Building Energy Simulation

User News

For Users of the DOE-2, PowerDOE, SPARK and BLAST Programs

Vol. 17, No. 1 -- Spring 1996

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What's New?

■ ***User News* on the Web!** Current and future issues of the newsletter are at

http://eande.lbl.gov/BTP/SRG/UNEWS

The website has instructions for downloading the newsletters in PDF format and reading them with Adobe's *Acrobat* software, available free of charge.

■ **PowerDOE Status** Beta testing of PowerDOE began in May. A first release is expected this Fall.

■ **Download Weather Data Sets** You may now download both TMY and TMY2 weather data sets from the world-wide web:

TMY: ***http//oipea-www.rutgers.edu/html_docs/TMY/tmy.html***

TMY2: ***http://rredc.nrel.gov/solar/data/nsrdb/tmy2/***

■ **Fenestration R&D Newsletter** From the Windows and Daylighting Group at LBNL. To get on the free subscription list, please fax Pat Ross at (510) 486-4089. You may also download the newsletter from the Building Technology Program's web site at

http://eande.lbl.gov/BTP/BTP.html

■ **Free DOE-2 Help** Call or fax our modeling expert, Bruce Birdsall, for questions about DOE-2. This free service is supported by LBNL's Simulation Research Group. Phone Bruce at (510) 829-8459 between the hours of 10 a.m. and 3 p.m. PDT.

What's Inside?

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The *User News* is published by the Simulation Research Group at LBNL with cooperation from the BLAST Support Office at the University of Illinois. Direct comments or submissions to Kathy Ellington, Editor, MS: 90-3147, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, or email kathy@gundog.lbl.gov or send us a fax at (510) 486-4089. BLAST-related inquiries should be directed to the BLAST Support Office, phone (217) 333-3977, email support@blast.bso.uiuc.edu

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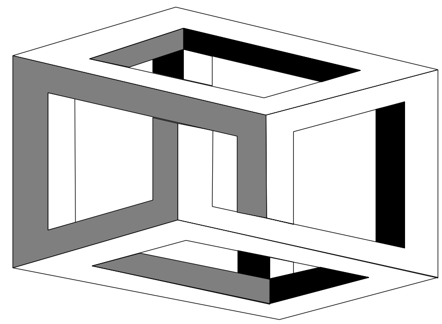
The SPARK Simulation Environment: A Non-Graphical Primer



by
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Introduction
SPARK is a modular simulation environment that generates simulation programs from user-defined calculation components; it allows you to easily create new components and to connect existing components in innovative ways. The SPARK components are algebraic (static) or differential (time dependent) equations, which may be linear or non-linear. The power of SPARK lies in its ability to efficiently handle large systems of non-linear equations. Large simulation programs like DOE-2 and BLAST are preconfigured and hard to modify; however, SPARK easily adapts to meet your simulation needs because it allows you to create your own program. This article will give you a feel for what goes on inside SPARK. We do not, however, describe SPARK's graphical interface, which simplifies connecting components. [*If you would like to be a SPARK beta tester, please see "Call for SPARK Beta Testers on page 36 of this newsletter.*]

An Example Steady-State Problem
Creating a SPARK simulation involves several steps:

1. Write down the equations to solve for.
2. Create the SPARK object files associated with the equations.
3. Create a simulation file by connecting the objects; i.e., linking their common variables.
4. Run the simulation

These steps will be illustrated with a simple (but numerically difficult) steady-state problem.

1. Let us solve the set of equations:

   x1 + x3 + x2**2 + sqrt(x2) = con1 (1)
   x2 = x1*exp(x1) (2)
   x1*x4 + x3*x4 + x4**3 = con2 (3)
   x4 = x3*exp(-x3) (4)

   The equations thus written, we go to step 2.

2. The SPARK object file associated with an equation supplies the solver with the inverses of the equation for each of its variables. For example, the object file for equation (1) might be the following object, called *"r1"*, which contains the inverses for variables x1, x3, and con1 (but not for x2 since its inverse cannot be obtained directly).

```
/*+++
  Identification:  Example  object,  equation 1
                        r1.ob

Abstract:  One of a set of 4 simultaneous nonlinear equations used as the
first SPARK example.
Notes:
```

```
    None
   Interface:
    x1:   First variable
    x2:   Second variable
    x3:   Third variable

    con:  First constant

   Acceptable input set:
    con = 3000.0, x2 = 50, x3 = 0.5

   Recommended matches:
    None

   Suggested breaks:
    None

   Local variables:
    None

   Equations:
    x1 + x3 + x2**2 + sqrt(x2) = con

   Location of inverses:      example.c ---*/

#ifdef SPARK_PARSER

PORT x1  "First variable"     [scalar]

         INIT = 1 ;
PORT x2  "Second variable"    [scalar]
         INIT = 1 ;
PORT x3  "Third variable"     [scalar]
         INIT = 1 ;
PORT con "First constant"     [scalar]
         INIT = 1 ;

FUNCTIONS   {
   x1       = r1_a( x2, x3, con ) ;
   x3       = r1_c( x1, x2, con ) ;
   con   = r1_con( x1, x2, x3 ) ;
}
#endif /* SPARK_ PARSER */

#include "spark.h"

#define x2     args[0]
#define x3     args[1]
#define con    args[2]
#define x1     result
      double
r1_a ( ArgList args )
{
   double result;
   x1 = con - (x3+x2*x2+sqrt(x2));        [ The inverse equation for x1 ]
   return(result);
}
#undef x1
#undef x2
```

[*A sample set of values for which the problem can be solved*]

[*x1 is a "port" that can be connected to other ports or take an input value; its starting value is 1*]

```
#undef x3
#undef con

#define x2  arg[1]
#define x1  arg[0]
#define con arg[2]
#define x3  result
      double
r1_c ( ArgList arg )
{
   double result;
   x3 = con - (x1+x2*x2+sqrt(x2));        [ The inverse equation for x3 ]
   return(result);
}
#undef x1
#undef x2
#undef x3
#undef con

#define x1  arg[1]
#define x2  arg[0]
#define x3  arg[2]
#define con result
      double

r1_con ( ArgList arg )
{
   double result;
   con = x3 + (x1+x2*x2+sqrt(x2));        [ The inverse equation for con ]
   return(result);
}
#undef   x1
#undef   x2 #
#undef   x3 #
#undef   con
```

Because writing these object files is cumbersome (albeit straightforward) we have automated the process with a symbolic interface written in the MACSYMA computer algebra language. A version in MapleV is also available. (If neither MACSYMA nor MapleV is available at your site, a simple interface called Mkspark creates code for numerical inversion, replacing symbolic inversion.) Using the symbolic interface is simple: you supply the equations in symbolic form as arguments to interface functions that create the needed SPARK code. The following command creates r1.ob for equation (1):

```
makespark(x1+x3+x2**2+sqrt(x2)=con,"r1",[]);
```

The objects r2, r3 and r4 for the other equations are created in a similar fashion.

3. Once the objects are available and archived into the SPARK object library it is time to use them. Object use and reuse is an important aspect of SPARK. To use the objects just created, you need to create an instance of each one and then connect them so that their common variables are linked. For example, the sample equation system is expressed in the SPARK connection language as the following problem specification file, *example.pr*.

```
declare r1 r1;        [Create an instance of r1, call it by the same name]
declare r2 r2;        [Create an instance of r2, call it by the same name]
declare r3 r3;        [Create an instance of r3, call it by the same name]
declare r4 r4;        [Create an instance of r4, call it by the same name]
```

```
input con1 r1.con;        [Let variable con of r1 be an input value, called con1]
input con2 r3.con;        [Let variable con of r3 be an input value, called con2]

link x1 r1.x1,r2.x1,r3.x1  REPORT;    [r1, r2 and r3 share a variable called x1]
link x2 r1.x2,r2.x2        REPORT;    [r1 and r2 share a variable called x2]
link x3 r1.x3,r3.x3,r4.x3  REPORT;    [r1, r3 and r4 share a variable called x3]
link x4 r3.x4,r4.x4        REPORT;  [r3 and r4 share a variable called x4]
```

4. SPARK is now ready to run. You invoke the SPARK parser with a command of the form:

   parser -p $SPARK_DIR/CLASSES example.pr

   The parser analyzes the above problem specification file and creates a "setup" file, *example.stp,* that determines - using graph theory - an efficient solution method for the overall problem. Then, with the following command, the setup program translates *example.stp* into a C++ program, *example.c++*, that embodies the efficient solution method:

   setup example.stp example.c++

   After SPARK compiles *example.c++* you run it using the command *example*, which asks you for inputs and then returns the results. If you want the inputs to be defaulted, then you can run *example* as follows:

   example < auto.inp

   The resulting printout from SPARK would look like the following:

```
Program example Started
con2: 1
con1: 3000
Initial Time [0] 0
Number of time steps [1] 1
Time increment between steps [1] 1
Reports begin at time step [0] 0
Time steps between reports [1] 1
Input for time 0:
   con1[scalar] (-1e+20,1e+20) 3000:
   con2[scalar] (-1e+20,1e+20) 1:
Numerical exception # 1 on break # 0, recover...
Numerical exception # 21 on break # 0, recover...
Numerical exception # 541 on break # 0, recover...
Numerical exception # 561 on break # 0, recover...
Numerical exception # 581 on break # 0, recover...
Convergence too slow! Bad scaling or singularity.
Convergence too slow! Bad scaling or singularity.
Convergence too slow! Bad scaling or singularity.
Convergence too slow! Bad scaling or singularity.
Report at time 0:
            con1: 3000
            con2: 1
              x2: 54.6527
              x3: 2.75737
              x4: 0.174978
              x1: 2.92702
```

   That was indeed a hard case! SPARK found a solution after recovering from several numerical exception and convergence problems (often encountered in solving nonlinear equations).

