THE DOE–2 USER NEWS

PUB-439
Vol. 12, No. 3
Fall 1991

DOE-2: A COMPUTER PROGRAM FOR BUILDING ENERGY SIMULATION

The Simulation Research Group
Energy and Environment Division
Lawrence Berkeley Laboratory
One Cyclotron Road
Berkeley, California 94720

Editor: *Kathy Ellington*
Bldg. 90 — Room 3147

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☞ ☞ HANDS ON ☜ ☜

☞ Back to Basics

A new piece of documentation, *DOE-2 Basics,* has been created for new users of the program. It covers approximately 80% of typical simulation applications, yet requires the user to be familiar with only 25% of the input variables available in the program. *DOE-2 Basics* is being printed now and will be offered through the National Technical Information Service. So that you can have an idea of what the new manual contains, the table of contents for *DOE-2 Basics* has been reprinted in this newsletter. For more information on obtaining *DOE-2 Basics* please call Kathy Ellington at (510) 486-5711 or FAX at (510) 486-4089 or 486-5172.

☞ Oooops!

A correction needs to be made to the DOE-2.1D Supplement, Appendix A, page A.3. Find LOADS hourly report variable number 51 for VARIABLE-TYPE = GLOBAL and replace THSUND with THSNHR. The description of THSUND is incorrect; it should read *"Solar azimuth (degrees) measured counter-clockwise from south"*, not *"Solar azimuth (degrees) measured clockwise from north"*. The corrected page A.3 of Appendix A has been reprinted on page 31 of this newsletter for insertion in your set of documentation.

☞ A rose by any other name ...

The Simulation Research Group has joined the LBL Windows and Lighting Program. This Program, headed by Steve Selkowitz, has been involved in windows and lighting research for 15 years and has been making extensive use of DOE-2 as an analytic tool. Among Windows and Lighting's accomplishments are the development and commercialization of low-E windows and the development of high-frequency electronic ballasts (which have made compact fluorescent lamps possible). They have also produced software, such as WINDOW-3 and SUPERLITE. SRG has collaborated with Windows and Lighting on several projects, including development of the daylighting capability in DOE-2. In recognition of SRG's membership, Windows and Lighting's name has been changed to the Building Technologies Program.

Although our address remains the same, there are some other changes:

☞ The area code for Alameda County has been changed to 510; our main phone number is now (510) 486-5711; our FAX number is (510) 486-4089.

PLANT OPERATING STRATEGIES

by
Bruce E. Birdsall
Simulation Research Group

Introduction
Most building plants are composed of one or more heating boilers, one or more chillers, a service hot water heater, and a cooling tower (or air-cooled condenser). In addition there are chilled-water and condenser-water pumps, gas or oil burners, and fans for the tower and burners. Usually the equipment is of one type (e.g., the chillers are either reciprocating or centrifugal) and all heating equipment is fired with the same fuel type. In this case, the DOE-2 PLANT input is simple and the program has no difficulty sizing the equipment automatically and simulating optimal performance.

However, many plants are complex. An example is a retrofit where one of the two original absorption chillers is to be replaced by a new centrifugal chiller, and where the owner wants to base load the centrifugal using the remaining absorption chiller on peak days. To model this situation we have to specify the "load management" strategy that determines how the two different chillers are to be operated.

Examples:
Following are annotated examples to help users prepare inputs for a variety of common plant configurations and operating strategies. The examples are presented in order of increasing complexity:

1) No plant - all heating and cooling is done by packaged units in SYSTEMS.

2) A simple plant with boiler, chiller, and domestic hot water heater.

3) Heat recovery from a double bundle chiller.

4) Heat recovery from an engine driven chiller.

5) Sequencing of two differently sized boilers.

6) Lead/lag operation of two differently sized chillers.

7) Using an absorption chiller for peak shaving of electric demand.

8) Using a natural-gas engine generator for peak shaving by scheduling it on during the utilities on-peak periods.

9) Sequencing the operation of a gas turbine and diesel engine so that the gas turbine part load never drops below 50%.

10) Recovering heat from a diesel generator engine jacket to heat both the building and domestic hot water using instantaneous heat exchangers. The generator operates only from 7AM to 10PM.

11) A cogeneration system that recovers heat from a gas turbine generator and provides it to a two-stage absorption chiller, with the remaining heat available for heating the building and domestic hot water.

12) A cogeneration system that recovers heat from a gas turbine generator and diesel generator engine exhaust and provides it to a two-stage absorption chiller. The remaining recovered heat is available for heating the building and domestic hot water. Both generators track the electric load except that from 1PM to 5PM during summer months the generators run at maximum output and the excess electricity is sold back to the utility. The gas turbine fuel is diesel oil and the turbine does not run below a 0.5 part load ratio.

Input Descriptions for Typical Plant Configurations*

1) No plant - all heating and cooling by packaged units in SYSTEMS

DOE-2 input	Notes
INPUT PLANT ..	A plant must be input in order for plant reports to be printed. A plant is also needed to pass fuel and electric energy consumption to the ECONOMICS section of DOE-2.
DHWH = PLANT-EQUIPMENT TYPE = DHW-HEATER SIZE = -999 ..	When there is no domestic hot water load input in LOADS, the user should input TYPE = COOLING-TWR as a dummy since the program requires at least one type of plant equipment.
END .. COMPUTE PLANT ..	

2) A simple plant with boiler, chiller, and domestic hot water heater

DOE-2 input	Notes
INPUT PLANT ..	
HWG = PLANT-EQUIPMENT TYPE = HW-BOILER SIZE = -999	Boiler will be sized automatically. Whenever the actual size of equipment is known, the simulation accuracy will be improved by using that information in the input.
INSTALLED-NUMBER = 1 ..	The installed number defaults to one.
CHW = PLANT-EQUIPMENT TYPE = HERM-REC-CHLR SIZE = -999	Chillers will be sized automatically and load split evenly between two units.
INSTALLED-NUMBER = 2 ..	
DHW = PLANT-EQUIPMENT TYPE = DHW-HEATER SIZE = -999 ..	
PLANT-PARAMETERS BOILER-FUEL = FUEL-OIL DHW-HEATER-FUEL = FUEL-OIL ..	Demonstrates how to change the fuel type (defaults to NATURAL-GAS for domestic hot water heaters).
END .. COMPUTE PLANT ..	

* DOE-2 input is shown on the left-hand side and notes to individual lines of input are given on the right-hand side.

3) Heat recovery from a double bundle chiller

```
INPUT PLANT ..

HWG = PLANT-EQUIPMENT
  TYPE = HW-BOILER
  SIZE = -999 ..
```

The boiler will supplement the recovered heat from the double bundle chiller.

```
CHW = PLANT-EQUIPMENT
  TYPE = DBUN-CHLR
  SIZE = -999 ..

HEAT-RECOVERY
  SUPPLY-1 = (DBUN-CHLR)
  DEMAND-1 = (SPACE-HEAT) ..
```

This is the default for HEAT-RECOVERY and is therefore not required input.

```
(or)
HEAT-RECOVERY
  SUPPLY-1 = (DBUN-CHLR)
  DEMAND-1 = (SPACE-HEAT,
              PROCESS-HEAT) ..
```

Specifies that heat recovered from the double-bundle chiller be assigned to both space heating and domestic water heating, with space heating (SPACE-HEAT) taking precedence over domestic hot water heating (PROCESS-HEAT). If *a domestic hot water heater* is input, it will take precedence over heat recovery, not supplement it.

```
END ..
COMPUTE PLANT ..
```

4) Heat recovery from an engine driven chiller

```
INPUT PLANT ..

HWG = PLANT-EQUIPMENT
  TYPE = HW-BOILER
  SIZE = -999 ..
```

The program will size the boiler for the peak heating load. The boiler will supplement the heat recovery.

```
ECH = PLANT-EQUIPMENT
  TYPE = ENG-CHLR
  SIZE = 2.0 ..
```

The manufacturers recommend that an engine chiller be sized at less than the peak cooling load so that it will operate in an overload condition at peak load. Therefore the user should manually size the unit.

```
HEAT-RECOVERY
  SUPPLY-1 = (ENG-CHLR)
  DEMAND-1 = (SPACE-HEAT,
              PROCESS-HEAT) ..
```

The engine heat-exchanger is furnished with the unit.
Space heating takes precedence over domestic
hot water.

