **Research capabilities and skills:**

1. PNNL staff were instrumental in preparing and administering energy plan review certification examinations for building department personnel in California, one of only three states which certifies plan reviewers for their commercial and residential energy code.

2. PNNL staff members serve on the ASHRAE SSPC 90.1 committee which is developing ASHRAE/IESNA Standard 90.1-1989R

3. PNNL staff work with national standards and model code development organizations in the United States to promote the adoption and use of codes that promote energy efficiency. This includes the ICC, ASHRAE, SBCCI, ICBO, and BOCA.

4. Staff from Pacific Northwest National Laboratory work with a wide variety of stakeholders--particularly designers, product manufacturers, builders, and code officials--to base codes and standards on the application of sound scientific principles. Further, Program staff work with individuals in the federal government, States, code development organizations, and the buildings community to provide direct technical assistance and to deploy code support tools that simplify the use of the code. PNNL provided direct technical support to 42 states and created qualified energy code instructors in 32 states through its outreach activities

5. PNNL has materials available for training, including the following: training materials for both the 90.1 code and the Model Energy Code (MEC); training videos; distance learning and multi-media (e.g., video conferencing, satellite downlink, video training, interactive computer learning tools, and in-class training).

ii. **Research facilities:**

iii. **Selected Publications:**
The following items are available at no cost while supplies last:

General

1. GEN-01. Subscription--Building Standards and Guidelines Newsletter, Setting the Standard

2. GEN-02. Information Packet--Building Standards and Guidelines Program, includes fact sheets and brochures.

3. GEN-03. Brochure--Reducing Operating Costs and Saving Energy in Residential and Commercial Buildings.

4. GEN-04. Fact Sheet; MECcheck--CABO Model Energy Code Compliance Made Easy.

5. GEN-05. Fact Sheet--Training Opportunities

6. GEN-06. Report--PNL-9386, A History of the Building Energy Standards Program.

7. GEN-07. Fact Sheet; COMcheck-EZ--Commercial Energy Code Compliance Made Easy.

Residential

8. RCM-05. Report--PNL-10121 Comparison of Current Residential Energy Codes with the 1992 Model Energy Code for One- and Two-Family Dwellings (1994).

9. RCM-06. Report--PNL-10387, Differences Between the 1992 and 1993 CABO Model Energy Codes.

10. RCM-07. Report--PNNL-10775, Differences Between the 1993 and 1995 CABO Model Energy Codes.

11. RCM-08. Report--PNNL-10975, Cost Effectiveness of the 1995 Model Energy Code in Massachusetts.

12. RCM-09. Report--PNL-9400, A Technical Support Document for Proposed 1994 Revision of the MECcheck Thermal Envelope Requirements.

13. RCM-10. Software--Automated Residential Energy Standard (ARES). Develops cost-effective energy standards.

14. RCM-11. Software--Automated Compliance for Residential Energy Standards (ACRES). Computer-aided compliance forms for ARES

Commercial

15. FED-01. Users Manual--Federal User?s Manual: Performance Standards for New Commercial and Multi-Family High-Rise Residential Buildings (applicable to Federal building requirements)

16. COD-01. Users Manual--90.1 Code Compliance Manual, applicable to codified version of Standard 90.1.

iv. **Standards/guidelines/protocols/software tools:**
Residential Products

Products marked with an asterisk (*) may be downloaded at no cost from this web site.

1. *MECcheckTM--Designers, architects and builders can quickly and easily determine whether new homes and additions meet the requirements of the Model Energy Code (MEC) with the MECcheck product group. Building officials, plan checkers and inspectors can simplify compliance determinations using MECcheck.

2. Inspecting Houses for Model Energy Code Compliance Video--Field inspection personnel or builders interested in energy code topics can learn techniques for verifying that construction meets or exceeds the Model Energy Code in this 22-minute video.

3. MECcheckTM Training Materials--These reference materials include presentation items, faculty notes and in-class notes about the Model Energy Code requirements for residential construction, completion of compliance documentation for the Model Energy Code and use of the MECcheck compliance tools.

Commercial Products

Products marked with an asterisk (*) may be downloaded at no cost from this web site.