An Example Dynamic Problem

Dynamic problems can be solved by SPARK for any user-specified time step. Following are the steps for solving an example dynamic problem - calculating the motion (in two dimensions) of a damped oscillator.

1. Write the equations:

```
xdot = y                [“xdot” is the time derivative of oscillator’s x coordinate]
ydot = b*y+o*x+f        [“ydot” is the time derivative of oscillator’s y coordinate]
```

2. With the symbolic interface create a macro-object, called “damposc_macro”, corresponding to this system of two equations:

```
writedynmacro([[xdot = y]],
[[ydot = b*y+o*x+f]],
"damposc", [b,o,f], [x,xdot]);
```

3. Create the problem specification file:

```
declare damposc_macro   d; [        create an instance of damposc_macro called d]
link  x d.x           REPORT;
link  y d.y           REPORT;
link  xdot d.xdot     REPORT;
link  ydot d.ydot     REPORT;
```

4. Run the problem. The following command line shows how to calculate the oscillator’s trajectory for values -2, -1.5, and -1 of the damping factor:

   dynsparksens damposc 2 x y 1 b -2. -1.5 -1.

   SPARK then plots the calculated trajectories. An example plot is shown below. In general, results can be plotted after the simulation is complete or they can be plotted dynamically (the plot expands in real time as solutions are found for new time steps). Variables can be plotted vs. time or vs. each other (phase plots). For sensitivity analysis, as in the damped oscillator example, the results for the chosen parameters can be shown together on the same plot for easy comparison.

Library

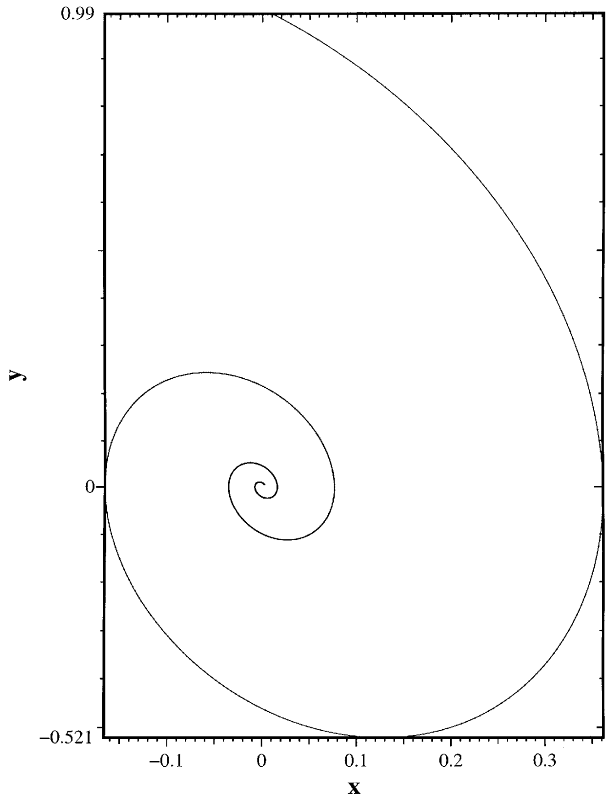
The above examples were fairly simple, but creating more complicated objects from scratch is done exactly the same way. SPARK can thus model non-linear equation systems of arbitrary complexity. SPARK also comes with a library of preassembled HVAC components that you can link together into complete systems. These components are from the ASHRAE HVAC toolkit and have been tested. They come with a set of recommended inputs and corresponding results. You can connect these components and create a simulation problem automatically with the parser and setup programs, then run the problem through the solver and plot the results. The library components include psychrometrics, balance equations, NTU calculations, heating coil, cooling coil, heat exchangers (cross- and counter-flow), pump, fan, cooling tower, controls, a zone model, and complete systems (such as variable air volume, dual duct, and constant volume reheat).

User Interface

SPARK can be used with command lines as shown in this article; however, there are friendlier interfaces. One is the Graphical Editor, which allows you to graphically create and connect objects at the initial stage of building a simulation. Another, written in XLib via TCL/TK, makes the whole set of command lines available via buttons and menus and allows you to click on a button to invoke the Graphical Editor. Both of these interfaces have on-line help. There is also an interactive tutorial to help you learn SPARK.

What You Need to Run SPARK

SPARK runs on UNIX workstations or PC's, under the UNIX, MSDOS, or Windows operating systems. It requires C and C++ compilers. The UNIX version requires the (free) TCL/TK package. The optional MACSYMA and MapleV computer algebra systems are commercial products and must be purchased separately. Please watch this newsletter for information on how to obtain SPARK when it becomes available.



SPARK Plot of Trajectory of Damped Oscillator

DOE-2 VALIDATION: Daylighting Dimming and Energy Savings: the Effects of Window Orientation and Blinds

by

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Abstract
The Daylighting Test Facility (DTF), located at the Florida Solar Energy Center, was used to study daylight dimming systems and to learn how orientation and blinds affect energy savings. To evaluate the impact of blinds on dimming savings, the energy consumption was compared in two pairs of offices for all four window orientations: north, south, east and west. One office in each pair had blinds in a fixed position (down and open) and the other office had no blinds. From September through December of 1994, data were collected on the north- and south-facing offices. The DTF was rotated 90 degrees and data were collected from January through April for east- and west-facing offices. The DTF was also modeled on DOE-2.1 and the predicted energy usage was compared to the actual data.. The study showed that daylight dimming systems can provide significant energy savings of from 24% to 51% depending on the orientation and whether the office had blinds. The research suggest adjustments be made to parameters used with the DOE 2.1E daylighting model to improve the accuracy of its predictions.

Introduction
Until 1900, most buildings were "daylit" in the sense that daylight was the major source of daytime illumination. Due to the electricity use and increased cooling load that is created by electric lighting, there is a renewed interest in daylighting commercial buildings. Numerous theoretical studies have shown significant potential for energy savings in daylit buildings [1]. In order for a daylit building to realize energy savings, the electric lighting system must be manually switched in an effective fashion or else be linked to some type of integrated control system. The shortcomings of reliance on manual control are extensively documented in the literature [2]. A study by Hunt and Cockram [3] showed that continually occupied offices experienced little manual switching during occupancy. Most of the switching was at the start and the end of the work day. Thus, reliable savings are likely only with automated controls.

One type of dynamic lighting control system available is the continuous dimming system which constantly adjusts the electric lighting level based on the amount of daylight available. A continuous dimming system consists of a photosensor that provides the control signal that is used by the dimming electronic ballast to vary the light level according to changes in daylight availability. These systems seem attractive since they reduce the use of electric light automatically without occupant intervention.

Significance of the Problem
Computer simulations such as DOE-2 and other programs [4] can be used to predict energy savings for such continuous dimming systems. However, these simulations do not accurately account for human behavior such as seasonal blind adjustment related to window orientation. The use of automatic daylight controls and potential energy savings has been studied [5], but the position of the blinds was not taken into

account. Studies on window blind usage show that people use window blinds to block solar radiation (both as a source of localized overheating as well as glare) [6,7]. However, typically, occupants did not change blind positions within a day. Preference for window blind position seems to be based on long-term perceptions of solar radiation or other factors. Other considerations such as privacy and security may be ancillary concerns.

Little data have been collected *in situ* to quantify the energy savings as a result of daylight dimming systems. Actual savings may vary depending on the window orientation and window management strategies. A metered study conducted by Lawrence Berkeley National Laboratory [8] showed the energy savings were less in the south daylit zone than in the north daylit zone due to the occupants using drapes to reduce glare and thermal discomfort on the south orientation. A National Bureau of Standards study [9] found that window area does not influence lighting load as strongly as the type of window system. A window system may include window coatings, external shading devices, and internal shading devices such as blinds. However, preliminary data of an on-going study [10] in a Wisconsin commercial building showed that savings were greatest on the south side of the facility even though occupant manipulation of the window blinds did reduce savings. The building being monitored had windows on all four sides with a dimming system and blinds. During the winter, the amount of light entering through the east and south faces was so great that occupants often manipulated the blinds to reduce the heat, light, and glare. The report also stated that many occupants on the north side often had their blinds fully raised in order to have an unrestricted view throughout the day.

The contrary results of the limited research performed so far underscore the need for a more rigorous evaluation of the effects of orientation on daylighting system performance. The purpose of this research is to monitor the electric lighting energy usage of eight offices with windows and a continuous dimming system.

Daylighting Test Facility

Test Site Description The test site, the Daylighting Test Facility (DTF), is located at the Florida Solar Energy Center, Cape Canaveral, Florida (latitude 28^o, longitude 80^o). Eight offices are located within the test site. The offices vary in size, number of windows and window orientation as shown in Table 1 for both phases of testing. All windows are 0.84m x 0.71m (2'9" x 2'4") located 1.2m (4') from floor. The ceiling height is 2.3m (7'9"). The trailer can be rotated so that the north- and south-facing windows become east- and west-facing windows. The offices contain work desks and other furnishings usually found in the typical office environment. Each office has a video display terminal; visual tasks include reading, writing, drafting, and typing. The interior floor surface is brown carpet with an approximate reflectance of 0.20. The four interior walls are beige and have a reflectance of 0.45. The ceiling is finished off-white with a reflectance of 0.70. The exterior surface on the sides of the trailer is grass with no obstructions. The windows consist of double pane clear glass 1/8" thick with a light gray tint. The measured visible transmittance of the single pane windows is 0.67. Each window has one-inch mini-blinds that are white and have a reflectance of ~0.70. The blinds remained fixed to eliminate occupant related variation. The blinds remained down with the slats at 90 degrees. All offices have blinds except two offices that were intentionally left without blinds to examine their relative effect.

