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DOE-2 USER NEWS

PUB-439

A COMPUTER PROGRAM FOR BUILDING ENERGY USE ANALYSIS

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SUNSPACE/ATRIUM MODEL IN DOE-2.1C

In a collaboration between the Building Energy Simulation Group and the RAMSES Group at the University of Paris-South in France,[†] new capabilities have been added to the DOE-2.1C version of the program which will allow residential sunspaces (such as attached greenhouses) and commercial atria to be simulated. This work was stimulated by the fact that sunspaces and atria are currently very popular architectural elements, and, being quite complex from a thermal and daylighting point of view, require an accurate energy analysis to produce a design which is energy-efficient and comfortable year-round.

The new algorithms will allow simulation of different forms of heat transfer between the sunspace (or atrium) and adjacent rooms which could not be calculated with DOE-2.1B. These include (see Figure 1)

- (1) solar gain through interior windows or openings,
- (2) convection through vents or an open doorway,
- (3) delayed conduction through heavy interior walls,
- (4) conduction through interior windows.

The calculation of beam solar radiation which passes through the sunspace into adjacent rooms is done by using the DOE-2 shadow routines to project the solar image of each exterior window onto the different interior surfaces in the sunspace. Diffuse solar radiation transmitted through interior windows is also calculated.

All of the sun control options which are available for windows in exterior walls — such as scheduling of the shading coefficient multiplier, or deployment of shading devices when transmitted solar gain exceeds a threshold value — are also applicable to interior windows in a sunspace.

The user will be able to specify any of several different forms of convection between the sunspace and adjacent rooms. These

(continued on page 2)

BULLETIN BOARD

- Item:** The DOE-2.1C version of the program is now available. Please call or write to us at LBL for details on obtaining the new program.
- Item:** In the last several issues of this newsletter, we have run a series of articles on the new features to be incorporated in DOE-2.1C. These include functional values, the powered induction unit, advanced cogeneration strategies, electrical rate structures, and sunspaces. The sunspace model is discussed in the next column.
- Item:** Our thanks to those who responded to our questionnaire in the last issue concerning DOE-2 usage and computing environment. The returns so far confirm our belief that, with the availability of moderately-priced mini-computers such as the VAX 700 series, more and more firms are turning to in-house computing. If you missed the questionnaire and still wish to participate, it appeared on page 5 of the Fall 1984 issue, or you may call us and we'll send you out another copy. We are especially interested in hearing of independent conversions of DOE-2 to the smaller machines now on the market.

[†] For a brief description of the RAMSES Group and its work, see Vol. 4, No. 2, the May 1983 issue of the newsletter, page 2.

include fan-forced or natural thermocirculation between upper and lower vents, free convection through a doorway opening, and, for residential applications, use of a sunspace to preheat outside ventilation air. For commercial applications, the program allows return air from adjacent spaces to be passed through the sunspace, where, after mixing with the sunspace air, it is either exhausted or transferred back to the central air handling system. A venting algorithm, which operates with any of the DOE-2 system types, allows outside air to be circulated through the sunspace to prevent overheating.

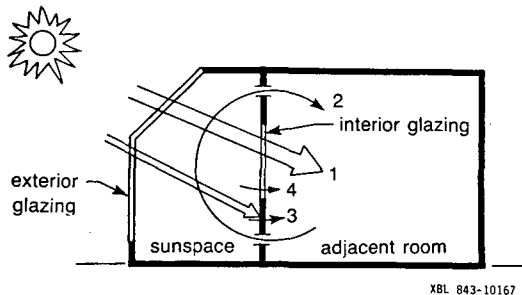


Figure 1. Cross section showing different forms of heat transfer between a sunspace and an adjacent room: (1) solar radiation passing from sunspace to room through interior glazing; (2) natural convection by thermocirculation through upper and lower vents; (3) delayed conduction through interior wall; (4) conduction through interior glazing.

