User's Manual

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Chapter 1-Introduction

Introduction to LabPro

LabPro is a software tool that simplifies the laboratory airflow decision-making process by allowing you to easily compare laboratory airflow control configurations. With these comparisons, you can define the laboratory configuration that achieves the lowest capital costs, optimum energy savings, and most efficient operations. LabPro will help you compare costs and benefits of different airflow designs.

What LabPro is

LabPro is a planning and decision-support tool operating in a Microsoft® Windows® environment. LabPro will help you specify optimum airflow ranges and room pressurization to determine the most efficient control configuration for mechanical and airflow systems in a laboratory.
LabPro features:

- Mechanical system diversity analysis
- Airflow analysis functions
- Room balance schedules
- Comparisons of initial costs, life cycle costs, and energy costs analyses
- An intelligent "What If" analysis tool that instantly compares the cost impact of variations in fume hood turndown ratios, watts per square foot, sash positions, air change rates, and design confidence levels.
- On-line help that gives you access to extensive references that can assist you with the concepts and technical issues of laboratory design.

What's in this Document

You will find this document divided into 5 chapters:

Chapter 1: Introduction

This chapter covers general information on LabPro, its methodology, input and output overviews.

Chapter 2: Getting started and Using LabPro

This chapter covers system requirements, setting up, running and using LabPro. The sections provide detailed information on how to use all of the functions of LabPro's graphical user interface.

Chapter 3: Explanations of Inputs

This chapter provides a detailed explanation of each input field including how to set up defaults as well as a range for valid input.

Chapter 4: Analysis and "What If"

This chapter provides a description of LabPro's analysis functions as well as how to use the "What If" function.

Chapter 5: Reports and Graphs

This chapter provides a description of LabPro's output functions, a description of what to expect in and how to print each report or graph.

Fume Hood Usage Diversity Methodology Overview

Until recently, there has not been a repeatable method for calculating laboratory mechanical system diversity. Much caution and fear exists around this topic. The question has always been - How can I know where to size my mechanical system? As a result, many people have ignored diversity and installed full capacity mechanical systems that have high initial costs, operate inefficiently, and are costly to operate and maintain.
LabPro uses a simple, empirically based method that reflects real laboratory situations. The foundation for this methodology is the ability to accurately predict the number of occupied (operator present) and unoccupied

(operator absent) fume hoods in the facility, then determine how long the occupied hoods are in use during a typical day, and select a control approach which enables you to safely downsize mechanical systems.

Several studies have shown that typical hood usage is about one hour per day. LabPro uses data from a study in which actual usage of hundreds of fume hoods were monitored. The results reveal average usage ranges from about one hour per day for a typical research hood to four and five hours for some analytical and process hoods. Employing a simulation program which can run thousands of simulations in seconds, LabPro can predict the number of fume hoods in the facility that will be occupied at any given time. It also predicts average number of fume hoods being used during a typical day. By entering the number of fume hoods on a manifold, the probability that the users are in front of their hoods, (example: one hour in a ten hour day equals a 10 percent probability) and the percent design criteria (defined as the design point such that the system requirements are met a given percent of time), along with the airflow levels for occupied and unoccupied fume hoods, LabPro can determine both design and average airflow requirements for the facility.

Once LabPro determines the design flow requirements, it uses accepted sizing calculations to estimate the size of supply, exhaust, and central plant equipment. After calculating the equipment size, LabPro again uses standard practices to estimate the initial capital cost of the mechanical and control systems.

Costs associated with energy savings are another important area that LabPro helps you analyze when designing a laboratory. Just as mechanical system sizing is determined from the design airflow, energy costs and savings estimates are calculated from the average airflow requirements. Using the United States Climatic Center's Engineering Weather Data for the location of the facility along with the calculated average flow requirement, LabPro uses standard ASHRAE calculations to estimate the energy usage and costs for different control approaches.

Input Overview

You can enter data into LabPro by typing values in tables and input fields in each of the program's section tabs. LabPro comes pre-loaded with default values for most data fields. There are two kinds of defaults: global and project. The system defaults allow you to preset the common parameters that are used in the determination of exhaust, supply, and temperature control applications. You can edit these items individually within a project or globally so that the next project will have most of the input pre-entered.

LabPro inserts the global defaults defined in the System Defaults screen into all new projects as you create them. If you make changes to the System Defaults screen *after* you create a project, LabPro *will not* change the values within your existing projects.

You can overwrite the default values individually in each data field. The only data that you cannot overwrite is the Lab Usage Type and the database that contains the United States Climatic Center's Engineering Weather Data for approximately 256 cities worldwide. For a more detailed description, see Chapter 3.

Output Overview

LabPro's outputs include:

- Estimates of System Diversity
- Room Balances Schedules
- Initial and Operating Cost Estimates
- Economic Analyses

For a more detailed description of the outputs available, see Chapter 5 Reports, and Graphs.

Basic Concepts

The next few paragraphs explain basic concepts that are fundamental to designing a laboratory airflow control system.

Air Changes per Hour (ACH)

Air change rate is defined as the ventilation rate of a space divided by the total volume of a space. You can calculate air changes per hour (ACH) by dividing the total exhaust rate (the volume of all air leaving the space per hour in cubic feet per hour (cfm x 60)), by the total volume of the space (in cubic feet).

Conversely, by selecting an ACH, you can calculate the required supply air rate (exhaust rate –room offset) to provide that ACH.

You should select air change rates based on the ventilation requirements of the materials present within a space as well as the number of occupants. The generally accepted range of air change rates for laboratories is four to twelve air changes per hour. Increasing the air change rate has the effect of raising both the exhaust and supply air rate, which will increase the dilution of contaminants in the air. If the ventilation of a space provides for a thorough mixing of the air within the space, then six ACH will "result in more than 98.4% of the original air being exchanged" (*Handbook of Laboratory Safety*).

Room Offset

Room offset is the flow rate of air which enters (or leaves) the room from (to) the corridor or adjacent areas. When the room is under negative pressure, the offset is a supply component (air flows into the room out of adjacent areas.) When the room is under positive pressure, the offset is an exhaust component (air flows out of the room into adjacent areas.) Typically, laboratory rooms are maintained at a negative pressurization with respect to adjacent spaces, while non-laboratory rooms may be maintained at either a negative or positive pressurization, dependent upon their use.

Offset CFM %

Calculating room offsets as a percentage of the maximum total room exhaust (or room supply for positively pressurized rooms) ensures proper pressurization polarity of a room during normal operating conditions. It is prudent to use a percentage at least twice the tolerance of the equipment controlling the room supply and exhaust volumes. For example, if VAV devices within a room have a tolerance of ± 5%, you should select an offset percentage of not less than 10%. In a worst case condition, i.e., the supply volume is +5% of set point and the exhaust volume is -5% of set point, a room designed for negative pressurization would still maintain a slightly negative state. In this example, entering an offset percentage of less than 10% could result in a loss of negative pressurization during normal operation.

Duct Static Pressure

Fans are selected based on an analysis of the total system, which can be represented by a pressure ("wc) versus flow curve. The system curve is a graphical representation which displays the total net pressure drops for the entire system including the ductwork, terminal units, and air valve pressure drops with respect to the total airflow passed through the system.

By plotting both the fan and system characteristic pressure versus flow curves together, you can find the condition of operation of the fan and system. Because the fan can only perform at conditions on the fan curve, and the system can only perform at conditions on the system curve, the point of intersection of the system and fan curves is the operating point of the system.

The generation of the system curve will help ensure that the air valves will have sufficient pressure drop across them in order to function to their specifications.

User Presence Probability

Studies have shown that fume hood occupancy is nearly statistically independent over the time span of occupied building hours. Independence of fume hood occupancy allows the use of a statistical tool to calculate how many operators will be in front of a given number of fume hoods for a given percent of the time. This will vary depending on the type of lab and number of users per hood; LabPro's default is one user per hood. User presence probability is defined as the number of hours per day that a fume hood user is in front of his or her fume hood divided by the total number of building occupied hours. For example, one hour per day of fume hood occupancy in a chemistry research facility is assumed. The building is open from 8 a.m. to 6 p.m., or ten hours per day. Since each fume hood's occupancy is independent from that of other hoods, and there is one hour of fume hood occupancy in a ten hour day (one hour per day is the average use of a fume hood in the average lab), there is a one in ten chance that any fume hood will be occupied. This yields a 10% user presence probability.

User Absence Probability

The user absence probability is defined as the number of hours per day that a fume hood user is away from his or her fume hood divided by the total number of building occupied hours. As an example, one hour per day of fume hood occupancy in a chemistry research facility is assumed. The building is open from 8 a.m. to 6 p.m., or ten hours per day. Since each fume hood's occupancy is independent from that of other hoods, and since there is one hour of fume hood occupancy in the ten-hour day, there is a one in ten chance that any fume hood will be occupied. This yields a 90% user absent presence probability.

Calculations

You can access the results of LabPro's calculations in four sections:

Project Summary

LabPro provides the total design and average airflow requirements for different control approaches along with specifying minimum ventilation, maximum cooling, and minimum heating volumes.

Reports

LabPro can generate the following reports:

- Project Defaults
- Room Detail Report
- Room Balance Report
- Fume Hood Summary
- Corridor Detail Report
- Fan Systems Summary
- System Summary
- System Diversity Summary
- System Cost Comparison
- Financial Analysis (NVP, IRR, Simple Payback, and Life Cycle Costs) Comparison
- Weather Data
- System Defaults
- Default Fume Hood Types

Graphs and Charts

LabPro can generate the following graphs and charts:

- Energy Cost Comparison Chart
- First Cost Comparison Chart
- Life Cycle Cost Comparison Chart
- Exhaust System Flow Graph
- Supply System Flow Graph
- Central Plant Flow Graph

What If…

LabPro lets you change the following factors and instantly analyze their airflow, diversity, and cost impacts on 3 different control strategies:

- Daily User Present Hours
- Heat Gain
- ACH Occupied
- ACH Unoccupied
- Fume hood turndown (x: 1)
- Sash Position – User Present
- Sash Position – User Absent
- UBC Hood Mode - Standby
- UBC Hood Mode - Normal
- Design Percentile - Exhaust
- Design Percentile - Supply
- Design Percentile - Central Plant

Chapter 2-Getting Started and Using LabPro

Getting Started

Computer System Requirements

- The minimum system requirements to run LabPro are:
- 16 MB RAM
- CD-ROM drive
- Pentium 100 MHz or greater
- 10 MB of available hard drive space
- Windows 95, 98, 2000, ME, or NT

Setting Up LabPro on a Hard Drive

Please take a few minutes before you install LabPro to read the LabPro README.TXT file that is on the last installation disk. If there are corrections or additions to online help or to the printed manual, they will be listed in this file. After the installation, this file can be read by double-clicking the LabPro ReadMe icon in the LabPro active window.

Running Setup

Before running the setup program, make sure you have at least 10 MB available on your hard drive to store the program.

To start Setup from Windows:

1. Insert the LabPro CD.
2. Press the Start button; choose Run from the Menu.
3. Press the Browse button.
4. Select the Install.exe file.
5. Follow the Setup instructions on the screen.

Running LabPro on a Hard Drive

LabPro can only be run from your PC's hard drive. To run the program, select the LabPro icon from within the LabPro Group.

Backing Up Your LabPro Project Files

As you create and develop projects in LabPro, you will want to be sure to backup your *.lpr files, which are the project files, onto a floppy disk or in your normal hard drive backup. You can either copy them to a floppy disk using the DOS copy command, drag and drop in Windows Explorer, or File Manager in Windows.

Using LabPro

Starting LabPro

To run the program double-click on the LabPro icon from within the LabPro Group.
When you launch LabPro, it will show a startup screen while the program is loading. This screen shows the program version number, the name of the person to whom it is licensed, and the corresponding registration number. Once loaded, LabPro displays an empty screen with only the toolbars showing. Begin by clicking on Project on the menu bar to display the Project menu as shown in Figure 2-1.

Project Menu

Click on Project on the menu bar to display the Project menu as shown in Figure 2-1.

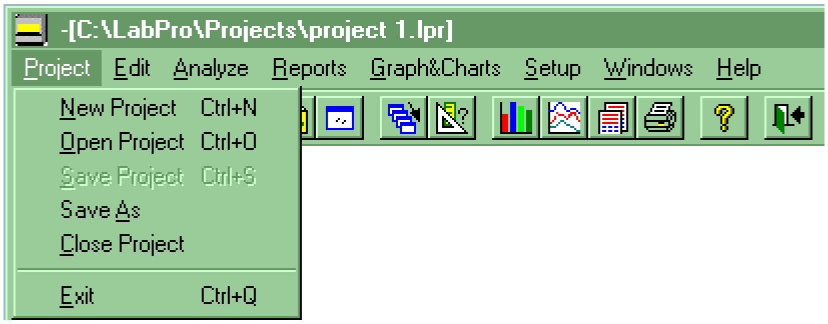

Figure 2-1 Project Menu.

Table 2-1 Project Menu Selections

Click on:	And you can:
New Project	Create a new project.
Open Project	Open the currently selected project so you can edit it.
Save Project	Save the previously named project.
Save As	Name and save the project.
Close Project	Close the currently selected project.

Edit Menu

Click on Edit on the menu bar to display the Edit menu as shown in Figure 2-2. If you choose, you can right-button click the mouse to bring up the Add, Edit, Copy, and Delete choices instead.

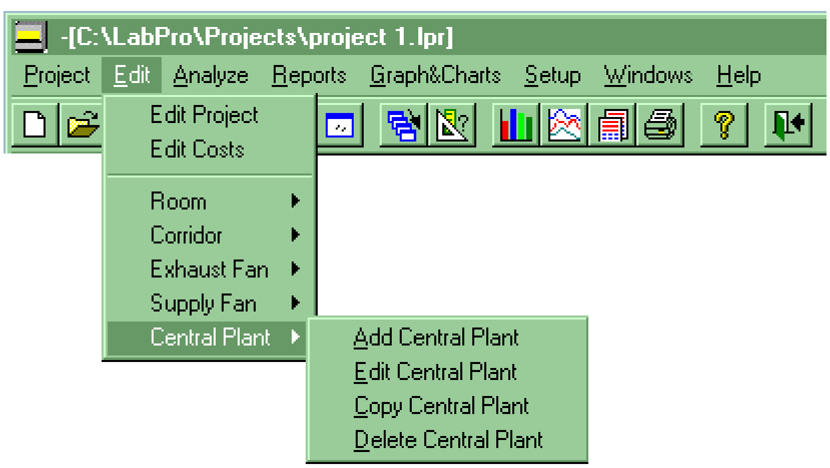

Figure 2-2 Edit Menu.

Table 2-2 Edit Menu Selections

Click on:	And you can:
Edit Project	Enter project locations, project owner, owner/project address, and select the building occupancy hours and weather site location.
Edit Costs	Specify energy, HVAC, lab, and operating costs and define financial analysis information.
Room	Define the design parameters for each laboratory including laboratory use, supply and exhaust fans, the adjacent corridor serving the laboratory, the types and quantity of fume hoods, and a cooling load profile. Also select laboratory attributes (i.e., area, air change rate, etc.).
Corridor	Define the design parameters for each corridor including the supply and exhaust fans serving the corridor, and a cooling load profile. Also select corridor attributes (i.e., area, air change rate, etc.).
Exhaust Fan	Define the design parameters for each exhaust fan.
Supply AHU	Define the design parameters for each supply air-handling unit.
Central Plant	Define the design parameters for each Central Plant including Cooling, Heating efficiency, and Supply air temperature.

Analyze Menu

Click on Analyze on the menu bar to display the Analyze menu as shown in Figure 2-3.

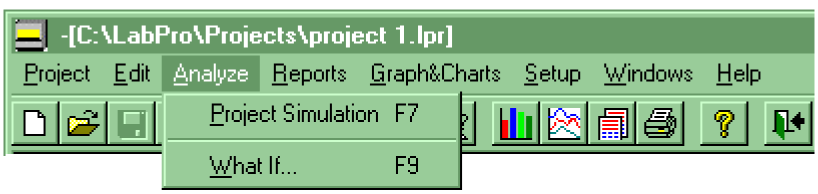

Figure 2-3 Analyze Menu.

The Analyze menu permits you to perform balancing, project simulation, and cost calculations for the project. Project Simulation for a project (which includes each of the previously mentioned elements) can be performed simply by selecting this one menu item.

Table 2-3 Analyze Menu Selections

Click on:	And you can:
Project Simulation	Perform balancing, simulation, and cost calculations for the project.
What If	Examine the effect that changes in one or more variables have on up to three different design approaches.

Reports Menu

Click on Reports on the menu bar to display the Reports menu as shown in Figure 2-4.

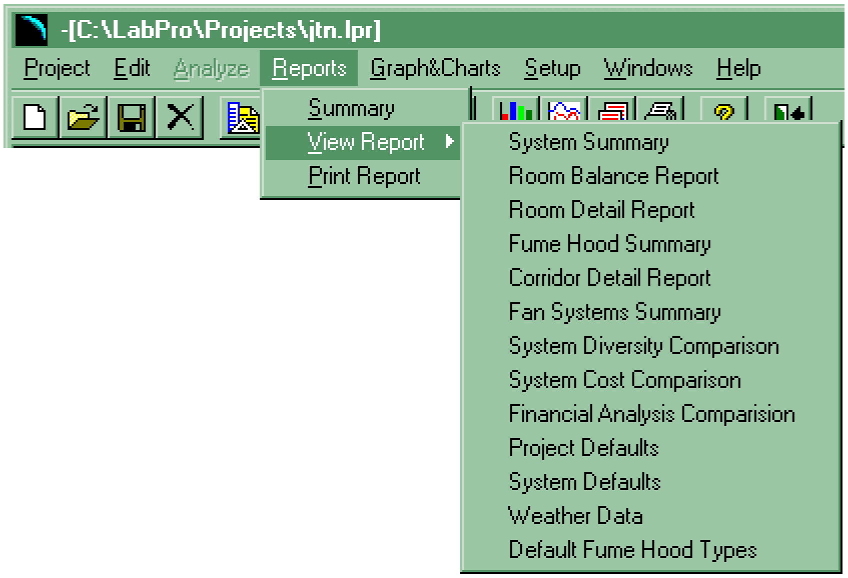

Figure 2-4 Reports Menu.

The Reports menu provides a list of available reports (see Chapter 5 for a detailed explanation of each report). Click on the desired report and either print or preview the information.

Table 2-4 Reports Menu Selections

Click on:	And you can:
Summary	Read a listing of all of the defaults you have set for this project only.
Project Defaults	Read a listing of all of the defaults you have set.
Room Balance Report	Check the values of the four critical conditions for room balance
Room Detail Report	Read a summary of all the attributes and flows for an individual room
Fume Hood Summary	Read a summary of all the fume hoods on the project.
Corridor Detail Report	Read a summary of all the attributes and flows for an individual corridor
Fan Systems Summary	Read a summary of all the individual exhaust, supply, and central plant systems on the project.
System Summary	Read a summary of all the supply fan systems on the project.
System Diversity Comparison	Read a report providing a diversity comparison for the different types of laboratory airflow control methods.
System Cost Comparison	Read a listing of all the major system components, annual costs, and energy costs associated for the project, based on the method of lab control being used
Financial Analysis Comparison	Read a report providing key financial information to help analyze the financial benefits of different control approaches.
System Defaults	Read a summary of the system defaults currently stored in LabPro on your computer.
Weather Data	Read a report listing the Bin Weather Data from United States Climatic Center's Engineering Weather Data for the location selected.
Default Fume Hood Types	Read a summary of what fume hoods types are available in the database for use within a project.
Print Report	Select more than 1 report to be printed in a batch print job.

