The Energy Waste Information Tool (EWIT) program developed by the New Mexico firm of Area, Inc., offers architects and environmental designers a new and viable means to model the energy performance of their building designs while in the schematic phase by means of a personal computer. Previously the only way that such data could be obtained was by purchasing time on large mainframe computers to run such programs as BLAST or DOE II. EWIT, however, is a program designed specifically to be run on the IBM personal computer; a machine well within the means financially of even the most modest office. The program yields data proven accurate to within 80-90% of the aforementioned BLAST and DOE II mainframe programs.

The purposes of this research effort is to investigate EWIT's potential as a tool for evaluating retrofit options for existing commercial buildings. To achieve this goal two case buildings in the Denver area were analyzed by means of the EWIT program. The first building is a one-story structure of 10,000 square feet in floor area while the second is a hi-rise office building of almost a million square feet. The goal of the project is to produce a documented procedure for utilizing EWIT in retrofit applications and in the process develop VISICALC financial templates that can be integrated with the output from EWIT which would provide a comparative economic basis where the merits or shortcomings of various retrofit options can be quickly determined. While the above two case studies were conducted, space limitations would allow only the findings for the smaller structure (day care center) to be published in these proceedings. However, this case study does present a comprehensive picture of the EWIT retrofit analysis and its potential to architects and designers.

**BASIC PRINCIPLES AND OPERATIONS OF THE EWIT PROGRAM**

EWIT is a machine language program written for one exclusively on the IBM personal computer. It requires up to 120 pieces of input data regarding the building under study as well as environmental factors, occupant information, and environmental systems. The user must supply certain climatic data to Area, Inc., for a moderate charge, will develop a weather file for the location of the building site. This weather file is then implemented easily into the main program where it is utilized during the calculation phase of the program's execution.

The program has three main operations: 1) building data entry, 2) calculation, and 3) data plot. When initially implementing EWIT in the investigation of a particular building, the above mentioned input data is entered into the computer where a "base-building" file is created. The computer then performs a simulation of the building's energy performance over a year's time. This simulation can be executed either as a seasonal or monthly basis depending on the user's preference and requires from 3-5 minutes of calculation time. The program achieves this by calculating the performance of the building by calculating the energy loads for an "average" four days for each month or in the case of the seasonal option, four days from one month of each season. The calculation operation yields heating and cooling loads as well as BTU output produced by lights, appliances, occupants, solar gain, and conductance by the building's skin.

The final operation by EWIT involves the program's extensive graphics plotting capability. Any three of twenty-seven different variables can be plotted over a four season period showing peak BTU magnitude on a 24 hour basis. Thus the designer can study individual factors in a format that renders significant relationships more readily identifiable than in numeric form. For example, a plot of allowable heat gain, heat loss, and auxiliary loads would reveal the need for additional heating or cooling and show the impact of different themo settings.

**ADAPTATION OF EWIT FOR RETROFIT STUDY**

As it was stated earlier, the primary thrust of this research effort is to explore EWIT's capability as a means of evaluating retrofit options for existing commercial buildings. The process for using the program in a retrofit mode involves steps that differ substantially from the conventional process followed for schematic design. When studying a building for possible retrofit modifications, a weather file based on a specific year must be established into the main program. To create this file, the program requires area, lat., wind data consisting of the average minimum and maximum wet bulb and dry bulb temperature for each month of the same year. This can be a formidable undertaking as many weather agencies are geared toward providing climatic data that is intended mainly for air and naval travel. Even institutions such as the Solar Energy Research Institute or the National Center for Climatic Research will be hard pressed to have data such as solar radiation statistics readily available. As
A last resort is the National Climatic Center in Asheville, N.C. will have all essential data on hand stored on computer tape.

The next step in a retrofitting evaluation using EWIT is to obtain as-built construction drawings of the building in question. Drawings showing floor plans, elevations, and wall/roof sections they exist in reality are essential. One must also obtain a complete set of utility records of the building for the year under study. The building's management must be interviewed to determine day and night thermostat settings, and whether or not an economizer-cycle includes a computer energy management system is used in the building. In addition, the plant management can give important facts on the HVAC system including system efficiency and coefficient of performance; factors critical to the success of the evaluation. The users of the building must also be interviewed to determine hours of building use as well as general occupant patterns. Such information might include after-hours use in regards to the number of personnel present in the structure at night or on weekends as well as any unusual seasonal use patterns.