4. *Envelope Standard, Program Version 2.4 (ENVSTD24) Software--Architects and designers can implement the system performance requirements for the building envelope portion of ASHRAE/IES Standard 90.1-1989 with the ENVSTD24 software and users guide.

5. *Lighting Standard, Program Version 2.4.1 (LTGSTD241) Software--With LTGSTD241 and accompanying users guide, users can implement the system performance requirements for lighting in ASHRAE/IES Standard 90.1-1989.

6. Energy Efficiency: The New Design Reality Video--The video, developed in conjunction with the American Institute of Architects, describes the requirements of the ASHRAE/IES Standard 90.1-1989.

7. *COMcheck-EZTM--Designers, builders and code officials alike will discover a quick and easy way to deal with commercial building energy codes in COMcheck-EZ.

8. ASHRAE/IES Standard 90.1-1989 Training Materials--The in-class notes and slides included in these training materials provide a good resource for trainers who teach compliance with the ASHRAE/IES Standard 90.1-1989 energy code for commercial construction.

v. **WWW links:**
http://www.energycodes.org

IV. **Demonstration Projects:**
Not applicable.

V. **International Activities:**
Russia, India, Mexico - Building Energy Codes

VI. **Future Projects:**
Distance Learning Initiative, DOE Office of Codes and Standards.

VII. **Collaborations with Insurance Industry:**
None currently.

VIII. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: PNNL-2

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Sector:
Buildings

I. **Technology Studied:**
Microtechnology-Based Absorption Heat Pump

A. **Description:**
The microtechnology-based absorption heat pump uses the high rates of heat and mass transfer attainable in microstructures to radically reduce the size of an absorption heat pump. The availability of a low cost modular heat actuated heat pump will enable the use of multiple small heat pumps in place of one large central heat pump. This will reduce the need for, and losses associated with, ducting and will improve reliability by reducing the impact of the failure of any individual heat pump.

B. **Avoided Insurance Losses:**
The availability of inexpensive module heat pumps used in place of one central heat pump will improve system reliability by reducing the impact of the failure of any individual unit. This will reduce insurance losses associated with the loss of space conditioning in commercial and retail buildings resulting from power service disruption.

C. **Resources**

i. **Research capabilities and skills:**
Pacific Northwest National Laboratory (PNNL) has an ongoing program in the applications of microscale technology to the miniaturization of energy and chemical systems. Currently, PNNL is developing compact heat pumps, power generators, chemical reactors and separations systems for many applications.

ii. **Research facilities:**
PNNL has established the micro thermal systems and micro chemical systems laboratories for the development of miniature energy and chemical systems. These facilities include specialized equipment and instrumentation for the fabrication, assembly and testing of microtechnology based thermal and chemical systems and components.

iii. **Selected Publications:**
Drost, M. K.and M. Fridrich, "Miniature Heat Pump for Portable and Distributed Space Conditioning Applications," Proceedings of the International Energy Conversion Engineering Conference, Honolulu, Hawaii, Vol. 2, pp. 1271-1274 (1997).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.pnl.gov

D. **Demonstration Projects:**
PNNL is currently demonstrating a microtechnology-based absorption heat pump for manportable defense applications.

E. **International Activities:**
None currently.

F. **Future Projects:**
PNNL is developing the microtechnology-based absorption heat pump technology for automotive and residential applications.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: PNNL-3

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Sector:
Buildings

I. **Technology Studied:**
Building Commissioning

A. **Description:**
Ideally, commissioning is a systematic process (beginning in the design phase, lasting at least one year after project close-out, and including the training of operating staff) of ensuring, through documented verification, that all building systems perform interactively according to the documented design intent and the owner's operational needs. Commissioning does not have to be linked to new installations and capital improvements. Existing equipment can be commissioned to ensure that it operates optimally and meets the building owner's and occupant's current needs.

B. **Avoided Insurance Losses:**
Building commissioning will help reduce insurance losses filed under workers compensation, professional liability insurance, product liability insurance, and

commercial property insurance.

Building commissioning can help avoid insurance losses in more than one way. First, it provides documented verification of a building's performance and operation. Commissioning process can include testing of outside-air flow rates, a primary factor affecting indoor air quality. If an existing building has deficiencies, the commissioning authority also records the repairs made. Commissioning should be repeated throughout the life of a building, and performance documentation should be updated regularly. This documentation provides owners (and design professionals if they remain involved in the commissioning process over time) with a record of building performance that can be used as evidence in the event of a lawsuit.

