Calculating Heat Energy Requirements

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Overview

- Introduction
- Equations
- Graphical Analysis
- Issues
- Other Applications
- Discussion

Introduction

- H.T.C is a software program coded in Visual Basic using Microsoft Visual Studio .NET.
- It calculates
  - The amount of energy and fuel needed for the heat treatment of the facility.
  - Provides a graphical analysis of variations of fuel consumption with respect to changes in temperature and duration of heat treatment.

Equations

- Surfaces

$$q_S = \Delta T \times Area \times U$$

or

$$q_S = \Delta T \times Area \times \left(\frac{1}{\frac{x}{k}} \right)$$

ΔT: Temperature difference of the exposed wall.
U: Coefficient of heat transfer of the material.
k: Thermal Conductivity
x: Thickness

Equation applied to walls, windows, doors, ceiling and floor

Equations

- Infiltration

$$q_I = \Delta T \times 0.018 \times Volume \times aircirculations$$

- Steel

$$q_{St} = \Delta T \times 0.12 \times Steelweight$$

- Total

$$q_{Total} = \sum q_S + q_I + q_{St}$$

Equations

- Fuel consumption

$$Fuel = \left(\frac{q_{Total}}{q_{unit}} \right) \times \frac{1}{efficiency}$$

q_{unit} is the amount of energy produced by the fuel per unit

- The required energy is converted into fuel consumption to estimate the cost of energy needed

Equations

- In the software, the user has the option of
  - Changing efficiency values of fuels suiting the machinery used for heat up.
  - Choosing Raise and Peak Phases of the heat treatment
  - Adding new structural materials, fuels to the database

Graphical Analysis using HTC

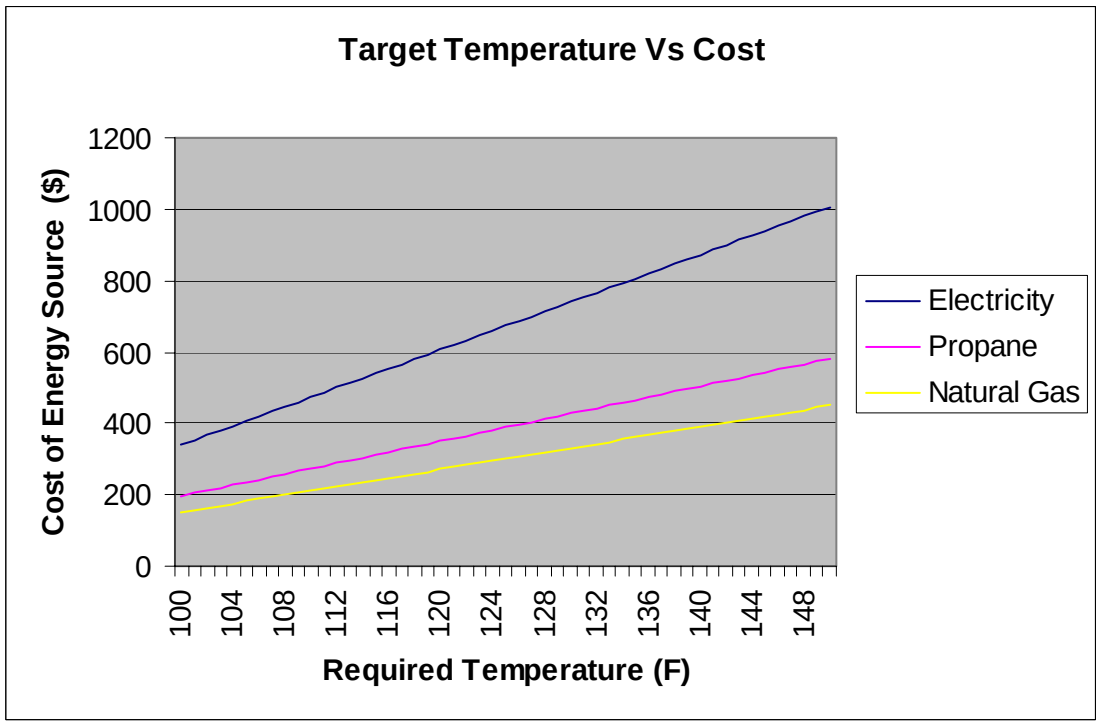
- It can be used to predict the effects of a particular variation in heat treatment setting.
- In this sense, it is a tool to virtually compare two heat treatments on a building with different temperature and fuel settings.
- In this presentation, we take up an example and run the various analysis tools.

Facility Description

Rooms: Floor 1: 3 Floor 2: 2 Floor 3: 4 Floor 4: 2	Steel : 3000 Pounds Volume: 175616 Cubic Feet Air circulations per hour: 3
Temperature Settings: Outside 75 F Inside 80 F Ground 65 F Period 48 Hours	Target Temperature 140 F Target Rate of Increase 5.4 F/hr in temperature

