

## **BUILDING SIMULATION '91—NICE**

*Edward F. Sawell, IBPSA President*

If you were there, let me recall the experience for you. If you were not, too bad—you missed a great conference! First, some statistics:

- Over 80 papers written by over 200 authors representing 83 institutions in 19 countries were presented in 29 technical sessions to 160 conference participants.
- The Proceedings is over 700 pages.
- Conservatively estimated, results from over 100 person-years of building simulation research were reported.
- The final reports are not yet compiled, but it appears that it was a financial success as well. This will give us seed money for planning the next conference, and funds for improved IBPSA member services.
- Our European members should note that a significant portion of any surplus will go to technical groups in Europe that helped raise the funds. These funds will go towards increased levels of building simulation professional activity in Europe.

By the preceding numerical measures, Building Simulation '91 must qualify as a conference of major importance. But the numbers alone can not describe this conference. The setting was fabulous—the sun, the sea, the mountains, and GREAT restaurants. Many of us coupled the experience with a European holiday, making it doubly enjoyable. We are truly indebted to our French hosts, AFME, for making the fine facilities at Sophia Antipolis available to us in this marvelous part of the world.  
(See BS '91—Nice on page 2)

## **IBPSA ELECTIONS**

Ballots for the 1992 IBPSA election of officers and board of directors will be mailed to all paid IBPSA members in January. Please watch for your ballot and return it promptly.

## **IBPSA AWARD WINNERS**

Congratulations to the recipients of the 1991 IBPSA awards which were presented in Nice during Building Simulation '91. **Gintas P. Mitalas**, of the National Research Council of Canada, was honored for "Outstanding Contributions to the Science of Building Performance Simulation". **Jeffrey D. Spitzer**, of Oklahoma State University, was honored for "Outstanding Early Achievements in the Science of Building Performance Simulation". Congratulations, and thank you for your efforts!

## **NEXT IBPSA MEETING: ANAHEIM**

The next meeting of IBPSA will be held on **Saturday, January 25**, in conjunction with the ASHRAE Winter Meeting in Anaheim, California, USA. The Board of Directors will meet at 6:30 p.m., and the general membership will meet at 8:00 p.m. The meeting will be held in the Cerritos Room (first floor, Sierra Center) of the Disneyland Hotel.

This meeting is open to anyone interested in building simulation; only paid IBPSA members may vote. (For membership information, see the end of this newsletter.)

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**Building Simulation '91 Proceedings**  
Now Available (See page 11 for details)  
\$55US for IBPSA and SCS Members  
\$90US for Non-Members

*(Continued from page 1)*

And by all accounts the technical content was superb. We heard state-of-the-art papers on new developments, such as new ways of viewing the model coupling problem, software integration in building CAD and simulation, CFD techniques applied to room ventilation, and simulation of fuzzy logic and other advanced building control techniques. We also got update reports on the ongoing next-generation building simulation environment projects, such as IDA (Sweden), CLIM-2000 and ZOOM (France), and the EKS/UK. In addition to these research-oriented reports, there were numerous papers on the applied side: graphical interfaces, PC screening tools, and simulation of new technologies such as low temperature air cooling systems to name a few. Lively discussions followed most presentations. Although the number of papers forced parallel sessions, chairmen provided summaries in plenary sessions the following day so everyone was exposed to the highlights of all papers.

In my opinion, these papers represent a new high in technical content, both in quality and quantity. But don't take my word for it—read the Proceedings yourself! All participants received a copy of the Proceedings as part of their registration materials. If you missed the conference, be sure to order your copy now (see page 11 of this newsletter).

In addition to the technical sessions there were plenary sessions of general interest. We received a welcome address from J. P. Dellaporta, Director of the Sophia Antipolis Establishment and Director of the Dwellings and Commercial Buildings Department of AFME. He emphasized the importance of our work on policy within his department. Our Keynote Speaker was L. Laret, Head of the Division of Modeling and Software Engineering at CSTB, who spoke on the setting, status, and likely future directions of simulation in building design and operation. His remarks were on target, with many being amplified in other reports later in the conference. At the close, John Mitchell provided a very thoughtful summary of the entire conference, capping it off nicely.