Electric Lighting System Each office has two or three two-lamp ceiling-mounted wrap-around prismatic fluorescent luminaires. Two T-8 lamps (4100^{o}K) and one integrally controlled electronic ballast are used in each luminaire. Manufacturer's data suggest that the ballasts can be dimmed over a range from 100% to approximately 20% of full power. The luminaires are four feet on center and operate on 120 Vac. The lighting design setpoint for each office was 538 lux (50 footcandles).

Table 1

Office	Dimensions	Number of Windows	Orientation	
			Phase I	Phase II
A	3.4m x 4.0m (11' x 13')	2	North and east	West and north
B	3.4m x 4.0m (11'3" x 13')	2	South and east	East and north
C	2.2m x 2.9m (7'1'" x 9'7")	1	South	East
D	2.2m x 2.9m (7'1" x 9'7")	1	South	East
E	3.4m x 4.3m (11'3" x 14')	2	Both south	Both East
F	3.4m x 4.3m (11' x 14')	2	Both north	Both West
G	2.3m x 2.7m (7'9" x 9')	1	North	West
H	2.3m x 2.7m (7'9" x 9')	1	North	West

Photosensors The dimming photosensor is a ceiling mount, low voltage photocell that interfaces with an electronic ballast. The sensor is used to control the output of light based on the availability of natural light and on the required task illumination level. The photosensor has a Fresnel lens which allows the sensor to measure light levels uniformly across a 60 degree field of view. An analog output to the control ballast provides a dimming range from 10% to 100% illumination output.

Instrumentation

Electrical Measurements The lighting power and current to the four branch circuits serving the offices are individually monitored with watt-hour transducers with a current transformer to supply the input. These transducers accurately measure true root mean square (RMS) power and current regardless of any current wave shape distortion. All the transducers are mounted in a central location in the trailer. The watt-hour transducers are factory calibrated with an accuracy of ± 1.0%.

Photometric Measurements Light levels in the offices are monitored with color- and cosine-corrected photometers. One photometer is mounted in each office at desktop height, two-thirds away from the window wall. The photometers were mounted directly below the ceiling-mounted ambient sensor used by the dimmable lighting system to control the electric light levels. Global horizontal insolation data are concurrently taken on a horizontal plane at the building using silicon cell pyranometers.

Data Acquisition All measured values are recorded using a datalogger (12-bit precision). The datalogger scans all instrumentation every ten seconds with integrated averages output to storage at fifteen-minute intervals. Data is transferred daily from the DTF to FSEC's mainframe computer. Data are then archived and daily plots produced to describe system performance on the previous day.

Experimental Procedure Data for the north- and south-facing offices were collected for four months (September - December) to cover half the seasonal daylight availability cycle. At the end of this cycle, the trailer was rotated 90 degrees so that the windows are oriented east and west, respectively. This was accomplished on January 11, 1995. Data were collected for the east- and west-facing offices for four months (January-April).

Discsussion of Measured Results

Illumination and power consumption data were taken between September 1 and December 31, 1994 for the north- and south-facing windows. The same data were taken between January 17 and May 16, 1995 for the east- and west-facing windows. Data analysis concentrated on the hours of 6 AM and 6 PM since it is more expensive to supply and use energy during this time. This is also the most common period during which office lighting systems are used in commercial facilities.

The lighting system was powered 24 hours a day so that the percent energy reduction was calculated by using the nighttime data as the baseline. The nighttime monthly average wattage for each office was calculated by estimating the mean electrical demand between the hours of 10 PM and 6 AM. The average was multiplied by twelve to compare to the 12-hour daytime period. The total kWh was also plotted for each month between the hours of 6 AM and 6 PM. Table 2 shows the total monthly kWh data taken of the dimming system over the entire period from September 1, 1994 to December 31, 1994 for the four north- and south-facing interior offices.

Table 3 shows the total monthly kWh data for the period from January 17 to May 16, 1995 for the four east- and west-facing interior offices. The daytime data was divided by the baseline data to obtain the percent energy reduction. For the purposes of the analysis, these calculations assume that the lights would be on continuously between the hours of 6 AM and 6 PM.

Table 4 shows a summary of the percent lighting energy reduction for the same period. The energy reduction ranged from 24% to 45% depending on orientation and blind condition. The south-facing office with no blinds had the lowest power consumption over the test period with a 45% lighting energy reduction for the period. The north-facing office with blinds had the highest power consumption with a 24% energy reduction. Blinds show a 7% effect on the energy savings for both orientations.

Table 2
Monthly Lighting Energy Consumption For Four Offices North-South Orientation (Total kWh)

Condition	Office	Month				
		Sept	Oct	Nov	Dec	Total
North-No Blinds	G	59	71	71	76	278
North-Blinds	H	62	79	74	78	293
South-No Blinds	C	52	68	68	70	259
South-Blinds	D	56	75	73	79	283

Table 3
Monthly Lighting Energy Consumption For Four Offices East-West Orientation (Total kWh)

Condition	Office	Month				
		Jan	Feb	Mar	Apr	Total
East-No Blinds	C	67	81	74	72	255
East-Blinds	D	61	72	65	64	304
West-No Blinds	G	65	78	71	70	278
West-Blinds	H	62	73	67	64	270

Table 4
Percent Lighting Energy Reduction* North and South Offices

Condition	Office	Month				
		Sept	Oct	Nov	Dec	Total
North-No Blinds	G	42%	30%	30%	21%	31%
North-Blinds	H	35%	19%	25%	18%	24%
South-No Blinds	C	54%	47%	42%	37%	45%
South-Blinds	D	48%	39%	38%	26%	37%

* Energy reduction is based on assuming the lights would have been on continuously between the hours of 6 AM and 6 PM. The baseline data was taken as an average of the system wattage between the hours of 10 PM and 6 AM.

Table 5
Percent Lighting Energy Reduction* East and West Offices

Condition	Office	Month				
		Jan	Feb	Mar	Apr	Total
East-No Blinds	C	44%	47%	49%	51%	48%
East-Blinds	D	22%	27%	32%	37%	30%
West-No Blinds	G	28%	31%	32%	34%	31%
West-Blinds	H	33%	33%	34%	41%	35%

* Energy reduction is based on assuming the lights would have been on continuously between the hours of 6 AM and 6 PM. The baseline data was taken as an average of the system wattage between the hours of 10 PM and 6 AM.

Table 5 shows a summary of the percent energy reduction for the east-west orientation during the period described. The energy reduction ranged from 22% to 51% depending on the orientation and blind condition. The east-facing office with no blinds had the highest period energy reduction of 48%. For this orientation, blinds had an 18% effect on power consumption. The west-facing offices did not yield expected results. The office with blinds had a 3% higher power consumption.

To verify the west-facing office data, the blind condition was switched. The blinds were removed from one west-facing office and installed in the control office (office without blinds). The data taken for one month from June 17 to July 17 showed an energy reduction of 44.9% for the office without blinds and 18% for the office with blinds. These results indicated that once the blind condition was switched, the blinds did make a significant difference of 26.8 percent. This data led researchers to believe that the dimming system was not working properly in the office without blinds during the four-month test period. Since these data were taken during the summer solstice, it is expected that the energy reduction would be higher than the test period.

Simulation Analysis

The facility was modeled and compared to the field data with the DOE-2.1E program, which evaluates energy use, peak loads, and energy cost; it allows the user to predict the impact of daylighting on electric lighting energy consumption.

The DOE-2.1E daylighting calculation simulates control of lighting fixtures in response to the level of natural lighting from the sun, sky, and reflection off the inside surfaces of the space. devices such as blinds and overhangs, and the luminance distribution of the sky. Continuously dimming control systems and window shade management can be modeled.

The eight offices were modeled in the north-south orientation. Parameters that affect the daylighting calculations include window visible transmittance, blind transmittance, blind schedule, window location in the wall and orientation. The glass visible transmittance at normal incidence was measured at 0.67. A user-specified blind visible transmittance schedule with values between 0.0 and 1.0 multiplies the glass transmittance on an hourly basis depending on the blind coverage and slat position. A value of 0.0 indicates the blind is down with the slats closed and 1.0 is a blind completely up. Since the blinds were fixed, the blind schedule was set at 0.23 for the simulation period. The value of 0.23 is an estimate of the blind transmittance when the blinds are down and the slats are open at 90 degrees.

The DOE-2.1E input file for the DTF simulations is available from the authors by request. This input file was run for the north-south orientation with a building azimuth of 0 degrees. To simulate the east-west orientation the building azimuth was changed to 270 degrees. The simulations were run using typical meteorological year (TMY) weather data recorded on an hourly basis at Orlando, FL.

The kWh usage for the offices, which was predicted by DOE-2.1E, was compared to the actual DTF data; tables 6 and Table 7 show a comparison. For total lighting energy consumption, DOE-2 agreed with measurements to 17.4% or better. The agreement was best for cases without blinds, with an average absolute discrepancy of 3.9%. With blinds, the average absolute discrepancy was 11.5%. In general, DOE-2.1E overpredicted the lighting energy use in offices with blinds, implying that, in this case,

Input parameters include window size and orientation, glass transmittance, inside surface reflectance of the space, sun-control

the measured dimming exceeds that predicted. As a result of this analysis, it was concluded that the blind schedule and the visible transmission of the blinds are important parameters that affect the predicted power consumption.

DOE-2.1E makes two assumptions about blind transmission that may account for the discrepancy:

1) The blind transmittance is independent of the angle of incidence of light hitting the blind.

2) The blind is a perfect diffuser.*

Although these may be poor assumptions, there are very little data on the transmission angular dependence for common blind types

Summary

The study shows that daylight dimming systems provided significant energy savings that ranged from 22% to 51% depending on orientation and whether the office had blinds. The east-facing office with no blinds had both the highest energy reduction of 51% and the lowest monthly energy reduction of 22%. Although the blinds were fixed, they had a 7% average reduction on the energy savings for both the north- and south-facing offices. The east-facing offices had an 18% blind effect. The data taken one month after the blind condition was switched in the west-facing offices indicated the energy reduction may be similar to the east-facing offices. Use of DOE-2.1E indicated that parameters such as window

and blind visible transmission and blind schedule can change the predicted energy consumption. In all interior offices with blinds and the north-facing no blind condition, DOE-2.1E agreed with measurements to within 17%, which indicated that program estimates for daylight dimming savings might be be conservative for offices with blinds operated like those in our study.

