

# **PRACTICAL BUILDING ENERGY SIMULATION APPLICATIONS**

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## **ABSTRACT**

The author provides a retrospective viewpoint of his over 30 year experience in applying building energy simulation methods to actual projects. The paper begins with ASHRAE Simplified Energy Analysis using the Modified Bin Method through DOS based Trane Trace 600, custom Excel Cogen spreadsheet analysis, DOE-2.2 building description language (BLD), eQUEST and finishing with EnergyPlus. The author highlights some of the trials and tribulations of his experience in energy modelling as well as the successful outcomes as it applied to specific projects. Further, the author identifies beneficial skills and knowledge beyond knowing the intricacies of the software programs. The author concludes with suggestions on strategies to transfer the knowledge gained by experienced building simulation modellers.

## **BACKGROUND**

### **EARLY DESIGN, ANALYTICAL AND PROGRAMMING SKILLS**

The background to my migration to building energy simulation goes back four decades. Prior to graduation, I designed custom built homes on a drafting board to earn income for university. This developed my building plan reading skill significantly. During the early part of my engineering career, I designed a pneumatic start system for a gas turbine driven emergency plant. This developed my understanding of pneumatic systems, often a significant energy load in plants.

Other early design work included HVAC systems for commercial, industrial, residential and mid-rise multi-residential buildings, wherein only one corridor makeup air system was required. Furthermore, I designed retrofit steam heating plants for long-term care facilities and retrofit hydronic heating systems for institutional buildings which included arenas where process heating was required for the Zamboni. Not only was I engaged in the design phase of

construction documents, but I also performed on-site inspection of the installations.

My analytical skills were developed as a sales application engineer wherein I analyzed the predicted natural gas well head production to optimize the selection of gas turbine driven natural gas compressors over a 25 year project life-time frame.

Programming skills in Microsoft QuickBASIC were developed when I wrote a custom program to access the noise level at a critical receptor of a cogeneration package with multiple noise sources.

Other efforts included on-site performance testing of gas turbines in the North West Territories and witness testing of industrial gas turbines in test cells and industrial fan testing, both in Ontario. This was an opportunity to validate on-site performance with manufacturer's tabulated data.

### **THE BEGINNING OF BUILDING ENERGY SIMULATION**

My beginning in building energy simulation began in the 1980's when a colleague approached me with a project opportunity that he did not have the time to take on because of other commitments. An energy management company was installing building automation systems (BAS) in high-rise condominium buildings in and around the areas of Toronto, Ontario. They needed the annual baseline natural gas and electrical energy consumption and the potential energy savings and cost savings attributed to the installation of the building automation system. The purpose, the why of this project was to justify the expenditure of the automation control system. Notice this why – a single dollar amount of annual savings so that the energy management company could show the value of the system to the condominium developer. The condominium developer then could use this feature as an additional benefit to prospective buyers to reduce the annual condominium fees as compared to other buildings in the market place.

## ANALYSIS TOOLS

### Initial Computing Platform

At that time I was still using a computer with an 8-bit Zilog Z80 microprocessor, 64 kilobytes of RAM, and two 5 ¼ -inch double-density floppy disk drives. The computer ran on the Digital Research CP/M operating system, short for Control Program for Microcomputers. It was equipped with several software packages including a word processor and a spread sheet program. I needed a method to solve the problem within the constraints of my computing system. Through research of the ASHRAE catalog, I ordered the report "Simplified Energy Analysis Using the Modified Bin Method" published in 1983.

### Simplified Energy Analysis Using the Modified Bin Method

The modified bin method recognizes that the building and zone loads consist of time dependent loads (solar and scheduled loads) and temperature dependent loads (conduction and infiltration). To compute the energy consumption, two or more computational periods are selected, normally representing the occupied period and the unoccupied period. For each period, the time dependent loads are averaged and added to the conduction loads such that the load is characterized as a function of outside air temperature for the calculated period.

