BUILDING ENERGY SIMULATION USER NEWS

Volume 20 Number 3 Fall 1999

For Users of EnergyPlus, DOE-2, BLAST, SPARK, GenOpt and their Derivatives

What's New ?

❖ **Building Design Advisor - Beta 2 Release ...**

The Beta 2 release of the Building Design Advisor (BDA), with links to DOE-2.1E, is available (http://kmp.lbl.gov /BDA-20). This beta release is just like the 1.0 version with the addition of links to DOE-2.1E. The DOE-2 output parameters are accessible through the Building Browser. In Beta 2, five DOE-2 output parameters at the building level and two parameters at the space level have been implemented.

There will be more information on BDA Beta 2 in the Winter *User News*.

❖ **New DOE-2 Consultants ...**

Jim Kelsey and **Kevin Warren,** of Oakland, CA, are our newest DOE-2 consultants. Their company, **KW Energy Engineering,** specializes in commercial, institutional and industrial mechanical systems.

KW ENERGY ENGINEERING
175 Filbert Street, Suite 205
Oakland, CA 94607-2541
Phone: 510×834×6420 www.kw-energy.com
Fax: 510×834×6373 info@kw-energy.com

❖ **New Address for Swiss DOE-2 Resource Center ...**

Réne Meldem has relocated to:
MELDEM ENERGIE SA
Avenue de Cour 61
CH-1007 Lausanne
Switzerland
Phone: +41 21 401-4090 Fax: +41 21 401-4091
(email remains meldem.energie@bluewin.ch)

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10/99 2000

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What's Inside ?

RIUSKA and SMOG: Integrated Building Design and Facilities Management

Antti Karola, Tuomas Laine, Kenneth Lassila, Hannu Lahtela and Markku Jokela
OLOF GRANLUND OY, CONSULTING ENGINEERS

PO Box 59 (Malminkaari 21) **Tel. +358 9 3510 31** **www.granlund.fi**
FIN-00701 Helsinki, FINLAND **Fax +358 9 3510 3421**

Introduction

Olof Granlund Oy[1] (OGO) has developed an integrated simulation system for building services design and facilities management. The RIUSKA and SMOG program pair are meant to be used in the "everyday" design process; between them, they cover the thermal simulation needs of the whole building life cycle, from preliminary design to energy efficient retrofits and renovations. SMOG is Granlund's 3-D space modeling program. It performs heat loss calculations, space area calculations, space management software in FM systems and visualization of building services systems and equipment. It is used to transfer information on building geometry and structures to RIUSKA, Granlund's energy simulation program. Currently, RIUSKA, which uses DOE-2.1E as the calculation engine, contains a new "Cooled Beam" system implementation, and SMOG is now IFC[2] 1.5.1 compatible. This article describes the present state of the programs and how they are used in the design process.

The Everyday Design Process

The main components of the simulation system are RIUSKA (the interface for the simulation database, result module and calculation engine) and SMOG (the building geometry modeler). Both programs are used intensively, every day, in all of the HVAC-design projects at Granlund. The thermal simulation tasks vary from single-space sizing simulations to energy calculations for large commercial buildings in different design stages. RIUSKA and SMOG have been used in dozens of whole-building system comparisons, energy consumption calculations and heat loss calculations. Including space simulations, the projects where these tools have been used already number in the hundreds.

RIUSKA and SMOG are used within Granlund's designer teams by specially trained team members. These team members perform most of the basic simulations immediately, when they are needed in the design process. However, the most complex simulations are performed with the assistance of Granlund's R&D group, which has deeper knowledge of thermal simulation. This division of work has proved to give excellent results. HVAC designers are realizing that these simulation tools are useful in different stages of the design process and accurate simulation results have been achieved with a reasonable expenditure of time. One feature that encourages designers to use RIUSKA and SMOG for thermal simulation purposes is that they get the results from steady-state heat loss calculations for the building as it is modeled by SMOG. Figure 1 shows how simulation is used in the design process.

The RIUSKA Thermal Simulation Interface

User interface

The user interface is used to import 3-D geometry from SMOG, to fill in the missing data needed for the thermal simulation, to perform the simulation, to store all the input/output data and, finally, to report the results through a result module. After the building geometry is imported from SMOG into RIUSKA, the missing input data is filled in with default values based on statistical data, know-how and library values; the default values can be changed, if required, before thermal simulation. The user can also easily create copies of simulation cases to make quick comparisons, for example, between different window or AC-system types. All of the data created before and after thermal simulation is stored in a database for future re-use. The RIUSKA database structure only represents data to be used in an application area, e.g., thermal simulation. The simulation database contains all parameters for a particular building or project.

[1] Olof Granlund is the leading building services consulting firm in Finland. The company was founded in 1960 and employs about 240 building technology professionals. Company's approach is based on maintaining a continuous relationship with the client throughout the entire life cycle of the building.

[2] IFC (Industry Foundation Classes) is a file format, which will in the future provide wide coverage of the needs for data transfer in building design, construction and facilities management and will offer totally new opportunities for the life-cycle-based data management of buildings. IFC's are defined and published by the IAI (International Alliance for Interoperability).

The DOE-2.1E Calculation Engine With New Features

RIUSKA was designed so that the calculation engine could be changed just by writing new input/output converters for the new engine. Presently RIUSKA is using DOE-2.1E. As a result of cooperation between OGO and Lawrence Berkeley National Laboratory (LBNL), DOE-2.1E has a new cooled beam air conditioning system. The cooled beam system is widely used in commercial buildings in Scandinavian countries. Space cooling is achieved by circulating chilled water through ceiling-mounted finned-tube heat exchangers. There are two main types of cooled beams, active and passive. In the active beam type, the supply air passes through the beam and increases its cooling power. In the passive beam type, the heat exchange is by natural convection. The water inlet/outlet temperature range is approximately 15°-17°C. The same cooled beam system is also being implemented in the EnergyPlus simulation program. Eventually EnergyPlus will replace DOE-2.1E as the calculation engine in RIUSKA, opening new possibilities for further development of RIUSKA.

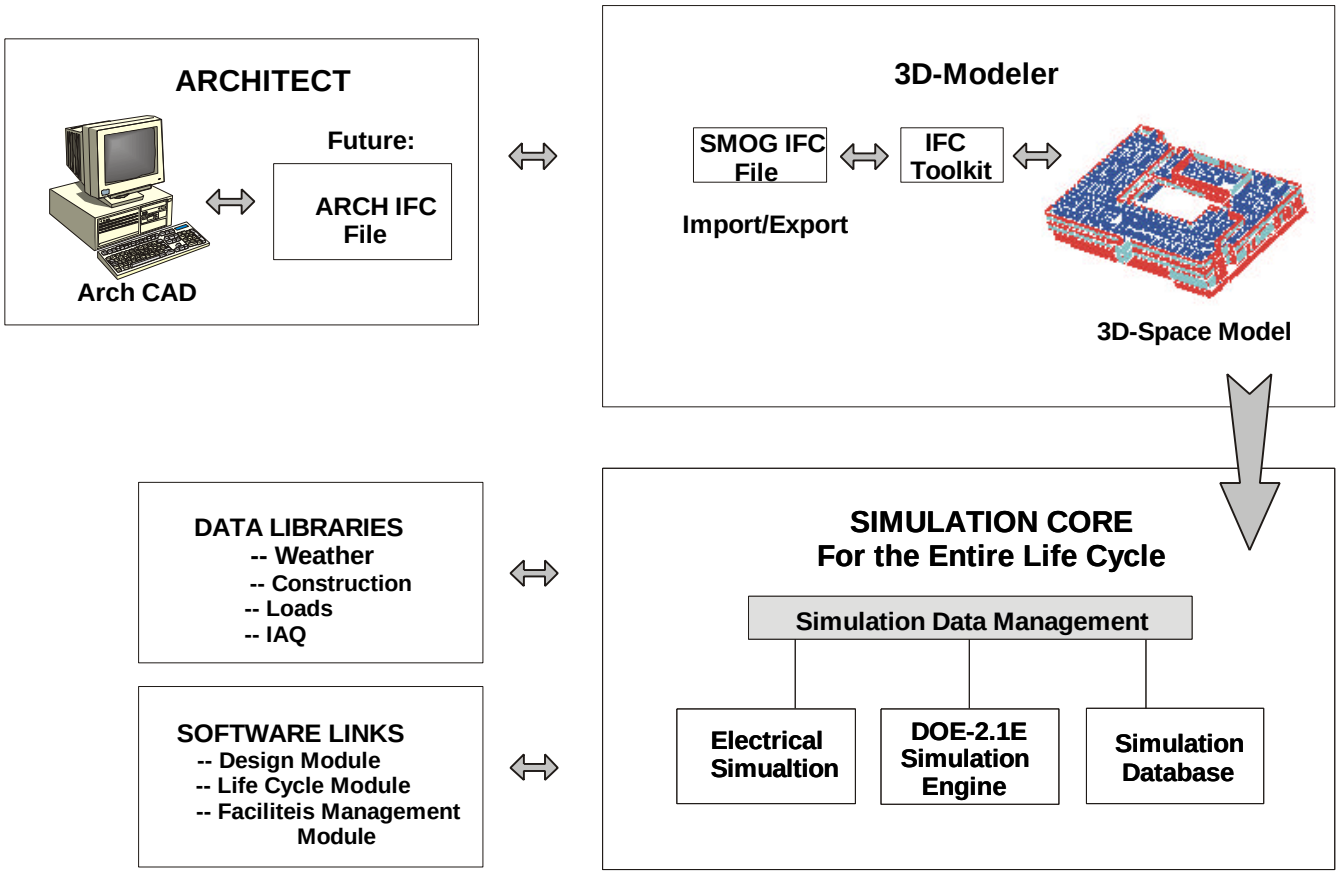


Figure 1: Design process of a simulation model.

The Result Module: Reporting Styles for Different Needs

A group of different report types has been developed for different needs. Much attention was paid to the appearance of reports and to their easy readability. This is important since the reports must serve the needs of the practical design process and discussions with architects and builders. The reports also serve as documentation for the design process. The simulation results are used in the early stages of the design process to set targets for energy consumption and to make system comparisons. The results from annual energy consumption simulations are used when the energy consumption is measured with facility management systems. The thermal simulation results can be viewed and printed within the program using a stand-alone result viewing application. This enables a teamwork method, in which one team member performs the simulations and others study the results of different simulations. There are number of different report styles for different needs concerning space and building simulations. See figs. 2a and 2b for report examples.

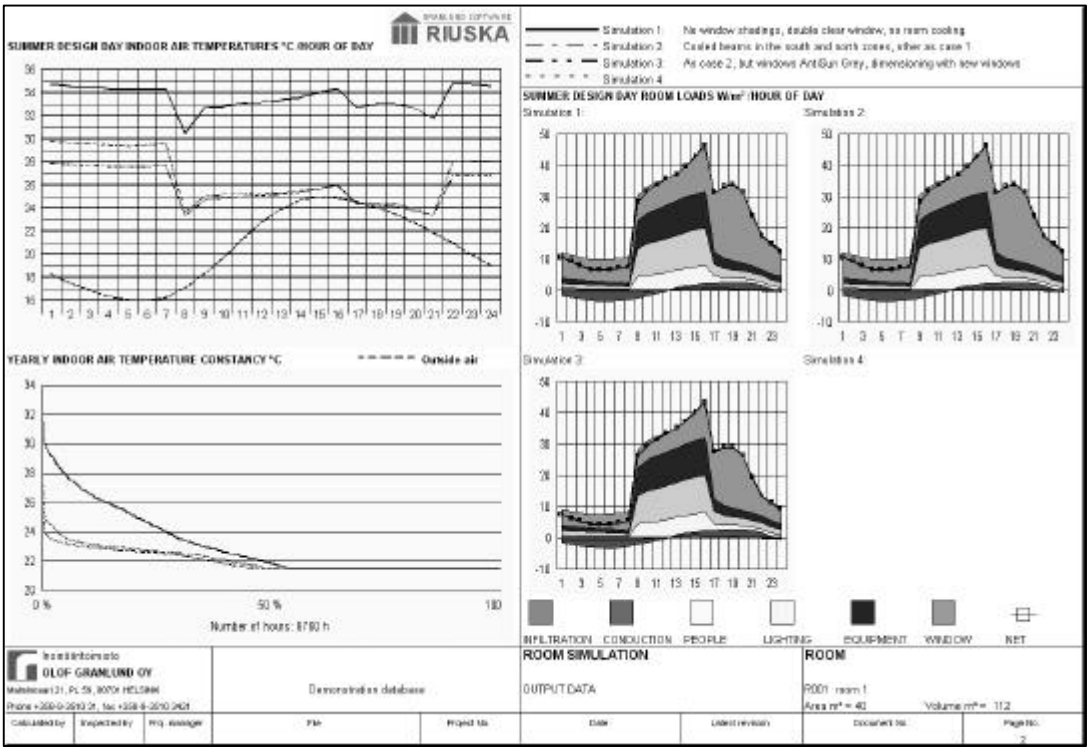


Figure 2a: Example of space simulation output from equipment sizing calculations.