Follow-Up

A blind usage study will be conducted in a large facility on a statistically valid sample of offices to examine how occupants use their blinds related to window orientation and season. This research may lead to the development of a blind usage multiplier for energy simulation programs like DOE-2.

[Editor's note: DOE-2.2, the next version of DOE-2, contains an improved blind model that is expected to give even better agreement with daylighting measurements. In this model you enter the slat characteristics (like width, separation, reflectance and angle), from which the program calculates the incidence-angle-dependent transmittance taking interreflection between the slats into account. This new model was developed by Hans Simmler of EMPA, the Swiss Federal Materials Testing Laboratory in Dubendorf, Switzerland, and Uwe Fischer of the University of Karlsruhe, Germany.]

Table 6
DTF/DOE kWh Data Comparison North-South Orientation

Month	North No Blinds Office G		North Blinds Office H		South No Blinds Office C		South Blinds Office D	
	DTF	DOE	DTF	DOE	DTF	DOE	DTF	DOE
September	59.2	65.9	62.3	84.4	52.4	60.8	56.4	78.0
October	73.7	74.7	79.0	88.7	68.4	64.4	75.5	78.0
November	71.3	77.2	74.1	86.8	68.0	63.4	72.8	74.1
December	76.2	80.7	77.6	90.0	69.9	68.1	78.5	78.7
Total	280.4	298.5	293.0	349.9	258.6	256.6	283.0	308.8
Percent Difference DTF/DOE	+ 6.0		+ 16.3		-0.8		+ 8.3	

Table 7
DTF/DOE kWh Data Comparison East-West Orientation

Month	East No Blinds Office C		East Blinds Office D		West No Blinds Office G		West Blinds Office H	
	DTF	DOE	DTF	DOE	DTF	DOE	DTF	DOE
January	66.8	70.7	81.1	84.5	74.2	71.6	71.6	86.4
February	60.5	59.9	71.9	74.8	65.4	60.6	64.0	76.8
March	65.3	77.5	78.0	80.5	70.8	64.2	70.1	83.1
April	62.2	76.5	72.7	76.5	67.1	59.6	63.5	79.6
Total	255.1	253.3	304.2	316.4	277.8	255.8	269.2	325.9
Percent Difference DTF/DOE	-0.71		+3.9		-7.9		+17.4	

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Free Fenestration Software from LBNL

Four programs (RESFEN-2.4, SUPERLITE-2.0, WINDOW-4.1, and THERM-1.0) are available from the Building Technologies Program at Lawrence Berkeley National Laboratory. Fax (510-486-4089) or email (PLRoss@lbl.gov) your request to Pat Ross.

RESFEN-2.4	A Microsoft Windows-based PC program (RESFEN-1.4 for DOS) for calculating residential fenestration heating and cooling energy use and costs. You may also download RESFEN from the web at http://eande.lbl.gov/BTP/WDG/RESFEN/resfen.html or you may ftp the program from ftp://theo.lbl.gov/btp/resfen/RESFEN.ZIP.
SUPERLITE-2.0	A PC program that calculates daylight illuminance distributions for complex room and light source geometries. It will model daylight coming through five openings and reflected from up to 20 opaque surfaces.
WINDOW-4.1	A thermal analysis PC program used by manufacturers to characterize product performance. It is also used by the National Fenestration Rating Council as the basis for development of energy rating labels for windows.
THERM-1.0	A Microsoft Windows-based 2-D heat transfer analysis tool, based on finite element analysis.

I B P S A

International Building Performance Simulation Association

Fifth International Conference
Prague, Czech Republic
September 8-10, 1997

ANNOUNCEMENT AND CALL FOR PAPERS

BUILDING SIMULATION '97 Computer modeling and simulation is arguably the most powerful approach for addressing the complex interactions encountered in buildings and the systems that service them. Modeling and simulation are evolving rapidly, and techniques not feasible just a few years ago are now becoming commonplace. The International Building Performance Simulation Association (IBPSA) was founded in 1986 to advance and promote the science of building performance simulation, with application to the design, construction, operation, and evaluation of new and existing buildings worldwide.

CONFERENCE THEMES BS '97 will address the following themes:

- Fundamentals and approaches for building related phenomena, such as heat, moisture, air, fluid and power flow, artificial and day lighting, fire acoustics, indoor air quality and environmental impact.
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The conference program will allow for hardware and software demonstrations, and a side-programme is envisaged for student presentations of short papers.

CALL FOR PAPERS Please submit extended abstracts (maximum of two pages) to the Conference Secretariat. Only original papers not published elsewhere will be accepted. All accepted papers will be published in the Conference proceedings. The official language for the conference and papers is English.

Abstracts due	15 September 1996
Abstracts accepted	1 November 1996
Manuscripts due	15 February 1997
Papers accepted	15 April 1997
Camera-ready papers due	15 June 1997

REGISTRATION FEES The planned registration fees and dates are:

ECE participants (before 15 May 1997)	USD 125
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IBPSA members will receive a USD 25 discount.

The registration fee includes conference attendance, proceedings, lunches, morning and afternoon refreshments, early-bird reception, welcome reception, and banquet. The accompanying persons registration excludes conference attendance and proceedings.

VENUE Prague (or Praha), the city of the hundred spires or the "Golden City" in the picturesque valley of the Vltava river, is the capital and center of industry, science, and culture of the Czech Republic. Prague is located in the centre of Europe and belongs among the best preserved historical cities with unique collections of architectural and cultural monuments. The Dean of the Faculty of Mechanical Engineering welcomes you to the Czech Technical University in Prague (CTU) which will host BS '97. CTU is situated just north of the centre of Prague, and is in easy reach from almost anywhere in Prague by the excellent metro system.

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email bs97@fsid.cvut.cz

news: http://www.fsid.cvut.cz/bs97

DOE-2 DIRECTORY

Program Related Software and Services

Contact the vendors for prices and ordering information

Mainframe and Workstation Versions of DOE-2

DOE-2.1D and 2.1E (Source code, executable code and documentation) For 2.1E DEC-VAX, Order #000158-DOVAX-02 For 2.1E SUN-4, Order #000158-SUN-0000 For 2.1D DEC-VAX, Order #000158-D6220-01 For a complete listing of the software available from ESTSC order their "Software Listing" catalog ESTSC-2. [See *User News* Vol. 16, No. 3, p. 21]	Energy Science / Technology- Software Center (ESTSC) P.O. Box 1020 Oak Ridge, TN 37831-1020 Phone: (615) 576-2606 Fax: (615) 576-2865 email:ESTSC@ADONIS.OSTI.GOV www: http://www.doe.gov/html/osti/estsc/estsc.html
FTI-DOEv2.1E (Source code and documentation) Combined source code package for both VAX and SUN versions of DOE-2.1E. Available on most distribution formats and for most operating systems (1/4" QIC tape, TK50 tape, 3.5" floppy, etc). Note: this is the distribution package only, no executables. Complete documentation for DOE-2.1E, digitally reproduced, spiral bound, and separated into multi-volume sets. [See *User News* Vol. 12, No. 4, p. 16]	Finite Technologies, Inc 3763 Image Drive Anchorage, AK 99504 Contact: Scott Henderson Phone: (907) 333-8933 Fax: (907) 333-4482 email: info@finite-tech.com www: http://www.finite- tech.com/fti/home.htmld

PC Versions of DOE-2

ADM-DOE2 ADM-DOE2 (DOE-2.1E) is compiled for use on 386/486 PCs with a math co-processor and 4MB of RAM. It runs in a DOS or Windows environment and is a highly reliable and tested version of DOE-2 which contains all of the 1994/95 enhancements to the program. The package contains everything needed to run the program: program files, utilities, sample input files, and weather files. More than 300 weather files are available (TMY, TRY, WYEC, CTZ formats) for the U.S. and Canada. [See *User News* Vol. 7, No. 2, p. 6]	ADM Associates, Inc. 3239 Ramos Circle Sacramento, CA 95827 Contact: Marla Sullivan, Sales Phone: (916) 363-8383 Fax: (916) 363-1788
CECDOEDC (Version 1.0A) A microcomputer version of DOE-2.1D with a pre- and post-processor designed strictly for compliance use within the State of California. It generates some of the standard compliance forms as output. Order P40091009 for the CECDOEDC Program with Manuals. Order P40091010 for the DOE-2.1 California Compliance Manual. [See *User News* Vol. 12, No. 4, p. 13]	MS: 13 -- Publication Office California Energy Commission P.O. Box 944295 Sacramento, CA 94244-2950 Phone: (916) 654-5106 www:http://agency.resource.ca.gov/cectext/ETEC.html

Caveat : We list third-party DOE-2-related products and services for the convenience of program users, with the understanding that the Simulation Research Group does not have the resources to check the DOE-2 program adaptations and utilities for accuracy or reliability.

