Figure 6. Solar radiation influxes from a weather tape
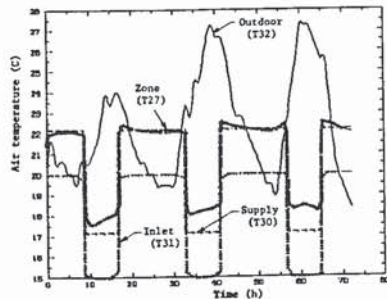

Figure 7. Outdoor temperature and the zone, supply, and inlet air temperatures for Zone 3
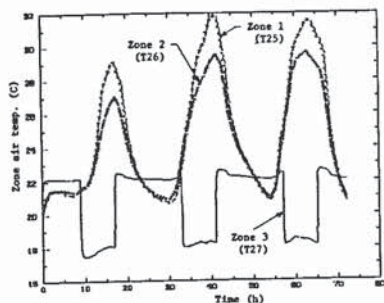

Figure 8. Zone air temperatures in the three-zone model
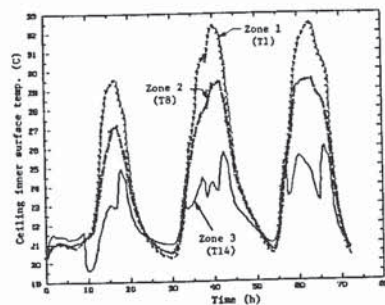

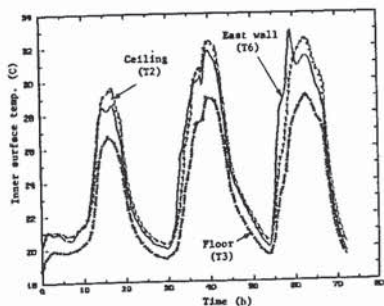Figure 9. Ceiling inner surface temperatures of the three-zone model

Figure 10. Inner surface temperatures of the selected building surfaces in Zone 1
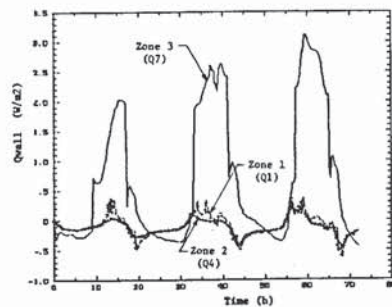

Figure 11. Convective heat flow rates from the building inner surfaces

The BESA Approach

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ABSTRACT

Public Works Canada (PWC), responsible for the design and management of federal real property in Canada, has embarked on a major program involving the improvement and enhancement of state-of-the-art energy analysis techniques for a variety of building types.

The program, Building Energy Systems Analysis (BESA), has three distinct phases. Phase I - "Review" was completed in September 1982 and aimed at identifying software development needs. Phase 2 - "Development" will see the development of a comprehensive building design and analysis software package. Phase 3 - "Support" will address the maintenance and support of the software on a national basis.

Phase 1 addressed itself to the identification of current and potential uses of various energy analysis tools, present weaknesses in existing software, and the industry's views on energy analysis in general. Based on a nation-wide survey of practicing engineers, architects, property managers, and researchers, and subsequent discussions with program developers, PWC developed a philosophy for the BESA package.

The author presents an account of the development phase, including specific details of the software development strategy with emphasis on user interface capabilities, reviews the status of the project, and discusses plans for nation-wide support.

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RESUMÉ

Travaux publics Canada, qui est responsable du design et de la gestion des biens immobiliers du gouvernement fédéral, a lancé un programme d'envergure qui vise à mettre au point et à appliquer des techniques de pointe à l'analyse des systèmes énergétiques de divers types de bâtiments.

La réalisation du programme BESA ("Building Energy Systems Analysis") se fera en trois étapes. La première étape, qui a été menée à terme en septembre 1982, visait à cerner les besoins auxquels les progiciels devaient répondre. C'est au cours de la deuxième étape que seront développés les progiciels d'analyse des systèmes énergétiques, progiciels qu'on voudrait le plus complets possible. La troisième étape est celle de la maintenance des logiciels et du soutien à accorder aux utilisateurs à l'échelle nationale.

