DEVELOPMENT OF AN EVALUATION PROCEDURE FOR BUILDING ENERGY DESIGN TOOLS

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ABSTRACT - The objective of this paper is to describe the development and limited application of a systematic procedure for investigating, evaluating and reporting on building energy design tools. This development process consisted of two steps, with the completion of an extensive evaluation procedure in a workbook format as the culmination of this process. The final evaluation procedure has been applied to four public domain building energy design tools, and the results will be described herein.

INTRODUCTION

Over the past several years, the Department of Energy (DOE) has produced a number of new methods (or tools) for analyzing conservation and passive solar heating, cooling and daylighting strategies. Private energy consultants have expanded upon this work by developing methodologies of their own. The products of these efforts have been accepted slowly by the mainstream of the building design industry. This has been due to several factors. Among the factors are the slow penetration of solar technology into the mainstream building community, a lack of full understanding of the best applications of the tools (i.e., what stage of design and what types of projects), a fear of the cost and learning time required to use them, the time required per tool application, the data that tools require may not be available in the form required, and confidence in the results is not always high.

To help government and industry sort out some of these problems and issues, the Building Design Tool Council (BDTC) was formed. BDTC is an association of over fifteen national building trade groups, professional societies, and research organizations. One of its first projects, under DOE sponsorship, was to assess the state of the art of building energy design tools and to develop an evaluation procedure for these tools. A project team was assembled to perform the work for BDTC, with the majority of the effort administered by the American Consulting Engineers Council Research & Management Foundation (ACEC/RMF).

This paper concentrates on the development of the evaluation procedure. It is important to note that tool evaluation in the context of this project does not mean tool validation. It is a step or two below validation in technical rigor, cost and expediency. However, it is intended to provide a reasonable means to determine tool capability and enable the user to readily select the tool (s) which best is suited to a particular need.

The development of an evaluation procedure necessitated defining the term "design tool". A definition was derived for this project, which states that a design tool is any device which assists the user in formulating and/or evaluating energy efficient strategies for new or existing buildings. Using this definition, the evaluation procedure included passive solar as well as conservation design tools. This project reviewed past evaluation efforts and created a new categorization for all building design tools. Once this step was completed, the evaluation procedure was created, concentrating on the tool categories which are of greatest interest and use in the design community.

STEP 1: REVIEW AND ASSESS PREVIOUS EVALUATION & CATEGORIZATION EFFORTS

The purpose of this first step was to establish a base of knowledge from which the development of the evaluation procedure could proceed. This was accomplished by identifying and reviewing (where possible) published reports and results of previous design tool surveys and evaluations. This review process was aimed at providing an objective assessment of the merits and pitfalls of the past attempts.

One of the major results of this effort has been the development of matrix of over 50 evaluation performed. The matrix provides an easy to reference listing of the different types of evaluations and surveys that have been performed, their authors, and date published. Each listing is identified as one of the following types:

- o Survey
- o Categorization/Evaluation/Comparison
- o Calibration/Validation
- o Bibliography
- o Other

This matrix provided the basis for the development of a design tool categorization method. Since design tools have been developed and produced with a wide variety of capabilities, formats and levels of complexity, it was necessary to segment design tools by function into logical categories based upon design tool technical approach. Figure 1 shows the design tool categorization "tree" which was created, with the dark outline showing the path which this project has taken.

This categorization "tree" starts at the highest level (or tier) with a division between analysis tools (tools which calculate or evaluate a problem) and strategy tools (tools which offer specific

