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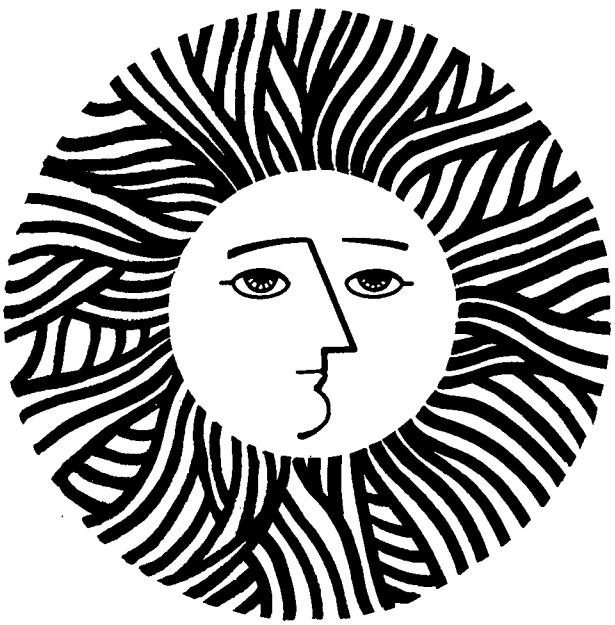

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LBID-475

MONTHLY PROGRESS REPORT

December 1981 - January 1982

ENERGY EFFICIENT BUILDINGS PROGRAM

Energy and Environment Division
Lawrence Berkeley Laboratory
University of California, Berkeley
Berkeley, California 94720

February 1982

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Energy Performance of Buildings

SCOPE OF WORK

The work in this program can be divided into three primary areas: the Envelope Thermal Test Unit (ETTU), air infiltration studies, and the Computerized Instrumented Residential Audit (CIRA).

OBJECTIVES

1. ETTU

To develop an improved understanding of the actual thermal performance of walls in the field using the Envelope Thermal Test Unit and the Simplified Thermal Parameter model.

2. AIR INFILTRATION

To complete validation of the LBL residential infiltration model. To extend infiltration measurement and modeling efforts to multi-family residential buildings. To develop consensus construction quality standards for air leakage in U.S. housing in collaboration with ASHRAE and ASTM.

3. CIRA

To integrate the auditing of house energy, data gathering on costs and savings, and feedback to the audit into a single microcomputer-based procedure.

RESEARCH ACTIVITY DURING REPORTING PERIOD

1. Envelope Thermal Test Unit (ETTU)

October/November, 1981

Difficulties have been encountered with the stability of the calibration of ETTU. The problem has been traced to two sources: 1) radio frequency noise pickup by the thermistor leads and 2) instability of the heating power of the ETTU blankets. The first problem has been solved through RC-filters. The second is being investigated at present. It is possible that quality control during fabrication of ETTU heater foils may have to be greatly improved.

Problems persist in the calibration of ETTU: the blanket U-values change too much from one run to the next. We are currently researching alternate insulating materials (rather than styrofoam) to provide a more stable U-value for the ETTU blankets.

December 1981/January 1982

Problems persist in the calibration of ETTU: the blanket U-values change too much from one run to the next. We are currently researching alternate insulting materials (rather than sytrofoam) to provide a more stable U-value for the ETTU blankets.

Laboratory accuracy and reproducibility test were done in January. Results demonstrate that the surface heater elements are less uniform than expected, presumably due to weak solder joints on the surface. Efforts are underway to replace the multiple strip heaters with single-piece construction. Further tests have shown that the thermistors and blanket insulation have stable behavior over time.

2. Air Infiltration

October/November, 1981

MITU is being overhauled prior to its relocation to Reno, Nevada, for winter measurements.

Four sets of AIM's (average infiltration monitor) were sent to Minnesota for long-term measurements.

Apartments and college dorms were surveyed for use in multi-chamber study. The apartment and college dorm were selected.

Data analysis and reduction for the retrofit houses in Rochester, NY, and Midway, WA, continuing, with a house doctor manual (draft) appended to the Midway study.

Continued long-term infiltration and wind measurements are being made at the Research House for model validation.

December 1981/January 1982

MITU calibration continued; preparations were delayed due to software problems. New static pressure sensor developed.

Nine AIM units are in the field collecting long-term infiltration data. Grab bags from two of the units were sent back to LBL for analysis.

Measurements were taken in a nine-story collge dormitory of infiltration rates, pressures, temperatures, etc. Results will be used to verify a model for infiltration in high-rise buildings.

3. CIRA

October/November, 1981

An algorithm was written for the economic optimization of up to 200 retrofit measures. It is currently being tested and will be added to the CIRA package. Also developed was a graphic output format for the

optimized retrofit measures.

Passive solar features (trembe walls, water walls, sunspaces) as well as active solar features were added. The SLR methodology developed at LANL was used for the passive solar. F-chart was used for active solar.

An economic input feature was also added, inquiring about fuel types, prices and escalation rates, discount rates, and life cycles.

December 1981/January 1982

The final section on retrofit optimization was completed. CIRA was demonstrated at an audit test for PG&E. Documentation of CIRA 1.0 is complete.

MEETINGS/CONFERENCES

10/23/81 - D. Grimsrud attended workshop given by Gas Research Institute in Chicago, Illinois.

10/15-18/81 - D. Grimsrud presented a talk, "Separate Infiltration and Ventilation--Build a Tight House," at the Minnesota Energy Agency, Minneapolis, MN.

12/8-11/81 - M. Sherman attended DOE/ORNL/ASTM conference in Clearwater, Florida.

12/15-16/81 - R. Sonderegger attended a committee meeting on Passive Solar Design and Physical Sciences, Los Alamos, NM.

1/12/82 - D. Grimsrud attended a BPA meeting in Portland, OR.

1/24-27/82 - R. Sonderegger, D. Grimsrud, M. Sherman, R. Lipschutz, and J. Adams attended ASHRAE meetings in Houston, TX.

PERSONNEL

VISITORS

Helmut Fuestal from Free University, Berlin, and Pierce Ninane from Universite of Liege are working on infiltration projects with the group (Oct/Nov).

DELIVERABLES

OTHER PAPERS

LBL-13508. "Simplified method for calculating heating and coding energy in residential buildings." Sonderegger, R.C., and Garnier, J.Y., October 1981.

LBL-13436. "Envelope Thermal Test Unit (ETTU): field measurement of wall performance." Sonderegger et al., October 1981.

LBL-13520. "Predictive air infiltration model— field validation and sensitivity analysis." Sherman et al., November 1981.

LBL-13510. "Determination of dynamic performance of walls." Sherman et al., December 1981.

LBL-13509. "Predictive air infiltration model -- long-term field test validation." Modera et al., December 1981.

LBL-13503. "STP: A model of the dynamic performance of walls." Sherman et al., January 1982.

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Buildings Energy Data Group

SCOPE OF WORK

The DOE-funded work in this program supports the Buildings Energy Use Compilation and Analysis (BECA) project, which currently includes three elements: existing residences, new residences, and commercial buildings. A fourth element, dealing with appliances and equipment, will be added in the future.

OBJECTIVES

1. To monitor the actual progress in improving energy efficiency in new and retrofitted buildings (compared to identified technical and economic potentials for conservation) by compiling, analyzing, and comparing measured data on energy savings and cost-effectiveness, based on empirical research and program monitoring.

2. To examine the range of conservation savings and costs, in order to identify the technical, institutional, or programmatic factors associated with high or low levels of performance.

3. To compare actual energy savings (as determined by utility-metered usage or instrumented measurements) and cost-effectiveness with predicted levels, and assess the reasons for any discrepancies.

4. To encourage the exchange of documented conservation results among utilities, government agencies, and private firms, and to help establish widely accepted standards for the collection and analysis of such data.

