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

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* * Keywords!! * * *

* Best of BLAST and DOE-2

If funding permits, work will soon begin to combine the best features of BLAST and DOE-2 into a single program. The first release is planned for the end of 1997. As a first step, the User News and the BLAST newsletters will be combined into a single publication starting with the Winter 1995 issue, which will contain more details on what the combined program will look like. The work will be done by the Simulation Research Group at LBNL and the BLAST development group at the University of Illinois. The combined User News will also report progress on planning and development, over the next five years, of a "next-generation" program that will go beyond DOE-2, BLAST and other current-generation whole-building simulation programs. Stay tuned!

* PowerDOE Update

Beta-testing is about to start on PowerDOE, the new EPRI/DOE-sponsored version of DOE-2 featuring a graphical user interface running under Microsoft Windows. A general release of PowerDOE and its mainframe equivalent, DOE-2.2, is scheduled for Spring 1996.

* Documentation Update

We inadvertently omitted the Metric Example from the DOE-2.1E Sample Run Book. Turn to the back page for ordering instructions.

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The User News is written by members of the Simulation Research Group. Direct suggestions, comments or submissions to Kathy Ellington, Editor, MS: 90-3147, Lawrence Berkeley National Laboratory, Berkeley, CA 94720. Fax (510)486-4089/email kathy@gundog.lbl.gov

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√ User √ Survey √ Results

A few months ago, a DOE-2 User Survey was sent to everyone on the newsletter distribution list. We would like to thank the people who responded to it; your feedback is needed in order for us to make intelligent decisions about future program development.

Not surprisingly, most people who responded were consulting engineers, researchers, and users from large architectural/engineering firms. And, predictably, most DOE-2 applications centered on large commercial and industrial buildings. What DID surprise us was the extent to which DOE-2 has been used on retrofits of existing buildings vs. new building construction. According the the survey, DOE-2 was used four times as much for retrofits last year as for new buildings. The figures for new buildings to date versus retrofit of existing buildings showed retrofit over new construction by a margin of two to one. We also learned that the average energy savings using DOE-2 on (both new and retrofitted) building was 22%.

We would like to acknowledge your "wish list" of approximately 200 suggested improvements to the program. Even though we don't have the personnel or funding to consider all the suggestions, here is a breakdown of planned improvements to DOE-2.2 and PowerDOE.

Included in		
DOE-2.2	**PowerDOE**	**Calculation Improvements**
√	√	Higher limit on number of zones, systems, and schedules
√	√	Primary and secondary pumping
√	√	Ground source heat pump
√	√	Comfort calculation including radiant temperature
√	√	Increased number of allowed layers in constructions
√	√	Dual-fan/Dual-duct system type
√	√	Higher limit on number of walls and windows
√	√	Better modeling of multiple chillers/cooling towers
√	√	Multiple chillers of same type and different performance curves
√	√	Cooling tower with variable-speed fan
√	√	More robust metric version
√	√	Better modeling of non-residential natural ventilation
√	√	Zone-level humidity calculation
√	√	Faster Calculation
√	√	Integration of SYSTEMS and PLANT

Included in DOE-2.2	Included in PowerDOE	User Interface Improvements
	√	Windows front end
	√	3-D building view
	√	On-line help
	√	Library of pre-packaged systems
	√	Better input error checking
	√	Parametric analysis manager
	√	Ability to start from a scalable building template
	√	Graphical display of equipment part load curves.
	√	Library of operation schedules
	√	Library of space types.
	√	Graphics of systems and plant layouts
	√	Map and hooks for shell development.
√	√	Better reporting of equipment default values
√	√	Worldwide weather capability
	√	Show seldom-used variables on secondary menus
	√	Custom units for reporting (e.g. tons instead of Btuh)

Included in DOE-2.2	Included in PowerDOE	Results Display Improvements
	√	Graphical output
	√	Easy link to spreadsheet
	√	User-customized report formatting
	√	Scatter plots
	√	Cut and paste results to other applications
	√	Display execution status
	√	Standard hourly, monthly, annual graphic display pallet
	√	Easy method of choosing hourly report data
	√	Make reports fit in standard width screen
	√	Custom units for reporting (e.g. tons instead of Btuh)

Included in DOE2.2	Included in PowerDOE	Documentation Improvements
√	√	Combine Reference Manual and Supplement
√	√	Index
	√	On-line documentation
	√	Hypertext
√	??	WWW site for documentation updates
√	√	Topic-based
√	√	Better organization and overview

TMY2 Weather Data for DOE-2

by

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Weather data is an essential and critical part of performing energy simulations for buildings. Fortunately, our government had the foresight in the past to set up weather monitoring stations all over the United States and in some U.S. territories. The data collected by the National Oceanographic and Atmospheric Administration (NOAA) and other government agencies have been organized and presented into formats used by energy professionals and others.