Commissioning also helps prevent many indoor air quality problems through its focus on training building operators in the proper maintenance of building systems. Properly run and maintained HVAC systems, with clean coils and air intakes and regularly-changed filters, are less likely to contribute to indoor air quality problems. In addition, trained operators can spot potential air quality and ventilation problems before they develop.

C. **Resources**

i. **Research capabilities and skills:**

1. Policy development and collaboration to promote the adoption of building commissioning practices throughout the United States.

2. Market research and informational material development, including developing, implementing and analyzing market research surveys and developing information materials for distribution to all segments of the potential and existing commissioning market.

3. Developing protocols, guidelines and specifications that can be used to define and standardize commissioning processes.

4. Commissioning implementation and pilot research projects.

5. Professional commissioning training/workshops.

ii. **Research facilities:**
Case study database, library of commissioning publications and tools.

iii. **Selected Publications:**

1. Bonneville Power Administration/PECI, *Building Commissioning Guidelines*, PECI, Portland, OR., 1992.

2. Florida Power & Light/PECI, *Commissioning for Better Buildings*, PECI, Portland, OR., 1996.

3. Oregon Office of Energy/PECI, *Commissioning for Better Buildings in Oregon*, PECI, Portland, OR., 1997.

4. USDOE/PECI, *Model Commissioning Plan and Guide Specifications*, PECI, Portland, OR., 1997.

5. PECI, *Proceedings of the National Conferences on Building Commissioning*, PECI, Portland, OR., 1993-1997.

iv. **Standards/guidelines/protocols/software tools:**
Commissioning Existing Buildings, sponsored by USDOE (ORNL), expected to be completed in Spring 1998.

v. **WWW links:**
http://www.peci.org

D. **Demonstration Projects:**
Under a joint DOE/EPA grant, PECI demonstrated that significant savings can be obtained through tuning up (commissioning) existing buildings. The demonstration involved performing and evaluating the tune-up process on five existing commercial buildings located across the United States.

PECI is leading a project for the USDOE Seattle Regional Support Office that involves commissioning and tuning the HVAC and control systems in a 152,000 sf GSA-owned, historic federal office building in Seattle, Washington. PECI developed boilerplate commissioning plans and procedures for this project that can be applied to future projects. Due to the positive results of these commissioning efforts, PECI will commission two additional existing GSA buildings in the Northwest.

PECI assessed and commissioned the Chattanooga State Office Building in Tennessee to demonstrate the benefits of existing building commissioning for the state. Based on the results of this demonstration, Tennessee has asked PECI to develop a program for tuning up 135 existing state facilities.

PECI led a project for Southern California Edison to identify whether common building commissioning practices can be improved. The project involved surveys of commissioning service providers, on-site assessments of over 50 buildings, and the commissioning of seven buildings. The project was a groundbreaking effort to obtain data regarding the costs and savings attributable to commissioning commercial buildings.

E. **International Activities:**

None currently.

F. **Future Projects:**
PECI is currently working on the following tasks under the Rebuild America contract held by PNNL:

1. In conjunction with DEQ, Rebuild America staff, and the State of Montana's Rebuild America Program, PECI is designed and presenting a retrocommissioning (commissioning existing equipment) training to be held in Missoula, Billings, and Bozeman, Montana in the Spring of 1998.

2. PECI is researching and writing the National Strategy for Promoting Building Commissioning. The draft version will be available for comment in spring 1998. The final version is expected to be completed this fall.

G. **Collaborations with Insurance Industry:**
PECI conducted a telephone survey and two focused discussion groups with DPIC policyholders to assess policyholder knowledge of and attitudes regarding building commissioning.

In addition, DPIC was one of a group of sponsors (including USDOE FEMP) of PECI's 1996-97 commissioning case study collection, database development and analysis, and resulting marketing brochure, "What Can Commissioning Do for Your Building?". PECI and DPIC are currently collaborating on a paper for the 1998 ACEEE Summer Study on commissioning as a loss prevention strategy.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: SNL-1

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Sector:
Utilities

I. **Technology Studied:**
Renewables

A. **Description:**
The following renewable energy projects are being conducted:

1. Photovoltaic systems--Systems that produce electricity directly from sunlight. R&D on system performance, reliability, and cost.