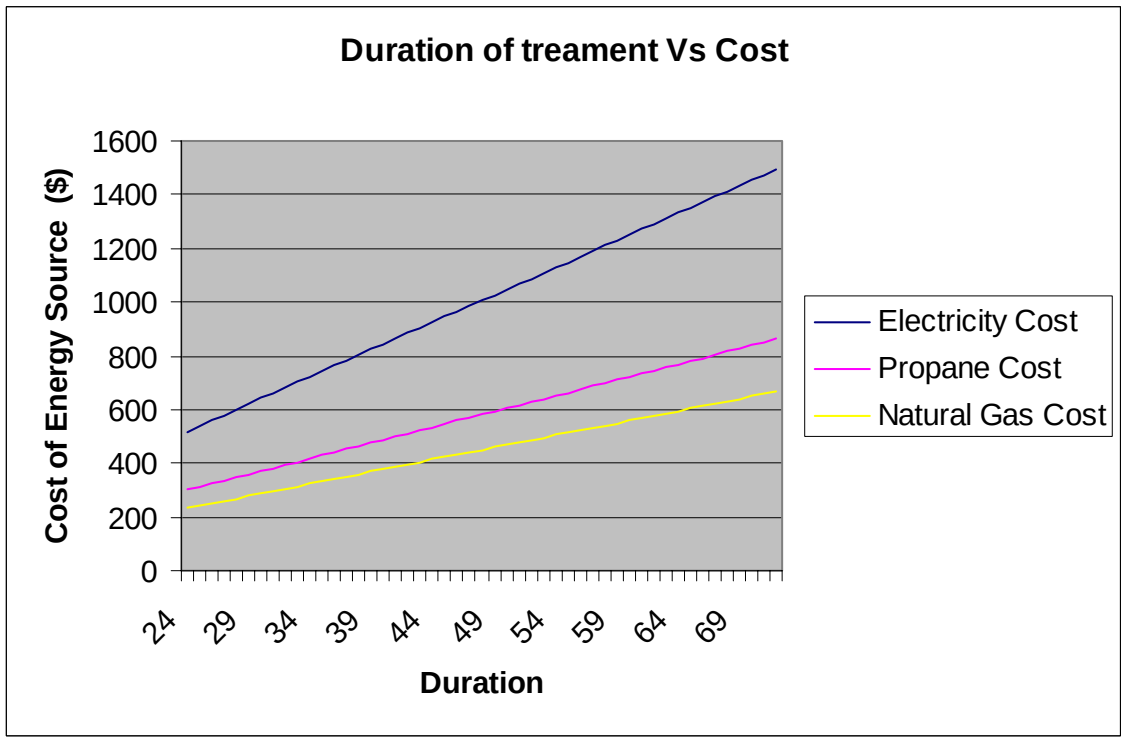
Cost of fuels

- Effects of variation in target temperature



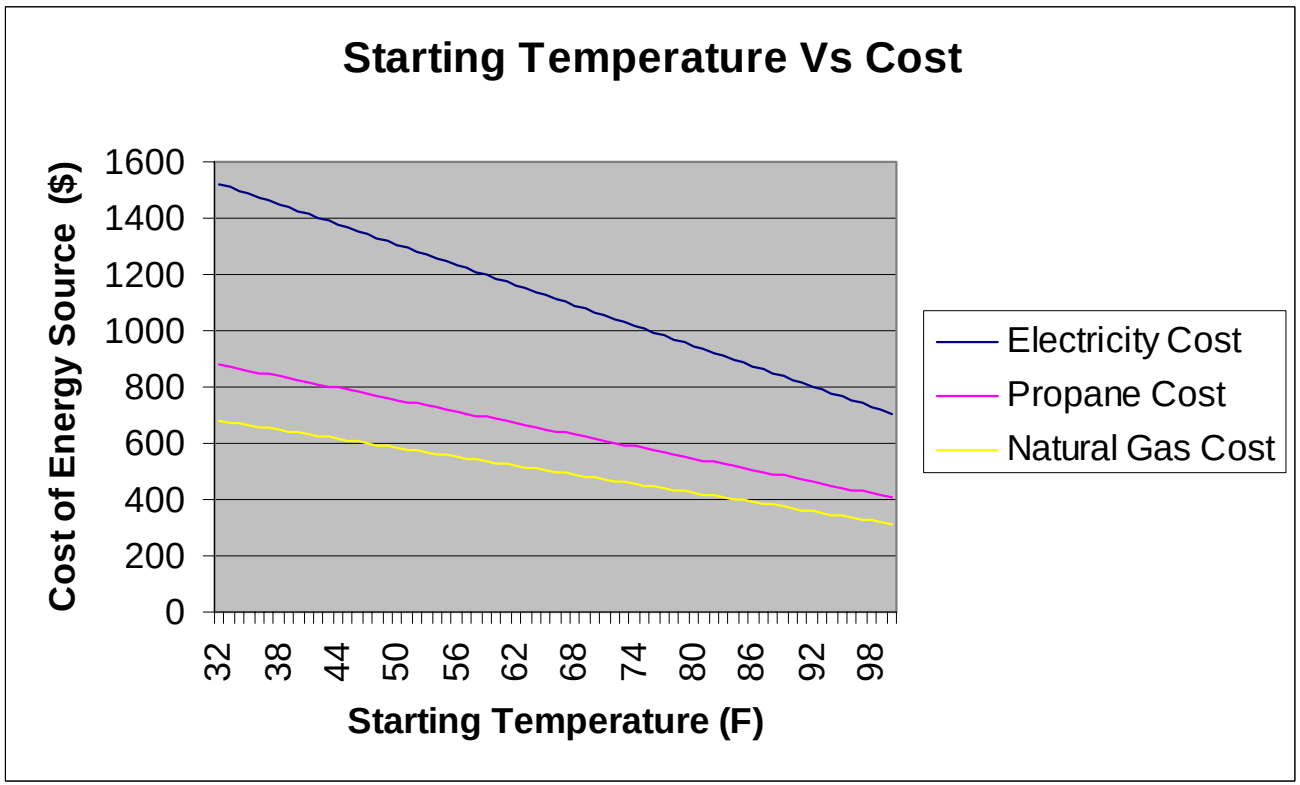
Cost of fuels

- Effects of variation in duration of heat treatment



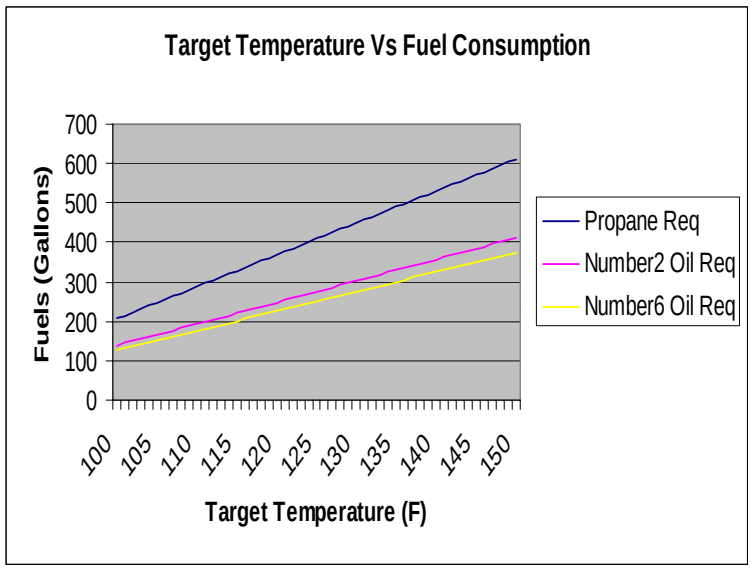
Cost of fuels

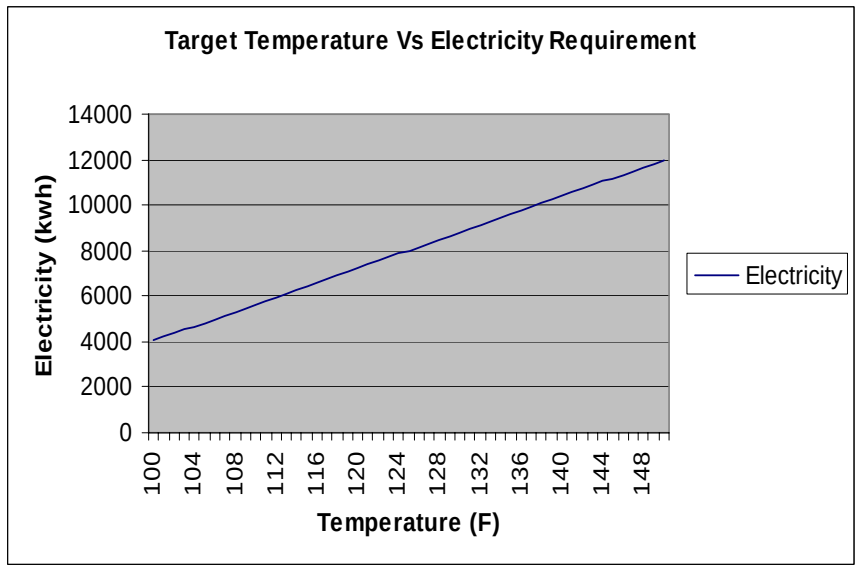