PC Versions of DOE-2 (continued)

DOE-24/Comply-24 DOE-24 is a special DOE-2 release which is both a California-approved compliance program for the state's non-residential energy standards, and a stand-alone version of DOE-2.1E that includes a powerful yet easy-to-use input preprocessor. A demonstration program is available upon request. [See *User News* Vol. 12, No. 2, p. 2]	Gabel-Dodd Associates 1818 Harmon Street Berkeley, CA 94703-2416 Contact: Rosemary Howley Phone: (510) 428-0803 Fax: (510) 428-0324
DOE-Plus ™ DOE-Plus, a complete implementation of DOE-2.1D, is used to interactively input a building description, run DOE-2, and plot graphs of simulation results. Features include interactive error checking, context-sensitive help for all DOE-2 keywords, a 3-D view of the building that can be rotated, and several useful utilities. Also from ITEM Systems: **Demand Analyzer ™,** uses templates of building types and vintages to simplify DOE-2 input requirements. Online help feature. **Prep ™,** a batch preprocessor, ideal for parametric studies, that enables conditional text substitution, expression evaluation, and spawning of other programs. [See *User News* Vol. 11, No. 4, p. 4 and Vol. 13, No. 2, p. 54, and Vol. 16, No. 1, p. 28-32	ITEM Systems 1402 - 3rd Avenue, #901 Seattle, WA 98101 Contact: Steve Byrne Phone: (206) 382-1440 Fax: (206) 382-1450 email: byrne@item.com
EZDOE EZDOE is an easy-to-use PC version of DOE-2.1D. It provides full screen, fill in the blank data entry, dynamic error checking, context-sensitive help, mouse support, graphic reports, a 750-page user manual, extensive weather data, and comprehensive customer support. EZDOE integrates the full calculation modules of DOE-2 into a powerful, full implementation of DOE-2 on DOS-based 386 and 486 computers. [See *User News* Vol. 14, No. 2, p. 10 and No. 4, p. 8-14]	Elite Software, Inc. P.O. Drawer 1194 Bryan, TX 77806 Contact: Bill Smith Phone: (409) 846-2340 Fax: (409) 846-4367 email: 76070.621@compuserve.com
FTI-DOEv2.1E Highly optimized version of DOE-2.1E software, available for most computing systems. Current support: MSDOS and Windows 3.x, Windows NT, OS/2, RS/6000 (AIX), NeXT, SUN, UNIX (most systems). Call for platforms not listed. Documentation and weather files are available. Also FTI-DOEv2.1E source code, highly optimized and portable version; will compile for most systems. [See *User News* Vol. 12, No. 4, p. 16]	Finite Technologies, Inc 821 N Street, #102 Anchorage, AK 99501 Contact: Scott Henderson Phone: (907) 272-2714 Fax: (907) 274-5379 email: info@finite-tech.com www:http://www.finite-tech.com/fti/home.htmld

PC Versions of DOE-2 (continued)

MICRO-DOE2ä MICRO-DOE2 (2.1E), which runs in a DOS or windows environment, is a widely used, reliable, and tested PC version of DOE-2. It includes automatic weather processing, batch file creation, and a User's Guide with instructions on how to set up a RAM drive. System requirements: 386/486 PC with 4 MB of RAM and math co-processor. Also from Acrosoft, International, Inc.: **NETPath**, a network edition of MICRO-DOE2, allows you to store and run DOE-2 application files on one machine using input files from another machine. The result is improved space usage and project file management. **POWERPath**, for single machines, allows you to keep MICRO-DOE2 application files in one directory and submit input from any other directory. **BDL Builder** is a pre-processor for DOE-2.1E that allows you to describe specific building and HVAC characteristics by preparing databases, or building blocks , and then selecting records from the databases to assemble a complete input. **E2BB** translates DOE-2.1E text input to **BDL Builder**. [See *User News* Vol. 7, No. 4, p. 2; Vol. 11, No. 1, p. 2; Vol. 15, No. 1, p. 8; Vol. 15, No. 3, p. 4; Vol. 16, No. 2, p. 1,7; Vol. 16, No. 4, p. 7-8]	Acrosoft International, Inc. 3435 South Yosemite St., #220 Denver, CO 80231 Contact: Gene Tsai Phone: (303) 696-6888 Fax: (303) 696-0388 email: 102447.2611@compuserve.com
PRC-DOE2 A fast, robust and up-to-date PC version of DOE-2.1E. Runs in extended memory, is compatible with any VCPI compliant memory manager and includes its own disk caching. 377 weather data files available (TMY, TRY, WYEC, CTZ) for the U.S. and Canada Also from the Partnership for Resource Conservation: **PRC-TOOLS**, a set of PC programs that aids in extracting, analyzing and formatting hourly DOE-2 output. Determines energy use, demand, and cost for any number of end-uses and periods. Automatically creates 36-day load shapes. Custom programs also available.	Partnership for Resource Conservation 140 South 34th Street Boulder, CO 80303 Contact: Paul Reeves Phone or FAX: (303) 499-8611 email: paulreeves@aol.com
VisualDOE-2.0 for Windows ™ VisualDOE-2.0, which uses DOE-2.1E as the calculation engine, enables architects and engineers to quickly evaluate the energy savings of HVAC and other building design options. Program is supported by context-sensitive on-line help. Program includes climate data for the 16 California weather zones. [See *User News* Vol. 15, No. 2, p. 10; Vol. 16, No. 4, p. 9-16]	Eley & Associates 142 Minna Street San Francisco, CA 94105 Charles Eley or John Kennedy Phone: (415) 957-1977 / Fax: -1381 email: celey@eley.com www: http://www.eley.com

Pre- and Post-Processors for DOE-2

DrawBDL DrawBDL, Version 2.02, is a graphic debugging and drawing tool for DOE-2 building geometry; it runs on PCs under Microsoft Windows. DrawBDL reads your BDL input and makes a rotatable 3D drawing of your building with walls, windows, and building shades shown in different colors for easy identification. [See *User News*, Vol. 14, No. 1, p. 5-7, Vol. 14, No. 4, p. 16-17, and Vol. 16, No. 1, p.37]	Joe Huang & Associates 6720 Potrero Avenue El Cerrito, CA 91364 Contact: Joe Huang Phone/Fax:: (510) 236-9238
Visualize-IT^{TM} Visual Data Analysis Tools The ***Energy Information Tool^{TM}*** is a Microsoft Windows 3.1 program for looking at and understanding metered or DOE-2.1E hourly input data. It provides the unprecedented ability to see all 8760 (or 35040) data points for a year's worth of data. You get an overview of the data with an EnergyPrint^{TM} and can then explore the data with a variety of tools including load shapes, load duraction curves, etc. This program requires a 486 computer and SVGA grapics capabilities. The ***Calibration Tool^{TM}*** is a Microsoft Windows 3.1 program for comparing DOE-2.1E hourly output data to total load and/or end-use metered data. Options include monthly demand and load 2D graphs, maximum and seasonal load shapes, average load profiles, end use residuals, monthly average week and weekend days, and dynamic comparison load shapes. This program requires a 486 computer and SVGA grapics capabilities.	RLW Analytics, Inc. 1055 Broadway, Suite G Sonoma, CA 95476 Phone: (707) 939-8823 Fax: (707) 939-9218 Contact: Jim McCray jam@rlw.com Pat Bailey patb@rlw.com Jedd L. Parker jeddlp@rlw.com
D O E 1 2 3 Uses Lotus 1-2-3 to graphically display DOE-2.1D output as barcharts, pie charts, and line graphs. [See *User News* Vol. 10, No. 3, p. 5]	Ernie Jessup 4977 Canoga Avenue Woodland Hills, CA 91364 Phone: (818) 884-3997
Graphs for DOE-2 2-D, 3-D, hourly, daily, and psychrometric plots [See *User News* Vol. 13, No. 1, p. 5]	Energy Systems Laboratory Texas A&M University College Station, TX 77843 Contact: Jeff Haberl Phone : (409) 845-6065 Fax: (409) 862-2762
Pre-DOE A math pre-processor for BDL.	Nick Luick 19030 State Street Corona, CA 91719 Phone: (714) 278-3131

R E S O U R C E S

User News **(a quarterly newsletter)** Sent without charge to DOE-2 and BLAST users, the newsletter prints documentation updates and changes, bug fixes, inside tips on using the programs more effectively, and articles of special interest to program users. Regular features include a directory of program-related software and services and an order form for documentation. The winter issue features an index of articles printed in all the back issues.	Simulation Research Group Bldg. 90, Room 3147 Lawrence Berkeley National Laboratory Berkeley, CA 94720 Contact: Kathy Ellington Fax: (510) 486-4089 email: kathy@gundog.lbl.gov
Help Desk -- Bruce Birdsall Call or fax Bruce Birdsall if you have a question about using DOE-2. If you need to fax an example of your problem to Bruce, please be sure to telephone him prior to sending the fax. This is a free service provided by the Simulation Research Group at Lawrence Berkeley National Laboratory.	Bruce Birdsall Phone/Fax: (510) 829-8459 Monday through Friday 10 a.m. to 3 p.m. Pacific Time
Training DOE-2 courses for beginning and advanced users.	Energy Simulation Specialists 64 E. Broadway, Suite 230 Tempe, AZ 85282 Contact: Marlin Addison Phone: (602) 967-5278
DOE-2 training for small groups and individuals.	Gary H. Michaels, P.E. 1512 Crain Street Evanston, IL 60202 Phone: (708) 869-5859
Instructional DOE-2 Video and Manual Takes you step-by-step in DOE-2.1D input preparation and output interpretation.	JCEM/U. Colorado Campus Box 428 Boulder, CO 80309-0428 Contact: Prof. Jan Kreider Phone: (303) 492-3915

DOE-2.1E Bug Fixes via FTP

If you have Internet access you can obtain the latest bug fixes to DOE-2.1E by anonymous ftp. Here's how...

ftp to either gundog@lbl.gov or to 128.3.254.10
login: *type* anonymous
passwd: *type in your email address*

After logging on, go to directory pub/21e-mods ; bug fixes are in files that end with **.mod** . A description of the fixes is in file **VERSIONS.txt** in directory **pub** . Each fix has its own version number, ***nnn*** , which is printed out as DOE-2.1E- *nnn* on the DOE-2.1E banner page and output reports when the program is recompiled with the fix. You may direct questions about accessing or incorporating the bug fixes to Ender Erdem (ender@gundog.lbl.gov).