In order to track the large temperature swings that can occur in sunspaces, the venting and interzone convection calculation is done in small timesteps, ranging from 0.6 to 3 minutes depending on the sunspace heat capacity and load in a given hour. (The conventional one-hour timestep used in DOE-2 was found to give inaccurate or unphysical results for the convection calculations, particularly when the temperature difference between sunspace and adjacent room was large at the beginning of an hour.)

The interior walls in a sunspace are often fairly massive, so that the delay in the heat transfer by conduction through the wall can be important. The DOE-2.1B program was modified so that interior wall response factors are passed from the LOADS to the SYSTEMS program where they are used to calculate delayed conduction, taking into account time-varying space temperatures. This calculation also considers the interior sol-air effect, i.e., the effect of solar radiation absorbed on the sunspace side of the interior walls.

Illuminance levels in adjacent rooms due to daylight originating in the sunspace cannot be calculated in DOE-2.1B due to the geometric complexity involved. To remedy this situation, DOE-2.1C will allow users (via the functional keyword feature) to input daylight factors obtained from scale model measurements. These factors are then used by the program to calculate hourly daylight illuminance levels and the resulting energy impact.

An important limitation of the sunspace model is that it does not account for air temperature stratification or in-space convection. We therefore caution against its use for multi-story atria unless the atrium air is well-mixed by the distribution system.

The French RAMSES group will validate the sunspace model against measurements they have made of insolation, temperature, and air flows in different sunspaces in an apartment building near Paris.

Sample results of the sunspace simulation are shown in Fig. 2, which is based on SYSTEMS hourly reports from the residential sunspace example in the DOE-2.1C Sample Run Book (forthcoming in the 2.1C documentation Update Package).

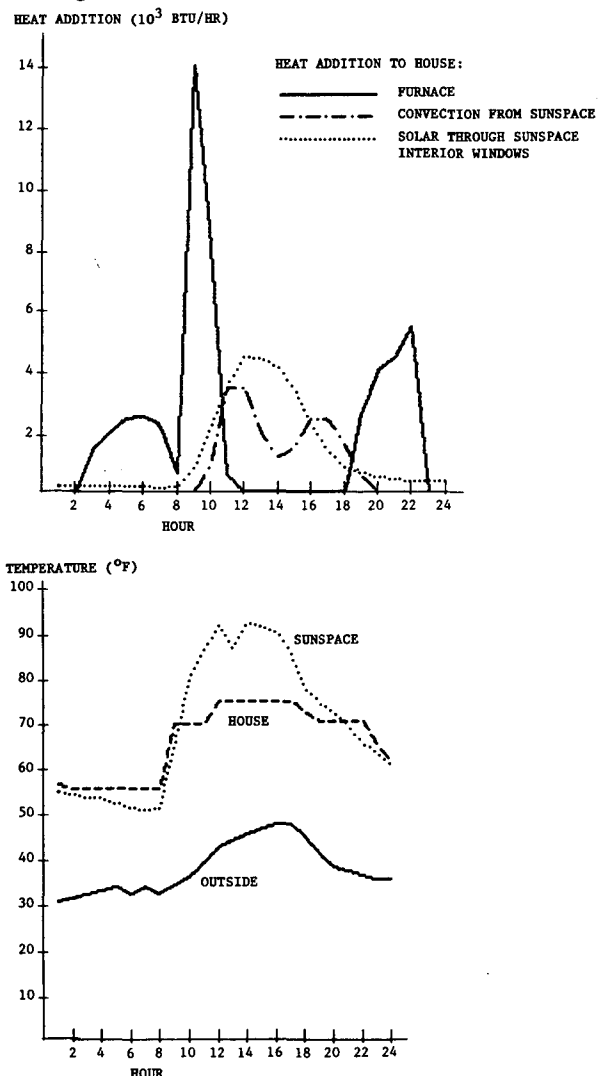


Figure 2. Sample hourly output for a clear January day in Chicago from a DOE-2.1C simulation of a house with an attached sunspace. The heating setpoint of the house is 70°F during the day and 55°F at night. Warm air from the sunspace is circulated to the house at 200 CFM whenever the sunspace-house temperature difference exceeds 4°, and the house temperature is below 74°F. The sunspace is vented with outside air at 20 air changes per hour whenever the sunspace temperature exceeds 90°F.