One of the most popular formats is the Typical Meteorological Year (TMY). The TMY weather data represent one year of hourly radiation and meteorological data. The main idea behind the TMY is to make a weather file that represents the long term averages of radiation and meteorological data for a weather stations by stringing together different months of data from different years. The Solar Meteorological (SOLMET) data base from 1952 to 1975 was used to form the original TMY data. There were originally 234 locations provided when the TMY user manual became available (NCDC 1981).

That was then...this is now. The new TMY2 data files are available now and show significant improvement over the older version. The TMY2s were formed using 30 years, from 1961 through 1990, and include 239 sites. The TMY2s were derived from the National Solar Radiation Data Base (NSRDB), Version 1.1, which was completed in March 1994 by the National Renewable Energy Laboratory (NREL). TMY2 data is believed to provide more accurate values of solar radiation for several reasons:

1. Better model for estimating values (more than 90% of solar radiation data in both SOLMET and NSRDB are modeled).
2. More measured data, some of which is direct normal radiation.
3. Improved instrument calibration methods.
4. Rigorous procedures for assessing quality of data.

NREL's incentive for developing the TMY2 was a comparison of the old SOLMET data base with the new NSRDB. On an annual basis, 60% of all stations were found in disagreement for direct normal radiation by more than 5% -- some up to 33%! For global horizontal radiation, 40% of the stations were in disagreement 5% or more, some up to 18% on an annual basis (Marion and Myers 1992). Monthly disagreements were found to be even greater than annual comparisons.

The latest high-tech scientific weather instrument is . . . Tasmanian pine trees? Scientists have taken cores from ancient pine trees growing on Tasmania, a large island south of Australia. The trees, which can live for well over 1000 years, provide a record of temperature conditions in their annual growth rings. The results? Since 900 A.D. – in Tasmania, at least – the warmest period recorded was from 1965 to 1988. One possible explanation is that global warming is making itself felt.

Great, we have new TMY2 data but how can we use it? TMY2 data cannot be used directly with the current version of DOE-2 because of format incompatibilities. LBNL has a new weather processor in the

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works, but what if you want to use the TMY2s now? One of the easiest answers is to convert the raw data to a WYEC2 (Weather Year for Energy Calculation) and then process the WYEC2 file using the latest version of DOEWTH.EXE that comes with DOE-2.1E. The resulting binary file will work with DOE-2, using all of the necessary solar and meteorological data needed for simulation.

You can convert your TMY2 files by referring to the table below. The WYEC2 format was provided by Joe Huang of LBNL, with TMY2 format and remarks supplied from the TMY2 user manual and experience of the author.

TMY2 to WYEC2 Conversion

Data	TMY2 Position	WYEC2 Position	Remarks
Station number	002-006	001-005	TMY2 position in header
Year	002-003	007-008	
Month	004-005	009-010	
Day of the month	006-007	011-012	
Local standard hour	008-009	013-014	
Global horizontal radiation	018-021	019-022	Convert to TMY2 from Wh/m^2 to Kj/m^2
Direct normal radiation	024-027	025-028	Convert to TMY2 from Wh/m^2 to Kj/m^2
Weather condition place holders	n/a	075-082	Use 1 as an arbitrary place holder
Station pressure	085-088	084-088	Justify TMY2 value *left* in WYEC2
Dry bulb	068-071	090-093	
Dewpoint	074-077	095-098	
Wind direction	091-093	100-102	
Wind speed	096-098	104-107	Justify TMY2 value *right* in WYEC
Total sky cover	061-061	109-110	
Opaque sky cover	064-065	112-113	

After converting the TMY2 to WYEC2 format you can pack the file for use with DOE-2 using DOEWTH.EXE and specifying WYEC2 as the unpacked file type in the INPUT.TMP file. Older versions of DOEWTH (before DOE-2.1E) will not be able to process the WYEC2 format.

If you don't feel like going through the hassle of conversion, ENERGOS will provide TMY2 data for 239 cities converted for use with DOE-2 for many PC vendors of DOE-2.1C through DOE-2.1E. ENERGOS will provide you with:

- Original TMY2 data files
- Converted WYEC2 files
- More than 35 weather statistics for each city
- Packed binary files for use with your PC version of DOE-2.

The price per city is \$20 + shipping and handling. A CD-ROM with all 239 cities is available for \$185 + shipping and handling. Call or fax for order forms.

The author wishes to personally thank the following people for information and/or technical help with the conversion process: Ferdinand Schmid, Fred Buhl, Kathy Ellington, and Joe Huang.