Note that if a domestic hot water heater is input, it will take precedence over heat recovery, not supplement it.

```
END ..
COMPUTE PLANT ..
```

5) Sequencing of two differently-sized boilers

INPUT PLANT ..	
HWG1 = PLANT-EQUIPMENT	
TYPE = HW-BOILER	
SIZE = 2.0	2 million Btu/hr output capacity.
INSTALLED-NUMBER = 1 ..	Manual sizing is required for this situation.
HWG2 = PLANT-EQUIPMENT	
TYPE = HW-BOILER	
SIZE = 3.0	3 million Btu/hr output capacity.
INSTALLED-NUMBER = 1 ..	
BOILER-CTRL = LOAD-ASSIGNMENT	This input overrides program optimization routines.
TYPE = HEATING	Identifies the function of the equipment involved.
OPERATION-MODE = RUN-NEEDED	The boilers will run in sequence.
LOAD-RANGE = 5.0	Maximum anticipated combined load.
PLANT-EQUIPMENT = HWG1	The 1st boiler to run in this load range.
NUMBER = 1	The number of units is mandatory input.
PLANT-EQUIPMENT = HWG2	The 2nd boiler to run in this load range.
NUMBER = 1 ..	
LOAD-MANAGEMENT	
PRED-LOAD-RANGE = 99	Required input. A large value signifies that no threshold applies.
LOAD-ASSIGNMENT = (BOILER-CTRL, DEFAULT, DEFAULT) ..	BOILER-CTRL is the u-name of the heating LOAD-ASSIGNMENT. The load assignment u-names for cooling and electric are defaulted, which means the program will control any cooling equipment and source of electricity.
END ..	
COMPUTE PLANT ..	

6) Lead-lag operation of two differently-sized chillers

INPUT PLANT ..	
CHW1 = PLANT-EQUIPMENT	
TYPE = HERM-REC-CHLR	
SIZE = 2.0	2 million Btu/hr output capacity. Manual sizing is required for this situation.
INSTALLED-NUMBER = 1 ..	
CHW2 = PLANT-EQUIPMENT	
TYPE = HERM-REC-CHLR	
SIZE = 3.0	3 million Btu/hr output capacity.
INSTALLED-NUMBER = 1 ..	
CHILLER-CTRL = LOAD-ASSIGNMENT	This input overrides program optimization routines.
TYPE = COOLING	We are assigning cooling equipment.
OPERATION-MODE = RUN-NEEDED	The chillers will run in sequence.
LOAD-RANGE = 4.0	Chiller CHW1 will lead CHW2 up to 4.0 MBtuh.
PLANT-EQUIPMENT = CHW1	The 1st chiller to run in this range.
N = 1	The abbreviation for NUMBER = 1.
PLANT-EQUIPMENT = CHW2 N = 1	The 2nd chiller to run in this range.
LOAD-RANGE = 99	From 4.0 to 99 MBtuh chiller CHW2 will lead CHW1.
PLANT-EQUIPMENT = CHW2 N = 1	The 1st chiller to run in this range.
PLANT-EQUIPMENT = CHW1	The 2nd chiller to run in this range.
N = 1 ..	
LOAD-MANAGEMENT	
PRED-LOAD-RANGE = 99	No threshold applies.
LOAD-ASSIGNMENT = (DEFAULT, CHILLER-CTRL, DEFAULT) ..	CHILLER-CTRL is the u-name of the cooling LOAD-ASSIGNMENT.
END ..	
COMPUTE PLANT ..	

7) Using an absorption chiller for peak shaving electric demand.

INPUT PLANT ..	
STM = PLANT-EQUIPMENT TYPE = STM-BOILER SIZE = 4.5 ..	The size of the steam boiler is matched to the absorption chiller, i.e. 4.5 = 3.0/(.66 COP).
ABS = PLANT-EQUIPMENT TYPE = ABSOR1-CHLR SIZE = 3.0 ..	Chiller sizes must be entered; automatic sizing is not appropriate for two different units, both of which are full sized.
CHW = PLANT-EQUIPMENT TYPE = HERM-CENT-CHLR SIZE = 3.0 ..	Ditto
OFF-PEAK = LOAD-ASSIGNMENT TYPE = COOLING LOAD-RANGE = 3 PLANT-EQUIPMENT = CHW NUMBER = 1 ..	This assignment allows the centrifugal chiller to run.
PEAK-DEMAND = LOAD-ASSIGNMENT TYPE = COOLING LOAD-RANGE = 3 PLANT-EQUIPMENT = ABS NUMBER = 1 ..	This assignment allows the absorption chiller to run, thus lowering the electric demand.
LOAD-MANAGEMENT HEAT-MULTIPLIER = 0.0	The contribution of heating to summer electrical peak demand is estimated at 0.0.
COOL-MULTIPLIER = .20	The contribution of cooling to summer electrical peak is primarily compressor energy.
ELEC-MULTIPLIER = 1.0	The total contribution of lights and equipment, fans, etc. to electric demand is 100%.
PRED-LOAD-RANGE = ***	The user's estimate of the threshold electric demand (in MBtuh) below which the centrifugal is allowed to run.
LOAD-ASSIGNMENT = (DEFAULT, OFF-PEAK, DEFAULT)	OFF-PEAK is the load assignment that references the centrifugal chiller.
PRED-LOAD-RANGE = 99	An electric demand (in MBtuh) between *** and 99 will cause the absorption chiller to run.
LOAD-ASSIGNMENT = (DEFAULT, PEAK-DEMAND, DEFAULT) ..	PEAK-DEMAND is the load assignment that references the absorption chiller. The u-name is in the cooling position since cooling demand when converted to electric demand is being addressed.
END .. COMPUTE PLANT ..	

8) **Using a natural-gas engine generator for peak shaving by scheduling it on during the utility's on-peak periods.**

INPUT PLANT ..	
GGEN = PLANT-EQUIPMENT	
TYPE = DIESEL-GEN	
SIZE = .34 ..	A 100kW gas engine generator output expressed in MBtuh.
PLANT-PARAMETERS	
DIESEL-FUEL = NATURAL-GAS	changes fuel type from diesel (default) to natural gas.
DIESEL-GEN-EFF = .28 ..	To reset efficiency representing a naturally aspirated gas engine.
OFF-PEAK = LOAD-ASSIGNMENT	
TYPE = ELECTRICAL	
LOAD-RANGE = 99	A large number representing maximum anticipated load.
PLANT-EQUIPMENT = UTILITY	UTILITY in this example represents purchased electricity.
NUMBER = 99 ..	NUMBER when used with UTILITY must be the maximum demand in MBtuh.
ON-PEAK = LOAD-ASSIGNMENT	
TYPE = ELECTRICAL	
LOAD-RANGE = 99	No threshold applies.
PLANT-EQUIPMENT = GGEN	Referencing the gas generator first makes it base loaded.
NUMBER = 1	
PLANT-EQUIPMENT = UTILITY	
NUMBER = 99 ..	The utility picks up any load above that satisfied by the gas engine generator.
WD-P-HRS = DAY-ASSIGN-SCH	
(1,12) (OFF-PEAK)	References the OFF-PEAK load assignment.
(13,18) (ON-PEAK)	References the ON-PEAK load assignment.
(19,24) (OFF-PEAK) ..	References the OFF-PEAK load assignment.
WEH-HRS = DAY-ASSIGN-SCH	
(1,24) (OFF-PEAK) ..	Again we reference the OFF-PEAK load assignment for use on weekends and holidays.
DEMAND-CTRL = SCHEDULE THRU DEC 31	
(WD) WD-P-HRS	WD stands for weekdays.
(WEH) WEH-HRS ..	WEH stands for weekends and holidays.
LOAD-MANAGEMENT	
PRED-LOAD-RANGE = 99	No threshold applies.
ASSIGN-SCHEDULE = (DEFAULT,	
DEFAULT,	
DEMAND-CTRL) ..	Here we reference the DEMAND-CTRL schedule, which has the generator on from noon to 6PM during the week and off at all other times.
END ..	
COMPUTE PLANT ..	