The venue for Building Simulation '91 was selected in order to firmly establish IBPSA's

commitment to an International dimension. To this end, the technical program was augmented with a formal meeting of the IBPSA Board of Directors, as well as a General meeting. This was the first time either meeting was held outside of North America, but it will not be the last. Considering the new membership subscriptions through conference registration, the center of gravity has moved significantly eastward, and we look forward to lots of future IBPSA activity in Europe. Indeed, one of the main things coming out of these meetings was a resolution to establish a committee to review the Constitution and By-laws with the aim of making IBPSA more effective as an international umbrella organization, aiding and assisting local groups with similar missions. This idea was well received at the General meeting, where suggestions were also made for improving communications. Minutes of the Board meeting appear elsewhere in this newsletter.

*On behalf of IBPSA, I want to thank all those who contributed to the success of Building Simulation '91.* First, we must thank our sponsors and supporters. State-side we had generous financial support from EPRI, GRI, US-DoE, BPA, and CERL. In Europe, there were financial and/or in-kind contributions from AFME, EDF, GDF, CEC, CSTB, and ENSMP. Since registration fees alone cannot meet all expenses for a first-rate conference, we are indeed fortunate to have had the support of these organizations. Also to be acknowledged in this regard is the work of the Steering Committee members, notably **Carol Gardner** and **Rik Van de Perre**, who carried the conference plan to these organizations and convinced them of its merits. Second, let us recognize our **authors**. After all, without their efforts, quite literally, there would be nothing to have a conference about! Thanks also go to our Conference Program Manager, **Rik Van de Perre**, and to the Conference Secretariat **Philippe Geril** of SCS, who together did the planning and arrangements; everything was handled very professionally and all went smoothly. They were ably and generously assisted by the Scientific and Steering Committees, and especially **John Mitchell** and **Joe Clarke**, who edited the Proceedings. Through the efforts of all of these people and organizations, we can record Building Simulation '91 as another IBPSA success!

## NICE MEETING MINUTES

**IBPSA Board of Directors Meeting**  
August 19, 20, & 22, 1991  
Nice, France

### MINUTES

*Present: Alereza, Clarke, Mitchell, Seth, Sowell, Van de Perre*

*By proxy to Sowell: Ayres, Sonderegger*

The formal agenda was set aside to focus on the issues below:

#### 1. BS '91 Conference Proceedings

Moved (Van de Perre) / Seconded (Sowell) / Passed (9-0): That the BS '89 and BS '91 Conference Proceedings are to be sold on a nonexclusive basis by the Society for Computer Simulation International for \$90US (\$55 to IBPSA or SCS members).

#### 2. Revisions to IBPSA Constitution and Bylaws

Moved (Sowell) / Seconded (Van de Perre) / Passed (9-0): That the IBPSA mission statement, constitution, and bylaws be revised, for approval of the membership, to focus on activities appropriate for an international umbrella organization, such as international conferences, other forms of information exchange, and encouragement of the development of national and local bodies to further the goals of IBPSA.

A committee is to be formed to implement this motion.

#### 3. Executive Secretary

The Executive Secretary position was discussed. Alereza presented a proposal from a California firm engaged in similar activity. The proposal covered secretarial aspects only and had a price of \$10,000 per year plus postage and materials. Seth presented an Executive Director position description developed by himself at the request of the Board at the Indianapolis meeting. These documents were discussed without formal action.

(Continued 21 August 1991)

*Present: Alereza, Clarke, Mitchell, Seth, Sowell, Van de Perre*

*By proxy to Sowell: Ayres, Sonderegger, Winkelmann*

*Guest: K. Johnson (EPRI)*

#### 4. Executive Secretary (continued)

The Executive Secretary/Director position was discussed further, but no conclusions were reached. Johnson pointed out that the proposal in hand was from an EPRI contractor, and in his opinion the firm was reliable and had demonstrated necessary skills on previous EPRI projects.

Van de Perre and Clarke advanced the view that there should be a separate person for handling European activities. Sowell pointed out that certain functions, such as membership list and accounting, were best centralized for better coordination and effectiveness; he therefore proposed that there be a European coordinator to supplement the Executive Director.

Seth strongly advocated that we hire an Executive Director instead of a Secretary; others supported this concept. Sowell pointed out that IBPSA could afford a Secretary now, and had a viable proposal on the table. Mitchell pointed out that we really had to do something with regard to routine matters like membership records, mailing lists, and maybe we would be better off to move on that front now and consider a Director later when we could afford it.

