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DOE-2 USER NEWS
: A COMPUTER PROGRAM FOR BUILDING ENERGY USE ANALYSIS

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BULLETIN BOARD

Item: The long-awaited DOE-2 Engineers Manual has now been published and is available from NTIS. This document describes the engineering basis of the program. It contains detailed descriptions and derivations of the algorithms used to perform the program calculations. The order number is DE83-004575 and the cost is $59.50.

Item: The next version of the program, DOE-2.1B, is nearing completion at NESC, and is expected to be released next month. The DOE-2 Supplement will contain the documentation for using the new features and it, together with an updated BDL Summary, will be published concurrently with the release of the tape.

Item: The University of California, through the Continuing Education in Engineering, University Extension, is offering a three-day intensive course, "Building Energy Performance Analysis Using the DOE-2 Computer Program" on July 19 through 21, 1983, on the Berkeley campus. The course is being taught by James J. Hirsch and Fred Buhl, LBL, two of the principal authors of the program. It will cover the BDL input language, present overviews of the simulation techniques and program capabilities, and will include discussions of the new features in the 2.1B version of the code. Registration is limited and advance enrollment is required. The fee is $595, and if you use Visa or MasterCard, you may enroll by phone. For more information, call or write Dept. B, UC Extension, 2223 Fulton Street, Berkeley, CA 94720, (415) 642-4111.

ELECTRICAL GENERATION STRATEGIES

Renewed interest in cogeneration and the on-site production of electricity has prompted the development of improvements to the electrical generation sections in the PLANT subprogram of DOE-2. This interest has been stimulated primarily by the cost of purchased utilities but has been reinforced greatly by changes in regulatory attitudes toward grid-interconnection by small power producers. As a result of these changes, potential small producers have been accorded a substantial degree of flexibility in the design and operation of their systems. To reflect this changing need in the user community, new operating strategies for the generation of electricity are being introduced into the program, and the simulations of the generating equipment are being modified.

In particular, the passage of the Public Utilities Regulatory Policy Act (PURPA) removed the old constraint that cogeneration or on-site power production facilities usually had to leave the electricity grid entirely. DOE-2.1A reflected the effect of this constraint in that electrical equipment was scheduled to satisfy just the electrical load passed "down" to it from LOADS, SYSTEMS, and the cooling portions of PLANT (to the extent that sufficient generating capacity had been specified). Under the new law, however, the electrical demands of the facility are less of an over-riding concern, and other considerations can enter into the designer's evaluation of a system. For example, a high price offer by the utility for electricity bought from the small producer increases the incentive to maximize electricity production. Conversely, a low price for sales to the utility increases the need to maximize the use of the recovered heat in a cogeneration system.

When completed, DOE-2 will be able to simulate all of the cogeneration operating strategies that interconnection with an electricity grid now permits. These strategies are: tracking electrical demands, running full-out, tracking thermal demands, switching between these modes of operation, and not running at all. The new capabilities are being phased into DOE-2 sequentially.

Currently, DOE-2.1B has the capability to run electricity generating machines at full capacity, where the fuel-efficiency of the machines is typically at its highest. This option can be specified through the use of a new keyword in the PLANT-PARAMETERS command or can be scheduled with the traditional LOAD-ASSIGNMENT and LOAD-MANAGEMENT commands using a very simple modification. Along with this capability is a shorthand method for calculating the quantity of electricity sold to the utility. Both of these features are described in the upcoming DOE-2 Supplement.

For DOE-2.1C, work is in progress to permit the simulation of a cogeneration system that can track the thermal demands of a facility, can choose to follow the greater/lesser of the thermal or electrical loads, or not run at all.

The basic idea underlying the revisions is the explicit recognition that reciprocating engines, gas turbines, and steam turbines are all heat engines that, in principle, can be controlled to satisfy either a thermal or electrical load. That is, in simulating the performance of equipment, PLANT treats one productive output of the energy conversion processes of these prime movers as the input to an equipment simulation and, along with design information about the machines, calculates the other productive outputs and required inputs. Currently, only the electrical output of the machines can be the controlling input. Hence, at the heart of the new work is the revision of the equipment simulations so that the machines can operate to meet either a thermal or electrical load.

An additional benefit of the new equipment simulation structure will be greater ease in translating manufacturer's data into inputs for use in simulating such equipment. It should be noted too that reworking the simulations has been accompanied by revisions to the default performance curve coefficients. These new coefficients are being taken from readily documented sources, e.g. ICES Technology Evaluations.