References:

Marion, W., Myers, D. (1992). *A Comparison of Data from SOLMET/ERSATZ and the National Solar Radiation Data Base*. NREL/TP-463-5118, National Renewable Energy Laboratory, Golden, CO.

NREL (1995). *User Manual for TMY2*. NREL/SP-463-7668, National Renewable Energy Laboratory, Golden, CO.

NCDC (1981). *Typical Meteorological Year User Manual*. NCDC/TD-9734, National Climatic Data Center, Asheville, NC.

Calling all DOE-2 Users!

Please contact us if you have the program running on a platform other than a DEC, SUN, or PCs. Email KLEllington@lbl.gov or phone us at (510) 486-5711, Fax (510) 486-4089. Thanks in advance!

New software available: ADELINE 1.0

The Building Technologies Program at Lawrence Berkeley National Laboratory is pleased to announce the availability of ADELINE 1.0 (Advanced Day-and Electric Lighting Integrated New Environment). ADELINE 1.0, the product of an international collaboration coordinated through the International Energy Agency Solar Heating and Cooling Program, integrates the capabilities of a 3D CAD solid modeling program (SCRIBE) with two lighting analysis tools (SUPERLITE and RADIANCE) on an MS-DOS platform with software links to whole-building thermal simulation tools (DOE-2 and TSB13). To obtain ADELINE 1.0 or for more information, contact one of the research centers:

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Check out the ADELINE world wide web site at http://radsite.lbl.gov/adeline/HOME.html; you can download a slide show demo diskette.

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A Simplified Tool for the Design of Compressorless Houses

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Abstract

A simple user front-end in *Excel* has been linked to a detailed residential model in DOE-2 to produce an easy-to-use analytical tool for architects to evaluate the thermal performance of house designs during peak cooling periods in the summer and fall. This tool was developed for use by architects and builders attending an intensive 2-day workshop to design "compressorless" houses in California transition climates. The inputs for the design tool require no specialized knowledge and can be completed in a few minutes, while the DOE-2 simulations take slightly over a minute. The outputs consist of plots of indoor temperatures for four different operating conditions over two 5-day peak design periods.

Background

Recent concerns about increased energy use, and in particular the continued rise in peak electricity demand on hot summer afternoons, has motivated research into developing designs and strategies that can enable homes to maintain indoor comfort without mechanical air-conditioning.

For the past two years, the author has been involved in the project, "Alternatives to Compressive Cooling in California Transition Climates", funded jointly by the California Institute for Energy Efficiency and the U.S. Department of Energy, to demonstrate that "compressorless" houses are feasible in most of California. A key project activity in 1995 was an intensive two-day workshop with over 20 architects, contractors, and architectural students to produce prototypical house designs incorporating alternative cooling techniques such as minimizing solar heat gain, evaporative cooling, increased thermal mass, natural ventilation, or night precooling.

The effectiveness of these strategies is highly dependent on the building and climate characteristics, and nearly impossible for designers to determine, particularly in the context of a design *charette.* Overdesign is costly, while underdesign will result in unacceptable indoor conditions.

To provide technical guidance for the workshop participants, the author produced a Simplified Design Tool by taking a state-of-the-art building energy simulation program, DOE-2.1E, and adding a front-end based on a widely-used commercial spreadsheet

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*Joe Huang is a staff scientist with the Energy Analysis Program at Lawrence Berkeley National Laboratory. He can be reached at (510)486-7082/fax 486-4673/e-mail YJHuang@lbl.gov. Joe is also the author of the ***DrawBDL*** program, a Windows-based program for displaying the building geometry of DOE-2 input files (see p. 21). This paper was originally presented at the fourth working meeting of the International Energy Agency Annex 28 on Low Energy Cooling, held in Paris in October 1995.

program. This implementation allowed the workshop participants to input familiar meeting architectural specifications, hit a button, and then see the hourly indoor temperatures of the proposed design over two 5-day design sequences under various control options. The creation of the design weather sequences, detailed building energy simulations, and plotting of the results are all done automatically by the design tool.

Objective

The objective of the design tool is to provide a quick but reasonably reliable assessment of the thermal performance of a proposed house design over two extreme 5-day design periods, one in mid-July .and the other in mid-September. Although the design tool can be easily modified to perform annual energy simulations, the focus is placed on the two design sequences since the acceptability of these house designs will depend not on their energy savings, but their ability to maintain comfort under extreme conditions.

The five-day design sequences are necessary because strategies such as thermal mass, ground cooling, or night ventilation rely on the ability of the building to store cooling over a period of several days. Two design periods are studied to account for differences in solar angles. This is particularly important for California climates where hot spells can occur on very different times of the year.