Van de Perre informally offered to provide the same services as the California proposal at the same price. Sowell pointed out that it was inappropriate for a Board member to present a competing bid based on a submitted proposal. Clarke agreed.

The meeting adjourned without resolution.

(Continued 22 August 1991)

*Present: Alereza, Clarke, Mitchell, Seth, Sowell, Van de Perre*

*By proxy to Sowell: Ayres, Sonderegger, Winkelmann*

*Guest: Gardner*

*By proxy to Gardner: Knipe*

(Continued on page 4)

## **NICE MEETING MINUTES**

*(Continued from page 3)*

An agenda was agreed as indicated by the following discussions:

### **5. Building Simulation '91**

The Conference Program Manager (Van de Perre) was asked to provide Sowell with a complete list of names, institutions, and amounts contributed for all conference sponsors so formal thank-you letters can be sent by the IBPSA President. Van de Perre proposed that the CPM should send these letters. After discussion it was agreed that the list would be provided to Sowell and the letters would carry the signatures of the IBPSA President and the CPM. Gardner will provide the information from the US sponsors to the CPM who will forward the complete list and draft letters to the President.

The CPM was asked to prepare a complete and final budget for the conference when final figures become available. This budget should show all income and all expenses by major category in an accepted format. Sowell will provide the format to the CPM. The CPM indicated that he should be able to prepare the final budget by 15 October 1991; this was agreeable to the Board.

Since the IBPSA brochure, prepared especially for the conference, was omitted from the conference materials, the CPM will have to send it separately to all attendees. It must be done immediately because other materials to be mailed, such as session summaries, will likely not be available for several months. Alereza will mail the brochures to the CPM.

It was noted that the Proceedings fail to credit the Construction Engineering Research Laboratory (CERL) for its cash support. Apparently this contribution was received after the CPM requested the list of US sponsors on 6/21/91. CERL will be recognized in the final package to be sent to all attendees.

### **6. Building Simulation '93**

The location and date of the next Building Simulation Conference was discussed. The nominal date was set for 1993, with final date set after location has been established. Locations discussed included:

Australia, Hawaii, Boston, Japan, New Orleans (before/after ASHRAE)

Williamson and Delsante, both from Australia, have made verbal offers to prepare a conference proposal. By general consensus it was agreed that Van de Perre should contact them and ask them if they can have a business plan available for consideration by the Board at its Anaheim meeting in late January 1992. He will provide them with budget data from BS '89 and '91.

### **7. Executive Secretary (continued)**

Sowell reopened discussion by calling for action on the bonafide proposal in hand. After lengthy discussion, Mitchell made a proposal to this effect, seconded by Sowell (exercising a proxy). This proposal was later modified, and ultimately defeated.

It was then moved by Mitchell that we carry out another request for proposal process on the following timetable:

15 September 1991: An RFP based on the position description presented by Seth will be completed by Gardner for approval by the Board by mail ballot.

15 October 1991: RFP will be sent out to bid to a minimum of 3 vendors.

15 November 1991: Bidders' responses due.

After lengthy discussion this proposal was passed with a 6-3 vote. Sowell did not vote, but did exercise proxies held by him. Gardner exercised the proxy which she held.

To implement this motion, Gardner will solicit inputs from the Board and incorporate these in the RFP. She will then forward the document to Sowell for balloting.

### **8. Nominations for the Board**

It was agreed that a higher European representation should be sought. Also, we should try to maintain continuity by reelection of a significant portion of the current board. It is anticipated that naturally occurring roll-off will vacate about 1/3 of the 15 positions so these objectives can be met. The Committee will poll the current Board to see who wants to roll off and who will accept reelection. All nominations should be forwarded to the Nominations Committee established in Indianapolis. Clarke suggested that each nominee should be asked to prepare a brief vita and position paper to provide to the membership along with the recommended slate.

## **A TOOLKIT TO HELP CALIBRATE THE DOE-2 SIMULATION PROGRAM TO NON-WEATHER DEPENDENT MEASURED LOADS**

*Doug Bronson, Sharon Hinchey, Jeff Haberl, Dennis O'Neal, David Claridge*  
*Mechanical Engineering*  
*Texas A&M University*  
*College Station, Texas, USA*

### **ABSTRACT**

Hourly building energy models such as DOE-2 and BLAST provide an effective method for simulating the energy usage of a building during the design stage. Increasingly, such models are being used to evaluate retrofits in existing buildings. However, little agreement exists among the users of the models as to how to calibrate the simulation to the measured data from a building.