The modified bin method utilizes bin weather data. Bin weather data is the number of hours in a specified time period, such as a year or a month that the dry bulb temperature is within a bin, wherein the bin may be 5 degrees F. The distribution is further divided into 3 periods of the day (01-08 hrs), (09-16 hrs), and (17-24 hrs).

In expressing building loads as a function of outdoor temperature, the following assumptions are made:

1. All exterior loads can be expressed as a linear function of outdoor temperature.
2. On a daily basis, the interior loads can be averaged over the "system on" or "system off" time periods.

The procedure begins with a load estimation for the occupied and unoccupied operating modes. Although the calculations are similar to the design type calculations, they are averaged internal and external loads, and are also performed at intermediate temperatures.

The load calculations are performed at four temperature bins, judged to be significant for the

given building and location. The bins are identified by their mid-point temperatures (e.g. the 89.5-94.5 F bin is identified as the 92 F bin), and represent the following four temperature bins:

- Peak Cooling,  $T_{pc}$
- Intermediate Cooling,  $T_{ic}$
- Intermediate Heating,  $T_{ih}$
- Peak Heating,  $T_{ph}$

An alternate approach to developing the loads is to develop an equation of the load profile. This results in a system of linear equations of the form:  $Y = mx + b$ , where Y represents the load, m is the slope, x is outside temperature, and b is the intercept. Using the methods described in the report, I developed a multi-page spread sheet for performing the analysis wherein each page represented a month of the year.

### Limitations on the Simplified Energy Analysis Method

The procedure is based on time averaging techniques and as such has limited capability in accurately dealing with highly dependent problems. The major premise is that the net time dependent energy rate, added to or removed from the space during a given computational period, is equivalent to the average energy rate added or removed from the space times the duration of the computational period. The weakness is this premise is the approximation used in developing the average rates of energy gains or losses from the space. The thermal capacitance of the space will induce a time lag before the thermal load to the space actually becomes a load on the HVAC system. Thus, the load computed by averaging many not become the actual load on the HVAC systems. Furthermore, variation of space temperatures characteristic of any control system, which causes heat storage and release, is not accurately represented. This issue may also be argued in hourly simulation programs since the space temperature variation may occur within the hourly time step. Large space temperature variations associated with dead band controls and night set back and set up conditions may show significant variation with hourly simulators.<sup>(1)</sup>

### Simplified Energy Analysis Method Background

The development of the Simplified Energy Analysis Using the Modified Bin report, was based on many years of effort by the members of the subcommittee for simplified energy analysis of the TC 4.7 Energy Calculations Committee, and was the result of research sponsored by ASHRAE.

The report provides an excellent background source for an understanding of load calculations, air system component analysis, air system simulation, and plant component simulation. It also includes program code for analysis of a variety of systems. The report is still available in paperback format on the ASHRAE store web site.

The following is an excerpt from Chapter I – Introduction<sup>(1)</sup> which largely applies today.

#### A. The Need for Energy Analysis

Energy analysis plays an important role in developing an optimum HVAC and architectural design for new buildings and in determining the cost effective modifications to existing buildings. In new buildings, it is important that the energy analysis process be implemented for individual design decisions early in the design process. Maximum benefit will be obtained if proper optimization techniques are applied to each step of the evolution from concept to working drawings. In existing buildings a comprehensive energy analysis is the basis for making rational decisions on cost effective building alterations and system modifications. A large number of separate analyses are necessary to adequately analyze the economic benefits of various energy conserving modifications.

As the need for making accurate energy utilization decisions has become more and more important, many standards and codes have been adopted which require energy analysis procedures to demonstrate compliance. An example of this type of standard is ASHRAE 90. Standard 90 is basically of a prescriptive nature, and requires the use of energy analysis to show compliance if all the prescriptive requirements are not met.