9) Sequencing the operation of a gas turbine and diesel engine so that the gas turbine part load never drops below 50%.

```
INPUT PLANT ..

TURB = PLANT-EQUIPMENT
     TYPE = GTURB-GEN
```

A characteristic of gas turbines is that they do not operate efficiently at part loads less than 50%.

```
     SIZE = 6.8
```

Always size generators in MBtuh; here the electrical output is 2000 kW * 3413 = 6.8 MBtuh.

```
     INSTALLED-NUMBER = 1 ..

DGEN = PLANT-EQUIPMENT
     TYPE = DIESEL-GEN
```

The diesel engine unloads more efficiently and will be used to trim the electric load.

```
     SIZE = 3.4
```

The size is 1000 kW

```
     INSTALLED-NUMBER = 2
     MAX-NUMBER-AVAIL = 1 ..
```

We will use only one of two diesel generators, the other providing standby capacity during maintenance.

```
GEN-CTRL = LOAD-ASSIGNMENT
     TYPE = ELECTRICAL
```

The type of equipment is electrical.

```
     LOAD-RANGE = 3.4
```

Up to 1000 kW only one diesel generator will run.

```
     PLANT-EQUIPMENT = DGEN
          N = 1
     LOAD-RANGE = 9.8
```

From 1000 kW to 3000 kW the generators will be sequenced.

```
     PLANT-EQUIPMENT = TURB
          N = 1
```

The gas turbine is the first on and will start at 1000 kW or 50% load.

```
     PLANT-EQUIPMENT = DGEN
          N = 1 ..
```

From 2000 kW to 3000 kW both units will run.

```
LOAD-MANAGEMENT
     PRED-LOAD-RANGE = 99
```

No threshold applies.

```
     LOAD-ASSIGNMENT = (DEFAULT,
          DEFAULT, GEN-CTRL) ..

END ..
COMPUTE PLANT ..
```

10) Recovering heat from a diesel generator engine jacket to heat both the building and domestic hot water using instantaneous heat exchangers. The generator operates only from 7AM to 10PM.

INPUT PLANT ..	
HWG = PLANT-EQUIPMENT TYPE = HW-BOILER SIZE = -999 ..	This sizes the boiler to maximum heating load.
DGEN = PLANT-EQUIPMENT TYPE = DIESEL-GEN SIZE = .34 ..	A 100 kW diesel engine generator is installed that uses diesel oil.
HEAT-RECOVERY SUPPLY-1 = (DIESEL-JACKET)	Only heat from the engine jacket is recovered.
DEMAND-1 = (SPACE-HEAT, PROCESS-HEAT) ..	Building heat is first to be satisfied and any excess goes to domestic hot water.
DGEN-ON = LOAD-ASSIGNMENT TYPE = ELECTRICAL	This load assignment is used to schedule the diesel generator.
LOAD-RANGE = .34	Up to 100 kW (.34 MBtuh), the diesel generator is base loaded.
PLANT-EQUIPMENT = DGEN NUMBER = 1 ..	The utility supplements the diesel as the default condition.
DGEN-OFF = LOAD-ASSIGNMENT TYPE = ELECTRICAL	This load assignment covers the period that the generator is not operating.
LOAD-RANGE = 99 P-E = UTILITY N = 99 ..	N = 99 (NUMBER = 99) is the peak anticipated electrical load.
DGEN-SCH = DAY-ASSIGN-SCH (1,7) (DGEN-OFF) (8,22) (DGEN-ON) (23,24) (DGEN-OFF) ..	This schedule controls the daily generator operation, which requires use of the DAY-ASSIGN-SCH instruction.
DGEN-CTRL = SCHEDULE THRU DEC 31 (ALL)	ALL means all days of the week.
DGEN-SCH ..	The DAY-ASSIGN-SCH is referenced.
LOAD-MANAGEMENT PRED-LOAD-RANGE = 99	
ASSIGN-SCHEDULE = (DEFAULT, DEFAULT, DGEN-CTRL) ..	Heating and cooling are defaulted; u-name of the schedule is referenced for electrical.
END .. COMPUTE PLANT ..	

11) A cogeneration system that recovers heat from a gas turbine generator for use by a two stage absorption chiller, with the remaining heat available for heating the building and domestic hot water.

INPUT PLANT ..

ABS = PLANT-EQUIPMENT TYPE = ABSOR2-CHLR SIZE = -999 ..	A two stage absorption chiller with automatic sizing. Approximately 19.7 MBtuh is recoverable from the gas turbine.
STMB = PLANT-EQUIPMENT TYPE = STM-BOILER SIZE = -999 ..	A steam boiler to supplement the heat recovered from the gas turbine. The user should adjust capacity of boiler to insure that it meets the total requirements of absorption chiller minus recoverable heat.
GTUR = PLANT-EQUIPMENT TYPE = GTURB-GEN SIZE = 6.8 ..	A gas turbine electric generator of 2000 kW capacity (6.8 MBtuh) has a peak efficiency of 0.19. Therefore its input energy is 6.8/.19 = 35.8 and approximately 55% of this heat may be recovered.
HSTO = PLANT-EQUIPMENT TYPE = HTANK-STORAGE SIZE = 167 ..	A storage tank to store hot water for building heat and domestic hot water. The SIZE is MBtu stored, not the physical size. In this case 500 K gal * 8.33 lb/gal * 40F dt = 167 MBtu stored heat.
HEAT-RECOVERY SUPPLY-1=(GTURB-GEN)	Heat source is exhaust gas from the gas turbine.
DEMAND-1=(ABSOR2-CHLR)	The first priority for heat at the highest temperature level is the absorption chiller, which requires 125-lb steam.
SUPPLY-2=(GTURB-GEN,HTANK-STORAGE)	The source for SUPPLY-2 is turbine exhaust but the absorption chiller has first priority. The HTANK-STORAGE is a supplier since the tank has stored heat as a DEMAND-3.
DEMAND-2=(SPACE-HEAT,PROCESS-HEAT)	The order in which the demands occur sets their priority over each other.
SUPPLY-3=(GTUB-GEN)	All remaining heat goes to storage.
DEMAND-3=(HTANK-STORAGE) ..	Here the HTANK-STORAGE is a demand.
GGEN-OP = SCHEDULE THRU DEC 31 (ALL) (1,24) (1) ..	This schedule controls when heat is recoverable for charging the storage.
ENERGY-STORAGE HEAT-STORE-RATE = 19.7	This is the maximum rate only when there is no other demand.
HEAT-SUPPLY-RATE = ***	This must be set by the user to match the building heating load.
HEAT-STORE-SCH = GGEN-OP	References the schedule for when heat can be recovered.

HTANK-LOSS-COEF = 200	The tank's UA value (the heat loss from the surface of the tank per degree temperature difference between the environment and the storage medium (Btuh/F)). It must be calculated by the user.
HTANK-BASE-T = 140	Is the return water temperature of the building heating system.
HTANK-T-RANGE = 40	Is the temperature drop of the heating water loop.
HTANK-ENV-T = 70 ..	Is the average ambient temperature surrounding the tank.
HRCVY = LOAD-ASSIGNMENT	Whenever ENERGY-STORAGE is used, the program requires a LOAD-ASSIGNMENT to tie the storage tank and supplemental heating equipment together.
TYPE = HEATING	
LOAD-RANGE = 99	No threshold applies.
PLANT-EQUIPMENT = HSTO	References the u-name of the storage.
NUMBER = 1	
PLANT-EQUIPMENT = STMB	References the u-name of the boiler supplementing the storage.
NUMBER = 1 ..	
ELEC = LOAD-ASSIGNMENT	This assignment controls operation of the gas turbine, which is always on.
TYPE = ELECTRICAL	
LOAD-RANGE = 6.8	The capacity of the gas turbine.
PLANT-EQUIPMENT = GTUR	References the u-name of the gas turbine.
NUMBER = 1 ..	
LOAD-MANAGEMENT	
PRED-LOAD-RANGE = 99	No threshold applies.
LOAD-ASSIGNMENT = (HRCVY,	The u-name of the heating L-A.
DEFAULT,ELEC) ..	ELEC is the u-name of the electric L-A.
END ..	
COMPUTE PLANT ..	