Design Weather Conditions

Design calculations are generally done using an extreme temperature at a selected criterion, such as the 1%, 2.5%, or 5% of summer hours listed in the ASHRAE *Handbook of Fundamentals*. For California, a 1982 publication provides design temperatures at 0.1%, 1%, and 2.5% of annual hours for over 600 locations (ASHRAE 1982). Although such climate data are useful for their geographical coverage, the dynamic simulations used in this design tool require temperature profiles of several days' duration. An artificial 5-day design sequence has been devised to capture extreme temperature peaks, while recognizing that the duration of such conditions changes with location.

Discussions with housing industry representatives indicated that residents will tolerate only one episode of significant overheating over the course of a year. To meet that criterion, the 0.1% design temperature is used as the extreme peak temperature of the design sequence, which represents a frequency of 9 hours of a year. Analysis of long-term temperature data for several California locations show significant differences between the extreme maximum on the hottest day and the average maxima on the remaining four days. For example, "heat waves" in the Bay Area rarely lasting more than 3 days, while those in the Central Valley are less pronounced and longer-lasting.

Figure 1 shows the frequency distribution of hourly temperatures over a five-day period for an Inland (Sacramento) and a Coastal location (Sunnyvale). The Sacramento plot has 5 years of data, while that for Sunnyvale only one typical weather year. The 5-day periods are sorted by the average temperature over that period, indicated by the thick dashed line. The other three lines are from left to right, the extreme minima, the average daily peaks for the remaining 4 days, and the extreme peaks on the hottest day. The plots reveal not only that the inland site has higher temperatures and larger temperature swings, but smaller differences between the extreme and average maxima. Table 1 shows that for Transition and Inland climates, the extreme temperatures are close to the 0.1% peak temperatures, while the average maxima are slightly higher than the 2% design temperature.

Figure 1. Temperature distribution of hourly weather data

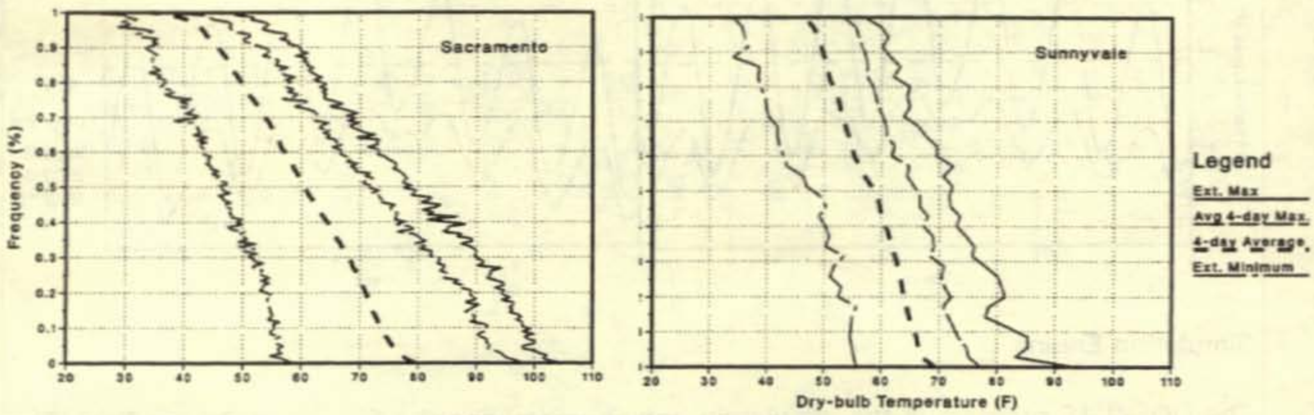

Table 1. Design temperatures in different California locations

	0.1% frequency temperatures (F)			ASHRAE DesignTemperatures (F)		
	extreme max temp.	average max.other 4 days	avg.tem p over 5 days	0.1%	0.5$	2.0%
Coastal climates :						
Oakland	82.0	79.5	67.0	91	84	77
Long Beach	90.0	85.5	74.9	99	90	84
Transition climates :						
Pasadena	97.0	91.0	77.8	99	94	88
El Toro	96.0	92.2	77.4	96	89	82
Inland climates :						
Sacramento	105.0	97.5	80.2	104	100	94
Riverside	109.0	103.2	83.2	104	100	95
Fresno	105.0	99.2	85.7	104	101	97

After comparing long-term temperature frequencies to published design temperatures for available California locations, the following procedure is established for creating a 5-day design sequence for any location: a peak day at the 0.1% design temperature, preceded and followed by two days of progressively lower temperatures tapering to the 2% design