Along with the new equipment simulations, the algorithms for allocating loads to the equipment, by default or by user input are being modified. Although, in effect, these algorithms will be allocating thermal demands to reciprocating engines or gas turbines, the user will continue to make a LOAD-ASSIGNMENT on the basis of an electrical LOAD-RANGE. The opportunity to refine the load allocation algorithms will also result in a more accurate calculation of the extra fuel required for an electrical generator so that the electrical output driving a compression chiller plus the thermal output running an absorption chiller just match the cooling demand.

The completion of the revisions to electrical generation sections of PLANT will greatly increase the power of DOE-2 to simulate the innovative cogeneration systems being contemplated for application in buildings. Comments or questions concerning these new capabilities are encouraged, as they will allow us to anticipate the present and future needs of the user community.

Looking even farther ahead, the final step in assessing cogeneration projects, indeed, all energy projects — the determination of the economic worth of the systems — will also be addressed in DOE-2.1C when we implement new capabilities for handling the myriad of utility rate structures, for both the purchase and sale of electricity, that are in use today.

NEWS FROM FRANCE

Many of our U.S. users might not realize how international DOE-2 has become. We have contact with users all over the world, but our friends, the RAMSES Group, at the Laboratoire de l'Accélérateur Linéaire, Université Paris-Sud, in Orsay, France, are not only running the program but are very active in code development as well. In fact, the metric conversion, available in DOE-2.1B, is a result of their collaboration with us.

They are presently developing new code to simulate low temperature (~ 95°F/35°C) radiant panels. Their code requires additional weighting factors to simulate the actual radiant effects on interior surfaces and on furniture, as well as to represent the delay in the conversion of absorbed heat into convective gains to the space. At the present time, it is not possible to change the radiant surface temperature via user input. Also, the ratio of convective/radiant heat off the panel is considered to be constant. Check the first item in the Heat Exchanger, page 5, for a discussion on modelling a radiant panel system using the U.S. version of the program.

Our own group member, Dr. Fred Winkelmann, is on a year's leave of absence working with the RAMSES Group in France. He is presently developing code for attached sunspaces. He tells us that the RAMSES Group has also started work on new code for fan-forced circulation of Trombe walls (a basic Trombe wall is now available in 2.1B). We can make no promises on the schedule for when these French features will be incorporated into our U.S. version of DOE-2, but do expect to add at least low temperature radiant panels in either 2.1C or D.

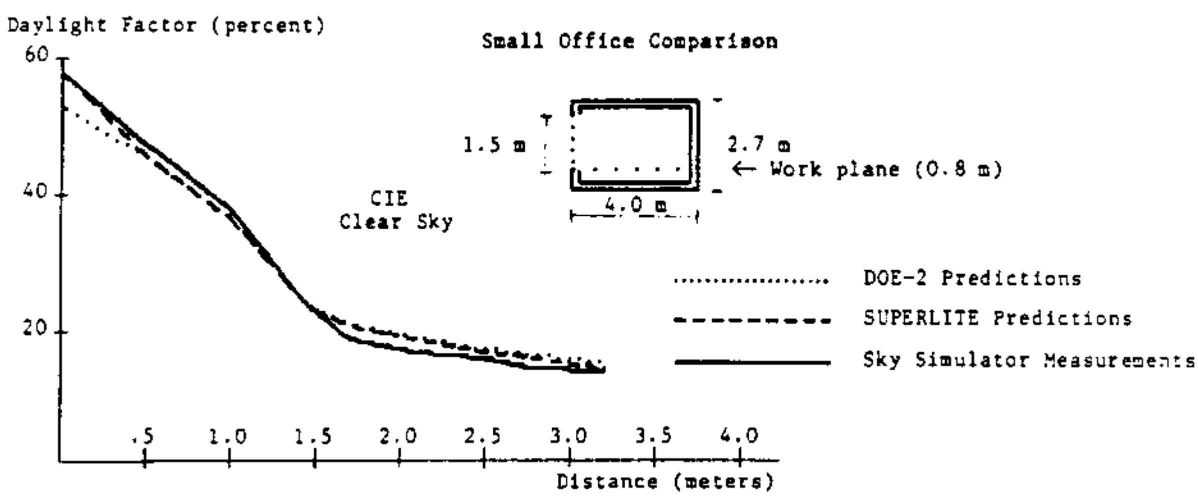
THE SKY SIMULATOR AT LBL

Lighting accounts for about 20% of the total electricity consumption in the United States. Using natural lighting is a cost-effective way to reduce this consumption, and at the same time, enhance the quality of the indoor environment. To successfully integrate daylighting as an energy-conserving strategy into the design process, the designer must have available appropriate tools to determine levels of interior daylight for different building configurations and orientations. Traditionally, model tests conducted out of doors have provided the practical data for most design decisions. With the advent, however, of the new generation of energy efficient buildings, often incorporating a multitude of innovative and complex daylighting schemes, it becomes important to be able to reproduce sky conditions for comparative measurement purposes in a way that Mother Nature cannot provide — the sky is a constantly changing light source and no two days are ever exactly alike. If detailed and accurate comparisons are needed between two or more alternative design strategies, a constant and reproducible "sky" is required for model testing.