The ASHRAE TC 4.7 has been largely responsible for the development of comprehensive hourly simulation algorithms to determine accurate heating and cooling requirements and simulate performance of heating and cooling systems/equipment. Numerous building energy calculation procedures have

emerged since the late 1960's encompassing methods from simple degree day procedures to comprehensive and computerized procedures which simulate building heat transfer and system/equipment performance on a minute by minute basis. Although these programs are considered very comprehensive and accurate, they are not readily accessible to practicing engineers because of their complexity, cost and difficulties in usage. A simplified procedure, which is transparent to users and whose calculation procedures are familiar to practicing engineers is needed; at least for the pre-planning analysis where most engineering hours are spent.

It shall be noted that the Simplified Bin Method was developed because of the barriers to widespread usage of hourly analysis programs. The following is another excerpt from Chapter I.

These programs can be very useful and provide reliable results, however they face several barriers to widespread usage. They require a mainframe computer with large memory and high speed. The cost of leasing these programs can be high. Additionally, special training in the use of particular programs due to their complexity, and access to a computer terminal are required. Therefore, the average consulting engineering firm may not have the resources or the volume of projects to justify their use.

In addition, because of the complexity of the algorithms, average practicing engineers find it difficult to assess the accuracy of credibility of the results obtained. The services of specially trained energy consultants are often needed to make use of these programs. Very few of these hourly simulation programs are currently available on microcomputers.

Today of course, hourly analysis programs are readily available for use on personal computers; in fact you can download some of them from the internet either in trial versions or complete programs. However, today, the complexity of these programs

requires extensive training and understanding of building systems.

### Simplified Energy Method Challenges

Creating the initial spreadsheet formulas and data took considerable development time and were constantly being enhanced or changed based on the building being modeled. Although the background data and structure of the spreadsheets remained somewhat consistent, each project became a custom effort. Furthermore, the method did not accurately address custom occupancy schedules.

### Trane Trace 600™

An opportunity came my way to be part of a team to submit a preliminary design bid for a large commercial complex. A component of the bid submission and a key factor in bid evaluation process was the energy consumption of the building. My portion of the work was to estimate the overall building natural gas and electrical consumption based on preliminary design drawings. One of the energy cost savings strategies was to consider a natural gas fired Trane Absorption Chiller. As part of the preliminary design team I was able to obtain access to the DOS based Trane Trace 600™ program to model the Trane Chiller. The why in this case, was winning the design bid.

By this time, I had upgraded to a computer with an 8MHz 16-bit Intel 80286 processor with 640 kB of ram, 3 ½ inch disk drive and a hard drive. I was familiar with the design load portion of Trane Trace, working as an HVAC design engineer for an architectural-engineering firm in Calgary Alberta circa 1980. At that time, one had to write down the inputs on several forms representing computer input cards. The data on the forms was transposed into punch cards and input into a main-frame computer off-site for program execution. This process was quite familiar, having to learn FORTRAN programing code in University with program execution on an IBM 360 mainframe computer.

### Trace 600™ Features and Structure

The Trace 600™ program offered modified hour-by-hour type building energy simulation with reasonable simulation run times given the personal computing power of the era. The program input is divided into 4 sections, JOB, LOAD, SYSTEM, and EQUIPMENT. A separate ECONOMICS program used the output of the simulation to determine the Utility costs. The program can analyze energy use and lifecycle costs for up to four different building models or alternatives commonly referred to as parametric runs.

The TRACE 600™ dataset could be created using the Input Editor in field mode and full screen as a text editor. A screen in field mode will typically translate into one line or “card” of data in full screen format. In full screen mode, each field is separated by a forward slash “/” and each line or “card” type is prefixed by a two-character code. In addition, each “section” of data is separated by its related acronym, e.g. JOB, LOAD, SYSTEM or EQUIPMENT. Note that the term “card”, I believe stems from the program’s early development for a mainframe computer.

I found that you had to become adept at both the field mode and text editor mode of input. The latter required learning the input syntax and could also be generated or modified out of the Trane program in a text editor. Having experience in FORTRAN and later QuickBASIC programming assisted in this learning process.