- Effects of variation in starting temperature



Fuel consumption

- Effects of variation in target temperature





Fuel consumption

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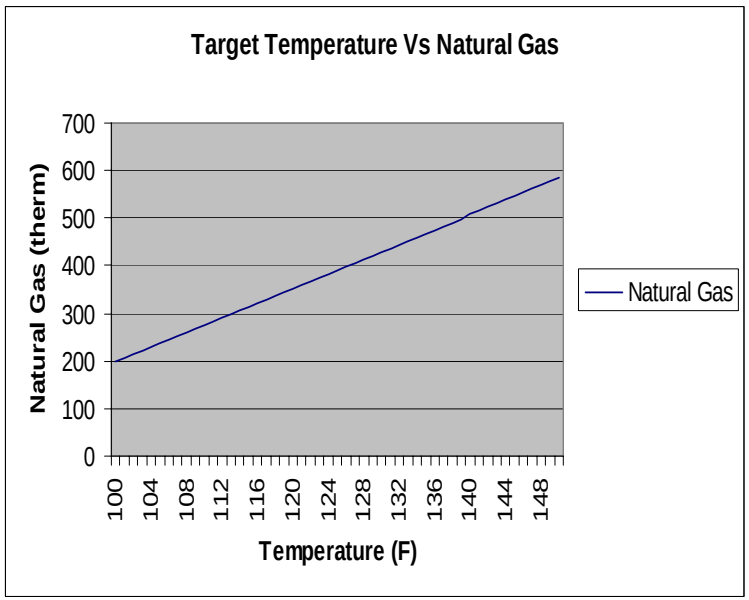
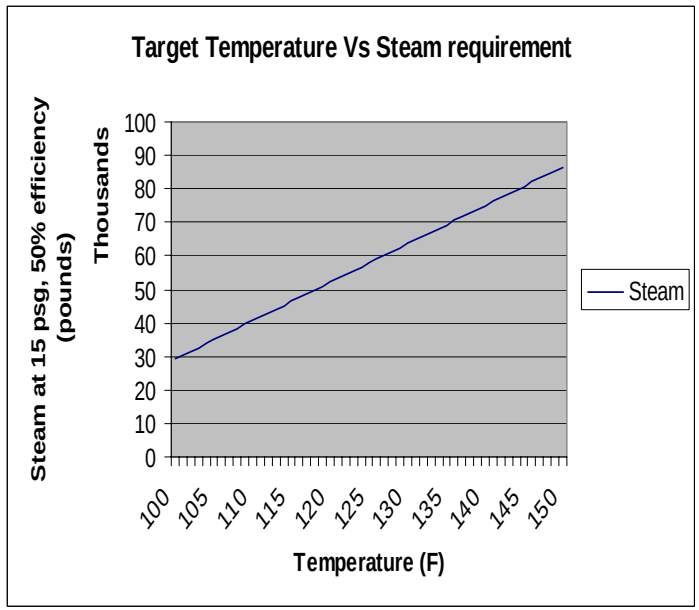
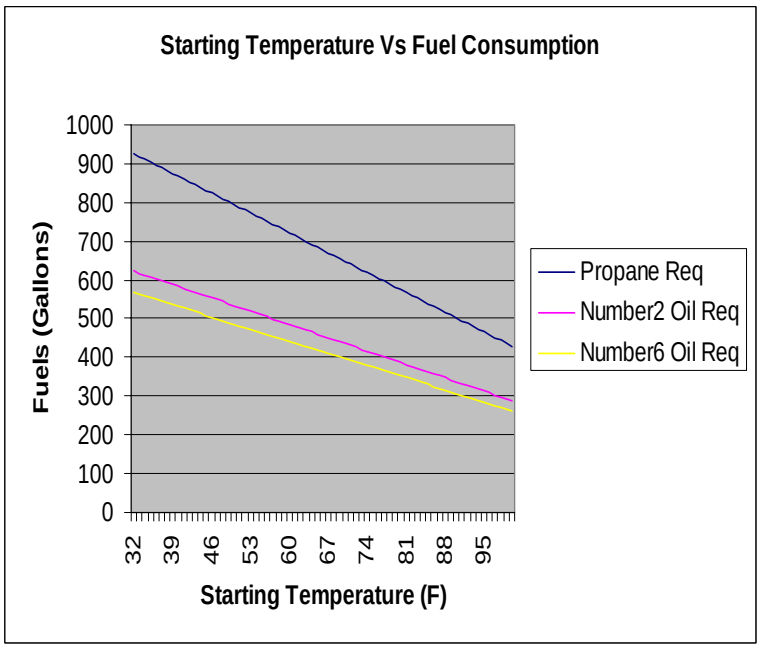
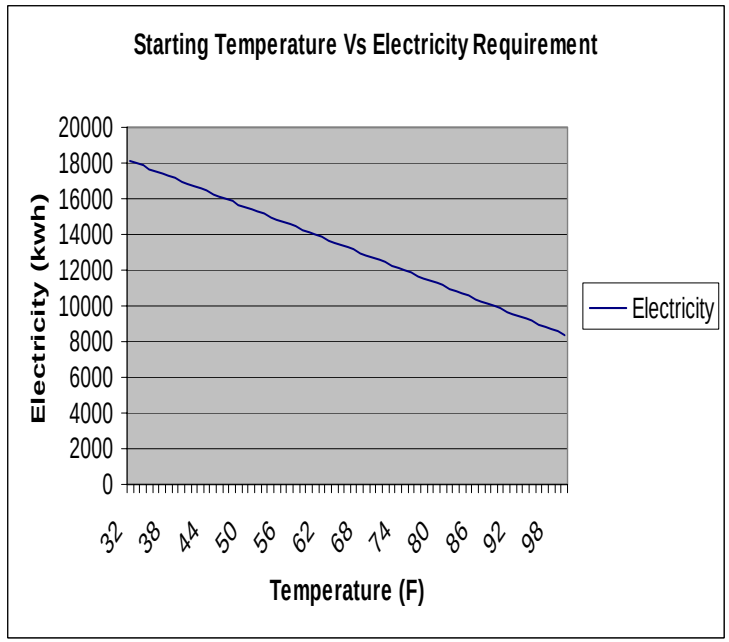




