



Calculating Heat Energy Requirements

Sham Kashyap

Computing and Information
Sciences

Kansas State University



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

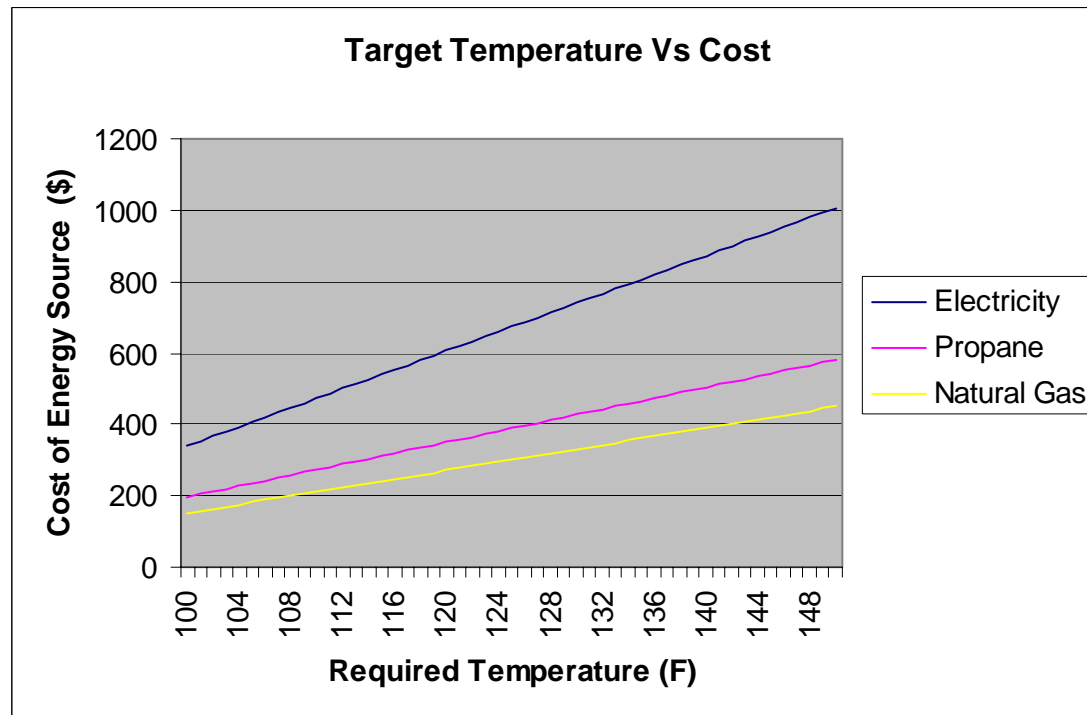
- It can be used to predict the effects of a particular variation in heat treatment setting.
- In this sense, it is a tool to virtually compare two heat treatments on a building with different temperature and fuel settings.
- In this presentation, we take up an example and run the various analysis tools.