Although I had used the Carrier HAP™ program on the odd occasion, Trace 600™ became my go-to software package because I became very familiar with the program and because I could input the data in Metric. I also preferred the output results generated by the LOAD analysis portion of the program for HVAC design.

```
SYSTEM - 1
39/1/BASE CASE SYSTEMS
40/1/RAD/ROOMDK
41/1/1/1
45/1/OFF/////AVAIL/AVAIL
40/2/RAD/ROOMDK
41/2/2/2
45/2/OFF/////AVAIL/AVAIL
40/3/SZ/ROADK/75/70/AVAIL/AVAIL/0.25
41/3/3/4/9/9
45/3/ASEMRCHW/////AVAIL/AVAIL
```

### Trace 600™ System Code Snippet

#### Trace 600™ Challenges and Limitations

Trane Trace 600™ is not a full hourly analysis program since in addition to a design day type, it limited the execution into one “typical” 24-hour day of weather per month for four different day types. These are Sunday, Monday, Weekday and Saturday. Furthermore, when the calculation level was set to ZONE, the maximum number of zones could not exceed 50 for each system. With the buildings I was modeling, I was approaching this limit. I recall modeling a high-rise condominium building and the program was taking 4 days to run on my 286 computer then crashed. I quickly upgraded my

hardware to a 66 MHz 486 with simulation computation running typically between 10 and 20 minutes, but sometimes over 30 minutes when running multiple alternatives.

I used Trace for a number of condominium buildings, most often with 2-pipe fan coil units for the suites, central chiller and corridor makeup air systems sometimes with a chilled water cooling coil and sometimes with a DX cooling coil. Some condominium buildings systems were 4-pipe water source heat pumps. I also used the program to model buildings with cold storage and also with cogeneration systems. Learning and developing the input methodology of these various systems required first understanding their operation and controls but also how best to model them. Early in my career I had worked with a consultant that had double degrees in Mechanical and Electrical engineering. Later, I had taken the Honeywell Pneumatic controls course in Minneapolis and I also gained experience with Solar Turbine gas turbine generator packages. These experiences provided the foundational knowledge in mechanical systems, electrical systems, controls and generators required for these projects.

With growing knowledge and familiarity, the program was quite flexible and I was able to use it in creative ways. In one project I modeled a greenhouse to generate the indoor temperature profile in the winter time to investigate why the greenhouse structure collapsed.

Transposing the results from the Trace output into Excel™ spreadsheets for a custom report format was time consuming for each project. Though not specifically related to Trace, doing building takeoffs during this time period required a lot of manual effort as most drawings were available only in print form. A number of days were involved with an architectural scale in hand to determine zone dimensions to calculate zone areas.

#### Custom Excel™ Cogen Spreadsheets

Not all projects lend themselves to using standard energy simulation tools. For several assignments I had to evaluate the economics of a multitude of cogeneration proposals. The why in these cases was to determine if the capital investment was worth the economic payback over a 20 year project life accounting for key financial parameters.

There were 16 different prime movers for these projects and were either a reciprocating engine or gas turbine engines, operating on either natural gas or

diesel fuel oil. The recip engine was rated at 6 kW and the gas turbine engines were rated from 30 kW to 9,200 kW. In a cogeneration project, you want to determine the generator output, and the heating energy that is offset by recovering waste heat from the prime mover. In the case of a gas turbine engine, the output power is a function of the outdoor air temperature, elevation, intake and exhaust losses and parasitic loads. The heat recovery is a function of the exhaust gas mass flow and temperature output power of the prime mover.

For these projects, I custom programmed Excel™ spreadsheets with weather data and engine performance algorithms combined with financial formulas. Creating the algorithms for the gas turbine engine performance involved transposing data points on printed performance curves into a curve fitting software program. In this way I was able to select an expression with the best  $r^2$ , the statistical coefficient of determination.