2. Solar thermal electric systems--System that produce electricity by using the sun's heat to make steam and drive a turbine generator. R&D on large (100MW central receiver) and small systems (25kW dish Stirling) reliability, performance, cost.

3. Solar thermal heat--systems that produce hot water and/or steam for direct use including ice makers, building air conditioning, and ovens. R&D on system cost, performance and reliability.

4. Biomass--systems that burn waste bio products (e.g., corn stalks) to produce heat to make steam and drive a turbine electric generator and/or to use the heat directly. R&D on cost, performance and reliability.

5. Wind--systems that use the wind to produce electricity. R&D on cost, performance and reliability of the wind generators.

6. Geothermal--system that use the earth's heat to produce steam to drive electric generators. Also, use the earth as a heat source/sink for augmenting the performance of electric heat pump systems. R&D on cost, performance and reliability.

B. **Avoided Insurance Losses:**
These systems can provide backup power, so service interruptions can be reduced when power service is interrupted.

Photovoltaic systems as well as solar thermal ice makers and ovens, can be used (and have been used) in disaster relief situations. Photovoltaic systems properly installed on a home may produce electicity during grid outages and prevent equipment failures such as refrigerators. Solar ovens can be used to sterilize medical instruments and food when normal grid power is out. Solar ice makers can make ice for preserving food and medicine when the grid fails.

C. **Resources**

i. **Research capabilities and skills:**
Sandia National Laboratories has strong engineering skills in all areas of research ranging from basic to applied. It has extensive indoor as well as outdoor facilities capable of performing R&D tests and evaluations on components and systems. Sandia was the first national DOE laboratory to perform research on renewable energy.

ii. **Research facilities:**
Sandia has both indoor and outdoor R&D facilities for energy- related research. Major facilities include the PV fabrication labs, PV outdoor test facilities, the National Solar Thermal Test Facility, and a number of indoor labs used for energy R&D.

iii. **Selected Publications:**
Sandia researchers have produced many publications. The best source of information about Sandia research results is the national DOE database. Other information can be obtained by accessing the Sandia WWW site. "Sandia Perspectives," a recent Sandia publication about lab capabilities, is a good reference document. Contact David Menicucci for a copy.

iv. **Standards/guidelines/protocols/software tools:**

1. Computerized economic analysis tool for the U.S. Army Corps of Engineers to assess the cost-effectiveness of solar thermal technology in any location in the US.

2. Methodology for surveying facilities for renewable energy applications; applied the technique at several installations including Camp Pendleton and the Marine corps Mountain warfare training center.

3. Manual for refurbishing solar energy systems that are not operational.

4. Test standards for solar ovens.

5. Test standards to test solar concentrators; submitted to ASHRAE for inclusion in ASHRAE test standards.

6. Standardized technique for monitoring the performance of solar thermal systems.

v. **WWW links:**
http://www.sandia.gov/Renewable_Energy/renewable.html

D. **Demonstration Projects:**
Numerous field demonstration projects since 1973. Projects range from small batch water heaters for single homes or small phototovoltaic lighting for a single building to a 10MW central receiver system

E. **International Activities:**
Sandia is involved with research organizations in all parts of the world.

F. **Future Projects:**
R&D is expected to continue in all renewable areas listed above.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: SNL-2

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Sector:
Utilities

I. **Technology Studied:**
Solar Thermal Heat

A. **Description:**
The solar thermal heat projects cover the following end uses: Solar Water Heating, Process Heat, Water Distillation, Cooking and Ice Making. Sandia has studied Active and Passive designs for water heating and process heat for single family, dormitory and commerical buildings. Water distillation, cooking and ice making apply to more rural areas where electricity is not available.

B. **Avoided Insurance Losses:**
By providing solar energy, service interruptions can be reduced when power service is interrupted. In addition, solar buildings can provide a moderate indoor environment during times of extreme temperatures, thus reducing health and life insurance losses.