Fuel consumption

- Effects of variation in starting temperature





Fuel consumption

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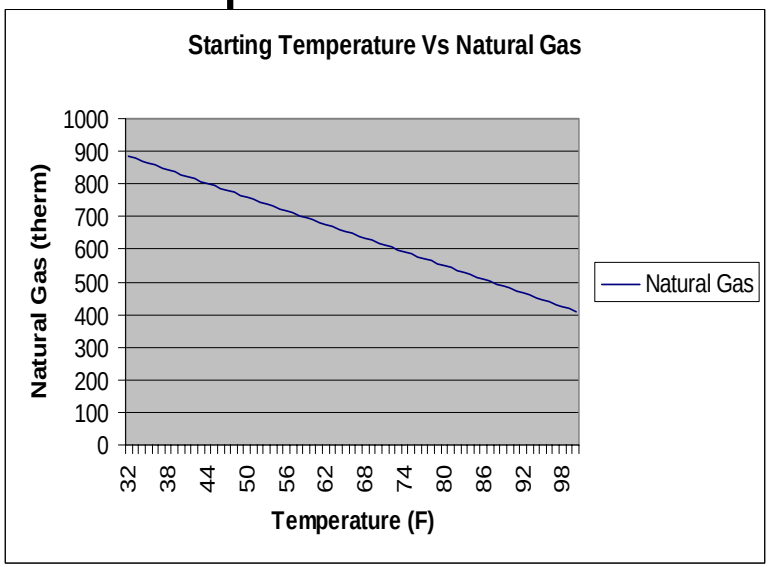
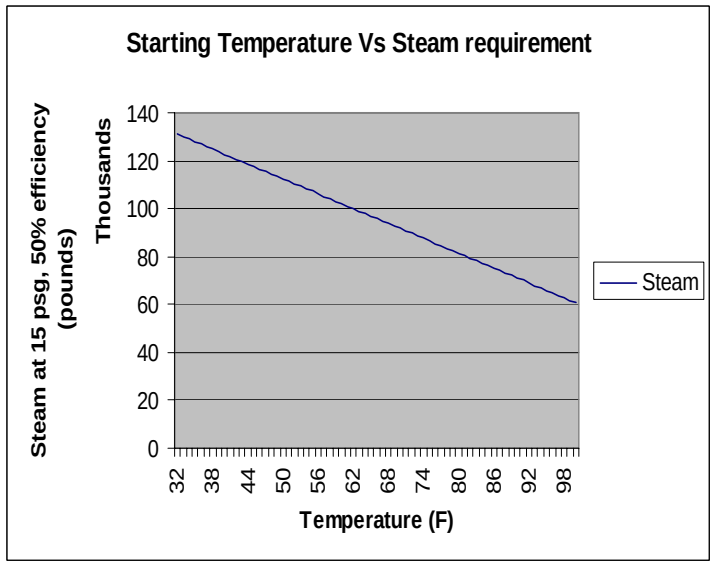
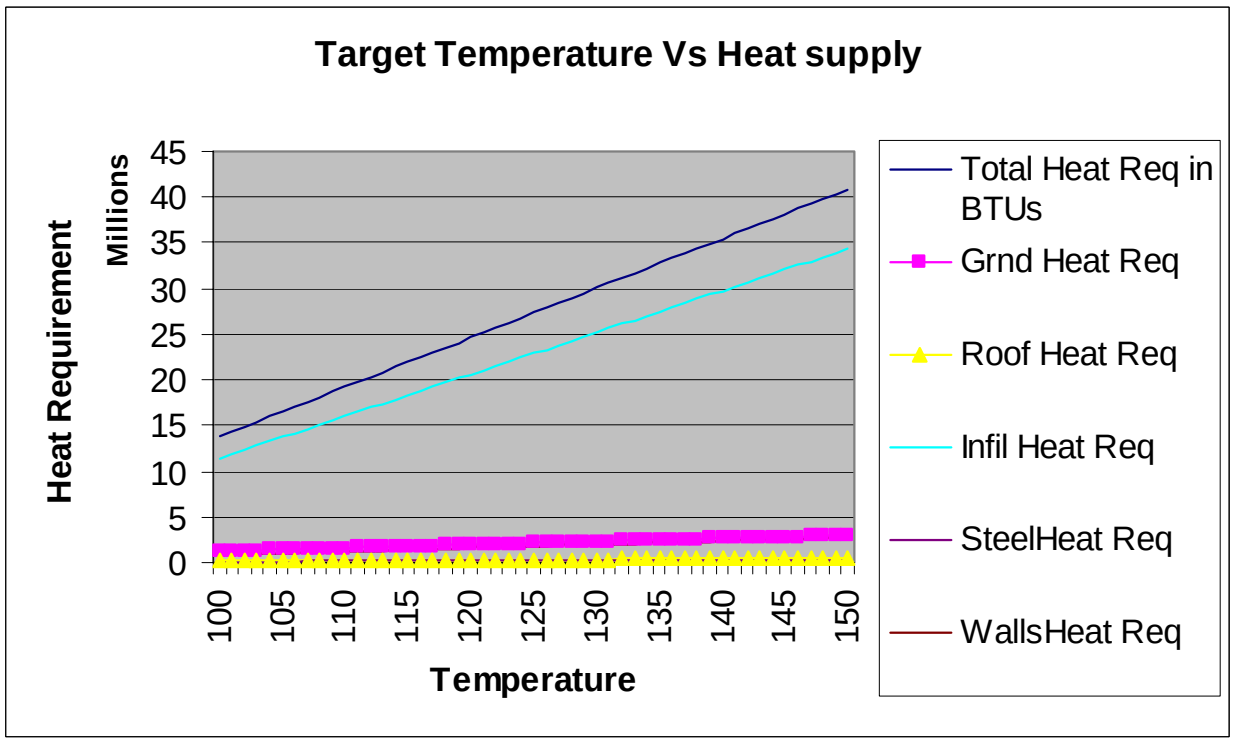