R E S O U R C E S (continued)

Weather Data

TMY2 weather data for DOE-2. ENERGOS will provide TMY2 data for 239 cities converted for use with DOE-2 for PC versions of the program (DOE-2.1C through DOE-2.1E).	Kurmit Rockwell ENERGOS 1705-14th Street, #401 Boulder, CO; 80302 Phone: (303) 499-7907 / Fax: (303) 449-7605
Comprehensive collection of **TRY**, **TMY** and **CTZ** weather file libraries, from NCDC, which can be used on all PC versions of DOE-2. Includes original source data and pre-formatted packed versions on a single IBM format CD. For Canadian users, the CD contains five weather files representing the five climate regions established by the Canadian energy codes. Individual sites available.	Jenny Lathum or Martyn Dodd EnergySoft 100 Galli Drive, Suite 1 Novato, CA 94949 Phone: (800) 467-4738 / Fax: (415) 883-5970
European Weather Files	Andre Dewint Alpha Pi, s.a. rue de Livourne 103/12 B-1050 BRUXELLES, Belgium Phone: 32-2-649-8359 / Fax: 32-2-649-9437
TMY data sets - download from the World Wide Web **TMY2** data sets - download from the World Wide Web	TMY: http//oipea-www.rutgers.edu/html_docs/TMY/tmy.html TMY2: http://rredc.nrel.gov/solar/data/nsrdb/tmy2
TMY data sets **TRY** data sets	National Climatic Data Center 151 Patton Avenue, #120 Asheville, NC 28801 Phone: (704) 271-4871 order / Fax 271-4876
CTZ (California Thermal Climate Zones)	California Energy Commission Bruce Maeda, MS-25 1516-9th Street Sacramento, CA 95814-5512 1-800-772-3300 Energy Hotline
WYEC (Weather Year for Energy Calculation)	ASHRAE 1791 Tullie Circle N.E. Atlanta, GA 30329 Phone: (404)636-8400 / Fax: (404)321-5478
Canadian Weather Files in **WYEC2** Format [Note: the original long-term data sets, up to 40 years of data, from which the CWEC files were derived can also be obtained directly from Environment Canada. Contact Mr. Robert Morris at (416) 739-4361.]	Dr. Didier Thevenard Watsun Simulation Lab University of Waterloo Waterloo, Ont., N2L-3G1 Canada Phone: (519) 888-4904 / Fax: (519) 888-6197 watsun@helix.watstar.uwaterloo.ca

DOE-2 ENERGY CONSULTANTS

Consulting Engineers Charles Fountain Burns & McDonnell Engineers 8055 E. Tufts Avenue, #330 Denver, CO 80237 (303) 721-9292	**Consultant** Greg Cunningham Cunningham + Associates 512 Second Street San Francisco, CA 94107 (415) 495-2220
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Consultant Steven D. Gates, P.E. Building HVAC Design/Performance Modeling 11608 Sandy Bar Court Gold River, CA 95670 (916) 638-7540	**Consultant** Donald E. Croy CAER Engineers, Inc. 814 Eleventh Street Golden, CO 80401 (303) 279-8136
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Consultant Martyn C. Dodd Gabel Dodd Associates 100 Galli Drive, # 1 Novato, CA 94949 (415) 883-5900	**Consulting Engineer** Prem N. Mehrotra General Energy Corporation 230 Madison Street Oak Park, IL 60302 (708) 386-6000
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Consulting Engineer Robert Mowris, P.E. 606 Pelton Avenue Santa Cruz, CA 95060 (408) 454-0606	**Energy/DSM-Consultant** Adrian Tuluca Steven Winter Associates 50 Washington Street Norwalk, CT 06854 (203) 852-0110
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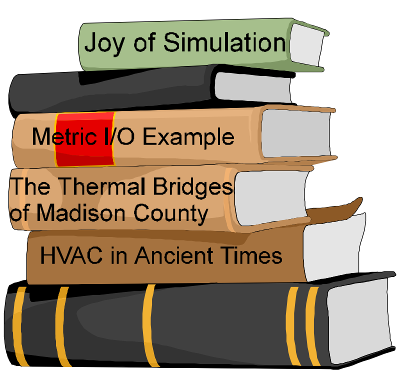
Energy and Environmental Engineering Neil A. Caldwell D. W. Thomson Consultants, Ltd. 1985 West Broadway Vancouver, BC V6J 4Y3 Canada	

DOE-2.1E Documentation Update



Sample Run Book:
Metric Input/Output Example

Recently, it was brought to our attention that Section 13 of the DOE-2.1E Sample Run Book was missing. Sure enough, due to an error on our part Section 13, the Metric I/O Example, was never sent to the printer. If you would like a copy of this example, please fax your request to Kathy Ellington at (510) 486-4089.
You may also email KLEllington@lbl.gov

DOE-2 RESOURCE CENTERS

The people listed here have agreed to be primary contacts for DOE-2 program users in their respective countries. Each resource center has the latest program documentation, all back issues of the User News, and recent LBNL reports pertaining to DOE-2. These resource centers will receive copies of all new reports and documentation. Program users can then make arrangements to get photocopies of the new material for a nominal cost. We hope to establish resource centers in other countries; please contact us if you are interested in establishing a center in your area.

South America Prof. Roberto Lamberts Universidade Federal de Santa Catarina Campus Universitario--Trindade Cx. Postal 476 88049 Florianopolis SC BRASIL Telephone: (55)482-31-9272 Fax: (55)48-231-9770 email: Lamberts@ecv.ufsc.BR	**Australasia** Dr. Deo K. Prasad/P. C. Thomas SOLARCH University of New South Wales P.O. Box 1 Kensington, N.S.W. 2033 AUSTRALIA Telephone: (61)-2-697-5783 (P.C. Thomas) Fax: (61) 2-662-4265 or -1378 email: PC.Thomas@unsw.EDU.AU
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World-Wide Web and Internet Sites for Building Energy Efficiency

(net) sci.engrg.heat-vent-ac	**HVAC** discussion group.
(net) sci.engrg.lighting	**Lighting** discussion group.
http://energy.ca.gov/energy/cectext/ETEC.html	**California Energy Commission's Energy Technology and Education Center** . See *User News* , Vol. 16, No. 1, p. 42.
http://www.hike.te.chiba-u.ac.jp/ikeda/CIE/publ/110-94.html	**The International Commission on Illumination - CIE** See *User News* , Vol. 16, No. 1, p. 44.
http://www.eren.doe.gov/	**EREN**: Energy Efficiency and Renewable Energy Network of the U.S. Department of Energy . See *User News* , Vol. 16, No. 1, p. 44.
http://www.doe.gov/	**U.S. Department of Energy** . See *User News* , Vol. 15, No. 4, p. 1.
http://www.whitehouse.gov/	**The White House** home page contains an Interactive Citizens Handbook that lists U.S. Government servers by agency. Use this site as a jumping-off point to explore other Federal agencies. See *User News* , Vol. 15, No. 4, p. 1.
http://www.fedworld.gov/	**FedWorld** is the U.S. Government's Federal Information Network home page. It lists web servers, ftp, gopher, and telnet sites and is organized by subject categories.
http://www.fedworld.gov/ntis/ntishome.html	**National Technical Information Service** NTIS is part of the U.S. Department of Commerce; it gathers and markets scientific, technical and business-related information and disseminates it electronically, on paper copy, on diskette, or on CD-ROM. NTIS has access to more than two million documents, reports, studies, computer programs, and databases; it adds an average of 1,300 titles each week. Call (703) 487-4650 for info.
http://www.caddet-ee.org	**Center for the Analysis and Dissemination of Demonstrated Energy Technologies** CADDET is an International Energy Agency program responsible for collecting and disseminating information on demonstrated, energy-efficient and renewable energy technologies. See *User News* , Vol. 16, No. 2, p. 23.
http://crest.org/aceee	**American Council for an Energy-Efficient Economy** ACEEE is a non-profit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection. See *User News* , Vol. 16, No. 2, p. 23.
http://www.ashrae.org	**American Society of Heating, Refrigeration and Air-Conditioning** ASHRAE is an international membership organization operated for the exclusive purpose of advancing the arts and sciences of heating, refrigeration, air conditioning and ventilation. ASHRAE sponsors research, develops standards for industry, publishes technical and scientific data, and organizes conferences and educational activities. *User News* , Vol. 16, No. 3, p. 31.
http://www.cisti.nrc.ca/irc/irccontents.html	**[Canadian] Institute for Research in Construction** IRC is an integral part of the National Research Council, Canada's premier science and technology agency. IRC is the leader in research, technology and innovation for the Canadian construction industry through the development of national construction codes. See *User News* , Vol. 16, No. 3, p. 31.
http://eicbbs.wseo.wa.gov/	**Washington State Energy Office/Energy Ideas Clearinghouse** Information and technical support for increasing energy efficiency in the commercial and industrial sectors. Clients include utility staff, engineers, facility owners and operators, consultants and other energy professionals. Up-to-date information on products and technologies; national, state, and local programs; and the environmental aspects of energy use is available at the Clearinghouse.
http://next1.mae.okstate.edu/ibpsa/	**International Building Performance Simulation Association** IBPSA is a not-for-profit international society of building performance simulation researchers, developers and practitioners, dedicated to improving the built environment.
http://www.fsec.ucf.edu/	**Florida Solar Energy Center** FSEC is the State of Florida's energy institute specializing in energy research and education in partnership with private and public organizations.
http://beijing.dis.anl.gov/ee-cgi-bin/hem.pl	**Home Energy Magazine** An impartial source of analysis to aid the energy practitioner and the public in making informed decisions on energy conservation measures.