RESEARCH ACTIVITY DURING REPORTING PERIOD

October/November

1. BECA-A, New Residences

We were fortunate in securing the services of a "RIF'd" SERI staff member who had been working there on compiling performance data on new solar homes and a few super-insulated homes. Adding to the data base he brought with him from the cancelled SERI project, we have now identified about 150 potential data points (one to several homes each) to incorporate in an updated version of the original BECA-A paper (LBL-8912 Rev.), which will appear shortly in Energy and Buildings. The original paper had fewer than 1/10th this number of data points to draw upon. We have the data and are beginning to analyze about 40 of the data points.

We have begun to develop display formats for tables and scatterplots, and have drafted detailed data sheets for internal use and guidance to collaborators who are willing to adopt our data-base format. We have also held an initial discussion of options for time-shared or

microprocessor-based computer systems, with knowledgeable staff at LBL and the UC campus. (This last item applies to the other elements of BECA, as well.)

December 1981/January 1982

We continued the compilation and analysis of data and the identification of new leads. Formats for long and short data sheets were finalized, as well as formats for tabular and graphic presentation of data, based on the approaches used in the BECA-A and BECA-B work.

2. BECA-B, Residential Retrofits

October/November, 1981

Thanks to the time contributed this past summer and early fall by Prof. Leonard Wall of Calif. State University at San Luis Obispo, we completed an initial draft of a BECA-B paper, analyzing results of retrofitting about 60 homes or groups of homes in the U.S. and Canada. A preliminary version of this paper was presented by A. Rosenfeld in a panel discussions held at the ICEUM Conference in Berlin (October 1981).

Work continues on revising the data analysis, editing the draft paper based on reviewer comments, and checking our interpretations of and calculations made with raw data, by feeding back the results to the original sources. We are also soliciting additional data points to add to the computerized data base over the next several months. Already, word-of-mouth communication about the BECA-B data base has prompted a request from the Pennsylvania Governor's office that the preliminary results be presented by Prof. Wall in a regulatory proceeding concerning the use of state revenues derived from incremental gas pricing for conservation retrofits.

December 1981/January 1982

We completed much of the editing and preparation of a review draft, to be released in March 1982. L. Wall has agreed to work with us at LBL on BECA and other projects during his sabbatical year leave, beginning in July 1982.

3. BECA-C, Commercial Buildings

October/November, 1981

Initial data on more than 200 retrofitted commercial buildings have been compiled and analyzed by collaborators H. Ross and S. Whalen of the DOE/CE Buildings Division. An initial draft is out for review, and the data are being encoded in LBL's computerized interim data base. The addition of other commercial building retrofits, and establishment of a data base on new energy-efficient commercial buildings, will await determination of additional project funding (see below).

December 1981/January 1982

We encoded a subset of the data from the Ross and Whalen draft, and modified the FORTRAN program to handle it. A new, more flexible scatterplot program was developed and will be debugged; when completed it will reduce the time and expense of producing updated figures. Our next steps on BECA-C are to complete encoding of the Ross/Whalen data base, and assign staff to begin broadening that data base to include additional building types, other areas of the country (especially West Coast and Sunbelt), and new commercial construction.

COLLABORATIVE ACTIVITIES

1. BECA-A

The data now being compiled and analyzed reflect prior SERI efforts, and have also attracted offers of assistance from Prof. Wayne Shick of the U. of Illinois and Prof. William Colborne of the U. of Windsor in Ontario, Canada (who was also a leading co-author of the first BECA-A paper). Both individuals are planning visits to LBL early next calendar year. The University of Oklahoma has also contacted us, indicating interest in collaborative data-gathering on earth-sheltered homes. (Oct/Nov)

Visits from Colborne and Shick took place in early January. Both visitors reviewed current working drafts of the three BECA documents, and provided a number of helpful suggestions and leads to additional data sources. (Dec/Jan)

2. BECA-B

As noted earlier, Prof. Wall's time has been partly supported by CSU/SLO. Also, Dr. G. Dutt of Princeton U. was a contributing author of the ICEUM draft version of the paper, and contributed several of the most detailed data points, based on the Princeton Modular Retrofit experiments and a few retrofitted multifamily buildings. The Princeton Energy Group, engaged in assembling a data base on local government conservation programs, under contract with a private information systems consultant, has also contacted us about possibly sharing our data sources. Finally, Rosenfeld's talk at the ICEUM conference stimulated interest by several potential European collaborators (Oct/Nov).

3. BECA-C

(See above, re: DOE co-authors (Oct/Nov).)

MEETINGS/CONFERENCES

BECA-B: (See ICEUM, above (Oct/Nov).)

All three elements of the BECA project have generated interest from researchers, utilities, and government/industry organizations concerning possible participation in a Summer Study on documenting the results of energy conservation in buildings, now being planned (tentatively for next August) under the co-sponsorship of DOE/LBL, the American Council for an Energy Efficient Economy (ACEEE), and the U. of California's Energy Institute. (Oct/Nov)

Next month, Jeff Harris will participate in an EPRI-sponsored workshop, organized by Eric Hirst of ORNL, on the subject of evaluating the results of utility-sponsored conservation programs. This should yield valuable contacts for the BECA-B data base, and perhaps the other two elements. (Dec/Jan)

Planning continued for the 1982 ACEEE Summer Study, with a focus on identifying panel leaders, prospective co-sponsors and funding sources, and likely contributors of technical papers. A call for papers will be issue in February. (Dec/Jan)

VISITORS

BECA-A: (See above, re: Shick and Colborne (Oct/Nov).)

PROBLEMS

The principal difficulty continues to be uncertainty about the total funding that may be available to the project this year, and consequently the scale of the project. Without additional support, we will concentrate on analyzing only the data already in house, and will make little or no effort to initiate additional contacts with potential sources (including data on new energy-efficient commercial buildings and appliance/equipment, for which no data collection has begun). Nor will we be able to work with some of our contributors to help them upgrade incomplete or inconsistent data, or to provide technical guidance to prospective data sources in designing their data collection procedures to be consistent with our data base. Even if additional funds become available later in the year, some of these opportunities will have been lost (Oct/Nov).

DELIVERABLES

Preliminary schedule is as follows:

- BECA-A: Review draft - 6/1/82.
- BECA-B: Review draft - 4/1/82; Revised draft for publication - 8/1/82.
- Input to Santa Cruz Summer Study, plus participation during last week in August.

MONTHLY PROGRESS REPORT
December/January--FY'82

Ventilation Program

SCOPE OF WORK

The Building Ventilation and Indoor Air Quality (BVIAQ) Program consists of five projects:

1. Program Administration and Information Dissemination (CE)

2. Radon (CE & ER/OHER)

3. Combustion Appliances (ER/OHER, CPSC)

4. Passive Monitors (CE)

5. Control Techniques (CE)

OBJECTIVES

1. PROGRAM ADMINISTRATION AND INFORMATION DISSEMINATION

To provide technical and fiscal management for the Building Ventilation and Indoor Air Quality (BVIAQ) group and to disseminate LBL research findings via technical reports, pamphlets (terminated due to DOE policy decision), a user-oriented database system (terminated due to budget recison), presentations at conferences, response to inquiries, press releases, and television/radio interviews.

2. RADON

To study the effects that energy-conservation measures in buildings have on indoor concentrations of radon and its radioactive decay products. To develop monitoring instrumentation and to make laboratory and field measurements of source strengths and concentrations in conventional and energy-efficient housing, testing the effect of various control strategies. To study the characteristics of soil as a source of indoor radon. To study in a room-sized chamber properties of radon progeny relating to attachment to particulates, deposition on room surfaces, and filtration by mechanical devices, including forced-air furnaces. To assess the suitability of various monitoring instruments for field application.

3. COMBUSTION APPLIANCES

To characterize pollutants emitted by indoor combustion processes. To determine pollutant source strengths in laboratory studies. To assess the impact of combustion sources on indoor air quality in field studies. To determine the effects of ventilation and other control strategies on combustion-generated indoor pollution. To evaluate instruments suitable for such studies.

4. PASSIVE MONITORS

To develop low-cost, portable instruments (optimally, passive monitors) suitable for measuring indoor air quality in research and energy-conservation programs, and to test and evaluate commercially developed monitors for suitability to indoor air monitoring.