For this and other reasons, researchers at Lawrence Berkeley Laboratory have recently developed a sky simulator — a dome-shaped enclosure 24 feet in diameter, within which scale-model buildings, up to 6 feet across (or 4 by 4 by 4), can be placed.† The simulator, which has a high-reflectance white interior surface illuminated by banks of high-output fluorescent lamps, is equipped with a lighting control system that allows easy conversion from one simulated sky condition to another including uniform sky, CIE overcast and CIE clear sky distributions. Other advantages of the artificial sky, in addition to its reproducibility, include the ability to separate the direct illuminance from the sun from the diffuse sky distribution, and the control of ground-reflected light.

Validation studies of the new daylighting simulation in DOE-2.1B have been carried out, in conjunction with the SUPERLITE program, against an extensive series of measurements made in scale models in the sky simulator. Good agreement was found among the three methods as illustrated below.‡ SUPERLITE is a very detailed main-frame program that predicts the spacial distribution of illuminance in a building. SUPERLITE and the sky simulator are now being used to develop the next generation daylighting algorithms for DOE-2. These algorithms will be able to simulate the performance of the more complex daylighting designs being utilized in current practice.

Given the value of this facility for design studies, computer model validation, and lighting quality studies, the sky simulator, located on the Berkeley campus, will be made available for teaching purposes and to assist design firms in evaluating building design concepts. With the information provided by these design tools, sky simulator and computer programs alike, scientists and designers will be better able to predict the potential electrical energy savings which maximize the useful role of daylight while minimizing adverse effects such as glare and excessive heat gain from sunlight.



† S. Selkowitz, "A Hemispherical Sky Simulator for Daylighting Model Studies", Proceedings of the 6th National Passive Solar Conference, J. Hayes and W. Kolar, eds, 1982, pp. 850-854, and LBL-12286 (and LBL-12967, abridged), July 1981.

‡ S. Selkowitz, J.J. Kim, M. Navvab, and F.C. Winkelmann, "The DOE-2 and SUPERLITE Daylighting Programs", Proceedings of PASSIVE '82: The National Passive Solar Conference, Knoxville, TN, August 29 - September 3, 1982 and LBL-14569, (June 1982).

MORE ABOUT SCHEDULES

In the last issue of the newsletter (February 1983), we presented some of the shortcuts that can be taken in the preparation of schedules. We will now discuss how schedules are used in the program; many of these issues are presented in the Reference Manual, but not in the unified manner attempted here.

Not many users have difficulties with schedules in the LOADS section of the program. However, it should be re-iterated that all of the internal gain schedules in SPACE-CONDITIONS command default to always "off". Therefore if one inputs both NUMBER-OF-PEOPLE = 10 and PEOPLE-HEAT-GAIN = 450, but fails to input a PEOPLE-SCHEDULE, the sensible and latent gains of people is never calculated. Identical problems will occur with ambient lighting, task lighting, equipment, and source gains whenever their schedules are omitted.

There is one exception to the above. Infiltration, which is input through the keyword INF-METHOD, defaults to always "on" rather than "off". Most users make the INF-SCHEDULE a mirror image of the FAN-SCHEDULE input in SYSTEMS as it is generally agreed that a building is pressurized when the fans are on. Therefore, these two schedules might appear as follows:

In LOADS

```
BLDG-INFIL = SCHEDULE THRU DEC 31 (ALL)
             (1,7) (1) (8,18) (0) (19,24) (1) ..
```

In SYSTEMS

```
FANS-ON = SCHEDULE THRU DEC 31 (ALL)
          (1,7) (0) (8,18) (1) (19,24) (0) ..
```

There are instances where the user may wish to deviate from the above. One example is an entrance where the infiltration might be better represented as a function of people traffic. An example for an office building might be:

```
ENTRY-INFIL = SCHEDULE THRU DEC 31 (ALL)
              (1,8) (.1) (9) (1) (10,12) (.2)
              (13) (1) (14,16) (.2) (17,18) (.8)
              (19,24) (.1) ..
```

Another example is a loading dock for a warehouse or factory where the infiltration is more a function of materials traffic. For a small bank or store one could even assign the same schedule to both people and infiltration.