La phase 1 a permis de définir les utilisations courantes et possibles de divers instruments d'analyse énergétique, de cerner les lacunes des logiciels existants et de recueillir le point de vue de l'industrie sur l'analyse énergétique en général. A partir des renseignements obtenus à l'occasion d'un sondage national mené auprès des ingénieurs, architectes, gestionnaires immobiliers et chercheurs, et suite aux discussions qui ont eu lieu avec les concepteurs des logiciels, TPC a arrêté les principes généraux qui le guideront pour la réalisation des progiciels BESA.

Dans la description qu'il fait de la phase de développement, l'auteur explique en détail la méthode utilisée pour élaborer les progiciels, laquelle accorde une grande importance à l'interface utilisateur. Il fait également le point sur l'état d'avancement du projet et examine de quelle façon le soutien nécessaire pourrait être offert à la grandeur du pays.

OBJECTIVES

BESA is an applied R and D initiative aimed to assist engineers, architects, property managers, building owners and operators with the design and management of both new and existing energy efficient buildings.

BESA addresses various stages of the building design and management cycle such as Pre-design, Concept design, Detailed design, Commissioning and Operation, and Retrofit. By featuring many technical capabilities that do not presently exist, BESA builds on and enhances present state-of-the-art energy analysis programs. Thus BESA features powerful design tools in addition to its analytic capabilities.

BACKGROUND

PWC began using energy analysis programs in 1974/75 with a view to conserving energy in its building stock. At that time, PWC supported the Meriwether Energy Systems Analysis (ESA) program and provided training on its use to engineers across Canada. This action was partly in response to the energy
crisis of 1973 and partly because computers were becoming an important tool in heating and cooling load calculations. As some of you may know, the use of computers in the design and analysis of building mechanical and electrical services systems was first accepted by the consulting industry in 1965.

Since that time over 100 energy analysis programs have been developed by both the public and private sectors, each capable of performing analysis of the building envelope, and mechanical and electrical systems.

Our feedback from industry has suggested that currently available programs are not being used to their full potential due to the fact that many programs are difficult to learn, too complex to use, poorly supported and costly to run.

APPROACH

PWC's approach has been to first clearly identify user needs, and then to develop appropriate software package(s) to address those needs.

To clearly identify user requirements, PWC and Candaplan Group Inc. conducted a national survey of user needs for the design and development of the BESA Software programs during the months of May and June, 1984.

Over 400 participants who attended the one day symposium, held in nine major centers across Canada, took a preliminary look at BESA, discussed its appropriateness to their professional needs and gave us suggestions, criticism and an indication of priorities. In addition, the participants voluntarily filled out a questionnaire. Here are some of the highlights of the questionnaires:

Figure 1:   Refers to the distribution of attendees by discipline.

Figure 2: Illustrates the mix of small, medium and large companies. Numbers in parenthesis refer to the sum total of employees.

Figure 3: It is interesting to note that a large percentage of small firms already own Microcomputers.

Figure 4: Twice as many firms own IBM PCs as do Apple and Radio Shack.

Figure 5: It is interesting to note that a large percentage of firms who did not own Microcomputers were planning to acquire the equipment in 18 months time, which is about now.

Figure 6: A great majority of the firms did not consider $8,000 or above an exorbitant expense for the Microcomputer equipment.

Figure 7: With the exception of the Detailed design stage in every other design stage, firms plan to use computers a great deal more than their present usage. Retrofit however, had the most appeal to all size firms.

Figure 8: It is remarkable that practitioners plan to use computers for Architectural design, Cost estimating and Life-cycle costing a lot more than for Mechanical and Electrical design at the current levels. This points to an interesting trend in the Architectural and Engineering professions across the country.

Based on this input we fine tuned our approach for the BESA development and adopted the following strategy: that

1. BESA will be divided into 12 software modules addressing the five design stages. All modules will be designed to run on in-house personal computers, and

2. The top priority was assigned to the retrofit module.

Programming for the retrofit programs began in September 1984. To ensure that user needs are being met, a BESA User Review Committee was established in October 1984. Membership on this committee was drawn both from public and private sector users.