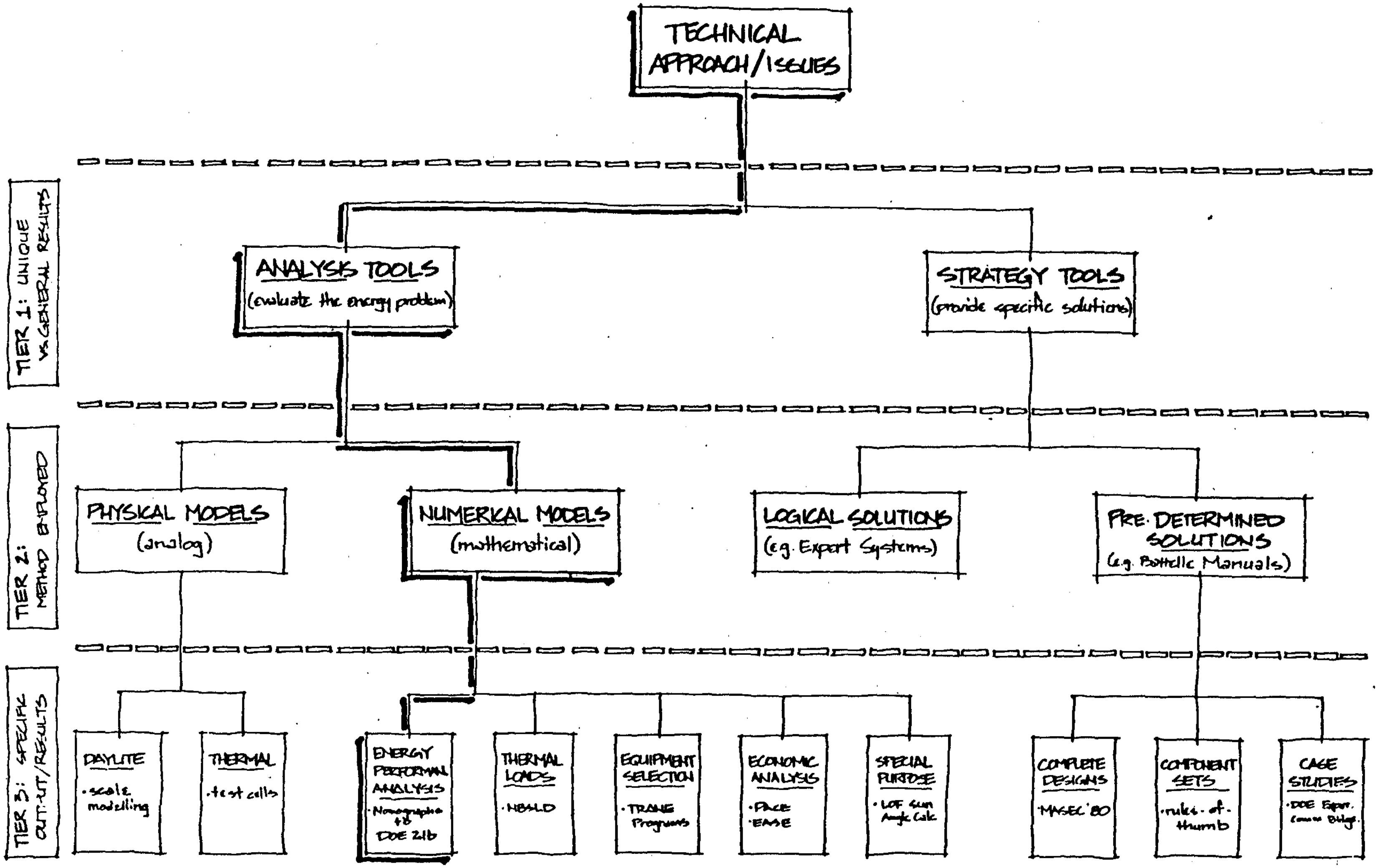

FIGURE 1. CATEGORIZATION 'TREE'

solutions). Under the analysis tools tier, physical models (such as test cells) and numerical models (purely mathematical functions) exist. At the level of tier 3, under numerical models, is a variety of categories. The most prolific, is the category labeled Energy Performance Analysis. This is where the preponderance of previous evaluations and validation work has been accomplished, and it was thus the starting point for the development of the design tool evaluation procedure.

STEP 2: DEVELOPMENT AND TESTING OF THE EVALUATION PROCEDURE

The purpose of this second step was to produce an evaluation procedure (EP) which addressed both the technical capabilities and user utility features of design tools. It was noticed in the first step that most previous evaluation efforts had focused entirely on the technical side, with little or no mention of the important user features. Thus, a decision was made at an early stage that this EP was to be developed with equal weight given to both technical capabilities and user features.