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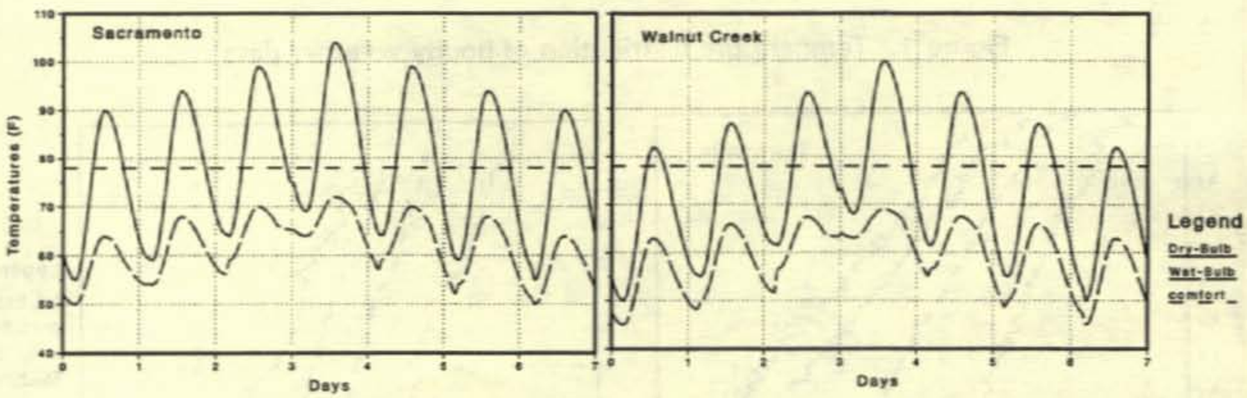
temperature. The daily temperature swing, coincident wet-bulb temperatures, and design wind speeds are all taken from the published climate data. Figure 2 shows the resultant 5-day design sequences for an Inland location (Sacramento) and a Transition location (Walnut Creek) 10 miles from the San Francisco Bay.

Figure 2. Design temperature sequences for Sacramento and Walnut Creek



Simulation Engine

The DOE-2.1E program is the simulation engine underlying the Simplified Design Tool. The decision to embed a detailed hourly simulation program directly into the design tool was not originally planned, but evolved as its advantages became apparent. The original concept for the design tool was to develop a simplified calculation or use regression equations to estimate the impact of alternative cooling designs and strategies. Either of these approaches would require substantial effort in either algorithm development or parametric analyses, as well as validation against more detailed methods. There was also concern that such simplified methods might be contradicted when more detailed simulation methods are used later in the design process.

Using a detailed simulation in the beginning, eliminates the above tasks and concerns, while tapping all the modeling capabilities of that program. For example, work is now underway for the Simplified Design Tool to use DOE-2's new capability to calculate operative temperatures. The main drawbacks against using a detailed simulation program have been in terms of their inputs and outputs, and the computer time needed to do the simulations. Each of these problems are addressed in developing the Simplified Design Tool. A commercial spreadsheet program, *Excel*, is used to simplify the input procedure and display the output results. Since simulations are done for only two 5-day periods, they require less than a minute on a 486 PC.

Input Data

The input procedure for the Simplified Design Tool is done through an *Excel* spreadsheet template. Figure 3 shows the inputs for a typical one-story house in Fairfield built to Title-24 building energy standards, but with no particular attention paid to reducing cooling loads. The required input information are non-technical and available to architects even during the schematic design phase. Engineering details that are extraneous or undetermined

Figure 3. *Excel* template with inputs for a typical Title-24 house in Fairfield CA

General info									
Location	3	walcrk=1	pittsb=2	fairfd=3	davis=4	sacram=5	pasade=6	pomona=7	rivers=8
building orientation	0	0..360 deg	North=0 deg						
floor area	1650	sq ft							
ceiling height	9	feet							
Wall									
wall surface	1	stucco=1	wood=2	alum=3					
wall r-value	19	0 to 30							
wall color	0.8	0 to 1							
layers of gypboard	3	1 to 3							
Roof									
attic roof area	1650	sq ft							
roof tilt	18	0 to 45 deg	0=horiz						
roof r-value	38	0 to 60							
roof color	0.8	0 to 1							
cathdral roof area	0	sq ft							
Floor									
floor condition	4	carpet=1	exposed=2	wood=3	carp/exp=4	carp/wood=5			
Window									
window type	2	single=1	double(.25)=2	double(.5)=3	low-e=4				
frame type	2	wood=1	vinyl=2	aluminium=3	aluminium with thermal break=4				
Garage	1	yes=1	no=2						
floor area	440	sq ft							
exterior wall area	576	sq ft							
interior wall area	180	sq ft							
roof area	440	sq ft							
Envelope	*North*	*South*	*East*	*West*					
wall area	224	224	456	456	sq ft				
window area	85	85	20	20	sq ft				
window height	4	4	4	4	feet				
number of doors	0	1	0	1	number				
overhang height	1	1	1	1	above window in feet				
overhang extension	0	0	1	1	feet				
neighbouring building	1	1	2	1	yes=1	no=2			
other stuff									
infiltration	2	loose=1	medium=2	tight=3					
foundation insulation	1	yes=1	no=2						