5. CONTROL TECHNIQUES

To evaluate the energy performance, contaminant control capabilities, and cost-effectiveness of residential mechanical ventilation systems with heat recovery (i.e., residential air-to-air heat exchangers). To investigate factors that degrade heat-exchanger performance. To develop and utilize computer models for predicting the energy savings potential and economic desirability of heat-exchanger systems. To develop and evaluate other indoor air pollution control techniques (e.g., dehumidifiers, air washers, electrostatic precipitators, spot ventilation).

RESEARCH ACTIVITIES DURING REPORTING PERIOD

1. Program Administration and Information Dissemination

October/November, 1981

New project proposals were prepared for potential funding by DOE-EP, BPA and EPRI. The new proposals cover studies on the following research: control techniques, formaldehyde passive monitors, wood stoves, and general indoor air pollution issues. Craig Hollowell devoted considerable effort as an organizer of the International Symposium on Indoor Air Pollution, Health and Energy Conservation, held in Amherst, MA, October 13-16, 1981.

December 1981/January 1982

No input.

2. Radon

October/November, 1981

INSTRUMENTATION: The radon transfer system (from cooled traps to scintillation cells) was overhauled. Twenty-five grab-sample vessels for field use were fabricated (from 1-liter aluminum fuel bottles) and tested for leaks. Work on the radon daughter carousel continued; software to run the instrument under manual control from a terminal was completed.

RADON RESEARCH HOUSE: The radon source was installed and operated for the first time. The specific source magnitude was found to be 7 pCi/(1-hr), corresponding to the highest values we have found in conventional houses. Under natural infiltration conditions we can achieve a whole-house average radon concentration of 100 pCi/l. The radon

monitors showed significant variation in response.

An apparent drop in the radon source strength was traced to a leaky pump; the source appears to have a stable radon output on the order of 50% of the rate from the radium in the NBS ampoule. The continuous radon monitor response was narrowed to a relative standard deviation of 5% by rearranging the sampling configuration; with separate calibration factors the intercomparability will be even better. A problem with condensation in the flowmeters and scintillation cells, which may be due to oversized sampling pumps, was discovered. We began work on identifying leaks in the furnace system. With the furnace fan off the infiltration rate is 0.1 ach or less, but with the furnace fan on the ventilation rate jumps to 0.8 ach. We installed a gas stove to generate particulates for radon daughter studies. We also installed a range hood.

AARDVARK FIELD PROJECT: We began to discuss the possibility of using the Aardvark in a new field project. It would operate in a single house for six months with expanded weather and radon source monitoring capability. We began investigating possible field sites and planning the necessary equipment changes/additions.

A series of tests were run which indicate that the SF_6 analyzer will work adequately in the 1-5 ppm range (as opposed to the 10-50 ppm range). We designed and began fabricating a probe, based on a scintillation cell/photomultiplier tube, to measure the concentration of radon in the soil on a real time basis, on a time-scale of 1 hour or so. We specified and began working on the necessary equipment changes for this field project, and we continued our efforts, with some progress, towards identifying an appropriate site.

SOURCE STUDIES: Work continued on the characterization of charcoal canisters for radon flux measurements.

The field portion of a cooperative project with Southern California Gas was postponed due to difficulties in executing a contract between LBL and the Institute of Gas Technology, which holds the prime contract with Southern California Gas. The analysis of soil and rock samples, and of data from the Mt. Airy field study, carried out in April, was completed.

MODELING: We began to discuss the possibility of basing a physical indoor air quality model on recently developed computer programs that simulate the movement of air due to free convection or forced ventilation.

December 1981/January 1982

INSTRUMENTATION: The radon daughter carousel was operated for six day days in a private residence having low radon levels. With the exception of a few minor software and hardware bugs, the instrument performed as designed. Because the filters were reused, the contribution of thoron daughters to the observed counts was significant. A third alpha channel is being used to correct for the thoron contribution.

RADON RESEARCH HOUSE: The leaks in the furnace system were eliminated by sealing the furnace room from the outside and providing combustion air to the furnace through ducts. The continuous radon monitors continue to exhibit problems. Although they were tuned in November to respond within a range of 10%, a calibration in January showed more than 20% variation between instruments. We have been working in collaboration with the Heat exchanger project staff on the preparation for a study of ventilation efficiency using window-mounted air-to-air heat exchangers. The study will be done in the research house during February.

AARDVARK FIELD PROJECT: A suitable site for the study was found in Hinsdale, Illinois, on the outskirts of Chicago. Argonne National Laboratory personnel will provide field service for the system. All of the system modifications were completed in late January. The system is equipped to measure air-exchange rate, outdoor weather (wind speed and direction, and temperature), four indoor temperatures, indoor radon concentration, radon concentration in the soil near the house, the radon concentration above a crack in the basement floor, and the pressure differences between indoors and four points outdoors.

SOURCE STUDIES: A preliminary investigation into the National Uranium Resource Evaluation (NURE) project revealed that the extensive aerial survey data collected in that project may be useful in efforts to map areas having high indoor radon levels. Work was initiated on a laboratory study of radon migration in soil. Preliminary work on the effect of fly ash on radon emanation from concrete was completed for the Environmental Protection Agency and the National Fly Ash Association.

3. Combustion Appliances

October/November, 1981

SOURCE STUDIES: Tuning tests were conducted on a 30,000 BTU/h unvented gas-fired space heater (with holes, not slots, for burner ports) to investigate the role of O_2 depletion on CO emissions. By varying the ventilation rate, steady-state O_2 levels of 20% and 18% were achieved in our 27-m^3 chamber. At 20% O_2, the CO steady-state concentration varied from 4 to 90 ppm by varying the air shutter opening from 0 to 47% open. At 18% O_2, the steady-state CO concentrations varied from 7 ppm to 153 ppm at the same shutter settings. As a result, steady-state O_2 levels are poor predictors of steady-state CO levels. In order to predict steady-state CO levels one must know the steady-state O_2 level (determined from the house volume, the air exchange rate, and the heater's fuel consumption rate), the type of heater used, and the state-of-tuning (i.e., shutter opening).

Under the same O_2 and shutter conditions, steady-state NO_2 and CO_2 levels were also investigated. At 20% O_2, NO_2 levels varied from 1.8 to 2.3 ppm and CO_2 levels varied from 6,200 to 6,800 ppm. At 18% O_2, NO_2 levels varied from 2.6 to 3.7 ppm and CO_2 levels varied from 15,800 ppm to 15,900 ppm. Obviously O_2 levels are better predictors of NO_2 and CO_2 levels than they are of CO levels.

FIELD STUDIES: The Walnut Creek house data reduction has been completed. The results were presented at the International Symposium on Indoor Air Quality, Health, and Energy Conservation. One of the results of the study showed that a range hood removes 60 to 87% of the pollutants from a gas stove when the hood is operated from 90 to 240 ft^3/min.

December 1981/January 1982

No input.

4. Passive Monitors

October/November, 1981

CARBON MONOXIDE: Tests showed that $K_2Pd\ (SO_3)_2$ was more reactive than $PdCl_2$ at typical humidity levels. Neither compound was reactive at humidities of less than 20%. The use of a fine mesh silica gel as a humidifying agent and substrate for $K_2Pd\ (SO_3)_2$ is being investigated. Preliminary results are encouraging.

FORMALDEHYDE: Pre- and post-exposure stability tests were run for up to two weeks. Excellent results were obtained in both cases. The sensitivity of the passive monitor sampling method was increased by a modification of the chromotropic acid analytical method. Experiments are in progress to verify the passive monitor sampling rate measured previously.

December 1981/January 1982

CARBON MONOXIDE: A comparison was made between silica-coated thin layer chromatography (TLC) plates and fine mesh silica gel impregnated upon acetate sheets to determine the best matrix for palladium-catalyzed carbon monoxide oxidation. Both types of silica responded well, although TLC plates are more convenient. TLC plates coated with $K_zPd(SO_3)_2$ showed a linear relationship between exposure time and reactivity when exposed to 20 ppm CO. TLC plates coated with $K_zPd(SO_3)_2$ were stored during the laboratory shutdown period. When exposed to carbon monoxide, they showed a diminished capacity to react. Other sulfite and hydrated palladium compounds are under consideration as possible sites of CO oxidation.