* * * Featured Sites This Issue * * *

World-Wide Web and Internet Sites for Building Energy Efficiency

FLORIDA SOLAR ENERGY CENTER (FSEC)
http://www.fsec.ucf.edu/

FSEC is the State of Florida’s energy institute specializing in energy research and education in partnership with private and public organizations. On their home page, you may select links to either their Building Design Assistance Center (BDAC) or the Building Energy Efficiency Rating System (BEERS).

Building Design Assistance Center (BDAC)
BDAC promotes energy-efficient building design in Florida and provides the architectural and engineering communities with free design assistance through plan reviews, building energy simulations, development of construction details, and selection of appropriate materials and equipment. BDAC also conducts extensive laboratory and field tests to measure the effectiveness of new and existing products designed to improve energy efficiency. Send email to janet@fsec.ucf.edu for a copy of the *BDAC Energy Files* newsletter.

Building Energy Efficiency Rating System (BEERS)
BEERS uses two discrete rating systems: one for residential buildings and one for commercial buildings. Each rating systems provides consumer friendly, graphic information with overall estimates for annual purchased energy cost in dollars, annual energy use in MBtu, and a rating relative to all other buildings of the same size, class, and use. In addition to the overall estimate of the building’s energy efficiency, ratings also provide separate energy end-use estimates and efficiency ratings that are combined to arrive at the overall rating.

HOME ENERGY MAGAZINE
http://beijing.dis.anl.gov/ee-cgi-bin/hem.pl

For over a decade, Home Energy magazine has been providing energy professionals with reliable, easy-to-read reporting on the latest energy-efficient technologies for the home--from weatherization, to heating and cooling systems, to lighting, windows, appliances, and indoor air quality. Published by the non-profit organization Energy Auditor & Retrofitter, Inc., Home Energy Magazine offers an impartial source of analysis to aid the energy practitioner and the public in making informed decisions on energy conservation measures.

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homeenergy@envirolink.org

Phone: (707) 939-8823 / Fax: (707) 939-9218

DOE-2 PROGRAM DOCUMENTATION

DOE-2 documentation is available from several sources.

- The National Technical Information Service offers a complete set of DOE-2 manuals, available for purchase separately; prices and ordering information are below.
- Kinko's Copy Center of Berkeley offers the DOE-2.1E updated documentation (BDL Summary, Sample Run Book, and Supplement) as a set; their price includes shipping within the U.S.; see below
- The Energy Science Technology Software Center at Oak Ridge, TN, offers the DOE-2.1E updated documentation free of charge when you purchase the mainframe or workstation version of DOE-2. See the "DOE-2 Directory of Program Related Software and Services" in this issue.
- And finally, many of the PC vendors of DOE-2 offer some or all of the documentation when you buy their program. Names and addresses of all DOE-2 vendors are found in the "DOE-2 Directory of Program Related Software and Services" in this issue.

To order any or all of the DOE-2 manuals from the National Technical Information Service:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone (703) 487-4650
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Document Name	Order Number	Price
DOE-2 Basics Manual (2.1E)	DE-940-13165	44.50
BDL Summary (2.1E)	DE-940-11217	27.00
Sample Run Book (2.1E)	DE-940-11216	91.00
Reference Manual (2.1A)	LBL-8706, Rev.2	126.00
Supplement (2.1E)	DE-940-11218	91.00
Engineers Manual (2.1A) [algorithm descriptions]	DE-830-04575	52.00

To order the DOE-2.1E "update" documentation from Kinko's Copy Center in Berkeley, California:

Ms. Dani Aalfs
Kinko's Copy Center
901 University Avenue
Berkeley, CA 94710
Phone: (510) 204-0781
Fax: (510) 644-9704

"Update" documentation includes the 2.1E BDL Summary, 2.1E Supplement, and 2.1E Sample Run Book. Cost of the three manuals is $125 which includes any applicable taxes, shipping, and handling. For foreign orders, please fax Ms. Aalfs to ascertain extra shipping costs. VISA, MasterCard.

"Building Load Analysis and System Thermodynamics"

blastnews

The **Building Loads Analysis and System Thermodynamics** (**BLAST**) program is a comprehensive energy analysis tool that allows users from a wide range of experience levels to calculate building heating and cooling loads as well as simulate primary and secondary equipment. The current PC version of BLAST includes several pre- and post-processing auxiliary programs to create BLAST input files and reduce program output data. Documentation in a Windows™ Help format is included in the standard BLAST package; printed documentation is also available. Source code may be obtained from the BLAST Support Office (BSO), allowing BLAST to be ported to other computing environments. The BSO also distributes the WinLCCID96 life cycle cost program [See *User News* Vol. 16, No. 4, p. 5]. Please consult the BSO web page or catalog for the latest information on prices, system requirements and available weather sites.

The **Heat Balance Load Calculator** (**HBLC**) interface provides a graphical, Windows™-based environment for obtaining BLAST input files and analyzing simulation results. Within HBLC, each story of the building is represented as a floor plan which may contain several separate zones. Numerous other building details may be investigated and accessed through simple mouse operations. On-line helps provide valuable on-the-spot assistance that will benefit both new and experienced BLAST users. HBLC makes the process of developing input files more intuitive and efficient; it is available as part of the standard BLAST package. A free demo may be downloaded from the BSO web page or obtained by contacting the BSO.

BLAST Support Office (BSO)

30 Mechanical Engineering Bldg

University of Illinois

1206 West Green Street

Urbana, IL 61801

Telephone: 333-3977

FAX: (217)244-6534

email: support@blast.bso.uiuc.edu

WWW: http://www.bso.uiuc.edu

The Heat Balance Method of Calculating Building Heating and Cooling Loads

The following is an excerpt from an article which appeared in the European Directory of Sustainable and Energy Efficient Building 1996 published by James & James Ltd. The article was written by D.E. Fisher and C. O. Pedersen of the BLAST Support Office to explain the use of heat balance based simulations in the calculation of heating and cooling loads. The heat balance method is currently being implemented in the energy analysis program under joint development by DOE and DOD (the BestOf! project).

The Heat Balance Method

The "heat balance" method defines the thermal zone in terms of four control volumes, yielding a sufficient amount of detail without incurring a significant penalty in computation time. The first law of thermodynamics is applied at the exterior and interior surface of each building construction element, to the building element itself and to the mass of air in the thermal zone as follows:

1. Outside Surface Heat Balance: calculates the rate at which heat energy is exchanged with the outdoor environment by radiation and convection.

2. Building Element Heat Balance: calculates the rate at which heat energy is conducted through walls, floors, roofs, doors and windows.

3. Inside Surface Heat Balance: calculates the rate at which heat energy is exchanged with the indoor environment by radiation and convection.

4. Air Heat Balance: calculates the rate at which heat energy is added to or removed from the zone air by convection from surfaces and equipment, infiltration of outside air and mechanical ventilation of conditioned air.

Energy sources and sinks are shown for each of the four zone heat balances in Figure 1. Complexity is introduced not only by the algorithms describing various heat transfer processes, but also by the fact that the entire set of equations, representing all four heat balance formulations (including replications of the building element heat balance for multiple building elements), must be solved simultaneously in order to calculate the net rate of heat transfer to the zone air and the temperatures of various interior surfaces.

Thermal Load Calculations Using the Heat Balance Method

A complete formulation of the heat balance equations required for zone thermal load calculations can be found in the computer codes based upon the method. For example, the Building Loads and System Thermodynamics (BLAST) program, which was developed by federally sponsored research initiatives in the United States, consists of a complete set of heat balance algorithms describing all modes of building heat transfer.

Simplifying assumptions are generally incorporated in heat transfer models both to reduce computation time and to simplify the required input to the program. The BLAST algorithms include simplifications to both the radiation and conduction models. The radiation models assume that all surfaces are gray and diffuse. Spectral emissivity is approximated as a two band model with constant emissivities in the visible and infrared bands. The radiation equation is linearized; and for the radiant exchange in the enclosure, a two surface model is employed. This model, which was developed by Walton [1980], calculates the radiation exchange between a single surface and the rest of the enclosure. The enclosure is approximated as a single surface with a mean emissivity and temperature.