This article provides a brief glimpse of a toolkit we've developed for calibrating DOE-2 to non-weather dependent loads. The procedure relies on comparative 3-D graphics that allow for hourly differences to be viewed over the entire simulation period.

### **METHODOLOGY**

In general we use a multi-step, iterative procedure to calibrate DOE-2 to measured energy use for a specific building. A method that seems to yield good results is to extract DOE-2's hourly data for pre-specified variables, translate the data into a contiguous columnar format, merge it with measured data for the same period, and then compare the simulated hourly variable to its measured counterpart using various graphical and statistical techniques.

The simulations performed for this article were done on a super-minicomputer cluster using the DOE-2.1d version of the program. In addition to the DOE-2 program, other supporting software is also needed. The types of software depend on what is to be done and the volume of data to be handled. 2-D and 3-D plotting programs with good data-handling capabilities are mandatory for viewing the data. The procedures described here are specific to the graphics packages used to produce the plots yet are general enough to be of value for use with other packages.

DOE-2 contains many input variables that can be adjusted during the calibration process. One convenient grouping is to consider weather dependent and non-weather dependent input variables. Weather-dependent variables include energy that is consumed for space heating-cooling purposes (i.e., weather dependent); non-weather dependent energy use includes energy used for loads that are primarily schedule dominated (i.e., lights and receptacles). As one would expect, there is some overlap between the two categories.

This weather-dependent and non-weather-dependent categorization agrees well with monitored data from buildings especially when data are being measured for the whole-building electricity and thermal energy use, and sub-metered data are available for the motor control centers, and other important subsystems.

Figure 1 is a flow chart of the overall DOE-2 calibration procedure. Our primary sources of information include as-built drawings, audit reports, and information from on-site visits, as well as monitored data. A DOE-2 input deck is produced for each building and measured weather data are converted to suitable units, overlaid onto the TRY weather tape for a local site, and repacked for use with the DOE-2 program using the weather processing utilities that come with the DOE-2 program.

Hourly values are extracted from the DOE-2 program, translated to a common columnar format and compared to the measured data. This process is then repeated until the difference between the simulated and measured data fall within an acceptable range.

### ***Applying the procedure to a case study building.***

The Engineering Center (EC) is a large, multipurpose building which contains classrooms, laboratories, faculty-staff offices, and a large central computer facility. It is located on the Texas A&M University campus in central Texas about two hours Northwest of Houston. The EC, (and about 250+ other buildings) on the central campus receive steam, hot water, chilled water, electricity, and communication services from a centralized utility distribution system. The four story, 324,400 square foot facility was built in the early 1970's. The building measures 339 feet (the long axis) by 221 feet and is 60 feet in

height. Parking is provided under the facility for 82 cars.

The building can be characterized as an internal load dominated, high mass structure. Only about 9% of the exterior envelope is glazed. The building has a maximum occupancy of 2,300 occupants which occurs during peak periods each semester. The occupancy profiles are characterized by a 8 a.m. to 7 p.m. weekday schedule. Significant evening usage of the building occurs during the weekdays between 7 p.m. and midnight during semesters. Weekend usage is moderate. Internal lighting loads (2 W/ft<sup>2</sup>) and equipment loads (2.4 W/ft<sup>2</sup>) peak during the weekdays in the early afternoon. Considerable electricity is consumed in the evenings by a central computing facility. The building has 12 constant volume, dual-duct AHUs which continuously provide 330,500 CFM to the 90+ zones in the building. The AHUs are located in the parking garage with return air paths provided by concrete chaseways that encircle the exterior of the building.

## RESULTS

To demonstrate this procedure two different daytypes were created for the EC and input into the DOE-2 program. The resultant simulated profiles for the non-weather dependent loads were then compared to hourly measured data from the EC using 3-D comparative plots produced with a spreadsheet add-on package. Energy use for the building's lighting and equipment loads (or receptacle loads) was input as a W/SQFT value and scheduled according to different daytypes (e.g., Mon-Fri, and Weekends and Holidays).