Graphs & Charts Menu

Click on Graphs & Charts on the menu bar to display the Graphs & Charts menu as shown in Figure 2-5.

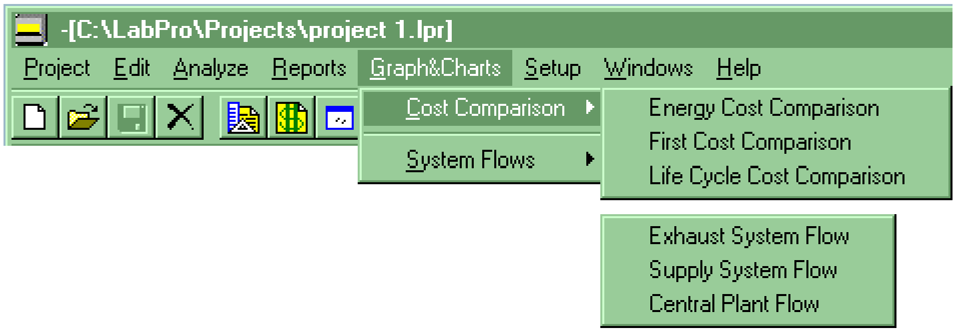

Figure 2-5 Graphs & Charts Menu.

Table 2-5 Graphs & Charts Menu Selections

Click on:	And you can:
Cost Comparison	Choose Energy Cost Comparison, First Cost Comparison, or Life Cycle Comparison charts:
System Flows	Choose Exhaust System Flow, Supply System Flow, or Central Plant Flow graphs

Setup Menu

Click on Setup on the menu bar to display the Setup menu as shown in Figure 2-6.

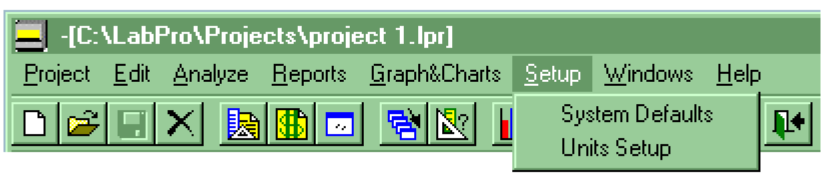

Figure 2-6 Setup Menu.

Table 2-6 Setup Menu Selections

Click on:	And you can:
System Defaults	Define standard building, equipment, usage, and costs in an Edit Program Default Values screen.
Units Setup	Select national currency and English or Metric units of measurement.

Windows Menu

Click on Windows on the menu bar to display the Windows menu as shown in Figure 2-7.

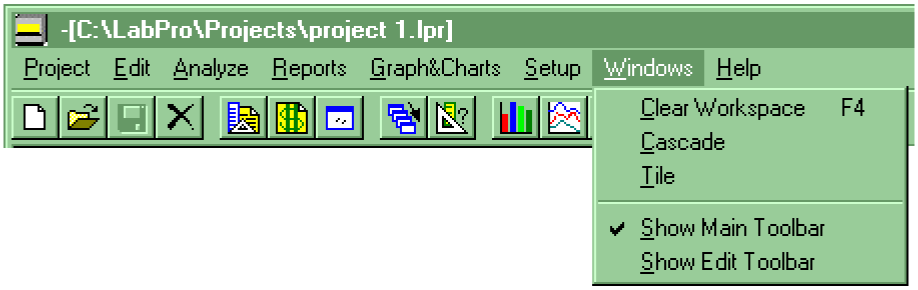

Figure 2-7 Windows Menu.

Table 2-7 Windows Menu Selections

Click on:	And you can:
Clear Workspace	Clear the workspace and return to the main screen.
Cascade	Cascade currently displayed screens.
Tile	Array the displayed screens like floor tiles
Show Main toolbar	Display the Main toolbar.
Show Edit toolbar	Display the Edit toolbar.

Help Menu

Click on Help on the menu bar to display the Help menu as shown in Figure 2-8.

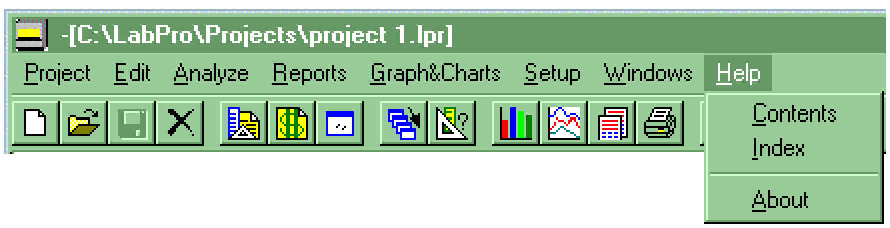

Figure 2-8 Help Menu.

Table 2-8 Help Menu Selections

Click on:	And you can:
Contents	View the main table of contents for Help on LabPro.
Index	Search for any word in the Help file.
About	Display the current version number of this software and the software agreement..

In addition, pressing the F1 key within any field within LabPro will bring you into the Help topic for that field.

Chapter 3 –Explanations of Inputs

Introduction

This chapter presents a detailed explanation of each input item for LabPro. The descriptions include a general explanation of the type of data, formatting, any special features, and how the input items relate to the rest of the program.

The input fields are organized by screen, with each screen presented in the following order:

Menu Item	Screen/Tab name
Setup	System Defaults
Setup	Units and currency setup
Edit	Edit Project
Edit	Edit Costs
Edit	Room
Edit	Corridor
Edit	Exhaust Fan
Edit	Supply Fan
Edit	Central Plant

Setup – System Defaults

You can define standard building, equipment, usage, and costs in an Edit Program Default Values screen. Note that if you change values here, you will not affect existing projects.

Table 3-1 Setup Menu – Systems Defaults Screen Selections

Click on:	And you can:
General Tab	Define weather, system sizing, and building hours
Hood Usage Tab	Define the fume hood mode and sash positions.
Fan & Central Plant Tab	Define the supply, exhaust, and central plant efficiencies and characteristics.
Initial Costs Tab	Define the initial cost of laboratory controls per hood and of the HVAC equipment.
Operating Costs Tab	Define the annual recurring costs, (e.g., maintenance costs and re-certification costs).
Fume Hood Tab	Define hood type, sash width, sash height, min flow, and max flow.
Room & Corridor Tab	Define the air changes per hour (ACH), size, and heat gain for rooms and corridors.
Energy Costs Tab	Define fuel, BTU, and unit cost.

Tip: if you right-click on an empty space in any tab except the General tab, a menu pops up to add, edit, copy, or delete whatever is being defined in that tab.

See Figure 3-1a Setup – System Defaults – General Tab Screen.

Setup – System Defaults – General Tab

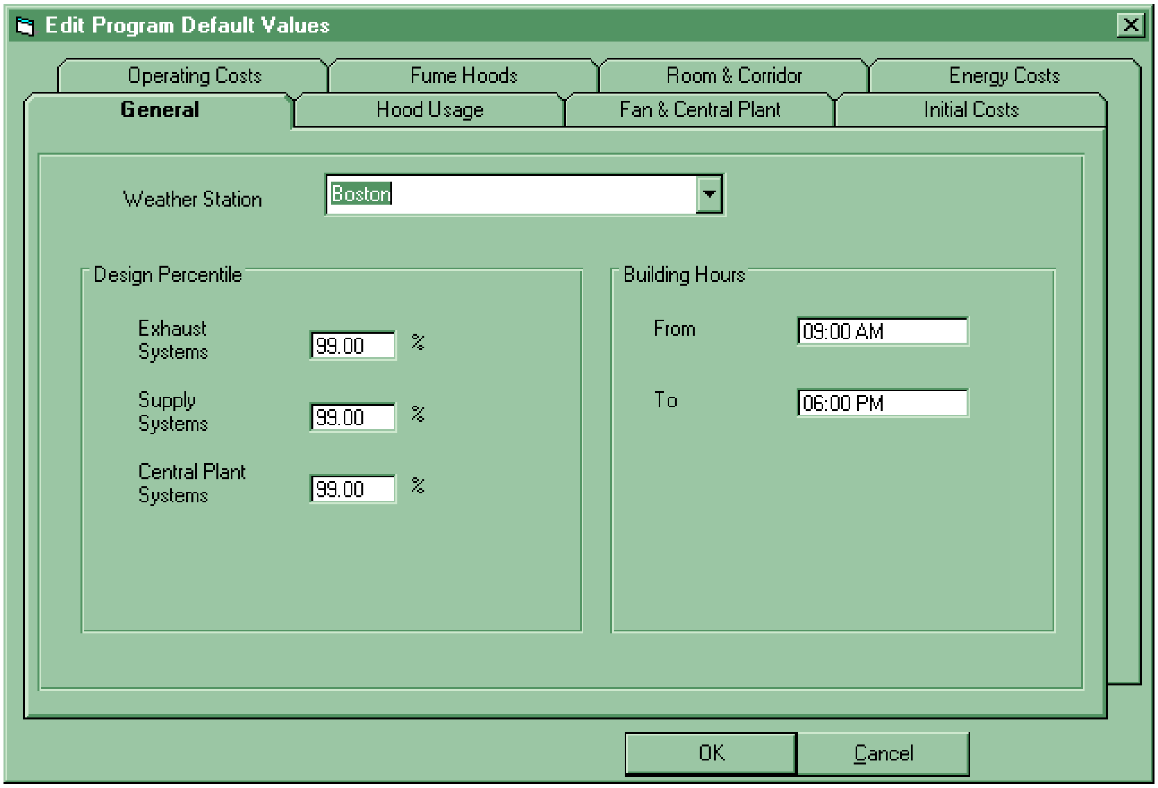

Figure 3-1a Setup – System Defaults – General Tab Screen.

Table 3-2 Setup Menu – General Tab Selections

Click on:	And you can:
Weather Station	Use the pull down menu to select the location of your project. Cities are listed alphabetically. If you cannot locate the exact city, use a similar geographic location in the table. This will enter the United States Climatic Center's Engineering Weather Data for that location. LabPro uses this data in its energy use calculations.
System Sizing – Exhaust Systems	Enter a value for the design percentile factor used for calculating exhaust system diversity. Using this factor results in a system that will meet system design fume hood exhaust requirements the specified percent of time. Each exhaust system that you define will use this factor.
System Sizing – Supply Systems	Enter a value for the design percentile factor used for calculating supply air handling system diversity. Using this factor results in a system that will meet system design supply air requirements the specified percent of time. Each supply air handling system that you define will use this factor.
System Sizing – Central Plant Systems	Enter a value for the design percentile factor used for calculating central plant diversity. Using this factor results in a central plant that will meet system design cooling, heating, and reheat requirements the specified percent of time. Each central plant system that you define will use this factor.
Building Hours – From and Building Hours – To	Enter the normal operating hours for the building. Use the hh:mm:ss a.m./p.m. time format, e.g., 8:00 a.m. to 9:00 p.m. If you wish, enter the time using 0001 – 2400 and LabPro will convert the display to the hh:mm:ss time format automatically. The maximum occupied time for building hours cannot exceed 23 hours, 59 minutes.

Setup – System Defaults – Hood Usage

You can define the default fume hood mode and sash positions. Note that if you change values here, you will not affect existing projects.

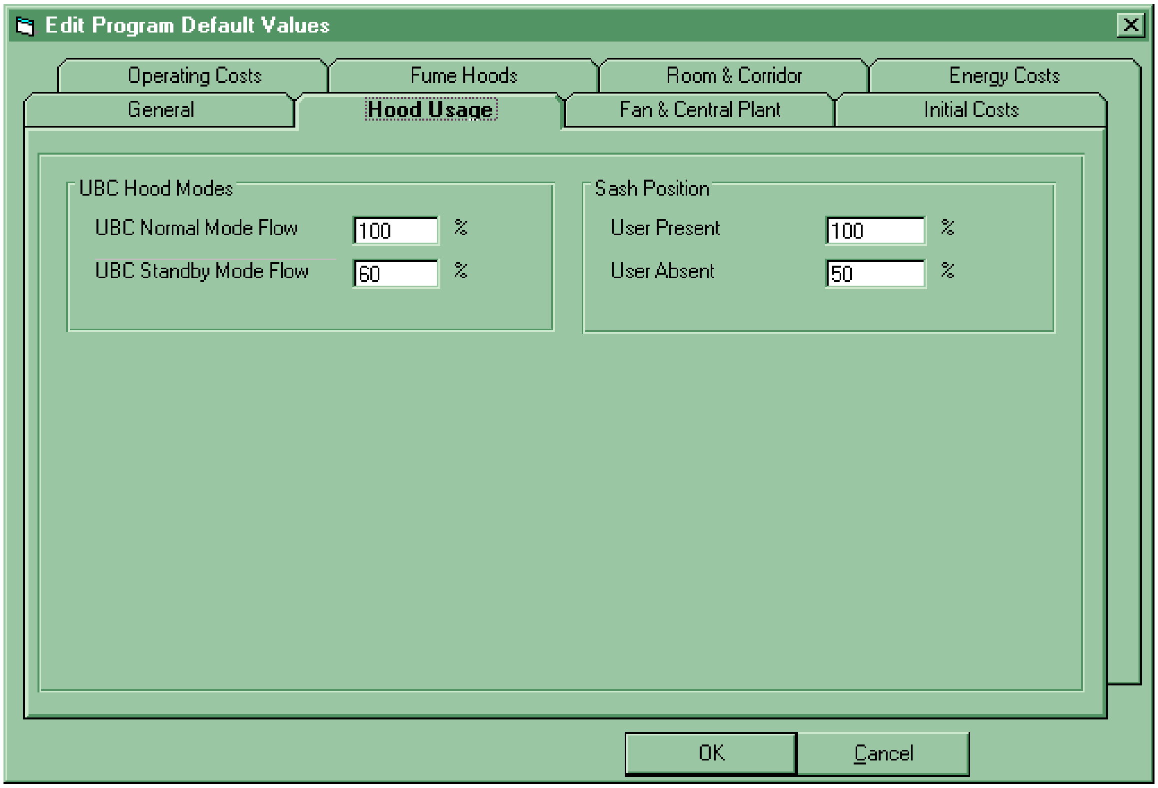

Figure 3-1b Setup – System Defaults Hood Usage Screen.

Table 3-3 Setup Menu System Defaults Screen Hood Usage Selections

Click on:	And you can:
UBC Hood Modes: Normal Mode Flow	Enter the percentage of full flow for the fume hoods when they are operating in Normal mode.
UBC Hood Modes: Standby Mode Flow	Enter the percentage of full flow for the fume hoods when they are operating in Standby mode.
Sash Position: User Present %	Enter a value that you want to be the default sash position when a user is present at a fume hood. LabPro will automatically fill the User Present field with this number whenever you add a new fume hood to the project.
Sash Position: User Absent %	Enter a value that you want to be the default sash position when a user is absent from a fume hood. LabPro will automatically fill the User Absent field with this number whenever you add a new fume hood to the project.

Setup – System Defaults – Fan and Central Plant

You can define the default supply, exhaust, and central plant efficiencies and characteristics. Be sure to check your local and federal regulatory standards and guidelines before selecting an exhaust fan control type. Note that if you change values here, you will not affect existing projects.

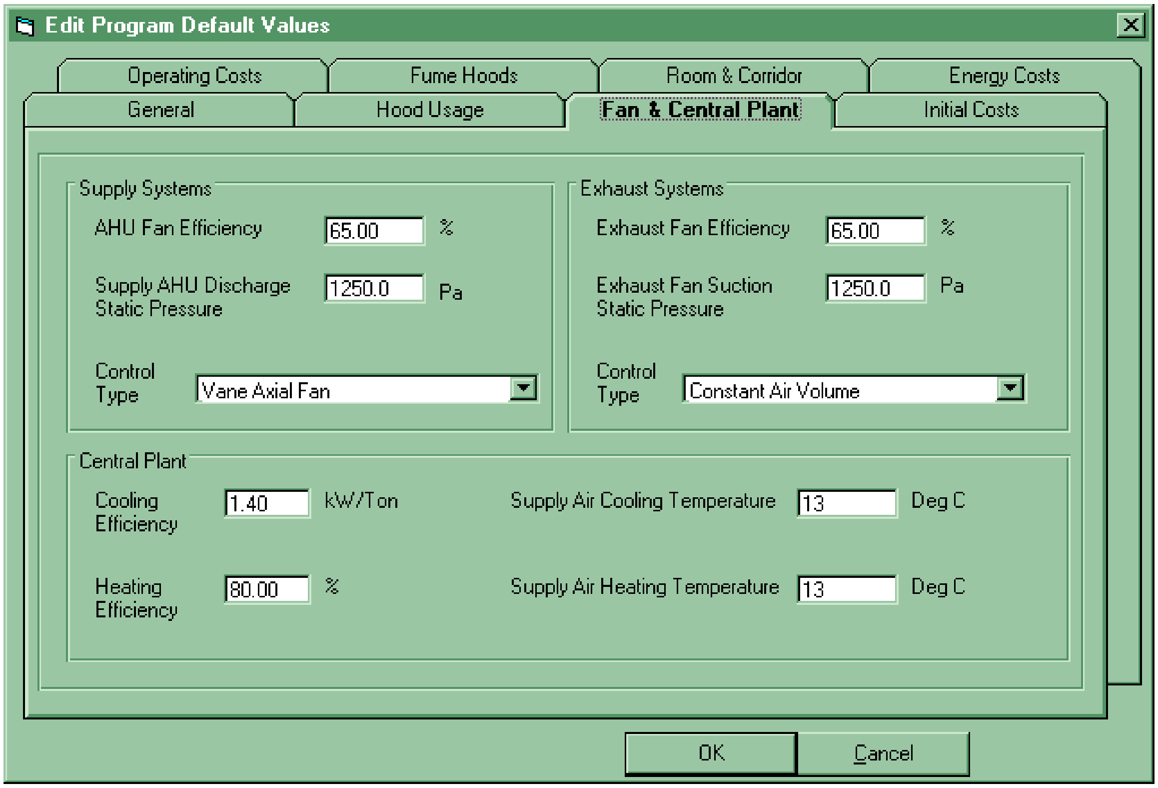

Figure 3-1c Setup – System Defaults: Fans & Central Plants Screen.