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

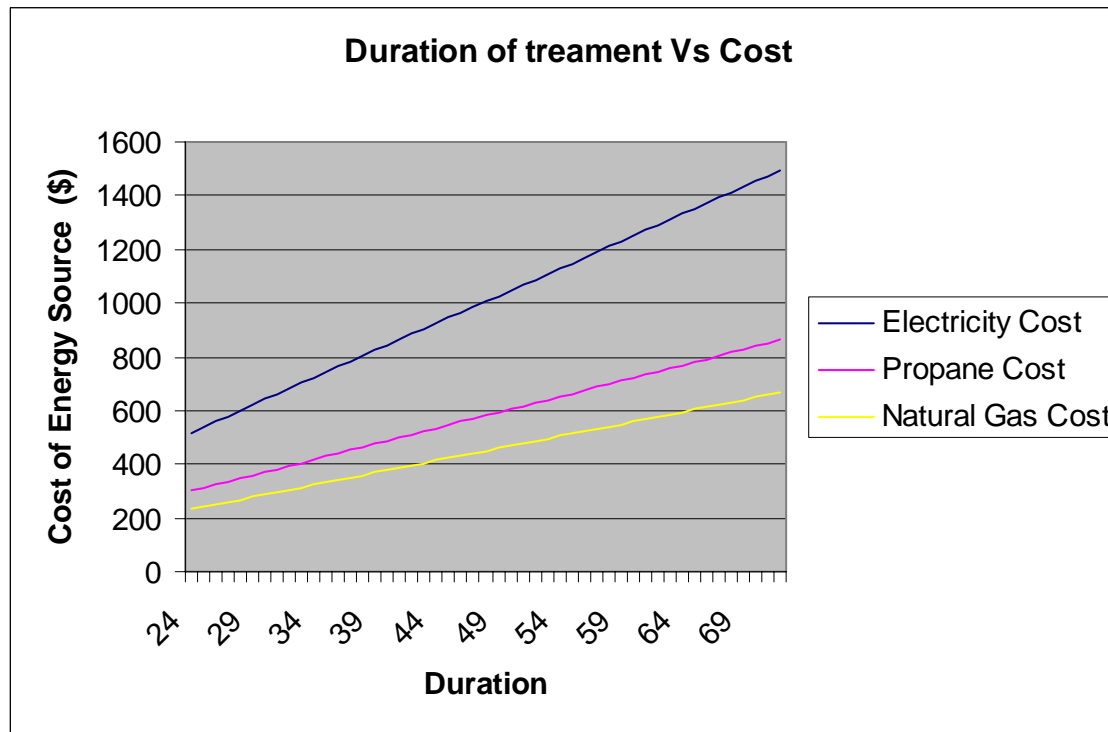
Cost of fuels

- Effects of variation in target temperature



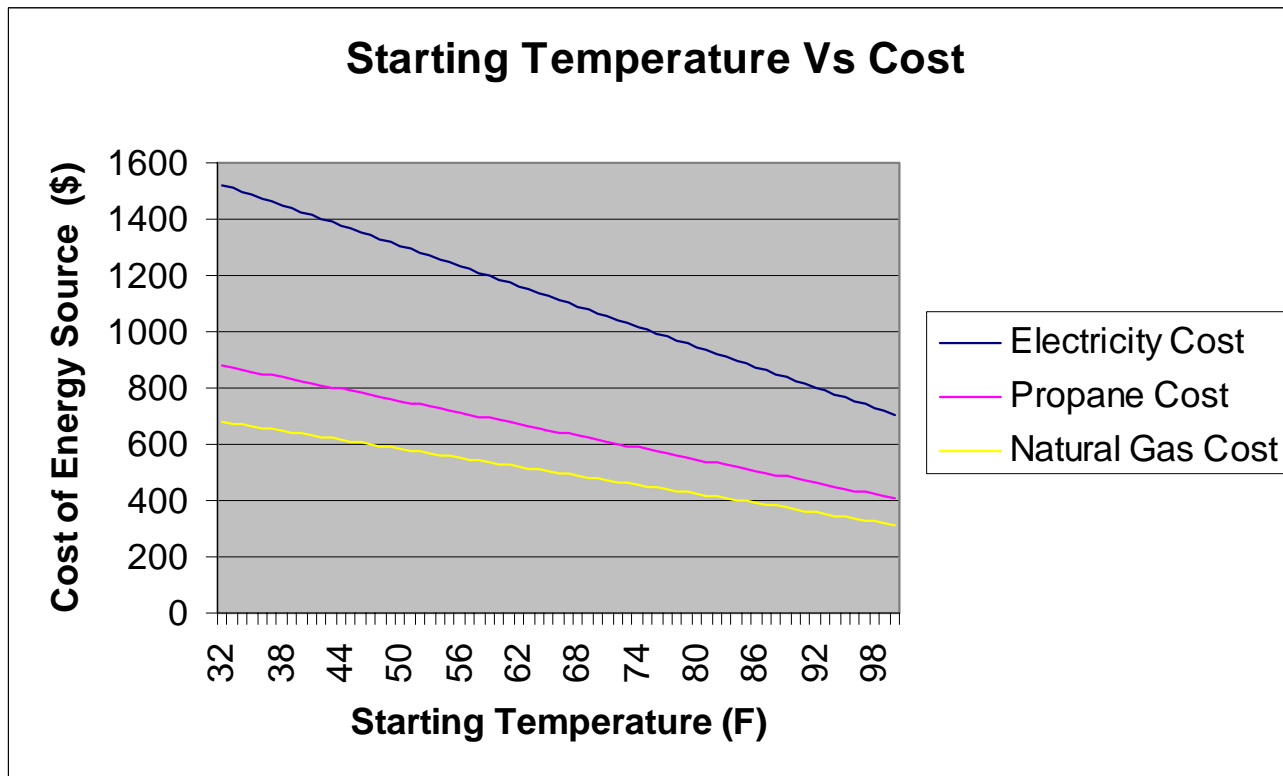
Cost of fuels

- Effects of variation in duration of heat treatment



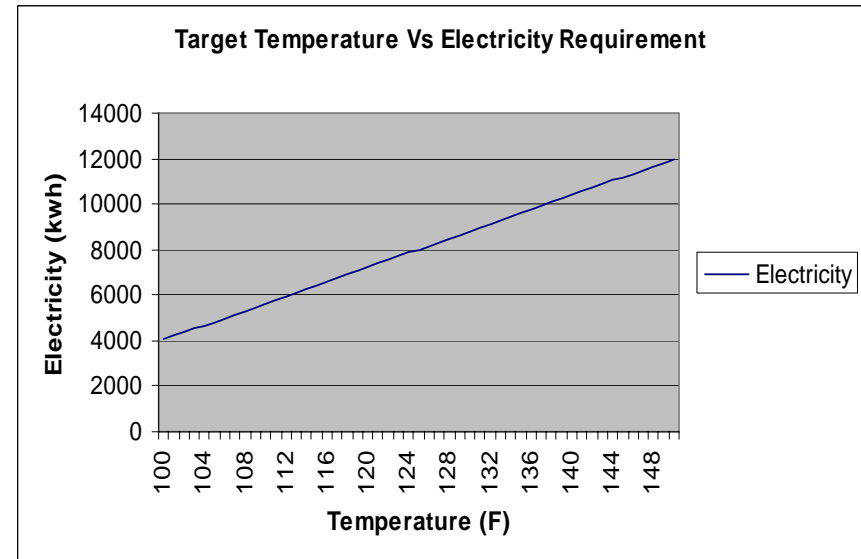
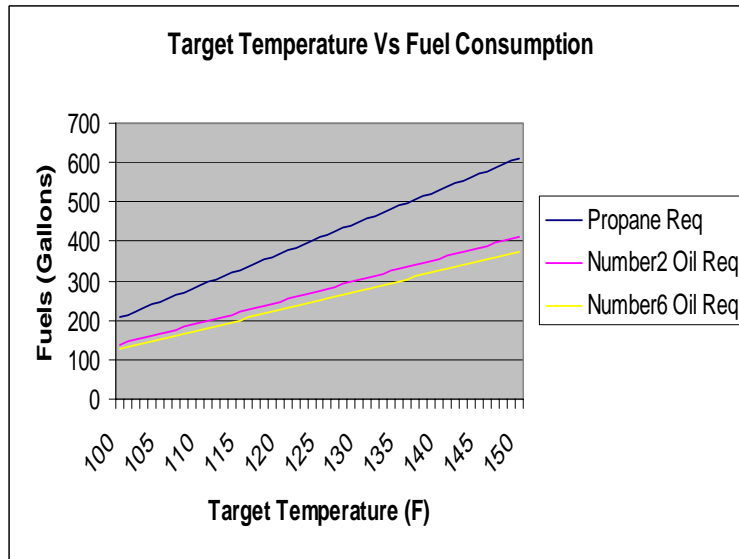
Cost of fuels