FORMALDEHYDE: The investigation of the passive monitor sampling rate was continued by running a series of constant exposure tests.

FIELD STUDIES: Four LBL office trailers were screened for high formaldehyde concentrations with passive monitors. Two locations in two trailers were subsequently monitored side-by-side with the standard LBL bubbler method and passive monitors. The agreement between the two methods was good. Eight energy-efficient houses in California were screened for high formaldehyde concentrations.

5. CONTROL TECHNIQUES

October/November, 1981

LABORATORY TESTING: Our thermal and humidity control system was upgraded and performs well. A series of tests were initiated to determine the temperature at the onset of freezing in the Flakt heat exchanger. Tests will be run with indoor relative humidities of 25, 40, and 60 percent. A paper on laboratory test results was presented at the Amherst conference. Work was initiated on a small computer system to log data and analyze test results at our test facility.

Onset of freezing tests was completed for 60% relative humidity and initiated for 40% relative humidity. Several minor problems with our test system were corrected. A final report for the Amherst conference was completed. Worked on preparation of a temperature, humidity, and flow measurement system for interface with the computer. A new Sr. Research Technician started work in late November to assist with our laboratory program.

FIELD PROGRAM-ROCHESTER: Continued work on the first draft of Rochester final report. A shorter paper on the Rochester study was completed and presented at the Amherst conference.

ENERGY AND ECONOMIC ANALYSIS: Work continued on the report describing results from this analysis. First draft should be completed in early December.

December 1981/January 1982:

LABORATORY TESTING OF HEAT EXCHANGERS: Onset of freezing tests are nearly completed for the Flakt heat exchanger. When the indoor temperature is 68°F, freezing occurs if the outdoor temperature is less than 25, 27, and 21°F, respectively, for indoor relative humidities of 60, 40, and 25 percent. With relative humidities of 40 and 60 percent, condensed water drains toward the colder regions of the core and freezes into a fairly transparent ice. When the indoor relative humidity is 25 percent, a layer of white frost forms on the colder regions of the core; apparently by sublimation since little or no condensation is observed.

Preparations are underway for an evaluation of the ventilation efficiency of two small wall-mounted heat exchangers (the Mitsubishi and Sharp units). The studies will be performed in the radon research house. A tracer gas (sulfur hexafluoride) will be injected into the test space and mixed until the concentration is uniform. With and without the heat exchanger operating, tracer gas concentration will be measured versus time at eight indoor locations. For initial tests, the ventilation of a single room will be studied; however, for later tests we will study the ventilation of three interconnected rooms.

ENERGY AND ECONOMIC ANALYSIS: A draft of the report describing results from this analysis is being reviewed.

AIR WASHING: We are initiating research to determine if air-washing is a suitable technique for removing contaminants from indoor air. Available literature is being reviewed and theoretical calculations are

being performed for a preliminary assessment. The technique appears fairly promising for the removal of formaldehyde and inappropriate for removal of radon. The feasibility of washing out nitrogen dioxide (NO_2) depends highly on the rate of reaction between dissolved NO_2 and water, and this reaction is poorly understood at low concentrations. Various additives to the water are being considered.

In preparation for laboratory tests of air-washing, a formaldehyde injection system is being designed. This system will allow us to produce airstreams carrying a range of steady-state formaldehyde concentrations.

COLLABORATIVE ACTIVITIES

Passive monitors for radon, nitrogen dioxide, and formaldehyde were given to a University of California, Berkeley, group so they could monitor indoor air quality at 16 energy-efficient houses for the California Energy Commission. (Dec/Jan)

MEETINGS/CONFERENCES

The following individuals presented papers at the International Symposium on Indoor Air Pollution, Health and Energy Conservation in Amherst, MA, October 13-16: William Fisk, Kristin Geisling, John Girman, Craig Hollowell, William Nazaroff, Tony Nero, Bud Offermann, and Greg Traynor (October).

Tony Nero presented a paper entitled "Indoor Radon Sources, Concentrations, and Standards" at the winter Meeting of the American Nuclear Society, held in San Francisco, Nov 30-Dec 4, 1981 (November).

PERSONNEL

Thuc Bui, a graduate student pursuing a PhD in Mechanical Engineering at UC Berkeley joined the radon group in October.

Helmut Feustel, a visitor from Germany to the Energy Performance of Buildings group, will be working with the radon group for several months on the new Aardvark Field Project, beginning in October.

Brian Pederson joined the heat exchanger project on November 21 as a Sr. Research Technician.

VISITORS

Donald Lavery, a consultant for Kero-Sun, visited the Combustion Appliance Group and was given a tour of the facilities. (Dec/Jan)

PROBLEMS

DELIVERABLES

The papers presented at the International Symposium on Indoor Air Pollution, Health and Energy Conservation served as a technical review of the LBL Building Ventilation and Indoor Air Quality Program (Oct/Nov):

W.J. Fisk and C.D. Hollowell, Performance Measurements for Residential Air-to-Air Heat Exchangers, LBL-12559.

K. Geisling, M. K. Tashima, J.R. Girman, R.R. Miksch, and S. Rappaport, A New Passive Monitor for Determining Formaldehyde in Indoor Air, LBL-12560.

R.R. Miksch, C.D. Hollowell, and H. Schmidt, Trace Organic Contaminants in office Spaces, LBL-12561.

J.R. Girman, M.G. Apte, G.W. Traynor, and C.D. Hollowell, Pollutant Emissions and Source Strengths from Indoor Combustion Appliances and Sidestream Cigarette Smoke, LBL-12562.

G.W. Traynor, M.G. Apte, J.F. Dillworth, C.D. Hollowell, and E.M. Sterling, The Effects of Ventilation on Indoor Air Pollution from a Gas-Fired Stove: Test Results from a Single-Family Dwelling, LBL-12563.

W.W. Nazaroff, K.L. Revzan, and A.W. Robb, Instrumentation for a Radon Research House, LBL-12564.

A.V. Nero and W.W. Nazaroff, Distribution of Indoor Radon Concentrations and Source Magnitudes, LBL-12565.

C.D. Hollowell, J.V. Berk, S.R. Brown, J. Dillworth, and R.A. Young, Indoor Air Quality in Energy Efficient Homes and Retrofitted Residences, LBL-12566.

F.J. Offermann, C.D. Hollowell, and G.D. Roseme, Low Infiltration Housing in Rochester, New York: A Study of Air-Exchange Rates and Indoor Air Quality, LBL-12567.

The BVIAQ Program will also be reviewed during the Annual LBL Energy and Environment Division review in April, 1982.

MONTHLY PROGRESS REPORT
December/January--FY82

Building Energy Analysis Group

SCOPE OF WORK

Research and development in the Building Energy Analysis Group encompasses four major areas:

1) the testing, maintenance, and documentation of the DOE-2.1 computer program for analyzing the energy use of buildings;

2) validation of the DOE-2.1 computer program;

3) completing the development of DOE-2.1; and

4) developing the next generation of the DOE energy-use analysis computer program.

OBJECTIVES

1. DOE-2 TESTING, MAINTENANCE, AND DOCUMENTATION

In view of the decision to terminate further development of DOE-2 in its present form after FY'83, it is imperative that the code be as free from error and as accurately documented as possible by that time. This project has, accordingly, three major objectives:

1) to test the program thoroughly, both internally and with the help of outside consultants, before release;

2) to fix "bugs" as they are discovered;

3) to complete remaining documentation tasks as well as correcting any errors in the existing documentation.

2. DOE-2 VALIDATION

To contribute to the validation of DOE-2 from a technical perspective by:

1) discovering what data on building energy performance currently exist to serve as a check on the validity of DOE-2; and

2) working from the DOE-2 code itself, propose data collection projects that would test the validity of the algorithms used in DOE-2.

3. DOE-2 DEVELOPMENT

To complete the work on DOE-2.1 during FY82 and FY83. By "complete" is meant to supply those features that will make DOE-2.1 a useful program for the design and research community for many years to come without requiring continuous upgrading. Specifically, to eliminate the artificial split between LOADS and SYSTEMS; i.e., to develop a new,

higher-order program.