Table 3-4 Setup Menu System Defaults Fan & Central Plants Screen Selections

Click on:	And you can:
Supply System: AHU Fan Efficiency	Enter a number for the default efficiency percentage of the supply fans.
Supply System: Supply AHU Discharge Static Pressure	Enter the value you want to be the default suction static pressure measured in inches of water (" wc) or in Pascals (Pa). This value represents the static pressure measured in the ductwork at the outlet of the supply fan.
Supply System: Supply Air Temp	Enter the default supply air temperature to be used whenever a supply air-handling unit (AHU) is added to a project. This value represents the air temperature measured in degrees Fahrenheit or Celsius after the discharge of a pre-heater or cooling coil.
Supply System: Control Type	Select the default control type for the supply fans from the drop-down list: • Variable Frequency Drive • Constant Air Volume • Discharge Damper - Forward Curve Fan • Discharge Damper - Backward Incline Fan • Vane axial Fans • Inlet Vane Control - Airfoil • Inlet Vane Control - Forward Curve Fan

Table 3-4 Setup Menu System Defaults Fan & Central Plants Screen Selections

Click on:	And you can:
Exhaust Systems: Exhaust Fan Efficiency	Enter a number for the default efficiency percentage of the exhaust fans.
Exhaust Systems: Exhaust Fan Suction Static Pressure	Enter the value you want to be the default suction static pressure measured in inches of water (" wc) or in Pascals (Pa). This value represents the static pressure measured in the ductwork at the inlet of the exhaust fan.
Exhaust Systems : Control Type	Select the default control type for the exhaust fans from the drop-down list: • Variable Frequency Drive • Constant Air Volume • Discharge Damper - Forward Curve Fan • Discharge Damper - Backward Incline Fan • Vane axial Fans • Inlet Vane Control - Airfoil • Inlet Vane Control - Forward Curve Fan
Central Plant: Cooling Efficiency	Enter the cooling efficiency of the central plant air chiller(s) in kilowatts of power per ton of refrigeration.
Central Plant: Heating Efficiency	Enter a value for the thermal efficiency of the central plant heating system as the ratio (expressed as a percentage) of total useful heat output versus the total energy input.
Central Plant: Supply Air Cooling Temperature	Enter the default supply air cooling temperature to be used whenever a supply air-handling unit (AHU) is added to a project. This value represents the air temperature measured in degrees Fahrenheit or Celsius after the discharge of a cooling coil.
Central Plant: Supply Air Heating Temperature	Enter the default supply air heating temperature to be used whenever a supply air-handling unit (AHU) is added to a project. This value represents the air temperature measured in degrees Fahrenheit or Celsius after the discharge of a pre-heater coil.

Setup – System Defaults – Initial Costs

You can define default initial costs for HVAC systems and for different types of laboratory air controls. Note that if you change values here, you will not affect existing projects.

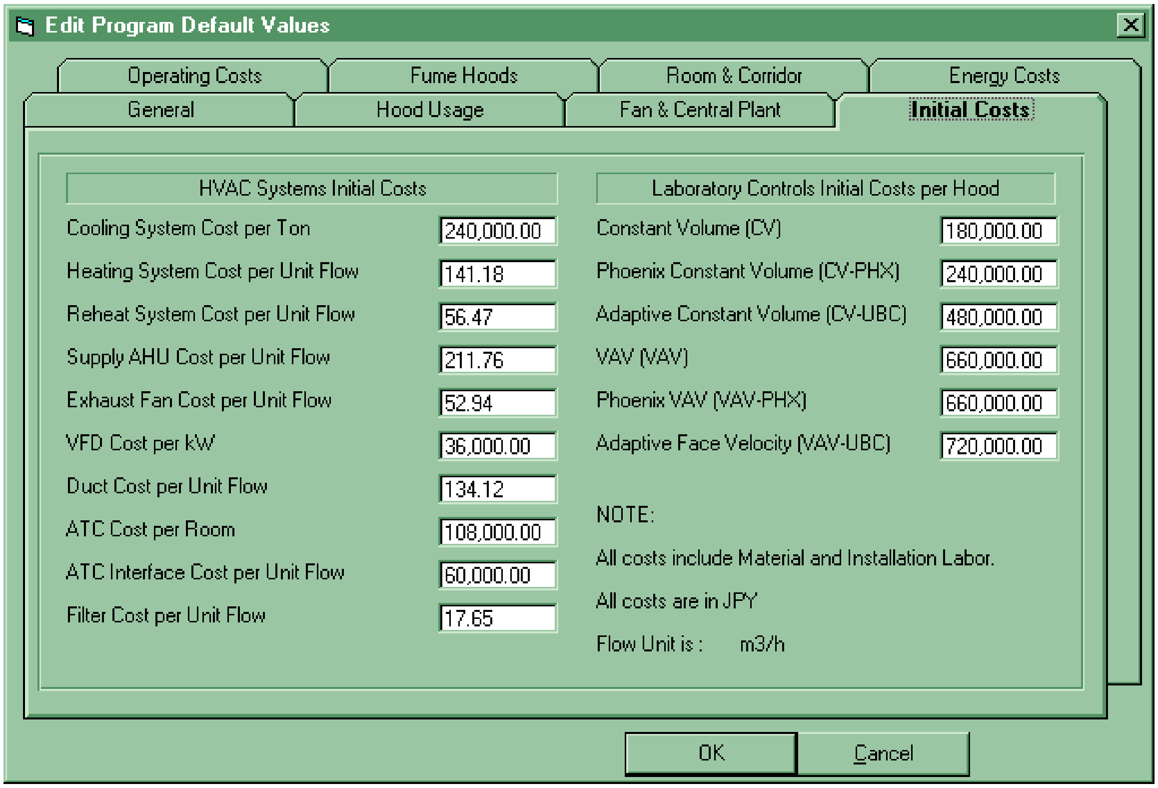

Figure 3-1d Setup – System Defaults: Initial Costs Screen.

Table 3-5 Setup Menu System Defaults Initial Costs Screen Selections

Click on:	And you can:
HVAC: Cooling System Cost per Ton	Enter a value for the average cost per installed ton of cooling including chiller, cooling tower, pumps, piping, variable frequency drives (VFDs) and all installation costs. Do not include supply fans, air handlers or cooling coils costs.
HVAC: Heating System Cost per Unit Flow	Enter a value for the average cost for heating equipment per installed CFM (or l/s or m^3/h) including boiler, piping, pumps, variable frequency drives (VFDs) and all installation costs.
HVAC: Reheat System Cost per Unit Flow	Enter a value for the average cost for reheat equipment per installed CFM (or l/s or m^3/h) including reheat coils, piping and all installation labor.
HVAC: Supply AHU Cost per Unit Flow	Enter a value for the average cost for supply AHU equipment per installed CFM (or l/s or m^3/h) including air hander, fan motor, cooling coils, filter housing and all installation labor.
HVAC: Exhaust Fan Cost per Unit Flow	Enter a value for the average cost for exhaust fan equipment per installed CFM (or l/s or m^3/h) including fan, dampers, and all installation labor.

Table 3-5 Setup Menu System Defaults Initial Costs Screen Selections

Click on:	And you can:
HVAC: VFD Cost per HP	Enter the average cost for variable frequency drive (VFD) equipment per installed HP (or kW) including VFD, damper, and all installation labor costs. LabPro will use this value to estimate the total mechanical system initial costs.
HVAC: Duct Cost per Unit Flow	Enter a value for the average cost for ductwork per installed CFM (or l/s or m^3/h) including ductwork material costs and all installation labor. Duct Cost per CFM (or l/s or m^3/h) includes both stainless steel and non-stainless steel duct. To calculate this value you must first determine a ratio of stainless steel to non-stainless steel duct, the cost per CFM (or l/s or m^3/h) of non-stainless duct, and then determine an average duct cost per CFM (or l/s or m^3/h).
HVAC: ATC Cost per Room	Enter a value for the average cost per room for Automatic Temperature Controls (ATC) including material costs and all installation labor.
HVAC: ATC Interface cost per Unit Flow	Enter a value for the average cost per room to integrate to the building management system, the laboratory controls with the Automatic Temperature Controls (ATC) including material costs and all installation labor.
HVAC: Filter Cost per Unit Flow	Enter a value for the average cost for Air Filter replacement per flow unit (CFM or l/s or m^3/h).
Laboratory: Constant Volume (CV)	Enter a value for the average cost per fume hood for constant volume laboratory controls including material costs and all installation labor.
Laboratory: Phoenix Constant Volume (CV-PHX)	Enter a value for the average cost per fume hood for Phoenix Controls constant volume laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Laboratory: Constant Volume Usage Based Controls (CV-UBC)	Enter a value for the average cost per fume hood for Phoenix Controls Constant Volume Usage Based Controls laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Laboratory: VAV (VAV)	Enter a value for the average cost per fume hood for traditional VAV laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Laboratory: Phoenix VAV (VAV-PHX)	Enter a value for the average cost per fume hood for Phoenix Controls VAV laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Laboratory: Adaptive Face Velocity (VAV-UBC)	Enter a value for the average cost per fume hood for Phoenix Controls Variable Air Volume Usage Based Control laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.

Setup – System Defaults – Operating Costs

You can specify recurring operating costs and factors used in financial calculations here. Note that if you change values here, you will not affect existing projects.

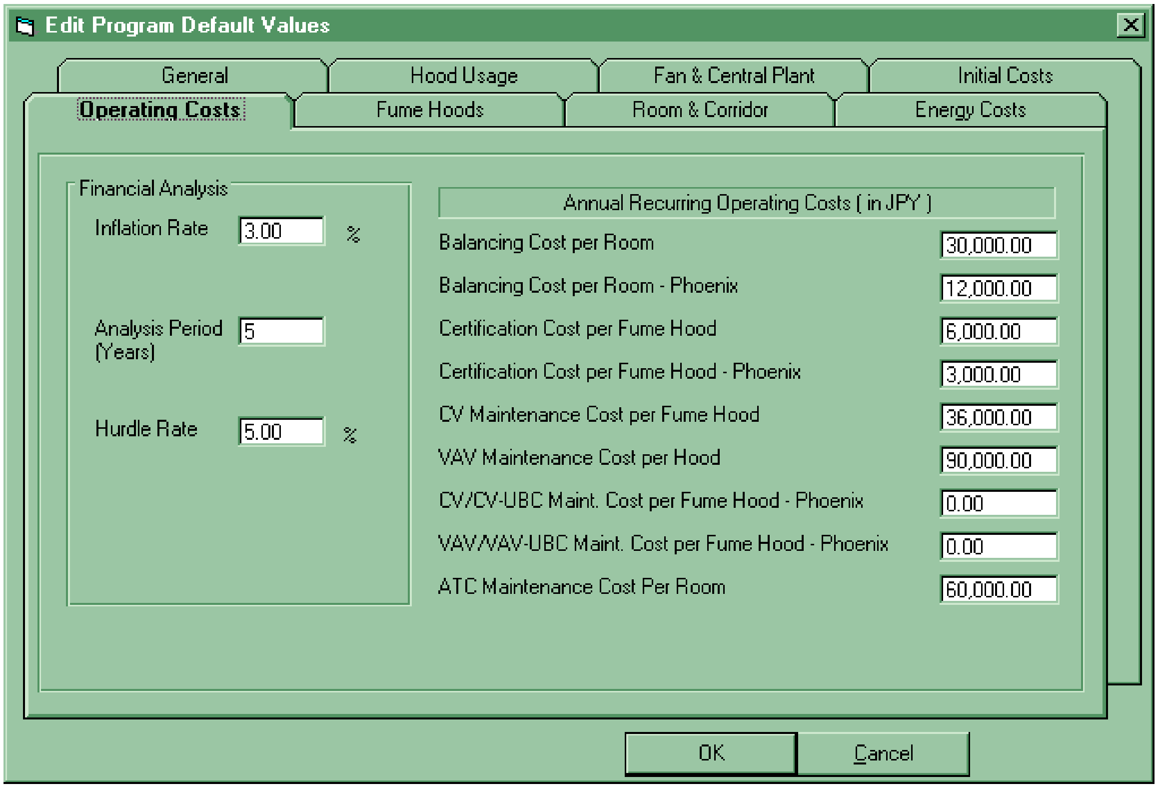

Figure 3-1e Setup – System Defaults: Operating Costs Screen.

Table 3-6 Setup Menu System Defaults Operating Costs Screen Selections

Click on:	And you can:
Financial Analysis: Inflation Rate	Enter a value for the expected general inflation rate. LabPro will use this data in the economic reports to escalate energy and maintenance costs in future years.
Financial Analysis: Analysis Period (Years)	Enter a value for the analysis period in years.
Financial Analysis: Hurdle Rate	Enter a value for the hurdle rate for this project. This is the rate of return for a competing investment choice.
Annual Costs: Balancing Cost per Room	Enter a value for the average cost to balance the airflow control system within a laboratory space including material and labor costs. LabPro assumes that a laboratory airflow controls system needs to be re-balanced annually. Therefore it will add half of the entered cost to the total annual maintenance cost. Also, LabPro uses the total entered costs to determine initial costs to install the mechanical system.
Annual Costs: Balancing Cost per Room - Phoenix	Enter a value for the average cost to balance a Phoenix Controls airflow flow control system within a laboratory space including material and labor costs. LabPro assumes that a laboratory airflow controls system needs to be re-balanced annually. Therefore it will add half of the entered cost to the total annual maintenance cost. Also, LabPro uses the total entered costs to determine initial costs to install the mechanical system.

Table 3-6 Setup Menu System Defaults Operating Costs Screen Selections

Click on:	And you can:
Annual Costs: Certification Cost per Fume Hood	Enter a value for the average cost to re-certify a fume hood system within a laboratory space including material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost and initial cost for the complete system. LabPro will also use the total entered costs to determine initial costs to install the mechanical system.
Annual Costs: Certification Cost per Fume Hood - Phoenix	Enter a value for the average cost to re-certify a fume hood system with a Phoenix Controls valve installed on the hood including material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost and initial cost for a complete Phoenix Controls system. LabPro will also use the total entered costs to determine initial costs to install the mechanical system.
Annual Costs: CV Maintenance Cost per Fume Hood	Enter a value for the average cost to maintain a constant volume (CV) or two-state fume hood system within a typical laboratory space. Include material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost for the complete system.
Annual Costs: VAV Maintenance Cost per Hood	Enter a value for the average cost to maintain a variable air volume (VAV) fume hood system within a typical laboratory space. Be sure to include material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost for the complete system.
Annual Costs: CV/CV-UBC Maintenance Cost per Hood - Phoenix	Enter a value for the average cost to maintain a Phoenix Controls Constant Volume or Constant Volume Usage Based Controls fume hood system. LabPro will use this value to estimate the annual operating and maintenance cost for a complete Phoenix Controls system.
Annual Costs: VAV/ VAV-UBC Maintenance Cost per Hood - Phoenix	Enter a value for the average cost to maintain a Phoenix Controls variable air volume (VAV) or Variable Air Volume Usage Based Control (VAV-UBC) fume hood system. LabPro will use this value to estimate the annual operating and maintenance cost for a complete Phoenix Controls system.
Annual Costs: ATC Maintenance Cost per Room	Enter a value for the average cost to maintain the Automatic Temperature Control (ATC) system within the laboratory. LabPro will use this value to estimate the annual operating and maintenance cost for a complete temperature control system.

Setup – System Defaults – Fume Hoods

You can define the names and characteristics of fume hoods in this tab. Note that if you change values here, you will not affect existing projects.

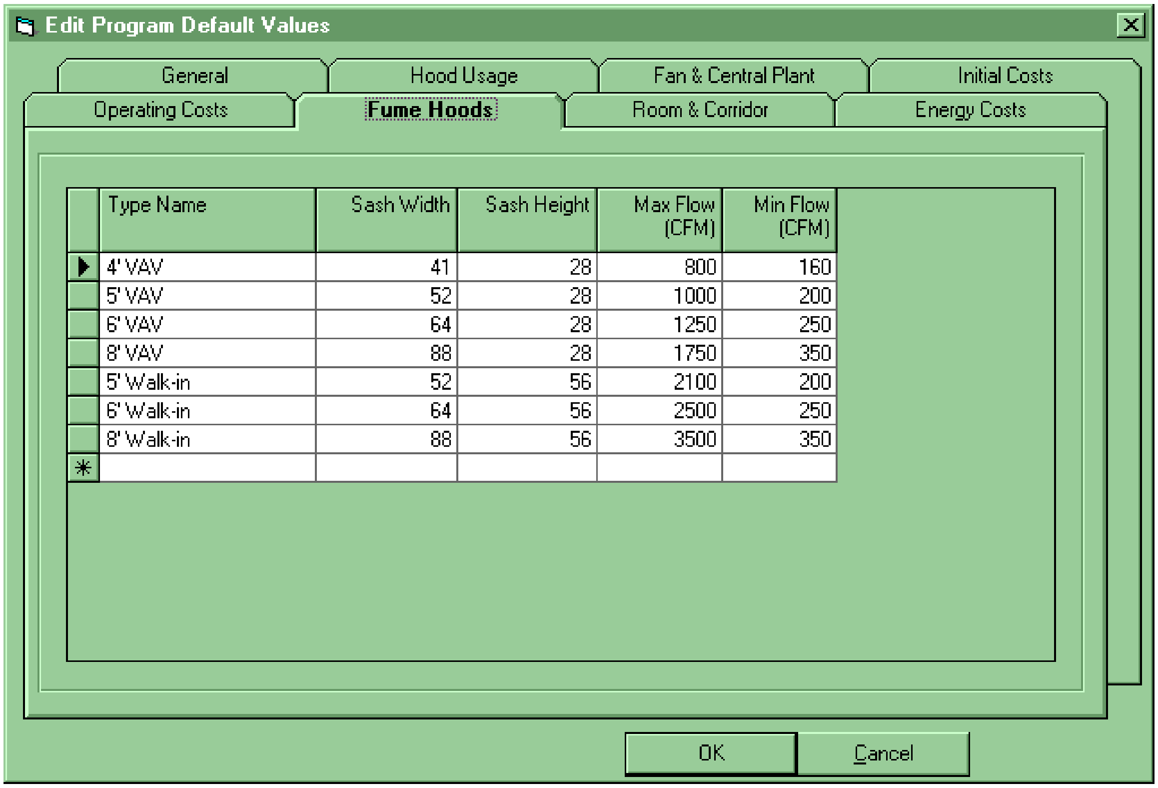

Figure 3-1f Setup – System Defaults: Fume Hoods Screen.

Table 3-7 Setup Menu System Defaults Fume Hoods Screen Selections

Click on:	And you can:
Type Name	Enter a name identifying this hood type.
Sash width	Specify the sash width for this hood type
Sash Height	Specify the sash height for this hood type
Max Flow	Specify the maximum flow (CFM or l/s or m^3/h) for this hood type
Min Flow	Specify the minimum flow (CFM or l/s or m^3/h) for this hood type

Setup – System Defaults – Room and Corridor

You can define the default air changes per hour and energy consumption of the rooms and corridors in this project.