In one case, the gas turbine generator studied was nominally rated at 2.5 MW. The power output for this gas turbine generator package in kW, is a function of the gearbox efficiency, generator efficiency, intake pressure losses, exhaust losses, altitude and the ambient intake air temperature. The actual Excel™ formulae for ambient intake air temperatures between -20 and +40 C is as follows:

$$=IF(H4<-20,"Error",IF(H4>40,"Error",IF(H4<-10,$B$152*$B$153*3.42*1000*cf_{pi}*cf_{pe}*cf_{pa},($B$152*$B$153*(OGT2500!$F$33+OGT2500!$F$34*H4+OGT2500!$F$35*H4^2+OGT2500!$F$36*H4^3+OGT2500!$F$37*H4^4+OGT2500!$F$38*H4^5))*1000*cf_{pi}*cf_{pe}*cf_{pa})))$$

Within the ambient temperature extremes, the first part covers from -20 to less than or equal to -10 C:

$$\text{Generator output in kW} = \eta_{gb} \times \eta_{gen} \times 3.42 \times 1000 \times cf_{pi} \times cf_{pe} \times cf_{pa}$$

And between -10 and + 40 C it takes the form of a modified 5<sup>th</sup> order polynomial expression:

$$\text{Generator output in kW} = \eta_{gb} \times \eta_{gen} \times (C_0 + C_1T + C_2T^2 + C_3T^3 + C_4T^4 + C_5T^5) \times 1000 \times cf_{pi} \times cf_{pe} \times cf_{pa}$$

Where:

$$\eta_{gb} = \text{gearbox efficiency}$$

$$\eta_{gen} = \text{generator efficiency}$$

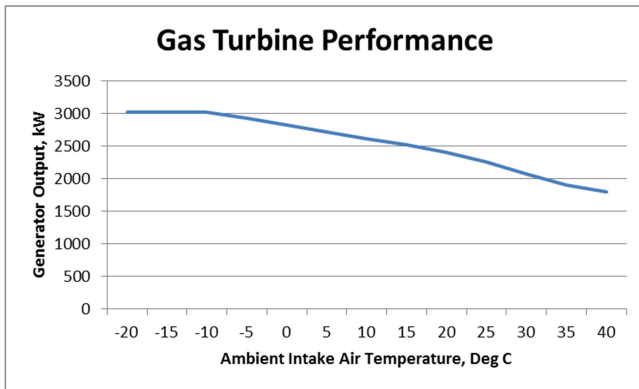
$cf_{pi}$  = intake pressure loss correction factor determined by a linear formula

$cf_{pe}$  = exhaust pressure loss correction factor determined by a linear formula

$cf_{pa}$  = altitude correction factor determined by a third order polynomial expression

$C_n$  = polynomial coefficient determined by a curve fitting program

The formulae expressed in chart form over the ambient temperature limits for an elevation of 100 metres, and intake and exhaust pressure losses of 100 and 200 mm respectively is as follows:



Excel™ Generated Gas Turbine Performance Curve

DOE-2.2 (eQUEST®)

Another opportunity came in Northern Ontario to assist a company apply for a Federal Government sponsored energy savings grant. The main objective of the energy analysis was to determine which of the available energy saving measures would provide the best economic benefit. The building manager had done some research and believed that energy savings could be realized by improving the roof insulation and using a white roof as a replacement for the current aging roof system.

I originally ran the energy simulation in Trace 600™. I also performed an analysis in RETScreen 4 which is a Natural Resources Canada Excel-based clean energy project analysis software tool that helps decision makers quickly and inexpensively determine the technical and financial viability of potential clean energy projects. However, in this specific case, the auditor that would approve the project funding, challenged the energy savings figures in the original funding application which included RETScreen 4 results. To overcome this challenge, I decided to perform another simulation in DOE-2.

```

$ *****
$ **
$ **           HVAC Systems / Zones
$ **
$ *****

