POWERDOE, A WINDOWS™-BASED VISUALLY ORIENTED ANALYSIS TOOL

J. J. Hirsch
Hirsch & Associates; Camarillo, CA USA
F. C. Winkelmann, W. F. Buhl, K. L. Ellington
Lawrence Berkeley Laboratory; Berkeley, CA USA
J. S. McMenamin, I. Rohmund, S. A. Criswell
Regional Economic Research, Inc.; San Diego, CA USA
A. Bhimani, B. Spurlock
Southern Company Services; Atlanta, GA USA
D. J. Borstein
D. J. Borstein & Associates; Los Altos, CA USA
K. F. Johnson
Electric Power Research Institute; Palo Alto, CA USA

ABSTRACT

PowerDOE, a new, PC-based building energy performance simulation tool, combines the full capabilities of DOE-2.IE with an easy-to-use, flexible Windows™ graphical user interfáce (GUI). This interface implements a number of unique approaches to fácilitate. developing an accurate building description. PowerDOE organizes architectural and HVAC elements in a hierarchy that is intuitive and familiar to designers and analysts. PowerDOE provides an interactive connection between the data input phase and the simulation, allowing the user to perform certain calculations prior to running the entire simulation. PowerDOE is a collaborative effort between the U.S. Department of Energy's Lawrence Berkeley Laboratory (LBL) and the Electric Power Research Institute (EPRI).

INTRODUCTION

PowerDOE, a new, PC-based building energy performance simulation tool, combines the full capabilities of DOE-2.1E with an easy-to-use, flexible Windows™ graphical user interface (GUI). PowerDOE development was initiated in 1992 as a collaborative effort between the U.S. Department of Energy's Lawrence Berkeley Laboratory (LBL) and the Electric Power Research Institute (EPRI). Additional support for the project comes from Bonneville Power Administration, Duke Power, Pacific Gas and Electric, Southern California Edison, and Southern Company Services

This paper describes the PowerDOE user interface and the methods used to unify the building description and building analysis process. The simulation engine structure and the way in which the program allows the simulation engine and user interface to interact are also discussed.

OBJECTIVE OF THE SOFTWARE

PowerDOE's objective is to combine the features of DOE-2 and micro-AXCESS to create a state-of-the-art program that will become a widely used and accepted tool for building simulation, energy analysis, and design. PowerDOE is targeted to serve an expanded range of users including building performance analysts, HVAC designers, architects, and electric and gas utility personnel and contractors.

TECHNICAL BASIS

PowerDOE has a modular structure that allows sections of the program to be externally accessed or to be connected with other analysis tools. For example, the Review Results module, can be used as a stand-alone application for post-processing DOE-2 results. The PowerDOE structure enables third-party developers to use these modules and the PowerDOE simulation engine in their applications. PowerDOE will also be linked to the Building Design Advisor (BDA), a multimedia, integrated building design support tool under separate development by LBL.

Unlike DOE-2's batch mode operation, PowerDOE provides an interactive connection between the data input phase and the simulation, allowing the user to perform certain calculations prior to running the entire simulation. For example, the user interface calls the simulation engine to perform zone-by-zone peak load calculations necessary for default HVAC equipment sizing. In this way, as the user passes from the architectural input phase to the HVAC description phase, all loads and resulting default equipment sizing are presented and changeable prior to the energy use analysis. Then, during the actual simulation phase, all building components are simulated together at each time-step. Other developments that can be calculated interactively include custom weighting factors, response factors for walls, and illuminance distributions (a new feature in PowerDOE).

The simulation engine performs an hourly time-step simulation based upon techniques used in the DOE-2 and micro-AXCESS programs, as well as other existing accepted and time-tested techniques. The simulation speed is expected to be approximately

25% faster than existing DOE-2 program implementations. Simulations can be performed in the background while the user performs other tasks on the computer.

The program requires a 386- or 486-based PC with a math co-processor, VGA graphics card, color VGA monitor, and 16 megabytes of memory. A Super-VGA (800x600) and/or a VGA with 256 or more color video card and monitor are suggested for best display of the application's graphics. Software requirements are Microsoft Windows™ version 3.1 (or higher).