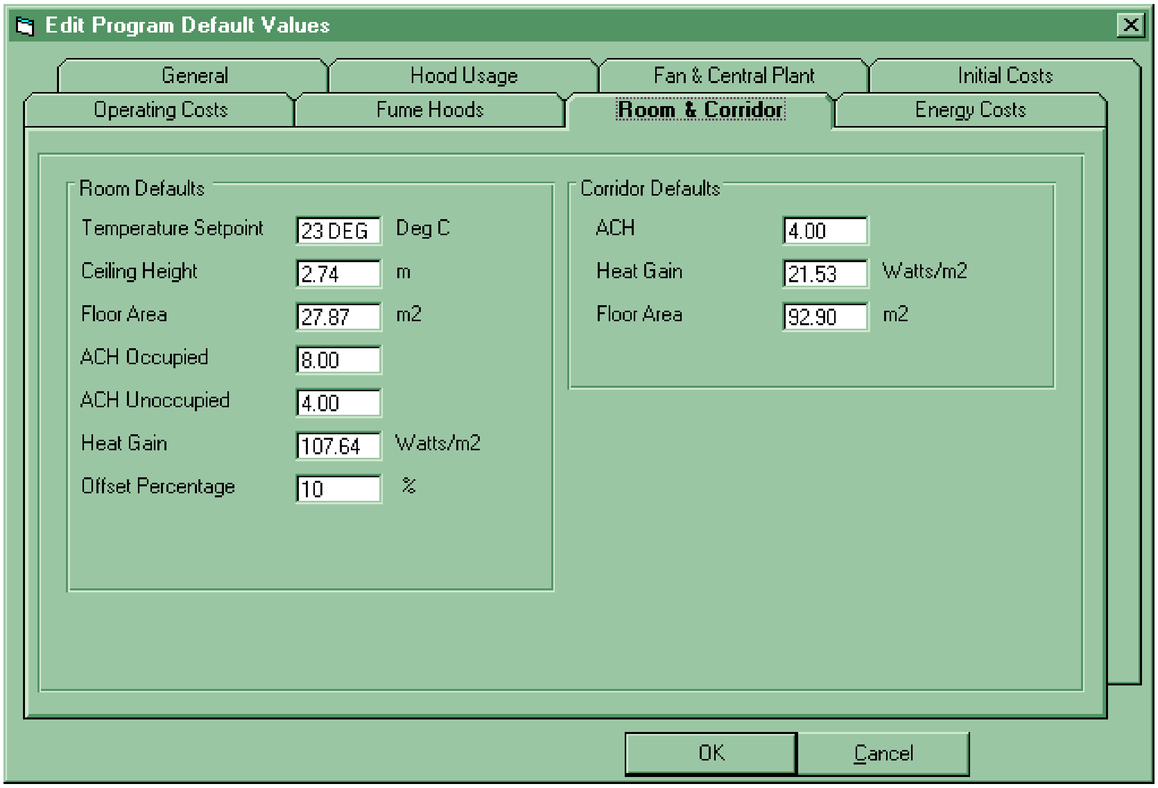

Figure 3-1g Setup – System Defaults: Room & Corridor Screen.

Table 3-8 Setup Menu System Defaults Rooms and Corridor Tab Selections

Click on:	And you can:
Room Defaults – Temperature Setpoint	Enter a value to be the default room temperature set point in degrees Fahrenheit/Celsius for all new rooms. As you define or edit each room, change individual room set points in the Add Room or Edit Room screens of the Rooms tab.
Room Defaults - Ceiling Height	Enter a value to be the default ceiling height in feet (for CFM) or meters (for m^3/h) for all new rooms. As you define or edit each room, change individual room ceiling heights in the Thermal Info screen in the Rooms tab.
Room Defaults - Floor Area	Enter a value to be the default floor area in square feet (or meters) for all new rooms. As you define or edit each room, change individual room floor areas in the Thermal Info screen in the Rooms tab.
Room Defaults - ACH Occupied	Enter a value for the default air changes per hour (ACH) for the building during occupied hours. You can change individual room values in the Ventilation screen within the Room tab as you define or edit each room.

Table 3-8 Setup Menu System Defaults Rooms and Corridor Tab Selections

Click on:	And you can:
Room Defaults - ACH Unoccupied	Enter a value for the default air changes per hour (ACH) for the building during unoccupied hours. You can change individual room values in the Ventilation screen within the Room tab as you define or edit each room.
Room Defaults – Heat Gain (Watts/Sq. Ft) or (Watts/m^2)	Enter the value to be used as the default maximum watts per square foot (or meter) of all new rooms. The watts per square foot (or square meter) value represents the total maximum heat gain in watts within a room divided by the total floor area of the room in square feet (or meters). Total maximum heat gain includes both sensible and latent heat from people, lighting, and equipment, as well as external heat sources such as sunlight. You can change individual room values in the Thermal Info. screen within the Room tab as you define or edit each room.
Room Defaults - Offset CFM (or l/s or m^3/h) Percent	Enter the value to be used as the default room offset CFM (or l/s or m^3/h) percentage whenever you define a new room. Offset flow rate percentage is the difference between room supply air flow rate and room exhaust flow rate expressed as a percentage of the maximum total room exhaust. You can change individual room values in the General screen within the Room tab as you define or edit each room.
Corridor Defaults – ACH	Enter a value to be the default air changes per hour (ACH). You can change individual corridor values in the Ventilation screen within the Corridor tab as you define or edit each corridor.
Corridor Defaults – Energy Consumption (Watts/Sq. Ft) or (Watts/m^2)	Enter the value to be used as the default maximum watts per square foot for all new corridors. The watts per square foot (or Watts per square meter) value represents the total maximum heat gain in watts within a corridor divided by the total floor area of the corridor in square feet (or square meters). Total maximum heat gain includes both sensible and latent heat from people, lighting, and equipment, as well as external heat sources such as sunlight. You can change individual room values in the Thermal Info screen within the Corridor tab as you define or edit each corridor.
Corridor Defaults – Floor Area (Sq. Ft.) or (m^2)	Enter the default size of floor area in square feet (or meters).

Setup – System Defaults – Energy Costs

You can define the default types of heating and cooling, as well as fuel costs per unit for heating, cooling, and power. Note that if you change values here, you will not affect existing projects.

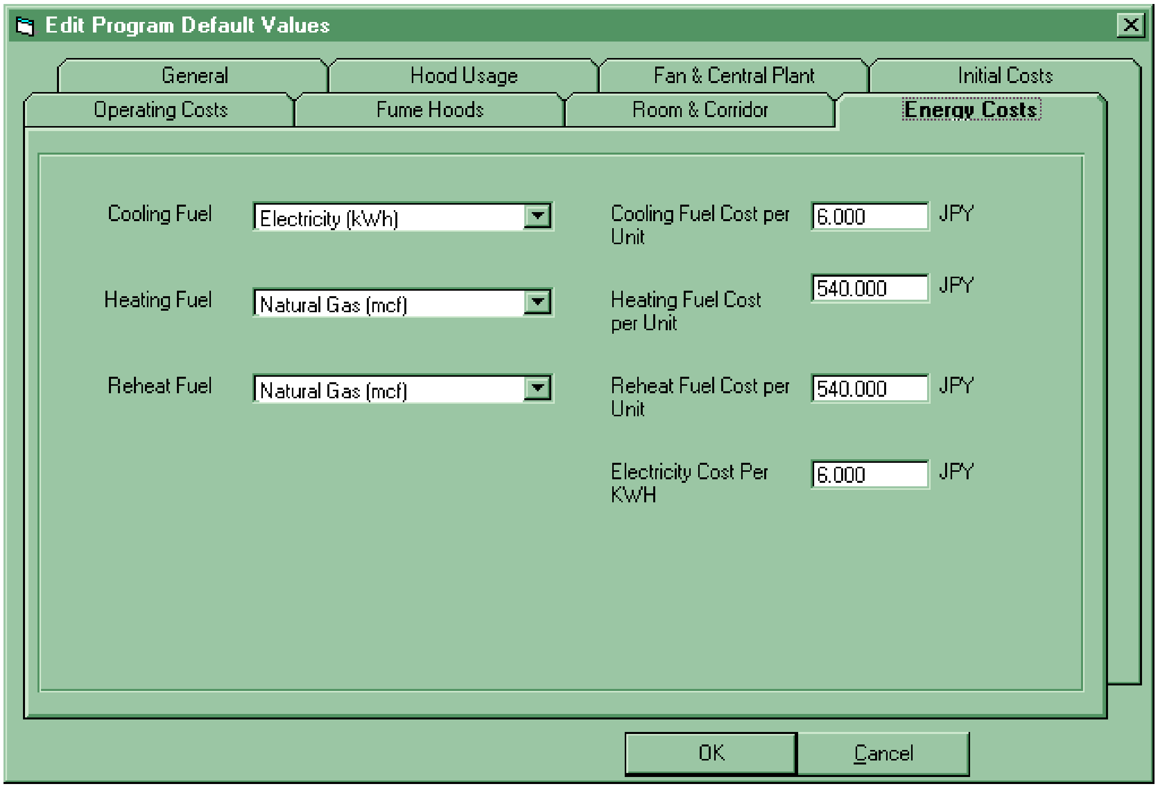

Figure 3-1i Setup – System Defaults: Energy Costs Screen.

Table 3-9 Setup Menu System Defaults Energy Costs Screen Selections

Click on:	And you can:		
Cooling Fuel Heating Fuel	From the drop down list, select one of the pre-defined fuels and their associated units and BTUs per unit to be used as the heating fuel. Select again to designate the reheat fuel. You cannot modify the units and BTUs per unit. The pre-defined list of fuel types and their units of measurement includes:		
Reheat Fuel	#2 Fuel Oil (gal) #2 Fuel Oil (metric ton) #4 Fuel Oil (gal) #4 Fuel Oil (metric ton) #6 Fuel Oil (gal) #6 Fuel Oil (metric ton) Anthracite Coal (lb) Anthracite Coal (metric ton)	Bituminous Coal (lb) Bituminous Coal (metric ton) Electricity (kWh) Kerosene (gal) Kerosene (metric ton) Natural Gas (ccf) Natural Gas (mcf) Natural Gas (therm)	Natural Gas (m^3/h, kWh) Propane (gal) Propane (metric ton) Steam (1,000 lbs) Steam (metric ton) SubBituminous Coal (lb) SubBituminous Coal (metric ton)

Table 3-9 Setup Menu System Defaults Energy Costs Screen Selections

Click on:	And you can:
Cooling Fuel Cost per Unit	Enter a value for the local cost per unit of the fuel and units selected in the Cooling Fuel field.
Heating Fuel Cost per Unit	Enter a value for the local cost per unit of the fuel and units selected in the Heating Fuel field.
Reheat Fuel Cost per Unit	Enter a value for the local cost per unit of the fuel and units selected in the Reheat Fuel field.
Electricity Cost per kilowatt-hour	Enter a value for the local cost per kilowatt-hour of electricity.

Setup-Units Setup Screen

You can specify English or Metric units in this screen. Your changes will be automatically displayed on the other screens and tabs.

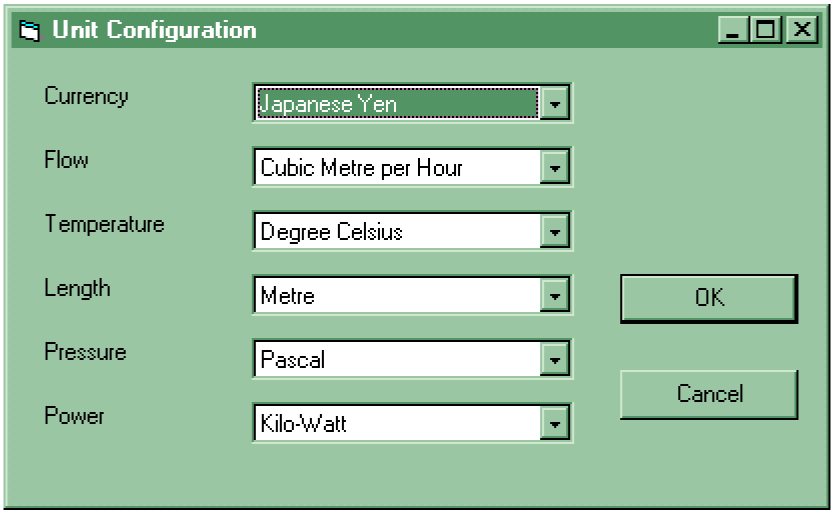

Figure 3-2 Setup – Units Setup Screen.

Table 3-10 Setup Menu Units Setup Screen Selections

Click on:	And you can:
Currency	Select US Dollar (USD), Canadian Dollar (CAD), European Currency Unit (ECU), UK Pound (GBP), Swiss Frank (CHF), Japanese Yen (JPY), Chinese Renmimbi (CNY) Hong Kong Dollar (HKD) Thai Baht (THB) South Korean Won (KRW), Singapore Dollar (SGD), or Australian Dollar (AUD)
Flow	Select CFM, Cubic m^3/h, or Liters/Second
Temperature	Select Degrees F or Degrees C.
Length	Select feet or meters.
Pressure	Select Inch of Water Column or Pascal.
Power	Select Horsepower or Kilowatt.

Edit Menu – Edit Project – General Information Tab

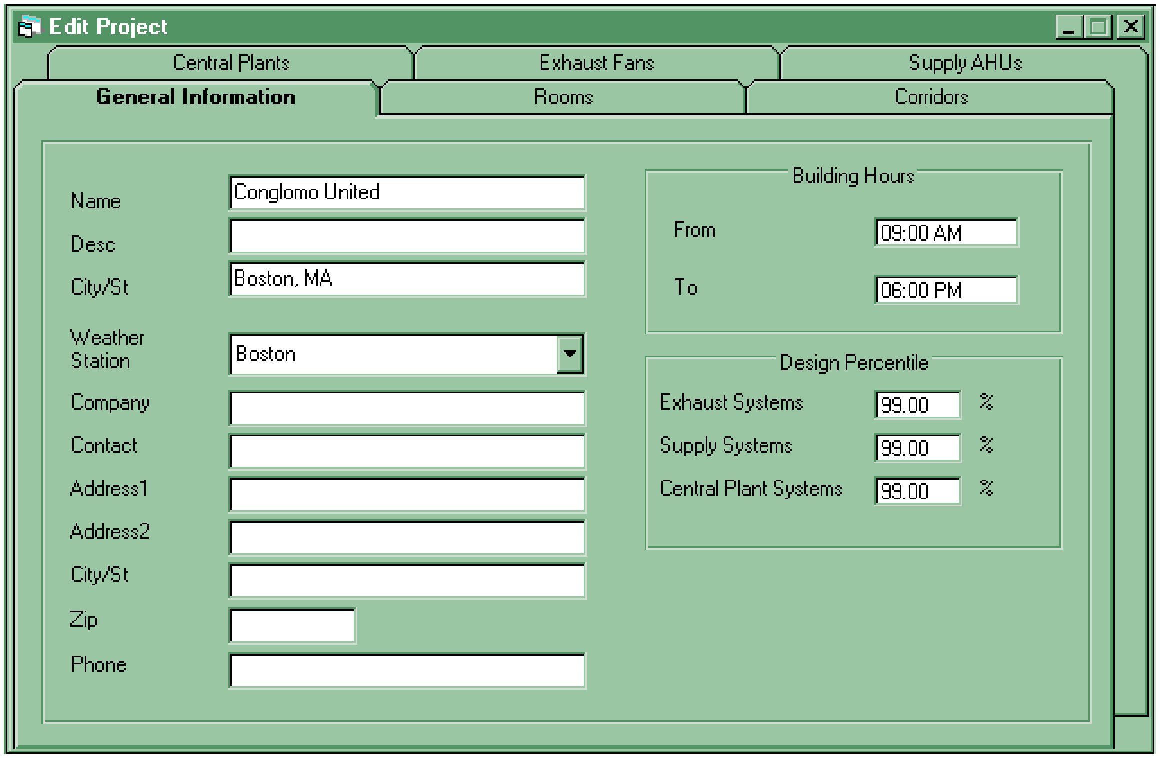

Figure 3-3a Edit Menu – Edit Project– General Information Tab

Table 3-11 Edit Menu – Edit Project – General Information Tab Selections

Click on:	And you can:
Name	Use any combination of alphanumeric characters to enter the name of the project.
Description	Use any combination of alphanumeric characters to enter the description of the project, i.e., Chemistry Laboratory or Life Sciences Building.
City/State	Use any combination of alphanumeric characters to enter the project's location by city and state. The project location can be different from the customer's location.
Weather Station	Use the pull down menu to change the location of your project. Cities are listed alphabetically by state. If you cannot locate the exact city, use the closest geographic location in the table. This will enter the United States Climatic Center's Engineering Weather Data for that location. LabPro uses this data in its energy use calculations.
Company	Use any combination of alphanumeric characters to enter the owner's/customer's company name.
Contact	Use any combination of alphanumeric characters to enter the building owner's/customer's name.
Address # 1	Use any combination of alphanumeric characters to enter the first line of the owner's/customer's street address.
Address # 2	Use any combination of alphanumeric characters to enter the second line of the owner's/customer's street address.

Table 3-11 Edit Menu – Edit Project – General Information Tab Selections

Click on:	And you can:
City/State	Use any combination of alphanumeric characters to enter the owner's/customer's city and state. You can use any combination of alphanumeric characters.
Zip	Use any combination of alphanumeric characters to enter the owner's/customer's zip code or postal code.
Phone	Use any combination of alphanumeric characters to enter the owner's/customer's phone number.
Building Hours	Enter the normal operating hours for the building. These are the hours when the majority of the people who use the facility. Use the hh:mm:ss time format, i.e., 8:00 a.m. to 9:00 p.m. Use the a.m. or p.m. designation when entering the time. If you wish, enter the time using 0001 – 2400 and LabPro will convert the display to the hh:mm:ss time format automatically. The maximum occupied time for building hours cannot exceed 23 hours, 59 minutes.
Design Percentile: Exhaust Systems	Enter a value for the design percentile factor used for calculating exhaust system diversity. Using this factor results in a system that will meet system design fume hood exhaust requirements the specified percent of time. Each exhaust system that you define will use this factor.
Design Percentile: Supply Systems	Enter a value for the design percentile factor used for calculating supply air handling system diversity. Using this factor results in a system that will meet system design supply air requirements the specified percent of time. Each supply air handling system that you define will use this factor.
Design Percentile: Central Plant Systems	Enter a value for the design percentile factor used for calculating central plant diversity. Using this factor results in a central plant that will meet system design cooling, heating, and reheat requirements the specified percent of time. Each central plant system that you define will use this factor.