Once the above information is obtained, the base building file can be compiled and the initial runs executed. At this point the investigation enters a phase where the user must possess a thorough understanding of the building components as well as a comprehensive knowledge of how each of the input variables affect the eventual output of the program. This aspect of the operation essentially involves comparing the heating and cooling loads of the building as projected by EWIT against the actual energy consumption during the year as documented by the year's utility records. Since the utility records are presented in a financial format, the EWIT load projections are most easily utilized if they too are presented in an economic base. This compares the economic factors of energy consumption and is accomplished by means of a VISICALC spreadsheet template specially created for the purpose.

It is hoped that the EWIT projections will closely reflect the actual energy performance of the building under study and after discussion with consulting engineers and other practitioners of EWIT, a reasonable degree of accuracy is deemed to be a realistic figure for which to strive, yet one that would provide a meaningful base from which to evaluate newer designs. Even in this case, the EWIT runs will achieve this range of accuracy and therefore a process of fine tuning or "gaming" the program must model existing building performance to more accurately reflect real-life conditions that govern the building. This ability to game the program requires a certain amount of ingenuity and resourcefulness which are at times beyond an art. However, this skill in gaming the input is important to the success of using EWIT in retrofit evaluations as the program must model existing building performance with a reasonable amount of fidelity.

CASE STUDY: DAY CARE CENTER

The first of the two case studies in a day care center located in metropolitan Denver. The structure is one story in height with a floor area measuring 10,035 sq. ft. The building is rectangular in configuration with very few intricacies in terms of design. Because of its relatively small floor area and straightforward design, the day care center will serve as the main vehicle in demonstrating the process for utilizing EWIT in a retrofit project for energy conservation.

Building Description

Built in 1977, the Day Care Center is a relatively new structure composed of brick veneer on a metal stud framing. The roof is a typical built-up bitumen system with a 4 inches of rigid insulation on metal decking. All windows are made of single-pane, solar bronze glazing encased in metal sash. Floors are covered with short woven carpet except in high traffic areas where vinyl tile is used. D-valves on walls and the roof are .07 and .10 respectively. Heating requirements are supplied by a gas-fired, forced air system while cooling is supplied by one evaporative chiller unit with a free back-up system. An economizer cycle is used with a 55-degree cut-off temperature. A Honeywell energy management system monitors and regulates the night time start-up and shut down of the heating/cooling systems. In essence, the computer monitors the outdoor temperature and compares this to interior mass temperatures where it then calculates the optimum start-up/shut-down time of the HVAC system.

Building Occupant Information

The center serves approximately 150 children daily during the workweek from September to May and in the summer months the figure drops down to about 105 children daily. The staff is composed of about 25 adults who oversee the facility from 7:30 a.m. to 6:00 p.m. daily except on weekends when the Center is closed. In addition, the Center is closed during the latter half of December through the month of January.

Creation of the EWIT Building File

At this point sufficient information has been acquired to actually begin the execution of the EWIT program. It is assumed that the appropriate climatic data has been entered to a reasonable degree of accuracy and that the input has been converted into a weather file specific to the locality and time frame particular to the situation at hand. Herein the case of this research effort, 5 weeks were required to gain acquisition of the necessary data). The following is an entry-by-entry listing of the prompts given by the program followed by the input data as per the program's instruction. (Note--in the case of this research effort, 5 weeks were required to gain acquisition of the necessary data)

Entry #1 Building location (latitude, longitude) and altitude of the site.

Entry #2 Floor area, slab floor perimeter, and floor area coefficient of the building.

Entry #3 Maximum outdoor air flow (ventilation and infiltration) in cfm.