C. **Resources**

i. **Research capabilities and skills:**
The staff at the National Solar Thermal Test Facility (NSTTF) are experts in the field of solar thermal energy from materials to design engineering and application.

ii. **Research facilities:**
The NSTTF is located at Sandia National Laboratories.

iii. **Selected Publications:**
"Using the Sun to Cook and to Make Ice" (brochure).

iv. **Standards/guidelines/protocols/software tools:**
None currently.

v. **WWW links:**
http://www.sandia.gov

At this Web site, a photo CD database is maintained which provides photographic examples of our projects.

D. **Demonstration Projects:**
A public museum at the NSTTF displays solar technology. Sandia has provided technical expertise on numerous installations in the public and private sector, nationally and internationally where visits could possibly be arranged.

E. **International Activities:**
Collaborative project with Mexico installing various renewable energy applications rurally to promote the renewable energy market and to combat global warming.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: SNL-3

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Sector:
Buildings

I. **Technology Studied:**
Architectural and Infrastructure Surety

A. **Description:**
This program area focuses on developing and applying technology to meet the requirements at the national level, including education and research to meet customer needs. It involves a risk management approach to solving problems of the as-built environment through the application of security, safety, and reliability principles developed through the nuclear weapons programs of the Department of Energy. The changing responsibilities of engineering design professionals is addressed in light of the increased public awareness of structural and facility systems vulnerabilities to malevolent, normal, and abnormal environment threats. The education and technology outreach programs have been initiated through an infrastructure surety graduate course taught at the University if New Mexico Civil Engineering Department and through the architectural surety workshops and international conferences already held and planned for the future. To date selected Sandia technologies that have a strong potential for application to specific

national architectural and infrastructure surety concerns include: (1) education and training, (2) super-computational modeling and structural response simulations, (3) window glass and building material fragmentation modeling, (4) risk analysis and risk management methodologies, (5) material life-cycle performance and aging, (6) instrumentation and health monitoring systems for buildings, and (7) 3D-CAD design and building response visualizations using virtual reality interactive techniques.

B. **Avoided Insurance Losses:**

The new and emerging threats to the infrastructure faced by today's engineering design and facility management community demand solutions that are innovative, and more risk management based in approach. In the wake of the World Trade Center, Oklahoma City, and Saudi Arabian bombings, global civil and ethnic unrest, criminal and political terrorism, recent natural disasters, and other indicators of a rapidly transforming social world, there is a growing awareness of public vulnerability to these potential threats. This awareness leads to increased expectations and responsibilities for the design, engineering, and construction professionals. The destruction, for example, that follows in the wake of such natural disasters as hurricanes, tornadoes, floods, and earthquakes also underscores the need for enhanced structural safety, security, and reliability to protect the public from potential injuries, death, and heavy property losses.

The escalating threats and risks to the public and the as-built infrastructure change the roles of the designers, architects, planners, engineers, and builders by increasing the focus on the importance for applying viable surety principles to the built environment. To save lives and significant costs, surety principles incorporate a systematic approach in the planning, design, engineering, contracting, construction, operation and management, and final disposal processes in the total life cycle of the as-built infrastructure systems (e.g., buildings, bridges, tunnels, airports, transportation systems). The principles of surety are also served by applying risk management approaches to facility designs through the process of identifying, assessing, analyzing, and mitigating risks from natural disasters and other human-induced impacts. Sandia National Laboratories continues to develop this multi-disciplinary program to address many of the critical national issues of public and commercial concern in this area by apply surety concepts and procedures as appropriate for government and non-government agencies and institutes.

C. **Resources**

i. **Research capabilities and skills:**

Sandia National Laboratory offers one of the best and the largest collection of technology and policy experts, scientists and engineers with experience and interest in multi-disciplined and integrative problem-focused research and development. The specialties cover a very wide

spectrum which is especially important for meaningful civil infrastructure systems technology development.