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at this stage of design are allowed to default, but care has been taken to include on the template all design options of concern to designers. The design climate conditions for the location can be either input by the user, or precalculated, as shown in Figure 3. In that case, the user simply inputs the location name. Participants in the design workshop found it took them 10 to 15 minutes to initially input their building designs, with most of that time devoted for "take-offs" of the building geometry. Subsequent simulations of variations in design options took much less time.

Once the *Excel* template is completed, the user presses a button labeled *"Run simulation"* to do the simulation. The Simplified Design Tool creates a DOE-2 input file by writing the template information into parameters, and appending a master residential input file. This master file contains the detailed information required for modeling, but written using DOE-2 *macros* that allow it to incorporate the specifications defined by the parameters.

The DOE-2 simulation is repeated for four operating conditions - (1) windows closed, (2) windows opened for natural ventilation, (3) mechanical ventilation, and (4) indirect evaporative cooling. The first case represents the worst case situation, and invariably produces significant overheating. This suggests that a "compressorless" house has to have an effective ventilation system. The results for the second case (natural ventilation) should be interpreted with care because of uncertainties about wind availability and whether occupants wish to leave their windows open at night. The third case (mechanical ventilation) models a low-speed whole-house fan producing 10 air-changes per hour whenever indoor temperatures are higher than that outdoors and above 65 F (18.3 C). The resultant indoor conditions are similar to those for natural ventilation, but more achievable The last case utilizes indirect evaporative cooling to boost the effectiveness of ventilative cooling on peak cooling days without introducing the potential problems of increased humidity. Other alternative cooling techniques can be added to the Simplified Design Tool as needed.

Output Data

The output data from the DOE-2 simulation consists of the hourly outdoor and indoor temperatures for the four control strategies. These are automatically imported from DOE-2 back into the same *Excel* spreadsheet at the conclusion of the simulation. Once the user hits a button labeled *"Plot results"*, the data is plotted on the screen (see Figure 4). A horizontal line is shown at 78°F (25.6°C) to represent the top limit of the comfort zone, and a vertical line added to separate the five-day sequence for July from that for September. On the sample plot shown in Figure 4 for a typical light-frame construction in Fairfield, it is apparent that the house substantially overheats, reaching over 100°F (37.7°C) on the peak day for three of the four control strategies considered. Ventilation is ineffective on the hottest days because the outdoor temperature never dropped below 82°F (27.8 C) even at night. However, the plot indicates that the fourth strategy, indirect evaporative cooling, can keep the peak indoor temperature at 81°F (27.2°C) due to the night cooling potential when using indirect evaporative cooling.