BUGS DISCOVERED IN DOE-2.1B AND INTERIM SOLUTIONS

The following is the complete and final list of bugs found in the DOE-2.1B version of the code. Now that the new DOE-2.1C program is available, we will no longer be reporting bugs peculiar to 2.1B, nor will we be able to actively support the old version. We encourage users to move up to the new DOE-2.

CLASSIFIED INDEX

This index is intended to cross-reference bugs by 1) abort routine, 2) system-type affected (except those which affect all systems), 3) report affected, and 4) subject matter, command, and/or keyword.

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BDL

- [1] The program will abort in routine FMTAP if the user neglects to close a TITLE LINE with an asterisk (*).
 Interim solution: Always end each TITLE LINE with an asterisk, and the whole command, as usual, with a terminator.
- [2] If hourly reports are requested, there must be at least one CONSTRUCTION command entered in LOADS. Failure to do so may result in an abort in LOADS.
 Interim solution: Create a CONSTRUCTION command, even a dummy one, if hourly reports are desired.
- [3] In Report LV-D, the FLOOR and ROOF designations are reversed. Also, if metric output is requested, the values for AREA of WALL and for U-VALUE of the combined WALL + GLASS are incorrect.
 Interim solution: For the first problem, read the designations in reverse. For the last two, none.
- [4] In Report LV-B, the breakdown of AREA and VOLUME by SPACE is not reported. In an English input deck, the building totals are reported correctly. However, if INPUT-UNITS = METRIC the totals are also incorrect. Additionally, the PEOPLE total in a metric deck is incorrect.
 Interim solution: For the breakdown of AREA and VOLUME, request the LV-C report, which does report the values correctly. For metric runs, none for the building totals problems.

LOADS

- [5] In Report LS-L, the figures reported under the column labelled "NUMBER OF HOURS MANAGEMENT WOULD BE EMPLOYED" are incorrect since they can include night-time hours. This is problematic only when DAYLIGHTING = YES.
Interim solution: None.
- [6] On CDC machines only, if DAYLIGHTING = YES, and a shading surface transmittance schedule is defined with SHADE-SCHEDULE in either the BUILDING-SHADE or FIXED-SHADE command, then the program will abort in subroutine SHDWS.
Interim solution: Use window management-related keywords instead of SHADE-SCHEDULE to simulate the effects of changing transmittance, if running on a CDC machine.
- [7] The new FIXED-SHADE command is not operable; the program does not respond to the input at all, and there is no warning message.
Interim solution: None.
- [8] Using Trombe walls in a run with one or more DESIGN-DAYS followed by a normal run period from the weather file will cause an abort or erroneous results.
Interim solution: Use Trombe walls with only design days, or only weather-file run periods, but not a combination of the two.
- [9] The default GLASS-CONDUCTANCE for the second and any later GLASS-TYPE commands in a deck is picked up from the first GLASS-TYPE command and is therefore determined by the value of PANES for the first command. This is only a problem if (a) there is more than one GLASS-TYPE command and also (b) the value of PANES for the second and later commands is different from that of the first command.
Interim solution: Specify GLASS-CONDUCTANCE rather than allow the program to choose a default value.
- [10] The window y-coordinate in the daylighting report LV-L is calculated incorrectly. No simulation results are affected.
Interim solution: None.
- [11] If, in a metric input run, a LAYERS command is referenced more than once by CONSTRUCTION commands, then the second and successive CONSTRUCTIONS will be calculated incorrectly. This is due to an error in the metric to English conversion of the response factors and u-values: each time a LAYERS command is referenced, the conversion process is invoked again, the result being that the English units calculated in the first pass are then converted into meaningless numbers.
Interim solution: Refer to a LAYERS command only once. Create a separate LAYERS for each CONSTRUCTION in a metric input deck.
- [12] In a metric input run, the conversions from metric to English for the values of HEIGHT and WIDTH in the UNDERGROUND-WALL or UNDERGROUND-FLOOR command are done incorrectly; the conversion factor for the area is applied twice, leading to loads incorrect by a factor of 11.
Interim solution: Use the AREA keyword instead of WEIGHT and WIDTH in a metric input deck.