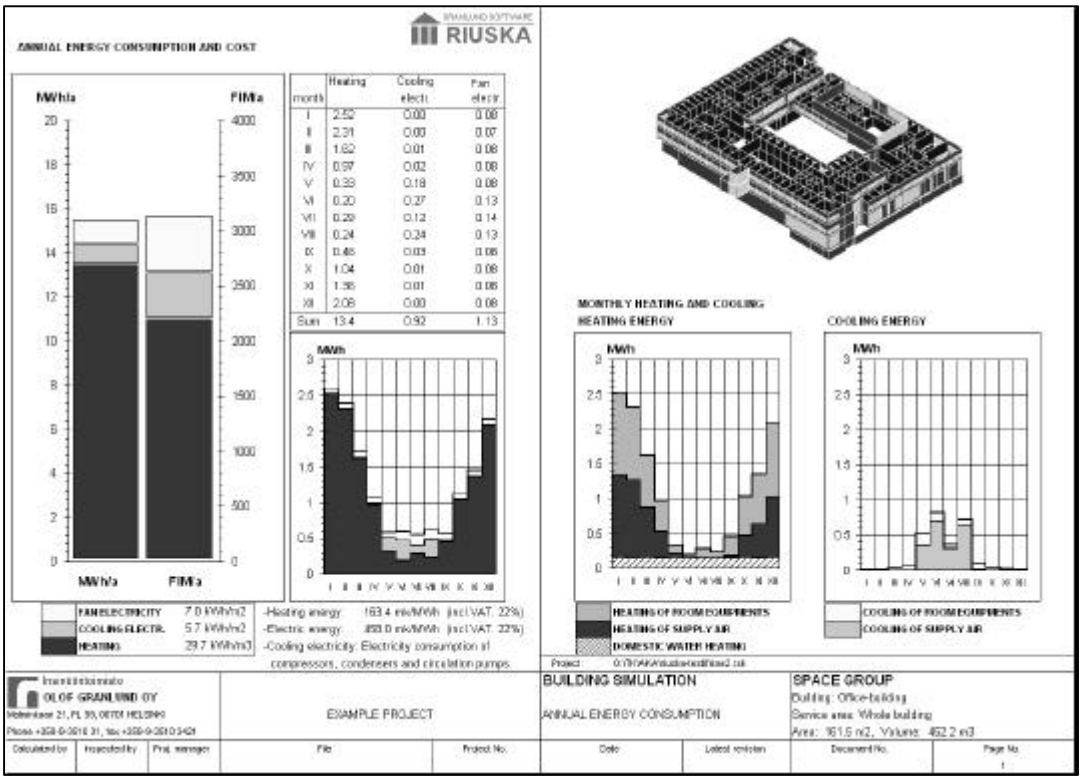
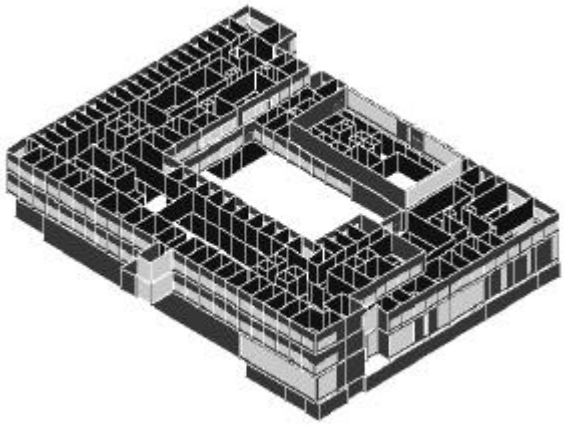


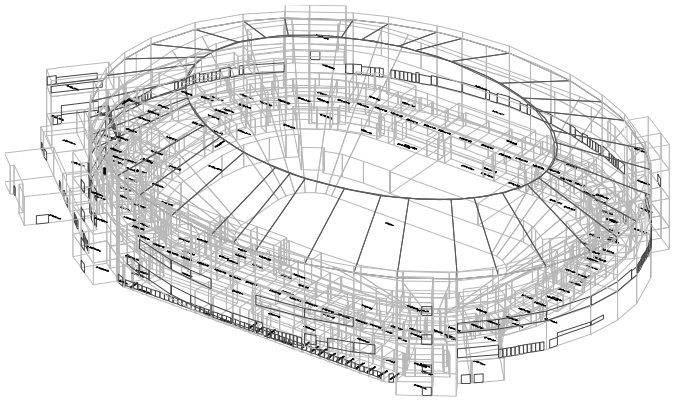
Figure 2b: Example of building simulation output from energy consumption calculations.

SMOG – 3-D Modeler

The most novel part of the simulation system is a space modeling tool called SMOG (Space Modeler by Olof Granlund). SMOG is an AutoCAD-based modeling tool that enables easy generation of the geometrical model of the building and makes the input reliable, fast and easy. SMOG creates 3-D objects of walls, windows, doors and spaces; it also creates *connections* among these objects. For example a wall object knows its neighbor objects and a space object knows all its wall objects. See fig. 3 for 3-D-model examples.



Office building



Ice-hockey arena

Figure 3: Examples of 3-D-model of buildings created with SMOG.

SMOG and IFC 1.5.1

SMOG currently has IFC 1.5.1 import/export features. This enables direct transfer of digital building geometry and construction data from IFC-compliant architect software. SMOG makes it possible to use this data for both space management and in design tools such as energy and comfort simulations, visualizations and life-cycle cost analyses. Results obtained in technical calculations can be exported to other IFC-compliant software

SMOG allows users to:

- draw basic objects such as walls, windows and doors
- move and edit objects; the SMOG modeler maintains connections among objects and updates properties related to these objects (e.g., it changes space areas when you move a wall)
- quickly calculate areas
- calculate static heat losses
- visualize the building
- import/export IFC 1.5.1 geometry and construction data

The Future of RIUSKA and SMOG

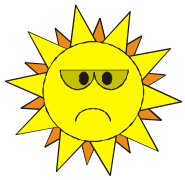
Both programs continue to be under development at OGO, thanks to feedback from real use in projects. The IFC-data management between SMOG and architect applications will be further tested and developed. At the moment both RIUSKA and SMOG are primarily used as internal products at OGO; however, RIUSKA is being considered for development as a commercial product and SMOG has been used successfully in outside pilot projects.

For further information contact

RIUSKA **Tuomas.Laine@granlund.fi** (PDF paper at http://www.granlund.fi/English/runko.htm)

SMOG **Hannu.Lahtela@granlund.fi**.

Has the Sun Set on Weather Data?



Joe Huang
Simulation Research Group
Lawrence Berkeley National Laboratory

Weather Data Crisis

Dynamic building energy simulation programs, such as DOE-2, BLAST, SPARK, TRNSYS, etc., all need detailed weather information, preferably hourly, as inputs for the simulation. Design simulations are often done with typical year weather data such as TMY2 or WYEC2, but there are many instances when actual year weather data is needed to diagnose measured building energy performance or to weather-normalize predicted savings in energy management. The major sources of this weather information are the surface weather observations reported by the National Weather Service (NWS)[1] and the Federal Aviation Administration (FAA)[2] at airports and other sites and archived at the National Climatic Data Center (NCDC)[3]. Unfortunately, beginning in 1992, the NWS and the FAA began to change the method used to collect the observations along with the types of data being collected. Credible building energy simulations can no longer be completed using the weather data currently being reported from these sites.

For building energy simulation, these minimum weather data are required:

- dry-bulb temperature
- some measure of humidity (wet-bulb, dew point temperature or relative humidity)
- station pressure
- wind speed and direction
- some measure of solar radiation.

All of these parameters except the last are generally available in the surface observation data. If measured solar radiation is unavailable then researchers use analytical and empirical models to estimate the amount of total, direct and diffuse solar radiation from reported conditions of cloud type, cloud cover and sky cover.

The Automated Surface Observing System (ASOS)[4]

In 1992, the NWS, the FAA and the Department of Defense began replacing manual observations with automated sensors and reporting systems, either ASOS or Automated Weather Observation System (AWOS). As of February 1999, there were 694 commissioned ASOS or AWOS stations in the United States. When the planned 900-plus stations are in place at the end of 1999, they will be the primary source of surface observations in the United States.

The ASOS instrumentation was designed primarily to meet aviation needs; data recorded include ambient and dew point temperatures, wind conditions, precipitation accumulation, cloud height to 12,000 ft and other weather phenomena such as lightning or freezing rain. A laser beam ceilometer[5] provides the only information on sky conditions. In addition to reporting ceiling heights to 12,000 ft, ASOS uses an algorithm that analyzes 80 ceilometer readings over an hour to deduce five categories of sky cover: Clear, Few, Scattered, Broken or Overcast. Data on cloud cover above 12,000 ft and minutes of sunshine may be included in the future through additional instrumentation or manual augmentation. ASOS data are reported on a one-minute interval format in the Aviation Routine Weather Report (METAR)[6]. Hourly data for previous periods of record can be obtained from the NCDC[7].

The Problem with ASOS

The reported ASOS data present major difficulties for those of us who perform building energy calculations because of the very limited information available on solar conditions. Furthermore, the automated methods that are used to determine cloud height and sky cover are not compatible with previously developed solar models.

[1] http://www.nws.noaa.gov/
[2] http://www.faa.gov/sitem.htm
[3] http://www.ncdc.noaa.gov/index.html
[4] http://www.nws.noaa.gov/asos/
[5] http://grappa.meteo.mcgill.ca/ceilometer.html
[6] http://www.nws.noaa.gov/oso/oso1/oso12/metar.htm format
[7] http://www.ncdc.noaa.gov/

There is a proposal to upgrade the ASOS/AWOS network to record minutes of sunshine; however, even if this proposal is adopted, a new solar model would have to be developed to make such sunshine data usable for building energy calculations.

For the present, procedures are urgently needed to estimate solar radiation from the weather elements now being reported by the automated weather stations. For predicting average year energy use, the older weather data are adequate, but for running weather normalization calculations, current data are necessary. And only with the development of new procedures can the currently available data be made usable for this type of building energy simulation.

What Is Being Done?

The ASHRAE weather committee is currently considering the implications of ASOS weather data and deciding what steps should be taken to address the problem. If you have an opinion or a solution, please contact either Dru Crawley (Drury.Crawley@ee.doe.gov) or Joe Huang (YJHuang@lbl.gov), president and secretary, respectively, of the ASHRAE weather committee.

A version of this article appeared in the Sept-Oct 1999 issue of *Home Energy Magazine*

DESKTOP RADIANCE

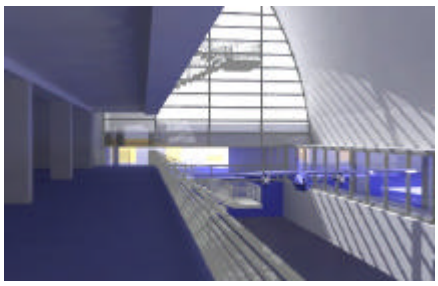
DESKTOP RADIANCE

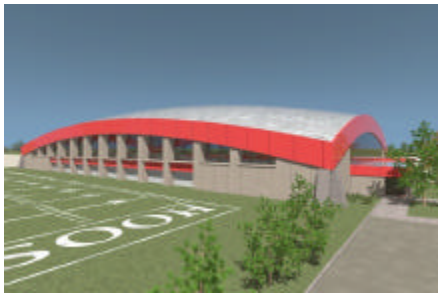
Lawrence Berkeley National Laboratory, in collaboration with Pacific Gas and Electric Co., has developed DESKTOP RADIANCE, a Windows 95/NT version of the RADIANCE Synthetic Imaging System. The RADIANCE engine has been linked to an AutoCAD front end and, through a user-friendly interface that accesses libraries of materials, glazings, luminaires and furniture, DESKTOP RADIANCE facilitates the choice of energy-efficient lighting and daylighting strategies in building design.

What is RADIANCE?

The RADIANCE Synthetic Imaging System is a suite of programs for the analysis and visualization of lighting in design. Input files specify the scene geometry, materials, luminaires, time, date and sky conditions (for daylight calculations). Calculated values include spectral radiance (i.e., luminance + color), irradiance (illuminance + color) and glare indices. Simulation results may be displayed as color images, numerical values and contour plots. The primary advantage of RADIANCE over simpler lighting calculation and rendering tools is that there are no limitations on the geometry or the materials that can be simulated. RADIANCE is used by architects and engineers to predict illumination, visual quality and appearance of innovative design spaces, and by researchers to evaluate new lighting and daylighting technologies. RADIANCE is UNIX software.

Sample RADIANCE Images





For more information and to download DESKTOP RADIANCE, go to http://kmp.lbl.gov/dt-rad/

A Utility Program for Use With the ENERGY-10 Design Tool Computer Program

WeatherMaker

WEATHER FILE CONVERSION AND EVALUATION SOFTWARE[1]

J. Douglas Balcomb
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401, USA

Introduction

A common problem that most developers and users of building simulation programs face is dealing with weather data. Some programs run directly from weather data in a standard ASCII text format, which is slow and requires large files. Others use special binary formats, which are fast and more compact, but cannot be read directly and limit a user in accessing data for new locations.

To solve this problem in the *ENERGY-10* design tool computer program, a special weather-data utility program has been written called *WeatherMaker*. This stand-alone program is bundled with *ENERGY-10* on the same CD-ROM. (References 1 through 4 for information about *ENERGY-10*). The weather data for *ENERGY-10* is packed binary, which is 17.5 times smaller than a TMY2 file. This is important when working with the 239 hourly weather files in the United States because it requires 17 MB of hard disk rather than 300 MB to store all the files. The *ENERGY-10* CD-ROM (Version 1.3 and later) contains the 239 United States *ENERGY-10*-format files for ready access.

WeatherMaker has three main features:

Convert — Weather files can be converted from one format to another. For example, a TMY2 format file can be converted to an *ENERGY-10* binary file that can either be used in an simulation or converted to a text format that allows it to be used in WordPad or Excel.

Evaluate — *ENERGY-10* weather files can be studied in great detail. There are eight graphical displays of the data that provide insight into the data, and a summary tables that presents results calculated from the hourly data.

Adjust — Hourly temperature data can be adjusted starting with hourly data from a nearby TMY2 site. Dry-bulb and wet-bulb temperatures may be increased or decreased as required to match given monthly statistics. This feature can be used to generate weather files for any of 3958 sites in the United States where such monthly statistics are tabulated.

The paper shows a variety of results, explains the methods used, and discusses the rationale for making the adjustments.

Weather File Conversion

ENERGY-10 can be run only with weather data files that are in the *ENERGY-10* packed-binary format (the files are identified by an *.et1 extension). These files, although small (70.4 Kbytes) are opaque to a user. They cannot be read using any standard tool, such as a text editor or a spreadsheet. Furthermore, users have been dependent on NREL to provide the files. As of now, there are weather files available for 239 locations in the United States (all the TMY2 locations) plus a few files provided on a custom basis, primarily outside the United States.

The conversion feature of *WeatherMaker* allows individual users to make files for themselves, starting with data in an ASCII text format. *ENERGY-10* weather data files can be made from data provided in either of two formats: a standard TMY2 format (5), or an *ENERGY-10* ASCII-text format. The standard TMY2 format is somewhat difficult to work with. It is a columnar format with a header and 8760 lines, each of which contains 25 variables. This is far more information than required by *ENERGY-10*. The *ENERGY-10* ASCII text format is a comma-separated file with several header lines and 8760 hourly lines containing just the day and hour plus the eight data items required

[1] *Proc. SOLAR '99, 24th National Passive Solar Conference, American Solar Energy Society, June 12-17, 1999, Portland, Maine*

by *ENERGY-10*. This is much easier to work with in a spreadsheet than a columnar format. In either case, the user must provide the hourly data required: global solar radiation, beam solar radiation, diffuse global solar radiation, dry-bulb temperature, dew-point temperature[2], wind direction, wind speed, and cloud cover.

Weather Data Evaluation

Users of building simulation programs are often provided little insight into the nature of the weather data they are using. The programs focus on output, not input; *ENERGY-10* is no exception. A few of the output options show one or two weather parameters, but most are not plotted or are only given indirectly. Yet in some building types, the weather should be a major determinant in the building design. The very title of his classic book, *Design With Climate*, highlights the design approach advocated by Victor Olgyay (6). Olgyay's work, and this book in particular, set in motion a whole approach to building design that continues to this day. The international group, *Passive and Low-Energy Architecture* (PLEA), sponsors conferences in which climate-based design is strongly featured. Olgyay developed a special graph to show climatic patterns that he called *bioclimatic registration of climate needs,* more commonly called a *comfort chart* today*.* This graphic displays monthly average daily cycles of temperature *vs*. relative humidity. This graph format proved to be very valuable in providing an understanding of the nature of a climate and giving clues into how a building might be designed appropriately for the climate.