In general, SYSTEMS schedules default to always "on". These schedules appear to cause more problems for users. FAN-SCHEDULEs are in themselves no problem, but some users assign the same values to the HEATING-SCHEDULE and COOLING-SCHEDULE when there is no need to do so since the program does not calculate a heating or cooling coil load unless the fan is scheduled "on". The real purpose of HEATING- and COOLING-SCHEDULEs is to lock out the availability of the coil transfer media on a calendar basis. This SYSTEMS information in turn controls the operating periods of boilers and chillers in PLANT. A new feature in DOE-2.1B will allow the user to control the availability of heating and cooling as a function of outside dry-bulb temperature — heating on below the setpoint, cooling on above the setpoint. An example of these schedules and their input is:

```
HEAT-ON = SCH THRU DEC 31 (ALL) (1,24) (65)  ..
COOL-ON = SCH THRU DEC 31 (ALL) (1,24) (55)  ..
```

HEAT- and COOL-RESET-SCHs seem to cause few problems, except that people sometimes forget that the DAY-RESET-SCH must be explicitly input since reset schedules cannot be nested. The reason for this is that the keyword SUPPLY-HI, OUTSIDE-HI, etc., are not legitimate keywords in any command except DAY-RESET-SCH. The real problem is the confusion between the use of reset schedules and HEAT- and COOL-SET-SCHs. The reset schedules are used to reset a medium as a function of outside air temperature (i.e., master, submaster, pneumatic controllers). The HEAT- and COOL-SET-SCHs are used to represent manual reset of media controllers (i.e., setting supply air temperatures at 55°F in summer and 65°F in winter through an EMCS).

The HEAT- and COOL-TEMP-SCHs are used to represent the zone thermostat setpoints for heating and cooling. Whenever the values between the heating setpoint and cooling setpoint are greater than the throttling range, the user is inputting a deadband. Some system types require that the user input only one type, HEAT- or COOL-TEMP-SCH; but no harm is ever done if both are input. However, if one fails to input the schedule that is required, the default will cause there to be no active control. When inputting these schedules, think of what you do with your own residential thermostat. If you have a 365-day programmable thermostat that has been programmed for a setback of 65°F at 10 PM and back to 72°F at 6 AM, weekdays, but different on weekends, the schedule might be input as follows:

```
DAILY-SETPT = WEEK-SCHEDULE (WD) (1,6) (65)
              (7,22) (72) (23,24) (65)
              (WEH) (1,10) (65) (11,24) (72) ..
HEAT-SETPT = SCH THRU MAY 15 DAILY-SETPT
                 THRU OCT 15 (ALL) (1,24) (55)
                 THRU DEC 31 DAILY-SETPT     ..
```

If you set the thermostat manually, but change the times to suit your work and weekend habits, the schedules might look like this:

```
HEAT-SETPT = SCH THRU DEC 31 (WD) (1,7) (65)
             (8) (72) (9,17) (70) (18,22) (74)
             (23,24) (65)            $ WEEKDAY $
             (SAT) (1,24) (65) $ GONE FISHING $
             (SUN) (1,9) (65) (10,22) (74)
             (23,24) (65)           $ SLEEP IN $
             (HOL) (1,8) (65) (9,13) (74)
             (14,24) (65) ..        $ VISITING $

HEAT-ON = SCH THRU MAY 15 (ALL) (1,24) (1)
              THRU OCT 15 (ALL) (1,24) (0)
              THRU DEC 31 (ALL) (1,24) (1)  ..
```

THE HEAT EXCHANGER

This section is devoted to questions from users and responses from the Building Energy Simulation group and its consultants. Your questions and comments are most welcome.

We have accumulated a number of questions concerning system modelling problems and therefore are devoting this issue to them.

* * * * *

Question: Can DOE-2 model a Radiant Panel Heating and Cooling system?

Answer: This question has come up several times recently. Some users have approached the problem using the Four Pipe Induction System (FPIU), by setting the INDUCTION-RATIO = 1.0 and COOL-CONTROL = WARMEST. This is a reasonable approach because the simulation of the induction system considers only sensible heating and cooling occurring at the terminal. It is true that radiant effects are not modelled, but since panel systems operate at such small temperature differences between the space and the panel, the energy is nearly the same as if it were all convective. All moisture removal and ventilation of the space is modelled as being performed by the primary air system. The user should, of course, assign the correct air flow to each space. (A low temperature radiant panel system is planned for incorporation in DOE-2.1C or D.)