Two other significant decisions were made in the approach to the development of the EP. First, the EP was created with the intent that it would be completed by a knowledgeable tool user/developer under the sponsorship of professional or trade organization. The project team quickly recognized the fact that the value of the results of a tool evaluation would be directly related to the quality of work done by the tool evaluator, and hence decided that it would be best for the EP to carried out by an individual with an extensive background in the use of design tools. Further, this tool evaluator must not be affiliated with the development (and/or sales) of the design tool under evaluation.

The final important decisions regarding the approach to the development was that the EP must include numerical annual energy calculations using standardized building data sets. The impetus for this decision was that the design tool will be used in building design, and hence results of the numerical calculations for predicted annual energy performance are an integral part (but not the only part) of the technical evaluation. Whereas some may argue that the results are more important than how the answer is derived, the project team decided that this technical aspect should be given equal weight to the other technical characteristics. Building data sets of a sample residential building and a sample commercial building are included for the energy calculations.

With these approach issues settled, the EP was created. As shown in Figure 2, there are three major sections:

- User Utility Characteristics
- Technical Capability Characteristics
- Final Report

This figure also shows the individual characteristics examined in each of the first two sections, and the elements of the final report. Written in a workbook format, the EP also contains an initial section containing the operating instructions, which describes how the workbook is to be completed. Figure 3 shows the Key Characteristics List, one part of the final report which provides a quick overview of tool features. The other two parts of the final report provide additional detail from the completed worksheets. An example of completed worksheets and a completed final report is given in the Operating Instructions section of the final EP (1).

After the EP was finalized, the project team decided it would be best to use the procedure on four public domain energy performance design tools. This would provide a comparison of tool strengths and limitations and begin assessment of tool development needs. The EP was implemented on the following tools:

- ASEAM (Version 1)
- CALPAS3
- CIRA
- SERI-RES

Independent tool evaluators, who had exhibited a solid knowledge of these design tools, were given the EP with an assignment to complete all worksheets and produce the three part final report. All work has now been completed, and final reports on each of these four design tools are available (2).

CONCLUSIONS

Two overall conclusions have been derived from this project:

1. Building energy design tools exhibit a wide range of features and applications. When the project team first attempted to classify tools, the array of possibilities was immense. In an effort to bring about a meaningful system of classification, simplicity was an overriding criteria. This conclusion again surfaced when the task of collecting all user and technical features was undertaken. In order to perform this task, several review cycles were necessary to gain valuable insight into which features should and should not be included. The project team is confident that the final document represents the best effort for the current generation of design tools, but updating this evaluation procedure will surely be necessary.

2. The EP which has been developed can be readily used to identify and evaluate design tools to provide both DOE and the private sector with a better idea of where gaps and limitations exist. While this was not the main reason for producing the evaluation procedure it is a function for which it can be used. This would be an aid to those who want to see what design tool features have been developed, and what features need to be developed. As a standard measurement mechanism for design tools, this procedure serves both the needs of the private design community and those who are charged with planning for future design tools.