The *WeatherMaker* evaluation feature provides a user with a tool that facilitates an understanding of a particular climate; in most cases this is done by a graphical display. Figure 5 is the Olgyay comfort chart; fig. 6 plots the same information on the axes of a psychometric chart, as advocated by Baruch Givoni (7). This format is particularly useful in understand which design strategies might be most appropriate in the summer months, such as adding thermal mass, night-vent cooling, and evaporative cooling. Other graphs show different relevant information, including hourly temperatures and solar radiation.

The graphical output options are as follows.

- Average by month (dry-bulb, wet bulb, and three solar options),
- Average hourly by month (dry-bulb, wet bulb, and three solar options),
- Hourly dry bulb and/or wet bulb temperature,
- Hourly solar radiation (three options),
- Comfort chart for typical days for each month (as used by Olgyay),
- Psychometric chart for typical days for each month (as used by Givoni),
- Hourly data on a psychometric chart color-coded by frequency of occurrence, and
- Hourly data on a psychometric chart color-coded by month.

The two hourly plots allow you to zoom in on any selected time period. Figure 8 shows a tabular summary by month of average dry bulb temperature, average daily maximum dry bulb temperature, average daily minimum dry bulb temperature, maximum dry bulb temperature, minimum dry bulb temperature, average wet bulb temperature, average wind speed, average daily horizontal solar radiation, relative humidity, and heating degree days and cooling degree days to any desired base. All results are available in any of five sets of units.

Samples of Graphs

Samples of the graphs and summary produced by *ENERGY-10* are shown in figs. 1-10. Because of ASES requirements, the units used are metric although USA units can be specified.

New Weather Data Generation

New weather data can be generated for sites where only long-term monthly average data are available. The procedure is to adjust the hourly dry-bulb temperatures in an hourly weather file (the "parent" site) to achieve the desired monthly average daily high temperature and monthly average daily low temperature at a neighboring "child" site. Wet-bulb temperatures are also adjusted, based on matching the parent–site temperature-relative humidity characteristics for each month. In this way, hourly weather data can be generated for 3968 weather data locations in the United States. The monthly data for all 3968 sites are stored on board for easy and automatic access. A user can also enter the data in a dialog box for any other location that is not one of the 3968 sites. In a later version of WeatherMaker, solar radiation data will also be adjusted, based on a new 40-km solar radiation data base generated using satellite data (8).

[2] *Dew-point temperature is required for TMY2; wet-bulb temperature is required in the ENERGY-10 ASCII-text format. Each can be calculated given the other.*

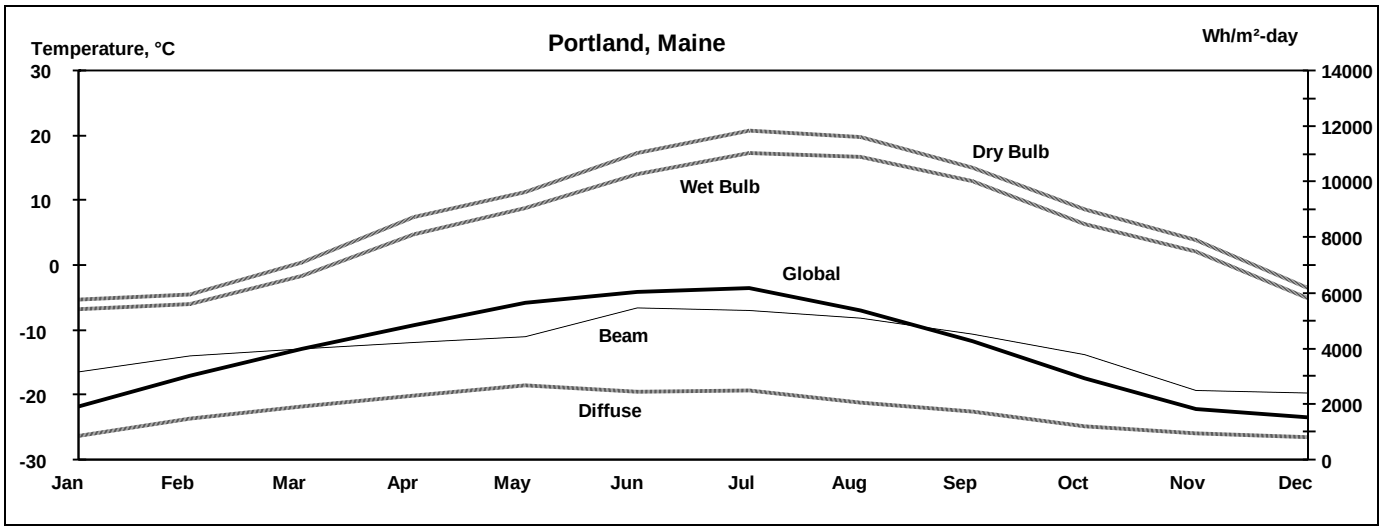


Figure 1: ***Average temperatures and solar radiation by month.***

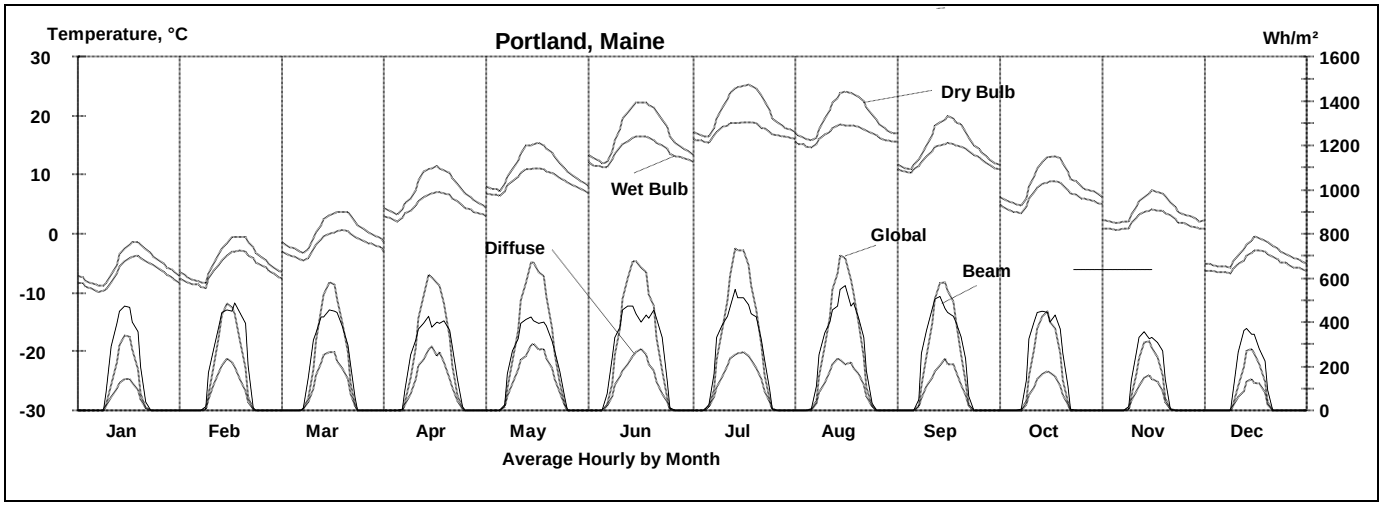


Figure 2: ***Average hourly temperatures and solar radiation. Each month is plotted separately. This is the same plot as Fig. 1 except that it shows the typical daily variation of each variable for each month.***

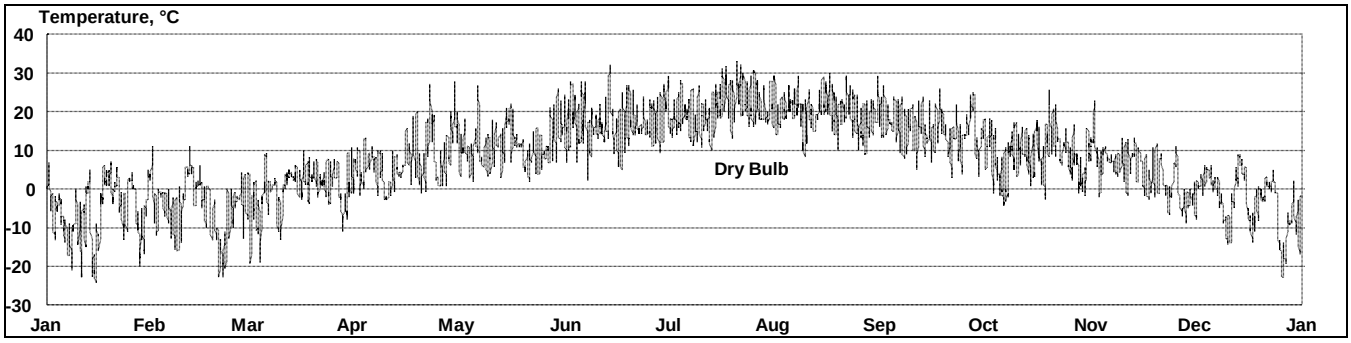


Figure 3: ***Hourly temperatures for Portland, Maine. For clarity, this shows only dry bulb temperature; however, the wet bulb may be co-plotted. The plot can be expanded to show any shorter time segment such as one week, in which case plotting the two temperatures together becomes quite informative.***

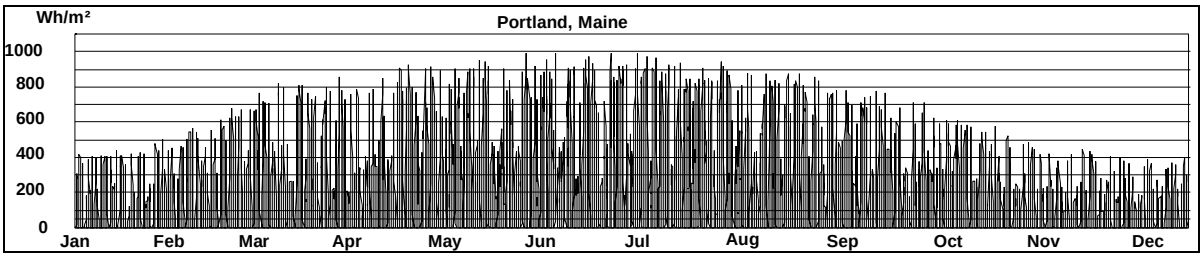


Figure 4: Hourly solar radiation. For clarity, this plot shows only global radiation; however, both beam and diffuse solar radiation may be co-plotted. The plot can be expanded to show any shorter time segment such as one day, in which case plotting the three values together becomes quite informative.

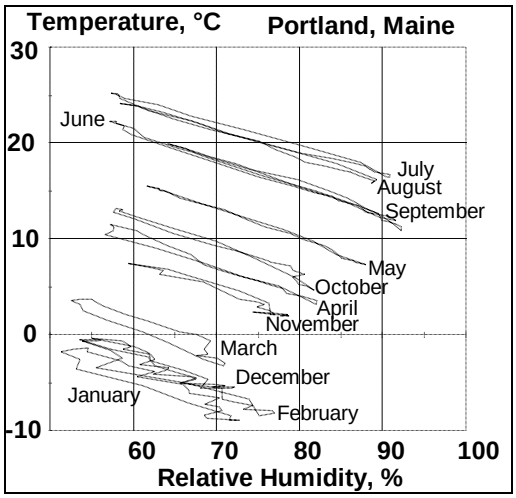


Figure 5: Comfort chart. This shows the same information as the two temperatures in Fig. 2, except plotted on different axes. This chart, developed by Olgyay, can be plotted with the comfort zone showing instead of the grid. Each month is a loop.

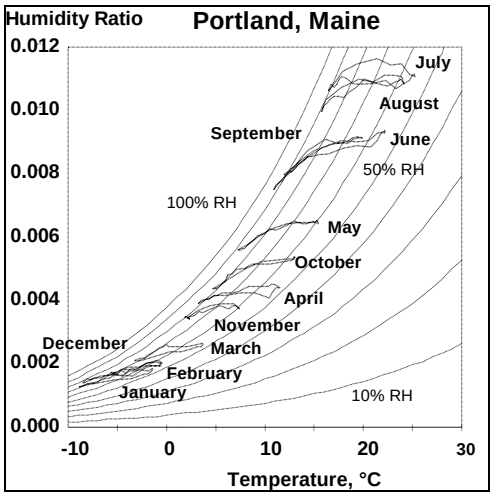


Figure 6: Psychometric diagram. This shows the same information as in Fig. 4, except plotted on different axes. This chart, developed by Givoni, can be plotted with the comfort zone showing instead of the grid. Each month is a loop.

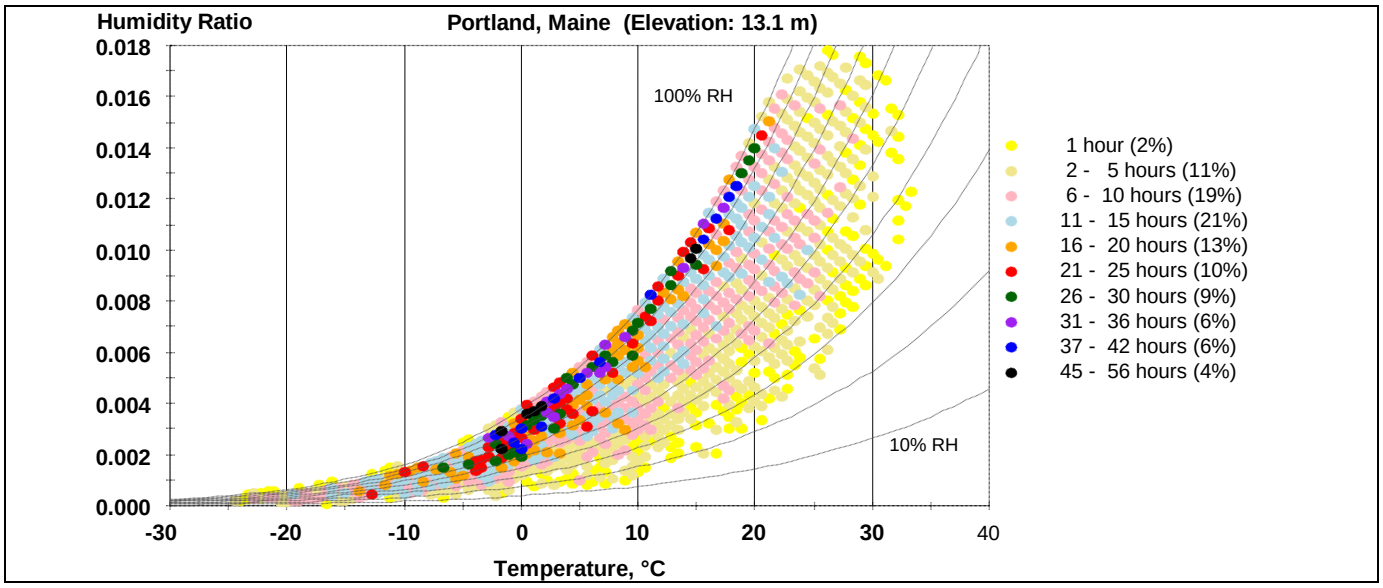


Figure 7: Hourly psychometrics. This shows the frequency of individual occurrences of conditions on a psychometric diagram. It is easy to distinguish the code in color, but in this black and white print the gray scale only gives a rough idea of the frequency of points, with darker being more frequent. The bin size used is 1 degree Fahrenheit, in both dry-bulb and wet-bulb temperature.