The committee has been reviewing and evaluating the BESA software programs throughout its development and advising PWC on its suitability to the professions. In addition, the BESA User Review Committee tested the program along with 12 other BETA test sites that were chosen from the list of attendees at our May-June 1984 symposia. Thus the package you will be using has been put through its paces and as much as possible, all bugs have been fixed. Also a number of improvements have been incorporated to reflect practical considerations.

Obviously, no software program is 100% bug free and BESA is no exception. As with all software programs during their early introduction phase a lot of improvements are possible to make it an even better product. To this end we are committed to providing the user with the most technically advanced product of its kind available on the market today.

Those of you who attended our user survey symposia would remember our stated intentions to privatize the BESA technology when it was developed and ready for commercialization. We believe this should be done as soon as possible so that free market forces decide whether it is a cost effective technology to sustain. The Canadian tax-payer has borne the brunt of the development cost and should not have to subsidize support and maintenance.

It is with this view in mind that Candaplan Resources Inc. has been granted the license to market, support and distribute the BESA programs throughout North America and Overseas. Under the terms of the license agreement, Candaplan is to provide users of the program with both the customer and program support. This will include hot-line services, how to use the program, debugging, updates and new versions. In addition, the purchasers of the program will receive program diskettes and documentation, as well as training in the use of the program.

As the programs will be used by you the user, it will provide much needed feedback to improve on its many capabilities. This we believe is the way to handle communications between suppliers and users of the BESA program.

RETROFIT MODULE

The main components of the retrofit module are pre-audit and audit analysis.

The pre-audit component allows the user to analyze past utility bill and to plot monthly energy consumption by source for the year(s) specified. In addition, it compares the data to an optimum average derived from a database of the same building type. By comparing the building to a standard average, it can be quickly determind whether the building in question is a candidate for further audit analysis. This determination is made on the basis of a variety of building parameters such as age, gross building area, location, energy source and its functional use. If it is established that a building is a candidate for retrofit, an audit analysis may be carried out.

The audit analysis routine first creates a base model of the building from existing physical and operating data input by the user.

Electively, based on the generated model, the building's energy consumption and/or efficiency may be improved by modifying the data previously input through one of the following options:

1. User Specified Changes

   This option allows user-modification of any or all of the base data's individual records. New results are generated automatically upon exit from this routine, and may be viewed separately or in conjunction with the base model.

2. User Selected Energy Conservation Measures (ECMs)

   There are 50+ user selectable ECMs available. Any number of these measures may be chosen in order to evaluate their effectiveness. The program executes each in a cascading manner. Each ECM's priority is assigned on a cost basis. In other words, the least costly measures are run first. In this way, only the incremental savings of each measure are identified. The ECM run generates results in terms of energy. These results may be obtained with or without the base model and/or used as program data for financial analysis of energy savings/penalties.

   The financial analysis option offers choices to determine internal rate of return, simple payback and benefit cost analysis.

3. Parametric Analysis

   This option allows evaluation of the effect of four incremental or decremental values on any one of the variables (e.g. cooling temperature, roof insulation, glazing area, etc...). There are over a dozen variables for which parametric analysis can be performed. This type of analysis allows a comparison with the base model for the purpose of optimization.

PROGRAM FEATURES

1. Energy calculations are based on ASHRAE's TC 4.7 simplified energy analysis bin method with numerous sophisticated extensions for monthly bin calculations. These include, solar loads as well as state-of-the-art system simulations. Peak load calculations are conducted on a monthly/hourly basis not just for zone loads but also for all system loads being analyzed.

2. Secondary systems and primary plants configurations are simulated through twelve months to determine part load conditions for monthly energy consumption by usage and fuel type and monthly demands. Peak loads (zone and systems) as well as all equipment sizes are determined via hourly calculations.

3. Equipment sizes (CFMS, fans, boilers, chillers...) may be either program or user-defined. In the former case, BESA will automatically determine the size required, and in the latter, will measure the effect of over-sizing through part load conditions.