BUGS DISCOVERED IN DOE-2.1B (Continued)

- [13] For a space with DAYLIGHTING = YES, the MAX-GLARE keyword works only on windows for which MAX-SOLAR-SCH and/or CONDUCT-TMIN-SCH has been specified. Otherwise, use of MAX-GLARE will cause the daylighting and glare calculation to be done with the shade always closed, whether or not the MAX-GLARE value is exceeded.

Interim solution: To get glare control without solar gain or outside temperature shade control, specify MAX-GLARE and specify a dummy MAX-SOLAR-SCH for each window in the space with movable shades. The dummy MAX-SOLAR-SCH should have high values so that the shades are never closed due to exceeding the solar gain threshold. The following would suffice:

DUM-MAX-SOL = SCHEDULE THRU DEC 31 (ALL) (1,24) (10000) ..

SYSTEMS

- [14] When the program calculates the maximum and minimum extraction rates and these turn out to be equal, the count of hours undercooled will be underestimated. This situation can occur for VAVS system type, for example, if the MIN-CFM-RATIO is 1.0 and no heating is allowed.

Interim solution: None.

- [15] SS-O Report, the Temperature Scatter Plot, will contain all zeros unless the user also requests the printing of at least one of the following reports: SS-B, SS-C, SS-H, SS-I, SS-J, SS-K, SS-L, SS-N.

Interim solution: Include at least one of the above reports when requesting SS-O.

- [16] In the PTAC system, the sensible load used to select high- or low-speed ratio should be the net zone extraction minus the extraction done by mixed air. The current calculation incorrectly sums the two values. The error can be significant in runs with large fractions of outside air coincident with high values of zone-to-outside-air-temperature difference combined with small low-speed ratios.

Interim solution: Avoid large outside air quantities with small low-speed ratios in the PTAC system.

- [17] If the COOL-CONTROL or HEAT-CONTROL is specified as RESET, and the corresponding COOL- or HEAT-RESET-SCH references a DAY-SCHEDULE rather than a DAY-RESET-SCH, then the program will abort in subroutine DKTEMP with a "divide by zero" error without printing an ERROR message.

Interim solution: Correct input; use properly defined reset schedules.

- [18] If COEFFICIENTS are specified in the CURVE-FIT command in SYSTEMS or PLANT to enter coefficients for a SYSTEMS-EQUIPMENT or EQUIPMENT-QUAD curve, the results will be incorrect. The program currently transposes the values entered, producing a meaningless curve.

Interim solution: None; use DATA points instead of COEFFICIENTS.

PLANT

- [19] In the LOAD-ASSIGNMENT command, if the first and last PLANT-EQUIPMENTS in a LOAD-RANGE are not both set equal to UTILITY, and the capacity is defined by keyword NUMBER = a value which is less than the peak demand calculated by the program, then any intervening PLANT-EQUIPMENT assignments will be ignored and the entire load is given to the utility.

Interim solution: Correct input. Use the LOAD-MANAGEMENT command when trying to simulate a peak-shaving strategy. See the Reference Manual, page V.61, Example 3.

- [20] If, in the PLANT-EQUIPMENT command, a steam turbine is specified, but no diesel or gas turbine, and if the LOAD-ASSIGNMENT is allowed to default, then the program will abort in subroutine OPELEC.

Interim solution: Always specify, in this case, a LOAD-ASSIGNMENT.

NOTE: The steam turbine simulation is intended for use only with a gas turbine or diesel engine, to generate electricity when there is no other use for the waste heat from these prime movers; it is a very inefficient device for producing electricity and would not ordinarily be used except in a combined-cycle plant.