The DOE-2 daytype profiles: Typical DOE-2 daytype profiles were obtained from the DOE-2 Reference manuals (i.e., The Office Lighting and Receptacle Load Profiles were used from Part 2, Version 2.1, Chapter 10, Pg. A-5, of the DOE-2 manuals) and applied to the EC by matching peak hourly profiles and then scaling the remaining hours. Weekend profiles were scaled in a similar fashion. No attempt was made to adjust the hourly profile shape.

Average hourly daytype profiles: The application of a simple hourly daytyping routine by Katipamula and Haberl (1991) to hourly data from a six month data set yielded six primary daytypes (K-H daytypes): Fall

weekdays and weekends, Spring weekdays and weekends, and semester-break weekdays and weekends. Spring and Fall daytypes were necessary since, during the break between semesters, the entire Computer Science department moved out of the EC to their newly constructed facilities in a different building, with the remaining space being reallocated to previously cramped departments.

### *Comparison of the daytype profiles.*

Each of the daytype profiles are compared to measured data for the corresponding period in Figures 2 and 3. Three dimensional profiles are an effective method of presenting the enormous amount of data that must be inspected when one is viewing hourly data over a six month period (Haberl et al. 1988). Small differences between different data sets can be quickly identified because the viewer can spatially compare the individual features or "small multiples" that the surfaces produce (Tufté 1990).

The 3-D plots display the hour-of-the-day along the x-axis and the day-of-the-year projecting into the page (beginning with September 1989 in the lower right corner and proceeding from right to left). The energy use is the height of the surface above the x-y plane. Comparing the minute differences between two surfaces can be further enhanced with the use of 3-D comparative plots (Haberl and Komor 1990). 3-D comparative plots are produced by merging two surfaces into positive and negative residuals.

For example, in Figure 2 the upper graph represents the actual measured data for the EC, and the second graph represents the daytype schedule that is based on the DOE-2 schedule. The third graph represents the positive residual (i.e., simulated - monitored data for values that are greater than zero), and the fourth graph is the absolute value of the negative residual (i.e., monitored - simulated data). Both positive and negative residuals are trimmed at zero to enhance the features.

Figure 2 clearly shows that the canned DOE-2 profile understates the energy use during unoccupied periods. Using the canned DOE-2 profile understates the electricity required for lights and equipment in the EC by 21% to 28%, depending on the month.

Figure 3 shows the comparison between the electricity use predicted by the K-H daytypes and measured electricity consumption for the same period. Clearly, as seen in the residual plots, the use of simple daytypes yield a shape that more accurately fits the hourly data for the EC. Only a few days during the Christmas break require further adjustment. The daytypes also provide an improved estimate of the monthly electricity use yielding estimates that differ from -3.3% to +4.0% for the six months that were investigated. Several other daytyping routines as well as the special adjustments that are necessary to the DOE-2 program are discussed in another paper to be released shortly.

## DISCUSSION

This article has briefly introduced a procedure for calibrating DOE-2 to non-weather dependent loads. The procedure relies on comparative 3-D graphics that allow for hourly differences to be viewed over the entire simulation period (8,760 data points if necessary). Two different types of daytyping routines were used to demonstrate the effectiveness of the procedure.

The use of the canned DOE-2 daytype profiles can produce significant error in the estimations of the non-weather dependent electricity consumption profiles. The availability of comparative 3-D surface plots significantly improves the ability to view small differences between the simulated and measured data which allowed for the creation of a "super-tuned" DOE-2 simulation. Automation of these routines dramatically cuts down on the processing time needed to produce a set of plots.