12) A cogeneration system that provides recovered heat from a gas turbine generator and a diesel generator's engine exhaust to a two-stage absorption chiller. The remaining recoverable heat from the diesel generator's jacket is available through storage for heating the building and domestic hot water. Both generators track the electric load, except that from 1PM to 5PM during summer months the generators run at maximum output and excess electricity is sold to the utility. The gas turbine fuel is diesel oil; the turbine does not run below a 0.5 part load ratio.

```
INPUT PLANT ..

ABS = PLANT-EQUIPMENT
    TYPE = ABSOR2-CHLR
    SIZE = -999
    INSTALLED-NUMBER = 2 ..
```

A two stage absorption chiller with automatic sizing.

```
STMB = PLANT-EQUIPMENT
    TYPE = STM-BOILER
    SIZE = -999 ..
```

A steam boiler to supplement the heat recovered from the gas turbine. The user should adjust capacity of boiler to insure that it meets the total requirements of absorption chiller minus recoverable heat.

```
GTURB = PLANT-EQUIPMENT
    TYPE = GTURB-GEN
    SIZE = 6.8 ..
```

A gas turbine electric generator of 2000 kW capacity (6.8 MBtuh) has a peak efficiency of 0.19. Therefore its input energy is 6.8/.19 = 35.8 MBtuh; approximately 55% of this heat may be recovered.

```
GGEN = PLANT-EQUIPMENT
    TYPE = DIESEL-GEN
    SIZE = 3.4 ..
```

A diesel engine generator of 1000 kW capacity (3.4 MBtuh) has a peak efficiency of 0.35. Therefore its input energy is 3.4/.35 = 9.7 MBtuh; approximately 23% of this heat may be recovered from the exhaust and another 20% from the jacket/lube oil.

```
HSTO = PLANT-EQUIPMENT
    TYPE = HTANK-STORAGE
    SIZE = 167 ..
```

A storage tank to store hot water for building heat and domestic hot water. The SIZE is MBtu stored, not the physical size. In this case 500 K gal * 8.33 lb/gal * 40F dt = 167 MBtu stored heat.

```
HEAT-RECOVERY
   SUPPLY-1 = (GTURB-GEN,
            DIESEL-GEN)
```

The source of high temperature heat is exhaust gas from the gas turbine and diesel engine.

```
   DEMAND-1 = (ABSOR2-CHLR)
```

The first priority for heat at the highest temperature level is the absorption chiller which requires 125-lb steam.

```
   SUPPLY-2 = (GTURB-GEN,
          DIESEL-GEN,
          HTANK-STORAGE)
```

SUPPLY-2 is heat remaining from turbine and diesel exhaust after the absorption chillers are satisfied. The diesel jacket and lube oil heat occurs at lower temperatures and can be used only for building heat and domestic hot water. HTANK-STORAGE is a supplier since the tank has stored any remaining heat at DEMAND-3.

DEMAND-2 = (SPACE-HEAT, PROCESS-HEAT)	
SUPPLY-3 = (GTURB-GEN, DIESEL-GEN, DIESEL-JACKET)	SUPPLY-3 is heat remaining including jacket heat of the diesel generator.
DEMAND-3 = (HTANK-STORAGE) ..	The storage tank is heated by any heat left over after the building and domestic hot water loads are satisfied. Here the HTANK-STORAGE is a demand.
GGEN-OP = SCHEDULE THRU DEC 31 (ALL) (1,24) (1) ..	This schedule controls when the storage is seen by the simulation as a heating load.
ENERGY-STORAGE	
HEAT-STORE-RATE = 23.8	This is the maximum combined rate only when there is no other demand.
HEAT-SUPPLY-RATE = ***	This must be set by the user to match the building heating load.
HEAT-STORE-SCH = GGEN-OP	References the schedule for when heat can be recovered.
HTANK-LOSS-COEF = 200	Is the heat loss from the surface of the tank per degree temperature difference between its environment and stored medium (Btuh/F). It must be calculated by the user.
HTANK-BASE-T = 140	Is the return water temperature of the building heating system.
HTANK-T-RANGE = 40	Is the temperature drop of the heating water loop.
HTANK-ENV-T = 70 ..	Is the average ambient temperature surrounding the tank.
HRCVY = LOAD-ASSIGNMENT	Whenever ENERGY-STORAGE is used, the program requires a LOAD-ASSIGNMENT to tie the storage tank and supplemental heating equipment together.
TYPE = HEATING	
LOAD-RANGE = 99	No threshold applies.
PLANT-EQUIPMENT = HSTO	References the u-name of the storage.
NUMBER = 1	
PLANT-EQUIPMENT = STMB	References the u-name of the boiler supplementing the storage.
NUMBER = 1 ..	
ELEC = LOAD-ASSIGNMENT	This assignment controls operation of the gas turbine and diesel which are always on.
TYPE = ELECTRICAL	
LOAD-RANGE = 3.4	Up to this capacity the diesel generator will run.
PLANT-EQUIPMENT = GGEN	References the u-name of the diesel generator.
NUMBER = 1	
LOAD-RANGE = 99	From 3.4 to maximum capacity both generators will run.
PLANT-EQUIPMENT = GTURB N = 1	
PLANT-EQUIPMENT = GGEN N = 1 ..	The order in which the units appear specifies how they are sequenced.

SELL-E = DAY-SCHEDULE (1,13) (1) (14,17) (5) (18,24) (1) ..	A value of 1 signifies track electric and a value of 5 signifies run at max output to sell electricity from 1PM to 5PM.
NO-SELL = DAY-SCHEDULE (1,24) (1) ..	For all other days of the year track the electric demand.
GEN-CTRL = SCHEDULE	
THRU JUN 1 (ALL) NO-SELL	
SEP 1 (WD) SELL-E	The contract with the utility is to sell electric during summer months on weekdays (WD).
DEC 31 (ALL) NO-SELL ..	
PLANT-PARAMETERS	
GTURB-FUEL = DIESEL-OIL	To change from the default of natural gas to diesel oil for the gas turbine.
COGEN-TRACK-SCH = GEN-CTRL ..	This references the schedule that determines how the generators are loaded.
LOAD-MANAGEMENT	References u-name of heating L-A, cooling defaults, and u-name of electrical L-A.
PRED-LOAD-RANGE = 99	No threshold applies.
LOAD-ASSIGNMENT = (HRCVY, DEFAULT, ELEC) ..	

END ..
COMPUTE PLANT ..

DOE-2 and CCIP

by
Vladimir Bazjanac, Ph.D.

Centre de Conferences Internationales de Paris (CCIP) is a new $400M conference center in Paris designed to serve the needs of France and United Europe in the 21st century. It is the latest of the "presidential" buildings (i.e., buildings commissioned directly by the president of France, such as the new Paris opera house or the new National Library) intended to leave a mark of our time on French architectural history.

The location of this building is unique and most prominent of all recent presidential buildings: on the left bank of the Seine at Quai Bronly immediately north of the Eiffel Tower. The building's design was the winner of a large competition judged by an international jury.

The design concept, by Parisian architect Francis Soler, calls for three large glass boxes (each approximately 150 ft by 300 ft by 90 ft on top of a large underground building (Figs. 1 and 2). Each glass box has a separate building structure inside.