Edit Menu – Edit Project – Rooms Tab

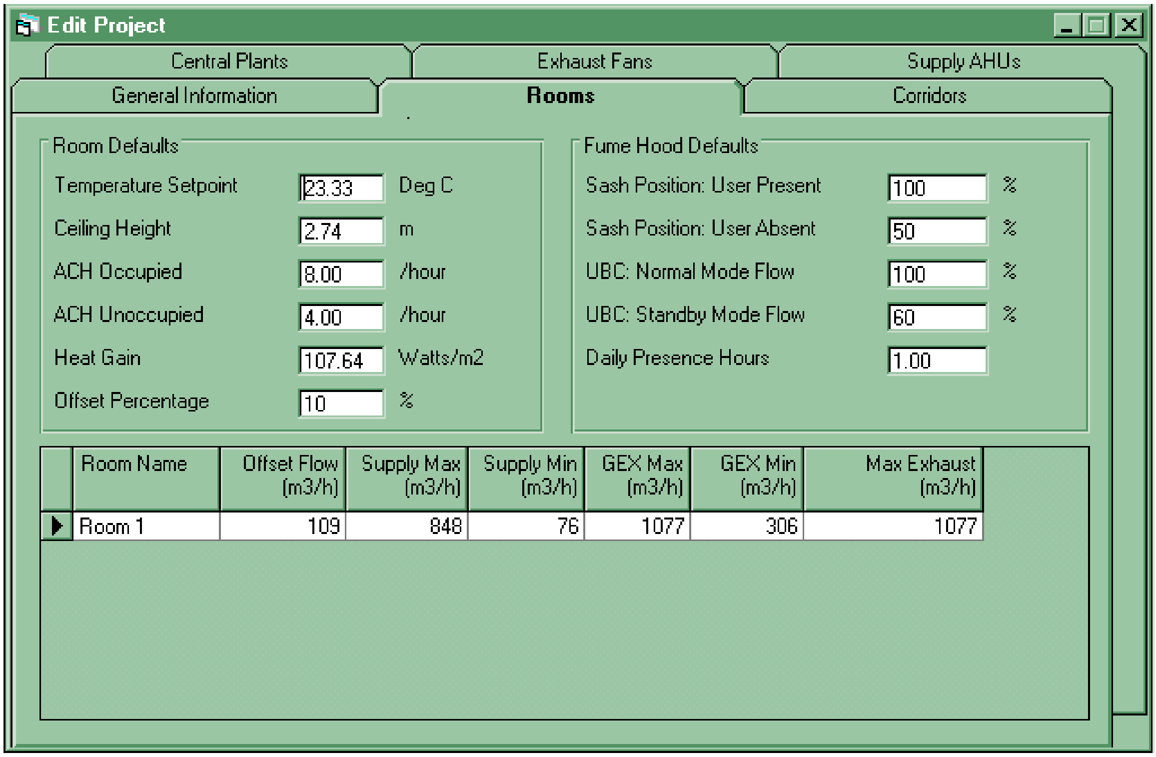

Figure 3-3b Edit Menu – Edit Project –Rooms Tab

Right-button click in the open area at the bottom to expose a pop-up menu. You can choose from these four options:
Add Room
Edit Room
Copy Room
Delete Room.

Table 3-12 Edit Menu - Edit Project – Rooms Tab Selections

Click on:	And you can:
Room Defaults – Temperature Set Point	Enter a value for the default room temperature set point in degrees Fahrenheit for all new rooms.
Room Defaults - Ceiling Height	Enter a value for the default ceiling height in feet (or meters) for all new rooms.
Room Defaults - ACH Occupied	Enter a value for the default air changes per hour (ACH) for the building during occupied hours.
Room Defaults - ACH Unoccupied	Enter a value for the default air changes per hour (ACH) for the building during unoccupied hours.
Room Defaults – Heat Gain (Watts/Sq. Ft) or (Watts/ m^2)	Enter a value to be used as the default maximum watts per square foot (or meter) for all new rooms. The watts per square foot (or meter) value represents the total maximum heat gain in watts within a room divided by the total floor area of the room in square feet (or meters). Total maximum heat gain includes both sensible and latent heat from people, lighting, and equipment, as well as external heat sources such as sunlight.

Table 3-12 Edit Menu - Edit Project – Rooms Tab Selections

Click on:	And you can:
Room Defaults - Offset CFM (or l/s or m^3/h) Percent	Enter a value to be used as the default room offset CFM (or l/s or m^3/h) percentage whenever you define a new room. Offset flow rate percentage is the difference between room supply air flow rate and room exhaust flow rate expressed as a percentage of the maximum total room exhaust.
Sash Position - User Present %	Enter a value to be the default sash position when a user is present at a fume hood. LabPro will automatically fill the User Present field with this number whenever you add a new fume hood to the project.
Sash Position - User Absent %	Enter a value to be the default sash position when a user is absent from a fume hood. LabPro will automatically fill the User Absent field with this number whenever you add a new fume hood to the project.
UBC Hood Modes – Normal	Enter the percentage of full flow for the fume hoods when they are operating in Normal mode.
UBC Hood Modes – Standby	Enter the percentage of full flow for the fume hoods when they are operating in Standby mode.
Fume Hood - Presence Hours	Enter the total cumulative time per day that the user(s) are apt to be in front of their hoods. Note: Presence hours cannot exceed the total building occupied hours.

Edit Menu – Edit Project – Corridors

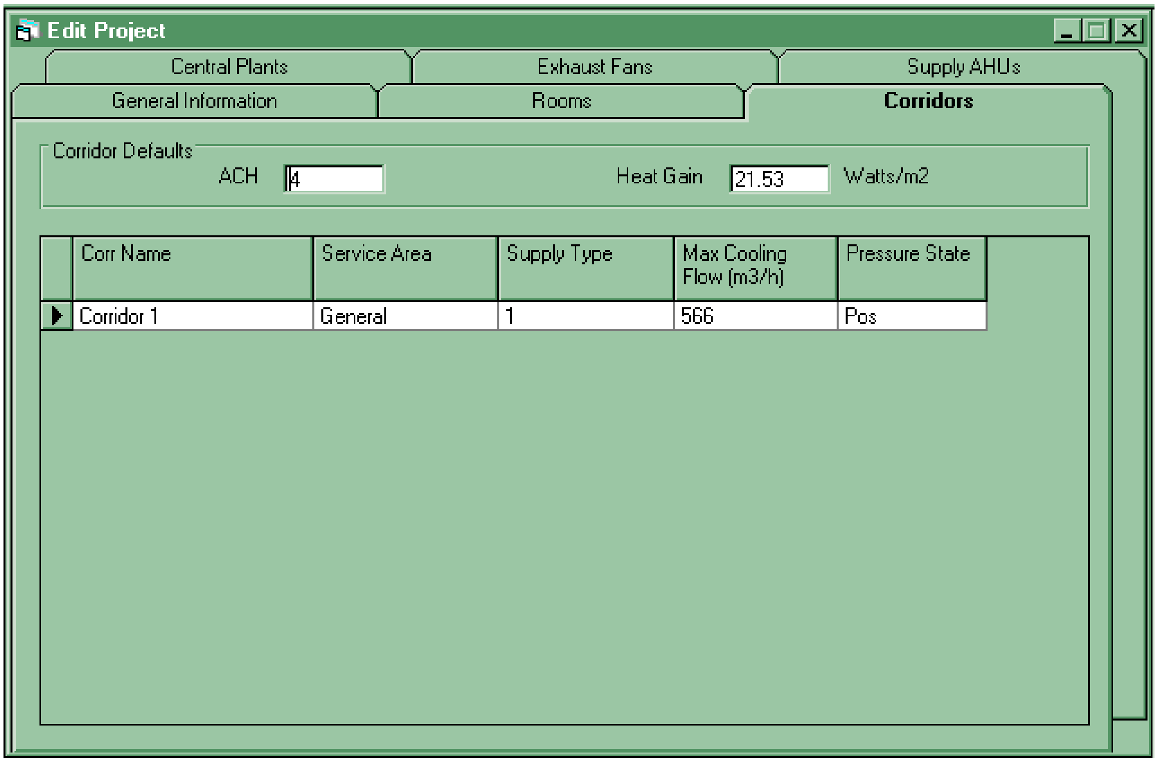

Figure 3-3c Edit Menu – Edit Project – Corridors Tab

Right-button click in the open area at the bottom to expose a pop-up menu. You can choose from these four options:
Add Corridor
Edit Corridor
Copy Corridor
Delete Corridor.

Table 3-13 Edit Menu - Edit Project – Corridors Tab Selections

Click on:	And you can:
Corridor Defaults – ACH	Enter a value for the default air changes per hour (ACH).
Corridor Defaults – Heat Gain (Watts/Sq. Ft) or (Watts/ m^2)	Enter a value to be used as the default maximum watts per square foot (or meter) for all new corridors. The watts per square foot (or meter) value represents the total maximum heat gain in watts within a corridor divided by the total floor area of the corridor in square feet (or meters). Total maximum heat gain includes both sensible and latent heat from people, lighting, and equipment, as well as external heat sources such as sunlight.

Edit Menu – Edit Project – Central Plants

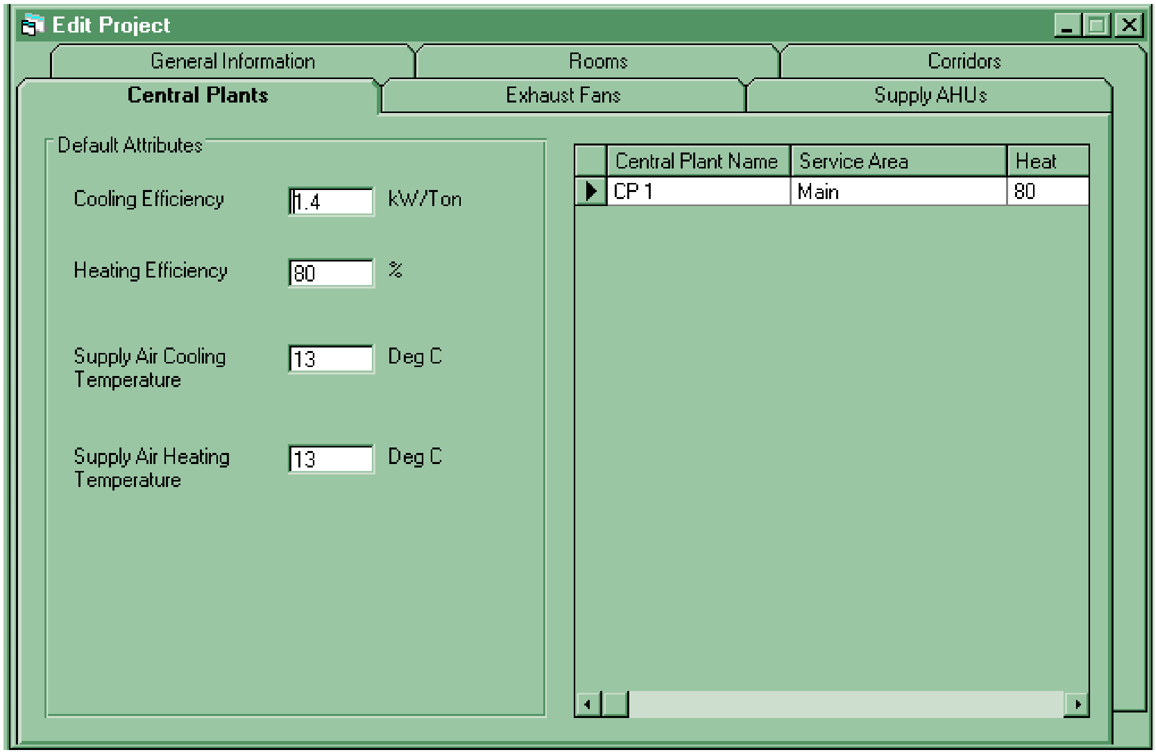

Figure 3-3d Edit Menu – Edit Project – Central Plants Tab

Right-button click in the open area on the right to expose a pop-up menu. You can choose from these four options:
Add Central Plant
Edit Central Plant
Copy Central Plant
Delete Central Plant.

Table 3-14 Edit Menu - Edit Project – Central Plants Tab Selections

Click on:	And you can:
Default Attributes: Cooling Efficiency	Enter the cooling efficiency of the central plant air chiller(s) in kilowatts of power per ton of refrigeration.
Default Attributes: Heating Efficiency	Enter the heating efficiency of the central plant heating system as the ratio (expressed as a percentage) of total useful heat output versus the total energy input.
Supply Air Cooling Temperature	Enter a value for the default supply air temperature whenever you add a supply air handling unit (AHU) to a project. This value represents the air temperature measured in degrees (Fahrenheit or Celsius) after the discharge of a pre-heater or cooling coil.
Supply Air Heating Temperature	Enter a value for the default supply air temperature whenever you add a supply air handling unit (AHU) to a project. This value represents the air temperature measured in degrees (Fahrenheit or Celsius) after the discharge of a pre-heater or cooling coil.

Edit Menu – Edit Project – Exhaust Fans

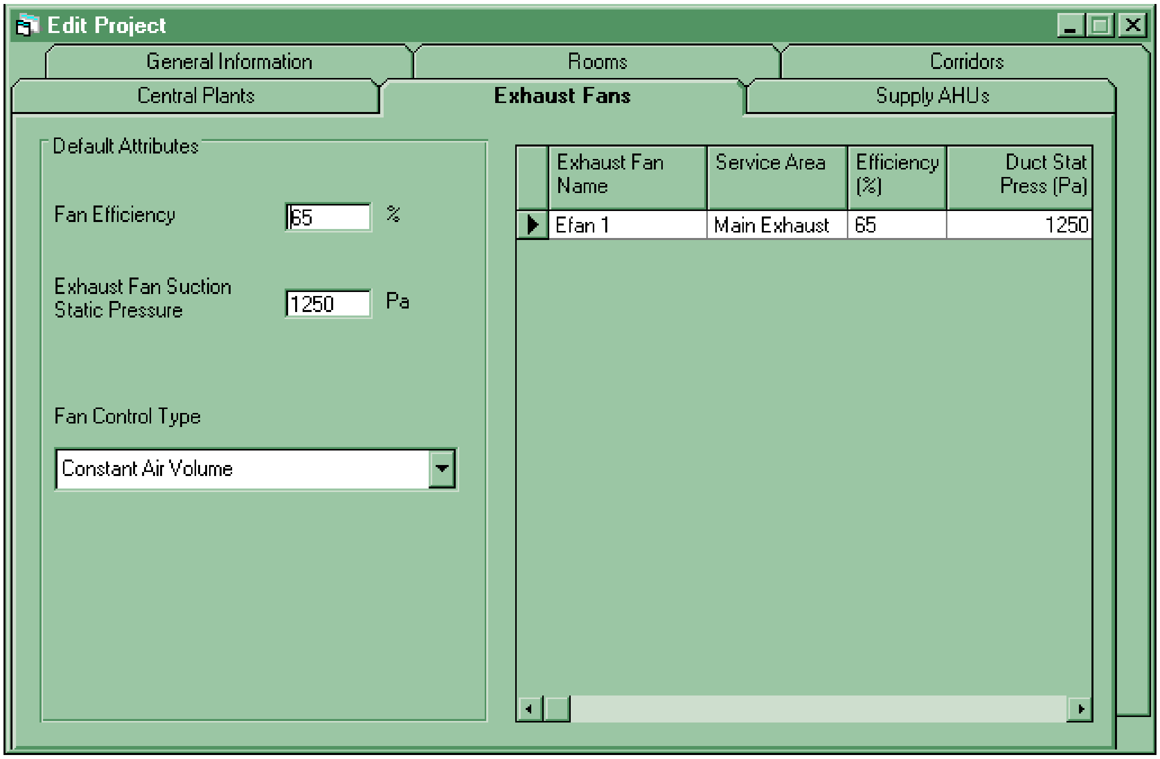

Figure 3-3e Edit Menu – Edit Project – Exhaust Fans Tab

Right-button click in the open area at the right to expose a pop-up menu. You can choose from these four options:
Add Exhaust Fan
Edit Exhaust Fan
Copy Exhaust Fan
Delete Exhaust Fan.

Table 3-15 Edit Menu - Edit Project – Exhaust Fans Tab Selections

Click on:	And you can:
Default Attributes – Fan Efficiency	Enter a number for the default efficiency percentage of the exhaust fan
Default Attributes – Exhaust Fan Suction Static Pressure	Enter the value you want to be the default suction static pressure measured in inches of water (" wc) or Pascals (Pa). This value represents the static pressure measured in the ductwork at the inlet of the exhaust fan.
Default Attributes Fan Control Type	Select the default control type for the exhaust fans from the drop-down list: • Variable Frequency Drive • Constant Air Volume • Discharge Damper - Forward Curve Fan • Discharge Damper - Backward Incline Fan • Vane axial Fans • Inlet Vane Control - Airfoil • Inlet Vane Control - Forward Curve Fan

Edit Menu – Edit Project – Supply Fans

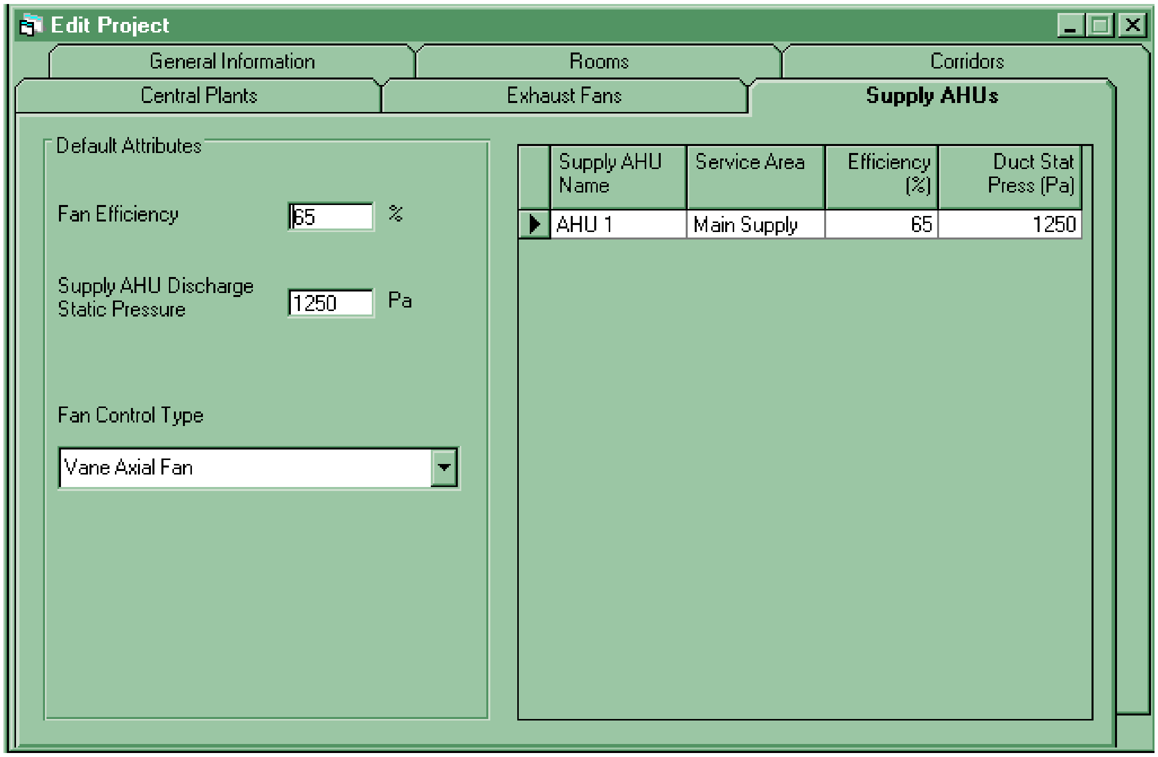

Figure 3-3f Edit Menu – Edit Project – Supply Fans Tab

Right-button click in the open area at the right to expose a pop-up menu. You can choose from these four options:
Add Supply Fan
Edit Supply Fan
Copy Supply Fan
Delete Supply Fan.