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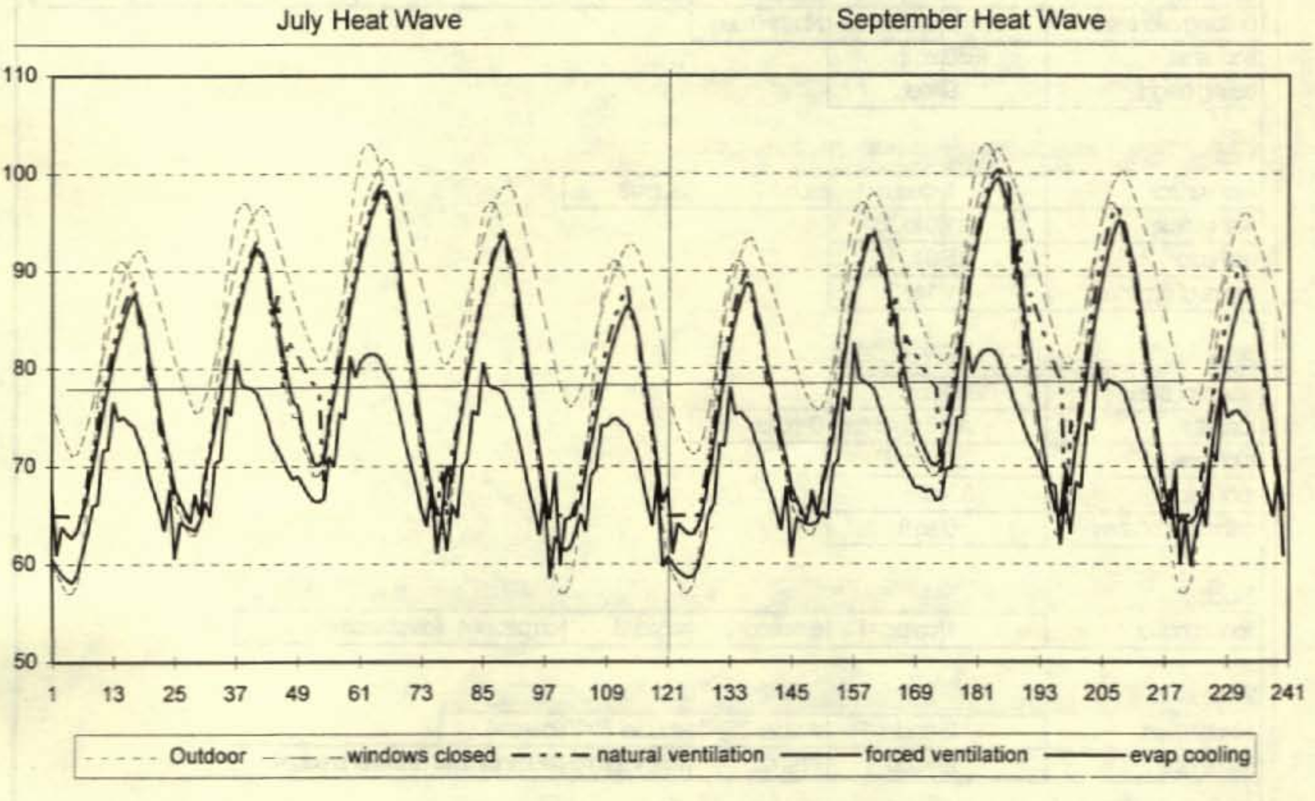
Figure 4. *Excel* output plot for a typical Title-24 house in Fairfield CA



Parametric Analysis

Once the general description for a building have been saved as a *Excel* spreadsheet, changing the inputs to study design options is very fast and easy. For example, the base building inputs shown in Figure 3 are modified in Figure 5 with higher levels of insulation, increased wall and roof albedo, three layers of gypsum board and exposed floor slab for thermal mass. As shown in Figure 6, these improvements produced a 10-12°F (6-7°C) drop in the peak indoor temperatures, but still 11-14°F (6-8°C) above the comfort zone even with mechanical ventilation. With indirect evaporative cooling, the peak indoor temperatures are held to 80°F (26.7°C), a reduction of 1-2°F (1°C) compared to the earlier design

Conclusions

Of the more than 20 participants at the design workshop, only two were familiar with building thermal analysis, and only one had ever worked specifically w ith the DOE-2 program. Since the focus of the workshop was to produce house designs that can maintain summer comfort, all of the design teams used the design tool during the course of their design and modified them in accordance to the DOE-2 results. The experience

Figure 5. *Excel* input spreadsheet for improved one-story house design in Fairfield CA

General info									
Location	3	walcrk=1	pittsb=2	fairfd=3	davis=4	sacram=5	pasade=6	pomona=7	rivers=8
building orientation	0	0..360 deg	North=0 deg						
floor area	1650	sq ft							
ceiling height	9	feet							

Wall				
wall surface	1	stucco=1	wood=2	alum=3
wall r-value	11	0 to 30		
wall color	0.5	0 to 1		
layers of gypboard	1	1 to 3		

Roof			
attic roof area	1650	sq ft	
roof tilt	18	0 to 45 deg	0=horiz
roof r-value	30	0 to 60	
roof color	0.3	0 to 1	
cathdral roof area	0	sq ft	

Floor						
floor condition	1	carpet=1	exposed=2	wood=3	carp/exp=4	carp/wood=5

Window					
window type	2	single=1	double(.25)=2	double(.5)=3	low-e=4
frame type	2	wood=1	vinyl=2	aluminium=3	aluminium with thermal break=4

Garage	1	yes=1	no=2
floor area	440	sq ft	
exterior wall area	576	sq ft	
interior wall area	180	sq ft	
roof area	440	sq ft	

Envelope	*North*	*South*	*East*	*West*		
wall area	224	224	456	456	sq ft	
window area	85	85	20	20	sq ft	
window height	4	4	4	4	feet	
number of doors	0	1	0	1	number	
overhang height	1	1	1	1	above window in feet	
overhang extension	0	0	1	1	feet	
neighbouring building	1	1	2	1	yes=1	no=2

other stuff				
infiltration	2	loose=1	medium=2	tight=3
foundation insulation	1	yes=1	no=2	