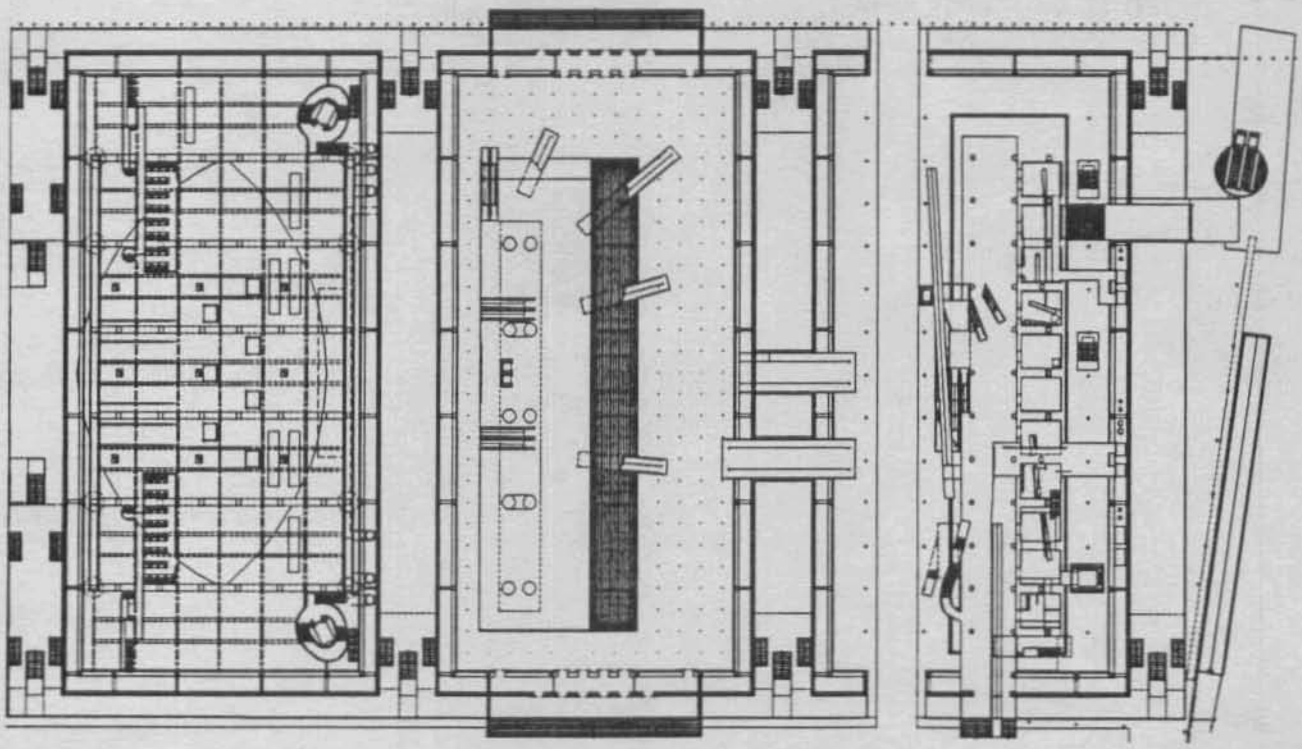

Figure 1

Vladimir Bazjanac is an energy consultant in Berkeley. He has taught at the University of California at Berkeley since 1968, and has been involved with DOE-2 since its inception. Contact Dr. Bazjanac at P.O. Box 4158, Berkeley, CA 94704.

Two of the three glass boxes have double skin (all glass); two of the three function as large glass atria (Fig. 2).

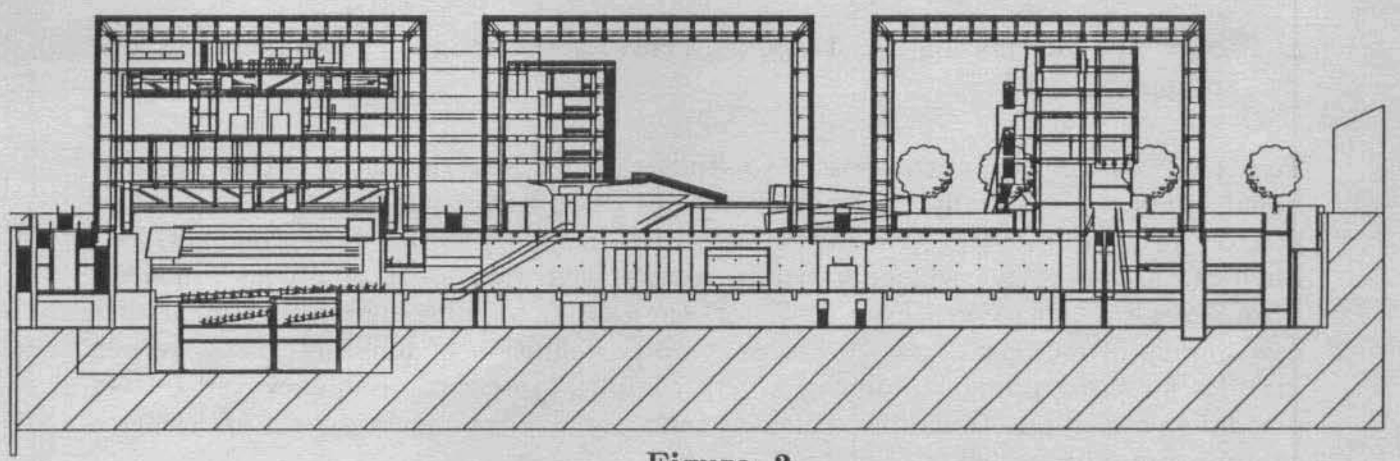

Figure 2

Each of the three glass boxes is devoted to a different function. The middle box provides main access and controlled separation of occupants according to their accreditation. All strictly diplomatic functions and meetings are in the high-security box to the west (toward Eiffel Tower). The press center with modern press facilities and an indoor park with trees from the region is in the box to the east. The underground structure contains large conference and exhibit rooms with all necessary support facilities.

The primary architectural reason for glass boxes is to provide visual uniformity. They also protect the inside building structures from the elements and allow unobstructed views inside and out. All glass is clear, and only low reflectivity is permissible because of possible multiple reflections. This poses a challenge to find the best balance between natural lighting and thermal loads, especially for atria in the middle and east glass boxes.

Solar radiation in Paris is too strong to leave clear glass unprotected. Glass boxes require some form of shading to reduce direct solar gain, but still allow sufficient natural light where needed and to eliminate glare in large public spaces. (Glare is potentially a very serious issue because of possibility of reflection of sun from multiple glass surfaces.) Three alternatives are currently under study:

1. fixed, soft, perforated surfaces (shading mesh)

2. movable, hard, perforated surfaces (panels) and

3. glass laminated with Solarflex (an interlayer that reflects solar heat, invented by Southwall Technologies and manufactured by Monsanto).

It is likely that the final solution will consist of a combination of all three alternatives.

Basic mechanical systems, as presently planned, are VAV with possible use of evaporative precooling. One of the large atria (in the glass box for the press) will only be ventilated. The City of Paris will supply steam and (possibly) cold water.

Simulation of CCIP's performance with DOE-2 serves a dual purpose:

1. to generate comparative data of performance of glazing and shading alternatives for the selection of glass types and shading, and

2. to provide information about thermal loads for the design of mechanical systems and plant.

To achieve the former it is necessary to study the effects of the use of several conventional glass types available from European suppliers, high-tech glass types of U.S. origin, and different perforation densities in soft and hard shading surfaces. Final recommendations will be based on comparative analysis of quantitative performance of all alternatives. For the latter, the DOE-2 building description includes a new library of European glass types, a complex definition of building shades (which includes all surrounding buildings), a very complex system of occupancy and related schedules, and input functions which account for daylighting in spaces adjacent to sunspaces for the modeling of atria.

All simulations were run with a beta-test version of DOE-2.1E using metric input and output. A weather tape with solar measurements for Paris (actually for Trappes, a suburb of Paris) was converted from French format. The new glass library with definition of glass-type codes takes into account angular dependence; it was developed with a beta-test version of the WINDOW-4.0 program.* All double-skin spaces are modeled as sunspaces.

The DOE-2 description of the building is evolving with the design. The first two versions had 62 and 64 thermal zones, respectively. Work is currently in progress on a new building description that will have approximately 100 zones, 40 systems and 620 schedules.

Each simulation run generates an enormous amount of information. To facilitate analysis, a group of *awk* programs automatically extracts the necessary data from LOADS, SYSTEMS and PLANT reports and places them in easy to read tables.

DOE-2 analysis is complemented with parallel studies of daylighting, glare, and reflection, based on experiments with a scale model of the building's superstructure in LBL's Sky Simulator. Analytical and design work are expected to be completed by the end of 1991. The building is scheduled for occupancy in 1995.

* WINDOW-4.0 allows users to create custom glass types for use in DOE-2.1E.