Table 3-16 Edit Menu - Edit Project – Supply Fans Tab Selections

Click on:	And you can:
Default Attributes: Fan Efficiency	Enter a number for the default efficiency percentage of the supply fans.
Default Attributes: Supply AHU Discharge Static Pressure	Enter the value you want to be the default suction static pressure measured in inches of water (" wc) or Pascals (Pa). This value represents the static pressure measured in the ductwork at the outlet of the supply fan.
Default Attributes: Control Type	Select the default control type for the supply fans from the drop-down list: • Variable Frequency Drive • Constant Air Volume • Discharge Damper - Forward Curve Fan • Discharge Damper - Backward Incline Fan • Vane axial Fans • Inlet Vane Control - Airfoil • Inlet Vane Control - Forward Curve Fan

Edit – Edit Costs Tabs

Use this screen to specify energy, HVAC, lab, and operating costs and define financial analysis information for the current project. Some data is automatically filled in with the values that were entered into the System Defaults screen.

Figure 3-4a Edit Costs Tabs.

Table 3-17 Edit Costs Menu Selections

Click on:	And you can:
Energy	Define types and cost of fuels, define potential rebates.
HVAC	Define the HVAC mechanical equipment costs.
Lab Controls	Define the Laboratory controls initial costs per hood.
Operating	Define the annual recurring costs, (e.g., maintenance costs, re-certification costs).
Financial	Define financial analysis information and annual recurring operating costs.

Energy Costs

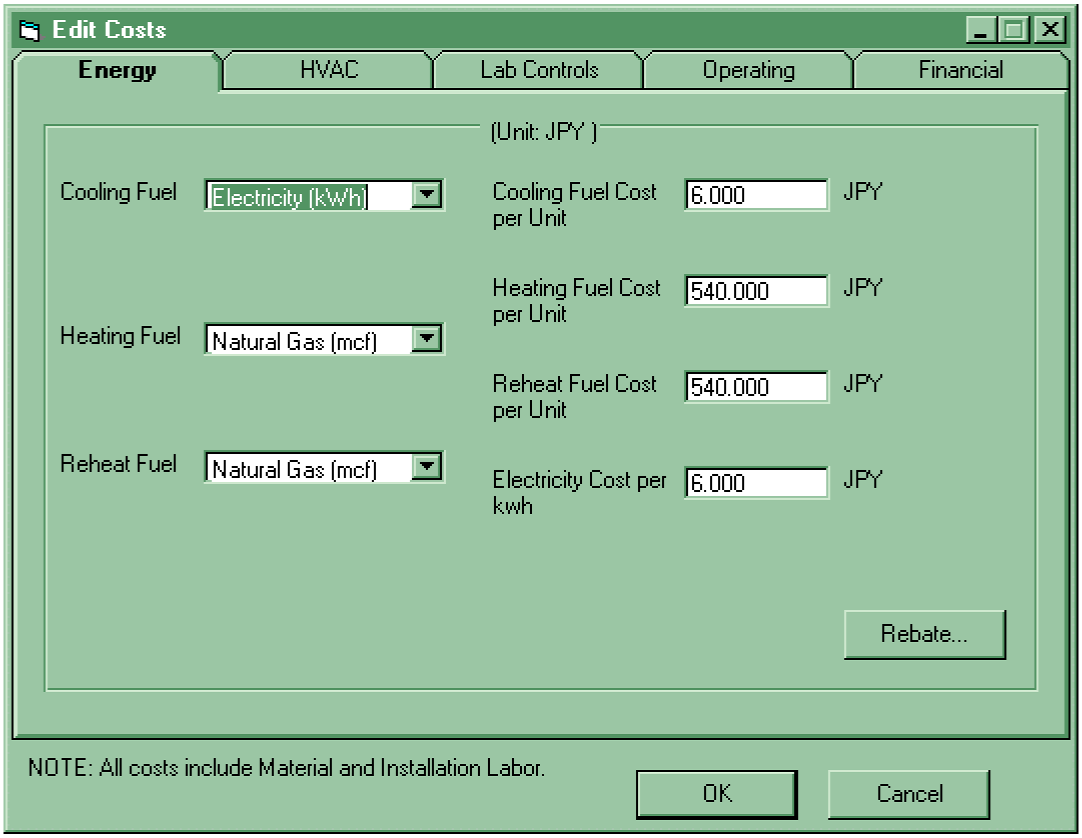

Figure 3-4b Edit Costs – Energy Costs Tab.

Table 3-18 Edit Costs – Energy Costs Tab Selections

Click on:	And you can:
Cooling Fuel Heating Fuel Reheat Fuel	Select the cooling, heating, and reheat fuels. The pre-defined list of fuel types and their units of measurement includes: #2 Fuel Oil (gal) #2 Fuel Oil (metric ton) #4 Fuel Oil (gal) #4 Fuel Oil (metric ton) #6 Fuel Oil (gal) #6 Fuel Oil (metric ton) Anthracite Coal (lb) Anthracite Coal (metric ton) Bituminous Coal (lb) Bituminous Coal (metric ton) Electricity (kWh) Kerosene (gal) Kerosene (metric ton) Natural Gas (ccf) Natural Gas (mcf) Natural Gas (therm) Natural Gas (m^3/h, kWh) Propane (gal) Propane (metric ton) Steam (1,000 lbs) Steam (metric ton) SubBituminous Coal (lb) SubBituminous Coal (metric ton)
Cooling Fuel Cost per Unit	Enter a value for the local cost per unit of the fuel and units selected in the Cooling Fuel field.
Heating Fuel Cost per Unit	Enter a value for the local cost per unit of the fuel and units selected in the Heating Fuel field.
Reheat Fuel Cost per Unit	Enter a value for the local cost per unit of the fuel and units selected in the Reheat Fuel field.
Electricity Cost per kWh	Enter a value for the local cost per kilowatt-hour of electricity.
Rebate button	Enter data about any rebate or incentives.

Energy Costs – Rebate Information

You can enter information about rebates or incentives for your project. If your local gas or electric utility provides incentives for energy saving laboratory control systems, this is where you enter that amount.
You must specify which systems will be given rebates. For example, many utilities will not provide rebates or incentives for traditional VAV systems since the energy savings is dependent on fume hood sash position — something over which the utility has no control. A rebate may be provided to use a traditional VAV system, but a larger rebate may be given if Usage Based Controls are used since Usage Based Controls are not dependent on sash position for minimum energy savings.
For each VAV, Constant Volume Usage Based Controls, and Variable Air Volume Usage Based Controls control option, enter the rebate amount (if any). The default value of zero dollars ($0) indicates that there is no rebate provided for this control system option. Constant volume systems are not eligible for rebates since they provide no energy savings.

When you click on this button, LabPro displays the Rebate screen. The rebate will be applied only to Constant Volume Usage Based Controls, Variable Air Volume or Variable Air Volume Usage Based Control systems.

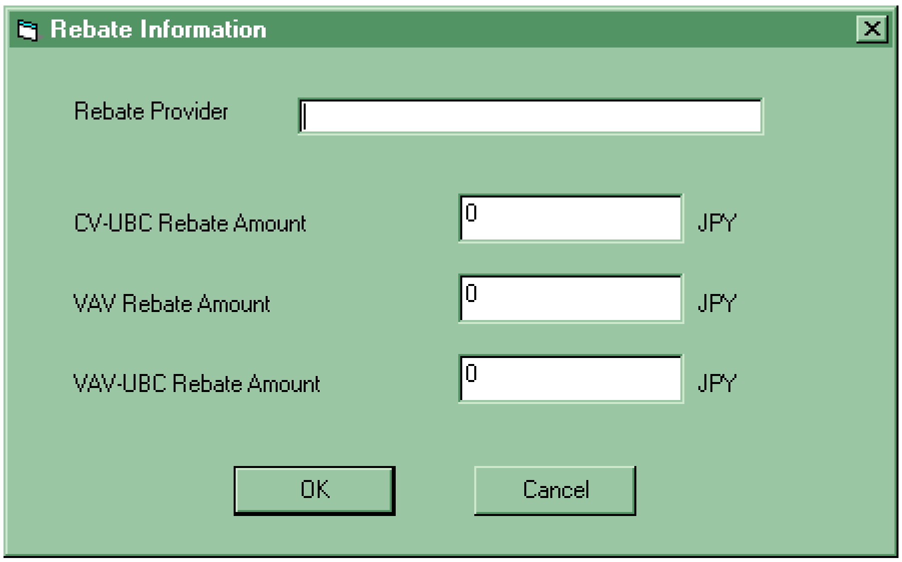

Figure 3-4c Edit Menu – Edit Costs – Energy Costs – Rebate Screen

Table 3-19 Edit Menu – Edit Costs – Energy Costs – Rebate Screen Selections

Click on:	And you can:
Rebate Provider	Enter any combination of alphanumeric characters for the name of the rebate provider. This name will be used on the Life Cycle Cost report. If there is no rebate available, leave this field blank.
CV-UBC Rebate Amount	Enter a value for the amount of the rebate for your CV-UBC system. If there is no rebate available, leave blank.
VAV Rebate Amount	Enter a value for the amount of the rebate for your VAV system. If there is no rebate available, leave blank.
VAV-UBC Rebate Amount	Enter a value for the amount of the rebate for your VAV-UBC system. If there is no rebate available, leave blank.

HVAC Costs

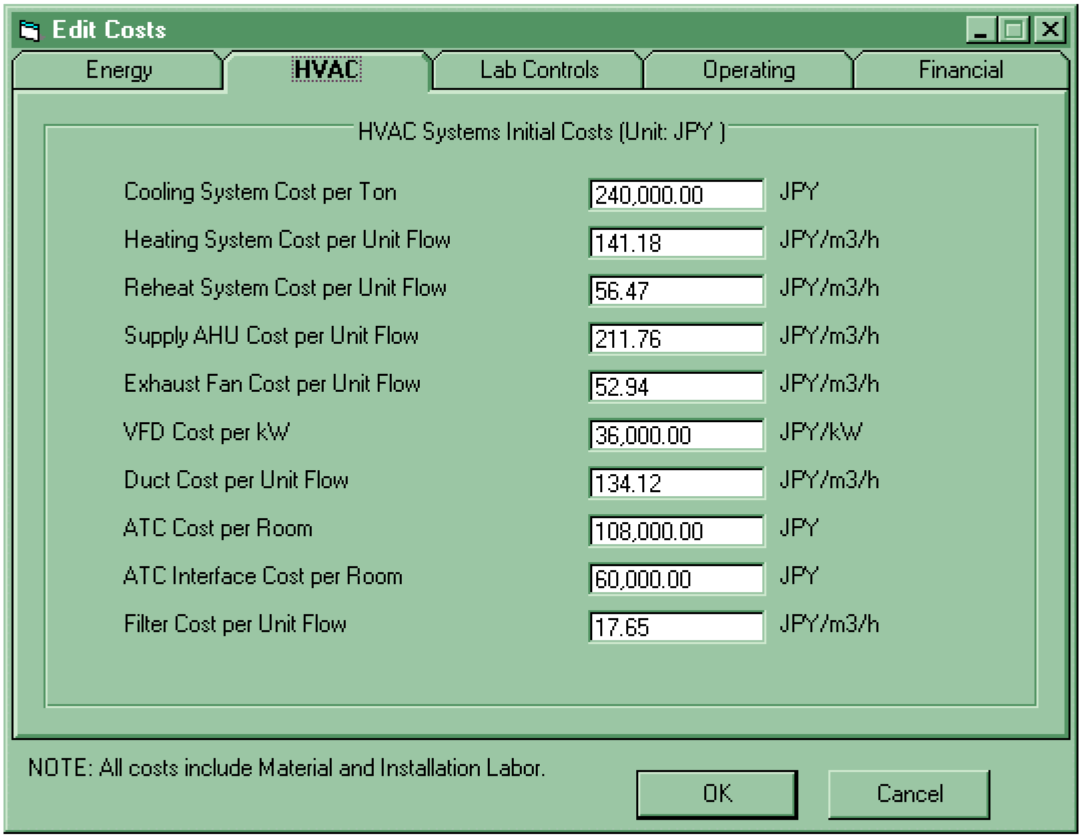

Figure 3-4d Edit Costs – HVAC Costs Tab.

Table 3-20 Edit Costs – Energy Costs Tab Selections

Click on:	And you can:
Cooling System Cost per Ton	Enter a value for the average cost per installed ton of cooling including chiller, cooling tower, pumps, piping, variable frequency drives (VFDs) and all installation costs. Do not include supply fans, air handlers or cooling coils costs.
Heating System Cost per Unit Flow	Enter a value or the average cost for heating equipment per installed CFM (or l/s or m^3/h) including boiler, piping, pumps, variable frequency drives (VFDs) and all installation costs.
Reheat System Cost per Unit Flow	Enter a value for the average cost for reheat equipment per installed CFM (or l/s or m^3/h) including reheat coils, piping and all installation labor.
Supply Air Handler Cost per Unit Flow	Enter a value for the average cost for supply AHU equipment per installed CFM (or l/s or m^3/h) including air hander, fan motor, cooling coils, filter housing and all installation labor.
Exhaust Fan Cost per Unit Flow	Enter a value for the average cost for exhaust fan equipment per installed CFM (or l/s or m^3/h) including fan, dampers, and all installation labor.
VFD Cost per HP	Enter a value for the average cost for variable frequency drive (VFD) equipment per installed HP including VFD, damper, and all installation labor costs. LabPro will use this value to estimate the total mechanical system initial costs.

Table 3-20 Edit Costs – Energy Costs Tab Selections

Click on:	And you can:
Duct Cost per Unit Flow	Enter a value for the average cost for ductwork per installed CFM (or l/s or m^3/h) including ductwork material costs and all installation labor. Duct Cost per CFM (or l/s or m^3/h) includes both stainless steel and non-stainless steel duct. To calculate this value you must first determine a ratio of stainless steel to non-stainless steel duct, the cost per CFM (or l/s or m^3/h) of non-stainless duct, and then determine an average duct cost per CFM (or l/s or m^3/h).
ATC Cost per Room	Enter a value for the average cost per room for Automatic Temperature Controls (ATC) including material costs and all installation labor.
ATC Interface Cost per Room	Enter a value for the average cost per room to integrate the laboratory controls with the Automatic Temperature Controls (ATC) including material costs and all installation labor.
Filter Cost per Unit Flow	Enter a value for the average cost for Air Filter replacement per CFM (or l/s or m^3/h).

Lab Controls

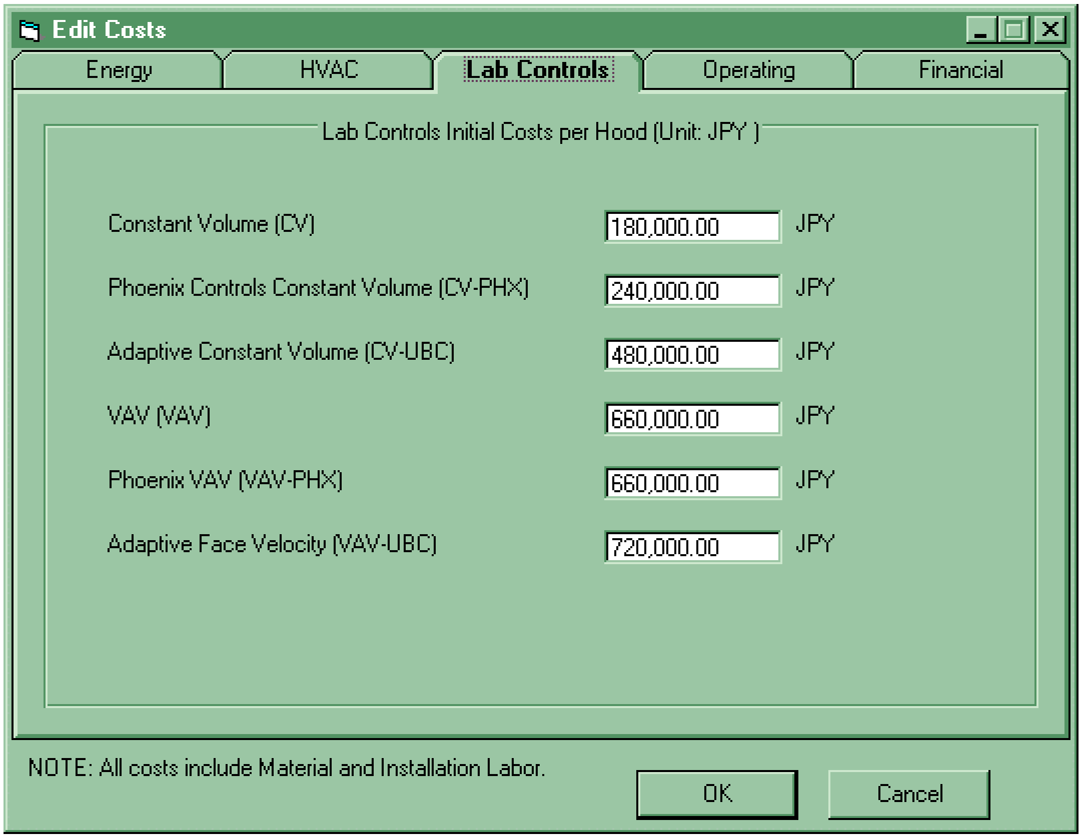

Figure 3-4e Edit Costs – Lab Controls Tab.

Table 3-21 Edit Costs – Lab Controls Tab Selections

Click on:	And you can:
Constant Volume (CV)	Enter a value for the average cost per fume hood for constant volume laboratory controls including material costs and all installation labor.
Phoenix Controls Constant Volume (CV-PHX)	Enter a value for the average cost per fume hood for Phoenix Controls constant volume laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Adaptive Constant Volume (CV-UBC)	Enter a value for the average cost per fume hood for Phoenix Controls Adaptive Constant Volume Usage Based Controls laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
VAV (VAV)	Enter a value for the average cost per fume hood for traditional VAV laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Phoenix Controls VAV (VAV-PHX)	Enter a value for the average cost per fume hood for Phoenix Controls VAV laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.
Adaptive Face Velocity (VAV-UBC)	Enter a value for the average cost per fume hood for Phoenix Controls Adaptive Face Velocity laboratory controls including material costs and all installation labor. Do not include the cost of the Fume Hood or balancing costs.