- Effects of variation in starting temperature



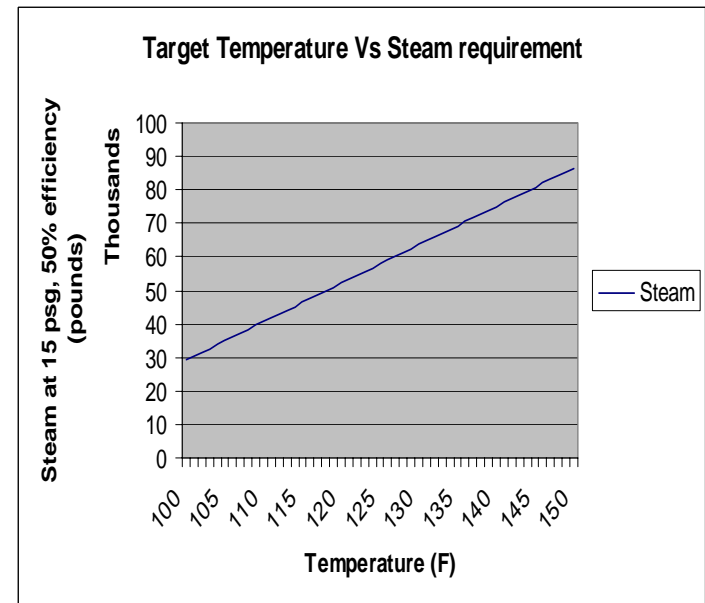
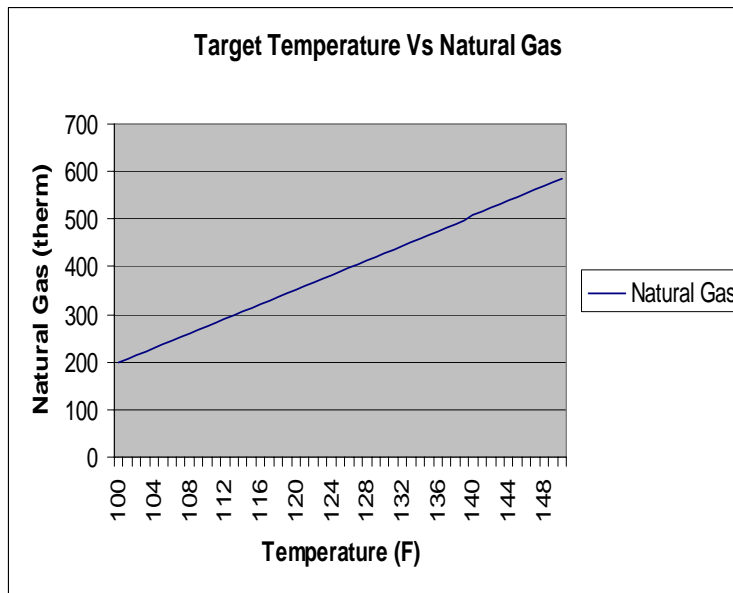
Fuel consumption

- Effects of variation in target temperature



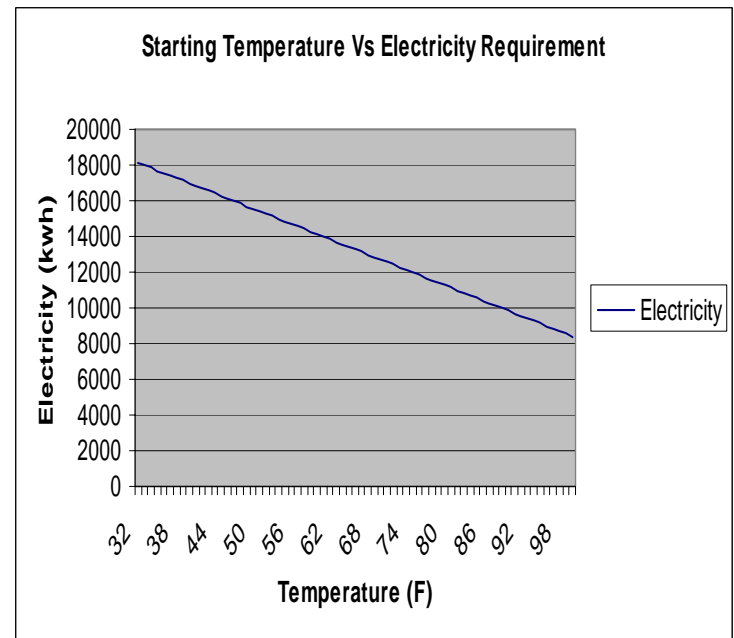
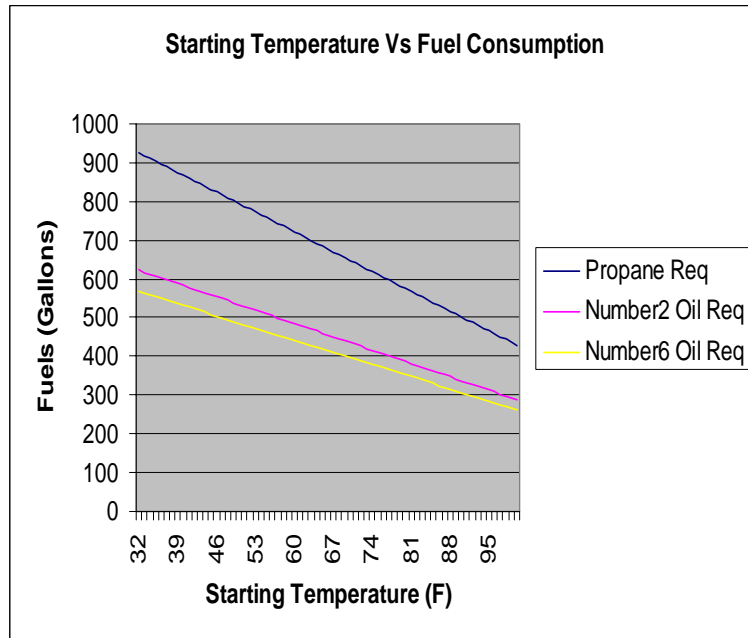
Fuel consumption