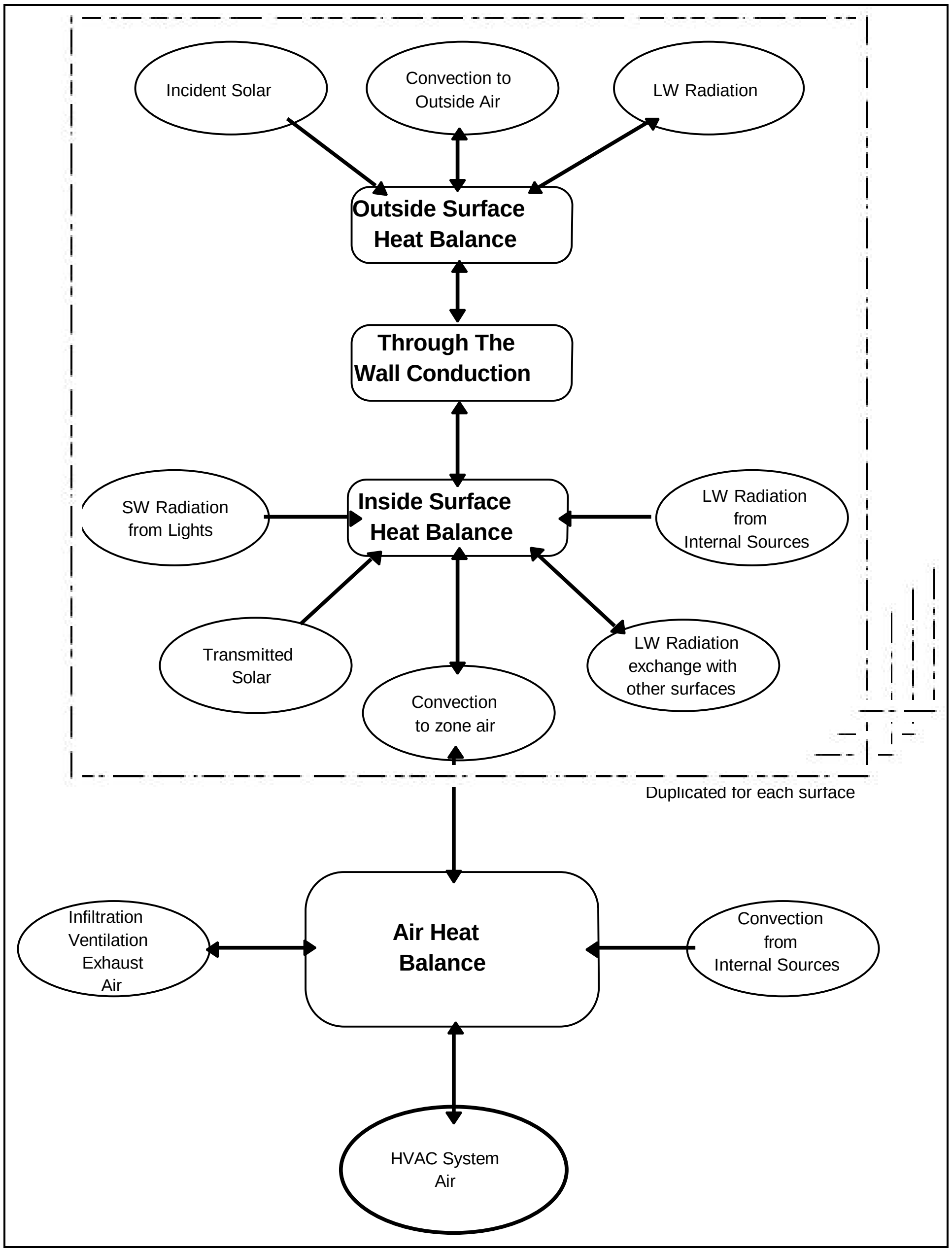

Figure 1. Schematic Representation of the Heat Balance Method

The conduction equation is typically simplified by assuming one dimensional, transient conduction through building elements. The differential equation is then solved numerically, usually by a finite difference, finite element or response factor method. BLAST calculates conduction transfer functions (CTFs), which were developed by Hittle [1981] as an extension to the response factor method. The BLAST formulation of the heat balance method has been extensively validated [Carroll, Christensen, Herron, Hittle, Lawrie, Yuill] and used successfully in the United States to calculate heating and cooling loads for both large and small buildings, including the six million square foot Pentagon, a massive solid masonry structure, and the 21-story State of Illinois Center, an envelope dominated structure located in Chicago, Illinois.

Using the Heat Balance Method

The main advantage of the heat balance method over simplified procedures is that it allows building designers to utilize the building envelope and internal mass in the design of the mechanical system. Figure 2 illustrates the effect of building mass on a simple rectangular zone with east-facing windows. The figure shows the total sensible cooling load for a single zone with different wall constructions. The zone electric load shown in the figure is the only internal heat source. The balance of the load is due to solar radiation transmission through windows and heat transmission through exterior surfaces. The "High Mass Cooling Load" shown in the figure is the zone load for a typical US Masonry construction. The exterior walls are brick veneer on eight inch cement block, and the partitions are eight inch block. The "Low Mass Cooling Load" in Figure 2 is the same zone with exterior walls and partitions typical of US residential construction--brick veneer on wood frame with light wood frame and plaster partitions. The overall thermal resistance of the exterior walls is nearly the same for both cases.

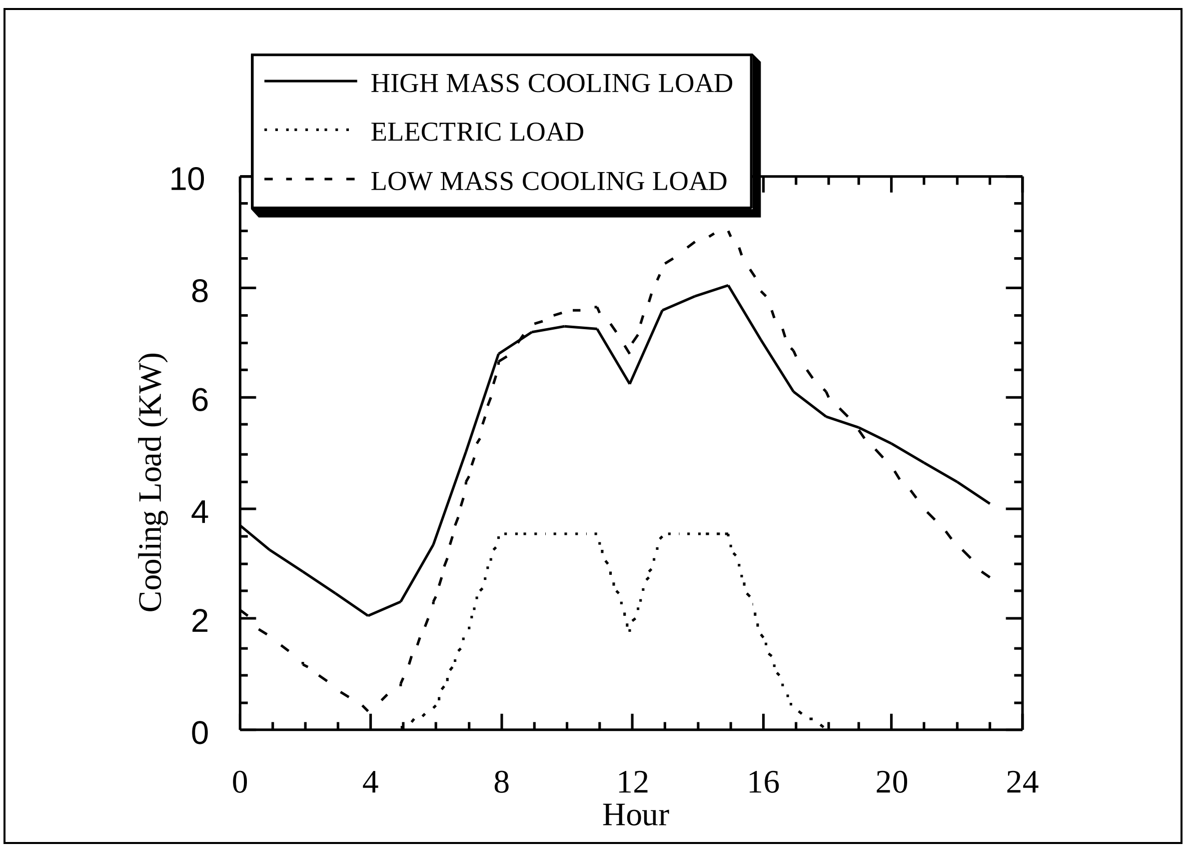

Figure 2. BLAST Sensible Zone Cooling Load for High and Low Mass Constructions

Conclusions

An additional feature of the heat balance method is that it can be seamlessly extended to a complete building energy analysis by including additional system and plant detail. An energy simulation typically uses hourly weather data in place of design day conditions, but the building model described by the heat balance does not change. The heat balance method allows architects and mechanical engineers to quantify and evaluate the interactions between the building and its mechanical systems. The method captures the essential physics of the complex building heat transfer model and, depending on the set of algorithms used, accurately predicts occupant comfort for both conventional and unconventional designs.

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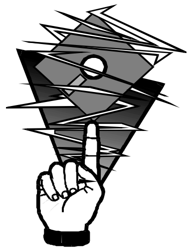
6. Yuill, G.K., Phillips, E.G., "Comparison of BLAST Program Predictions with the Energy Consumptions of Two Buildings," <u>ASHRAE Transactions</u>, Vol. 87, Part 1, pp. 1200-1206, 1981.
7. Walton, G.N., "A New Algorithm for Radiant Interchange in Room Loads Calculations," <u>ASHRAE Transactions</u>, Vol. 86, Part 2, 1980.



Call for SPARK Beta Testers

Beta testing of SPARK will begin soon. As you may know, SPARK will let you quickly build models of complex physical processes by connecting calculation modules from a library. It is aimed at simulation of innovative and/or complex building systems that are beyond the scope of programs like DOE-2 and BLAST. The main elements of SPARK are an interactive *graphical editor*, an *object library* containing calculation modules for building components and processes, and a *solver* for solving the set of simultaneous algebraic and differential equations that correspond to the physical problem being simulated. With the graphical editor you graphically link the objects into networks that represent a building's envelope, lighting or HVAC system. With the support of DOE, SPARK is being developed by the LBNL Simulation Research Group, California State University Fullerton and Chapman University.

SPARK differs from DOE-2 in several important respects: (1) its time step can be as small or large as you want; (2) it uses an iterative solution and so can handle non-linear systems; (3) it is equation based and so can simulate arbitrarily complex systems that can be described by sets of algebraic and differential equations; and (4) its algorithms are not hard wired, which means you can easily customize it to particular simulation problems. SPARK will be initially be made available as a stand-alone program. The first release will include a library of basic HVAC components like fans, mixing boxes, heat exchangers, coils, chillers, cooling towers, and controls that you can immediately begin to assemble into complete HVAC systems. Later, SPARK will be integrated into PowerDOE, DOE-2-2, and the combined BLAST/DOE-2 program, and will allow you to analyze the performance of innovative HVAC systems using loads calculated by these programs. We will also add a library of envelope component objects, at which point you will be able to use SPARK to add new heat transfer models. You will be able to run the beta version under UNIX, DOS or Microsoft Windows. However, to use the graphical editor you will need a machine that can run the X-Window operating system. Otherwise, you can use the SPARK command-line interface to define and link objects.

If you would like to be a beta tester please contact Kathy Ellington at kathy@gundog.lbl.gov or fax this page to 510-486-4089. We will contact you with more information prior to beta release.

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