4. BESA analyzes a multitude of system types and controls including, but not limited to:

- variable air volume systems
- constant volume systems
- constant volume/variable temperature systems
- dual duct
- fan coils
- unitary systems
- heat pumps (water loop, reverse cycle)
- chiller, boilers, double bundle condensers, strainer cycle, etc.

5. Up to five different secondary/unitary systems and twenty-five different zones having glass on ten different exterior surfaces, can be analyzed within one building model. The program allows each primary plant to serve all secondary systems. Secondary systems may be freely mixed to suit the need (unitaries and plant systems). System starting/ending hours can be set as desired.

6. BESA executes extremely quickly. Less than three minutes on an IBM-XT with a five zone/two system model.

7. Hardware configuration and program size.

   - Printer   - 512K RAM   - Colour Monitor
   - IBM DOS 2.1   - 4.5MB Hard Disk Storage   -   90,000 Lines of Code
                       - Math Co-Processor   - Pre/Post Proc. in BASIC
                                               - Over 800 I/O Screens

8. User selectable building category (includes most building types).

9. On-line help available for nearly every screen.

10. Two manuals available

   - General User Manual
   - Technical Reference Manual optional

11. Program provided in both English and French.

12. Metric or imperial units (user selectable for input and output independently).

13. The standard program is issued with weather data for 12 major Canadian and U.S. cities each. Additional weather data are available as an option.

14. Substantial defaulting options, taken from widely accepted sources, such as ASHRAE.

ONGOING DEVELOPMENTS

Retrofit programs are a fully stand alone package ready for use by the professionals. Candaplan Resources Inc. is fully committed to keeping it current with the changing market requirements and/or realities.

Current Public Works plans call for the ongoing development of the remaining BESA modules such as Pre-design, Concept design, Detailed design and Commissioning and Operation. In fact the next module to be released will be the Concept design sometime in July '86. Followed by Pre-design in early '87, and so on.

By developing program modules in phases, allows us to gauge user evaluation of program packages already released, and provides us with the much needed feedback to improve as future planned releases. In addition, we are in the process of requesting the National Research Council in Ottawa and a few prominent Universities to perform validation exercises to validate the BESA Retrofit package.

We have every confidence that the BESA programs are truly state-of-the-art software programs available on the market today. We believe the integrated approach of BESA design tools philosophy is a sound strategy, as this was also confirmed by experts at the August '85 Seattle Building Energy Simulation Conference.

Figure 1

Figure 2
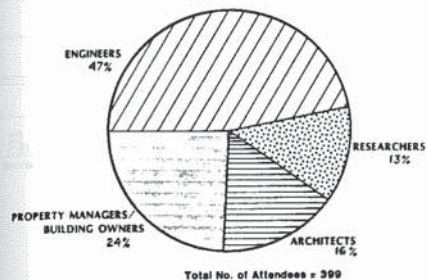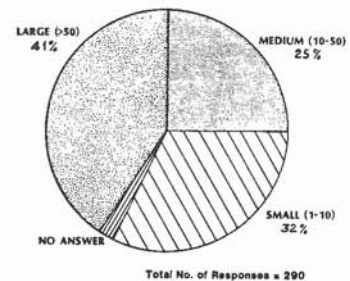

Figure 3

Figure 4

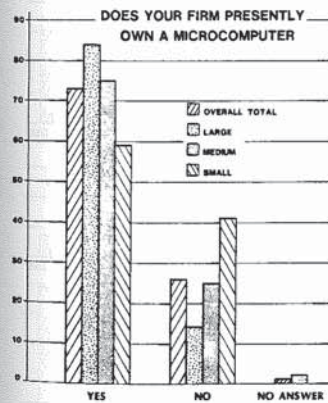DOES YOUR FIRM EXPECT TO PURCHASE
ANY MICROCOMPUTER EQUIPMENT
IN THE NEXT 18 MONTHS