- Effects of variation in target temperature



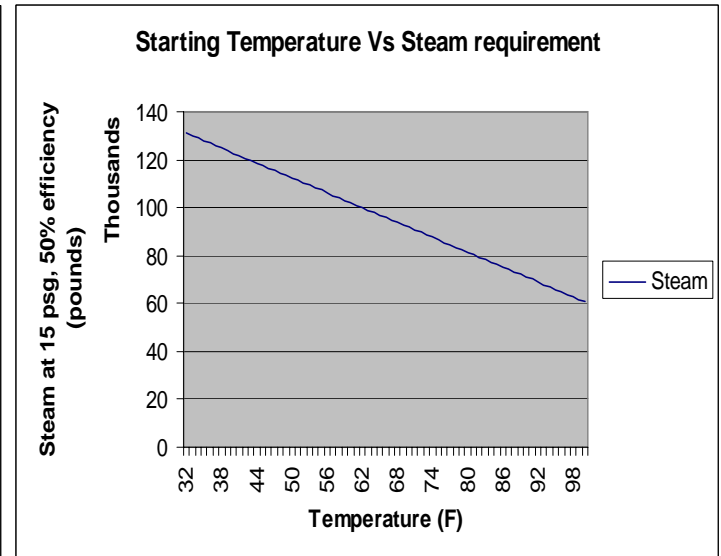
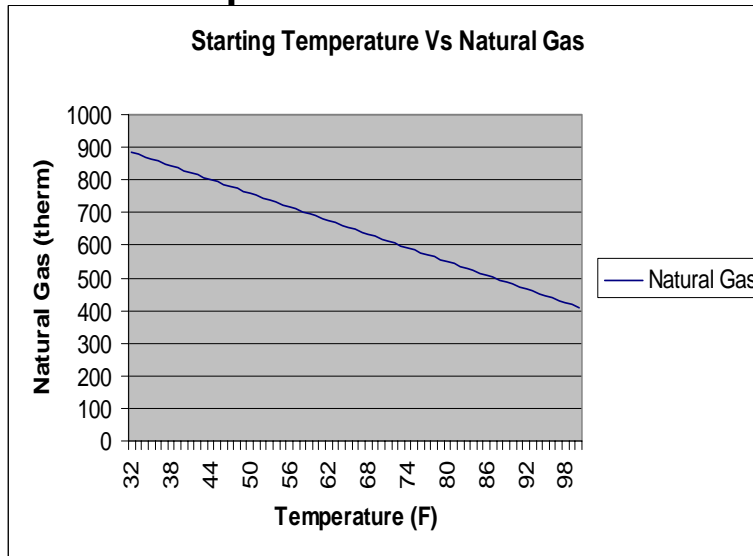
Fuel consumption