Operating Costs

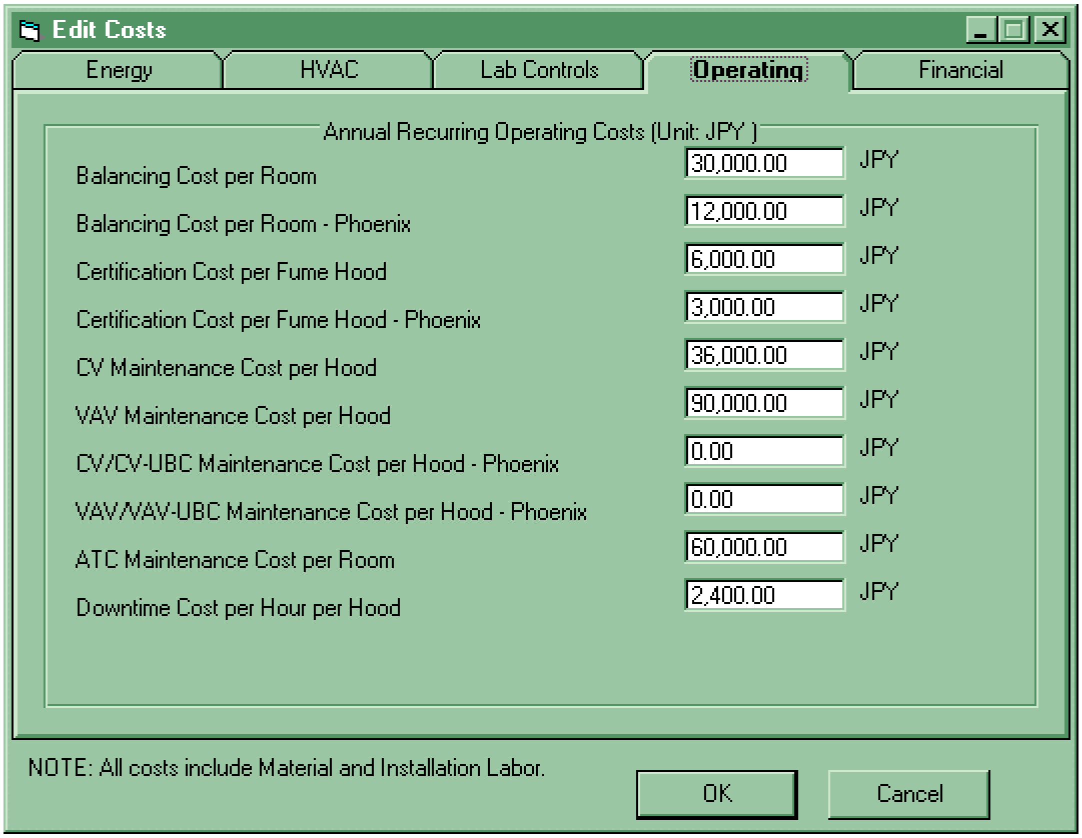

Figure 3-4f Edit Costs – Operating Costs Tab.

Table 3-22 Edit Costs – Operating Costs Tab Selections

Click on:	And you can:
Balancing Cost per Room	Enter a value for the average cost to balance the airflow control system within a laboratory space including material and labor costs. LabPro assumes that a laboratory airflow controls system needs to be re-balanced annually and will add the entered cost to the total annual maintenance cost. Also, LabPro uses this cost to determine to initial costs to install the mechanical system.
Balancing Cost per Room – Phoenix	Enter a value for the average cost to balance a Phoenix Controls airflow flow control system within a laboratory space including material and labor costs. LabPro assumes that a laboratory airflow controls system needs to be re-balanced annually and will add the entered cost to the total annual maintenance cost. Also, LabPro uses this cost to determine to initial costs to install the mechanical system.
Certification Cost per Fume Hood	Enter a value for the average cost to re-certify a fume hood system within a laboratory space including material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost and initial cost for the complete system. LabPro will also use this cost to determine initial costs to install the mechanical system.
Certification Cost per Fume Hood – Phoenix	Enter a value for the average cost to re-certify a fume hood system with a Phoenix Controls valve installed on the hood including material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost and initial cost for a complete Phoenix Controls system. LabPro will also use this cost to determine initial costs to install the mechanical system.

Table 3-22 Edit Costs – Operating Costs Tab Selections

Click on:	And you can:
CV Maintenance Cost per Hood	Enter a value for the average cost to maintain a constant volume (CV) or two-state fume hood system within a typical laboratory space. Include material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost for the complete system.
VAV Maintenance Cost per Hood	Enter a value for the average cost to maintain a variable air volume (VAV) fume hood system within a typical laboratory space. Be sure to include material and labor costs. LabPro will use this value to estimate the annual operating and maintenance cost for the complete system.
CV/CV UBC Maintenance Cost per Hood - Phoenix	Enter a value for the average cost to maintain a Phoenix Controls Constant Volume or Constant Volume Usage Based Controls fume hood system. LabPro will use this value to estimate the annual operating and maintenance cost for a complete Phoenix Controls system.
VAV/ VAV UBC Maintenance Cost per Hood - Phoenix	Enter a value for the average cost to maintain a Phoenix Controls variable air volume (VAV) or Variable Air Volume Usage Based Control (VAV UBC) fume hood system. LabPro will use this value to estimate the annual operating and maintenance cost for a complete Phoenix Controls system.
Operating Costs: ATC Maintenance Cost per Room	Enter a value for the average cost to maintain the Automatic Temperature Control (ATC) system within the laboratory. LabPro will use this value to estimate the annual operating and maintenance cost for a complete temperature control system.
Operating Costs: Downtime Cost per Hour per Hood	Enter the average cost incurred for downtime due to HVAC mechanical system maintenance and repair per hour per room. LabPro will determine the annual number of maintenance hours by dividing the total maintenance cost for each system by $100(USD)/hour (a realistic average hourly maintenance cost). It then multiplies the total number of maintenance hours by the average downtime costs to determine the cost impact of having a laboratory not in use because of maintenance.

Financial Analysis

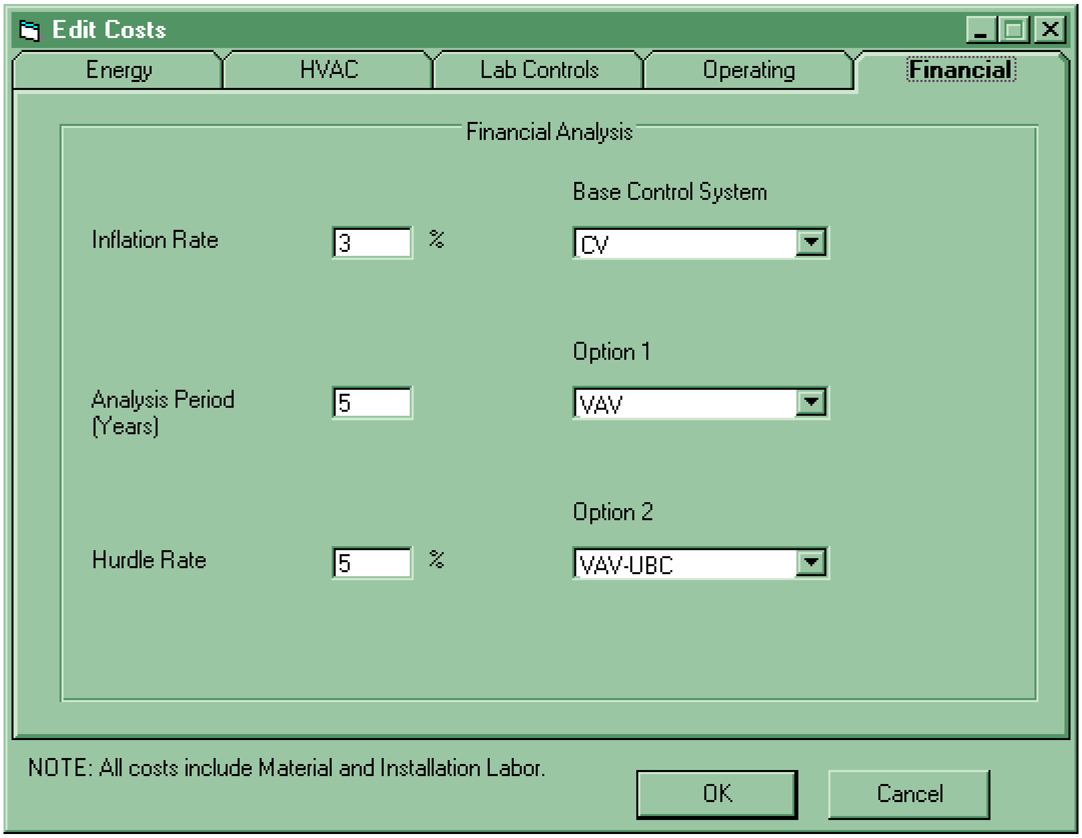

Figure 3-4g Edit Costs – Financial Analysis Tab.

Table 3-23 Edit Costs – Financial Analysis Tab Selections

Click on:	And you can:
Inflation Rate	Enter a value for the expected general inflation rate. LabPro will use this data in the economic reports to escalate energy and maintenance costs in future years.
Analysis Period (Years)	Enter a value for the analysis period in years.
Hurdle Rate	Enter a value for the hurdle rate for this project.
Base Control System	Select from the drop down list the type of airflow controls for your base control system against which you want to compare the life cycle costs, initial rate of return (IRR), and net present value (NPV) of control systems for options 1 and 2. Your choices are: • CV • VAV-PHX • CV-PHX • VAV UBC • VAV
Option 1 Control System	Select from the drop down list the type of airflow controls for the option 1 control system against which you want to compare the life cycle costs, initial rate of return (IRR), and net present value (NPV) of control systems for the base control system and option 2. Your choices are: • CV • VAV-PHX • CV-PHX• VAV UBC • VAV
Option 2 Control System	Select from the drop down list the type of airflow controls for the option 2 control system against which you want to compare the life cycle costs, initial rate of return (IRR), and net present value (NPV) of control systems for the base control system and option 1. Your choices are: • CV • VAV-PHX • CV-PHX• VAV UBC • VAV

Edit Menu – Room – Add Room

There are 4 actions grouped together: Add Room, Edit Room, Copy Room, and Delete Room. Adding, editing, and copying rooms all use the same screens; while deleting a room is simpler.
In addition, the Balance Sheet button is located at the bottom of each Edit-Add Room screen. Clicking this button displays a completed Room Balance Report for the room.

Edit Menu – Room – Add Room – General Information Tab

The Add Room menu item allows you to enter a new room with room-specific information as shown in the following 4 Tab screens.

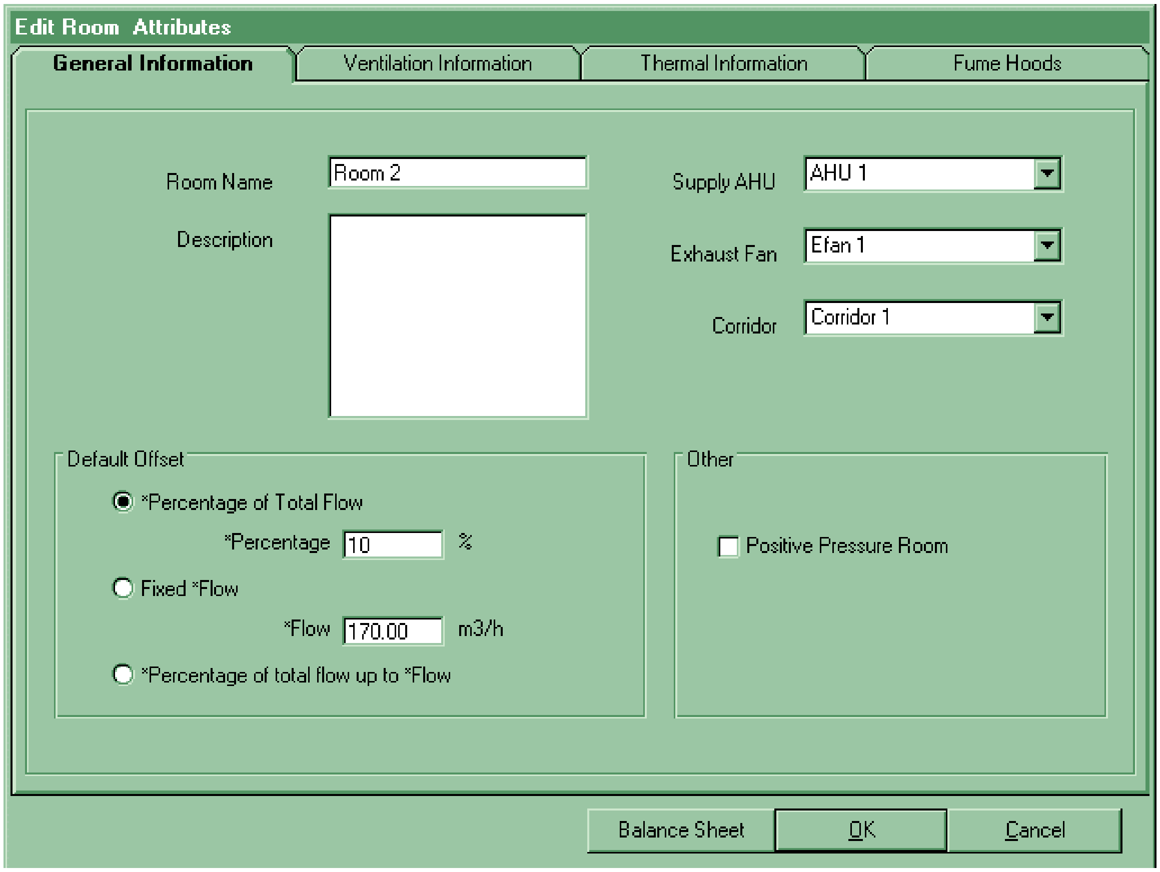

Figure 3-5a Edit Menu – Room – Add Room – General Information Tab

Table 3-24 Edit Menu - Room – Add Room General Information Tab Selections

Click on:	And you can:
Room Name	Enter the name or number of the room using any combination of alphanumeric characters. Each individual room name or number defines a pressurization zone.
Description	Enter a description of the room's control function using any combination of alphanumeric characters.
Supply AHU	Choose the name of the supply air handler that will be associated with this room.
Exhaust Fan	Choose the name of the exhaust fan that will be associated with this room.
Corridor	Choose the name of the corridor that will be associated with this room.
Default Offset – Percentage of Total Flow	When selected, LabPro takes the value entered in the Percentage field and multiplies it by the total flow to calculate the offset expressed as a percentage of total flow (exhaust).

Table 3-24 Edit Menu - Room – Add Room General Information Tab Selections

Click on:	And you can:
Default Offset – Percentage	Enter a value in this field.
Default Offset – Fixed Flow	When selected, LabPro sets the offset to the value entered in the Flow field.
Default Offset – Flow	Enter a value to be used in calculating the Default Offset – Fixed Flow value and the Default Offset – Percentage of Total Flow up to value.
Default Offset – Percentage of Total Flow up to	LabPro will calculate the offset expressed as the percentage (specified in the Percentage field) of total flow up to but not exceeding the value specified in the Flow field.
Other – Positive Pressure Room	If the room requires that the pressurization is positive (or the air migrates out of the room), then place an X in this box and LabPro will make the necessary calculations to determine the project totals.

Edit Menu – Room – Add Room – Ventilation Information Tab

The Add Room menu item allows you to enter room-specific ventilation information as shown in the following screen.

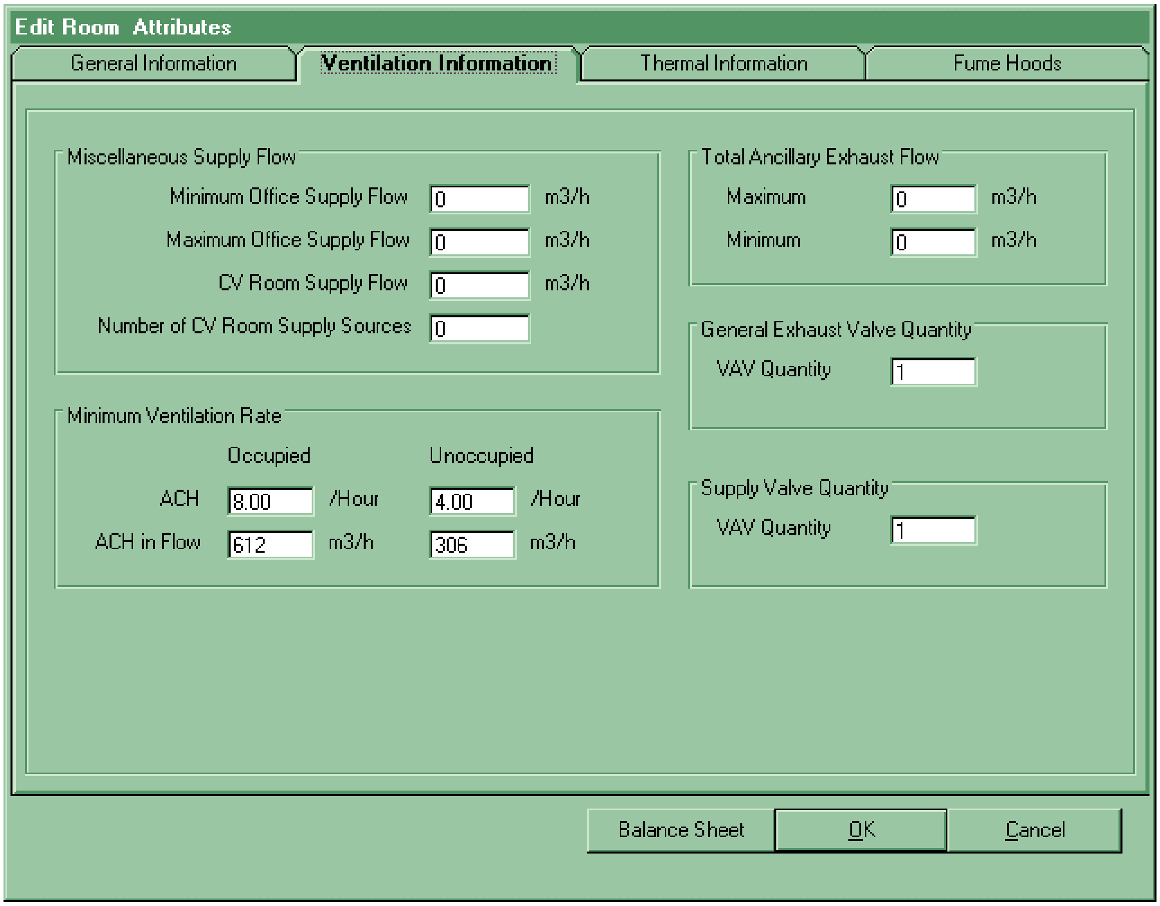

Figure 3-5b Edit Menu – Room – Add Room – Ventilation Information Tab

Table 3-25 Edit Menu – Room– Add Room – Ventilation Information Tab Selections

Click on:	And you can:
Miscellaneous Supply Flow	These four fields identify the miscellaneous supply devices that serve this pressurization zone. Use an office supply to provide temperature control to an office within the lab pressurization zone. (Office supplies provide conditioned supply air to the office they serve and unconditioned infiltration flow rate into the adjoining main room.) Use a Constant Volume Room supply to provide additional supply air into the main room.
Minimum Office Supply Flow	Enter a value for the total minimum office supply flow rate entering the room from all office supply sources within this pressurization zone.
Maximum Office Supply Flow	Enter a value for the total maximum office supply flow rate entering the room from all office supply sources within this pressurization zone.
CV Room Supply Flow	Enter a value for the total minimum additional supply flow rate entering the room from constant volume additional supply sources within this pressurization zone.