4. NEW ENERGY-USE ANALYSIS PROGRAM DEVELOPMENT

To develop a sophisticated energy-use analysis computer program that will transcend the limitations of existing public-domain models, especially in modeling innovative suggestions for passive design or energy-efficiency. The program to be developed will have the following properties:

1) It will not introduce spurious effects due to its inherent structure.

2) It will be separated into modules that represent the various heat-flow phenomena and routes so that 1) different people can work on different parts of the program in concert, and 2) improvements to algorithms can be made easily as knowledge increases.

3) It can be expanded to incorporate new devices and control strategies without altering the rest of the program.

4) It will have a "friendly" interface with the user so that input will be simple and output user-designed.

5) It will be transferable among the machines of the major computer maufacturers.

The objective of this project is, over the next two years and in association with other groups in the research community, to develop an overall strategy and structure for the proposed program and a cooperative strategy for its creation.

RESEARCH ACTIVITIES DURING REPORTING PERIOD

1. DOE-2 Testing, Maintenance, and Documentation

October/November, 1981

TROMBE WALL (DOCUMENTATION): Testing continued on the Trombe wall model (vented and unvented). A model house was developed to compare results with and without the wall. Initial documentation of the model was done. This will be completed in December. Work began on integrating Trombe walls with the daylighting code from Fred Winkelmann.

VAX VERSION: Modifications to run DOE-2.1A on VAX computers have been completed. All sample runs have been on the VAX. TRY and 1440 weather packing has been successfully tested on the VAX.

SYSTEM DEFAULTS:

METRIFICATION:

HOURLY REPORT MODS:

PROGRAM MANUAL:

REFERENCE MANUAL: The custom weighting factor caution and error message description has been rewritten to conform to the DOE-2.1A Automatic Custom Weighting Factor program.

2. DOE-2 Validation

BUILDING SURVEY (VALIDATION):

VALIDATION PAPER:

3. DOE-2 Development

October/November, 1981

SHERMAN-GRIMSRUD INFIL.:

SCHEDULE LIBRARY:

INSOLATION ALGORITHMS:

DAYLIGHTING: Debugging of the daylighting calculation routing using MNF4 TRACE was completed. Four daylighting summary reports were designed and implemented: LS-G, Space Daylight Summary; LS-H, percent lighting energy reduction by daylighting vs. hour-of-day (for each space); LS-I, percent lighting energy reduction by daylighting vs. hour-of-day (for entire building); and LS-J, daylight illuminance frequency of occurrence. These reports were formulated with advice from Steve Selkowitz (Windows & Daylighting) and Eliahu Ne´emann, a visiting daylighting expert from Israel. Twenty-nine daylighting-related variables were added to hourly reports.

December 1981/January 1982

Daylighting: New daylighting summary reports LS-G, LS-H, LS-I, and LS-J were debugged. A plan was developed (with Windows & Daylighting Group), to validate the DOE-2 daylighting proram against LBL/UCB sky simulator measurements on scale models and against a very detailed daylighting computer program called SUPERLITE.

WINDOW ALGORITHMS: Discussions were begun with Steve Selkowitz and Richard Johnson (of the Windows & Daylighting Group) on improvements to the DOE-2 windows and shading calculations. One possibility being considered is extending the ASHRAE shading coefficient concept such that each window would have several different shading coefficients -- one for sky diffuse radiation, one for ground diffuse radiation, and a set, for direct radiation, which depend on incidence angle.

MODIFIED THERMAL BALANCE:

SHADING:

FUNCTIONAL VALUES:

THERMINAL UNITS:

HEAT EXCHANGERS/EVAP COOLER:

RESPONSE FACTORS: The revised response factor code has been implemented in DOE2.1 DEV. Test runs show that this version is 20 to 30 times as fast as the previous code.

HOURLY REPORTS: Work has begun to implement a change in the HOURLY-REPORT format. It is proposed that for each day, month, and year there be provided the sum, average, maximum, and minimum for each variable required.

4. New Energy-Use Analysis Program

5. Miscellaneous

October/November, 1981

Fred Winkelmann attended a meeting sponsored by IBM's Real Estate and Construction Division to advise on technology transfer of building-energy-related work done over the last five years at the IBM Scientific Research Center in Los Angeles. Topics discussed were weather data grouping, daylighting, HVAC systems modelling, simplified energy functions, and automatic optimization.

COLLABORATIVE ACTIVITIES

MEETINGS/CONFERENCES

PERSONNEL

VISITORS

PROBLEMS

DELIVERABLES

MONTHLY PROGRESS REPORT
December/January--FY82

Lighting Systems Research

SCOPE OF WORK

The work in this program may be divided into five major areas: 1) advanced lighting systems research; 2) integrated lighting design research; 3) energy-efficient light sources; 4) visibility, and 5) health and environment.

OBJECTIVES

1. ADVANCED LIGHTING SYSTEMS RESEARCH

ADVANCED LAMP CONCEPTS: To measure and assess the performance of gas-discharge lamps at high frequency to determine their optimum performance range and the basis for their increased efficacy.

ADVANCED BALLAST CONCEPTS: To develop ballast circuits and components that can improve the performance of the current designs and permit operation at high frequencies (greater than 40 kHz).

ELECTROMAGNETIC INTERFERENCE: To measure the conducted and radiated EMI from solid-state ballasts and other lighting systems. Based upon a cumulative effect, to develop a computer model that simulates the generation of EMI in buildings and communities.

2. INTEGRATED LIGHTING DESIGN RESEARCH

ADVANCED LIGHTING COMPONENTS: To compile all available data on energy-efficient lighting.

CONTROLS RESEARCH: To develop innovative design concepts for automatic control systems by compiling data on the performance of control strategies and techniques and how those would incorporate new lighting technologies.

3. ENERGY-EFFICIENT LIGHT SOURCES

Hg ISOTOPE SEPARATION: To review potential commercial forms of Hg isotope separation methods and to determine which may be viable.

NEW PLASMA GASES: To explore the use of various gases as sources of UV for exciting the phosphor in a gas-discharge lamp.

Hg ISOTOPE ENRICHMENT: To determine the maximum obtainable efficiency for a gas-discharge lamp by reducing the entrapment of the UV through an optimum Hg isotope mix.

4. VISIBILITY/VIDEO DISPLAY TERMINALS

To determine which types of light sources contribute to visual fatigue for users of video display terminals.

5. HEALTH AND ENVIRONMENT

To complete construction of a test chamber and to conduct qualitative experiments to identify human responses to various lighting systems and conditions.

RESEARCH ACTIVITIES DURING REPORTING PERIOD

1. Advanced Lighting Systems Research

October/November, 1981

ADVANCED LAMP CONCEPTS: The starting performance curves of several standard low-pressure gas-discharge lamps have been measured from 60Hz to 100 kHz. The peak and RMS starting voltages have been recorded. A brief report has been completed.

The 400 w solid-state HPS ballasts from Data Power have been tested and are on life test. The ballasts show a 7% improvement in system efficacy, which is about the same efficacy as that of the Phase I ballasts. The final report is in progress and should be published.

The Luminoptics HPS solid-state ballasts have been received and will be tested in December. The final report is being prepared.

Litek International has delivered its lamps. LBL tests confirm the efficacy of these lamps at 53 lumens per watt. They are now on life-test. Litek's final report is published. LBL's report will be complete in December.

Spellman has delivered a lamp and is preparing its final report.

ELECTROMAGNETIC INTERFERENCE: LBL, with NEMA and the Naval R&D Center, is planning a two-day seminar to be held at LBL to explore EMI issues.

December,1981/January, 1982

ADVANCED LAMP CONCEPTS: Duro-Test delivered their lamps and will submit a final report in February. Westinghouse is scheduled to complete their contract in February. All tests are in progress.

ELECTROMAGNETIC INTEREFERENCE: The seminar is scheduled for March 18 and 19. R. Verderber visited with the committee; all the speakers have been obtained.

Invitations will be sent to about 100 people in early February.