Entry #4 The cutoff temperature of the economizer (if applicable)

Entry #5 Classify the internal zone according to the following:

1) carpet w/ acoustical ceiling
2) carpet w/ exposed wood walls or ceilings
3) vinyl tile floor
4) exposed mass floor and walls

Entry #6 Total number of surfaces (walls and

 Proceedings of the First Symposium on Improving Building Systems in Hot and Humid Climates, August 1984
Once the above information has been input into the program than the calculate phase of the program can be executed either on a month-to-month or seasonal basis. When the initial output is received from the computer than the main task of comparing the projected loads from EWIT against the actual utility records of the building can commence. The VISICALC conversion template performs the task of converting EWIT load output (BTU-Sq. Ft.) into dollars/sq. ft. which can then be readily compared against monthly utility costs.

Entry 118 The overall efficiency of the heating system.

Once the initial EWIT readout is ambushed then one can begin the investigative process to locate any input variable that may be in error. The heating loads should be checked against gas meter readings while projected cooling loads should reflect the electrical (kwh) readings. In the case of the Day Care Center, the first EWIT run indicated a much higher heating load than was shown in the utility records. Partial cause for this difference was a failure to remember that EWIT's projection was for heating loads. This is due to the fact that there was appliance loads in addition to the chiller plant load which was included within 1% of that logged during the building for 1983.

Establishing the accuracy of EWIT's cooling load projections proved to be a much more difficult task as compared to that of establishing correct heating loads. This is due to the fact that there are appliance loads in addition to the chiller operation which act to hinder the overall electrical utility records from reflecting the cooling load. It was determined that at best a correlation would have to be established between peak cooling loads shown by EWIT and the kwh recorded in the utility records during warm months of the year. In regards to EWIT accuracy, it is vital to remember true commercial buildings don't, in most cases, maintain a seven day work week. Therefore a special "weekend" run of the program must be performed that reflects the reduced number of occupants, lighting level, ventilation level, appliance loads, and other cutbacks in building use that occur on weekends. The loads that are produced by this special run must then be multiplied by 2/7 and then added of "applied" together with kwh of the usual load figure to give a final "true" seven day week figure. In addition peak week end will occur almost always during the work week and so a separate weekend calculation also helps to break out this important aspect. The weekend/weekday entry on the input sheet of EWIT allows this special operation.

Table 1 lists the VISICALC output data for a typical run for the day care center. The heating, cooling, lighting, and equipment loads are all translated into annual cost factors. The total cost estimate is $1.06/sq. ft./year, with lighting accounting for nearly 40% ($0.42/sq. ft./year) of the total. Heating costs make up 23% of the total cooling costs for this building located in Denver. The EWIT program can identify those and areas which are most significant, and retrofit options can then be tested to determine those most cost effective.

**RETROFIT EVALUATION**

The final step in the process involves the actual modeling of retrofit options in the study building by means of EWIT. There are different methods by which to "gauge" the affects of a retrofit device into the program depending on the building and nature of the option being considered. In most cases, however, the building envelops will not be altered but usually a simple add-on features will be added in to the structure without a large capital outlay.

In the beginning the evaluation phase the user will find the place in EWIT to be an invaluable aid in determining which aspects of the structure would prove most effective for retrofitting devices. In the case of the Day Care Center, the structure and use of the facility strongly suggested...
a skin-dominated situation. Therefore four plots were created that examined factors often found in structures to skin-dominated situations: amount of heat gain/loss to air, total amount of heat loss (determined by the "deadband"), the conduction load, the transmission loss of heat through glass and the auxiliary loading reacted by the building to remain in the comfort zone. Of particular note is the plot showing "allowable heat loss allowable heat gain/auxiliary heat required." This plot establishes the "deadband" mentioned above and shows immediately the need for additional heating or cooling within the structure (depicted by cross-hatched area). These remaining plots verified the intuitive judgement that conduction through walls, and to a lesser extent, heat loss through glass were indeed responsible for a fair share of the heat loss.

To remedy a condition of this nature, it is not unusual to simply try and fix the window with some type of insulating device. One such solution is an insulating shade known as the "Window Comforter" (an insulating fabric shade that mounts quickly into the existing window and delivers up to \( k \) value in insulation). This type of device is easily modeled on EWIT by simply changing the glazing type within the building files. In this case a type 10. The follows from Table 2 lists the results of the cost estimates using the window comforter as a retrofit option. The annual energy cost per square foot has been reduced from $0.22/sq. ft. /year. The window comforter installation could be analyzed in a similar fashion.

