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

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BULLETIN BOARD

Item: Judging from the number of calls we have been receiving lately, there has been a recent jump in the number of users of DOE-2. It also appears that there has been a shift away from the use of the computer service bureaus to in-house computer installations, including conversions of the program to machines other than those currently available from NESC and NTIS. We would very much appreciate your assistance in filling out the short questionnaire on page 5, so that we can assess the current DOE-2 user community. Although your name and affiliation are not essential to this study, it would be, if we wished to contact you regarding the information you have supplied us.

Item: The Bug List has not made an appearance in these pages for six months now. The number of bugs in DOE-2.1B has remained stable at 20 since last April, and therefore the listing published in the Spring 1984 newsletter is still current.* Either all of the problems have been uncovered (an unlikely event), or users are not reporting suspicious results, unworkable inputs, and the like. Please do contact us if you have encountered suspected bugs so that we can document and fix them. Example input and output are always helpful in tracking down the problem.

* There are a number of inquiries from Canada concerning metric verification report bugs, which we are currently trying to verify.

NEW ELECTRICAL RATE STRUCTURE IN ECONOMICS

In the upcoming 2.1C version of DOE-2, the calculation of energy costs will be moved from the PLANT sub-program to ECONOMICS. New commands and keywords have been added to encompass a wider variety of tariff schedules for energy. Seasonal and time-of-day rates will now be accounted for and the existing block rate structure has been upgraded. Major modifications have been made to enhance the treatment of electricity, including more sophisticated demand ratchet mechanisms and the Congressionally-mandated options for the sale of electricity to a utility.

Three new commands for all utilities, ENERGY-COST, CHARGE-ASSIGNMENT, DAY-CHARGE-SCH, and one special command for electricity, COST-PARAMETERS, will now be used in ECONOMICS for the calculation of energy costs. The interactions among them can be summarized as follows: The most basic features of a tariff — units, uniform cost rates, monthly charges, etc. — are all contained in an ENERGY-COST command, which is entered for each fuel or utility used in the previous PLANT run. The CHARGE-ASSIGNMENT is used primarily to specify block-rate structures but can also be used for simple uniform rate charges on demands as well as energy. CHARGE-ASSIGNMENTs can be referenced by the ENERGY-COST command in two ways, directly or through a SCHEDULE. Seasonal and time-of-day variations in tariffs require the use of a SCHEDULE (referenced in the ENERGY-COST command for that utility or fuel). The complex features of tariffs for electricity, which include provisions for demand ratchets and the sell-back of electricity to a utility, are specified through COST-PARAMETERS.

For each utility or fuel used in PLANT, a separate ENERGY-COST command will be entered in ECONOMICS. The ENERGY-COST command has associated with it several keywords that are similar to the old ENERGY-COST command found in PLANT. For a simple energy cost calculation in which all units consumed are valued at one rate, only the ENERGY-COST command and associated keywords need be entered. For more complex tariffs, involving either blocks or time-of-use/seasonal features, two additional new commands, CHARGE-ASSIGNMENT and DAY-CHARGE-SCH, are required.

The CHARGE-ASSIGNMENT command is used to specify block-style tariffs and has been structured in a manner that is roughly analogous to the LOAD-ASSIGNMENT command in PLANT. That is, several keywords associated with this command may be entered more than once.

(Continued on page 2)

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CHARGE-ASSIGNMENTs for a utility or fuel are referenced through the ENERGY-COST command in a manner similar to the way in which the LOAD-MANAGEMENT command in PLANT references LOAD-ASSIGNMENTS, directly or through a schedule. In the latter case, the DAY-CHARGE-SCH command is used in conjunction with the existing SCHEDULE and WEEK-SCHEDULE commands to reflect seasonal and time-of-day tariff schedules. A total of six CHARGE-ASSIGNMENTS may be entered for each utility or fuel.

The DAY-CHARGE-SCH command accepts integer values referring to hours and, for each of these groups of hours, up to two u-names of CHARGE-ASSIGNMENTs. In a manner similar to the DAY-ASSIGN-SCH command used in PLANT to schedule LOAD-ASSIGNMENTs, DAY-CHARGE-SCH is referenced by u-name in a WEEK-SCHEDULE command, which, in turn, is referenced by a SCHEDULE command. The u-name for the SCHEDULE is referenced in the ENERGY-COST command by the keyword ASSIGN-SCHEDULE.