Summary of the ENERGY-10 Weather File for Portland, Maine (portland.et1)

Latitude: 43.7
Longitude: 70.3
Elevation: 13m

Winter Design Day Dry Bulb (2.5%): -18.4 °C
Summer Design Day Dry Bulb (97.5%): 28.9 °C
Summer Design Day Wet Bulb (97.5%): 21.7 °C

Month	TAA	TMXA	TMNA	TMX	TMN	TWBA	RH	WSA	HS	HDD	CDD
January	-5.4	-0.7	-11.0	11.1	-24.4	-6.9	63.4	14.5	1896	740	0
February	-4.5	-0.0	-10.2	11.1	-22.8	-6.0	65.5	13.0	3008	647	0
March	0.4	4.7	-4.5	10.6	-19.4	-1.7	62.6	13.9	4001	556	0
April	7.4	12.3	2.1	27.8	-2.8	4.7	69.4	16.6	4855	327	2
May	11.3	16.3	5.9	26.7	1.7	8.9	75.5	16.5	5636	214	0
June	17.3	23.4	10.9	32.2	2.2	14.0	73.4	14.3	6061	46	20
July	20.7	26.4	15.4	33.3	10.0	17.3	74.4	11.1	6177	9	98
August	19.8	24.8	14.9	30.0	8.3	16.7	75.4	13.9	5357	13	71
September	15.1	20.2	9.3	26.7	2.8	13.0	80.9	14.2	4286	102	6
October	8.7	14.4	3.0	25.6	-4.4	6.3	71.5	13.9	2931	288	0
November	4.0	8.2	-0.4	22.8	-8.9	2.1	72.0	14.7	1836	422	0
December	-3.5	-0.0	-7.7	8.9	-22.8	-5.1	64.6	13.5	1515	678	0
Year	**7.6**	**12.5**	**2.3**	**33.3**	**-24.4**	**5.3**	**70.7**	**14.2**	**3963**	**4039**	**197**

TAA	Avg. Dry Bulb Temperature, °C	TWBA	Avg. Wet Bulb Temperature, °C
TMXA	Avg. Daily Maximum Dry Bulb Temperature, °C	WSA	Avg. Wind Speed, kmph
TMNA	Avg. Daily Minimum Dry Bulb Temperature, °C	HS	Avg. Daily Horizontal Solar Radiation, Wh/m²
TMX	Maximum Dry Bulb Temperature, °C	RH	Relative Humidity, %
TMN	Minimum Dry Bulb Temperature, °C	HDD	Heating Degree Days, Base 18.0 °C
CDD	Cooling Degree Days, Base 18.0 °C		

Figure 8: ***Output of the summary option from WeatherMaker. This gives the traditional weather statistics for the location. The user can select the base for the degree-day calculation as well as the units to be used.***

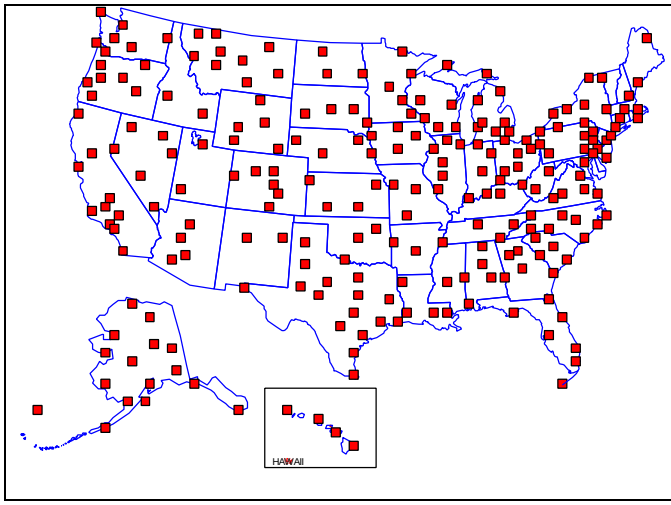


Figure 9: ***The ENERGY-10 "parent" weather file locations are the same as the 239 TMY2 locations.***

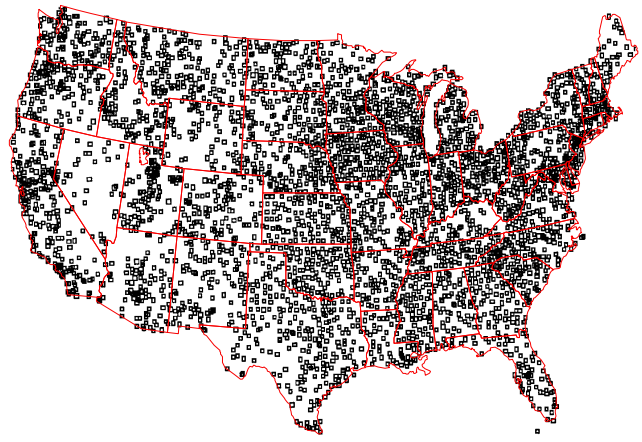


Figure 10: ***The location of the 3865 "child" weather locations in the contiguous 48 states that can be use to make ENERGY-10 weather files using the Adjust feature of WeatherMaker. There are and additional 93 sites in Hawaii and Alaska.***

Conclusion

WeatherMaker is a valuable new tool that enables building designers to gain a better understanding of a particular one-year set of hourly weather data. Although developed especially for users of the *ENERGY-10* program, many of the program's features could be utilized to advantage by others, including those using other hourly simulation design tools. Insight into the nature of the climate is valuable to anyone designing a building regardless of whether he or she simulates the building performance using a computer program.

Acknowledgements

Will Sare programmed *WeatherMaker* in Visual C^{++} according to the specifications of the author. This work was carried out within the NREL Center of Buildings and Thermal Systems, Ron Judkoff, Director. Funding for this work is from the US Department of Energy, Office of State and Community Programs, Mary-Margaret Jenior, program manager.

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Note from Doug Balcomb on the Availability of *WeatherMaker*

Our intent is not to make *WeatherMaker* available independently from *ENERGY-10*. The reason is that we don't want to distribute and support more than one package. Therefore, *WeatherMaker* will be bundled on the CD-ROM with *ENERGY-10*, starting with *ENERGY-10* Version 1.3, still planned for release in September 1999. Users of either *ENERGY-10* or *WeatherMaker* can get user support at the same location (see below). *ENERGY-10* is available from the Passive Solar Industries Council (PSIC). It comes as a package with the "Designing Low-Energy Buildings with *ENERGY-10*" guide, the textbook for two-day training workshops presented by PSIC. The guidebook and the program are designed to work together.

Cost of the package is $250 or $50 for students; order from PSIC by letter, fax, phone or web.

Passive Solar Industries Council
1331 H Street NW, Suite 1000
Washington, D.C. 20004

Phone: 202-628-7400, ext. 210
Fax: 202-393-5043
e-mail: PSICouncil@aol.com
http://www.psic.org/

Descriptions of *ENERGY-10* can be found on the web at:

http//www.nrel.gov/buildings/energy10/

WeatherMaker

A PROGRAM FOR ANALYZING TWO-DIMENSIONAL

HEAT TRANSFER THROUGH BUILDING PRODUCTS

THERM 2.0 is a state-of-the-art Windows-based program that uses the finite-element method to model steady-state two-dimensional heat-transfer effects. Developed at Lawrence Berkeley National Laboratory (LBNL) to model heat-transfer effects in windows, it can model thermal properties of a wide variety of building components, including walls, doors, roofs and foundations.

THERM has three basic components:

- a graphic interface that allows you to draw a cross section of the building component for which thermal calculations are to be performed,
- a heat-transfer analysis process that includes an automatic mesh generator to create the elements for the finite-element analysis, a finite-element solver, an error estimator, and a view-factor radiation model, and
- a graphic results display.

Although other software can solve two-dimensional heat-transfer problems, these programs are typically more complex and difficult to use than THERM, which explicitly models 2-D conduction and radiation and uses heat transfer correlations to model convection. A library of material properties and film coefficients accompanies the program.

THERM's Drawing and Graphic Capabilities

THERM has powerful drawing capabilities that make it easy to model the geometry of the cross section of a building component. A cross section can be drawn based on an imported computer-aided drawing (DXF) file or a dimensioned drawing. You can assign material, cavity and boundary condition properties from THERM's libraries of materials and properties.

Because THERM was developed for the Microsoft Windows environment, it has standard graphic capabilities, including: mouse and cursor operations; editing features such as Cut, Copy, Paste; a toolbar to access frequently used commands and shortcut keys; and windows so that multiple projects can be open concurrently. These features allow you to define a cross section as a collection of polygons. The program has many features that help create the cross section with no voids or overlapping elements, which is critical to the solution method. Figures 1 and 2 show examples of some of THERM's key drawing features.

THERM's Calculation routines

Many excellent references describe the finite-element method in detail (Zienkiewicz and Taylor 1989, Pepper and Heinrich 1992). THERM's steady-state conduction algorithm, CONRAD (Curcija 1995), is a derivative of the public-domain computer program TOPAZ2D (Shapiro 1986, Shapiro 1990). The radiation view-factor algorithm, VIEWER, is a derivative of the public-domain computer program FACET (Shapiro 1983). THERM contains an automatic mesh generator that uses the Finite Quadtree (Baehmann 1987) algorithm. THERM checks solutions for convergence and automatically adapts the mesh as required, using an error-estimation algorithm based on the work of Zienkiewicz and Zhu (1992a and b).

THERM's calculation routines evaluate conduction and radiation from first principles. Convective heat transfer is approximated through the use of film coefficients from engineering references. THERM's radiation view-factor

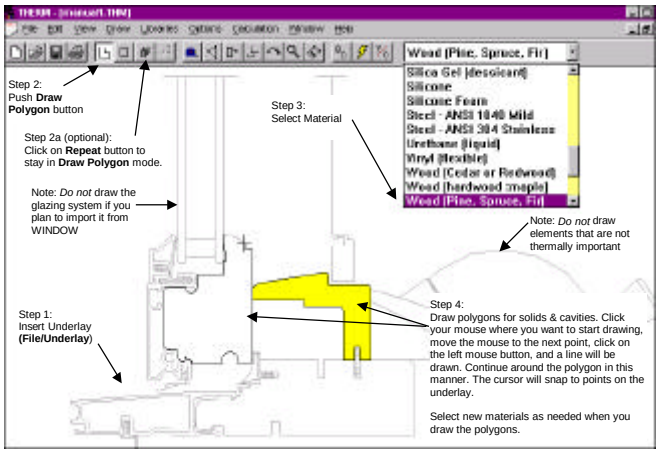

Figure 1: Drawing polygons and assigning materials.

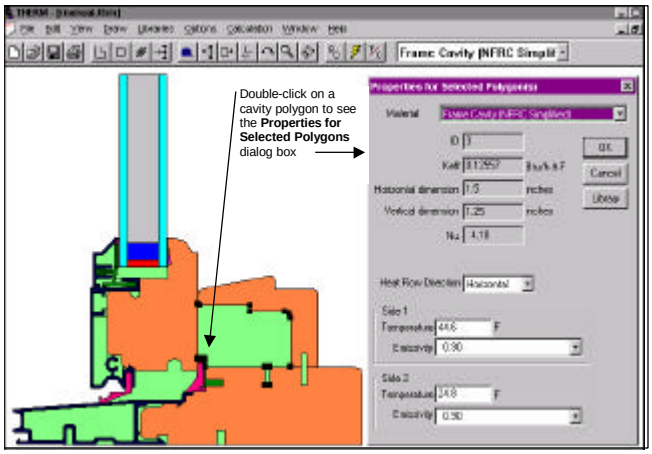

Figure 2: Assigning materials to polygons

feature enhances the program's accuracy when it analyzes non-planar surfaces that exchange energy through radiation heat transfer. This heat-transfer mechanism is important in components, such as greenhouse windows, which have surfaces that "see" other surfaces at temperatures significantly different from the ambient temperature. Convective heat transfer is approximated through use of film coefficients obtained through experiments or highly sophisticated computer simulations (ASHRAE 1997, Rosenhow et al. 1985, Zhao et al. 1996).

THERM's Output

When THERM has finished a heat-transfer calculation for a cross section, users can view total building component U-factors, as well as graphic results, in the form of: isotherms, color-flooded isotherms, heat-flux vector plots, color-flooded lines of constant flux and temperatures (local and average, maximum and minimum).

Of particular interest are isotherm plots, flux vectors and U-values. Isotherms are useful for seeing where there are extreme temperature gradients (i.e., isotherms very close together) that may lead to thermal stress or structural problems. Isotherms are also useful for identifying hot or cold areas in the cross section in order to predict thermal degradation or condensation. Flux vectors indicate the amount and direction of heat flow through the cross section. U-values are important for showing the overall heat-transfer rate and thus quantifying the total degradation resulting from a two-dimensional heat-transfer effect. THERM generates a text report that contains a summary of U-factor results as well as a description of the elements in the cross section. Figure 3 shows an example of THERM's graphic output.

THERM's Computer Requirements

THERM requires:

- an IBM-compatible 80486 or higher with a math coprocessor (a Pentium chip is preferable for speed),
- at least 16 MB of random access memory (RAM) (32 MB or more for optimum operation),
- Microsoft Windows 95/98 or Windows NT,
- a hard disk drive with at least 5 MB of available disk space and
- a printer supported by Microsoft Windows 95/98 or Windows NT (serial, parallel, or shared over a network).

THERM in Action

THERM is an excellent tool to analyze how a building's design will affect its energy performance. For example, the use of excellent insulating materials in the walls of residential buildings does not guarantee good energy performance; studs in walls create thermal bridges that compromise the insulation's performance. In the past, builders have typically used wooden studs, which do not create severe thermal short circuits. However, as wood becomes scarce, some builders have begun using steel studs; these create severe thermal bridges and greatly reduce the effectiveness of a wall's insulating material. One negative result is moisture buildup on interior walls.

THERM allows users to model changes in materials and thus to see, graphically, the results of using steel in place of wood studs.