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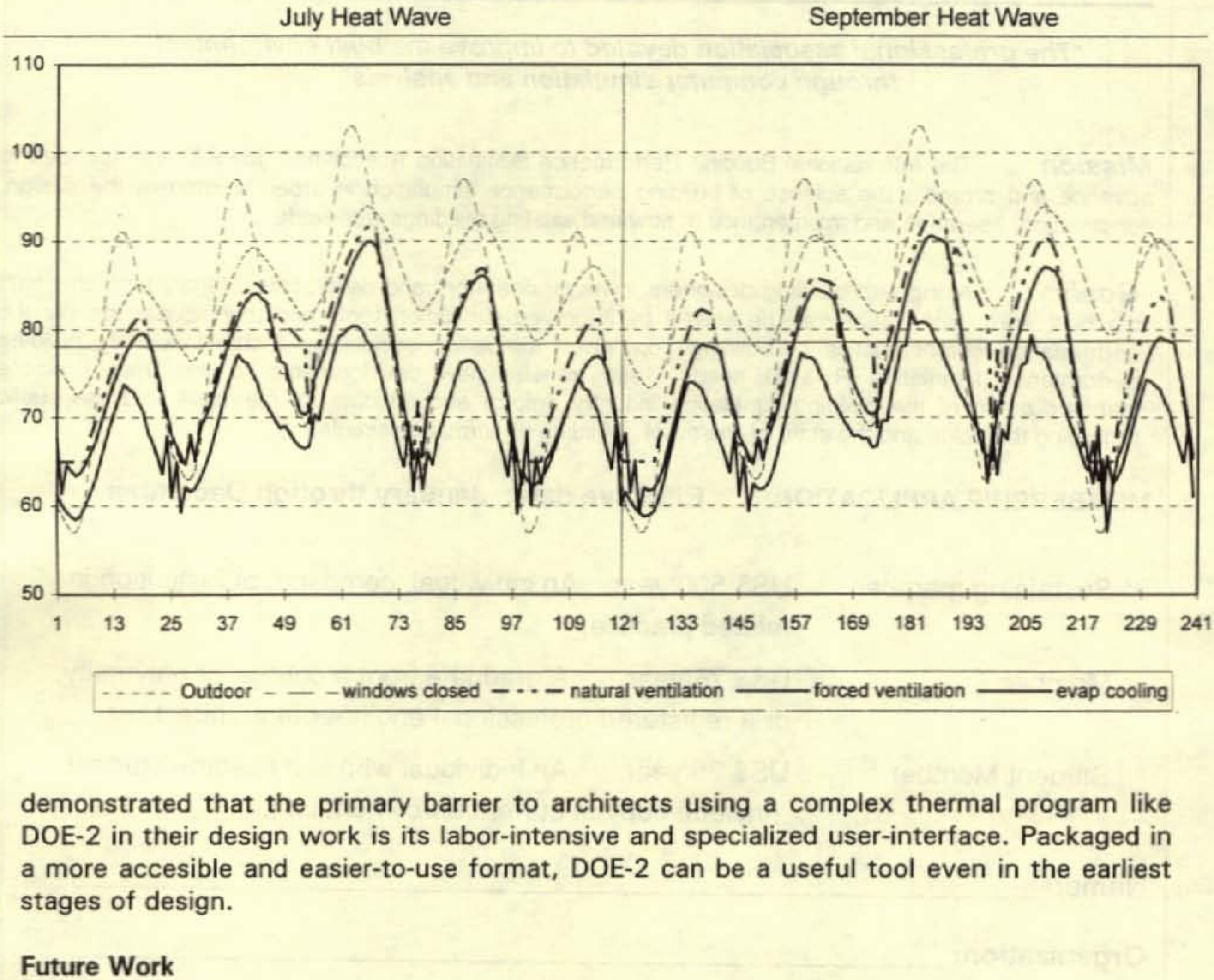
Figure 6. *Excel* output plot for improved one-story house design in Fairfield CA



demonstrated that the primary barrier to architects using a complex thermal program like DOE-2 in their design work is its labor-intensive and specialized user-interface. Packaged in a more accesible and easier-to-use format, DOE-2 can be a useful tool even in the earliest stages of design.

Future Work

The design tool as described in this report represents an initial effort done under tight deadlines and for a specific application. Work will be underway shortly to improve both the user input interface and the underlying calculations. In the area of user interface, improvements are planned to permit more accurate modeling of building geometry, especially for shading of windows and self-shading in courtyard or other irregularly-shaped houses. In terms of the underlying calculations, the new DOE-2 capability to compute operative temperatures will be utilized, and more design sequences will be defined, in particular design wet-bulb conditions that are the most critical for evaporative cooling.