```

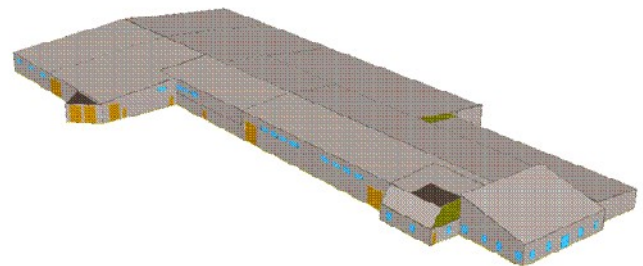
```

"SYS-1" = SYSTEM
TYPE = HVSYS
SIZING-OPTION = COINCIDENT
OA-SIZING-METHOD = SUM-OF-ZONE-OA
MAX-SUPPLY-T = 135
HEAT-CONTROL = CONSTANT
HEATING-CAPACITY = -437743
HEAT-SOURCE = FURNACE
ZONE-HEAT-SOURCE = NONE
RETURN-AIR-PATH = DIRECT
HEATING-SCHEDULE = "ON-YR"
FURNACE-HIR = 1.25
..
"ZONE-1" = ZONE
TYPE = CONDITIONED
DESIGN-HEAT-T = 70
HEAT-TEMP-SCH = "H70FSTAT"
SPACE = "Zone 1"
OA-FLOW/AREA = 0.15
EXHAUST-FLOW = 3098
EXHAUST-SOURCE = INFILTRATION
..

```

DOE-2.2 System Code Snippet

DOE-2 is a widely used and accepted freeware building energy simulation program that can predict the energy use and cost for all types of buildings. The program performs a building simulation hour-by-hour over a complete typical weather year. eQUEST is a graphical user interface with input wizards and graphical reports for the DOE-2.2 simulation engine.



eQUEST Energy Analysis 3-D Building Model

As I had built the building takeoff data in Trace, and because of the complexity of the building, I deemed it easier to create the DOE-2.2 BDL input file using a text editor for importing into the eQUEST® graphical user interface.

Interestingly, the conclusion of the simulation efforts showed that the savings results generated in Trace 600™ were similar to the results in DOE-2.2.

In another case, I used DOE-2.2 to determine the energy use in a large urban complex. The complex includes two condominium residential towers, a fitness component in a central Podium, a 12 storey office component, street level retail space facing South along the street level, retail space facing West along the street level with condo office space above to the 5 floor level. It also included a large ground floor level anchor food store with an entrance at the West face at the street level. Below the complex was a multi-level parking garage.



SketchUp of Urban Multi-Use Complex Modeled in DOE-2.2<sup>(2)</sup>

The main objective of this energy analysis was to determine the financial savings of energy efficiency measures beyond leadership in energy efficiency design (LEED) practices. The complex was originally modelled in EE4, a software tool that automates energy use assessments and applies all of Natural Resources Canada's (NRCan's) validation of new building designs rules to verify that a design is at least 25% more energy efficient than if constructed to meet Model National Energy Code for Buildings (MNECB) 1997 requirements. Another purpose for the simulation was to allocate the energy consumption to the various complex uses. There

were only two electric meters and five natural gas meters for the whole complex. The condominium board members wanted to ensure properly allocated energy billing for the complex.

EE4 uses the DOE-2.1 simulation engine version which has been superseded with a more enhanced version. DOE-2.2 software was selected to simulate this complex because of the similarity to DOE-2.1. As much as there are similarities between the versions, there are significant differences and porting the building inputs required a major rework of the input file in a text editor. The main difference between the two versions is that the DOE-2.2 version uses a methodology for connecting central plant equipment to zone HVAC systems, which more closely matches the physical reality in modern buildings. The DOE-2.1 input file did not have a geometric model of the complex, hence to save time; I used the NOSHAPE command in the DOE-2.2 BDL input file to circumvent building a geometric model.

This was the most complex building energy simulation model that I have performed. It consisted of 184 zones and to build the complete model, I had to break-up the model into stages.