Sandia has currently identified a broad range of technologies developed through DOE and other government programs that have a strong potential for application to specific national architectural and infrastructure surety concerns. These technologies include: (1) the application of the TERAFLOP supercomputer computational modeling and structural simulations for life-cycle engineering, (2) window glass and other construction material performance and fragmentation modeling, (3) risk management and assessment procedures, (4) instrumentation and health monitoring sensor systems, and (5) 3D-CAD virtual reality visualizations techniques for design evaluations. These technologies have already been tested and applied to several government and industrial problems and have shown promise for future use in the surety area.

ii. **Research facilities:**
Relevant laboratory facilities that are available at Sandia include: Component Modeling and Characteristics Laboratory, Microelectronics Development Laboratory, Intelligent Systems and Robotics Center, Materials and Process Diagnosis Facility, and Explosive Components Facility.

iii. **Selected Publications:**

1. Matalucci, Rudolph V., and Dominique Foley-Wilson, "Architectural Surety Workshop-Summary Report," Prairie Star Conference Center, Sandia National Laboratories, Albuquerque, NM 87185-0761, March 26-27, 1996. (draft).

2. Security Systems and Technology Center, "Assuring the Performance of Buildings and Infrastructures," Proceedings from a Conference on Architectural Surety, Hyatt-Regency Hotel, SAND97-2102, Sandia National Laboratories, Albuquerque, New Mexico 87185-0761, May 14-15, 1997.

3. Matalucci, Rudolph V., Dennis S. Miyoshi, and Sharon L. O'Connor, "A Curriculum for Infrastructure and Architectural Surety," Sandia National Laboratories, Albuquerque, New Mexico 87185-0761, October 1997 (in draft).

iv. **Standards/guidelines/protocols/software tools:**

v. **WWW links:**
http://www.sandia.gov/archsur

D. **Demonstration Projects:**
None currently.

E. **International Activities:**
None currently.

F. **Future Projects:**
None currently.

G. **Collaborations with Insurance Industry:**
Through conferences, workshops and meetings, collaborations with the insurance industry has been initiated and the response has been positive. Interactions with several larger insurance companies and insurance institutes have been on-going for over two years, and several projects are under development at the present time regarding response of buildings and facilities under severe environmental situations. The emphasis is on effects monitoring, risk assessment, and mitigation measures to reduce injuries, property losses, and to protect lives.

Work also is continuing with the professional societies regarding building codes, design guidelines, and new performance-based approaches for the building construction industry.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: SNL-4

Laboratory Name:
Sandia National Laboratories and Florida Solar Energy Center

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Sector:
Utilities

I. **Technology Studied:**
Photovoltaic Systems

A. **Description:**
The Florida Solar Energy Center (FSEC), as part of a contract with the U.S. Department of Energy and Sandia National Laboratories, is assessing electrical power needs during natural and man-made disasters. The goals are to identify the roles for photovoltaics (PV), to communicate these roles to the PV community, to coordinate activities with the solar industry, and to work with appropriate emergency management and relief organizations in implementing PV applications for disaster relief.

Building and photovoltaic designs will be studied to provide photovoltaic systems capable of withstanding natural disasters. Training will be provided to the building and photovoltaic industry and projects will be demonstrated.

B. **Avoided Insurance Losses:**
Reduction of business operation losses following the disruption of grid-based utility power supply.

C. **Resources**

i. **Research capabilities and skills:**
FSEC has assisted in relief efforts for hurricanes, floods, and earthquakes since 1992, providing technical assistance and/or electrical power generating equipment. Since 1974, FSEC has researched, developed, and tested equipment and systems, and provided technology transfer and education programs in many energy sciences. FSEC is a Type I non-profit research institute of the State University System of Florida and is administratively under the University of Central Florida. FSEC can provide technical assistance and limited photovoltaic power equipment to support relief organizations in a disaster.

ii. **Research facilities:**
In 1995, FSEC moved to a new 71,000 square-foot research facility on 9 acres of land on Brevard Community College/University of Central Florida campus in Cocoa.

iii. **Selected Publications:**

1. Young, W., "The Implementation of Photovoltaic Transportation Devices," FSEC Report FSEC-PF-248-93 (1993).

2. Young, W., "Real Life Applications of Photovoltaic Power to Hurricane Andrew Relief," FSEC Report FSEC-PF-284-94 (1994).