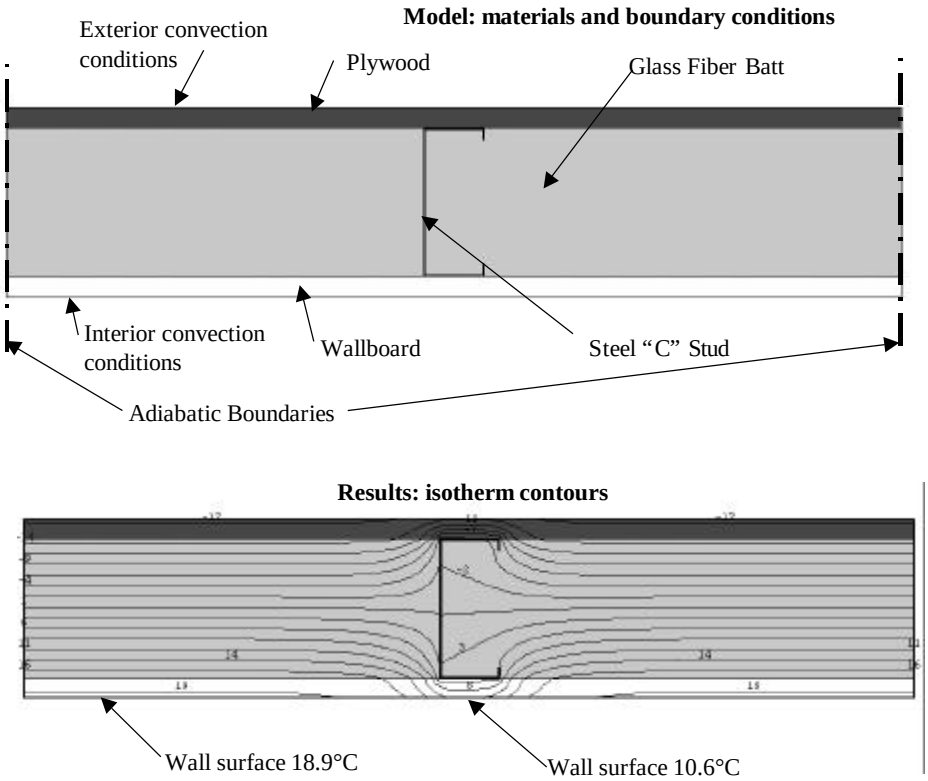

Figure 3: ***THERM model of an "insulated" steel stud wall: cross-section (top), results - isotherms (middle), results - heat flux vectors (bottom).***

For example, THERM was used to model a "thermal worst case" wall section with the following specifications: a layer of 13-mm plywood; 41-mm x 92-mm x 1.1-mm steel C-section wall studs (spaced 610 mm on center); 13-mm gypsum board; and wall and stud cavities completely filled with 1.94 m^2-K/W fiberglass batt insulation. Figure 3 shows THERM's results as isotherms. The overall wall U-factor was calculated at 1.57 m^2-K/W. THERM also shows that the surface temperature of the wall next to a metal stud was 10.6°C compared to 18.9°C next to a cavity. The metal stud degrades the wall's overall thermal performance by approximately 33 percent and makes it likely that moisture will condense and higher rates of dust and dirt will deposit on the wall along the stud line. For the same example, THERM was used to model a wood stud, which compromised wall performance by only 9 percent.

THERM has numerous advantages over other finite-element codes. It is easy to learn and allows users to solve complex heat-transfer problems. Its graphic capabilities allow quick definition and analysis of real-world heat-transfer problems as well as comparison of the thermal effects of choosing different building materials. THERM's radiation module permits the users to consider the effects of radiant exchange between surfaces, and THERM can directly model the effects of heat sources as well as temperature-induced heat transfer.

For more information about THERM, and how to obtain a free copy, go to windows.lbl.gov/software/software.html.

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Energy**Plus**

Status of EnergyPlus

EnergyPlus development is proceeding at a rapid pace. We're planning a series of four beta test version with increasing capabilities, culminating in a release of EnergyPlus 1.0 in early 2001. The beta versions are scheduled for December 1999, and April, July and September 2000. If you would like to be a beta tester please e-mail Kathy Ellington at KLEllington@lbl.gov.

Several organizations are now assisting the core development team. These include

GARD Analytics	formal testing
University of Wisconsin Solar Energy Laboratory	photovoltaic simulation
Krarti Associates	ground heat transfer
Penn State	ground heat transfer
Filtration Engineering	moisture adsorption/desorption
Florida Solar Energy Center	moisture adsorption/desorption and component models

The core EnergyPlus development team is currently

U.S. Department of Energy	Dru Crawley, program manager
University of Illinois	Curt Pedersen, Rick Strand and students
Construction Engineering Research Laboratory	Linda Lawrie
Lawrence Berkeley National Laboratory	Fred Buhl, Ender Erdem, Joe Huang and Fred Winkelmann
Oklahoma State University	Dan Fisher and students

Become an EnergyPlus Developer

Interested in developing a user interface for EnergyPlus or a specialized calculation module? Then the first step is to get an EnergyPlus Developer's License. This gives you access to everything you need -- source code, executables, utility programs, run procedures, sample input files and over-the-phone assistance from the core development team. (Note that we're not developing a graphical user interface for EnergyPlus. We're relying on private companies to do this. One of the reasons for offering developer's licenses is to encourage development of powerful, easy-to-use interfaces that embody all of the EnergyPlus capabilities, or custom interfaces for specialized applications.)

To help you get started we provide two manuals, "Guide for Interface Developers--Everything You Need to Know about EnergyPlus Input and Output" and "Guide for Module Developers--Everything You Need to Know about EnergyPlus Calculational Development."

In exchange we ask that you provide source code for any calculation module you develop so we can consider it for inclusion in the standard version of EnergyPlus. We also ask that you provide us with a test copy of the executable of any interface that you create. (Of course,you retain full ownership of any module or interface that you write.)

To become an EnergyPlus developer go to http://gundog.lbl.gov > EnergyPlus > EnergyPlus Developers License. There, you'll find instructions for executing the license. Once you have signed it we'll tell you how to access EnergyPlus over the Web.

¨ Subscriptions To *Building Energy Simulation User News* ¨

The *User News* is a quarterly newsletter, sent free of charge, to users of EnergyPlus, DOE-2, BLAST, SPARK, GenOpt and their derivatives. The newsletter is also available in PDF format at http://gundog.lbl.gov > Publications > User News.
To subscribe to the newsletter or to obtain back issues, please contact: Kathy Ellington (KLEllington@lbl.gov), Simulation Research Group MS: 90-3147, Lawrence Berkeley National Laboratory, Berkeley, CA 94720. Fax: (510) 486-4089

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Building Systems Laboratory (BSL)
30 Mechanical Engineering Building
University of Illinois
1206 West Green Street
Urbana, IL 61801
Telephone: (217) 333-3977 / Fax: 244-6534
support@blast.bso.uiuc.edu / www.bso.uiuc.edu

The **Building Loads Analysis and System Thermodynamics (BLAST)** system is a comprehensive set of programs for predicting energy consumption and energy system performance and cost in buildings. The BLAST system was developed by the U.S. Army Construction Engineering Research Laboratory (USACERL) under the sponsorship of the Department of the Air Force, Air Force Engineering and Services Center (AFESC), and the Department of the Army, Office of the Chief of Engineers (OCE). After the original release of BLAST in December 1977, the program was extended and improved under the sponsorship of the General Services Administration, Office of Professional Services; BLAST Version 2.0 was released in June 1979. Under the sponsorship of the Department of the Air Force, Aeronautical System Division, and the Department of Energy, Conservation and Solar Energy Office, the program was further extended; BLAST Version 3.0 was completed in September 1980. Since 1983, the BLAST system has been supported and maintained by the Building Systems Laboratory at the University of Illinois at Urbana-Champaign.

BLAST can be used to investigate the energy performance of new or retrofit building design options of almost any type and size. In addition to performing peak load (design day) calculations necessary for mechanical equipment design, BLAST also estimates the annual energy performance of the facility, which is essential for the design of solar and total energy equipment design, BLAST also estimates the annual energy performance of the facility, which is essential for the design of solar and total energy (cogeneration) systems and for determining compliance with design energy budgets. Repeated use of BLAST is inexpensive; it can be used to evaluate, modify, and re-evaluate alternate designs on the basis of annual energy consumption and cost.

The BLAST analysis program contains three major subprograms:

- The Space Load Prediction subprogram computes hourly space loads in a building based on weather data and user inputs detailing the building construction and operation.
- The Air Distribution System Simulation sub-program uses the computed space loads, weather data, and user inputs describing the building air- handling system to calculate hot water, steam, gas, chilled water, and electric demands of the building and air-handling system.
- The Central Plant Simulation subprogram uses weather data, results of the air distribution system simulation, and user inputs describing the central plant to simulate boilers, chillers, on-site power generating equipment and solar energy systems; it computes monthly and annual fuel and electrical power consumption.

Heat Balance Loads Calculator (HBLC)
The BLAST graphical interface (HBLC) is a Windows-based interactive program for producing BLAST input files. HBLC allows the user to visualize the building model as it is developed and modify previously created input files. 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 users. HBLC is an excellent tool which will make the process of developing BLAST input files more intuitive and efficient. You can download a demo version of HBLC (for MS Windows) from the BLAST web site (User manual included!).

HBLC/BLAST Training Courses
Experience with the HBLC and the BLAST family of programs has shown that new users can benefit from a session of structured training with the software. Such training helps to define the steps necessary to produce accurate and consistent output from BLAST and its auxiliary programs and gives users a solid foundation from which they can explore the more advanced features of the program with confidence. The Building Systems Laboratory offers such training courses on an as needed basis typically at our offices in Urbana, Illinois and lasting 2 or 3 days depending on the specific needs of the participants. Call the Building Systems Laboratory for additional information on pricing and availability.

WINLCCID 98
LCCID (Life Cycle Cost in Design) has been a standard in the DOD community since its initial release in 1986. LCCID was developed to perform Life Cycle Cost Analyses (LCCA) for the Department of Defense and their contractors, yet it goes far beyond being just a DOD study tool by providing many features of a general purpose life cycle costing tool. With LCCID, it's easy to carry out "what-if" analyses based on variables such as present and future costs and/or maintenance and repair costs. LCCID allows an analysis based on standard DOD procedures and annually updated escalation factors as well as Energy Conservation Investment Program (ECIP) LCCA. You can download a demo version of WINLCCID 98 (for MS Windows) from the BLAST web site http://www.bso.uiuc.edu [see *User News* Vol. 16, No. 4, p. 5]

To order BLAST-related products, contact the Building Systems Laboratory at the address above.

Program Name	Order Number	Price
PC BLAST Package The standard PC BLAST Package includes: BLAST, HBLC, BTEXT, WIFE, CHILLER, Report Writer, Report Writer File Generator, Comfort Report program, Weather File Reporting Program, Control Profile Macros for Lotus or Symphony, and the Design Week Program. The package is on a single CD-ROM and also includes soft copies of the BLAST Manual, 65 technical articles and theses related to BLAST, nearly 400 processed weather files with a browsing engine, and complete source code for BLAST, HBLC, etc. Requires an IBM PC 486/Pentium II or compatible running MS Windows 95/98/NT.	3B486E3-0898	$1500
PC BLAST Package Upgrade from level 295+	4B486E3-0898	$450
WINLCCID 98: executable version for 386/486/Pentium	3LCC3-0898	$295
WINLCCID 98: update from WINLCCID 97	4LCC3-0898	$195

The last four digits of the catalog number indicate the month and year the item was released or published. This will enable you to see if you have the most recent version. All software will be shipped on 3.5" high density floppy disks unless noted otherwise.

DOE-2 Directory of Program Related Software and Services[1]

Mainframe/Workstation Versions of DOE-2

Program Name	Operating System	Description	
DOE-2.1E From the Energy Science and Technology Software Center (ESTSC)	SUN DEC-VAX	Source code, executable code and complete current documentation for: DOE-2.1E/Version 094 for SUN DOE-2.1E DEC-VAX	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]
FTI/DOE (see FTI/DOE listing under PC Versions of DOE-2, below)			

PC Versions of DOE-2

Program Name	Operating System	Description
ADM-DOE-2 Based on J.J. Hirsch DOE-2.1E	DOS Windows 95	ADM-DOE-2 (DOE-2.1E) is compiled for use on 386/486 PCs with a math co-processor and 4MB of RAM. 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]
Compare-IT Based on J.J. Hirsch DOE-2.1E	Windows (98, 95, NT)	Compare-IT allows DOE-2 professionals to add value to their projects by giving clients "what-if" scenarios using DOE-2. The interface is designed for novice energy analysts and the GUI can be customized for each client's particular interests. A tabbed main window is configured based on the user's DOE-2 macro organization. All labels, drop-down list boxes, tool-tips, error checking, and help files are created dynamically from a "Compare-IT-ized" DOE-2 input file. Output are tables and powerful graphs of annual costs, annual energy and end-use and hourly end-use values. [See *User News* Vol. 19, No. 1]
DOE-PLUS Based on J.J. Hirsch DOE-2.1E Demo: www.halcyon.com/byrne	DOS Windows (3.1, 95, NT)	Complete support for all DOE-2 commands. Imports BDL files created with a text editor or other program. Interactive error checking. 3-D view of building can be rotated and zoomed. Windows, walls, etc., identified by DOE-2 U-name and allow component editing. User-defined libraries of schedules, HVAC systems, plant equipment, building components, etc. Exports results to spreadsheets and database programs. Graphical display of schedules. Utility programs included: Prep, Demand Analyzer, weather processor. Over 500 worldwide weather files. [See *User News* Vol. 13, No. 2, p. 54, Vol. 16, No. 1, p. 28-32]
EnergyPro Based on ESTSC DOE-2.1E V. 092 Demo: www.energysoft.com	Windows (95, NT)	Performs nonresidential load calculations for HVAC equipment sizing. Produces typeset quality reports/forms. Electronically exports forms to AutoCad for inclusion on blueprints. On-line help. 344 weather files for the U.S. and Canada. For California Users: Performs Title 24 compliance calculations, includes state-certified HVAC and DHW Equipment directories, Title 24 tailored lighting calculations. [See *User News* Vol. 18, Nos. 2, 4]
EZDOE Based on J.J. Hirsch DOE-2.1D Demo: www.elitesoft.com	DOS	Provides full screen, fill-in-the-blank data entry, dynamic error checking, context-sensitive help, mouse support, graphic reports, a 750-page user manual, and extensive weather data. EZDOE integrates the full calculation modules of DOE-2 into a powerful, full implementation of DOE-2 on DOS-based 386 and higher computers. On-line help. Includes some weather files. *[See User News Vol. 14, No. 2, p. 10 and No. 4, p. 8-14]*
FTI/DOE Based on ESTSC DOE-2.1E V. 092 No demo, 30-day trial period	DOS Windows (3.x, 95, NT) AIX, ULTRIX, VMS, Linux, NeXTStep,	FTI/DOE is 100% compatible with LBNL version. Highly optimized and extremely reliable. Version 3.1 will include a graphical user interface and will provide full command functionality and access to all reporting features of the original. Interface is Java-based and will be available for any system supporting Java. Source code versions will compile with most F77-compliant compilers. On-line help: Yes for Version 3.x, No for Version 2.x. 344 weather files for the U.S. and Canada. *[See User News Vol. 12, No. 4, p. 16]*
PRC-DOE-2 Based on J.J. Hirsch DOE-2.1E No demo	DOS Windows (95, NT)	This text-based version of DOE-2 is fast, reliable, and very up to date. Documentation includes 2.1E Supplement, 2.1E BDL Summary; original Reference Manual. Extensive information on new features is included on the disk as well, including information on new system types, new commands, new options, etc., added to later versions of 2.1E.
VisualDOE 3.0 Based on J.J. Hirsch DOE-2.1E, V. 083 Demo: www.eley.com	DOS Windows (3.1, 95, NT)	Dramatically faster construction of building geometry using pre-defined blocks and/or drawing interface. Import zone shapes from CADD file (dxf format). Point-and-click to define zone properties and HVAC systems. Define up to 20 design alternatives in each project file. View rotatable 3-D image of model. Create custom hourly output reports and customized graphs. Edit and expand library of constructions, schedules, equipment, and utility rates. Add custom performance curves. Network version allows sharing of libraries. On-line help. 400+ weather files for the U.S., 12+ weather files for Canada, plus selected locations around the world. *[See User News Vol. 15, No. 2, p. 10; Vol. 16, No. 4, p. 9-16; Vol. 17, No. 4]*

[1] 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.