#### DOE-2.2 (eQUEST®) Challenges and Limitations

One of the well-known limitations of DOE-2.2 is that one can only model one system per zone. The method for creating a dedicated outdoor air system (DOAS) is explained very well on the internet. One of the challenges of creating a DOE-2.2 BLD input file in a text editor and importing it into eQUEST is that not all of the code syntax in the DOE documentation is valid in eQUEST. This generates errors that have to be debugged. Also DOE does not directly simulate immersion heaters in domestic hot water connected to a building hydronic heating loop. This type of domestic hot water heating system is very common in high-rise condominium buildings.

Transposing the results from the DOE output into Excel™ spreadsheets for a custom report format was also time consuming for each project.

#### EnergyPlus™

An energy audit was required for a subsidized social housing 10 storey mid-rise apartment building constructed in the 1960's with 221 suites. The objective was to reduce the operating costs while maintaining excellent service to the community. This building featured a heating-only hydronic system with perimeter baseboards in each suite with no wall thermostats.



```

HVACTemplate:System:Unitary,
  AC-Unit1,           !- Name
  On-Discrete,       !- System Availability Schedule Name
  Office,            !- Control Zone or Thermostat Location Name
  autosize,          !- Supply Fan Maximum Flow Rate {m3/s}
  On-Discrete,       !- Supply Fan Operating Mode Schedule Name
  0.7,               !- Supply Fan Total Efficiency
  600,               !- Supply Fan Delta Pressure {Pa}
  0.9,               !- Supply Fan Motor Efficiency
  1,                 !- Supply Fan Motor in Air Stream Fraction
  SingleSpeedDX,     !- Cooling Coil Type
  Cooling-Coil,      !- Cooling Coil Availability Schedule Name
  autosize,          !- Cooling Coil Capacity {W}
  autosize,          !- Cooling Coil Rated Sensible Heat Ratio
  3,                 !- Cooling Coil Rated COP
  Gas,               !- Heating Coil Type
  On-Discrete,       !- Heating Coil Availability Schedule Name
  autosize,          !- Heating Coil Capacity {W}
  0.8,               !- Gas Heating Coil Efficiency
  ,                  !- Gas Heating Coil Parasitic Electric Load {W}
  autosize,          !- Maximum Outdoor Air Flow Rate {m3/s}
  autosize,          !- Minimum Outdoor Air Flow Rate {m3/s}
  ,                  !- Minimum Outdoor Air Schedule Name
  NoEconomizer,      !- Economizer Type
  NoLockout,         !- Economizer Lockout
  ,                  !- Economizer Upper Temperature Limit {C}
  ,                  !- Economizer Lower Temperature Limit {C}
  ,                  !- Economizer Upper Enthalpy Limit {J/kg}
  ,                  !- Supply Plenum Name
  ,                  !- Return Plenum Name
  BlowThrough,       !- Supply Fan Placement
  StayOff,           !- Night Cycle Control
  ,                  !- Night Cycle Control Zone Name
  None,              !- Heat Recovery Type
  0.7,               !- Sensible Heat Recovery Effectiveness
  0.65,              !- Latent Heat Recovery Effectiveness
  None,              !- Dehumidification Control Type
  ,                  !- Dehumidification Control Zone Name
  60,                !- Dehumidification Setpoint {percent}
  None,              !- Humidifier Type
  ,                  !- Humidifier Availability Schedule Name
  0.000001,         !- Humidifier Rated Capacity {m3/s}
  2690,              !- Humidifier Rated Electric Power {W}
  ,                  !- Humidifier Control Zone Name
  30;                !- Humidifier Setpoint {percent}

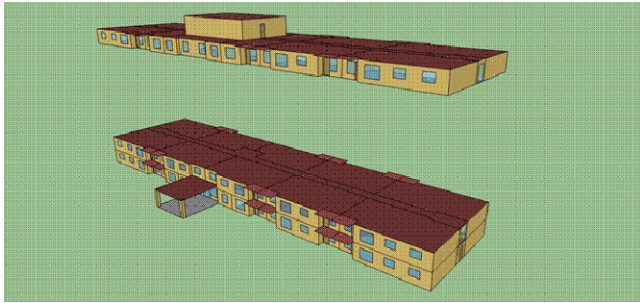
```

### EnergyPlus™ Code Snippet

From an energy management and space comfort perspective, this was a major control issue. For this project it was decided to determine the energy savings potential of implementing a modified boiler reset schedule based on the time of day. Evaluating that this would require a somewhat sophisticated simulation, and because I wanted to learn EnergyPlus™, this was the software tool of choice for this project.

