BRINGING ORDER TO THE ENERGY SIMULATION PROCESS

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ABSTRACT - Building energy simulation practices have become a myriad of approaches and computer programs. The US Army Corps of Engineers, as the largest engineering organization in the country, has been exposed to most of these differing simulation techniques.

Engineers who are cognizant of the-energy simulation criteria details and computer program applications find it difficult, professionally, to accept at face value the results of energy studies. The type of program used, the ability of the program user, the methodology dictated by the criteria all weigh heavily on the validity of the analysis. If the decision makers (in this case, building owners) are unaware of limitations in the energy analysis tool used for design studies, they may be led into making an incorrect architectural or mechanical system selection.

Providing consistently credible energy studies would appear to be in the best interest of the energy simulation community. Certainly, support in this effort is expected from the building owners and users.

This paper describes the recent efforts by the Corps in addressing these issues. Recommendations for the future are presented.

INTRODUCTION

The U.S. Army Corps of Engineers (USACE) is the largest engineering organization in the country. The Corps manages the design and construction for Army and Air Force installations in the U.S. and other parts of the world. The combined major construction program for the Army and Air Force in the current fiscal year (FY85) is approximately $2.8 Billion spread over 634 projects. In next fiscal year the program is expected to grow to $3.5 Billion and include over 800 projects. (1)

As required by Congress, the designs of each of these projects must consider energy conscious alternatives that may reduce the energy consumption of the building. The selection of which alternatives to design into the project is determined by a combination of both energy and economic analyses following specific criteria and methodologies. (2,3,4) Since over 80% of these studies is performed by contracted private architectural / engineering firms (1), the Corps policies applied in energy analysis (EA) have rippled throughout the country's building design community. The Corps treats this effect as both an opportunity and a responsibility; the opportunity to participate as a senior partner of the design and construction industry and the responsibility to do so with wisdom.

The conduct of Corps sponsored EA studies is constantly scrutinized both internally and externally because of the amount of resources that must be devoted to the effort. The Corps continually looks for ways to improve the efficiency and pay back of these studies. Some of the USACE concerns related to the current EA simulation process follow.

Building energy simulation programs proliferate the marketplace. One can select from several EA computer programs that will fit any hardware environment from mainframe to pocket calculator. If enough information were available for the designer to make an informed selection of an appropriate program, the proliferation of program choices would have benefit to the design community. Unfortunately, the information to make the application selection is not adequate nor is it always available.

The procedures and standards by which the energy efficiency of a building is analyzed and judged are as varied as the computer programs by which consumption is calculated. Attempts to standardize EA criteria provides some relief. ASHRAE 90 (as well as the current proposed revision), by virtue of its three separate methodologies, exemplifies continuing arguments which bar the adoption of a single energy analysis approach.

One of the obvious losers in the process is the building owner for he / she is not likely to realize that design decisions are being made on the basis of data that is dependent upon the philosophy and thoroughness of the designer. For example, the designer has been shown to be the key to the calculated energy consumption. (5) Energy studies are not made equal. EA remains an art but should be a science.

The U.S. Army Corps of Engineers is particularly sensitive to these issues; because of the sheer number of building projects, the Corps is exposed to a large variety of EA programs and approaches. As designers, we are confused by the proliferation of EA software. As building owners and operators, we rebel against the lack of clear cut guidance when making energy design decisions. More credibility, perhaps in the form of a means to categorize EA programs and their capabilities, is needed.

The Corps has been making a concerted effort in the last few years to improve our EA effectiveness. Meetings with building researchers, designers and owners, software developers, vendors and users, policy makers, interpreters and implementers have been conducted in attempts to determine the state-of-the-art. A Technical Center of Expertise (TCX) for Energy Analysis Programs and Energy Performance Standards has been appointed to continue this evaluation process and advise of its findings. An active research program is conducted to improve the quality of existing EA tools and to propose new application areas for EA tools.

EARLY ENERGY ANALYSIS APPROACHES REVIEWED

Executive Order 12003, signed on 20 July 1977 by President Carter ordered federal agencies to reduce the energy consumption of 1985 buildings by 45% when compared with those of 1975 vintage. (6) The Department of Energy (DOE) was tasked to devise guidelines for the Federal Departments such as the DOD to follow in achieving this goal. Energy budgets expressed in annual millions of BTUs per square foot per year were born. (7) To a limited degree the private sector followed.