## ACKNOWLEDGMENTS

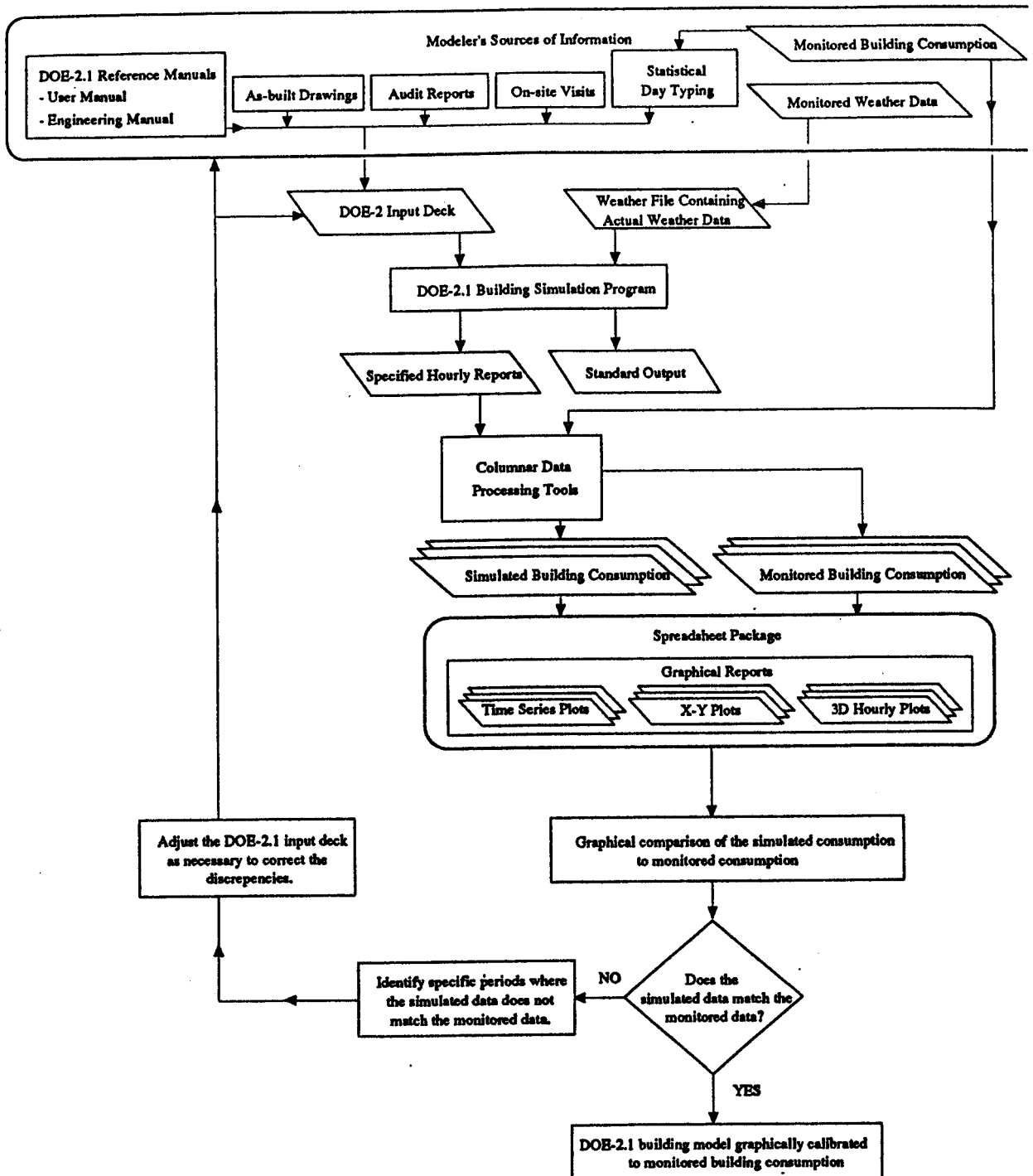
This project was funded and supported by the State of Texas, Governor's Energy Office, as part of Texas A&M's LoanSTAR Monitoring and Analysis contract using oil overcharge funds. Additional information on the LoanSTAR program can be obtained by writing to the authors, or by Email (Bitnet: JSH4037@TAMSIGMA, or Internet: jhaberl@loanstar.tamu.edu). Special thanks are due to Srinivas Katipamula, Dean Willis, Robert Sparks, and Robert Lopez for providing technical support.

Software used during the course of this project include: Data Exploration software from Lantern Corporation, Clayton, Missouri; the Lotus 1-2-3 Spreadsheet; Grapher and Surfer software from Golden Software, Golden, Colorado; a 3-D, 123 add-on package from Intex Solutions, Needham, Massachusetts; the Statistical Analysis Software from the SAS Institute, Cary, North Carolina; file transfer software from FTP Software Inc., Wakefield, Massachusetts; the ARCHIVE software (Feuerman and Kempton 1987); the GAWK columnar processing routines (FSF 1989); and Postscript typesetting with TeX (TeX 1986); Copies of the DOE-2 post-processing software used to produce the plots can be obtained from the authors.