Daylighting Design Tool Survey

The Windows and Daylighting Group at LBL has put together a **Daylighting Design Tool Survey**. Periodic updates will be printed in the User News. For more information, contact Michael Wilde, Bldg. 90 -- Room 3111, Building Technologies Program, Lawrence Berkeley Laboratory, Berkeley, CA 94720, FAX (510) 486-4089.

MAINFRAMES

- **DOE-2.1D**

  Simulation Research Group, Bldg. 90 -- Room 3147, Lawrence Berkeley Laboratory, Berkeley, CA 94720; phone (510) 486-5711, FAX (510) 486-4089. Contact: Kathy Ellington

  Daylighting and glare calculation integrated with hourly energy simulation and window management.
  Hardware: DEC and SUN-4
  Software: FORTRAN
  Cost and Availability: call or write for information

- **MUSES**

  School of Architecture, University of Texas, Austin, TX 78712; phone (512) 471-3148. Contact: Francisco Arumi

  Three levels of energy lighting analysis incorporated into a 3-D solid modeling program. Knowledge-based CAD. Analysis component based on DEROB.
  Hardware: SUN or Unix workstations with X Windows.
  Software: C
  Cost and Availability: call or write for information

- **RADIANCE**

  Lighting Systems Research Group, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Bldg 90-3111, Berkeley, CA 94720; phone (510) 486-4757. Contact: Greg Ward

  A ray tracing program that accurately predicts light levels and produces photo realistic images of architectural spaces in all sky conditions.
  Hardware: SUN, DEC, CRAY, UNIX, Macintosh II (A/UX)
  Software: C
  Cost and Availability: Free to anyone who wishes to develop further.

- **SUPERLITE 1.0**

  College of Architecture and Environmental Design, Arizona State University, Tempe, AZ 85287; phone (602) 965-8756. Contact: Jong-Jin Kim

  Allows modeling of complex building interior and exterior geometry; accurate calculation of internally reflected daylight component.
  Hardware: CDC, DEC, Apollo
  Software: FORTRAN — 370K
  Cost and Availability: $ 25.00 for manual and program.

- **UWLIGHT**

  Dept. of Architecture, Gould Hall JO-20, University of Washington, Seattle, WA 98105; phone (206) 543-4180. Contact: Brian Johnson

Useful as an educational tool.
Hardware: CDC
Software: FORTRAN 5
Cost and Availability: call or write for information

MINICOMPUTERS

- **SHIS/DAYLIGHT**
  S&H Information Systems, 11 West 42nd Street, New York, NY 10036; phone (212) 556-3251. Contact: Suro Das.

  Calculates lighting energy savings due to daylight from vertical openings on the basis of ratio of wall to glazing areas.
  Hardware: Microvax 3800
  Software: FORTRAN
  Cost and Availability: $600.00

MICROCOMPUTERSS

- **AAMASKY1** and **SKYLIGHT HANDBOOK**
  AAMA, 2700 River Road, Suite 118, Des Plaines, IL 60018; phone (708) 699-7310.

  Skylight design analysis with emphasis on optimizing for energy efficiency, incorporating both a worksheet and Lotus spread sheet tool.
  Hardware: IBM PC or compatible
  Software: Lotus 1-2-3
  Cost and Availability: $100.00/software package plus $50.00/handbook (half price for AAMA members)

- **AWNSHADE 1.0**
  Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 32920; phone (407) 783-0300. Contact: Ross McCluney

  Calculates the unshaded fraction of a rectangular window shaded by an awning for any given solar position.
  Hardware: DOS-based IBM PC or compatible
  Software: Microsoft, QuickBASIC 3.0
  Cost and Availability: $25.00

- **ADM–DOE2**
  ADM Associates, Inc., 3299 Ramos Circle, Sacramento, CA 95827; phone (916) 363-8383. Contact: Sekhar "Kris" Krishnamurti

  PC version of LBL's DOE-2.1D program.
  Daylighting availability and control, accurate solar shading for individual and whole buildings. Sophisticated window management. Daylighting simulation is on an hour-by-hour basis.
  Hardware: 80386 IBM PC (or compatible) with a 80387 math co-processor, 2 MB extended memory
  Software: DOS version 2.0 or better
  Cost and Availability: $295.00 with one weather data file of user's choice. Other weather

locations available.

- **BUILDING ENERGY ESTIMATION MODULE (BEEM)**
  Ross & Baruzzini, Inc., 1304 Baur Street, St. Louis, MO 63132; phone (314) 241-5001. Contact: Maurice Garoutte

  Useful in early design stages; evaluates energy impact of different types of windows.
  Hardware: IBM PC, IBM PCXT. Needs two disk drives for graphics.
  Software: BASIC, 128K
  Cost and Availability: $350.00

- **CONTROLITE 1.0**
  Lighting Systems Research, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Bldg 90-3111, Berkeley, CA 94720; phone (510) 486-4096. Contact: Francis Rubinstein

  Calculates energy savings and cost-benefit of using lighting controls in buildings. QUICK-LITE incorporated.
  Hardware: IBM PC XT, IBM PC AT or true compatible
  Software: 256K, PCDOS 2.0 or later
  Cost and Availability: $ Free. No support.

- **DAYLIT**
  Southern California Edison, Customer Energy Services, P.O. Box 800, 2244 Walnut Grove Avenue, Rosemead, CA 91770; phone (818) 302-3210. Contact: Gregg D. Ander

  Calculates daylight considering fins, overhangs, skylights and light shelves. Calculates electric light for three zones with five control strategies. Plots hourly and annually data, based on IES method.
  Hardware: IBM PC or compatible
  Software: FORTRAN, 256K - DOS 3.0
  Cost and Availability: $ Free for Beta Testers. Manual on disk. Send two formatted 5 1/4" disks.

- **DAYLITE 2.0**
  Solarsoft, 12672 Skyline Boulevard, Woodside, CA 94062; phone (510) 851-4484. Contact: Bill Ashton

  Daylighting design takes into account overhangs, fins, and skylights; calculates electric lighting demand.
  Hardware: IBM PC or compatible, MacIntosh
  Software: PASCAL
  Cost and Availability: $489.00

- **ENSAR**
  Ensar Group, P.O. Box 1898, Arvada, CO 80001; phone (303) 423-5512. Contact: Greg Franta

  Used with physical model; analysis capability flexible to room configurations.
  Hardware: Custom built
  Software: Custom built
  Cost and Availability: call or write for information

- **LUMEN MICRO**

  Lighting Technologies, 2540 Frontier Street, Suite 107, Boulder, CO 80301; phone (303) 449-5791. Contact: David DiLaura

  Analyzes complex interior lighting systems including daylight, direct/indirect lighting, mixed and even aimed luminaires. User friendly input.
  Hardware: IBM PC or compatible
  Software: FORTRAN
  Cost and Availability: $14.95. Free upgrade of new AutoCAD-based version of program.

- **MICRO-DOE2**

  Acrosoft International, 9745 E. Hampden Avenue, #230, Denver, CO 80231; phone (303) 368-9226. Contact: Gene Tsai.

  Micro version of DOE-2.1D mainframe program, with enhancements.
  Hardware: *Regular DOS Version*: IBM PC, XT, AT or Compaq 386 compatibles, Intel Math-coprocessor
  Software: 640KB RAM, DOS 2.1 or later
  Cost and Availability: $495.00 with two free weather data files.

  Hardware: *Extended DOS Version*: Compaq 386 compatibles, Intel or Weitek Math coprocessor.
  Software: 3 MB RAM, DOS 3.0 or later
  Cost and Availability: $625.00 with two free weather data files.

- **MICROLITE 1.0**

  Department of Architecture, Graduate School of Design, Harvard University, 48 Quincy Street, Cambridge, MA 02138; phone (617) 495-9741. Contact: Harvey Bryan

  Analyzes the daylight illumination for rectangular rooms with vertical glazing in exterior walls. Obstructions are not accounted for.
  Hardware: IBM PC, APPLE II
  Software: IBM 128K, APPLE: 40K BASIC
  Cost and Availability: $25.00

- **QUICKLITE 1.0**

  Windows & Daylighting Group, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Bldg 90-3111, Berkeley, CA 94720; phone (510) 486-5605.