Energy absorption in different materials

- Effects of variation in target temperature



Energy absorption in different materials

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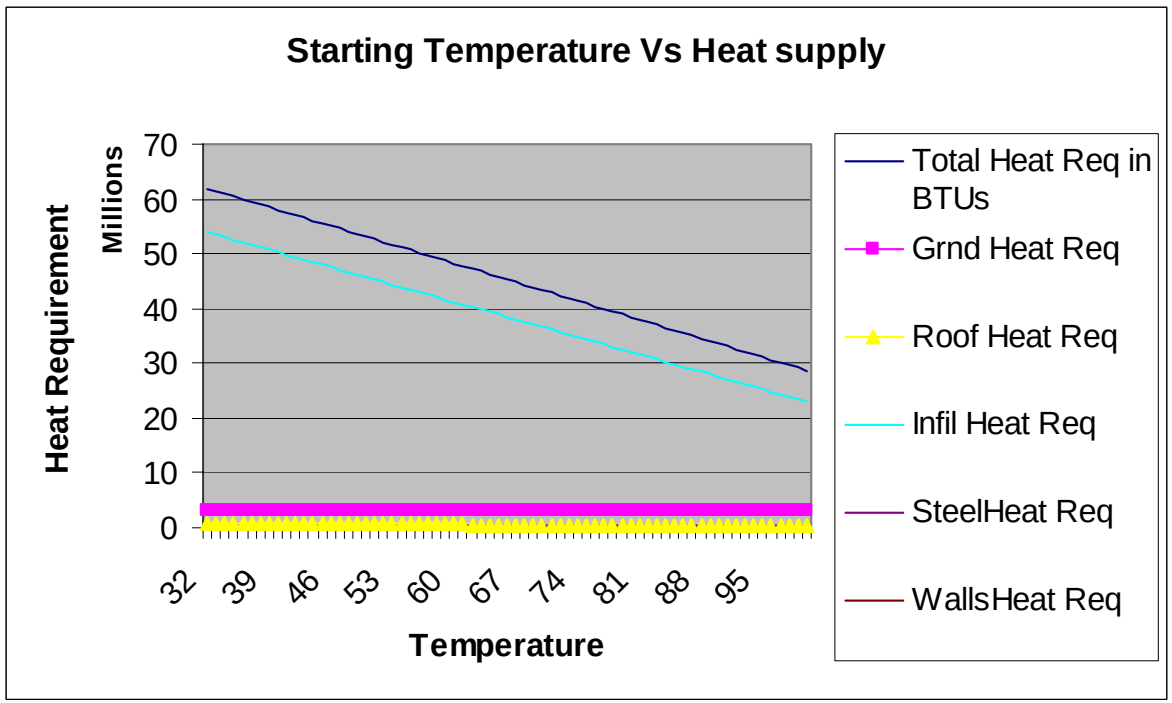
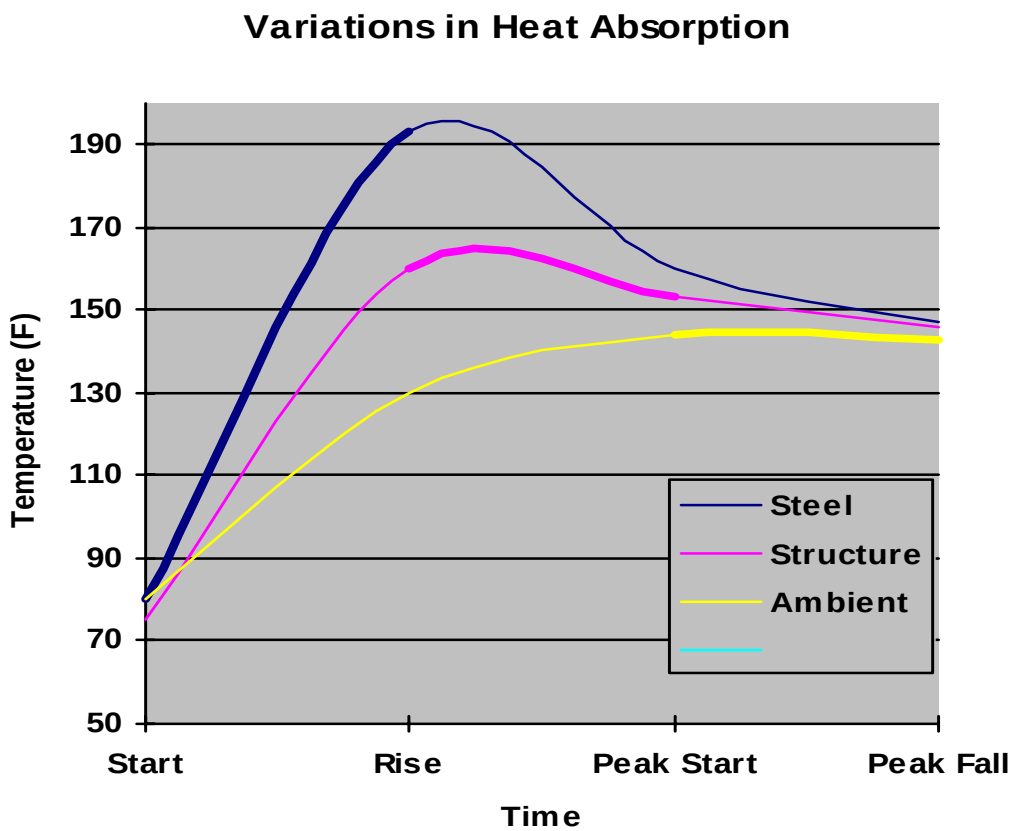