The PowerDOE user interface implements a number of unique approaches to facilitate developing an accurate building description. PowerDOE organizes architectural and HVAC elements in a hierarchy that is intuitive and familiar to designers and analysts. Building areas are grouped into floor plans, with each floor plan being composed of conditioned and unconditioned zones, plus any plenums. HVAC equipment is grouped by air and water flow paths that supply the heating, cooling, and ventilation requirements of the building areas. Electricity and fuel supply are grouped into meters that can reflect the actual building circuits and sub-metering, as well as provide end-use consumption and demand estimates.

The Describe Building module is where the user enters information describing the building and its equipment. As shown in Figure 1, the Describe Building menu consists of eight main components: 3-D Wire, Floor Plan, Zone Loads, Building Equipment, System Equipment, Central Plant, Schedules, and Refrigeration. A global summary worksheet with a spreadsheet-like format contains summary data for building elements and allows the user to quickly review and edit building data. This

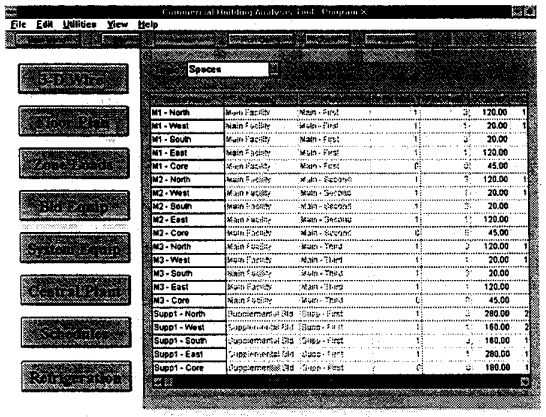

Figure 1: Describe Building Menu Screen

spreadsheet can also be setup to disallow the modification of some or all of the data.

PowerDOE incorporates several graphical features that provide visual feedback and reduce the time required to prepare an accurate building description. The 3-D wire screen (Figure 2) which displays a three-dimensional view of the entire site, including all defined buildings and external shading surfaces, allows the user to quickly catch gross building and external shading geometry errors. The user may shift the position of the viewer and the focal point of the view, and can also choose to view the building in a wire-frame or solid-fill mode utilizing hidden line removal techniques. To aid in solar analysis, this three-dimensional view will also show shadows cast by external shading surfaces for a given sun position or sequence of sun positions.

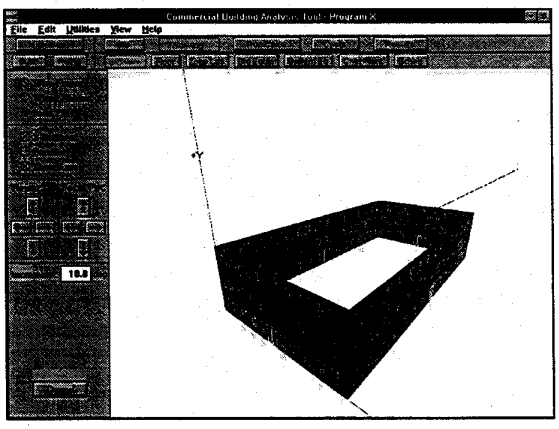

Figure 2: 3-D Wire Frame provides graphical feedback on the building description.

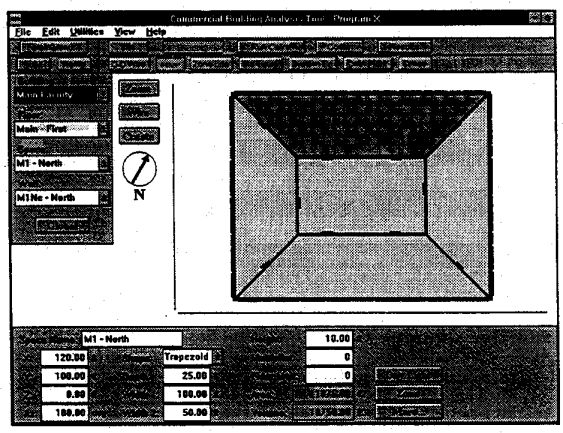

Figure 3: PowerDOE Floor Plan screen with space data displayed at bottom of screen.