The DOD, as the largest building owner in government (8), was placed at the cutting edge of this mandated new thrust. The impact was to be lasting and significant. Despite the development of some early versions of energy analysis computer programs, such as NBSLD, Trane TRACE, and BLAST to name some, the DOD was ill prepared in 1977 to set energy budget targets much less calculate projected consumption accurately. The methodologies and tools used to calculate building energy consumption were imperfect at best and the validity of their results was entirely dependent upon the skills of the user.

The Corps and the rest of DOD struggled to cope with this mandate. Hundreds of energy studies were conducted by in-house and private

sector designers with considerable increase in design costs which have not been fully measured to date. Aggressive new prescriptive design standards particularly for the building shell became policy. (9) As the usage of EA tools increased so did the number of tools to choose from. But the energy consumption of buildings as modeled and metered decrease significantly. (10)

With all the EA tools available (sole sourcing these tools was not permitted) (11) and with all the policies adopted (the Army, Air Force and Navy although governed by DOD central policies interpret and implement these policies in ways which are not always consistent), a state of confusion existed. This confusion within the Corps was shared by the private architectural / engineering firms they hired.

THE STATE OF THE ART

The DOD, pending issuance of draft policy revisions centering on ASHRAE 90, continues to calculate energy budgets for its buildings either through independent case by case energy studies or by reference to past studies with good correlation, using numerous EA computer programs. The effectiveness of all these studies is questionable at this stage because of the stringent DOD shell criteria which provides for an energy efficient shell design. A recent study of several new building designs at Fort Riley, Kansas revealed that additional energy consumption savings beyond that achieved with current prescriptive standards was not significant. However, another set of studies performed by the Sacramento District proved that this shell criteria, under certain circumstances, was not cost effective. More needs to be learned about the appropriateness of prescriptive standards and the correct applications of independent energy studies.

Another area which hampers our EA effectiveness is that the independent reviews of these studies conducted by the Corps is constrained by a lack of expertise in the nuances of all the energy programs and methodologies. To some degree, the EA reviewer is at the mercy of the analyst who prepares the building simulation.

The stress on facilities energy conservation continues unabated in the federal sector despite the leveling off of energy prices. However, the thrust of the policies is changing. Pending DOD criteria deemphasizes energy budgets and strict prescriptive standards in favor of case by case optimization studies. Prescriptive criteria in accordance with congressional mandate (12) will fall from the stringent DOD standards to the industry standard, ASHRAE 90. Continuing the thrust of recent years, design decisions will be guided by a comparison of the life cycle costs of various alternatives; the respective energy consumption of each alternative not withstanding. The private sector and the states are already beginning to follow this philosophy.

The ability of our EA tools to accurately model the comparative energy consumption of alternatives is still very questionable. A study performed by the Army's Construction Engineering Research Laboratory (USA-CERL) in 1984 (13) showed a wide variance in the calculated energy consumption for building shell design alternatives from one EA computer program to the other. In addition, methods for calculating the life cycle facility costs have typically varied in the federal sector (between the Army, Air Force and Navy). Very likely, a designer could select one alternative based on Air Force economic criteria and a different one based on Army economic criteria using results taken from a single energy study.

The private sector owners and designers suffer under a similar malaise. Designers working for private owners are free to select the EA tools of their choice; it is equally unlikely that they are aware of the strengths and weaknesses of the various energy analysis programs. In the ideal situation, designers and researchers would be aware of the applicability of each energy analysis simulation program and would be able to access any combination of such programs easily. Simple buildings with shell dominated loads would be analyzed with simple straightforward programs or hand calculations. Passive solar designs would be evaluated by a certain set of computer programs.

HVAC system alternatives would be analyzed by another set. In more comprehensive studies, the designer might select several EA tools from among these sets. Short time step analyses for research and development studies would be performed by another distinct set of programs.

As in other software markets, many EA computer programs are shielded under corporate proprietary rules. Regardless of their probable validity, proprietary programs remain suspect by virtue of the secrecy surrounding them. Government public domain programs are embattled by cries of the alleged unfair competition they offer to privately developed programs. Independent software developers attempt to discredit EA programs produced by equipment manufacturers and vice versa. The result is a lack of credibility for all EA programs.