DOE-2 Directory of Program Related Software and Services

Mainframe/Workstations Versions of DOE-2

Input Output	Support	Program Price	Vendor Information
	Limited "operational" support, which includes telephone assistance concerning installation, media or platform questions.	SUN version: Govt/Educ $400 U.S., Mexico, Canada $1305 Other Foreign $2000 VAX version: Govt/Educ $500 U.S., Mexico, Canada $1835 Other Foreign $2716	**Energy Science & Tech Software Center** P.O. Box 1020 Oak Ridge, TN 37831-1020 Ph: 423-576-2606 / Fx: 423-576-2865 ESTSC@ADONIS.OSTI.GOV www.doe.gov/html/osti
FTI/DOE (see FTI listing under PC Versions of DOE-2, below)			

PC Versions of DOE-2

Input Output	Support	Program Price	Vendor Information
No information given No information given	None	$395 + $15/SH including one set weather data (your choice) and documentation	**ADM-DOE- 2 (Richard Burkhart)** ADM Associates adm_asc@ns.net 3239 Ramos Circle Sacramento, CA 95827-2501 Ph: 916-363-8383 / Fx: 916-363-1788
Customizable windows GUI dynamically built based on DOE-2 macros. Tables and graphs exportable to MS Excel 97. Custom reports dynamically generated in Word 97.	Support price is negotiable; online help included with the program.	$500 consultant $2000 client Documentation available	**Compare-IT (Ed Erickson)** RLW Analytics, Inc. 1055 Broadway, Suite G Sonoma, CA 95476 Ph: 707-939-8823 / Fx: 707-939-9218 Info@rlw.com or www.rlw.com
Interactive, graphical, fill-in-the-blanks Customizable tables and graphics	Unlimited, except for DOE-2 modeling advice. On-line help.	$895 with DOE-2 and doc $495 without DOE-2 Source code not available.	**DOE-Plus (Steve Byrne)** Item Systems 321 High School Road NE #344 Bainbridge Island, WA 98110 Ph: 206-855-9540 / Fx: 206-855-9541 byrne @ item.com
Graphical Graphs, forms	Unlimited support	DOE-2 Module: Non-residential $ 700[1,2] Residential $ 250[1,2] Program Interface $ 195[3] [1] price reflects cash discount [2] includes documentation [3] required	**EnergyPro (Demian Vonderkulen)** Gabel Dodd/EnergySoft LLC 100 Galli Drive #1 Novato, CA 94949-5657 Ph: 415-883-5900 / Fx: 415-883-5970 demian@energysoft.com
Fill-in-the-blanks Standard DOE reports plus some custom graphic reports	Unlimited phone support	$1295 w/documentation Source code not available.	**EZDOE (Bill Smith)** Elite Software P.O. Box 1194 Bryan, TX 77806 Ph: 409-846-2340 / Fx: 409-846-4367 bsmith @ elitesoft.com
Version 2.x: text based Version 3.x: graphical All standard DOE-2 reports Run time and status graphics	Free support for 90 days from date of purchase. After 90 days, support is: $35 email per incident $55 hour per incident $125 per hour for engineering advice. Bugs reports free.	$ 995.99 US w/documentation $1066 Int'l w/documentation $4999.99 source code	**FTI/DOE2 (Scott A. Henderson)** Finite Technologies Inc. 3763 Image Drive Anchorage, Alaska 99504 Ph: 907-333-8937 / Fx: 907-333-4482 info @ finite-tech.com
Standard text-based	Unlimited support.	$ 495 w/documentation Source code not available.	**PRC-DOE-2 (Paul Reeves)** Partnership for Resource Conservation 140 South 34th Street Boulder, CO 80303 Ph: 303-499-8611 / Fx: 303-554-1370 Paul.Reeves@DOE2.com
Graphical Graphical	90 days free phone and email support. Support is $195 per year after first 90 days	Version 2.6 is $495 w/documentation Call for Version 3.0 pricing Source code not available.	**VisualDOE 3.0 (C. Eley or Erik Kolderup)** Charles Eley Associates 142 Minna Street San Francisco, CA 94105 Ph: 415-957-1977 / Fx: 415-957-1381 support@eley.com

Continued on next page

DOE-2 Help Desk: Bruce Birdsall

Call or fax Bruce Birdsall if you have a DOE-2 problem or question. If you need to fax Bruce, please be sure to phone him first. This is a **free** service provided by the Simulation Research Group at Lawrence Berkeley National Laboratory.

Bruce Birdsall
Phone/Fax: (925) 671-6942
M-F 10 a.m. to 3 p.m. PDT

DOE-2 Directory of Program Related Software and Services (continued)

Pre- and Post-Processors for DOE-2

Program Name	Description
DrawBDL	**DrawBDL,** Version 2.02, is a graphic debugging and drawing tool for DOE-2 building geometry. DrawBDL reads your BDL input and makes a rotate-able 3-D 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]*
Visualize-IT (Visual Data Analysis Tools)	The ***Energy Information Tool*** is used to review and understand metered or DOE-2.1E hourly output data. It provides the ability to see all 8760 (or 35040) data points for a year's worth of data. Use *Energy/Print* to get an overview of the data and then apply a variety of tools (load shapes, load duration curves, etc.). The ***Calibration Tool*** compares 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. Both programs requires a 486 or higher computer and SVGA graphics capabilities. *[See User News Vol. 17, No. 2, p. 2-6]*
PRC-TOOLS: **PRC-Grab** **PRC-Hour** **PRC-Peak**	***PRC-Tools*** aid in extracting, analyzing, and formatting DOE-2 output. ***PRC-Grab*** automates the process of extracting any number of answers from DOE-2 standard output files. ***PRC-Hour*** and ***PRC-Peak*** format the hourly output and create Peak-Day and Average-Day load shapes for any number of periods and for any combination of hourly values.

Special Versions of DOE-2

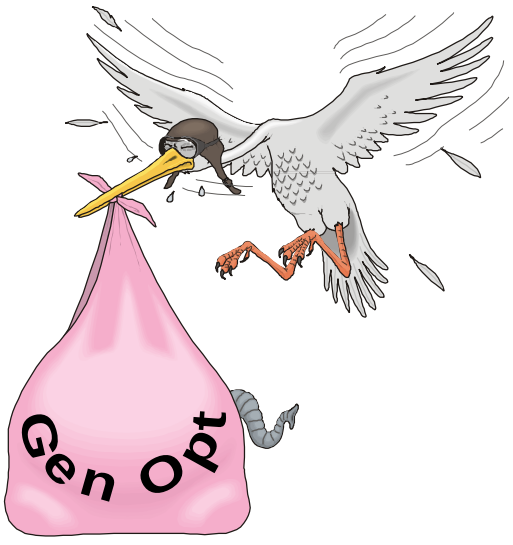
Program Name	Description
DesiCalc No demo	DesiCalc, from the Gas Research Institute, screens desiccant cooling applications. It estimates annual or monthly energy loads, using hour-by-hour simulations, and costs for 11 typical commercial buildings in 236 geographical locations in the United States. The tool uses electrical equipment from a library of five typical systems and compares the performance of any of the systems with an alternative configuration, the chosen electric system supplemented with a desiccant dehumidifier. Includes the latest TMY2 meteorological database
Energy Gauge USA (Residential DOE-2)	*Energy Gauge USA* allows the simple calculation and rating of residential building energy use in the United States. The simulation calculates a six-zone model of the residence (conditioned zone, attic, crawlspace, basement, garage and sunspace) with the various buffered spaces linked to the interior as appropriate. TMY weather data for the program are available for 213 locations around the U.S.
Home Energy Saver (Residential DOE-2) Free, interactive, Web-based program	The *Home Energy Saver* (HES) is designed to help consumers identify the best ways to save energy in their homes, and find the resources to make the savings happen. The HES calculates heating and cooling consumption using DOE-2.1E. The program performs a full annual simulation for a typical weather year (involving 8760 hourly calculations) from 239 locations around the United States in about 10-20 seconds.
Perform-95	Created for the State of California Energy Commission's, Title 24 energy code. Perform-95 is an interface shell with DOE-2 as the engine. Standard text-based input. Output is only California Title 24 compliant. Technical support available for $100/year from Gabel-Dodd Energy Soft LLC, 100 Galli Drive #1, Novato, CA 94960. Call 415-883-5900 for details.
RESFEN-3.1 No demo	RESFEN calculates the energy and cost implications of a building's windows compared to insulated walls. The relative energy and cost impacts of two different windows can also be compared against each other. RESFEN calculates the heating and cooling energy use and associated costs as well as the peak heating and cooling demand for specific window products. Users define a problem by specifying the house type (single story or two story), geographic location, orientation, electricity and gas cost, and building configuration details (such as wall type, floor type, and HVAC systems). Window options are defined by specifying the window's size, shading, and thermal properties: U-factor, Solar Heat Gain Coefficient, and air leakage rate.

GenOpt®: A Generic Optimization Program

Release of Version 1.0

GenOpt 1.0, a multi-parameter optimization program, has been released. It finds the values of user-selected design parameters that minimize an *objective function*, such as annual energy use, that is calculated by an external simulation program such as DOE-2, BLAST, TRACE, SPARK, TRNSYS, etc. It can also identify unknown parameters in a data-fitting process. GenOpt can be used with any simulation program that has text-based input and output. It also offers an interface for adding custom optimization algorithms to its library.

The Genopt 1.0 program and user's manual may be down-loaded free of charge from http://gundog.lbl.gov > GenOpt.



DOE-2 Directory of Program Related Software and Services

Pre- and Post-Processors for DOE-2

Operating System	Version of DOE-2	Price	Vendor
Windows 3.1, 95, NT	DOE-2.1E	$125.00 plus shipping	**Joe Huang & Associates** 6720 Potrero Avenue El Cerrito, CA 91364 Ph/Fx: 510-236-9238
Windows 3.1	DOE-2.1E		**RLW Analytics, Inc. (Ed Erickson)** 1055 Broadway, G Sonoma, CA 95476 Ph: 707-939-8823 Fx: 707-939-9218 Info@rlw.com / www.rlw.com
Windows 95, NT	DOE-2.1E	$99.00	**Partnership for Resource Conservation** 140 South 34th Street **(Paul Reeves)** Boulder, CO 80303 Ph: 303-499-8611 / Fx: 303-554-1370 Paul.Reeves@DOE2.com

Special Versions of DOE-2

Operating System	Based on this version of DOE-2	Price	Vendor
Windows 3.1, 95, 98, NT	DesiCalc is an overlay of DOE-2.1E and contains the complete DOE-2.1E program. It also contains the complete TMY2 data set.	$295 including documentation +8.75% tax in IL +4.5% tax in VA S/H $20	**DesiCalc GRI-98/0127 (Doug Kosar)** Order from: GRI Fulfillment Center Ph: 773-399-5414 Fx: 630-406-5995
Windows 95, 98, NT	DOE-2.1E	Contact Danny Parker at FSEC for availability.	**Energy Gauge USA (Danny Parker)** Florida Solar Energy Center 1679 Clearlake Road Cocoa, FL 32922 Ph: 407-638-1405 /Fx: 407-638-1439
Web-based	DOE-2.1E	free	**Home Energy Saver** interactive program at http://eande.lbl.gov/CBS/VH
DOS	DOE-2.1E	$250 including Perform-95 manual. Order #P440-96-0006	**California Energy Commission** Publications MS-13 P.O. Box 944295 Sacramento, CA 94244-2950 Ph: 916-654-5106
	DOE-2.1E	free	**RESFEN 3.1** Fax: (510) 486-4089 or mail your request to: Windows & Daylighting Group MS 90-3111 Lawrence Berkeley National Laboratory Berkeley, CA 94720

New Prices for DOE-2.1E documentation from the National Technical Information Service

These prices apply to shipments within the United States, Canada and Mexico only. For foreign prices, contact your local NTIS retailer (listed on our web site at http://gundog.lbl.gov > DOE-2 > Documentation).

National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161
Phone 1-800-553-6847 or 1-888-584-8332, FAX (703) 321-8547, http://www.ntis.gov/

Document Name	Order Number	Price*
DOE-2 Basics Manual (2.1E)	DE-940-13165	70.00
BDL Summary (2.1E)	DE-940-11217	41.00
Sample Run Book (2.1E)	DE-940-11216	144.00
Reference Manual (2.1A)	LBL-8706, Rev.2	200.00
Supplement (2.1E)	DE-940-11218	144.00
Engineers Manual (2.1A) [algorithm descriptions]	DE-830-04575	66.00
		*as of 09/01/99

News Releases

Pacific Gas and Electric Company

Fall 1999 Educational Programs

Offered throughout the year, programs address energy efficient design and application of new technologies for building envelope, lighting, HVAC, and training in the use of tools for measuring building performance. You may register by phone (415-973-7268), fax (415-896-1290), or via the internet (www.pge.com/pec).

HVAC

Title 24 (California Energy Code)

October 5, 1999
9:00 am - 4:30 pm

Revised Title 24 Energy Efficiency Standards took effect on July 1, 1999. In this session we will review the changes to energy efficiency requirements for new construction and address how the new standards affect the work of architects, engineers, and lighting professionals.

CoolTools: A Toolkit to Improve Evaluation and Operation of Chilled Water Plants

October 28, 1999
9:00 am - 4:30 pm

VisualDOE Plant-only Tool, Version 1 Rollout
This hands-on workshop presents CoolTools, publicly funded simulation tools for the evaluation of chilled water plant equipment, operation, and control. Participants should have a working knowledge of chilled water plant design and the Windows 95 operating system. Program participants will receive a free copy of the simulation software.

Architecture

DESKTOP RADIANCE

November 16-17
9:00 a.m. to 4:30 p.m.

RADIANCE is known as the best software tool for modeling lighting but one that is difficult to master. DESKTOP RADIANCE, a new interface, makes this highly accurate software more accessible to design professionals. In this two-day, hands-on course, students will learn how to model a space. Participants must be fluent in AUTOCAD-14. Attendees will receive a free copy of DESKTOP RADIANCE.

Daylighting

Daylighting Fundamentals

October 6
6:00pm to 9:00pm

George Loisos of the PEC will describe the fundamental principles of daylighting as a source of light, a strategy for saving energy, and a way to animate building interiors. He will cover basic prediction methods and strategies to deal with the potential liabilities of glare, solar gain, and heat loss.