OVERALL TOTAL
LARGE
MEDIUM
SMALL

YES   NO   NO ANSWER

Figure 5

HOW MUCH DO YOU EXPECT TO SPEND ON
MICROCOMPUTER EQUIPMENT
IN THE NEXT 18 MONTHS

OVERALL TOTAL
LARGE
MEDIUM
SMALL

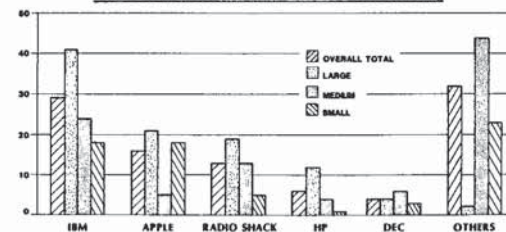$2,000 $2,000 to $4,000 to $6,000 to   > $8,000   NO ANSWER
         $4,000 $6,000
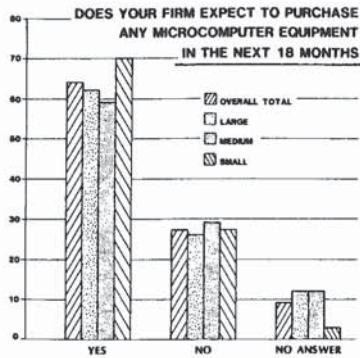
Figure 6

IN WHICH STAGE OF BUILDING DELIVERY DOES YOUR FIRM.
a) Currently use; and
b) Plan to use computers

PRE-DESIGN
USE   PLAN TO USE

CONCEPT DESIGN
USE   PLAN TO USE

DETAILED DESIGN
USE   PLAN TO USE

COMMISIONING
USE   PLAN TO USE

RETROFIT
OVERALL TOTAL   MEDIUM
LARGE   SMALL
USE   PLAN TO USE
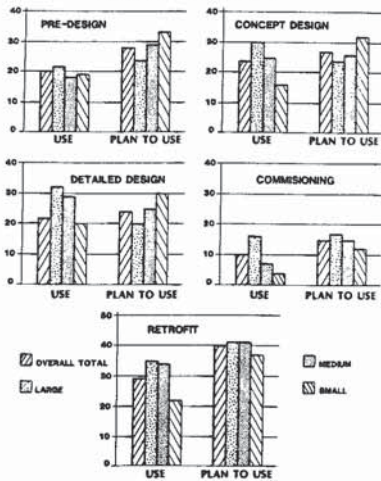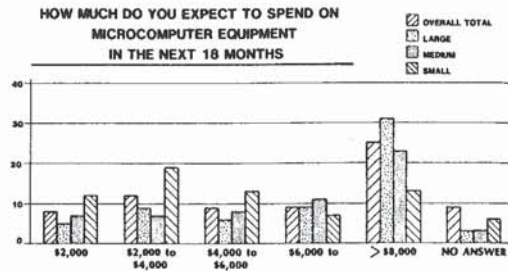
Figure 7

IN WHICH ASPECT OF THE DESIGN PROCESS DOES YOUR FIRM:
a) Currently use; and
b) Plan to use computers

OVERALL TOTAL   MEDIUM
LARGE   SMALL

ARCHITECTURAL DESIGN
USE   PLAN TO USE

ENERGY ANALYSIS
USE   PLAN TO USE

MECHANICAL DESIGN
USE   PLAN TO USE

ELECTRICAL DESIGN
USE   PLAN TO USE

COST ESTIMATING
USE   PLAN TO USE

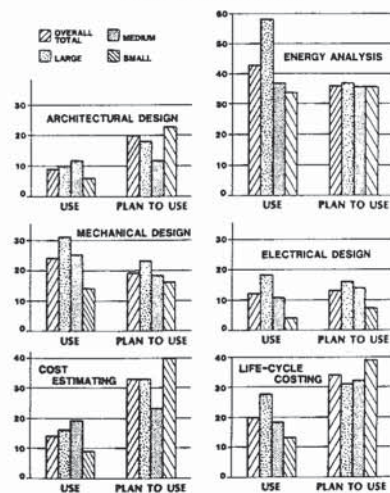LIFE-CYCLE COSTING
USE   PLAN TO USE

Figure 8

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4) Proposed Procedures for Simulating the Performance of Components and Systems for Energy Calculations, American Society of Heating, Refrigeration and Air Conditioning Engineers, Edited by W.F. Stoecker, New York, New York, 1969.

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