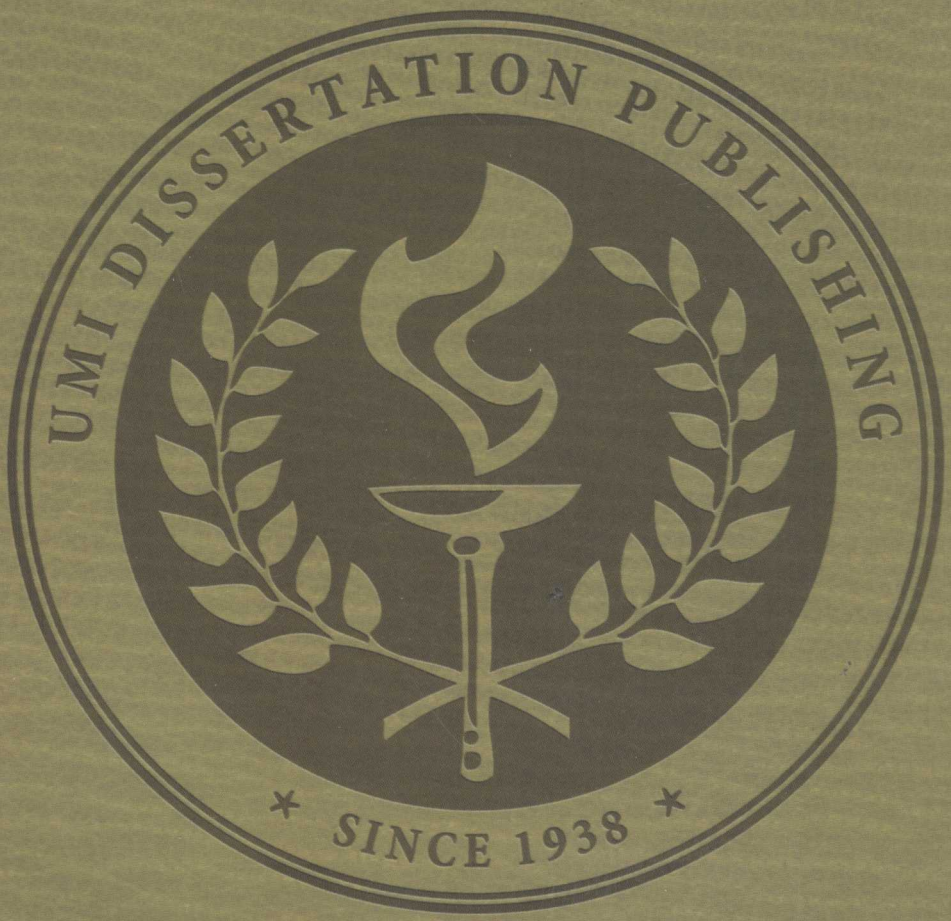
A study of combined energy simulations using eQuest and TRNSYS .

Cory Ray Duggin



A STUDY OF COMBINED ENERGY SIMULATIONS USING EQUEST AND TRNSYS

A Thesis

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by

Cory Ray Duggin

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AN ABSTRACT OF A THESIS

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Cory Ray Duggin

Master of Science in Mechanical Engineering

There are many energy modeling software packages available today, but the abilities of one program does not satisfy all energy modeling needs. The purpose of this study is to create a combined simulation using eQuest and TRNSYS. EQuest has the power of DOE-2 running its simulation engine, and consequently is the industry standard for building energy simulation. TRNSYS has a vast library of components, many of which are not capable of being modeled in other software packages. It also is developed and supported by an international group of engineering firms, so the span of the types of systems the user can create is truly global.

Five simulations were created for comparison, two of which are eQuest-TRNSYS combined simulations. The results of each simulation are compared to each other and the base simulation, which was validated using actual utility data. Then the two methods for combination, as developed by the author, are described. Both methods use outputs from an eQuest model as inputs for equipment in the TRNSYS simulation. One simulation uses the Direct Load Imposition Method and the other uses the Return Air Properties Method. The results of this study have truly shown how useful a combined eQuest-TRNSYS simulation can be.

CERTIFICATE OF APPROVAL OF THESIS

A STUDY OF COMBINED ENERGY SIMULATIONS USING EQUEST AND TRNSYS

by

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All the members of the eQuest and TRNSYS user groups online were a great help in figuring out how to bring the simulations in this thesis to fruition. I also owe a debt of gratitude to Matt Duffy and David Bradley at TESS for their patience and guidance while I learned TRNSYS.