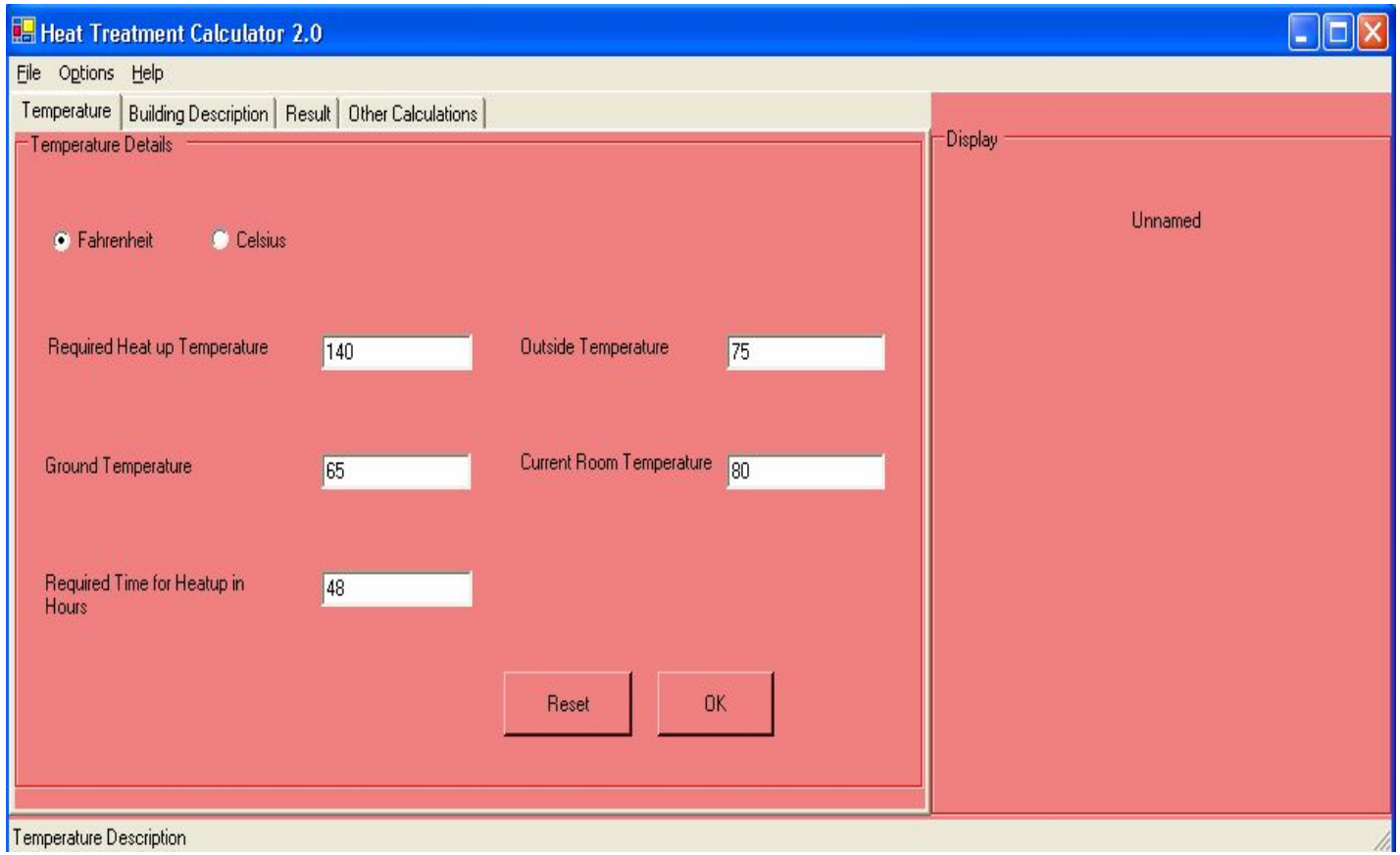
Issues

- Heat absorption by different materials
- Un-accountable losses
- Correction factor
- Effects of humidity and pressure
- Model verification

Heat Absorption and Temperature Rise



Screenshots



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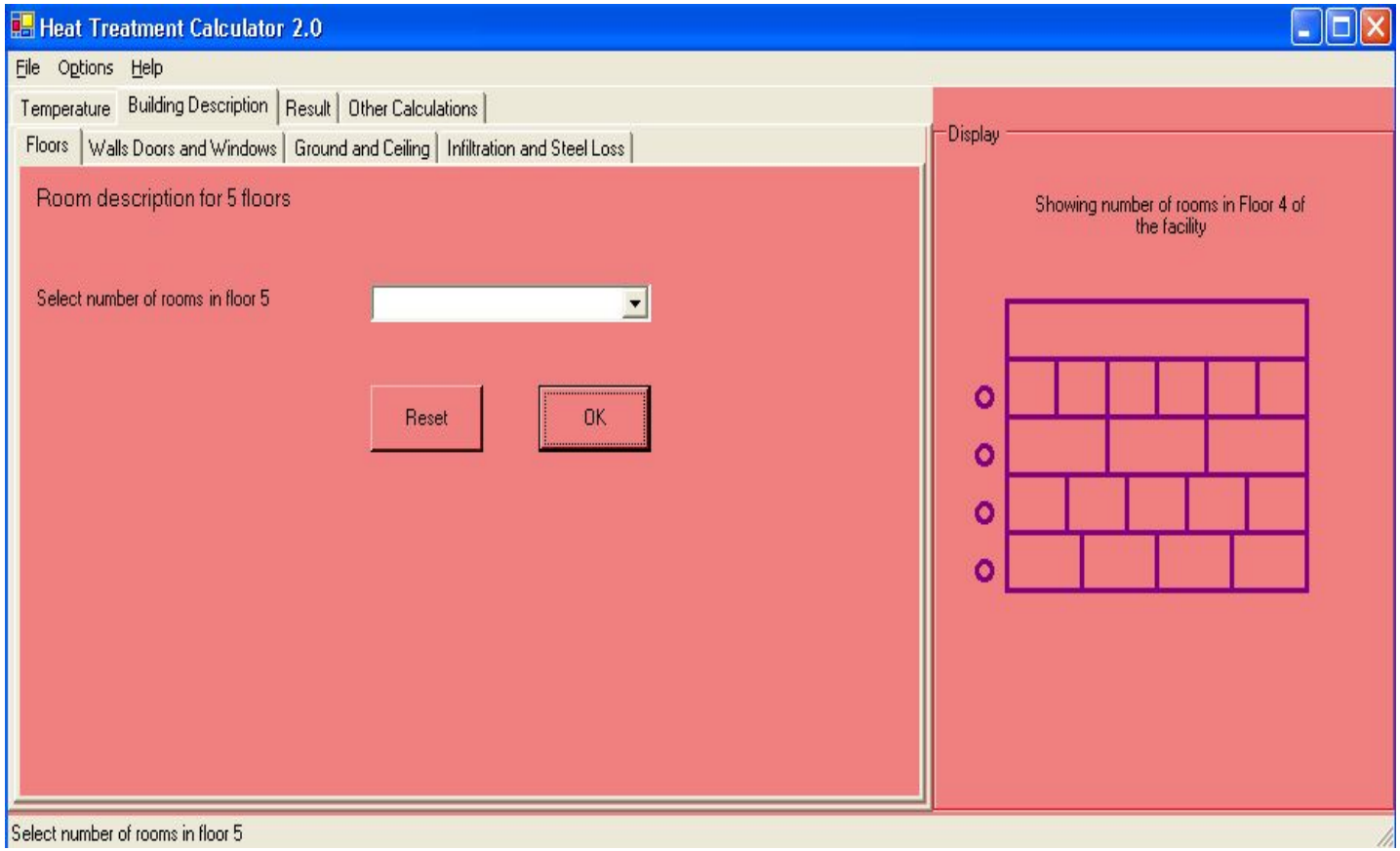