A final command, COST-PARAMETERS, is used to specify the special features of tariffs for electricity. These include the characteristics of demand ratchets, where the billing demand (kW) is taken to be the larger of the highest demand in the relevant period of the month and a "ratchet" based on previous recorded demands. In calculating demand ratchets, previous recorded demands can include months in the simulation that are "downstream" of the current one. That is, since DOE-2 run periods are for a single year, information from the entire year may be used in calculating the ratchet for a particular month. The COST-PARAMETERS command also accepts keywords that specify how electricity generated on-site (via diesel engines, gas and steam turbines) is to be accounted for with respect to interconnection with a utility.

The following two examples should give the reader an idea of the power of this new capability. Although we haven't defined the individual keywords in this discussion, their meaning should be largely self-evident.

Example 1. Although block rates have been used for years, many of them now incorporate marginal-cost and equity-related concerns. A recent example of the latter, currently in wide usage among residential customers, are inverted block rates. The basic idea is that increased consumption is discouraged by increased per unit costs. A simple inverted block has three tiers. In this example, the first 500 kWh of consumption (sometimes referred to as a "baseline" or "lifeline" quantity) are charged at $.0535 per kWh. All kWh consumed in excess of 500 kWh, but less than 900 kWh, are charged at $.0725 per kWh. The third tier covers all consumption in excess of 900 kWh at a charge of $.1245 per kWh. There is no seasonal variation in this rate and we will ignore minimum and fixed monthly charges in this example.

```
ENERGY-COST
   RESOURCE = ELECTRICITY
   ASSIGN-CHARGE = (INVBLK)                    ..

INVBLK = CHARGE-ASSIGNMENT
   RESOURCE = ELECTRICITY
   TYPE = ENERGY
   BLOCK-RANGE = (500,400,10000000)
$ THE SECOND ENTRY IS THE SIZE OF
$ THE "NEXT" BLOCK AND THE THIRD
$ IS JUST SOME LARGE NUMBER $
   BLOCK-CHARGE = (.0535,.0725,.1245)    ..
```

Example 2: The most significant difference between residential and commercial electricity tariffs is the inclusion of demand charges. Typically, the highest measured demand (integrated over some fraction of an hour) is compared against a "ratchet" chosen or calculated from some set of previous highest demands and the larger of the two is taken to be the billing demand. These tariffs can also include rate limitation features to ensure that when the charges are all totaled the effective rate per kWh is less than or equal to a specified amount. We first present an example in which the ratchet is taken to be 90 % of the highest demand recorded in the previous 12 months and the charge is $12.00 per kW. There is a flat charge on energy of $.05 per kWh but in no circumstance can the effective rate (i.e., including the demand charges) exceed $.07 per kWh.

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  RATE-LIMITATION = .07
  ASSIGN-CHARGE = (HIDEMAND)                   ..

HIDEMAND = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  TYPE = ENERGY
    UNIFORM-CHARGE = .05
  TYPE = DEMAND
    UNIFORM-CHARGE = 12.00                     ..

COST-PARAMETERS
  DEM-RATCHET-T1 = HIGHEST
  DEM-PERIOD-T1  = WHOLE-YEAR
  DEM-RATCHET-FRC1 = .90                       ..
```

We can alter this example by specifying the ratchet to be the average of the two highest demands in in the previous 12 simply by substituting code-words in the COST-PARAMETERS command as follows:

```
COST-PARAMETERS
  DEM-RATCHET-T1 = AVERAGE
  DEM-PERIOD-T1  = WHOLE-YEAR
  DEM-AVERAGE-MON1 = 2                         ..
```

The new report, ES-E, reproduced on the following page, demonstrates the detailed level of reporting for the components of electricity charges which will be available to the user in DOE-2.1C.

31-STORY OFFICE BLDG, CHICAGO - LOAD2 RUN 6 PACKAGED HEAT PUMPS ON PERIMETER PKG HEAT PUMPS INTERIOR WITH HW COILS DOE-2.1C 3-Aug-84 13:00:2 EDL RUN 6

REPORT- ES-E SUMMARY OF ELECTRICITY CHARGES

MONTH	CHARGE-ASSIGNMENT (U-NAME)	LENGTH (HR/MO)	CONSUMPTION BY C-A (KWH)	ENERGY CHARGE ($)	MEASURED DEMAND (KW)	BILLING DEMAND (KW)	DEMAND CHARGE ($)	TOTAL CHARGES ($)
JAN								
	ECOST	744	541056.	27052.78	2472.	2472.	0.00	
	WDCOST	744	541056.	0.00	2472.	2472.	24723.94	
								52526.72
FEB								
	ECOST	672	441217.	22060.85	2343.	2472.	0.00	
	WDCOST	672	441217.	0.00	2343.	2343.	23427.91	
								46238.76
MAR								
	ECOST	744	428664.	21433.21	2044.	2472.	0.00	
	WDCOST	744	428664.	0.00	2044.	2332.	23320.79	
								45503.99
APR								
	ECOST	720	463638.	23181.91	2106.	2472.	0.00	
	WDCOST	288	205641.	0.00	1897.	2332.	9328.31	
	SDCOST	432	257997.	0.00	2106.	2332.	20988.71	
								54398.93
MAY								
	ECOST	744	483135.	24156.76	2230.	2472.	0.00	
	SDCOST	744	483135.	0.00	2230.	2332.	34981.18	
								60137.94
JUN								
	ECOST	720	479960.	23998.01	2302.	2472.	0.00	
	SDCOST	720	479960.	0.00	2302.	2332.	34981.18	
								59979.19
JUL								
	ECOST	744	564035.	28201.74	2332.	2472.	0.00	
	SDCOST	744	564035.	0.00	2332.	2332.	34981.18	
								64182.92
AUG								
	ECOST	744	550960.	27548.00	2311.	2472.	0.00	
	SDCOST	744	550960.	0.00	2311.	2332.	34981.18	
								63529.18
SEP								
	ECOST	720	457414.	22870.69	2291.	2472.	0.00	
	SDCOST	720	457414.	0.00	2291.	2332.	34981.18	
								58851.87
OCT								
	ECOST	744	458735.	22936.73	1922.	2472.	0.00	
	SDCOST	384	226587.	0.00	1922.	2332.	18054.80	
	WDCOST	360	232148.	0.00	1906.	2332.	11284.25	
								53154.82
NOV								
	ECOST	720	394760.	19737.98	2106.	2472.	0.00	
	WDCOST	720	394760.	0.00	2106.	2332.	23320.79	
								43808.77
DEC								
	ECOST	744	492058.	24602.90	2345.	2472.	0.00	
	WDCOST	744	492058.	0.00	2345.	2345.	23447.31	
								48800.20
TOTAL			5755631.	287781.55			352802.71	651113.28

DEVELOPMENTS IN SYSTEMS

There are many variations on the basic HVAC system types on the market. DOE-2 models some but not all of them and we try to periodically add the most popular ones. In DOE-2.1C a model of the powered induction unit (PIU) will be added to the DOE-2 SYSTEMS simulation.

Historically, the variable air volume (VAV) system has been the choice for energy conservation. The VAV supplies cold air to a zone in proportion to the need for cooling, thus eliminating much of the need to reheat excess cold air from constant volume systems. As conservation efforts have progressed, some deficiencies in VAV systems have become apparent. One of the easiest and most popular conservation measures in buildings is to reduce internal heat gains, primarily by reducing lighting levels. With conventional VAV systems, this can result in very low supply airflow rates, and little air movement within the space, leading to considerable occupant discomfort. The PIU is an attempt to mitigate the deficiencies of the traditional VAV system, and in addition save energy by reclaiming excess heat from the building core.

The PIU system consists of a VAV terminal box with a small fan or blower that "induces" (i.e., draws) some amount of air from a ceiling plenum. The blower has two functions:

1) Warm return air from the core zone is sent into the plenum. The fan draws this air from the plenum into an exterior zone requiring heat, thus conserving heating energy;

2) The fan provides increased air movement when the VAV damper throttles the primary air down, providing increased occupant comfort. In addition, primary air may be decreased below levels normally allowed in standard VAV systems, thus saving additional energy.

Two types of PIU are modelled — series and parallel. In the series, as shown in Fig. 1, the fan draws air from both the primary (central system) and secondary (plenum) air streams. The proportion of primary to secondary air is controlled by the VAV damper. The amount of secondary plus primary air is constant, and the fan runs all the time (when the central fans are on) at constant speed.

The parallel fan unit is slightly more complicated. As is shown in the schematic, Fig. 2, the fan draws air from the secondary air stream only. In addition, the operation of the

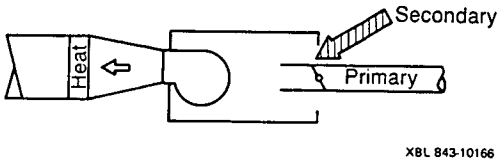

Figure 1. Series PIU

parallel blower is intermittent. A thermostat set point regulates turning the fan on and off. When cooling is required, the fan is generally off. Thus we have normal variable volume - constant temperature cooling with the primary air. When the primary air damper is closed and the fan is on, we have constant volume ventilating/heating. Therefore, total air to the zone is not a constant, as in the series cases. The parallel unit may use less energy than a series unit, since the fan runs only when needed.

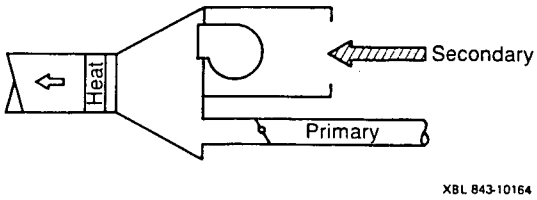

Figure 2. Parallel PIU