SKYCALC and Skylighting

October 28, 1999
6:00 pm - 9:00 pm

Jonathan McHugh of Heschong Mahone Group will present SKYCALC, an easy-to-use Excel-based software package that facilitates the quick design of skylights. Light levels and energy impacts are instantly calculated, giving the designer information for design decisions.

Prospecting for Daylight

December 7, 1999
6:00 pm - 9:00 pm

Existing buildings can benefit from new daylighting controls that make it possible to cut lighting energy use by as much as 60 percent in perimeter and skylighted areas. George Loisos and Ryan Stroupe of the PEC, along with Santosh Philip of Gabel Associates, will present the Daylighting Prospector, a tool developed by the Daylighting Initiative that predicts energy savings based on existing building conditions and retrofit scenarios.

The Pacific Energy Center 851 Howard Street San Francisco, CA 94103

VisualSPARK: *Available for Beta Testing*

http://gundog.lbl.gov > SPARK > I Want To Test VisualSPARK > License Agreement

VisualSPARK allows you to build models of complex physical processes by connecting calculation objects. 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 VisualSPARK are a *user interface*, *a network specification language*, an *HVAC toolkit* containing calculation modules for building components, a *solver* for solving the set of simultaneous algebraic and differential equations that correspond to the physical problem being simulated, a *results display processor* for graphically plotting results and an *interactive graphical editor* (not available in the initial beta release of VisualSPARK). With the network specification language or the graphical editor you link the calculation objects into networks that represent a building's envelope and/or HVAC systems. VisualSPARK was developed by the LBNL Simulation Research Group and Ayres Sowell Associates, with the support from the U.S. Department of Energy.

The UNIX version of VisualSPARK runs under the SunOS, Solaris, Linux and HPUNIX operating systems. The PC version of VisualSPARK runs under the Windows 95, 98 and NT operating systems. Both versions require a minimum of 30MB of disk space.

There is no charge for the beta version of VisualSPARK; however, a signed beta test license agreement must have been received by the Simulation Research Group at Lawrence Berkeley National Laboratory prior to testing. The agreement and all the instructions may be downloaded from the web address listed above. After the agreement is received, you will be emailed a password. If you would like to get an idea of what SPARK does before testing VisualSPARK, you can take a look at the SPARK User's Manual, which can be downloaded from http://gundog.lbl.gov > SPARK > SPARK User's Manual.

The Lighting Design Laboratory

400 E. Pine St., Suite 100
Seattle, Washington 98122

northwest lighting.com

The Lighting Design Lab (LDL) works to transform the Northwest lighting market by promoting quality design and energy efficient technologies. Almost every major manufacturer of lighting equipment has donated products for display at the Lab. Every lighting display is updated regularly. The LDL also offers regional lighting training, skylighting workshops and review workshops for professionals taking the exam to become "Lighting Certified."

www.northwestlighting.com

New Book ***Calibrated Simulation: An Improved Method for Analyzing Building Energy Use*** **by Jay Stein**

The increasing popularity of comprehensive efficiency projects involving HVAC systems demands more accurate methods for predicting and verifying energy savings. Traditional building energy simulation techniques often are too imprecise, too expensive, or too unsophisticated for complex projects. In response, some analysts now are "calibrating" building energy simulations to hourly whole-building data from the electric meter, rather than simply trying to match model outputs to monthly data. Calibrated simulation generally yields much more reliable results than traditional modeling. It also costs more and takes longer than traditional modeling, but it is less expensive and labor-intensive than metering individual end uses in a building. Once calibrated, simulation models also may be used to allocate energy consumption and electric demand among end uses, identify building system malfunctions, identify "phantom" loads, and optimize HVAC controls.

Order publication No. TU-97-10 from www.esource.com
E SOURCE, Inc., 4755 Walnut St., Boulder, CO 80301-2537,

E SOURCE | Energy Intelligence™

DOE-2.1E Bug Fixes via FTP

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

ftp to either gundog@lbl.gov or to 128.3.254.10
login: *type* anonymous
password: *type in your e-mail 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 (aeerdem@lbl.gov).

Newsletter Deadline	The Winter 1999 issue of the *User News* will be sent to the print plant in late December; please submit any articles by December 1, 1999.

INTERNATIONAL 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 may make arrangements to photocopy 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.

Australasia
Dr. Deo K. Prasad/P. C. Thomas, SOLARCH, University of New South Wales, P.O. Box 1, Kensington, N.S.W. 2033, Australia
email PC.Thomas@unsw.EDU.AU / Tel: (61)-2-9311-7136 (P.C. Thomas) / Fax: (61) 2-9662-1378

Australia
Murray Mason, ACADS BSG, 16 High Street, Glen Iris VIC. 3146, Australia / Tel: (61) 885 6586 / Fax: 885 5974

Egypt
Dr. Ossama A. Abdou, Center for Building Environmental Studies and Testing (C-Best), 15-El-Shibani Street, Almanza, Cairo, Egypt
oabdou@hotmail.com / Tel: (20-2) 391-1137 or 417-4583 / Fax: 519-4343

Germany
B. Barath or G. Morgenstern, Ingenieurbüro Barath & Wagner GmnH, Postfach 20 21 41, D-41552 Kaarst, Germany Tel: (0049) 2131 75 74 90 12 G. Morgenstern / Fax: (0049) 2131 75 74 90 29

Hong Kong, China, Taiwan, Japan
Dr. Sam C. M. HUI or K.P. Cheung, Dept of Architecture, University of Hong Kong, Pokfulam Road, Hong Kong (SAR), CHINA / cmhui@hku.hk or kpcheuna@hku.hk / http://arch.hku.hk/research/BEER/DOE-2/DOE-2.htm Tel: (852) 2859-2123 (direct to Sam Hui) / Fax: (852) 2559-6484

India
Jiten Prajapati or Anil K. Anand, Energy Systems Engineering, IIT-Mumbai, Powai, Mumbai 400 076, INDIA Tel : 91-022-578 2545 x7378

Korea (Chungnam)
Dr. Jun Tae Kim, Department of Architectural Engineering, Kongju National Univ., 182 Sinkwan-dong, Kongju, Chungnam, 314-701, Republic of Korea / jtkim@knu.kongju.ac.kr / Tel: (82) 416 850 8653 / Fax (82) 416 856 9388

Korea (Taejon)
Dr. Euy-Joon Lee and Jong-Ho Yoon, Passive Solar Research Team, Bldg 2 / Rm 202, Korea Institute of Energy Research, Daeduk Science Town, 71-2 Jang-Dong, Yusong-Gu, Taejon 305-343, Republic of Korea, Lee: ejlee@kier.re.kr, Yoon: yesru@kier.re.kr / Tel: (82) 42 860 3514 / Fax: (82) 42 860 3132

New Zealand
Tan Yune, Architecture Department, The University of Auckland, Private Bag 92019, Auckland, New Zealand tanyune@ccu1.auckland.ac.nz / Tel: 64-9-373-7999 x5647 / Fax: 64-9-373-7410

Portugal, Spain, Italy, and Greece
Antonio Rego Teixeira, ITIME, Unidade de Energia, Estrada do Paco do Lumiar, 1699 Lisboa, Portugal
art@itime.ineti.pt / Tel: (351) 1-350-29 31 / Fax: (351) 1-716-43 05

Singapore, Malaysia, Indonesia, Thailand, and the Philippines
WONG Yew Wah, Raymond, Nanyang Technological University, School of Mechanical and Production Engineering, Nanyang Avenue, Singapore 2263, Republic of Singapore, mywwong@ntu.edu.sg / Tel: (65) 790-5543 / Fax: (65) 791-1859

South Africa
Prof. L. J. Grobler, School of Mechanical and Materials Engineering, University of Potchefstroom, Private Bag X6001, Potchefstroom 2520, South Africa, mgiljg@puknet.puk.ac.za / Tel: (27 148) 299 1328 / Fax: (27 148) 299 1320

South America
Prof. Roberto Lamberts,Universidade Federal de Santa Catarina, Campus Universitario-Trindade, Cx. Postal 476, 88049-900 Florianopolis SC, BRASIL lamberts@ecv.ufsc.br / Tel: + 55 48 3319272/ Fax: + 55 48 3319770

Switzerland
Réne Meldem, Meldem Energie SA, Avenue de Cour 61, CH-1007, Lausanne, Switzerland. Tel: +41 21 401-4090, Fax: +41 21 401-4091, meldem.energie@bluewin.ch

INTERNATIONAL DOE-2 ENERGY CONSULTANTS

Australia
P. C. Thomas, Sustainable Building & Energy Consultants, 6/52 Houston Road, Kingsford NSW 2032, Australia. Tel/Fax: (61) 2 9662 0205, Mobile (61) 417 405 478, pc_thomas@iname.com

Belgium
Andre Dewint, Andre DEWINT, s.a. Alpha Pi n.v., Av Winston Churchill,232/7, B-1180 Bruxelles, BELGIUM, Tel: (02) 34 34 251 / Fax: (02) 343 03 77

Canada
Curt Hepting, P.Eng. EnerSys Analytics, 2989 Delahaye Drive, Coquitlam, B.C. V3B 6Y9 Canada enersys@infoserve.net / www.enersys.bc.ca/homepage / Tel: (604) 552-0700 / Fax (604) 552-0713

Dejan Radoicic, D. W. Thomson Consultants, Ltd., 1985 West Broadway, Vancouver, BC V6J 4Y3, Canada

Neil A. Caldwell, PE, DukeSolutions Canada, Inc., 1730 - 401 West Georgia St., Vancouver, BC V6B 5A1 Canada ncaldwe@duke-energy.com

Stephane Bilodeau, PE, Groupe Enerstat, Inc., 79 Wellington N. #202, Sherbrooke (Quebec) J1H 5A9, Canada bill@aramis.gme.usherb.ca / Tel: (819) 562-8040 / Fax (819) 562-5578

Gordon Shymko, G.F. Shymko & Associates, Inc., G. F. Shymko & Associates Inc., 129 Evergreen Crescent S.W., Calgary, Alberta T2Y 3R2, Canada

Germany
Jens Grundt and Ludwig Michel, GMW-Ingenieurburo, Vahrenwalder Str. 7, D-30165 Hannover, Germany GMW-Ing.buero@t-online.de / Tel: 0049-511 9357440/Fax 0049-511-935744

New Zealand
Paul Bannister Energy Group, Ltd., 14a Wickliffe Street (P.O. Box 738), Dunedin New Zealand eglstaff@earthlight.co.nz

Switzerland
Réne Meldem, Meldem Energie SA, Avenue de Cour 61, CH-1007, Lausanne, Switzerland. Tel: +41 21 401-4090, Fax: +41 21 401-4091, meldem.energie@bluewin.ch

Philip Schluchter, Institut fur Bauphysik Klein, Urs Graf-Strasse 1, CH4052 Basel, Switzerland

Gerhard Zweifel, Zentralschweizerisches Technikum Luzern (ZTL), Abt. HLK, CH-6048 Horw, Switzerland gzweifel@ztl.ch

Markus Koschenz, Building Equipment Section 175, EMPA, 129 Überlandstrasse, CH-8600 Dübendorf, Switzerland

U.S. DOE-2 ENERGY CONSULTANTS

Arizona				
Marlin S. Addison	M. S. Addison & Associates	1215 West 12th Place	Tempe, AZ 85281	(602) 968-2040
Chuck Sherman	Energy Simulation Specialists	64 East Broadway, #230	Tempe, AZ 85282	(602) 784-4500
Sarat Kanaka	EcoGroup, Inc., Suite 301	2085 E. Technology Circle	Tempe, AZ 85284	(602) 777-3000
California				
M. Gabel, R. Howley	Gabel Associates, LLC	1818 Harmon Street	Berkeley, CA 94703	(510) 428-0803
George Marton	1129 Keith Avenue		Berkeley, CA 94708	(510) 841-8083
Jeff Hirsch	James J. Hirsch Associates	12185 Presilla Road	Camarillo, CA 93012	(805) 532-1045
John R. Aulbach, PE	23508 Naffa Avenue		Carson, CA 90745	(310) 549-7118
Leo Rainer	Davis Energy Group, Inc.	123 C Street	Davis, CA 95616	(916) 753-1100
L. Heshong, D. Mahone	The Heshong Mahone Group	11626 Fair Oaks Blvd, #302	Fair Oaks, CA 95628	(916) 962-7001
Cliff Gustafson	Taylor Systems Engrg. Inc.	9801 Fair Oaks Blvd., #100	Fair Oaks, CA 95628	(916) 961-3400
Steven D. Gates, PE	11608 Sandy Bar Court		Gold River, CA 95670	(916) 638-7540
Tom Lunneberg, PE	Constructive Tech. Group	16 Technology Dr., #109	Irvine, CA 92618	(714) 790-0010
David J. Schwed	Romero Management Assoc	1805 West Avenue K	Lancaster, CA 93534	(805) 940-0540
Robert E. Gibeault	A-TEC	5515 River Avenue, # 301	Newport Beach, CA 92663	(714) 548-6836
Martyn C. Dodd	Gabel Dodd/EnergySoft, LLC	100 Galli Drive, # 1	Novato, CA 94949	(415) 883-5900
Jim Kelsey, Kevin Warren	KW Energy Engineering	175 Filbert Street #205	Oakland, CA 94607-2541	(510) 834-6420
Robert Mowris, PE	Robert Mowris & Associates	10 Ridge Lane	Orinda, CA 94563	(925) 254-9770
Patrick Nkwocha, PE	Global Tech Services	3360 Foothill Blvd., #108	Pasadena, CA 91107	(626) 583-8205
James Trowbridge, PE	Trowbridge Engineering	8240 Caribbean Way	Sacramento, CA 95826	(916) 381-4753
Greg Cunningham	EnerSys Solutions LLC	114 Sansome St., #1201	San Francisco, CA 94104	(415) 296-9760
Charles Eley, T. Tathagat	Eley Associates	142 Minna Street	San Francisco, CA 94105	(415) 957-1977
John F. Kennedy, PE	GeoPraxis, Inc.	18850 Robinson Road	Sonoma, CA 95476	(707) 996-9408
Chandra Shinde, PE	ENVIRODESIGN GROUP	385 S. Lemon Ave., E-266	Walnut, CA 91789	(909) 598-1980
Colorado				
Fred Porter	Architectural Energy Corp	2540 Frontier Ave, #201	Boulder, CO 80301	(303) 444-4149
Paul Reeves	PRC	140 South 34th Street	Boulder, CO 80303	(303) 499-8611
Ellen Franconi	P.O. Box 1284		Boulder, CO 80306	(303) 786-7319
Charles Fountain	Burns & McDonnell	8055 E. Tufts Avenue, #330	Denver, CO 80230	(303) 721-9292
Susan Reilly	Enermodal Engineering	1554 Emerson Street	Denver, CO 80218	(303) 861-2070
Joel Neymark, PE	2140 Ellis Street		Golden, CO 80401	(303) 384-3672
Norm Weaver, PE	Interweaver Consulting	P.O. Box 775444	Steamboat Spgs, CO 80477	(970) 870-1710
Connecticut				
Adrian Tuluca	Steven Winter Associates	50 Washington Street	Norwalk, CT 06854	(203) 852-0110
District of Columbia				
Kurmit Rockwell, PE	XENERGY, Inc., Suite 1110	1025 Connecticut Ave., N.W.	Washington, DC 20036	(202) 872-1626
Florida				
Philip Wemhoff	1512 South McDuff Avenue		Jacksonville, FL 32205	(904) 632-7393
Dr. Paul Hutchins PE,CEM	Reynolds Smith & Hills, Inc.	4651 Salisbury Road	Jacksonville, FL 32256	(904) 279-2277
Georgia				
Lung-Sing Wong, PE	Building Performance Engrs.	1351 Oakbrook Dr., #100	Norcross, GA 30093	(770) 409-0400
Illinois				
Gary H. Michaels, PE	G.H. Michaels Associates	1512 Crain Street	Evanston, IL 60202	(847) 869-5859
Prem N. Mehrotra	General Energy Corp.	230 Madison Street	Oak Park, IL 60302	(708) 386-6000
Robert Henninger, PE	GARD Analytics, Inc.	1028 Busse Highway	Park Ridge, IL 60068-1802	(847) 698-5686
Kansas				
Dr. Brian A. Rock, PE	A/E Dept, Marvin Hall	University of Kansas	Lawrence, KS 66045-2222	(785) 864-3603
Massachusetts				
Michael Andelman	JRMA & Associates	421 Watertown St.	Boston, MA 02210	(617) 964-8889
C. Kalasinsky PE, T.Chan	R.G. Vanderweil Engrs., Inc.	274 Summer Street	Newton, MA 02458-1113	(617) 423-7423
Mark Mullins	HEC Energy & Design Services	24 Prime Parkway	Natick, MA 01760	(508) 653-0456
Missouri				
Mike Roberts	Roberts Engineering Co.	11946 Pennsylvania	Kansas City, MO 64145	(816) 942-8121
Bruce A. Leavitt, PE	Wm. Tao & Associates Inc.	2357-59th Street	St. Louis, MO 63110	(314) 644-1400
Montana				
Michael W Harrison, PE	Harrison Engineering	139 Bluebird Lane	Whitehall, Montana 59759	(406) 287-5370
Nebraska				
Philip M. Schreier, PE	Farris Engineering	11239 Chicago Circle	Omaha, NE 68154-2634	(402) 330-5900
New York				
J. Fireovid, K. Yousef	SAIC Energy Solutions Div.	1 Marcus Boulevard	Albany, NY 12205	(518) 458-2249
H. Henderson, S. Carlson	CDH Energy Corporation	P.O. Box 641	Cazenovia, NY 13035	(315)-655-1063
Dave Pruitt, Scott Frank	Jaros, Baum & Bolles	80 Pine Street	New York, NY	(212) 530-9300
North Carolina				
Hank Jackson, PE	P.O. Box 675		Weaverville, NC 28787-0675	(828) 658-0474
Gopal Shiddapur, PE	DukeSolutions (MC: ST05A)	230 S. Tryon Street, # 400	Charlotte, NC 28202	(704) 373-4439
Oregon				
J. Karasaki, PE, R. Ogle PE	CBG Consulting Engineers	6650 SW Redwood Ln, #355	Portland, OR 97224	(503) 620-3232
Texas				
Jeff S. Haberl	Energy Systems Laboratory	Texas A&M University	College Stn., TX 77843-3123	(409) 845-6065
Virginia				
Dave Walker	Walker Engineering	P.O. Box 366	Staffordsville, VA 24167	(540) 921-4544
Washington				
Steve Byrne	ITEM Systems, suite 344	321 High School Road NE	Bainbridge Island, WA 98110	(206) 855-9540
Gregory J. Banken, PE.	Q-Metrics, Inc.	P.O. Box 3016	Woodinville, WA 98072-3016	(425) 825-0200