- Effects of variation in starting temperature



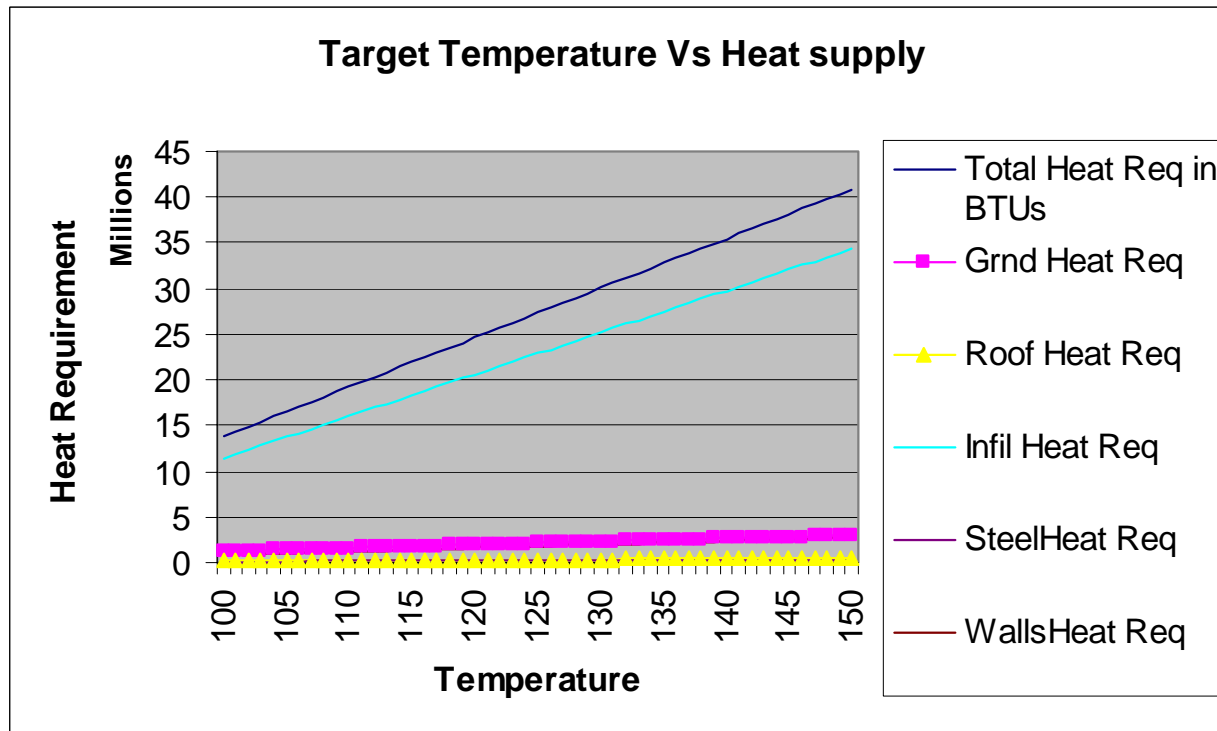
Fuel consumption

- Effects of variation in starting temperature



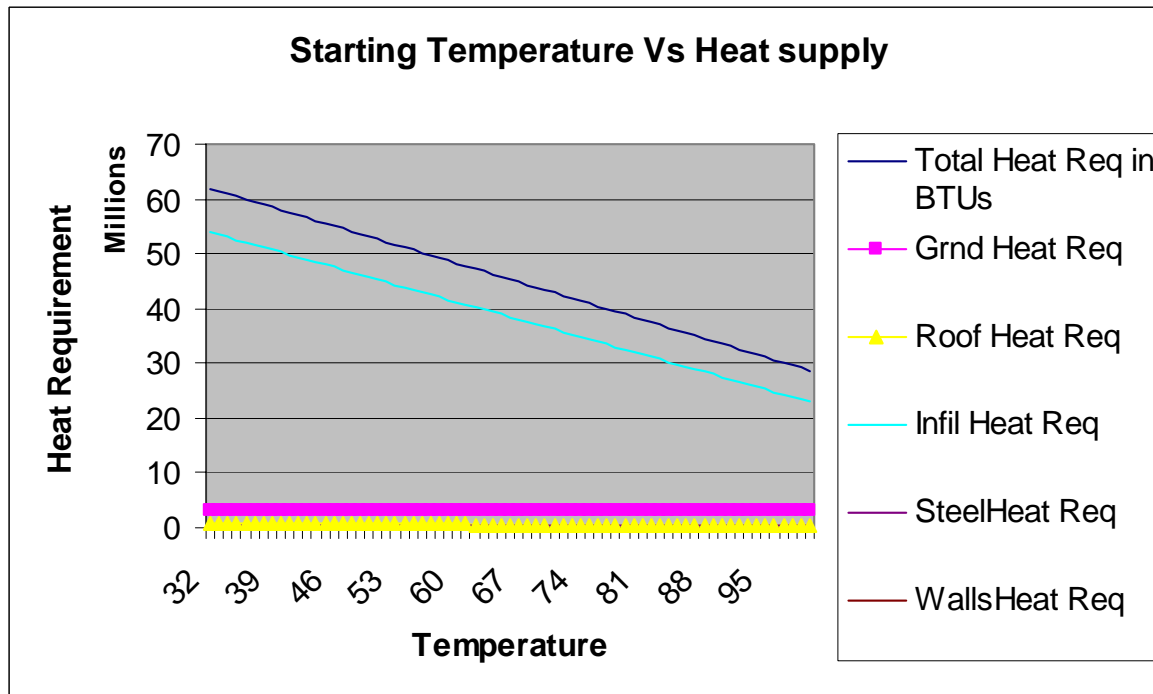
Energy absorption in different materials

