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

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* * * WORTH NOTING * * *

Item: The IBM version of DOE-2.1C has been completed. Please call or write us at LBL for details on how to obtain this (or any other) version of the program. We expect the Univac version to be available in a few months, a UNIX version is also in the works.

Item: Prices for DOE-2 documentation have been increased by NTIS. Please check the last page of this newsletter for the new prices.

Item: The First Building Energy Simulation Conference was held last August in Seattle. Proceedings of the Conference will be published by the Solar Energy Research Institute and will be available through NTIS some time near the end of calendar 1986. In the interim, proceedings are available from Engineering Resources Ltd., P.O. Box 2040, Corvallis, Oregon 97339. Copies may be obtained from the Oregon address at a cost of $20.00 within the continental United States, $30.00(US) in Canada and Mexico or by surface mail overseas; and $40.00US for air shipment overseas. The proceedings include 55 of the 58 papers presented in Seattle.

DOE-2 and the Next Generation

As many readers are probably aware, there is currently an ongoing effort in the Building Energy Simulation Group (BESG) at Lawrence Berkeley Laboratory and elsewhere to foster the development of the next generation of building energy programs. This has raised questions concerning the future of DOE-2 and other current-generation programs. The BESG is frequently asked "Is 2.1C the last version of DOE-2"?, and "Will there be continued support of DOE-2"? We would like to answer these questions, and give the DOE-2 user community some insights on what to expect in the next generation programs.

First, let us be clear that DOE-2 support will continue throughout the forseeable future, provided, of course, that funding is continued. The primary reason for continued supoort of DOE-2 is that it is very unlikely that any major, significantly different new whole-building programs will be ready for general use before the end of the decade. This is because work on next-generation software is just now beginning and, based on the DOE-2 experience, a significantly different program will take three to five years to develop, debug, and validate. In the meantime, DOE-2, BLAST, and other public domain programs will continue to be the principal tools for building energy analysis. Also, you can expect new versions of these programs to be released in the interim, for example DOE-2.1D is currently under development. However, subsequent versions of DOE-2 will depend on a number of factors, including funding availability and the feasibility of integrating new advances developed in connection with the next generation work. This newsletter will keep you informed.

The plan for the next generation program has been undergoing refinement over the last nine months here at LBL. During this period, we have had a number of building energy simulation experts from Europe, the United Kingdom, China, and the U.S. participating in discussions with the BESG staff. Proposals for new directions prepared by the BESG and other institutions were debated and refined. Out of this there emerged a plan that allows wide participation in the development of a flexibly structured, highly portable set of "software tools" to support building energy analysis. These tools would include all the necessary "pieces" for constructing a whole-building or special-purpose model. The thinking behind this approach is that by development of more or

less independent modules with a flexible interconnection scheme we will make it easier to construct both general and special purpose building models, and to incorporate new advances in particular areas. It is anticipated that once these tools become available, numerous public and private groups will use them to construct a new generation of building energy programs. The pay-off to the end user will therefore include a wider choice of quality software products so that a program better suited to particular needs can be selected. If we are successful in properly designing and implementing the software tools, these products will offer major improvements in flexibility, ease of use, and accuracy relative to the current generation programs.

If you are interested in obtaining a copy of the proposal for this next generation of software tools, please write to Kathy Ellington at the Building Energy Simulation Group.

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: **The method of specifying occupancy in DOE-2 is clumsy. The NUMBER-OF-PEOPLE must be specified for each space. Is there a way of inputting people/sqft?**

Answer: No, but you can do a lot with the PARAMETER command (Reference Manual, page II.20) and the TIMES feature (Reference Manual, page II.21). For instance, use floor area as a parameter:

```
PARAMETER  FA=20000 .. $ SET FLOOR AREA $
```

Then, in the SPACE command, if the space height is 13 ft.:

```
FLOOR1=SPACE   AREA=FA   VOLUME=FA TIMES 13
                  NUMBER-OF-PEOPLE=FA TIMES .01 $ 01 PEOPLE PER SQFT $ ..
```

Thus, if you change floor area (FA), the corresponding volume and number of people change automatically. For walls and windows, you could define a building width parameter:

```
PARAMETER    BW=20 ..
   •
   •
   •
```

Then in the wall and window algorithms:

```
NORTH-WALL1=E-W          WIDTH=BW  ..
N-WINDOW    =WINDOW      WIDTH=BW  ..
EAST-WALL1  =E-W         WIDTH=BW TIMES .5  ..
E-WINDOW    =WINDOW        WIDTH=BW TIMES .5  ..
                          etc.
```

So, changing two parameters allows you to change the size of your space, or of the entire floor of a building, if there were one space per floor.