3. Young, W., "Applying Photovoltaics to Disaster Relief," FSEC Report FSEC-PF-294-96 (1996).

4. Young, W., "Needs Assessment for Applying Photovoltaics to Disasters," FSEC Report FSEC-CR-935-97 (1997).

5. Young, W., "History of Applying Photovoltaics to Disaster Relief," FSEC Report FSEC-CR-934-97 (1997).

6. Young, W., "Photovoltaic Applications for Disaster Relief," FSEC Report FSEC-CR-849-95 (1995).

iv. **Standards/guidelines/protocols/software tools:**
Designs and testing are completed to the nationally accepted stardards of American National Standards Institute, IEEE, NEC and others.

v. **WWW links:**

http://www.fsec.ucf.edu
http://www.sandia.gov/pv

D. **Demonstration Projects:**
In 1992, FSEC provided technical assistance and photovoltaic equipment to several organizations after Hurricane Andrew struck south Florida (which resulted in insurance claims of $16 billion). Several stand-alone 1 kWp PV systems and other PV equipment were assembled at different temporary medical clinics in the disaster area. The equipment operated for weeks after the disaster providing needed electrical power.

E. **International Activities:**
None currently.

F. **Future Projects:**
Presently, developing a program to organize partnerships between the solar industry and disaster organizations to develop viable photovoltaic applications for disaster relief efforts and to provide technical training.

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.

Laboratory Identification Number: SNL/NREL-1

Laboratory Name:
Sandia National Laboratories and National Renewable Energy Laboratory

Contact:
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Sector:
Utilities

I. **Technology Studied:**
Solar Dish Engine Systems

A. **Description:**
Dish engine systems use parabolic reflectors in the shape of a dish to focus the sun's solar rays onto a receiver mounted above the dish at it's focal point. Through the use of a heat engine, one system can convert sunlight to up to 50 kilowatts of electricity, enough energy for approximately 25 households. It is a modular system, so it can be located as a stand-alone system, or modular systems can be sited together. When the sun is not available, the heat engine can be operated using fossil fuels.

B. **Avoided Insurance Losses:**
Because dish engine systems use solar energy, they can be used to provide back-up power when power lines are disrupted. Thus, these systems can avoid service interruption losses following disruption of grid-based utility power supply.

C. **Resources**

i. **Research capabilities and skills:**
Engineering and research staff of two National Laboratories (Sandia National Laboratories and National Renewable Energy Laboratory) collaborate on many levels, from materials to product design, on numerous aspects of solar renewable energy; the collaboration is known as the Sun Lab. Working together with industry partners, functional products are conceived and designed through to the prototype stage. Specific skills include: (1) system analysis studies (cost, performance and economics); (2) engine and concentrator testing; (3) material and component R&D; and (4) solar resource assessment.

ii. **Research facilities:**

1. National Solar Tower Test Facility (NSTTF) at Sandia National Laboratories at Alburquerque, NM, with test bed concentrators.

2. NREL High Flux Solar Furnace at NREL, Golden, CO.

iii. **Selected Publications:**
Numerous publications are available, including the following:

1. "DOE Technology Characterization: Dish Engine," available from DOE's web site: http://www.eren.doe.gov/utilities/techchar.html

2. "A Compendium of Solar Dish/Stirling Technology," Sandia report SAND 93-7026, UC-236, Sandia National Laboratories.

iv. **Standards/guidelines/protocols/software tools:**
Software tools: HELIOS, ODMF, HOMER, Financial Models.

v. **WWW links:**
http://www.sandia.gov/Renewable_Energy/solarthermal/nsttf.html

http://www.nrel.gov

http://www.eren.doe.gov./sunlab

http://www.eren.doe.gov./sunlab/furnace.htm

A photo CD database is maintained which provide photographic examples of projects.

D. **Demonstration Projects:**

1. Fort Huachuca, AZ

2. SAIC dish installation near Golden, CO

3. SAIC/STM/APS Joint Venture Program (JVP) with SunLab - Phase 2 of the program will do field demonstrations of 5 systems using Stirling engines

4. Dish Engine Component Commercialization (DECC) SunLab - Develop a dish system that uses an alternative engine.

E. **International Activities:**
A 5-10 kWe system is currently being tested in Germany.

F. **Future Projects:**
Phase 3 of JVP will demonstrate 40 additional systems

Phase 2 of DECC will demonstrate 40 additional systems

G. **Collaborations with Insurance Industry:**
None currently.

H. **Research Agenda:**
Nothing submitted.