- Effects of variation in target temperature



Energy absorption in different materials

- Effects of variation in starting temperature



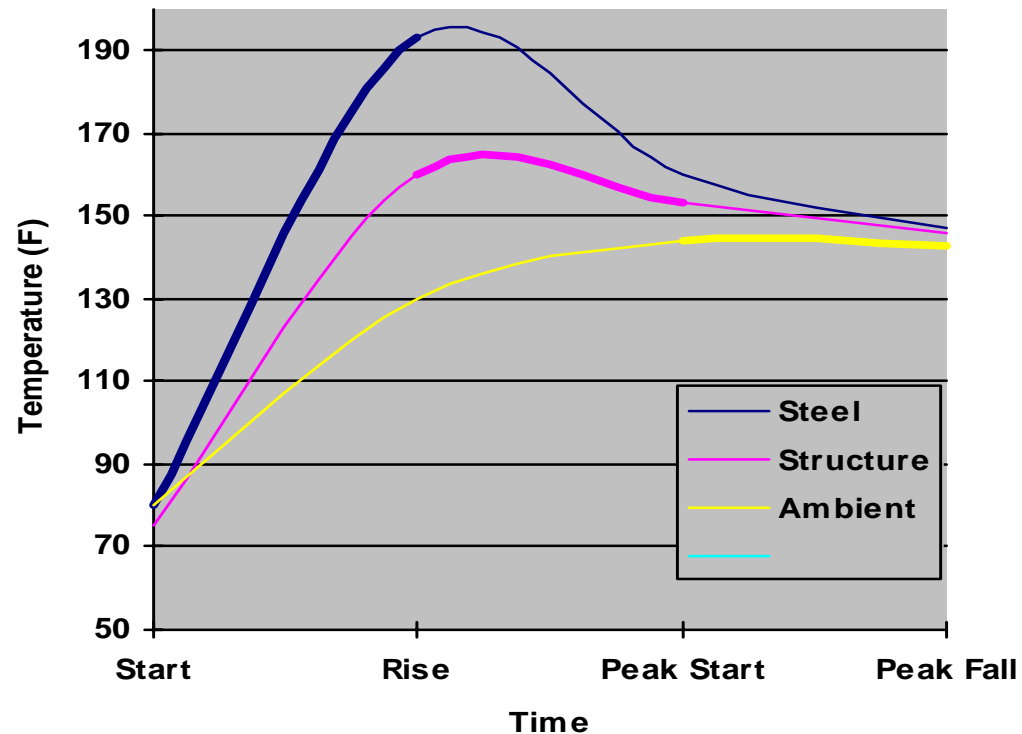


Issues

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

Heat Absorption and Temperature Rise

Variations in Heat Absorption

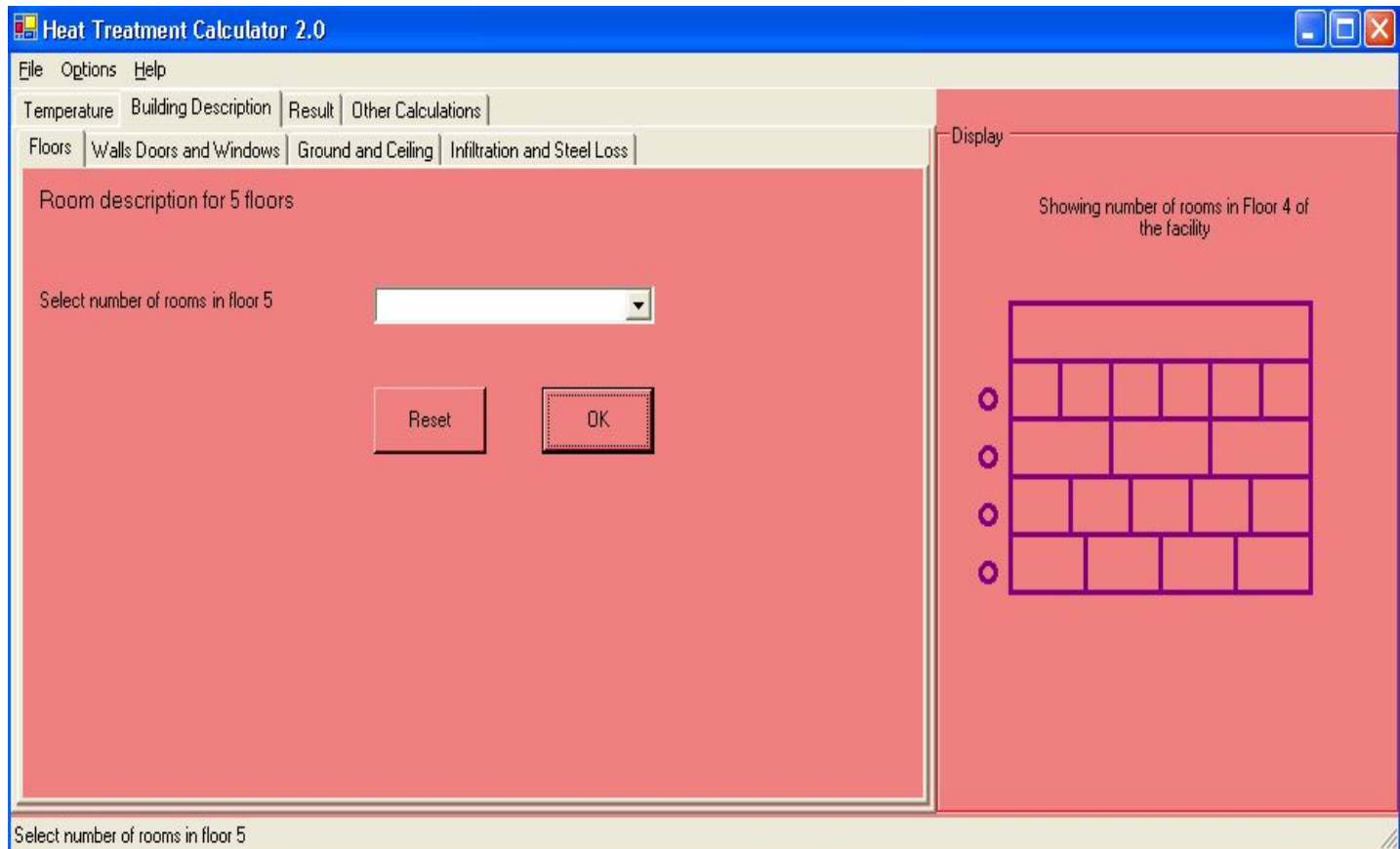


Screenshots

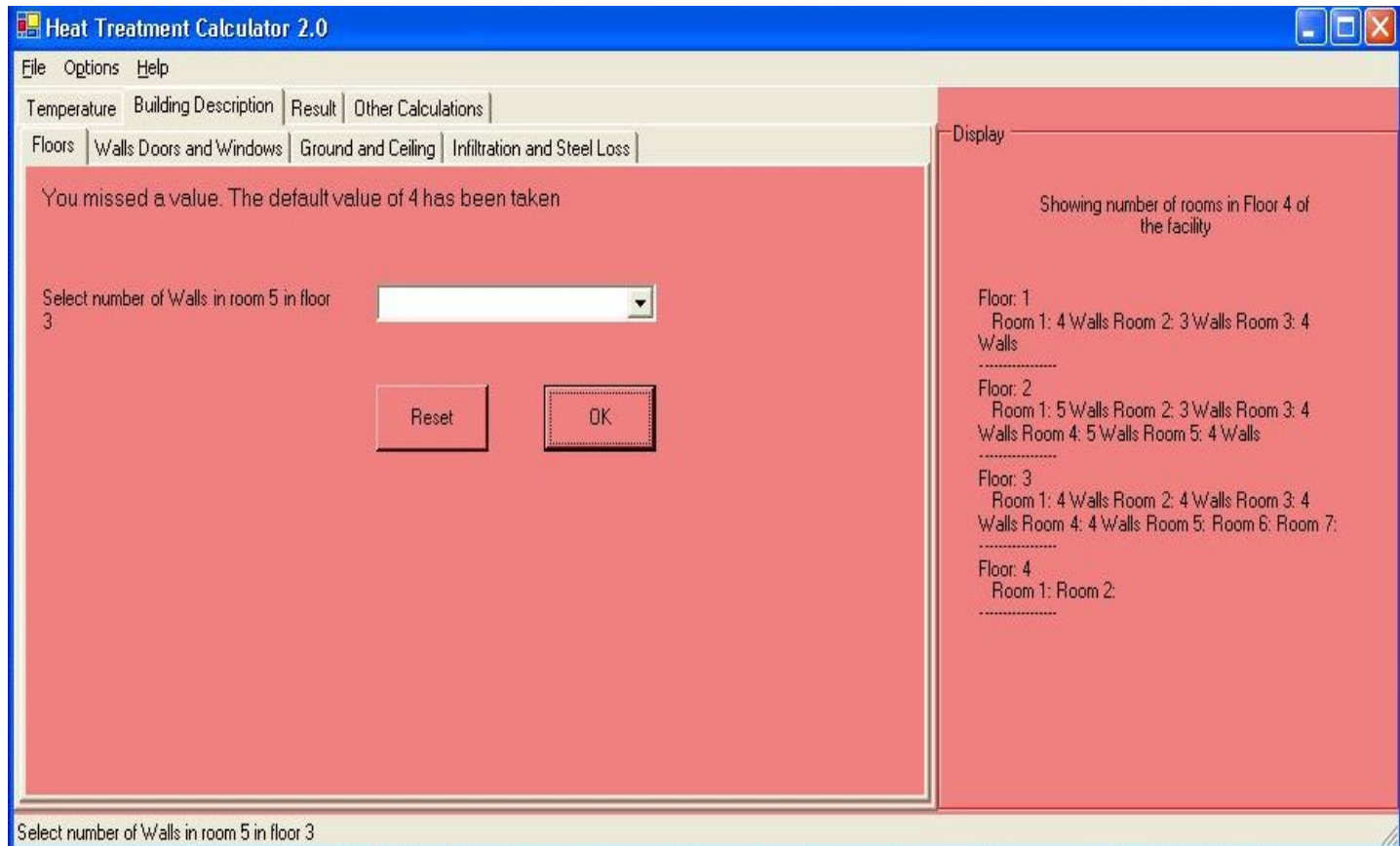
The screenshot shows the 'Heat Treatment Calculator 2.0' application window. The window has a blue title bar and a menu bar with 'File', 'Options', and 'Help'. Below the menu bar are four tabs: 'Temperature', 'Building Description', 'Result', and 'Other Calculations'. The 'Temperature' tab is active, showing a 'Temperature Details' section with radio buttons for 'Fahrenheit' (selected) and 'Celsius'. There are five input fields: 'Required Heat up Temperature' (140), 'Outside Temperature' (75), 'Ground Temperature' (65), 'Current Room Temperature' (80), and 'Required Time for Heatup in Hours' (48). At the bottom of this section are 'Reset' and 'OK' buttons. To the right is a 'Display' area labeled 'Unnamed'. The status bar at the bottom shows 'Temperature Description'.

Field	Value
Required Heat up Temperature	140
Outside Temperature	75
Ground Temperature	65
Current Room Temperature	80
Required Time for Heatup in Hours	48