2. Integrated Lighting Design Research

October/November 1981

CONTROLS RESEARCH: LBL is compiling the data from the PG&E and World Trade Center control demonstrations. We are also placing the computer program designed by Smith, Hinchman and Grylls on our computer. When this is complete we will be validating the computer program.

December 1981/January 1982

ADVANCED LIGHTING COMPONENTS: Data are still being compiled. Smith, Hichman & Grylls report was published.

3. Energy-Efficient Light Sources

October/November, 1981

Hg ISOTOPE ENRICHMENT: We have obtained our first results in the measurement of the 185 nm and 254 nm emission line from our test lamps. The relative intensities of these lines are near the predicted ratios. Thus, our instrumentation appears to be suitably calibrated. Little work has been done since the main scientist on this project left to visit China for a month and the question of funds minimized this work.

Two Chinese scientists would like to work with our staff for a year in this area. Depending upon funding, we wish to take part in this interchange in accordance with recent government edicts.

Hg ISOTOPE SEPARATION: No effort. We have an unsolicited proposal which we wish to support. We need a definitive budget to get it started.

December 1981/January 1982

Hg ENRICHMENT: Test lamp has been completed and is being tested for performance. If it meets our requirements, isotope tests will be made.

We are comtemplating some theoretical studies in this area to support our experiment.

Hg ISTOPE SEPARATION: Visited GTE to start contract so they can start work in this area.

NEW PLASMA GASES: No effort. We have a suitable unsolicited proposal. As for the above project, we need the new budget to start the subcontract.

4. Visibility/Video Display Terminals

October/November, 1981

The visibility laboratory is near completion. All of the display terminals and the Apple computer are in place. We are awaiting completion of the lighting system. It should be complete in January.

December 1981/January 1982

The lighting system has been completed. Symposium was attended in Ottawa, Canada; a paper was presented.

5. Health and Environment

October/November, 1981

The isolation test chamber has been shipped to the U.C. Medical Center. It has been painted, and the last of the lighting system was constructed at LBL.

The initial dry run of the system should be started in December to determine if the specified design requirements can be met (light levels, uniformity, relative light levels, and flicker ratios).

December 1981/January 1982

Test chamber is undergoing testing. Preparations are being made to obtain subjects for testing.

COLLABORATIVE ACTIVITIES

R. Verderber met with the California Energy Commission to assist in establishing criteria for high-efficiency ballasts. He also contributed to this group's health and safety measures for the new ballasts (Oct/Nov).

R. Verderber addressed the NEMA EMI radiation subcommittee (Oct/Nov).

R. Verderber visited the FCC to discuss their attitude toward the introduction of high-frequency equipment in the field of lighting. They indicated that they wished LBL to assist them in this area (Oct/Nov).

S. Berman visited EPRI to discuss the LBL lighting program (Oct/Nov).

We are waiting for the final report of 1980/81 activities from NBS (Oct/Nov).

MEETINGS/CONFERENCES

R. Verderber presented two papers on the VA Medical Center Report at the IEEE-IAS Meeting (Oct/Nov).

R. Verderber and F. Rubinstein presented invited papers at the Chicago International Energy Management Show, sponsored in part by the Chicago DOE office. R. Verderber also chaired a session. The above talks were concerned with solid-state ballasts and control systems (Oct/Nov).

Ottawa, Canada -- Public Work Symposium on Visual Performance: R. Clear, S. Berman, invited paper, "Relating Productivity to Visibility and Lighting." (Jan 25-27).

PERSONNEL

We are considering inviting two Chinese Scientists to work in the Physical Lighting Laboratory for a year as part of a U.S.-China exchange program (Oct/Nov).

VISITORS

M. Flynn, Thomas Industries (Oct/Nov)

H. Vaapamies, Oy Helvar (Oct/Nov)

J. Sherman, U.S. Navy Ships (Oct/Nov)

P. McNally, NBS (Oct/Nov)

PROBLEMS

Confirmation of the 1981/82 budget (Oct/Nov).

DELIVERABLES

October/November, 1981

15 Ballasts - Data Power

10 Lamps and Final Report - Litek

15 Ballasts - Luminoptics

December 1981/January 1982

1981 Annual Report - NBS

10 Lamps submitted - Duro-Test

Lamp and Final Report - Spellman

MONTHLY PROGRESS REPORT
December/January--FY'82

Windows and Daylighting Program

SCOPE OF WORK

Activities in the Energy-Efficient Windows and Daylighting Program encompass five major areas: 1) fenestration component performance; 2) fenestration optimization; 3) Mobile Window Thermal Test (MoWiTT) facility; 4) daylighting energy analysis; and 5) daylighting illumination research.

OBJECTIVES

1. FENESTRATION COMPONENT PERFORMANCE

To develop and expand the technical basis for determining the energy-related performance of glazing materials, window and skylight components, and fenestration systems. This project includes analytical modeling, laboratory and field measurements of performance, materials science studies, and exploratory development of advanced concepts in fenestration systems.

2. FENESTRATION OPTIMIZATION STUDIES

To integrate the technical performance data obtained by related projects into a comprehensive and usable set of guidelines that can assist designers in optimizing the energy-related performance of fenestration as a function of building type, occupancy, and climate.

3. MOBILE WINDOW THERMAL TEST (MoWiTT) FACILITY

To experimentally determine the net energy performance of fenestration systems by a method that permits direct comparison of the energy saved with different products, building designs, and operational strategies. Construction and operation of this mobile, modularized test facility will allow direct and accurate measurement of net energy flows through fenestration while maintaining that fenestration in a simulated building environment. This facility will provide basic performance data for 1) validating the detailed treatment of windows in computer codes that model building performance (e.g., DOE-2); 2) developing a new series of field-test procedures; 3) accelerating the specification and incorporation of fenestration products by convincingly demonstrating their in-situ performance; 4) identifying the performance characteristics required for new products.

4. DAYLIGHTING ENERGY ANALYSIS

To develop the technical basis for implementing daylighting strategies in new and existing buildings when such strategies promise to reduce energy consumption, reduce peak electric loads, and improve lighting quality.

5. DAYLIGHTING ILLUMINATION RESEARCH

To develop and validate predictive and evaluative tools that will assist in determining the daylight illumination levels and patterns which result from traditional and novel fenestration designs. These studies are a prerequisite to a related project that examines the energy and load implications of daylighting in commercial buildings.

RESEARCH ACTIVITIES DURING REPORTING PERIOD

1. Fenestration Component Performance

October/November, 1981

MATERIALS SCIENCE: Performed infrared spectroscopy on several 3M and ICI polyester film materials. Aside from dependency on thickness, absorption/transmission data is similar for all samples.

Performed auger spectroscopy on dielectric/metal solar control films by Deposition Technology, Inc. Films are titanium and stainless steel based.

Completed a paper invited for publication by the Vortex, a journal of the American Chemical Society. Paper, "Materials Chemistry and Optical Properties of Transparent Conductive Thin Films for Solar Energy Utilization," will be published December 1981. (LBL 13502)

Began paper entitled "Microstructure and Optical Properties of High-Transmission Coatings for Plastics" to be submitted to the International Journal of Polymeric Materials. (LBL 13396)

Revised LBL 13502, which will be published in the Vortex, journal of the American Chemical Society.

Worked on a paper dealing with the chemistry and optical properties of antireflected polyester.

Reviewed a paper for the ASTM-MICON conference in January, 1982, Houston TX.

Met with Ben Meckel of Deposition Technology, Inc., to discuss the use of IR-reflective and IR-transparent overcoating materials for thin metal heat mirrors.

ANALYTICAL MODELS: Submitted paper entitled "Infrared Properties of PET Films" to Solar Energy Materials. The paper derives the properties for calculating window heat transfer, providing simplified expressions for emittance and transmittance of films as functions of thickness.

Developed new representations for the solar optical properties of windows. A draft paper shows the advantages of Legendre polynomials over traditional power series representations and demonstrates that Zeroth order term is equal to hemispherical average property. Also, a

family of rational functions is shown to give much better accuracy than polynomials.