* * *

Question: **What hourly report variables correspond to the quantities reported in the BEPS report? I am particularly interested in the items in the ELECTRICITY column in BEPS.**

Answer: The electricity reported under SPACE HEAT in the BEPS report corresponds to hourly report variable 46 in SYSTEMS at the SYSTEMS level, or variable 5 in SYSTEMS at the PLANT-ASSIGNMENT level if there is more than one system in the plant, plus any electricity consumed in PLANT for heating. This is usually the electricity used by the boiler burner and induced draft fans (controlled by ELEC-INPUT-RATIO in the PART-LOAD-RATIO command) in the case of STM-BOILER or HW-BOILER, or the primary energy consumed by ELEC-STM-BOILER or ELEC-HW-BOILER. In either case, the boiler hourly electrical consumption can be obtained from the hourly reports with V-T set to the relevent equipment type, and V-L=(3)

The electricity under SPACE COOL in the BEPS report is the electricity used for cooling in SYSTEMS plus whatever is consumed by the chillers and cooling tower in PLANT. The former is V-L=(47) at the SYSTEMS level in SYSTEMS or V-L=(6) at the PLANT-ASSIGNMENT level. The electricity consumed by equipment in PLANT is always V-L=(3) for the relevant equipment type (V-T=OPEN-CENT-CHLR, etc.).

The electricity reported under HVAC AUX in the BEPS report comes from a variety of sources. The largest part is the electricity for fans in SYSTEMS (V-L=(33) at the SYSTEMS level or V-L=(7) at the PLANT-ASSIGNMENT level). Some minor components can come from the hot storage tank in PLANT, V-L=(3); the cold storage tank, V-L=(3); and the furnace, V-L=(3). The major contribution in PLANT comes from the pumps, which are not reported in the hourly reports.

The hourly electrical consumption by pumps can be calculated by hand, however. There are hot water and cold water pumps, and they are sized from the SYSTEM peak loads, as follows:

$$GPM = \frac{HTSUM}{HDESDT * 8.341\ lb/gal * 60\ min/hr * 1\ BTU/lb\text{-}{}^{\circ}F} \qquad (1)$$

where *HTSUM* is the peak space heating load from SYSTEMS in BTU/hr, *HDESDT* is the design temperature drop (°F) (keyword HCIRC-DESIGN-T-DROP in PLANT-PARAMETERS, default=30). *GPM* is the flowrate. The electrical power consumed at peak is

$$HPDSEL = \frac{HPHEAD * GPM}{HEFFM * HEFFI} * .643\ \frac{BTU\text{-}min}{ft\text{-}gal\text{-}hr} \qquad (2)$$

where *HPHEAD* is the pressure head across the pump (keyword HCIRC-HEAD, default=60 feet), *HEFFM* is the pump motor efficiency (keyword HCIRC-MOTOR-EFF, default=.9), and *HEFFI* is the pump impeller efficiency (keyword HCIRC-IMPELLER-EFF, default=.77). The cold water pump is sized in an analagous manner, except that the default for the design temperature drop is 10°F.

Hot water pumps are defined to exist whenever SYSTEMS has hot water coils, cold pumps when SYSTEMS has cold water coils. Operation is controlled by the keywords BOILER-CONTROL and CHILLER-CONTROL in PLANT PARAMETERS. Normally, the pumps operate only when there is a heating or cooling load from SYSTEMS. In the STANDBY mode the pumps will operate whenever heating or cooling is *available* in SYSTEMS, (as defined by the heating or cooling schedules). The standby flags are available as hourly variables 4 and 5 in PLANT for V-T=PLANT. Pumps can be fixed speed or variable speed. For fixed speed pumps (the default), the pumps operate at their design power for each hour that they are operating. In variable speed pumps the GPM is calculated by equation (1), and the electricity consumption (*HPELEC*) by equation (2). *HPELEC* is then the hot water pump electricity consumption for the hour, unless it is less than *HPDSEL * HMNPLR*, in which case *HPELEC=HPDSEL * HMNPLR*, where *HMNPLR* is the minimum part load ratio for the hot water pump (keyword HCIRC-MIN-PLR, default=0.5). The cold water pump is handled analagously.

Annual energy consumption by the pumps is shown in report PS-C.

The domestic hot water electricity consumption (DOM HOT WTR) in the BEPS report comes from variable 3, V-T=ELEC-DHW-HEATER and V-T=DHW-HEATER.