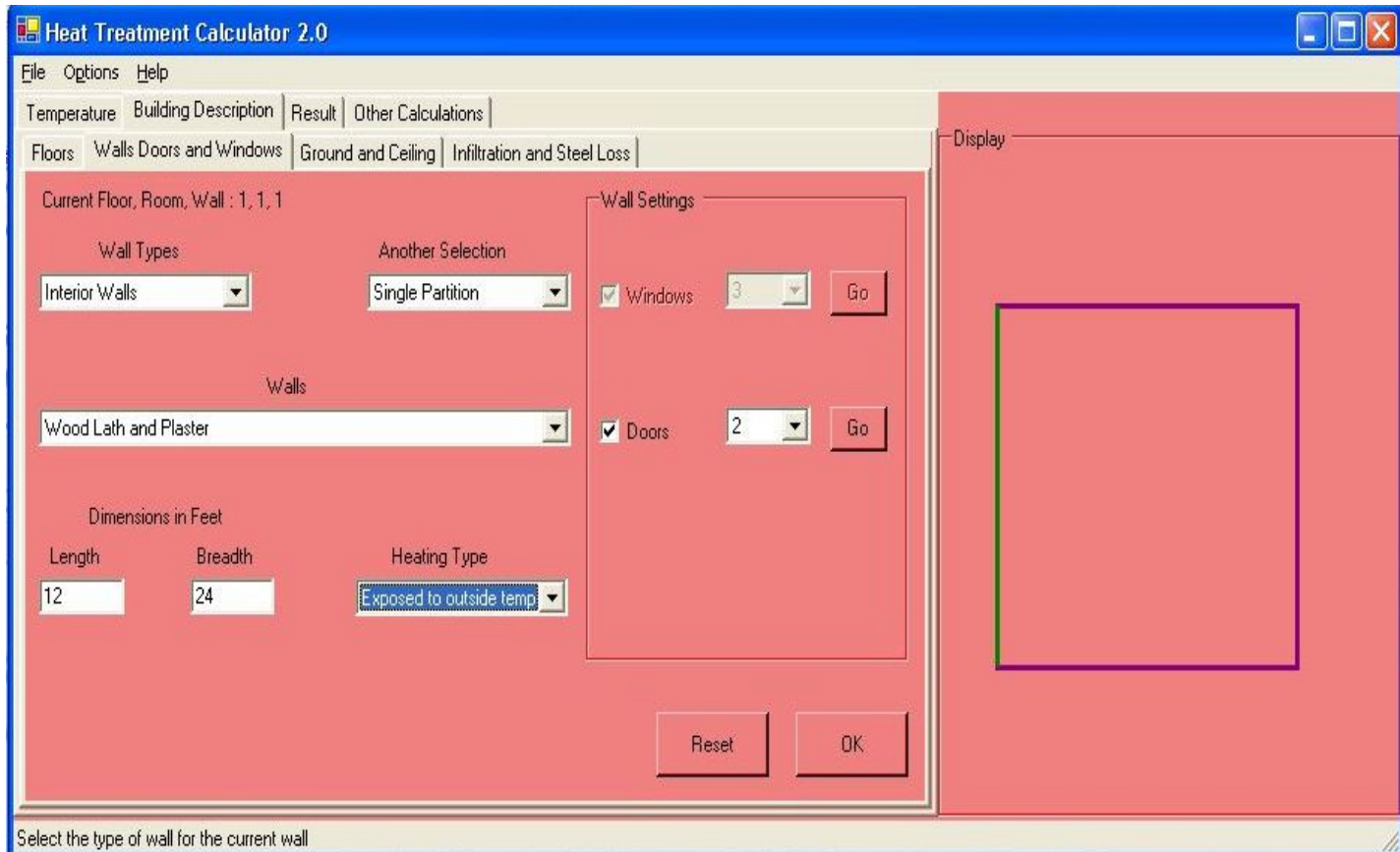
Screenshots



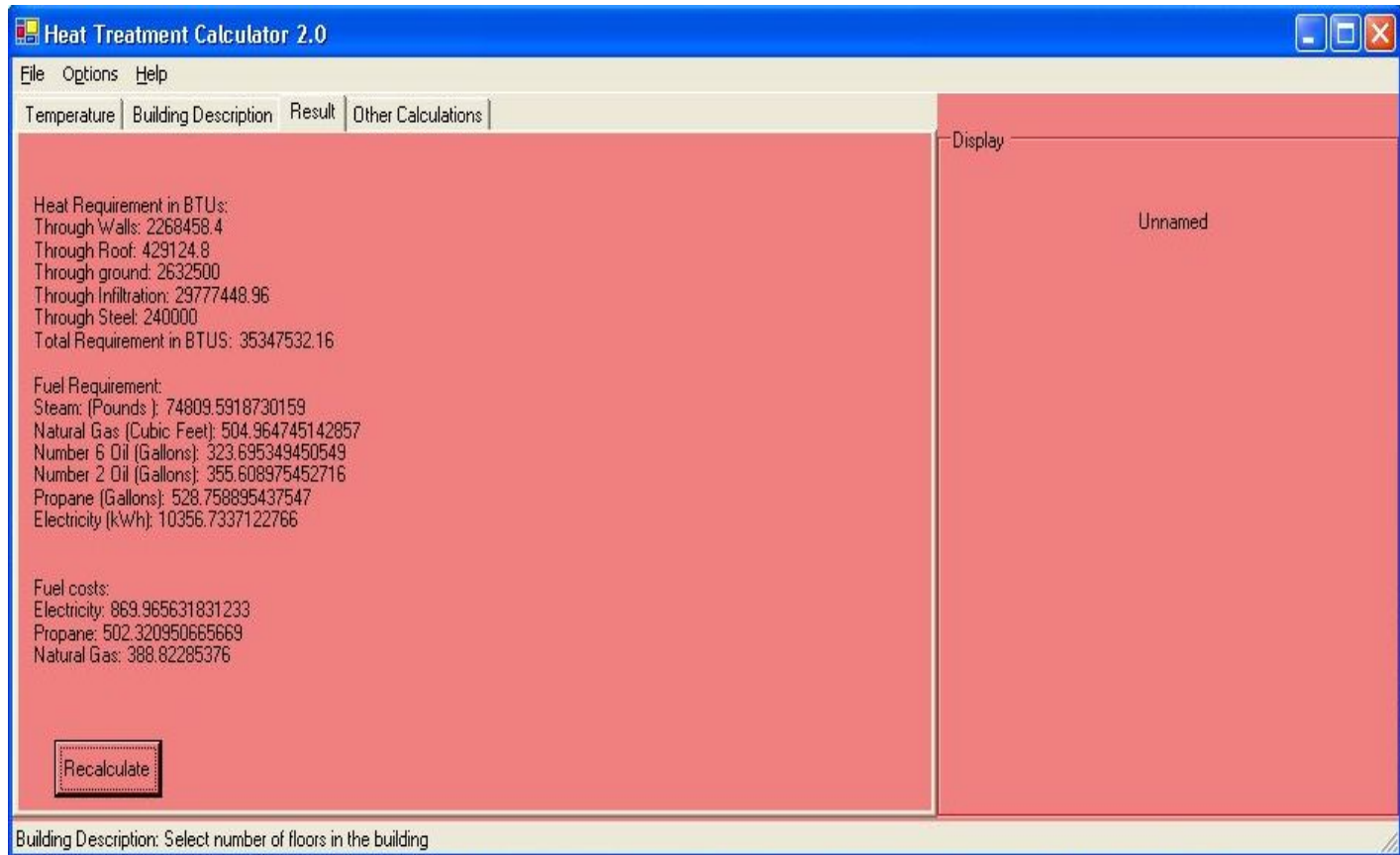
Screenshots



Screenshots



Screenshots





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 Plants and Food Plant Equipment, Engineering for Food Safety and Sanitation*" Second Edition



Discussion