ANALYTICAL MODELS--AIR INFILTRATION: Report on air infiltration through windows was completed and submitted for publication to Energy & Buildings.

LABORATORY TESTS: We have been forced to vacate space previously utilized in Wurster Hall, U.C. College of Environmental Design. All testing in the Building Technology Laboratory has been suspended pending relocation of test equipment. Some equipment will be relocated in Wurster Hall. Other experiments will be moved to LBL.

FIELD TESTS--INSULATING SHADE/YALE DEMONSTRATION: Subcontractor (Arga Associates) has completed a report to Insulating Shade. We have received an advance copy, and are awaiting formal submission of a full report by Insulating Shade.

FIELD TESTS--AIR-FLOW WINDOWS: No change for University of Utah or Arizona.

December 1981/January 1982

MATERIAL SCIENCE: Wrote paper entitled "Durable Innovative Solar Optical Materials--the International Challenge." Presented the paper at the International Optical Engineering Society (SPIE) Technical Symposium in Los Angeles in January. Paper will be published in the SPIE Proceedings for January. Constructed two posters that display results of research work on transparent heat mirrors for energy-efficient windows.

ANALYTICAL MODELS: Paper, "Infrared Properties of Polyethalene Terephthalate," was accepted for publication by Solar Energy Materials. Measured daylight transmittance of float glass and calculated transmittance of double- and triple-glazed windows. Approximated the directional properties with simple functions in preparation for studies on the effect of window elevation. Derived solutions for reflectance from inhomogeneous antireflection coatings. Propose to measure index profile by holographic interferometry. Studies of shading coefficient show unacceptable variation with angle of incidence and ratio of direct to diffuse radiation. Devised new procedure which accounts for these variations and averages over the day.

FIELD TESTS--AIR-FLOW WINDOWS: Draft report from University of Arizona has been reviewed and returned to contractor for revision.

2. Fenestration Optimization Studies

October/November, 1981

BUILDING ENERGY USE MODEL/DOE-2: Completed and submitted paper, "Glazing Optimization Study for Energy Efficiency in Commercial Office Buildings," for presentation at the Third International Symposium on Energy Conservation in the Built Environment to be held in Dublin, Ireland, March-April of 1982.

Work continues to further analyze results and display graphics. Computer program procedures are being documented. Planning is underway to extend the investigation to other fenestration systems, in particular fixed and operable solar shading, optical shutters, and operable insulation.

MODIFICATIONS TO DOE-2: Several meetings were held with F. Winklemann to discuss results from initial runs of DOE 2/Daylight. The glare algorithum was revised and new output formats were developed. Initial proposals for a new approach to treating shading coefficients of complex devices were reviewed.

CALCULATION AND DESIGN METHODS:

FIELD PERFORMANCE EVALUATION/CASE STUDY DATA BASE:

December 1981/January 1982

MODIFICATIONS TO DOE-2: Planning for extension of studies continues. Several discussions have been held with Fred Winkelmann regarding the modeling problems with window-shading devices and modifications to DOE-2.

3. MoWiTT Facility

October/November, 1981

MANAGEMENT AND CONSTRUCTION: The steel frame for the outer module was completed, including undercarriage. Framing and finishing of the outer unit is in progress; delivery to LBL is expected during the second week in December. The insulated panels and cable conduits have been installed on the interior chambers, which are almost ready to be installed in the outer module.

EXPERIMENTAL DESIGN AND HARDWARE SYSTEM: Design of the wattmeters for measuring heater input has been completed. Components for monitoring the coolant heat flow have been ordered. Work continued on the data base and executive software.

A paper describing the MoWiTT, by J. Klems, S. Selkowitz, and S. Horowitz, was submitted to the Third International Symposium on the Energy Conservation in the Built Environment, to be held in Ireland in March-April of 1982.

HEAT-FLOW METER: Evaluation of tests on the first heat-flow meter prototype was completed. The prototype shows excellent linearity of response to heat flux. A report describing the work on the heat-flow meter is being prepared for publication.

Calibration of two additional prototypes and tests of the first prototype under conditions of compression and of nonuniform heat flow have been done. The data currently await evaluation.

December 1981/January 1982

MANAGEMENT AND CONSTRUCTION: The outer unit of the MoWiTT arrived at the Laboratory on December 11. The unit's condition and construction are generally of high quality and meet or exceed our specifications.

Inspection of the inner unit, under construction in the LBL shop, revealed potential air leaks between the metering chambers and the air guard. These generally involved a complex 3-dimensional leakage path and in some cases resulted from manufacturing defects in the bonded fiberglass panels (e.g., delamination). Modification of the unit to eliminate the potential leakage paths and correction of the manufacturing defects are underway. Fabrication of the metering chamber's heating and cooling units is also underway.

EXPERIMENTAL DESIGN AND HARDWARE SYSTEM: Software interfaces for driving ADAC pulse counter boards (which accumulate flow-meter data) and DAC boards (which drive the HVAC control system) have been completed. Part of the Building Technology Laboratory has been moved to a trailer adjacent to the site where the MoWiTT will be checked out and calibrated. A prototype of the instrumentation and control system is being assembled to permit software-debugging prior to completion of the MoWiTT module.

HEAT-FLOW METER: A paper describing work on the heat-flow meter has been completed and is undergoing final editing. We explored methods for economically fabricating the heat-flow meters in quantity. We identified several alternative modifications to the laboratory prototype which would reduce cost of fabrication. Engineering prototypes for each alternative are being fabricated and will be tested.

4. Daylighting Energy Analysis

October/November, 1981

DAYLIGHT RESOURCE ASSESSMENT: Met with regional air quality board personnel to discuss sources of climatological data, primarily turbidity and humidity. Installation of the new vertical surface illuminance tower was completed. Overlays for determination of ground reflectance effects from the previous tower were completed.

ANNUAL ENERGY CALCULATION: First draft of the nomographs for estimating energy savings were received from TID and are being reviewed.

LOAD MANAGEMENT STUDIES: Discussions are underway with EPRI on the subject.

DAYLIGHTING CONTROLS:

OPTIMIZATION STUDIES OF COMMERCIAL BUILDINGS: See writeup under Fenestration Optimization.

DAYLIGHTING FIELD EVALUATION: We are continuing to formulate a data-collection plan.

December 1981/January 1982

DAYLIGHTING RESOURCE ASSESSMENT: A second tower to support illumination sensors has been placed on the roof of Building 90. Sensor housings are being designed and fabricated. The Dogniaux formula for zenith luminance at high sun elevation appears to be in error. We are exploring alternative formulae.

ANNUAL ENERGY CALCULATION: The DOE-2/Daylight model results are being systematically compared to SUPERLITE results and model measurements in the artificial sky.

DAYLIGHTING CONTROLS: The SKY 3 program is being used to estimate the effect of various lighting control strategies.

OPTIMIZATION STUDIES OF COMMERCIAL BUILDINGS: Analysis of data from parametric runs for four cities is continuing.

DAYLIGHTING FIELD EVALUATION: Contacts have been made with owners of a number of candidate buildings to investigate problems of access to the buildings.

5. Daylighting Illumination Research

October/November, 1981

GRAPHIC DESIGN METHODS/TOOLS: Expanded and improved computer graphics program that produces polar contour plots of daylight illumination. The plots are used as overlays to LOF sun-angle calculators. Plots can now be produced interactively on the terminal as well as on a plotter or 35-mm film.

COMPUTATIONAL DESIGN METHODS/TOOLS: A version of QUICKLITE in BASIC was developed. Limited work continues on the QUICKLITE Users Manual.

PHYSICAL MODELING (DESIGN METHODS/TOOLS)--ARTIFICIAL SKY: As part of the instrumentation of the artificial sky for model studies, the small switchbox with 12 Li-Cor photocells was completed and used during sky simulation operation by U.C. Berkeley students.

Construction of the ground reflectance simulator continued.