* * * * *

Question: When inputting a restaurant, how can I model a kitchen exhaust and heat recovery system?

Answer: The problem in this case is to get the heat from the stoves, ovens and fryers directly into the exhaust air so that you can truly model the elevated temperature of the exhaust air. One approach that has been used is that of a PLENUM to represent an exhaust hood. Using the SOURCE-TYPE, SOURCE-BTU/HR, and SOURCE-SCHEDULE keywords, this heat is assigned to the PLENUM (which is modelled as a return plenum with a return fan). Then, with the RECOVERY-EFF keyword, a heat exchange can be specified between the return (read `exhaust') and outside air. The best system types for this problem are either SZRH for heating only of make-air, with a COOLING-SCHEDULE to lock out cooling, or PSZ for a rooftop air unit with both heating and cooling.

We hope that in some future version of the program you will also be able to model an evaporative cooler for the make-up air unit.

* * * * *

Question: How can you model an older building that has steam radiation and no ventilation?

Answer: Again, one can make an approach to this problem, but DOE-2 cannot really model radiators or their radiant effect. One has to be satisfied with convective heat using baseboards, but in order to do this, a dummy system like the Unit Heater (UHT) is needed. Assign a small value like 10 CFM per space and a SUPPLY-KW of 0.0. If the radiators have no controls other than of holding constant, or variable steam pressures, use BASEBOARD-CTRL = OUTDOOR-RESET. If the radiators have automatic control valves, use BASEBOARD-CTRL = THERMOSTATIC.

* * * * *

Question: Many older school and laboratory buildings have a central ventilation make-up air system with steam radiators. How do I handle them?

Answer: Instead of using a dummy system as suggested above, use a SYSTEM-TYPE = HVSYS and an ASSIGNED-CFM for the correct quantity of ventilation air for each space. Normally these older systems were controlled at a set supply air temperature like 65°F year-around. Sometimes they were reset for 60°F in spring and fall, and 75°F in winter to prevent cold drafts, but <u>all</u> of the space heating was accomplished by the radiation system. We would discourage the use of HEAT-CONTROL = COLDEST as this keyword value specifies control of an air heating system — which was not usually the design concept of the central ventilation system.

Question: How about a school auditorium or classroom with heating/cooling unit ventilators?

Answer: In this case the best SYSTEM-TYPE is SZRH, eliminating the option for subzone reheat. Since SZRH is not a zonal system, you need to input multiple systems with all classrooms on a typical exposure lumped into a single zone. If the unit ventilators are packaged DX units with electric heating coils, use PSZ instead of SZRH, with HEAT-SOURCE = ELECTRIC. You can also have baseboard radiation with these units, as many schools were designed this way.

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DOE-2 COMPUTER SERVICE BUREAUS — UPDATE

Some names and numbers have changed in the list of service bureaus that offer DOE-2 to the private sector (see the Reference Manual, page viii). We also wish to remind users that, in addition to the UC Extension intensive course described in the Bulletin Board, these firms also conduct DOE-2 training courses, sometimes on a regional basis, and that those interested in up-coming programs should contact the central offices listed below.

LOCATION	CONTACT
California Berkeley Solar Group 3140 Grove St. Berkeley, CA 94703	Maggie Boyce (415) 843-7600
Colorado Martin-Marietta Data Systems P.O. Box 179 Mail Stop I4100 Denver, CO 80201	Allan Cheuvront (303) 740-3012
Kansas United Computing Systems, Inc. P.O. Box 8551 Kansas City, KS 64114	(913) 341-9161
Massachusetts University of Massachusetts Department of Mechanical Engineering Amherst, MA 01003	Prof. Lawrence L. Ambs (University and local government clients only)
Michigan Airflow Science Corporation/BACS, Inc 37461 Schoolcraft Rd. Livonia, MI 48150	James C. Paul (313) 464-8900 (Michigan area only)
Missouri McDonnell-Douglas Automation Co. P.O. Box 516, Dept. K-242 St. Louis, MO 63166	Don Buford (East Coast) (314) 232-8572
	or
c/o Engineering Services, MC K20-2 5555 Garden Grove Blvd. Westminster, CA 92683	Gerald Howell (West Coast) (714) 952-6152
Texas Cybernet User Service Control Data Corporation 14801 Quorum Drive Dallas, TX 75240	Michael D. Tuttle (214) 385-5302
Virginia Babcock & Wilcox P.O. Box 1260 Lynchburg, VA 24505	Paul Henningson (804) 385-2209
Boeing Computer Services Co. 7980 Gallows Court Vienna, VA 22180	Brian Alberts (703) 827-4349