Software from Lawrence Berkeley National Laboratory

Downloads	Download Site (http://)
BDA (Building Design Advisor) (for building decision-makers)	kmp.lbl.gov/bda
COMIS (multi-zone air flow and contaminant transport model)	www-epb.lbl.gov/comis
GenOpt ® (generic optimization program)	gundog.lbl.gov > GenOpt
RADIANCE (analysis and visualization of lighting in design) ***Desktop Radiance*** (integrates the Radiance Synthetic Imaging System with AudoCAD Release 14)	radsite.lbl.gov/radiance/license.html kmp.lbl.gov/dt-rad
RESEM (Retrofit Energy Savings Estimation Model) (calculates long-term energy savings directly from actual utility data)	eetd.lbl.gov/btp/resem.htm
SPARK (Simulation Problem Analysis and Research Kernel) (build simulations of innovative building envelope and HVAC systems by connecting component models)	gundog.lbl.gov > SPARK ***VisualSPARK*** - for Windows or UNIX
SUPERLITE (calculate illuminance distribution for room geometries)	eetd.lbl.gov/btp/superlite20.html
THERM (model two-dimensional heat-transfer effects in building components where thermal bridges are of concern)	windows.lbl.gov/software/therm/therm.html
WINDOW 4.1 (thermal analysis of window products)	windows.lbl.gov/software/window/window.html

Request by Fax from 510.486.4089	
RESFEN 3.1 (choose the most energy-efficient and cost-effective window for a given residential application)	windows.lbl.gov/software/resfen/resfen.html

Web Based	
Home Energy Saver (quickly compute a home's energy use)	hes.lbl.gov

Purchase	
ADELINE 2.0 (daylighting/lighting performance in complex spaces)	radsite.lbl.gov/adeline/HOME.html

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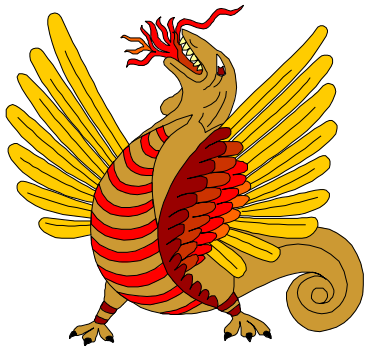


Run for safety, foolish pedestrians!

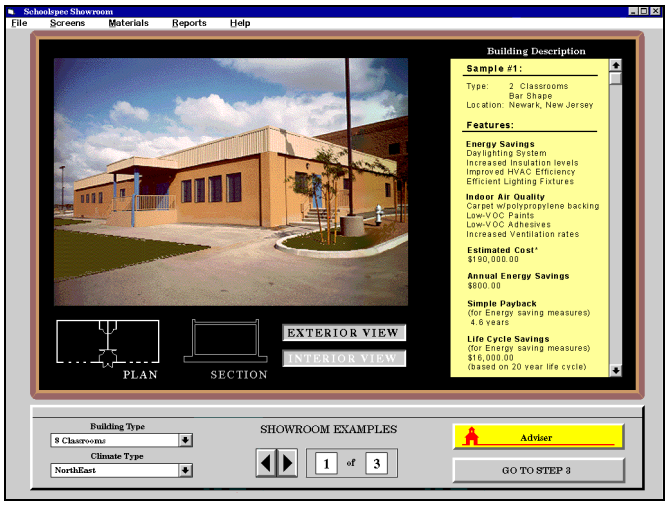
Steven Winter Associates ◂ 50 Washington St. ◂ Norwalk, CT 06854 ◂ swa@swinter.com

SCHOOL SPEC

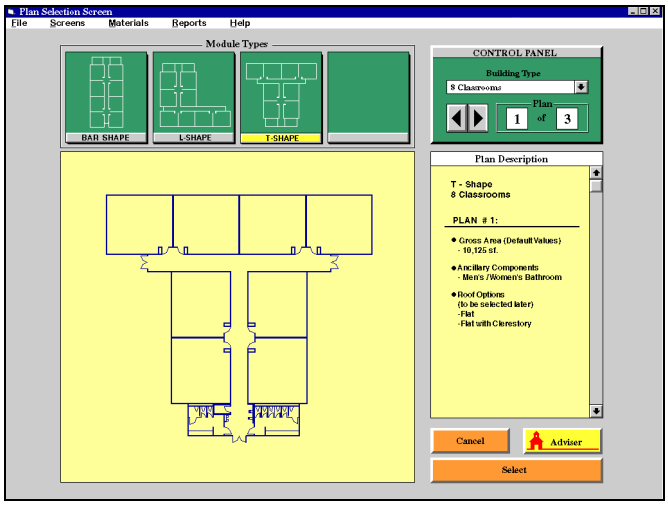
New software for the design of energy efficient school buildings

SchoolSpec™ is a new software application that optimizes energy, indoor air quality, and ”green” materials in the selection and specification of modular classrooms. The software produces building specifications, based on your selections, suitable for issue with bid documents. Here is SchoolSpec at a glance …

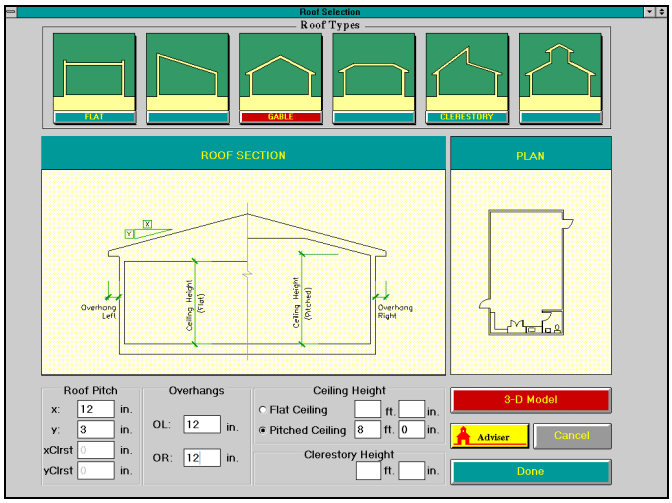
BUILDING DESIGN SELECTION



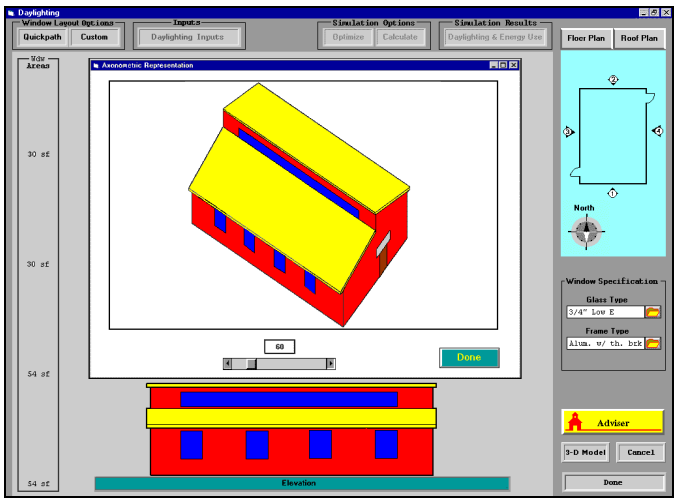
Review sample classroom designs in the SchoolSpec "showroom."



Select from dozens of classroom floor plans, including single and multiple classroom buildings.



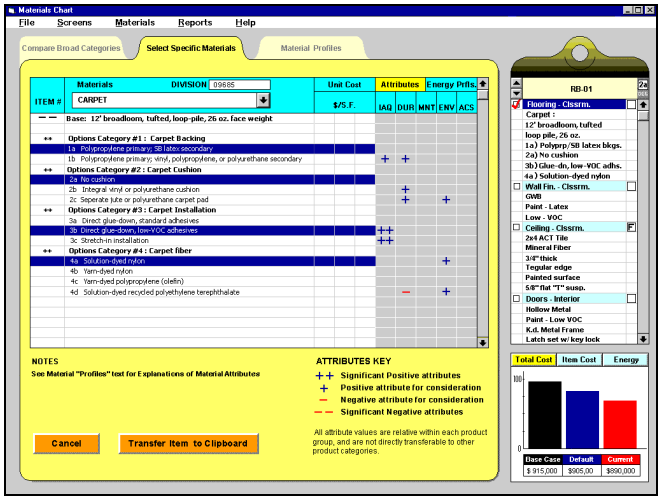
Select from various roof profiles, including gable, shed, hip, and clerestory.



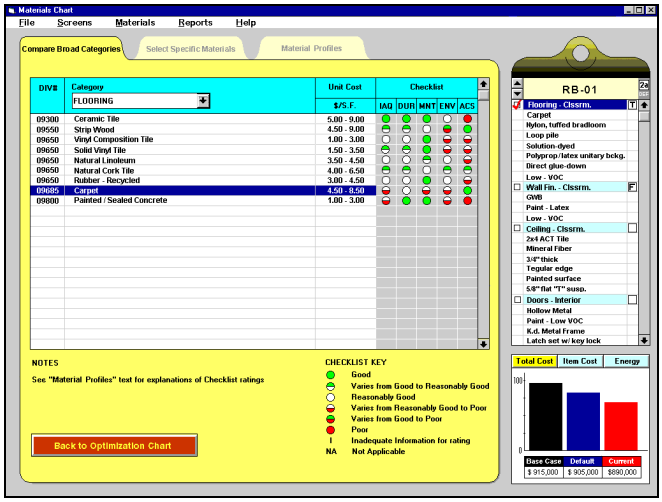
You may review the application and cost effectiveness of daylighting, natural ventilation, thermal mass/solar gain, etc.

MATERIAL REVIEWS

You may review the performance of materials and systems based on cost, durability, maintenance requirements, effects on indoor air quality, and environmental impacts.



SchoolSpec helps you compare broad categories of materials, like floor coverings, and then allows you to zoom in on specific choices, such as types of carpet.



It also provides specific, in-depth descriptions of the trade-offs to help you find the material that's right for your project.

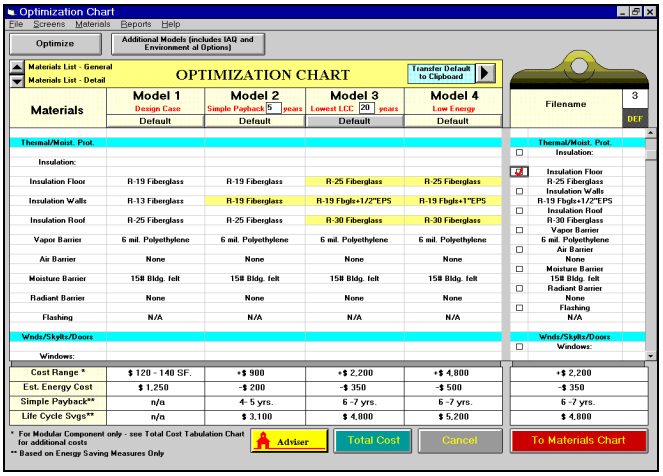
ENERGY EFFICIENCY OPTIMIZATION

Optimize insulation levels, window types, lighting systems, and HVAC systems based on:

simple paybacks
life cycle costs

or

"low energy" integrated design.



Steven Winter Associates ◂ 50 Washington St. ◂ Norwalk, CT 06854 ◂ swa@swinter.com