## REFERENCES

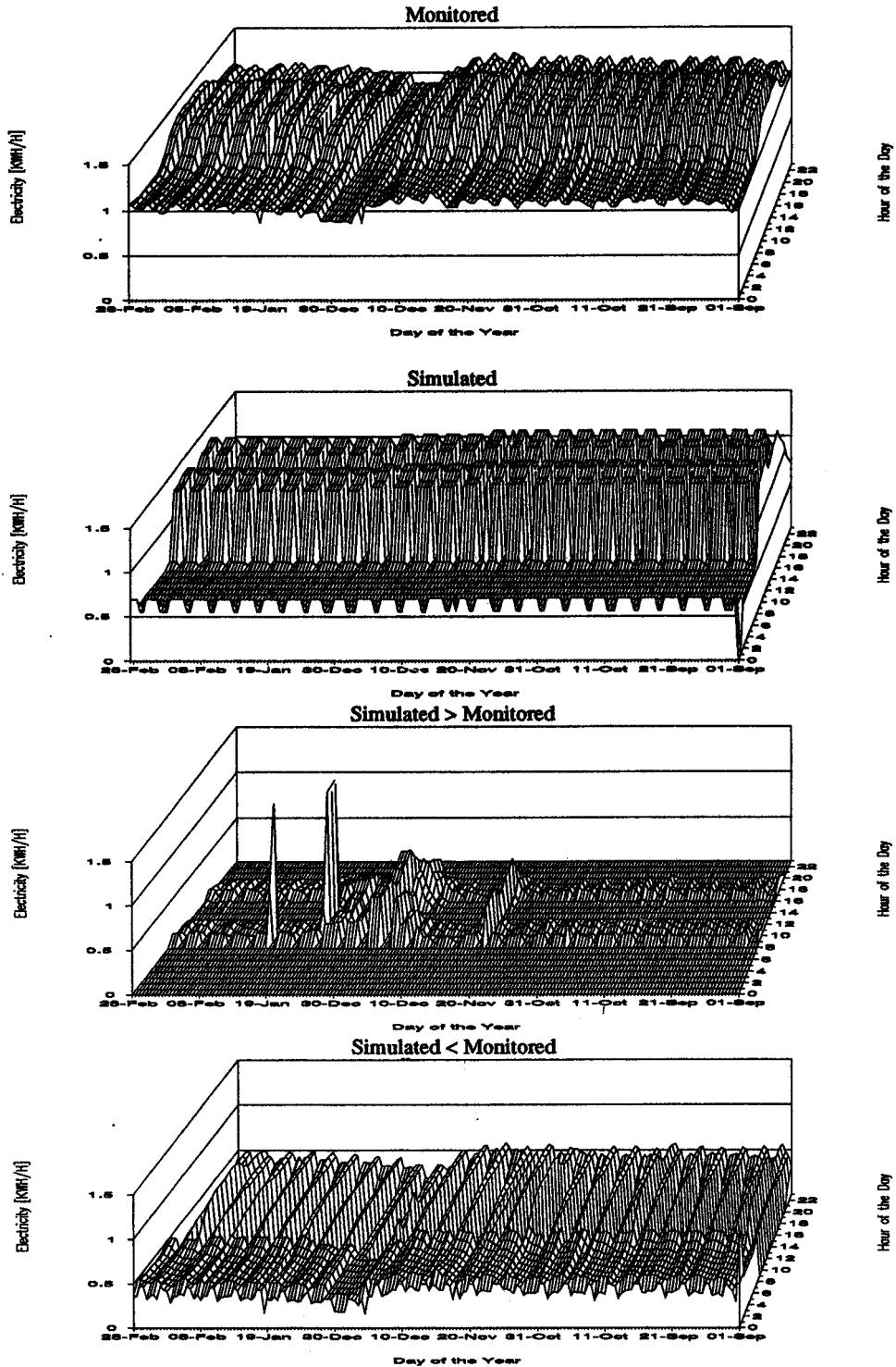
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**FIGURE 1: Flow diagram for the non-weather dependent calibration procedure.**