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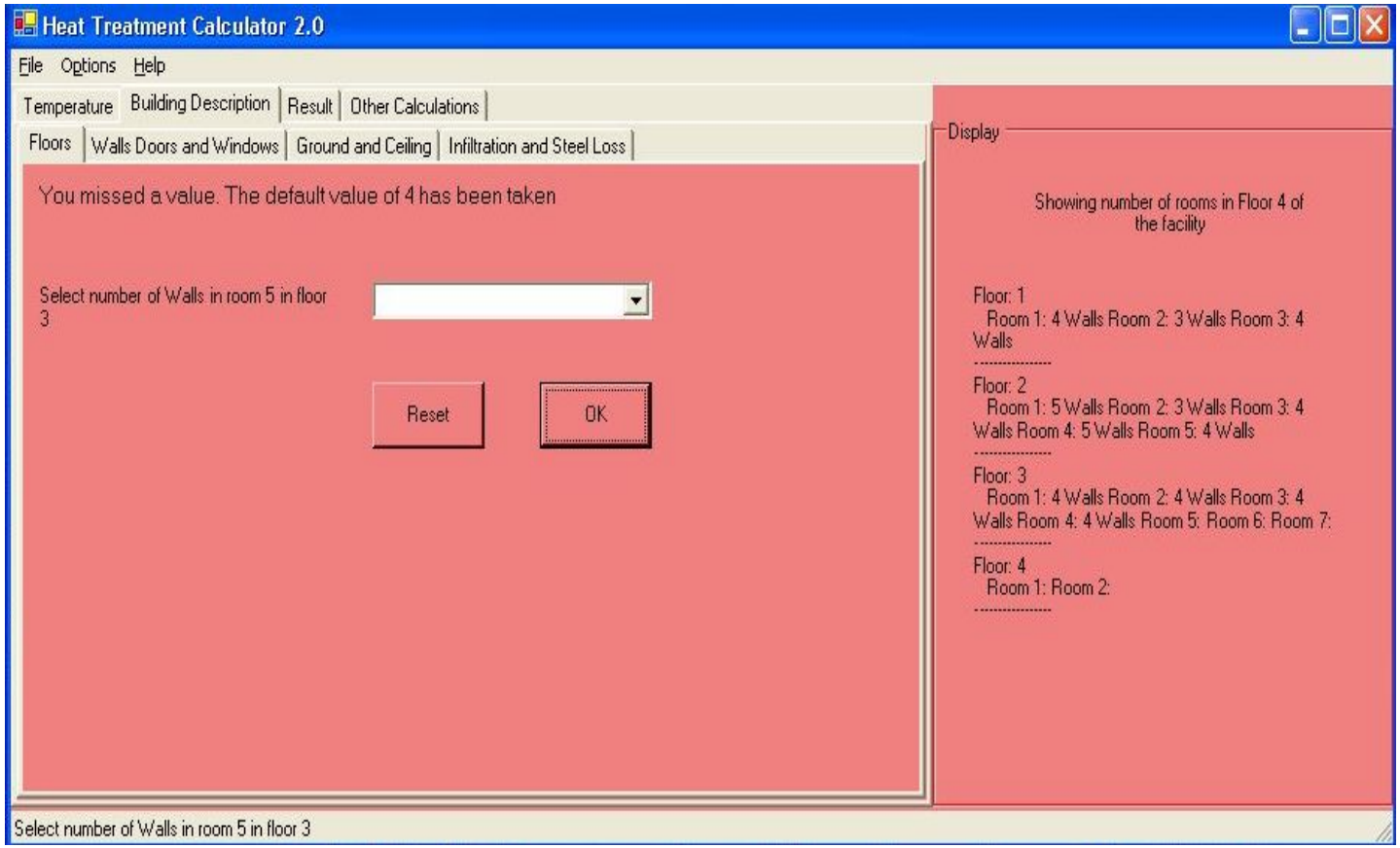