As originally designed, DOE-2 modelled zones as convectively independent. The exception was plenums — air could be supplied from a plenum to a conditioned zone, or returned through a plenum. However, air could not be taken from a conditioned zone and used as supply air in another. With the PIU system, this is now changed. One zone is denoted the supply or "induced air" zone. Return air from this zone is sent through the plenum (or a duct) and is used as part of the supply air for a zone with a PIU box. The induced air zone is simulated first. The return air temperature is calculated in the usual way. The return air from this zone is then available at this "return" temperature to be used as part of the supply air for the PIU zones. Frequently the amount of return air available from the core zone is not sufficient to supply all the secondary air needed for the exterior zones. In this case, the extra secondary air is induced from the exterior zones themselves.

For parallel PIUs, one of the equations relating the space temperature to the zone extraction rate must be altered. The temperature and the extraction rate are obtained from two equations. The first, the temperature deviation equation, relates the temperature to the extraction rate through the air temperature weighting factors. The weighting factors are characteristic of the room geometry and construction and basically give the response of the room to a change in air temperature. The second equation is the thermostat equation; this relationship is normally assumed to be piecewise linear. There is a heating action band, a dead band, and a cooling action band. For the parallel PIU, the dead band or the cooling band is divided in two by the blower thermostat setpoint — the extraction rate with the fan on is different from when the fan is off. Due to the increased complexity of the thermostat equation, additional iterations between the two equations are necessary to arrive at a solution for the hourly average temperature and the extraction rate.

Heat Recovery from Refrigerated Case Work

We have found that almost all new food stores are being built with a system to recover heat from the refrigeration systems that serve the food display case work.

A new set of keywords will be added to the PSZ (Packaged Single Zone) system to allow the simulation of refrigerated case work, with or without heat recovery. The model can also be used to simulate ice rinks with or without heat recovery. The user can specify refrigerated case work up to three different temperature levels and specify a corresponding load for each level. The temperature levels reflect the evaporator temperatures of different types of display cases for various products such as frozen foods, meats, dairy products, and produce.

Additional HVAC Systems Enhancements

The addition of the PIU system will be a major enhancement to the 2.1C version of the program. However, there were three smaller items, requested by users, that will also be added: Commercial Air/Air Heat Pumps, updated curves for Packaged Air Conditioning Units and Coils, and Optimum Fan Start.

1. Commercial Air/Air Heat Pumps normally are furnished with outside air economizer cycles. These units could not be simulated in previous versions of DOE-2, whereas they now will be. The heat pump model will also be expanded so that other types of supplemental heating, such as gas furnaces, can be simulated.

2. In 1980, when we first added the Packaged Air Conditioning Units, we had a great deal of difficulty in getting part load performance curves from the manufacturers of this type of equipment. Since that time, we have collected better part load information which has made it possible to replace the old curves with new ones.

3. Many buildings now have energy management control systems (EMCS) which allow the start-up of fans to be delayed until what is called Optimum Start time. This is an energy conservation measure that, because of its popularity, will also be added to DOE-2.

BUILDING ENERGY ANALYSIS INQUIRY

In order to better serve the building energy analysis community, we are requesting your participation in this inquiry. The questions are designed to gather data on the different types of users of DOE-2. We will use these data to construct profiles of the user community and to develop ways to meet your various needs.

1. Type of institution:

[ ] University or College
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[ ] Engineering Firm
[ ] Architectural-Engineering Firm
[ ] Computer Service
[ ] Other: _____
(please specify)

2. What version of the program are you currently using? DOE-2.1___

3. How frequently do you use the program? _____ Runs/year

4. Purpose of use of DOE-2: (Please check all that apply)

[ ] Building design
[ ] Teaching, training
[ ] Research
[ ] Performance standards compliance
[ ] Other: _____
(please specify)

5. What type of computer installation do you use?

[ ] In-house computer → Machine type: _____
[ ] Service bureau
[ ] Other: _____
(please specify)

Optional Information

Name : _____

Institution: _____

Address: _____

_____

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Thank you very much for your assistance. Please use this space for any comments you might have on DOE-2. Tear out sheet, fold on line, staple closed, and mail to the Building Energy Simulation Group.

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Lawrence Berkeley Laboratory
Building 90, Room 3147
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Berkeley, California 94720

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DOE-2 Building Energy Use Analysis Program

Version 2.1B

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