  A relatively quick, crude estimator of daylight levels in simple rectangular rooms. See CONTROLITE.
  Hardware: TRS 80, TI-59
  Software: BASIC, FORTRAN
  Cost and Availability: $ Free. No support.

- **SUPERLITE PC 1.0**

  College of Architecture and, Environmental Design, Arizona State University, Tempe, AZ 85287; phone (602) 965-8756. Contact: Jong-Jin Kim

  A modularized version of SUPERLITE 1.0; maximum number of nodes on windows and interior surfaces reduced for memory size. See SUPERLITE 1.0.
  Hardware: IBM XT or AT with 8087 math coprocessor chip or compatible.
  Software: FORTRAN 3.2 Compiler, 600 K
  Cost and Availability: $25.00 for manual and program.

- **WINDOW 3.1**

  Bostik Construction Products, P.O. Box 8, Huntingdon Valley, PA 19006; phone (800) 523-6530 toll free, or within PA (215) 674-5600

  A public-domain program developed by Lawrence Berkeley Laboratory for analyzing heat transfer through window systems. U-value and shading coefficient are calculated.
  Hardware: IBM PC or compatible.
  Software: DOS 2.1 or higher; math coprocessor decreases calculation time. 256 KB RAM
  Cost and Availability: Free

PROTRACTORS/TABLES

- **CLEAR SKY DAYLIGHT TABLES**

  Graduate School of Design, Harvard University, 48 Quincy Street, Cambridge, MA 02138; phone (617) 495-9741. Contact: Harvey Bryan

  Determines sky component contribution to the illumination of an interior point for a given window geometry and glazing description. Most useful at an early design stage, when scale drawings are not available yet.
  Cost and Availability: $25.00

- **CLEAR SKY WALDRAM DIAGRAMS**

  Graduate School of Design, Harvard University, 48 Quincy Street, Cambridge, MA 02138; phone (617) 495-9741. Contact: Harvey Bryan

  Assist in determination of sky component contribution to the illumination of an interior point, accounting for angle of incidence losses for vertical glazing and obstructions. Graphic method is useful in early design stages.
  Cost and Availability: $25.00

- **DAYLIGHT FACTOR DOT CHARTS**

  Concepts and Practice of Architectural Daylighting, by Fuller Moore, Van Nostrand Reinhold Co. New York, NY, 1985, pp. 234-242.

  Determines sky component of the daylight factor at a given interior reference point through overlay with an obstruction mask.
  Cost and Availability: approximately $30.00 for the book

- **LBL PROTRACTORS**

  Graduate School of Design, Harvard University, 48 Quincy Street, Cambridge, MA 02138; phone (617) 495-9741. Contact: Harvey Bryan

  Allows for determination of the sky component contribution to the illumination of an interior point for an interior point of finite height under overcast sky conditions.
  Cost and Availability: $25.00

- **LUME PROTRACTOR**

  Lighting Research Laboratory, P.O.Box 6193, Orange, CA 92613-6193; phone (714) 771-1312. Contact: Bill Jones

  Useful in early design analysis.
  Cost and Availability: $5.00

- **UW GRAPHIC DAYLIGHTING DESIGN METHOD (GDDM)**
  College of Architecture and Urban Planning, Gould Hall JO-20, University of Washington, Seattle, WA 98105; phone (206) 543-4180. Contact: Marietta Millet

  Determines daylight patterns for a room based on the proportions of the window openings, providing illumination level, distribution and gradient.
  Cost and Availability: $ 30.00

NOMOGRAPHS

- **DAYLIGHTING NOMOGRAPHS**
  Windows & Daylighting Group, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Bldg 90-3111, Berkeley, CA 94720; phone (510) 486-5605.

  Assist designers in determining potential daylighting benefits and costs; checking strategy for energy conservation and load management.
  Cost and Availability: Free, no support.

- **ENERGY NOMOGRAPHS**
  Burt Hill Kosar Rittelmann, 400 Morgan Center, Butler, PA 16001; phone (412) 285-4761. Contact: Al Sain

  Useful in early design analysis on commercial buildings; capable of total building energy analysis, including savings from daylight and heating/cooling loads.
  Cost and Availability: $50.00 for notebook and enlarged, reusable nomograph set from: TVA, Div of Conservation and Energy Management, Commercial and Industrial Branch, 35-D Signal Place, Chattanooga, TN 37401.

- **ENERGY NOMOGRAPHS**
  Ross & Baruzzini, Inc., 1304 Baur Street, St. Louis, MO 63132; phone (314) 241-5001. Contact: Maurice Garoutte

  Cost and Availability: See MICROCOMPUTERS

■ ■ ■ ■ DOE-2 DIRECTORY ■ ■ ■ ■

Program Related Software and Services

■■ Source Code ■■

(2.1D VAX and SUN-4 Only)
Simulation Research Group
Bldg. 90, Room 3147
Lawrence Berkeley Laboratory
Berkeley, CA 94720 (510) 486-5711

(2.1C and 2.1D Mainframe Only)
National Energy Software Center
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439 (708) 972-7250

■■ PC VERSIONS ■■

MICRO-DOE2 (DOE-2.1D for Microcomputers)
Acrosoft International (Gene Tsai)
9745 East Hampden Avenue
Denver, CO 80231 (303) 368-9225

ADM-DOE2 (DOE-2.1D for Microcomputers)
ADM Associates, Inc. (Taghi Alereza)
3299 Ramos Circle
Sacramento, CA 95827 (916) 363-8383

■■ Utility Programs ■■

DOE-Plus™ (Pre- and Post-Processor)
Building Blocks Software (Steve Byrne)
P.O. Box 5218
Berkeley, CA 94705-0218 (510) 549-1444

Graphs from DOE-2
Ernie Jessup
4977 Canoga Avenue
Woodland Hills, CA 91364 (818) 884-3997

COMPLY 24 – California Standards
Gabel Dodd Associates (Michael Gabel)
1818 Harmon Street
Berkeley, CA 94703 (510) 428-0803

Pre-DOE – (BDL math pre-processor)
Nick Luick
19030 State Street
Corona, CA 91719 (714) 278-3131

■■ VIDEO ■■

DOE-2 Instructional Video and Manual
Prof. Jan Kreider – JCEM
University of Colorado at Boulder
Campus Box 428
Boulder, CO 80309-0428 (303) 492-3915

■■ DOE-2 Training ■■

Mech. Engs., Consulting, Training
Marlon Addison
Energy Simulation Specialists
64 East Broadway, Suite 230
Tempe, AZ 85282 (602) 967-5278

■■ CONSULTANTS ■■

Consulting Engineers
Craig Cattelino
Burns & McDonnell Engineers
8055 E. Tufts Avenue, Suite 330
Denver, CO 80237 (303) 721-9292

Consultant
Greg Cunningham
Cunningham + Associates
512 Second Street
San Francisco, CA (415) 495-2220

Microcomputer Versions for European Users
Werner Gygli
Informatik Energietechnik
Weiherweg 19
CH-8604 Volketswil
Switzerland

Consultant
Jeff Hirsch
2138 Morongo
Camarillo, CA 93010 (805) 482-5515

Large Facility Modeling
George F. Marton, P.E.
1129 Keith Avenue
Berkeley, CA 94708 (510) 841-8083

Computer-Aided Mechanical Engineering
Mike Roberts
Roberts Engineering Co.
11946 Pennsylvania
Kansas City, MO 64145 (816) 942-8121

Mainframe Versions for European Users
Joerg Tscherry
EMPA, Section 175
8600 Dubendorf
Switzerland

Consultant
Philip Wemhoff
1512 South McDuff Avenue
Jacksonville, FL 32205 (904) 632-7393