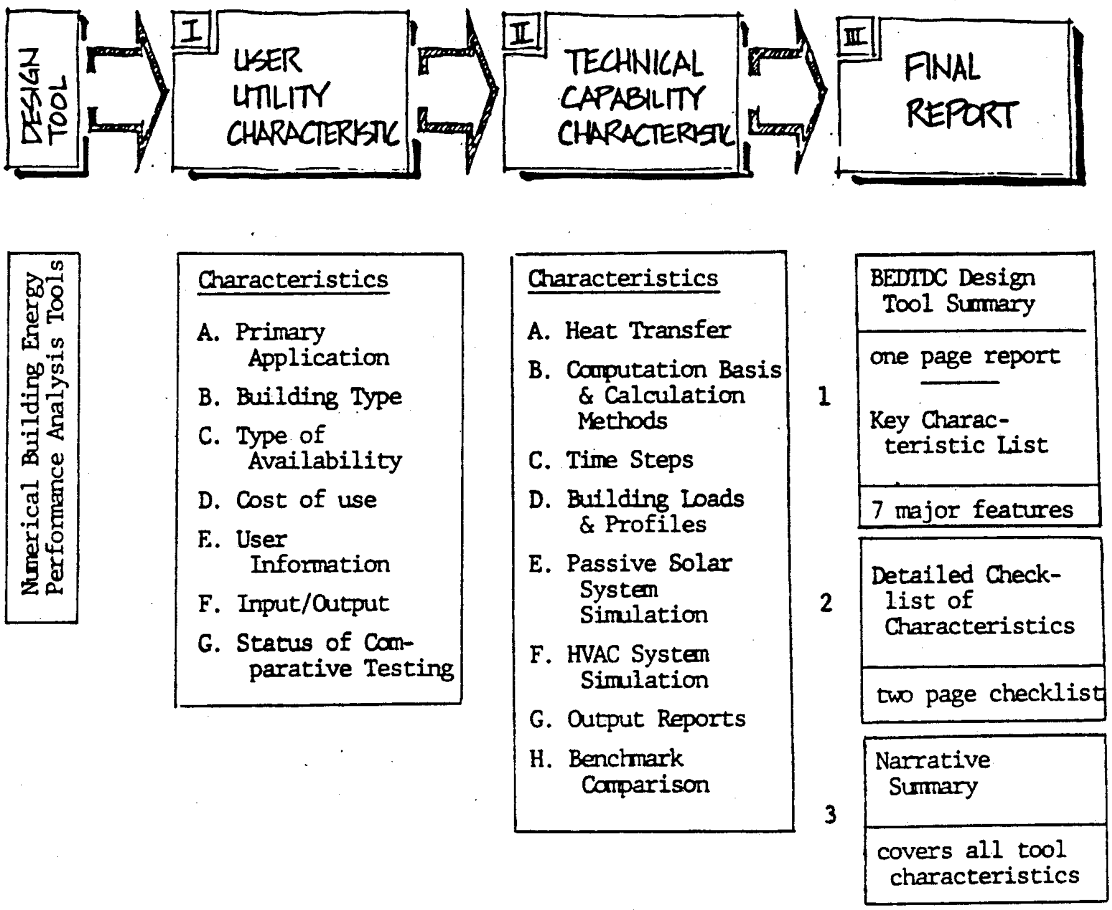

FIGURE 2. EVALUATION PROCEDURE SECTIONS

- ■ Name of Design Tool: BLAST (Building Load Analysis & System Thermodynamics)
- ■ Design Tool Category: Numerically based annual energy performance tool
- ■ Primary Application of Tool:
  - Building Design Phases ☑
    - — Programming ☐
    - — Schematic ☐
    - — Design Development ☑
    - — Construction Documents ☑
  - Research ☑
  - Education ☐
- ■ Applicable Building Type:

	HTG	CLG	DHW	LTG	Misc.	Other
• Single Family Residential	☑	☑	☑	☑	☑	☐
• Multi-Family Residential	☑	☑	☑	☑	☑	☐
• Small Commercial	☑	☑	☑	☑	☑	☐
• Large Commercial	☑	☑	☑	☑	☑	☐

- ■ Form of Tool Availability:
  - Manual/Hand Method ☐
  - Programmable Calculator ☐
  - Microcomputer ☐
  - Mini/Mainframe Computer ☑
- ■ Conventional HVAC Simulation Capabilities:
  - Seasonal/Annual Efficiencies ☐
  - Dynamic Equipment Simulation ☑
    (Specify major types: ______)
- ■ Alternate Energy Simulation Capabilities:
  - Active Solar ☑
    - — Space Heating ☑
    - — DHW ☑
    - — Industrial Process Heat ☐
  - Passive Solar ☑
    - — Space Heating ☑
    - — Space Cooling ☐
    - — DHW (thermosyphon) ☐
  - Other (specify ______) ☐
- ■ List Price: $ ______

FIGURE 3. KEY CHARACTERISTICS LIST

REFERENCES

1. Evaluation Procedure for Building Energy Performance Prediction Tools, Vol. 1. July 1984. Report prepared by Building Energy Design Tool Development Council, c/o ACEC/RMF, 1015 15th St., NW, Suite 802, Washington, DC 20005.

2. Final Reports for ASEAM, CALPAS3, CIRA, and SERI-RES available from: ACEC/RMF, 1015 15th St., NW, Suite 802, Washington, DC 20005.

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- CALPAS3 W.S. Fleming & Associates
- CIRA: Potomac Energy Group
- SERI-RES: Prof. Patrick Burns, Colorado State University