The designer, the design, the building and the owners all suffer from a "failure to communicate" completely the limitations and alternatives of energy simulation. It is particularly important to begin the process of improving communications and restoring credibility of EA simulations. The services of energy analysts, barring an energy price shock of some kind, will not be in full demand until a cooperative game plan is devised that tackles these problems and concerns. Indeed, with the reduction in federal, state and local subsidies for building energy conservation, building owners "will be even more discriminating in terms of efficiency, reliability, and pay back - as well as up front costs in contracting for any energy conservation improvements". (14)

THE BEGINNING OF THE COOPERATIVE PROCESS

Over the past two years work has begun on improving the understanding between the parties in the EA field. The authors have personally met with representatives of DOD and its three services (Army, Navy and Air Force), DOE, National Bureau of Standards, Lawrence Berkeley Laboratories, University of Wisconsin, Solar Energy Research Institute (SERI), Automated Procedures for Engineering Consultants (APEC), The Trane Company, American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE), private consultants and others to discuss EA matters generally and specifically. The Carrier Corporation, Elite and other producers of EA software have also been contacted. The objective of these discussions was to search for ways to improve the effectiveness of EA for the Army. It is the authors' opinion if Army EA studies are improved the entire EA community stands to gain in the process.

During this period through these and other initiatives the following improvements have occurred:

a. The DOD has established a tri-service committee to produce common energy conservation criteria. There will be pressure on the services to implement the criteria commonly as well. The result should be less confusion for in-house and contracted out DOD designers and project managers.

b. The DOD has established a tri-service committee to produce common economic analysis criteria. Action of this committee has already begun; the Air Force and Army have recently adopted like criteria. This standardization not only reduces confusion it permits the analyst to begin to understand patterns which can be applied to other services' studies.

c. DOE has updated the fuel escalation values that are used in the economic calculations. (15) DOE has also planned yearly updates for these values. Yearly updates of these values will add credibility to the process and improve the decisions which result from economic analyses since the differential escalation values will be more current.

d. A simplified economic analysis computer program, LCCID (16), has been developed by USA-CERL that will permit the analyst to produce life cycle cost studies meeting any DOD services' criteria. This program is public domain and has been intentionally developed to assist the designer in achieving the correct economic analysis calculation without having to refer to the

criteria documents. Versions modified by software vendors will be evaluated and certified as equivalent by the Corps Missouri River Division. Incorporation of this program into existing EA programs will enhance the chances of the EA program being used for DOD work because of its ability to meet DOD economic criteria.

e. Cooperative work has begun with Trane and APEC to increase the availability of their software products to the Corps. Other software vendors are encourage to follow suit. Discussions include solving licensing agreement problems and negotiating Corps wide rates.

f. The Corps is an active participant in plans for the DOE sponsored project to produce a new energy analysis tool for the research community.

g. The Corps has established a Technical Center of Expertise (TCX) for Energy Analysis Computer Programs and Energy Performance Standards at its Missouri River Division in Omaha, Nebraska. This office will coordinate the evaluation of EA tools and recommend suitability for Corps wide application. The TCX will stay attuned to the state-of-the-art in EA and Energy Performance Standards in order to act as a consultant to the Corps policy makers and USACE design districts and divisions.

h. Efforts are underway at USA-CERL to develop improved EA tools. The selection of R&D to be performed is guided by various user groups such as the BLAST User Group so that the R&D is germane to the end user's needs. The testing of these tools and their technology transfer is governed by a high level steering committee called the Corps of Engineering National Energy Team. The philosophy adopted in both the user group strategy and the steering committee is that end users should guide the direction of the research. Each R&D product is thoroughly evaluated for its suitability for transfer to the private sector (e.g. design engineering community and building operators). Proven software products, developed using public funds, become public domain so all can benefit from the development.

i. A more active role by Corps designers and reviewers in ASHRAE and other industry wide councils is being pursued so that the knowledge and experience of the Corps and these councils is freely shared.

j. A wide area computer network called the Corps of Engineers National Energy Network has been set up between Corps offices as a means to improve communication on EA studies and other energy topics. Through electronic mail, file transfer, and bulletin boards, lessons learned in EA are shared Corps wide. The network will be used to update management information data bases that track energy programs and milestones. New computer programs and enhancements to existing programs may be tested via the network prior to deciding to implement them Corps wide.

CONTINUING THE COOPERATIVE PROCESS

The Corps will continue efforts to increase the dialogue within the EA community with the twin objectives of improving the life cycle cost effectiveness of the buildings designed and constructed and reducing the resources devoted to the effort (design cost, time and manpower). These objectives at first seem to run counter to each other. Normally, to place emphasis on an area dictates increased effort, not less. It is the authors' opinion that the state-of-the-art has reached a point where both objectives can be achieved simultaneously.

Emphasis on ASHRAE 90, optimization, and alternative analysis will steer the Corps designers on a more sophisticated course than the energy budget era. After the Corps integrates new industrial standards into design scopes of work, both in-house and private sector designers will benefit from being able to speak the same language on energy conservation criteria.