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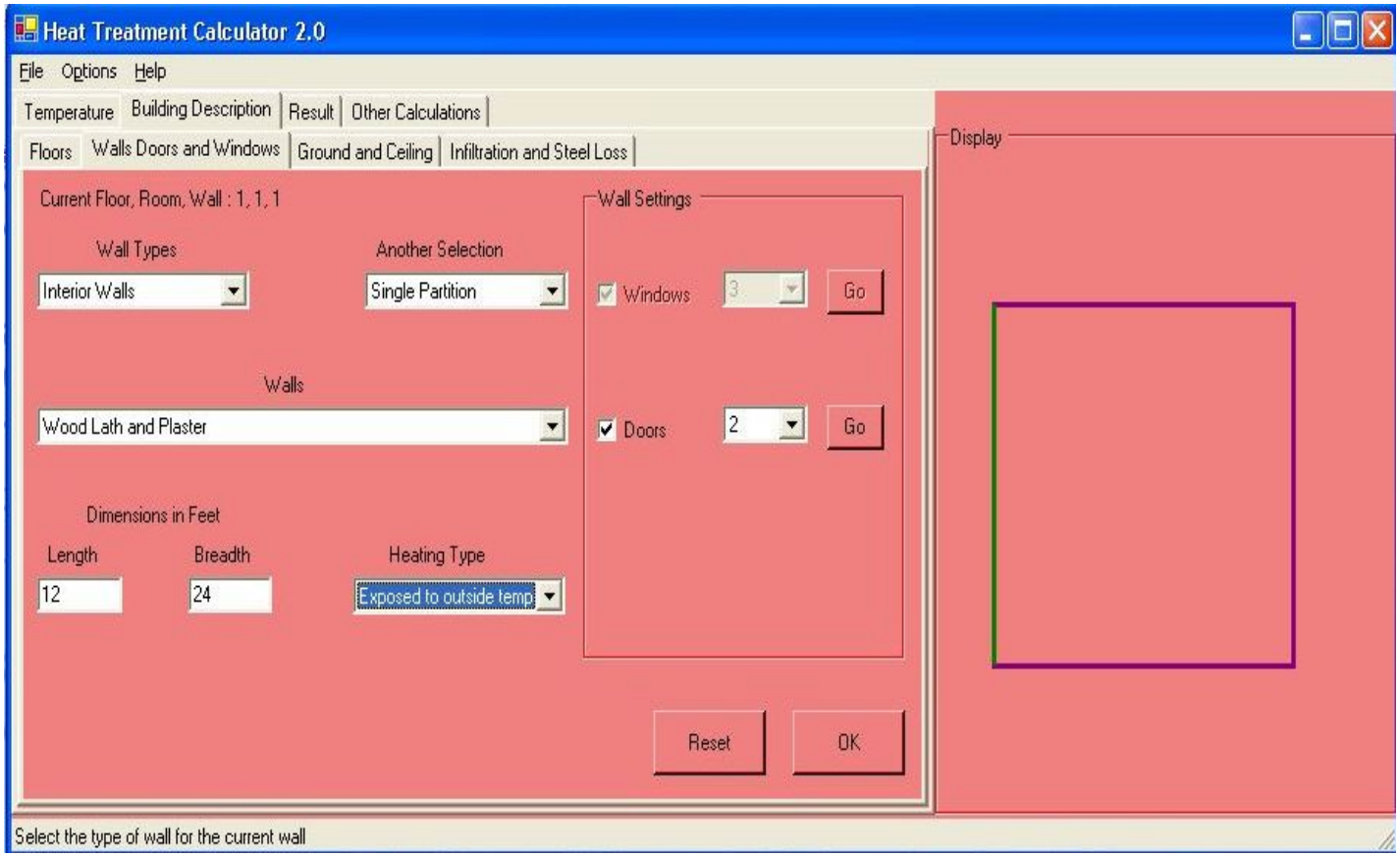

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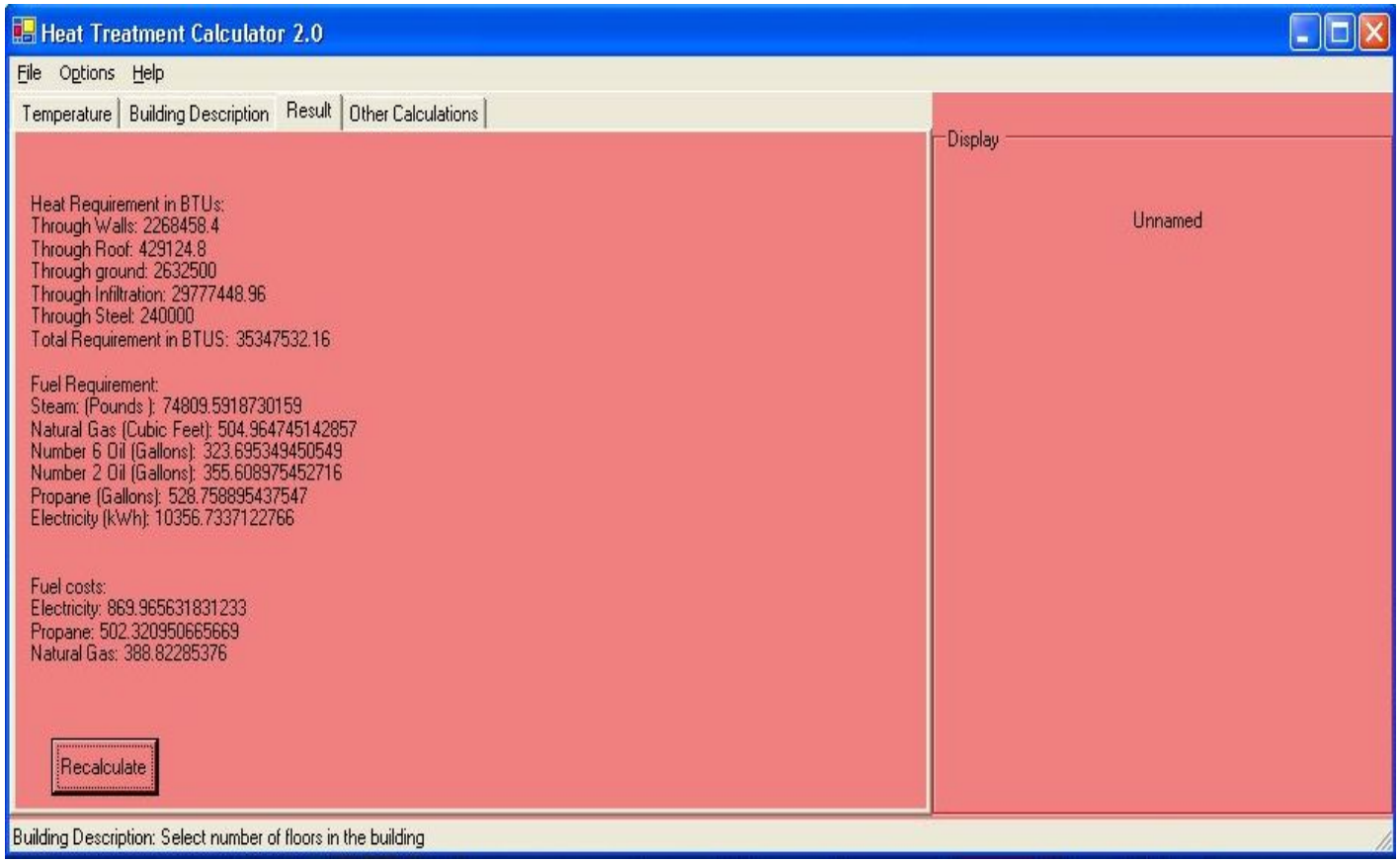

Other Applications

- How to reach a trade off between amount of fuel used, target temperature, peak temperature duration.
- If using multiple sources of energy, how to share energy requirement.
- Insect Mortality.

References

1. William H. Severns, Julian R. Fellows, "*Heating, Ventilating and Air Conditioning Fundamentals*" Second Edition, John Wiley & Sons, Inc 1949.
2. Burgess H. Jennings, "*The Thermal Environment*" Harper & Row, 1978.
3. Thomas J. Imholte,"*A guide to the Sanitary Design of Food Plamsts and Food Plam Equipment, Engineering for Food Safety and Sanitaion "* Second Edition

Discussion