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CHAPTER 1

INTRODUCTION

Motivation

In today's digital world, engineers and scientists have a vast array of tools at their fingertips that just 20 years ago were either unimaginable or in their infancy. Dual core processors and cheap memory has enabled users at home to have the processing power equivalent to a super computer not many years ago. This access to processing power has led to the development of many different analysis techniques, such as finite element analysis, computational fluid dynamics, and energy modeling, which have changed the way we solve engineering problems. Now problems can be simulated for a fraction of the cost of designing and building an experiment to collect comparable data.

Before the days of energy modeling software, building loads were calculated using time consuming hand calculations and educated guesses based on years of experience. Now a simple building geometry and materials can be input to a program in less than an hour's time producing very accurate results for loads, HVAC equipment performance, and simulated utility bills. This capability has led to numerous research groups producing energy simulation programs with varying capabilities. Energy simulation programs, such as eQuest, DOE-2, BLAST, EnergyPlus, Trane TRACE, Carrier HAP, ESP-r, and TRNSYS, are used every day by engineering firms to investigate energy savings of current systems and to design and size new systems. The focus of the work in this study will be on eQuest and TRNSYS [1, 2].

EQuest is the most widely used building performance simulation software in the world. DOE-2, which is the simulation engine for eQuest, has become the gold standard for building performance simulations through over 30 years of development by Lawrence

Berkeley National Laboratory. DOE-2 can simulate the energy use and calculate the energy cost for all types of buildings commercial and residential. By combining the power of DOE-2 with the usability of a modern graphical user interface, eQuest has changed the way energy modeling is performed.

TRNSYS is a transient energy simulation tool. It can provide transient performance of complex energy systems that eQuest can't, such as solar thermal systems, down to very small time steps. The international group that supports TRNSYS has taken a difficult to use program and made it as easy to develop with as dragging components to the workspace and connecting them together. Both tools have immense power in their respective areas. Even though TRNSYS has the ability to model building performance like eQuest, its main focus is on the transient simulation of the individual components in an energy system.

Objective of Study

The goal of this thesis is to combine eQuest and TRNSYS into one simulation by reading the results of eQuest into TRNSYS. Five simulations were performed to compare results. Two of the simulations are TRNSYS and eQuest combined simulations. The other three are eQuest simulations for comparison. One eQuest simulation is the base simulation for all the others to be compared. The base simulation was constructed to model a standard house where a full year of utility data was available to validate the model, and it is a simple structure for comparison [3, 4].

eQuest

EQuest, which stands for quick energy simulation tool, was originally developed under a partnership between James J. Hirsch and Associates and Lawrence Livermore National Laboratory. The purpose of eQuest is to provide detailed analysis results without the user having years of experience in building performance simulation. The construction of a building performance model was simplified by incorporating both a schematic and detailed building creation wizard along with an energy efficiency measure (EEM) wizard. EQuest will even produce a 3-D rendering of the building geometry based on the wizard inputs.