Skipping auxilliary solar, the rest of the BEPS quantities are straightforward. Electricity under LIGHTS in the BEPS report corresponds to hourly report variable 41, V-T=BUILDING, in LOADS, plus electricity from the ELEC-KW keyword in the BUILD-RESOURCE command (assumed to be outside lighting), hourly report variable 42. VERT TRANS in BEPS corresponds to variable 45, V-T=BUILDING in LOADS; and electricity for MISC EQUIP is variable 40, V-T=BUILDING, in LOADS.

* * *

Question: **What is included in hourly report variables 46 and 47, SKWQH and SKWQC, in the SYSTEM program, at the SYSTEMS level?**

Answer: SKWQH is the "electrical input to heating" and SKWQC is the "electrical input to cooling". These variables contain electricity consumed in the SYSTEMS sub-program only, and not any electricity used in LOADS or PLANT. SKWQH contains all electrical resistance heating, plus auxiliary electricity (spark ignition and pumps) for the oil furnace, plus electricity used by heat pumps in the heating mode (compressors, defrost and supplemental), plus electricity used for humidification if HUMIDIFIER-TYPE=ELECTRIC. SKWQC contains electricity used to run compressors for packaged and unitary equipment, and for heat pumps in the cooling mode, plus crankcase heat.

* * *

Question: **What does SKW, the hourly report variable 32 in SYSTEMS (SYSTEMS level), contain?**

Answer: It includes SKWQH, SKWQC, and FANKW, the fan electrical consumption.

NOTE: All building load hourly report variables in LOADS are in BTUH. Variable 34, QBELEC, was incorrectly labeled KW in DOE-2.1B (corrected in 2.1C).

☞ ☞ ☞ Documentation Update ☜ ☜ ☜

- **DOE-2.1C Supplement -- Errata. Page 4-12** The "A" Coefficient for **ABSOR1-HIR-FPLR** should read 0.0877733. The default value stored in the program is correct.

- **DOE-2.1C BDL Summary -- Errata. Page BDL-68** The following keywords were inadvertently dropped and should be added to the SYSTEM-EQUIPMENT list for the PSZ System-Type:

MIN-UNLOAD-RATIO	25
MIN-HGB-RATIO	25
MAX-HEAT-RCVRY	NO HEAT RECOVERY from condenser
CRANKCASE-HEAT	0.1 KW
CRANKCASE-MAX-T	runs when compressor is off
OUTSIDE-FAN-KW	no explicit condenser fan electric
OUTSIDE-FAN-T	45.0 °F
OUTSIDE-FAN-MODE	INTERMITTENT

CROSS INDEX BY DOE-2 ABBREVIATION

We had planned to print an index to the SYSTEMS portion of the DOE-2.1C version in this issue of the newsletter. Because of space limitations imposed by the printing process, however, we will have to print it in the next newsletter. If you need the full index now, call Kathy at (415) 486-5711 and she will mail a copy out to you.

BUGS DISCOVERED IN DOE-2.1C AND INTERIM SOLUTIONS

The following is a list of bugs discovered from September to December 1985 in the 2.1C version of the program. We encourage users to document suspected bugs, and report them to us. The dates appearing between the C D marks represent the fix date. If you received your tape after that date, there is no need to perform the fix. The UPDATE program fix statements appear below each bug fix. The location of bugs is indicated in the Classified Index. Bugs 1-10 were described in the Summer 1985 issue of this newsletter; bug 11 was in the Fall issue.

CLASSIFIED INDEX

Daylighting: 3, 6, 11, 12, 13, 18, 19, 20, 21
Heatpumps: 10
Hourly reports: 1, 17
INTERIOR-WALL: 7, 8, 13
LS-L report: 11
Metric option: 1, 12, 13, 14, 15, 16
Shade management: 2
SS-H Report: 10
Subroutine SSFCOR: 9
Sunspaces: 4, 5, 7, 8, 9, 21
WINDOW: 2, 3, 4, 5

[12] In metric runs, the conversion factor for the keyword RADIATIONS in the DAY-SCHEDULE command, used in conjunction with MAX-SOLAR-SCH for window blind control, is incorrect. It converts from W/ft^2 to W/m^2 using a factor 10.76392. It should convert from $Btu/hr/ft^2$ to W/m^2 using a factor of 3.15248.

```
*D SCEDDI 41
      6    4HRADI,4HATIO,4HNS    ,4H      ,4HRADT,4H      ,17,1,24,-1,100,1/
*D SCEDDI 121
       TEMP(25)=1  /VKONV(17)
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----
```