EnergyPlus™ is a new-generation building energy simulation program based on DOE-2 and Blast, with numerous added capabilities. Modeling the performance of a building with EnergyPlus™ enables one to optimize the building systems and controls to use less energy and water. Furthermore, the program has the capability of estimating the green-house gas emissions.





### EnergyPlus™ Generated Building Model

#### EnergyPlus™ Challenges and Limitations

Learning EnergyPlus™ takes dedication and effort. I used a combination of the IDF Editor and a text editor. The concept of setting up input and output nodes for the equipment and other nodes such as zone input nodes, requires a good understanding of what you are modelling. A recent limitation of the program that I discovered is that it does not have a command similar to NOSHAPE in DOE. You need to specify at least a starting vertex. You can however specify surfaces as height and width using the Wall:Exterior or Window objects rather than specifying each individual vertex of a BuildingSurface:Detailed. EnergyPlus™ is a powerful tool and as opportunities arise it shall be a simulation tool that I shall explore in more depth moving forward.

### SIMULATION SKILLS

The following list, I believe highlights the skills that contribute to an energy simulators ability to create accurate and timely building energy simulation reports for the types of projects in the market place.

#### DESIGN SKILLS

Design of the following types of systems:

- Automatic Control Systems
- Chilled Water
- Cogeneration Plants
- Electrical Distribution
- Hydronic Heating
- HVAC
- Pneumatic Systems
- Process Systems
- Steam Plants

#### OTHER SKILLS

- CAD and Computer programming
- Financial Analysis
- Report Writing
- Sales Skills

- Site Inspection and Performance testing

### SUMMARY

The following is a summary of the reasons why building energy simulation was performed for the various projects presented in this report:

- Determine the energy and cost savings attributed to the installation of a building automation system.
- Building energy consumption as a component of a design bid submission.
- Model the indoor temperature profile in the winter time to investigate why a greenhouse structure collapsed.
- Evaluate the economics of cogeneration proposals to determine if the capital investment was worth the economic payback over a 20 year project life span.
- Energy modelling to determine which available energy savings measures would provide the most economic government sponsored energy grant.
- Determine the financial savings of energy efficiency measures beyond LEED practices.
- Energy modelling to determine the allocation of metered energy consumption to various complex uses.
- Determine the energy savings potential of implementing a modified boiler reset schedule based on time of day.

### CONCLUSION

Becoming an effect resource for building energy simulation requires dedicated work over many projects. One must have the fortitude to push through learning curves and the willingness to take on new challenges. I believe that assigning energy simulation project to junior staff without additional direct support from more experienced engineers could impact the accuracy of the energy models. Undervaluing the economic benefit of energy modeling, forces companies to provide the service within the constraints of low fees. This drives the task to less experienced junior or intermediate simulators with little or no support from more experienced people. Furthermore, there is often limited financial support for staff to take formal training. This is my opinion is short sited.

An energy simulation modeller must take on the responsibility for learning and honing their skills to become excellent. Searching out mentors is a key

strategy for career development for junior staff. The online forums do provide support and knowledge. However, in my opinion it's not the same as sitting down with a person face-to-face. One of the challenges I see is that experienced modellers are located throughout the US and Canada and other countries as well. With the limited time people have today, it's not easy for experienced modellers to have the time to be mentors. Then again, anything worthwhile is not easy.

## REFERENCES

1. Knebel, David E., (1983), *Simplified Energy Analysis Using the Modified Bin Method*, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Atlanta, GA.
2. <https://3dwarehouse.sketchup.com/model.html?id=dcc2536287935895cfe89eb32da46ed1>