The Floor Plan screens (Figure 3) display either floor plan or elevation views of building elements, as well as the associated data for a particular space, wall, window, or door. Simply by clicking the mouse on a different element, the user can bring up and edit the

data for that element. Basic data on the space, wall, window, or door are displayed on screen, with buttons providing access to dialog boxes for specifying additional details.

The Zone Loads module (Figure 4) is where the user may view and/or edit a variety of data by zone, including equipment energy use and characteristics that affect heating and cooling loads. The Zone Loads module provides access to lower level dialog boxes for describing lighting, daylighting, infiltration, furniture, people, and equipment.

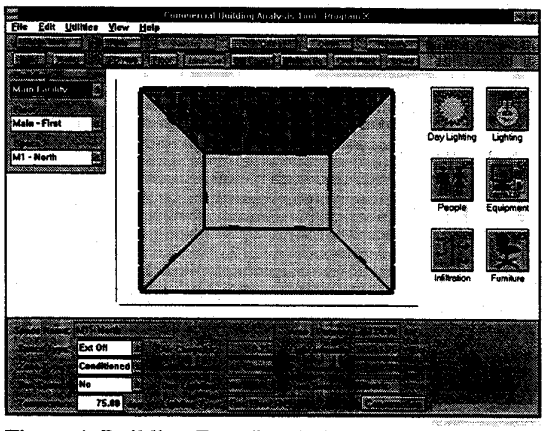

Figure 4: Building Zone Loads Screen

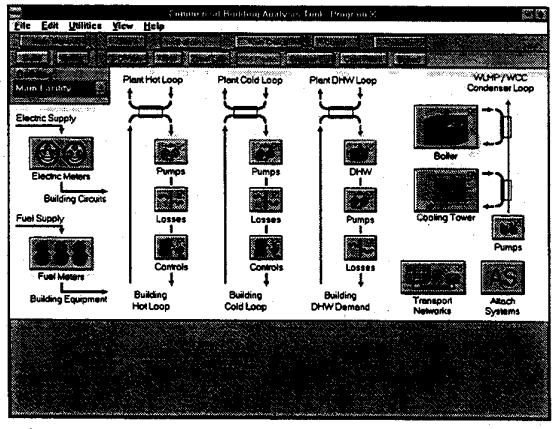

Figure 5: Building Equipment Screen

The Building Equipment module (Figure 5) is where the user defines building-specific HVAC system data such as electric and fuel meters; pumps, losses, and controls associated with building's hot and cold loops; boiler(s), pumps, and losses associated with the building's domestic hot water loop; boiler(s), cooling tower(s), and pumps associated with a water loop heat pump or water cooled condenser system; energy transport network assignments; and attachment of HVAC systems to defined buildings.

The HVAC and Central Plant modules (Figures 6 and 7) allow the user to specify these elements of the building equipment. Depending on the types of equipment selected from pick lists, PowerDOE will display the appropriate diagram and data fields for the user to complete. Beside each icon representing a particular equipment type, check marks indicate whether the user has entered specific information or is accepting the defaults.