[13] In metric runs using LOAD-ASSIGNMENT and LOAD-MANAGEMENT in PLANT, the plant equipment referenced in the LOAD-ASSIGNMENT command will not be assigned correctly. Also, if the LOAD-ASSIGNMENT was for a utility, the NUMBER keyword, representing MBTU's would not be converted to mWh. Both problems are corrected by the following fix.

```
*I LMLAO 107
       IF (METIN EQ 1)  CALL KDIV(IA(IPTR+4),50,1,METIN)
*D LMLAO 124
```

[14] For metric runs, under the SYSTEM-CONTROL command, MAX- and MIN-HUMIDITY are incorrectly labelled as absolute humidity units, (KG-WATER/KG-AIR), not relative (PERCENT). The calculations are correct. The fix is:

```
*D SDLKEY 385
MAX-HUMIDITY       MAX-H       38     1     1       30          80          -77777
*D SDLKEY 389
MIN-HUMIDITY       MIN-H       38     1     1        0          70          -77777
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----
```

[15] In metric runs, in some PLANT output headings, the unit $kWatt/m^2$-yr should read kWh/m^2-yr. No calculations are effected by this bug. The fix is:

```
*D UNITCD 74
  73     KWH/M2-YR              KBTU/SQFT-YR            3.15248
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----
```

16 If using metric in conjunction with Custom Weighting Factors, and the LIKE keyword is used for LAYERS, then the Custom Weighting Factors calculation uses incorrect response factors for the LIKE'd LAYERs. The amount of the error depends on size of the SPACE and number of LAYERS. The fix is:

```
*D CONSTO 140,142
      CALL MOVEN (AA(IRF+1),AA(IPT+9),NSTOR)
      IF (METIN EQ 1)  CALL KDIV(AA(IPT+9),6,1,METIN)
      IF (METIN EQ 1)  CALL KDIV(AA(IPT+12),6,NSTOR-3,METIN)
```

17 For system types DDS, MZS, and PMZS, the hourly report variable WR (No. 35 at the SYSTEM level), the return air humidity ratio, can be incorrectly reported when it should be at its minimum value. The calculation is not affected.

```
*I DDSF 235
      WR = WRMIN
```

18 ⊂ December 3 '85 ⊃ Bug in 2.1C and 2.1B in LOADS. Fixed in 2.1C on 12/3/85. If building AZIMUTH is entered as a negative value between -90° and -360°, the daylighting program will incorrectly calculate interior illuminance and glare if the sun is between south and the direction of the negative building x-axis. In this case, a solar bearing of 20° north of west is used instead of the actual bearing. (For example, if building AZIMUTH = -135°, then the building y-axis points southwest, the x-axis points northwest, and the negative x-axis points southeast, so solar bearings between south and southeast will have incorrect interior daylight values.)

This problem can be avoided by always using **positive** values of building AZIMUTH. The fix is

```
*D DAYCLC 139
      IF(THSUND GT 180 )THSUND=THSUND-360 *(1 +AINT(THSUND/540 ))
```

19 ⊂ November 26 '85 ⊃ There are two errors in the description of the daylighting verification report, LV-L. (1) the quantity VW-AZ (view azimuth) is given **relative to North**, not relative to the building y-axis as stated on p. 2-65 of the 2.1C Supplement. (Note that the corresponding keyword, VIEW-AZIMUTH, is input relative to the space y-axis.) (2) The quantity AZIM is the azimuthal angle of the window outward normal **relative to North**, not relative to the building y-axis as stated on p. 2-66 of the 2.1C Supplement. (Note that for horizontal windows, the value of AZIM in this report has no meaning and should be ignored.)

Interim solution: NONE

20 ⊂ December 19 '85 ⊃ Bug in 2.1C and 2.1B in the LOADS program, fixed in 2.1C on 12/13/85. In the daylighting calculation, the values of luminous efficacy and direct normal solar illuminance are too high for values of atmospheric turbidity (ATM-TURBIDITY in the BUILDING-LOCATION command) above 0.2. This results in overestimates of interior daylight illuminance.

Interim Solution: Restrict ATM-TURBIDITY values to ≤ 0.2.

21 ⊂ December 19 '85 ⊃ This is actually not a bug fix, but an improvement to the daylighting calculation. Previously, sun reaching the reference point directly (i.e. without reflecting from an interior or exterior surface or diffusing from a window shade) was not calculated on the assumption that a shading device would be deployed to prevent a sun patch from falling on the work surface. This assumption is, however, too restrictive in some situations, for example, in rooms with reflective glazing and no drapes or blinds, or in atria with transparent glass where direct sun is intentionally allowed to penetrate to floor level. The program has, therefore, been modified so that the illuminance of the sun patch is calculated. In addition, the program now calculates the glare due to the solar disk when it is visible from the reference point. [Implemented 12/19/85 in DOE-2.1C]