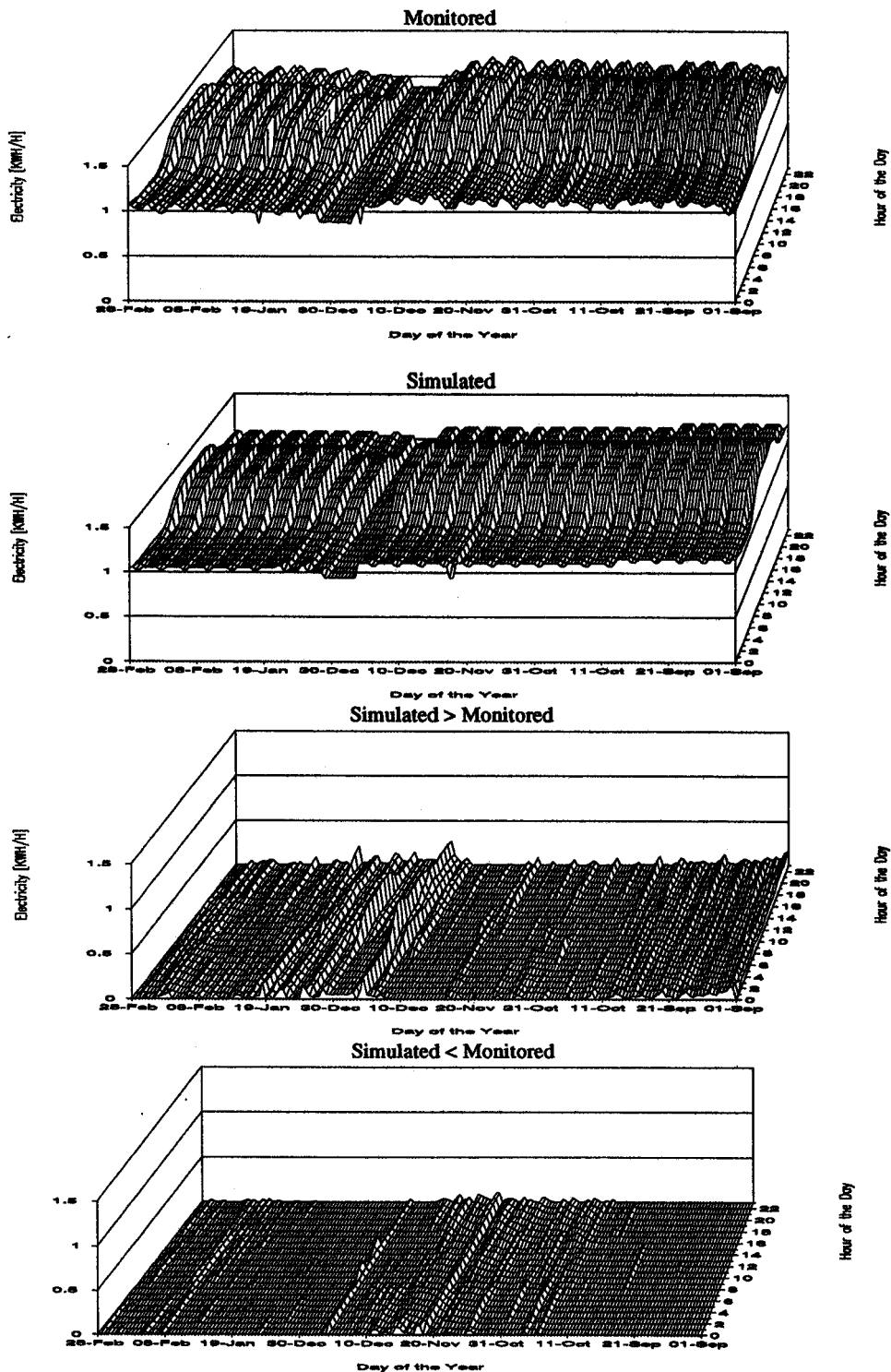




**FIGURE 2: 3-D Comparative plots using daytypes from the DOE-2 schedules.**



**FIGURE 3: 3-D Comparative plots using the K-H daytypes from the full data set.**



**UPCOMING CONFERENCES  
AND MEETINGS**

**New Construction Programs for Demand-Side Management**  
May 3-5, 1992  
Embassy Suites Hotel  
South Lake Tahoe, California, USA

*For more information, contact:*  
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**IBPSA MEMBERSHIP APPLICATION**

Membership Classification Desired  
(Check One)

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**PUBLICATIONS AVAILABLE**

**Building Simulation '91 Proceedings**

Proceedings from Building Simulation '91 are now available. The Society for Computer Simulation International (SCS) is distributing the proceedings for BS '89 and BS '91.

| Item #      | IBPSA or SCS Member | Non-Member |
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