Housings for the aircraft landing lamps were constructed and used to simulate a series of high-ratio helios around the sun for clear-sky distribution and direct sun studies. The new design for simultaneous simulation of direct sun and its helios was constructed, and is now being tested with different projection lamps, such as the (BHC/DYS/DYV) 600w, 120v Tungsten halogen and (DVY 650w) Tungsten halogen. As a part of the use of the facility for teaching, the sky simulator was calibrated for C.I.E. overcast and clear skies. It was used during November by graduate studies in the School of Architecture at U.C. Berkeley.

DAYLIGHTING RESOURCE CENTER--DATA BASES: All 900 entries have been input into the SPIRES data base system. This completes the first round of the daylighting bibliography. A complete printout is being edited and revised. Formats for input and output of the Who's Who data base are being written. Inputting of existing card files will then commence.

NOVEL DAYLIGHTING STRATEGIES:

DAYLIGHTING RESOURCE CENTER--RESOURCE PACKAGE: The first round of editing was completed by the Review Committee for Learning Unit 4 (integrated Design Methods). An editorial meeting was held on November 4th with Marietta Millet, author of Unit 4, to discuss final editing and to agree on a deadline. The author is providing final revisions to the UNIX output.

A decision to print and distribute each learning unit individually was agreed upon by the editor and executive editor.

December 1981/January 1982

COMPUTATIONAL DESIGN METHODS/TOOLS: A series of bugs has been identified and corrected in the SUPERLITE program. A contract extension for USC is being processed.

PHYSICAL MODELING (DESIGN METHODS/TOOLS)--ARTIFICIAL SKY: The new design for the direct sun and CIE clear sky distribution continued. The ground reflectance simulator was tested. Results show that, in order to achieve the equivalent of 100% ground reflectance under any sky conditions, high-intensity fluorescent lamps (110 watts) should be used. Two Licor photocells were calibrated in order to measure direct sun by simply adding a resistor to the small switch box. The measuring capability is up to 10,000 footcandles. As part of the DOE-2 computer program and the SUPERLITE daylighting program, the sky simulator was calibrated for sun altitudes 30 through 90, and model measurements were made. Further studies are underway. We are developing a design for two small boxes for measuring transmissivity of different types of glass at all angles of incidence.

NOVEL DAYLIGHTING STRATEGIES: A project was instituted with two graduate students to study the performance of designs incorporating light shelves.

DAYLIGHTING RESOURCE CENTER--DATA BASES: A complete printout of the bibliographic file of 900 entries has been generated so that proofreading and key wording can begin. Formats for inputs and outputs of the Who's Who file are being finalized before inputting can begin. Data input formats are being designed to assist current planning contracts with New York State ERDA, Bonnieville Power, and the Electric Power Research Institute.

DAYLIGHTING RESOURCE CENTER--RESOURCE PACKAGE: The author of Learning Unit 4 (Integrated Design Methods) is working on final revisions to the word-processed text. Learning Unit 19 (Instrumentation) was distributed (with no introduction) to the Daylighting Institute 1980 faculty

participants.

COLLABORATIVE ACTIVITIES

Met with BPA staff to discuss/refine R&D agenda. (Oct/Nov)

Finalized technical program for the SPIE/LBL conference on Optical Coatings for Energy Efficiency and Solar Applications. (Oct/Nov)

Contact was initiated with the Swedish research community to establish areas of mutual interest and to extend technology transfer. (Dec/Jan)

MEETINGS/CONFERENCES

Electric Power Research Institute, Palo Alto, CA -- S. Selkowitz met to discuss possible R&D activities. (Oct/Nov)

DOE/Washington, D.C. -- S. Selkowitz met with E. Bales and J. Boulin for program review. (Oct/Nov)

6th National Passive Solar Conference, Portland, OR -- S. Selkowitz presented a paper and chaired a Session (October).

American Vacuum Society, Anaheim, CA -- C. Lampert attended meeting (November).

Passive and Hybrid Cooling and Dehumidification Conference, Miami Beach, FL — S. Selkowitz and E. Ne´eman attended meeting, presented two papers and organized a seminar (November).

Florida Solar Energy Center, Cape Canaveral, FL -- met to discuss their daylight research activities (November).

C. Lampert met with Dr. Raghunathan of Berry Solar Products to discuss solar optical coatings and adhesives for thin laminants. He also met with Mr. Larry Legget, former president of AIRCO Temescal to discuss large-scale coating of glass. He met with Dr. John Thornton of Telic Corp. to discuss the future of cylindrical magnetron sputtering. (Dec/Jan)

C. Lampert served as chairman of the SPIE/LBL Conference on Optical Coatings for Energy Efficiency and Solar Applications (part of the SPIE Technical Symposium) in Los Angeles. He also organized a special night session on large-scale processing technology and research issues. S. Selkowitz served as session chairman. Session titles included "Transparent Heat Mirror Films," "Reflective Materials Research," "Solar Absorbers," and General Optical Coatings." (Jan)

DOE Passive Solar Commercial Buildings Workshop--attended by R. Johnson (Jan.)

ASHRAE Meeting in Houston, TX--R. Johnson attended (Jan.)

Occupant Response to Environmental Control--M. Wilde participated in several meeting on this project. (Dec/Jan)

DOE/Washington DC--S. Selkowitz met with Buildings Division staff for program review, and with G. Gillette, NBS, to coordinate daylighting research. (Dec/Jan)

Passive Solar Planning Meeting--S. Selkowitz attending R&D planning meeting at LASL. (Dec/Jan)

PERSONNEL

Prof. T. Nagata from Fukui University, Japan, arrived on an 8-month fellowship to work on daylighting. (Jan)

M. Spitzglas has arrived from the Technion Institute in Israel on a fellowship to participate in daylighting research projects. (Jan)

VISITORS

Prof. Hans Hauri, Technischen Hochschule, Zurich, Switzerland (testing for the development of a new facility in Zurich) (October).

Per-Lennart Beggren, Mats Olsson, Bo Gustafson, Nina Gustafson, from Thurfjell Arkitektkontor, Sweden (daylighting and annual energy modeling for design practice) (November).

Robert Higginbotham, Leo Egan, Egan Architects (reviewed and critiqued building design for daylighting and thermal efficiencies) (November).

G. Arnold, TVA (spent a week at LBL reviewing daylight research activities) (Dec/Jan).

D. MacGowan, University of Manitoba (visited to discuss glare research) (Dec/Jan).

P. McNill, NBS (discussed related research activities) (Dec/Jan).

Subajima and Ichiba, Teijin Inc. (visited to discuss heat-mirror technology) (Dec/Jan).

M. Melden, Exec. Director IES, and S. Squillace, Pres. IES, (visited to discuss daylight research) (Dec/Jan).

E. Bales and J. Boulin, DOE (visited for program review) (Dec/Jan).

K. Ribbing, Sweden (visited to discuss heat-mirror coatings) (Dec/Jan).

Susuki and Soma, Teijin, Japan (visited to discuss heat-mirror coatings) (Dec/Jan).

PROBLEMS

DELIVERABLES

Klems, J., Selkowitz, S., and Horowitz, S., "A Mobile Facility for Measuring Net Energy Performance of Windows and Skylights," Third International Symposium on Energy Conservation in the Built Environment. LBL 12765 (October).

Ne´eman, E., and Selkowitz, S., "Efficient Daylighting in Thermally Controlled Environments," Passive and Hybrid Cooling Conference. LBL 13399 (October).

Rubin, M., "Infrared Properties of PET Films," submitted to Solar Energy Materials. LBL 13347 (October).

Johnson, R., Selkowitz, S., and Winklemann, F., and Zentner, M., "Glazing Optimization Study for Energy Efficiency in a Commercial Office Building," Third International Symposium on Energy Conservation in the Built Environment. LBL 12764 (November).

Navvab, M. "Construction and Use of a Hemisphericial Sky Simulator," Master´s Thesis. LBL 13400 (November).

Lampert, C., "Materials Chemistry and Optical Properties of Transparent Thin Films for Solar Energy Utilization," paper invited for publication in The Vortex, a journal of the American Chemical Society. (LBL 13502) (December).

Lampert, C., "Durable Innovative Solar Optical Materials--the International Challenge," presented at SPIE Conference. (LBL 13753) (January).

ACKNOWLEDGEMENT

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