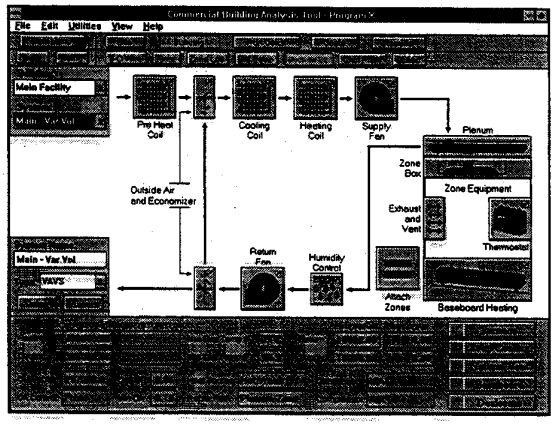

Figure 6: HVAC System(s) Screen - VAVS

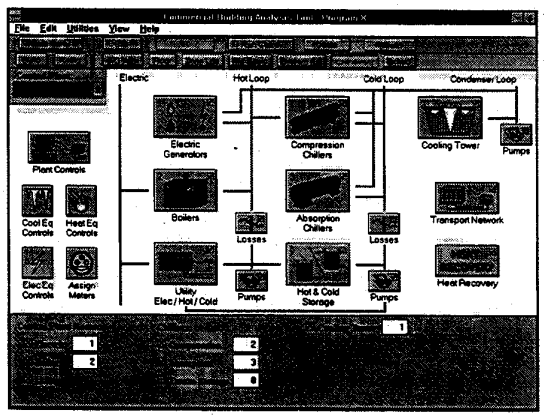

Figure 7: Central Plant Screen

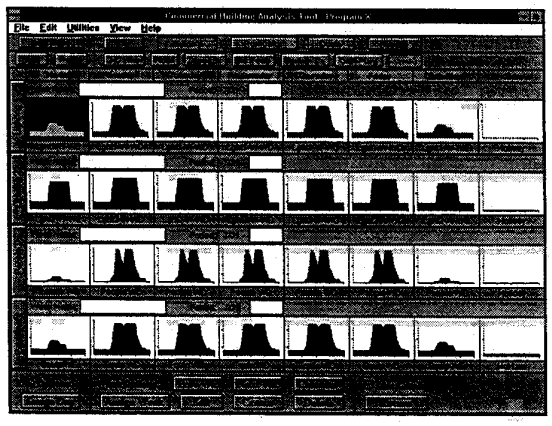

Figure 8: Compare Weekly Schedule Screen

The Schedules screens allow all building and HVAC schedules to be entered either graphically, numerically, or with expressions. A summary screen

shows an overview of each schedule and its assignment and allows navigation to the schedule itself for editing. For easily comparing various schedules, PowerDOE can display four different weekly schedules side-by-side, as shown in Figure 8. For example, these could be schedules for four different end uses, as shown in the figure, or four different time period schedules for a single end use.

The PowerDOE interface incorporates a utility called ScreenKey, which allows a "system administrator" to customize or re-configure the program screens. New screens can be added or existing screens altered, including the hiding, protecting, and moving of parameters. In this way, the application can be recast for specific users or to create new products. For example, a utility could create a customized version for field representatives that examined a limited number of building characteristics. The ScreenKey feature can be used to prevent non-technical users from altering building parameters that should only be edited by a more experienced user, and will also prevent them from becoming overwhelmed by the large magnitude of data. ScreenKey also simplifies translation of the input screens into other languages, so that PowerDOE can be quickly adapted for use in other countries.

Parameter defaults are intelligent and dynamic, including automatic load calculations and equipment sizing. User inputs and parameter defaults are context dependent and can be specified as general multi-line expressions involving other parameters and computed values. This provides a powerful and flexible capability to generalize inputs and defaults, as well as enabling rapid parametric analysis.

PowerDOE includes a comprehensive online help system. Context-sensitive help is available for every data entry field, as well as for every program screen. When the user points to a data field and clicks the right mouse button, PowerDOE displays a drop down "Quick Menu" beside that field. The user can then select Field Help for the particular field, or Topic Help for information on the current screen. Help is also available from the main menu bar or by pressing the F1 key, and includes standard Windows™ Help components such as Contents and a Search Keywords dialog box. In addition, the online help system contains extensive hypertext links that provide quick access to related topics and additional detail.

PowerDOE's Quick Menu is also used for attaching comments and/or descriptions to any named item, and for entering an expression to describe a building parameter. Comments are collected and stored with the specific named object, e.g., a comment entered in the Depth field for a space would be associated with that space rather than the Depth data field. For entering expressions, a dialog box presents up to four expressions including the program default expression, the current library expression, the user-entered default expression, and the standard user-entered expression.

PowerDOE includes a library of generic parameterized prototype buildings and building components, which can be altered to create new libraries. The user can select a prototype by building type (i.e.: office, residence, hospital, etc.), size (i.e.: large, medium, small), vintage (i.e.: pre 1970's, 1970's, 1980's, 1990's, etc.), and location. Once this selection is made, the prototype can readily be globally altered to conform to the actual design of interest. The global parameters, which are presented in "spreadsheet" style, include building size, area, number of floors, shape, usage breakdown (i.e.: entry, corridor, office, kitchen, etc.) by area percent, construction (wall and window type and percent), and HVAC configuration. Once a prototype has been customized, it can be simulated, entered as a new library choice, or altered in more detail using the visual interface.