The second case study is a large hi-rise office building located within the central business core of Denver. The building contains approximately 900,000 sq. ft. of floor area and houses one of Denver's largest banks as well as providing 14 stories of office space in downtown Denver. The building is actually three inter-connecting "towers" that form a complex that covers a square city block. This non-uniform configuration and the vast amount of floor area in the building led to a different approach in analyzing the structure with EWIT. Because the building is composed of three smaller "sub-buildings," it was decided to treat each of these separate structural individual buildings and then add the results of the three runs to produce composite analysis of the overall building.

de this point it must be pointed out that the accuracy achieved in the first case study will not be realistic in a building of this magnitude, in a building containing almost a million square feet of floor area the interplay of thermal gain and loss is highly complex and even mainframe programs would require many runs and a great deal of time to produce a detailed simulation for such a large scale problem. While EWIT cannot be expected to do what a mainframe can, it can give investigators and analysts valuable data concerning building performance for retrofit options. There are several data input problems that are unique to large buildings which were and encountered in the first case study. For example, the hi-rise case study in- volved several groups of users who utilized the building during different time schedules and required different energy demands. The EWIT program of this building differed greatly from the day care center as it involved a multiple unit chiller that operated at variable capacity during the different seasons of the year. These are only a couple of the special problems that require yet more "gaming" techniques that will, once again, adjust the input to give an accurate picture of the actual building performance. While EWIT was not able to achieve the simulation accuracy as in the case of the office center. it did prove to be an outstanding aid in determining the implications of major influences to the building. For example, buildings located within downtown cores of large cities are influenced by the shadows from neighboring tall structures. EWIT can simulate this "shadow condition" by changing the internal shading coefficient (entry P27) for a particular elevation to simulate the lack of radiation that enters the interior of the building under study.

CASE STUDY NO. 2: HI-RISE OFFICE BUILDING

As was stated initially in the paper, the limitation of space prohibits the detailed reporting of results for the second case study, the hi-rise office building. A brief discussion follows regarding the findings for that aspect of the research effort.

The second case study is a large hi-rise office building located within the central business core of Denver. The building contains approximately 900,000 sq. ft. of floor area and houses one of Denver's largest banks as well as providing 14 stories of office space in downtown Denver. The building is actually three inter-connecting "towers" that form a complex that covers a square city block. This non-uniform configuration and the vast amount of floor area in the building led to a different approach in analyzing the structure with EWIT. Because the building is composed of three smaller "sub-buildings," it was decided to treat each of these separate structural individual buildings and then add the results of the three runs to produce composite analysis of the overall building.

The building file. in this case a type 10, containing almost a million square feet of floor area the interplay of thermal gain and loss is highly complex and even mainframe programs would require many runs and a great deal of time to produce a detailed simulation for such a large scale problem. While EWIT cannot be expected to do what a mainframe can, it can give investigators and analysts valuable data concerning building performance for retrofit options. There are several data input problems that are unique to large buildings which were and encountered in the first case study. For example, the hi-rise case study in- volved several groups of users who utilized the building during different time schedules and required different energy demands. The EWIT program of this building differed greatly from the day care center as it involved a multiple unit chiller that operated at variable capacity during the different seasons of the year. These are only a couple of the special problems that require yet more "gaming" techniques that will, once again, adjust the input to give an accurate picture of the actual building performance. While EWIT was not able to achieve the simulation accuracy as in the case of the office center. it did prove to be an outstanding aid in determining the implications of major influences to the building. For example, buildings located within downtown cores of large cities are influenced by the shadows from neighboring tall structures. EWIT can simulate this "shadow condition" by changing the internal shading coefficient (entry P27) for a particular elevation to simulate the lack of radiation that enters the interior of the building under study.

REFERENCES

ANNUAL UTILITY COSTS ESTIMATE

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Table 1. Day Care Center Cost Estimate—BMIT Program

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Table 2. Day Care Center Cost Estimates Using the Window Comforter Retrofit Option.