■ ■ ■ ■ DOE-2 PROGRAM DOCUMENTATION ■ ■ ■ ■

National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

	NTIS Order No.	Shipments Within The U.S.	Shipments Outside The U.S.
DOE-2.1D User Manuals [Reference Manual (2.1A), BDL Summary (2.1D), Sample Run Book (2.1D), Supplement (2.1D)]	PB-852-11449	319.00	635.00
DOE-2.1D Update Package [BDL Summary (2.1D), Sample Run Book (2.1D), Supplement (2.1D)]	PB-901-43074	112.50	225.00
To Order by Separate Titles:			
Reference Manual (2.1A)	LBL-8706, Rev.2	109.00	218.00
BDL Summary (2.1D)	DE-890-17726	23.00	46.00
Sample Run Book (2.1D)	DE-890-17727	60.00	106.00
DOE-2 Supplement (2.1D)	DE-890-17728	55.95	111.90
Engineers Manual (2.1A) [algorithm descriptions]	DE-830-04575	45.00	90.00

For phone orders using Visa or Mastercard (703) 487-4650 or FAX (703) 321-8547
Overnight Express — 24-hr in-house processing — $22 surcharge per title
First Class Mail — 24-hr in-house processing — $12 surcharge per title

■ ■ Weather Tapes ■ ■

To order TMY or TRY tapes:
National Climatic Data Center
Federal Building
Asheville, North Carolina 28801
Phone: (704) 259-0871 climate data
Phone: (704) 259-0682 main number

To order CTZ tapes:
California Energy Commission
Attn: Bruce Maeda, MS-25
1516-9th Street
Sacramento, CA 95814-5512
Phone: 1-800-772-3300 Energy Hotline
or: (916) 654-5106

To order WYEC tapes:
ASHRAE
1791 Tullie Circle N.E.
Atlanta, GA 30329
Phone: (404) 636-8400

■ ■ User News ■ ■

To be put on the newsletter distribution list, to submit articles, corrections or updates to documentation, or for DOE-2 program questions, please contact:

Kathy Ellington
Simulation Research Group
Bldg. 90, Room 3147
Lawrence Berkeley Laboratory
Berkeley, CA 94720
Phone: (510) 486-5711
FAX: (510) 486-4089 or 486-5172
electronic mail: kathy%gundog@lbl.gov

Senior DOE-2 Analyst

The Fleming Group has an immediate opening for an experienced DOE-2 modeler in our new San Ramon, CA, office. Responsibilities will include

- **modeling of integrated packages of advanced energy-efficiency measures (EEMs) in new and existing residences and commercial buildings**
- **calibration of DOE-2 models using field-monitored end-use data,**
- **analysis of EEM energy savings,**
- **operation of data analysis systems on both 486-PC and SUN platforms.**

Strong candidates will have 7 to 10 years of DOE-2 experience, especially for building research applications. California Title 24 experience helpful.

We offer a competitive salary and benefits package and equal employment opportunities. Send resume to:

Harry Misuriello
Suite 175
The Fleming Group
3201 Danville Boulevard
Alamo, CA 94507

DOE-2 BASICS

TABLE OF CONTENTS

PRELIMINARY CONFERENCE ANNOUNCEMENT

The American Council for an Energy-Efficient Economy

1992 Summer Study on Energy Efficiency in Buildings

Asilomar Conference Center Pacific Grove, California
August 30 - September 5, 1992

ABOUT THE 1992 SUMMER STUDY

Since 1980, the ACEEE Summer Study has brought together the foremost researchers, practitioners and policy makers from around the world to discuss the technological basis and practical implementation of energy efficiency in buildings. Past meetings have been influential in setting new directions for research, policy, and program implementation in government, utilities and other organizations. The blind-abstract paper selection and peer-reviewed proceedings, the informal conference atmosphere, and the stunning natural setting at Asilomar have made it the central point for frank exchange of recent experiences, current issues, and cutting-edge ideas.

The Summer Study includes four types of sessions. Peer-reviewed research papers are presented at concurrent sessions, chaired by panel leaders who are experts in the topic area. Time is allocated for informal sessions as well, organized at Asilomar around topics of immediate concern, enabling participants to custom design the conference to meet their needs. Evening plenary sessions feature recognized experts in the energy efficiency and environmental fields, focusing on issues of major national or international importance. Poster sessions featuring innovative projects and technologies are also included.

The conference is open to anyone who wants to attend, but space is limited, so register early (registration opens September 15).

ABOUT ASILOMAR

Asilomar is located just above the Big Sur region on the tip of the Monterey Peninsula, overlooking the Pacific Ocean. The 105-acre conference center lies amidst a grove of pines behind the sand dunes and beach, and is just minutes from Monterey and Carmel. The grounds also serve as an ecological preserve. This beautiful, secluded setting is an ideal counterpart to the casual atmosphere of the Summer Study, promoting the informal, personal exchange of information for which the conference is noted.

PRELIMINARY CONFERENCE CALENDAR

Call for abstracts/Registration opens	September	15	1991
Abstracts due (200 words max.)	December	1	1991
Notification of abstract acceptance	January	15	1991
Draft papers due for peer review	March		1992
Final papers due for publication	June		1992
Summer Study begins	August	30	1992

Printed on Recycled Paper

CONFERENCE TOPICS

Key topics for the 1992 Summer Study include

- New technologies for residential, commercial, and industrial building envelopes, HVAC and lighting systems, appliances and equipment
- Cost-effective design strategies for new buildings and retrofits
- Human interactions affecting energy consumption
- Building impacts on humans--air quality and comfort
- Utility integrated resource planning processes and resource acquisition mechanisms
- Quantifying environmental costs and other externalities (global warming, acid rain, ozone depletion, life-cycle energy costs) and incorporating them in resource acquisition plans
- Policy and practice of designing and implementing efficiency programs for populations of buildings and their occupants
- Comparisons of theory and practice from field performance testing and program evaluations
- Incentives and oversight mechanisms for utility-based programs (collaborative processes, profit mechanisms)

JOIN ACEEE'S ELECTRONIC COMMUNITY!

The 1992 Summer Study is our first experiment in electronic networking. **PLEASE SEND US YOUR E-MAIL ADDRESS.** Contact us with an electronic message at

ACEEE@pnl.gov (Internet)

if you would like to receive future conference announcements through E-Mail. Internet is accessible from many commercial and private networks, such as CompuServe, the Well, MCI Mail, etc.

Questions? Problems? Please call for an instruction sheet. Call (415) 549-9914 [(510) 549-9914 after September 1991].

FOR MORE INFORMATION CONTACT:

1992 ACEEE Summer Study Office
2140 Shattuck Ave., Suite 202
Berkeley, CA 94704 USA
Phone: (415) 549-9914 [(510) 549-9914 after September 1991]
E-mail: ACEEE92@lbl.gov

LOADS

VARIABLE–TYPE = GLOBAL (continued)

Variable-List Number	Variable in FORTRAN Code	Description
31	ATMEXT	Atmospheric extinction coefficient
32	SKYDFF	Sky diffusivity factor
33	RAYCOS(1)	Solar direction cosine (x)
34	RAYCOS(2)	Solar direction cosine (y)
35	RAYCOS(3)	Solar direction cosine (z)
36	RDN	Direct normal solar radiation intensity on a clear day [calculated] (Btu/hr-ft^2)
37	BSUN	Diffuse solar intensity on a horizontal surface on a clear day [calculated] (Btu/hr-ft^2)
38	IYR	Year
39	IMON	Month
40	IDAY	Day
41	IHR	Hour (local time; with Daylight Saving Time if appropriate)
42	IDOY	Day of year (1-365)
43	IDOW	Day of week (1-7)
44	ISCHR	Schedule hour (DST corrected, IHR + IDSTF)
45	ISCDAY	Schedule day (Day of week; 1 = Sunday, 2 = Monday, ..., 8 = Holiday)
46	IDSTF	Daylight saving time flag (1 if daylight saving in effect, 0 if not)
47	PTWV	Pressure caused by wind velocity (inches of water)
48	ATMTUR(IMO)	Atmospheric turbidity factor according to Angstrom
49	ATMMOI(IMO)	Atmospheric moisture (inches of precipitable water)
50	PHSUND	Solar altitude (degrees above horizon)
51	THSNHR†	Solar azimuth (degrees) measured counter-clockwise from south
52	ETACLD	Cloudiness factor; ranges from 0 for overcast sky to 1.0 for clear sky
53	CHISKF	Exterior horizontal illuminance from clear part of sky (footcandles)

† corrected Sept. 1991