With the establishment of its new Technical Center of Expertise and National Energy Team, Corps designers will be able to share representative studies with each other thereby reducing redundancy. This sharing may not reduce the actual number of energy studies performed, but it may clarify when

they should be performed and on what range of alternatives. The research efforts of the USACE labs in conjunction with the Technical Center of Expertise, National Energy Team and various Users Groups will continue to devise more effective energy analysis tools, studies and methodologies. The next generation of energy criteria will ideally be based upon the results of such research efforts.

The implications of the efforts of the Corps to non-Corps work can be easily seen when one considers that these efforts will be guided by the same criteria that guides the rest of the energy analysis community. Likewise the findings by the private sector can be more easily transferred to the federal sector.

CONSIDERATIONS FOR THE FUTURE

The principal consideration for the EA community should be to increase the value of our product (energy analysis) and its demand to our customer, the building owner and operator, by delivering designs with more savings for the expended effort. When implementing any changes to the process, one should consider the following:

a. Recognize that there is not, and likely will never be, a single energy analysis tool to fit every energy study need. The building construction industry is too diversified to expect a single EA tool to exist that can fully analyze the relative merits of every building component and design strategy. EA tool developers should be encouraged to select a market niche in which to excel.

b. Pay more attention to analyzing the energy efficiency of new and future building materials, systems and equipment. If new product development can be supported by specialized EA tools, research in these areas will be enhanced.

c. Address owners concerns regarding the air and environmental quality of spaces designed to optimal energy criteria. Energy analysis must be constrained by the functional needs of the spaces.

d. Understand the objectives of the building owner in having the energy analysis performed. This understanding may often be reduced to being knowledgeable of the clients economic ranking criteria. Other times the owner will be swayed by aesthetics or high technology approaches.

e. Consider methods for sharing technology and software development which simultaneously protect the proprietary developments. If these methods could be implemented, software research enhancements could be tested within existing frameworks for feasibility of incorporation. In addition, the software user might be able to pick the parts of each software that are appealing to him / her (for whatever reason). At the very least, keep lines of communication open between EA software developers.

f. Consider methods of a single input and output interfaces for the EA tool user. This would additionally allow comparisons of EA tools simply.

RECOMMENDATIONS

The cooperative process should continue in earnest. In keeping with the above guidelines, the authors would support the following developments:

a. Monitor the future development plans for public domain EA tools to assure they will address the legitimate needs of the client and ultimately the building owner and operator. Seek the clients' direct input through product / system users groups. Emphasis should be placed on transferring the developments easily to the private sector tools.

b. Urge DOE to emphasize the needs for better research EA tools with which new and future building products can be simulated and the more complex heat transfer problems solved. This should be the major thrust of the next generation of EA tools. Establish an industry wide users group to guide its development and technology transfer process.

c. Establish a building energy simulation industry forum or steering committee that will meet periodically to discuss developments and problems of the EA community.

This forum could first establish an industry wide charter that projects EA as a cohesive engineering science.

d. Support the standardization of energy analysis criteria in building design and construction so that designer and owner alike better understand the objectives of the analysis.

e. Work actively to validate the results of energy analysis under the conditions by which the building was modeled to improve the credibility of the EA tools and approaches. Devise means to analyze and measure the cause and effect of occupant dependent variables such as operating hours, swings in internal loads, failure to properly maintain equipment and systems, occupant manipulation of control devices. Provide information that will educate the building owners and operators how to come closer to the energy consumption projected by the design by using sound maintenance and operating practices.

f. Review the marketing strategy for private sector EA tools. Consider methods for achieving greater dissemination of the program or product such as more flexible licensing agreements and corporate wide rate structures.

g. Direct EA studies to areas offering the best return on the client's investment. Publish results of significant findings to improve the level of awareness in the EA community.

h. Provide first class technical support to users of EA tools.

i. Actively work with the Corps organizations supporting energy analysis by participating in the testing and technology transfer of new tools and approaches developed in USACE labs. Seek USACE input in the initiatives undertaken elsewhere.

CONCLUSION

The Corps of Engineers is heavily involved in a reappraisal of its building energy analysis work. The Corps is vitally interested in reducing the present chaos in the EA community that results from its lack of a clear, cohesive strategy. This reappraisal includes the development of in-depth expertise into EA tools and standards. The Corps has the capability to effectively use their expertise for the benefit of the DOD and the general EA community. The hallmark of all these efforts is and will continue to be an active campaign to produce cooperative dialogue between competing members of the EA community.

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