In addition to the building prototypes, users will have access to libraries of materials, walls, roofs, windows, lighting fixtures, operation schedules, space types, secondary system types, and primary system components (boilers, chillers, etc.). Users will be able to customize these libraries as well.

Results are reviewed in a separate application called DOE2REV that enables preparation and display of customized reports. When running PowerDOE, DOE2REV is fully integrated, with full navigation functionality between the two applications. One can, however, execute DOE2REV as a separate application for post-processing DOE-2 results. The review results module serves three primary functions:

- Viewing and/or printing simulation inputs and results in pre-defined report formats (e.g., architectural, engineering, utility energy use, and utility costs reports)
- Modifying a report template or creating a new one, containing user-defined tables and graphs
- Displaying a full-page graph of simulation inputs and results for any period of time (day, week, or month)

Figure 9 shows the main Review Results screen, used for specifying the input and results files to be analyzed, and selecting an existing report template or creating a new one. This screen is also used to select and apply a utility rate file to the simulation results.

Other screens allow defining tables or graphs of either inputs or results, and specifying how they will appear in report pages, enabling the user to define what data series to view and in what format. Cutting and pasting between the analysis tool and other Windows™ applications is fully enabled. A sample report page is shown in Figure 10. Any hourly data series can be filtered into a daily, weekly, monthly, seasonal, or annual series. Filtering options allow selecting values, peaks, sums, and peak sums, which can then be incorporated into reports.

CONCLUSION

The initial version of PowerDOE will be released in late 1995. Subsequent releases are planned that will incorporate additional features and interface with other analysis tools. Under consideration are:

- A link to CAD packages, which will allow importing building drawings into PowerDOE
- A link to the LBL-developed Simulation Problem Analysis and Research Kernel (SPARK); users will be able to create models of advanced building technologies, processes, and controls with SPARK and insert them into PowerDOE for simulation
- Integration of the loads, system, and plant calculation, which will allow the effects of equipment undersizing and load shedding to be simulated
- A module for showing compliance with building energy standards, under development with support from a consortium of Canadian utilities and government agencies
- Building wizards for guiding the user step-by-step through the process of describing a building
- A module for simulating supermarket refrigeration systems, under development by EPRI
- A module for simulating foodservice installations, under development by EPRI
- A module for retrofit analysis

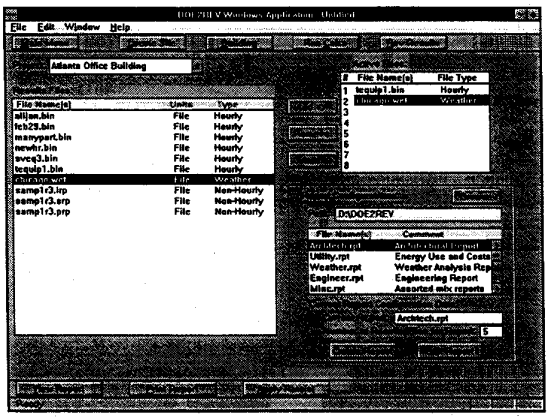

Figure 9: Review Results Screen

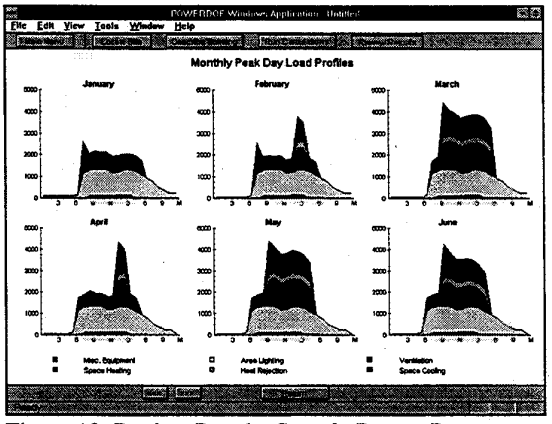

Figure 10: Review Results Sample Report Page