- [21] The program will abort in subroutine WTW if, in PLANT only, REPORT-BLOCKS are specified but no HOURLY-REPORTs are requested.
Interim solution: Delete (or comment out) the REPORT-BLOCK command in PLANT if no hourly reported are desired.
- [22] The energy performance of hot and cold storage tanks is not reported out in Report PS-D. No simulation results are affected.
Interim solution: None.

Weather Processor

- [23] The design temperatures reported in the statistical summary of the Weather Processor are meaningless.
Interim solution: None.

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.

Question: What building energy is reported as LIGHTS in the BEPS report?

Answer: This item on the BEPS Report has caused some confusion. Naturally, the general lighting and task lighting inputs in the SPACE-CONDITIONS command are summed into LIGHTS in the BEPS Report. But, in addition, any input for ELEC-KW under the BUILDING-RESOURCE command is treated as outside lighting and is therefore also summed under LIGHTS. If you have a non-lighting, electric load outside the building boundary (for example, a water pump to a decorative fountain), you should use SOURCE-BTU/HR = (pump motor load), SOURCE-TYPE = ELECTRIC, and SOURCE-SENSIBLE = 0.0, instead of ELEC-KW. This puts the load inside the building, but eliminates the internal thermal load; the electric energy will then be reported correctly under the MISC-EQUIP heading in the BEPS Report.

* * * * *

Question: Is there a way to model the buildings where perimeter fan coil units are used for heating only, and also cycle on at night to hold the night setback temperature?

Answer: With the release of DOE-2.1C, there is now a way to approach the modelling of this system. We suggest that you use the Powered Induction Unit (PIU) system with TERMINAL-TYPE = PARALLEL-PIU, and by minimizing the size of the core space, minimize also the effect of any warm induced air from the ceiling plenum. Then, by selecting NIGHT-CYCLE-CTRL = ZONE-FANS-ONLY (a new 2.1C code-word), the main system, which defaults to a VAVS, will only operate during daytime hours. The perimeter fans will cycle on for heating during the day, and will cycle on at night and on weekends to hold the setback temperature.

* * * * *

Question: In studying a daylighting project, we found an excessive number of hours when loads were not met. What were we doing wrong?

Answer: This is a low air-flow design problem that is usually caused by very low lighting power densities (i.e., 1.0 to 1.5 watts/sqft). The problem is compounded when air systems are designed with credits for daylighting and window management. One should realize that very low internal gains can result in very low system airflows when you allow the program to do automatic sizing. What one needs to do is to use the keyword CFM/SQFT to establish a minimum design air flow. This will prevent the system size from falling below that which is required for morning start-up loads and especially after a hot summer week-end. In many cases where the designer does not want a full credit given to the daylighting and window management, a run should be made with these strategies disabled to establish the air system size. A second run with the same strategies enabled, but using the airflow and equipment sizes from the previous run, should result in a satisfactory model.

* * * * *

Question: Is it possible to model an ice-storage system?

Answer: The documentation doesn't make it clear that the water storage modelled in PDL's ENERGY-STORAGE is always fully stratified. (Only the storage tank in the Solar Simulator is fully mixed.) The tank size reflects the initial Btu holding capacity which can include the Btus for a phase change, if that is what you want to model. An ice-storage system is characteristically a fully stratified charge up until all the ice is melted. One should also attend to the lowered temperature level of the evaporator by inputting a higher ELECTRIC-INPUT-RATIO consistent with the added work the compressor must do beyond that of a conventional chilled water system. And in the air system, select a MINIMUM-SUPPLY-T consistent with the lowered temperature of the supply air that may result from the circulating chilled ice-water.

DOCUMENTATION UPDATE

The following correction should be made in the Reference Manual, dated, revised May 1981.

- In the Weather Data section, page VIII.37, there is an error in the instructions for packing a weather tape. Under the description for columns 7-12 of Card 3, it states that the weather station number for 1440, 1440-3, and CTZ type weather tapes are not required, and that those columns should be filled with -999. That is untrue; for 1440 and 1440-3, the weather station number must be input as it is for TRY, TMY, and WYEC type tapes. For CTZ, enter the zone code-number.

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