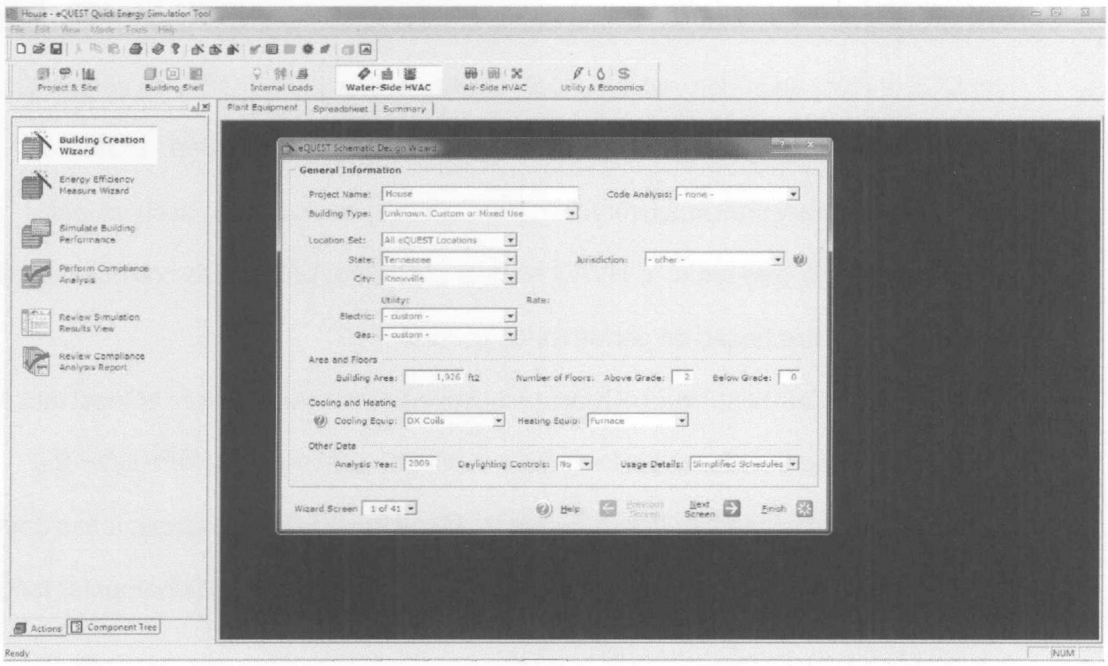

Figure 1: eQuest Screen Shot

The eQuest interface and schematic design wizard can been seen in Figure 1. Once all the parameters for a model have been specified in the wizard, a DOE-2 derived engine performs an hourly energy simulation. The outputs of the DOE-2 engine are then used to create reports with graphics, such as monthly energy consumption by source. EQuest is advertised as enhanced DOE-2 plus wizards and graphics. DOE-2 is known throughout the industry as the leader in building performance modeling. Having DOE-2 at its heart is what makes eQuest such a valuable simulation tool [3].

The DOE-2 derived engine in eQuest 3.64 is based on DOE-2.2, which is the most recent revision of the DOE-2 software. DOE-2 is a DOS box type of software that requires a lot of experience to effectively use. This means that DOE-2 takes an input text file, runs the simulations, and then gives a results text file. An entire language was developed for DOE-2 known as the building description language (BDL). The input files to DOE-2 must be in BDL, which is part of what makes plain DOE-2 so difficult to use. DOE-2 has a library of components from which the model is created. DOE-2's component library contains everything from building components, such as walls, windows, doors, and roofs, to HVAC models of chillers, boilers, DX coils, and cooling towers, which are based on performance curves.

The DOE-2 engine in eQuest first converts the user inputs to eQuest into a BDL DOE-2 input file in order to perform the simulation. A flow chart of the DOE-2.2 simulation engine can be seen in Figure 2. Once the building description has been converted to BDL, the BDL processor then converts the input file to computer language. Then the hourly simulation is performed.

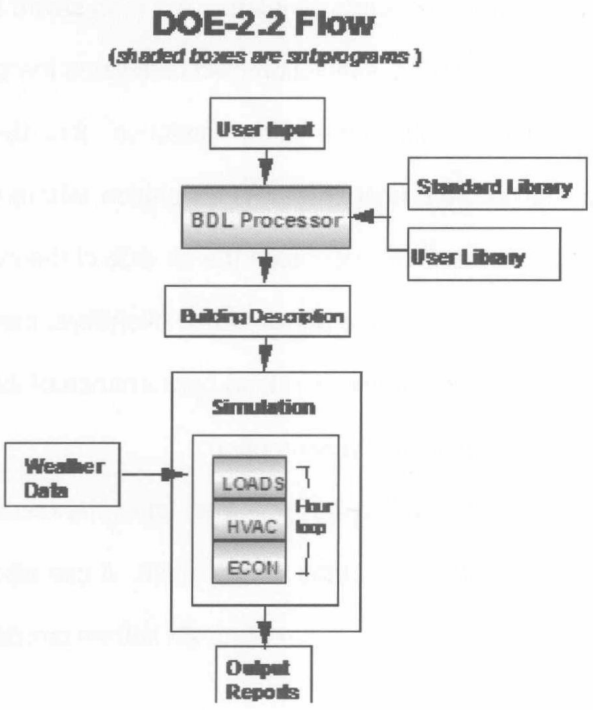

Figure 2: DOE-2.2 Simulation Flow Chart

The hourly simulation is divided into three sub programs as shown in Figure 2. First the loads simulation calculates the hourly sensible and latent heating and cooling loads for the building over an entire year. The loads simulation takes into account weather effects, solar effects, schedules based on people, lights, equipment, plug loads, and infiltration, and heat transfer through building surfaces.

DOE-2 uses typical meteorological year two (TMY2) data files for weather information. TMY2 weather data files contain hourly values for solar radiation and meteorological elements for a one year period. The data is compiled from the 1961-1990 National Solar Radiation Data Base. They were designed to be used for computer simulations to provide typical weather conditions, so they should not be used when designing for a worst case scenario.