Table 3-25 Edit Menu – Room– Add Room – Ventilation Information Tab Selections

Click on:	And you can:
Number of CV Room Supply Sources	Enter the number of constant volume supply sources in this room.
Minimum Ventilation Rate – Occupied Air Changes per Hour (ACH)	Enter a value for the number of air changes per hour (ACH) for the room (lab) during occupied hours.
Minimum Ventilation Rate – Occupied Air Changes per Hour in Flow	This value represents the total flow rate of exhaust air that must leave the room to provide the required air changes per hour when the room is occupied. LabPro automatically calculates this flow rate from the entered values for the room's Floor Area, Ceiling Height, and Unoccupied ACH.
Minimum Ventilation Rate – Unoccupied Air Changes per Hour (ACH)	Enter a value for the number of air changes per hour (ACH) for the room during unoccupied hours.
Minimum Ventilation Rate – Unoccupied Air Changes per Hour in Flow	This value represents the total flow rate of exhaust air that must leave the room to provide the required air changes per hour when the room is unoccupied. LabPro automatically calculates this flow rate from the room's Floor Area, Ceiling Height, and Unoccupied ACH.
Total Ancillary Exhaust Flow – Maximum	Enter a value for the total maximum volume of constant volume and two-position exhausts (i.e., canopy hoods, snorkels, maximum exhaust for two-position hoods) for the room.
Total Ancillary Exhaust Flow – Minimum	Enter a value for the total minimum volume of constant volume and two-position exhausts (i.e., canopy hoods, snorkels, maximum exhaust for two-position hoods) for the room. Note: If the exhaust device is constant volume, you should enter the total minimum value, which is equal to the maximum exhaust for those devices. For two-position devices, enter total minimum for those devices.
General Exhaust Valve Quantity (VAV Qty)	Enter a value for the quantity of VAV GEX valves serving the room.
Supply Valve Quantity (VAV Qty)	Enter a value for the quantity of VAV supply valves providing make-up air to this room.

Edit Menu – Room – Add Room – Thermal Information Tab

The Add Room menu item allows you to enter room-specific thermal information as shown in the following screen. In addition, there are two buttons of interest available located at the bottom of this screen:

- The Default Profile button will reset the Thermal Profile to the system default values.
- The Balance Sheet button will display a completed Room Balance Report for the room.

Figure 3-5c Edit Menu – Room – Add Room – Thermal Information Tab

Table 3-26 Edit Menu - Edit Project – Add Room Thermal Information Tab Selections

Click on:	And you can:
Thermal Requirements – Floor Area	Enter a value for the floor area (in square feet or square meters) for this room.
Thermal Requirements – Temperature Setpoint	Enter a value for the default room temperature setpoint in degrees F or C for this room.
Thermal Requirements – Heat Gain	Enter a value for the default maximum watts per square foot (or Watts per square meter) for this room. The watts per square foot value represents the total maximum heat gain in watts within a room divided by the total floor area of the room in square feet (or meters). Total maximum heat gain includes both sensible and latent heat from people, lighting, and equipment, as well as external heat sources such as sunlight.
Thermal Requirements – Ceiling Height	Enter a value for the ceiling height area (in feet or meters) for this room.

Table 3-26 Edit Menu - Edit Project – Add Room Thermal Information Tab Selections

Click on:	And you can:
Thermal Requirements – Calculate Maximum Cooling Flow	Select this option and LabPro automatically calculates the flow rate of air required to maintain the desired room temperature setpoint, based on the watts per square foot (or square meter) entered for this room. LabPro's default is to enable this option and create a generic profile. (For a more detailed analysis, perform a load profile analysis using data specific to this project.) If this option isn't selected and the room has a cooling requirement, you must enter a value for the Maximum Cooling flow.
Thermal Requirements – Maximum Cooling Flow	Enter a value for the maximum conditioned supply airflow rate required to cool the room during its peak thermal load.
Thermal Demand Profile	Each hourly value represents a percentage of maximum cooling flow required for varying sensible and latent heat loads in a space. During a 24 hour period, a room will have varying cooling flow requirements as a result of the heat generated by people, lights, and equipment, as well as, building skin loads which are a function of geographic location. You may choose to use the default values by entering the geographic location, or override some or all of the displayed values based on a more detailed analysis of cooling requirements.

Edit Menu – Room – Add Room – Fume Hoods Tab

You can add, copy, edit, and delete fume hoods from this room as shown in this screen.

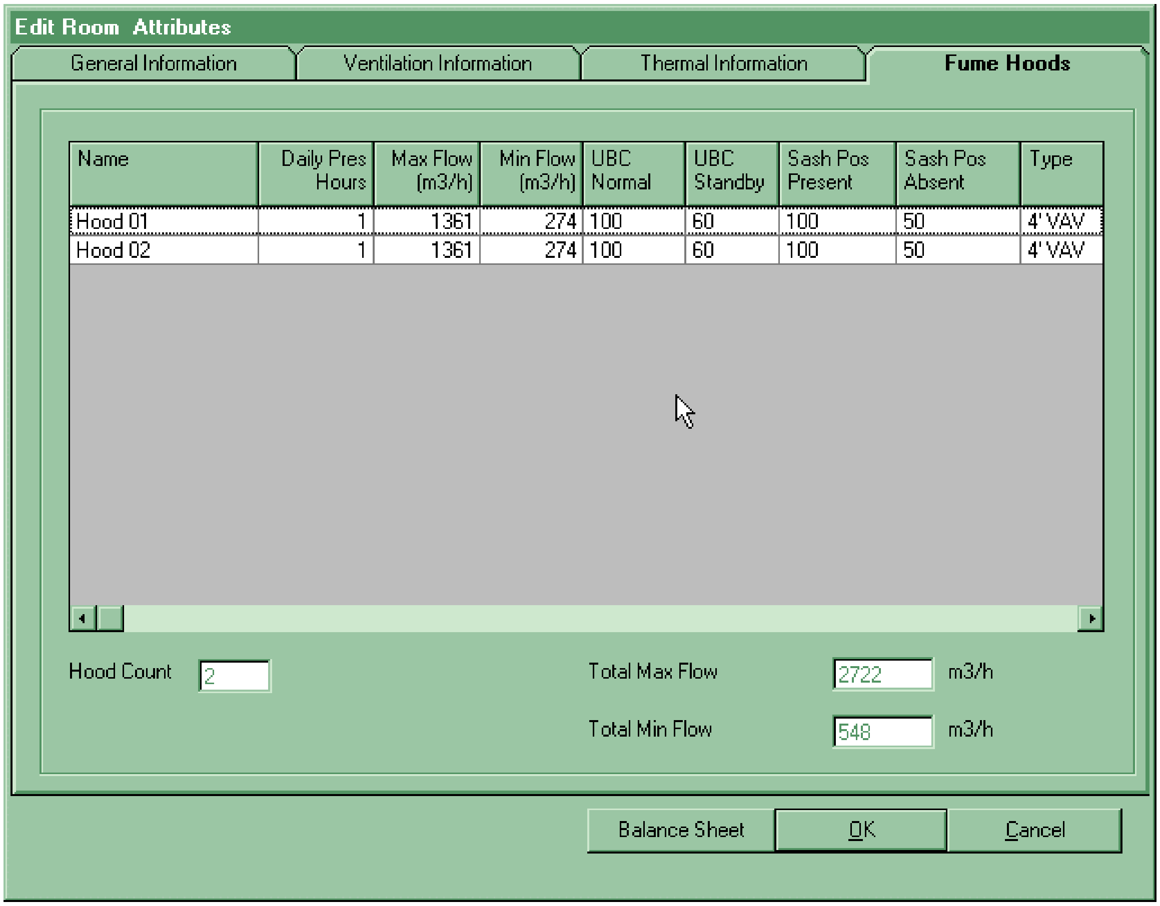

Figure 3-5d Edit Menu – Room – Add Room – Fume Hood Tab

Right-button click in the open area to expose a pop-up menu. You can choose from these four options:
Add Hood
Edit Hood
Copy Hood
Delete Hood.

Table 3-27 Edit Menu – Room – Add Room– Fume Hood Tab Selections

Click on:	And you can:
Name	Enter a unique identifier for the fume hood using any combination of alphanumeric characters; if you do not enter a name, LabPro will enter one automatically when you click on the Add Hood button. If you use a number in a hood's name such as "HOOD 1" and you have more than ten hoods, use a leading "0" before the single digits, (i.e., "HOOD 01" instead of "HOOD 1") so that the hoods will remain sequentially listed (i.e., "HOOD 01" will come before "HOOD 10").
Daily Present Hours	Enter a value for the number of hours that a user is apt to be in front of the hood. This value cannot exceed the total number of the building's Occupied Hours.
Maximum Flow	Enter the maximum flow through the hood.
Minimum Flow	Enter the minimum flow through the hood.

Table 3-27 Edit Menu – Room – Add Room– Fume Hood Tab Selections

Click on:	And you can:
Usage Based Control – Normal	Enter a value for the percentage of full flow for the fume hoods when they are operating in Normal mode.
Usage Based Control – Standby	Enter a value for the percentage of full flow for the fume hoods when they are operating in Standby mode.
Sash Position Present	Enter a value for the percentage of sash opening when a user is present at his or her fume hood. A value of 100 means that the sash is completely open and a value of 0 means that the sash is completely closed.
Sash Position Absent	Enter a value for the percentage of sash opening when a user is absent from his or her fume hood. A value of 100 means that the sash is completely open and a value of 0 means that the sash is completely closed.
Hood Type	Click on this button and select a fume hood from the drop down list of fume hood types in the Hood Type field. For each hood, the table contains: width, type, and minimum and maximum (typical ranges). Note: enter only fume hoods that have the potential to be VAV controlled (if the fume hood must always run at a constant volume or as a two-position valve, the total exhaust should be entered under the Total Ancillary Exhaust Flow).

Edit Room

The Edit Room menu item allows you to edit previously created room-specific information for the currently selected room.

Copy Room

The Copy Room menu item allows you to copy the currently selected room .

Delete Room

The Delete Room menu item allows you to delete the currently selected room.

Edit Menu – Corridor – Add Corridor

There are 4 actions grouped together: Add Corridor, Edit Corridor, Copy Corridor, and Delete Corridor. Adding, editing, and copying corridors all use the same screens; while deleting a corridor is simpler.

Edit Menu – Corridor – Add Corridor – General Information Tab

You can add, copy, and edit corridors as shown in this screen.

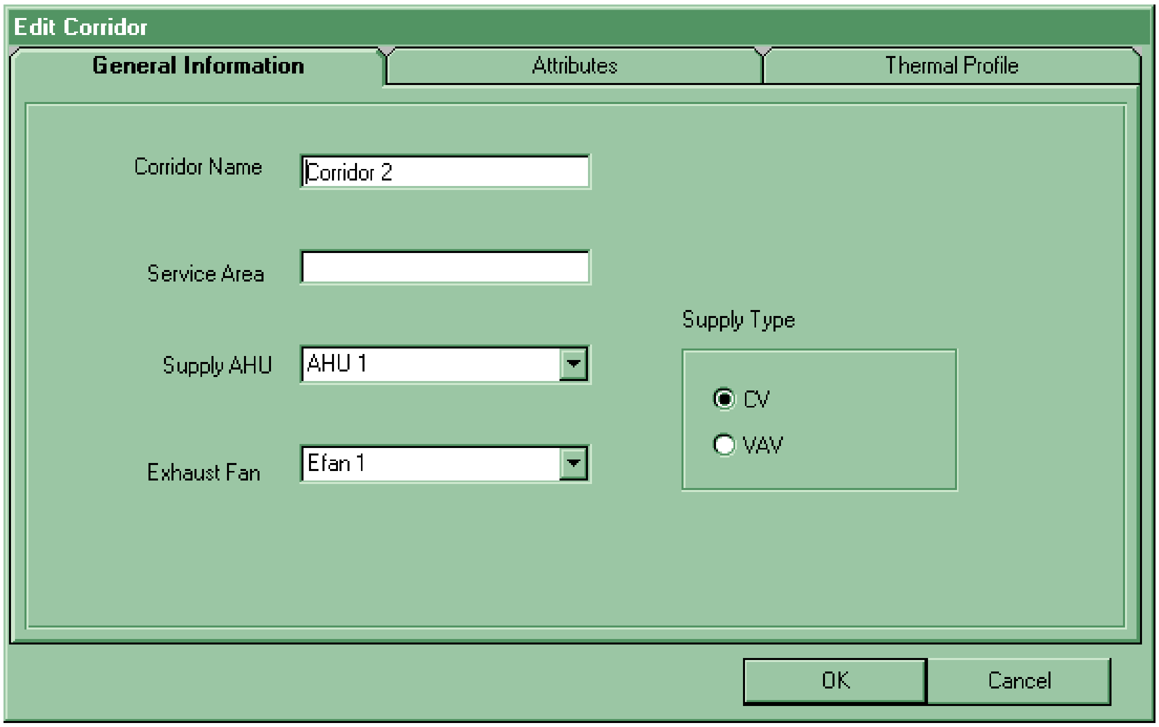

Figure 3-6a Edit Menu – Corridor – Add Corridor – General Information Tab

Table 3-28 Edit Menu - Corridor – Add Corridor – General Information Tab Selections

Click on:	And you can:
Corridor Name	Enter a name for the corridor using any combination of alphanumeric characters or you can accept the default that LabPro automatically assigns: a default number (Corridor-1). You can change or add to this number. If you use a number in a corridor's name, such as "Corridor 1" and you have more than ten corridors, use a leading "0" before the single digit, (i.e., "Corridor 01" instead of "Corridor 1") so that the corridors will remain sequentially listed (i.e., "Corridor 01" will come before "Corridor 10").
Service Area	Enter any combination of alphanumeric characters as a description of the area associated with the corridor.
Supply AHU	Use the drop down list to select the supply fan that serves the corridor. You can add, edit, delete or copy a supply AHU in the Supply AHU Tab. You must associate each corridor with a specific supply fan serving the building.
Exhaust Fan	Use the drop down list to select the associated exhaust fan that serves the corridor. You can add, edit, delete or copy an exhaust fan in the Exhaust Fan Tab. You must associate each corridor with a specific exhaust fan serving the building.
Supply Type	Select the type of supply control method that you will use in this room. The two control types are CV (constant volume) and VAV (variable air volume.)

Constant Volume (CV)

With a Constant Volume supply, the amount of supply air delivered to the corridor will be constant regardless of the thermal requirements within the space.

Variable Air Volume (VAV)

With a Variable Air Volume supply, the amount of supply air delivered to the corridor can vary depending upon the thermal requirements within the space.

Edit Menu – Corridor – Add Corridor – Attributes Tab

You can add, copy, edit, and delete corridors as shown in this screen.

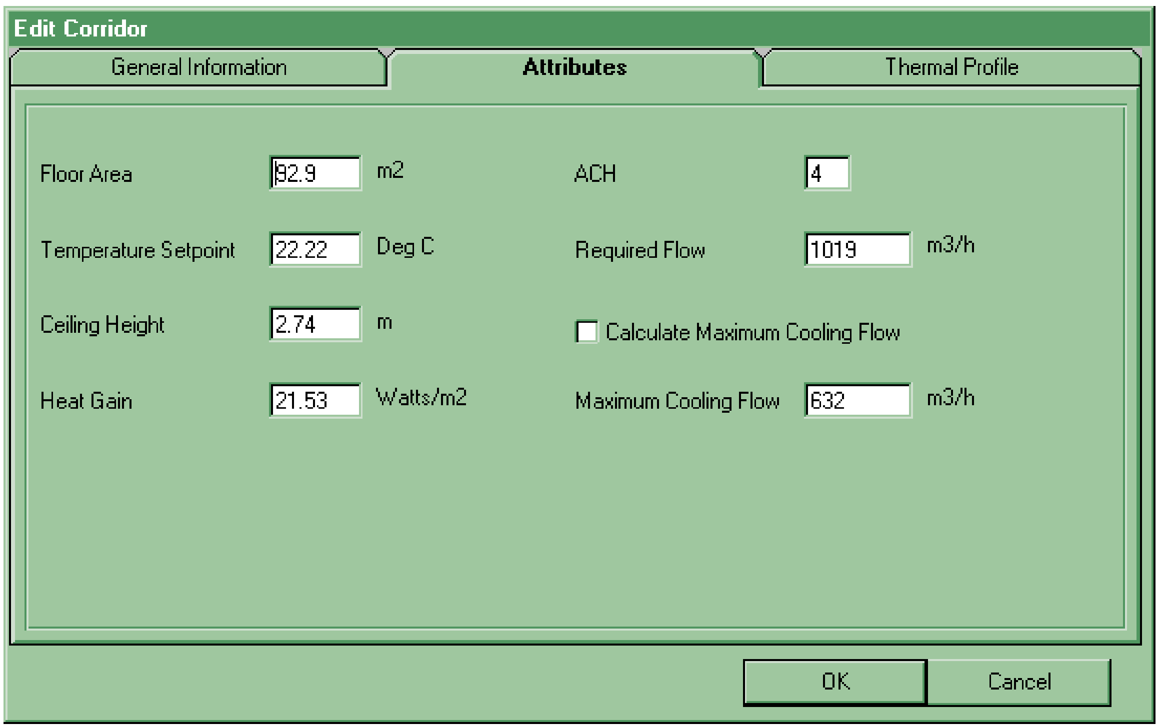

Figure 3-6b Edit Menu – Corridor – Add Corridor – Attributes Tab

Table 3-29 Edit Menu - Corridor – Add Corridor – Attributes Tab Selections

Click on:	And you can:
Floor Area	Enter a value for the corridor's area in square feet (or meters). Multiply the corridor's length in feet (or meters) by its width in feet (or meters) to get the area in square feet (or meters).
Temperature Setpoint	Enter a value for the default room temperature set point (in degrees Fahrenheit or Celsius) for this corridor.
Ceiling Height	Enter a value for the ceiling height in feet (or meters) for this corridor.
Heat Gain (Watts/Sq. Ft.) or (Watts/m^2)	Enter a value for the total Watts per square foot (or Watts per square meter) for the corridor. The value represents the total heat gain in watts within a corridor divided by the total floor area of the corridor in square feet (or meters). Total heat gain includes both sensible and latent heat from people, lighting, and equipment, as well as external heat sources such as sunlight.

Table 3-29 Edit Menu - Corridor – Add Corridor – Attributes Tab Selections

Click on:	And you can:
Air Changes per Hour (ACH)	Enter a value to be used as the air changes per hour (ACH) for this corridor.
Required Flow	This value represents the flow of air in cubic feet per minute (CFM) or l/s or m^3/h that will deliver the defined air change rate per hour (ACH). Once you enter a value in the ACH field, LabPro automatically calculates the flow units based on the volume of air in the corridor and the watts per square feet (or square meters).
Calculate Maximum Cooling Flow	Select this button and LabPro automatically calculates the flow rate of air required to maintain the desired corridor temperature set point, based on the Watts per square foot (or Watts per square meter) entered for this corridor. If you do not select this option and the corridor has a cooling requirement, you must enter the Maximum Cooling Flow. If you do not select this option and do not enter a value in the Maximum Cooling Flow field, LabPro will treat the corridor as being constant volume.
Maximum Cooling Flow	Choose LabPro's default, to use Calculate Maximum Cooling Flow, based on the watts per square foot (or meter). It creates a generic profile. For a more detailed analysis, perform a load profile analysis using data specific to this project.

Edit Menu – Corridor – Add Corridor – Thermal Profile Tab

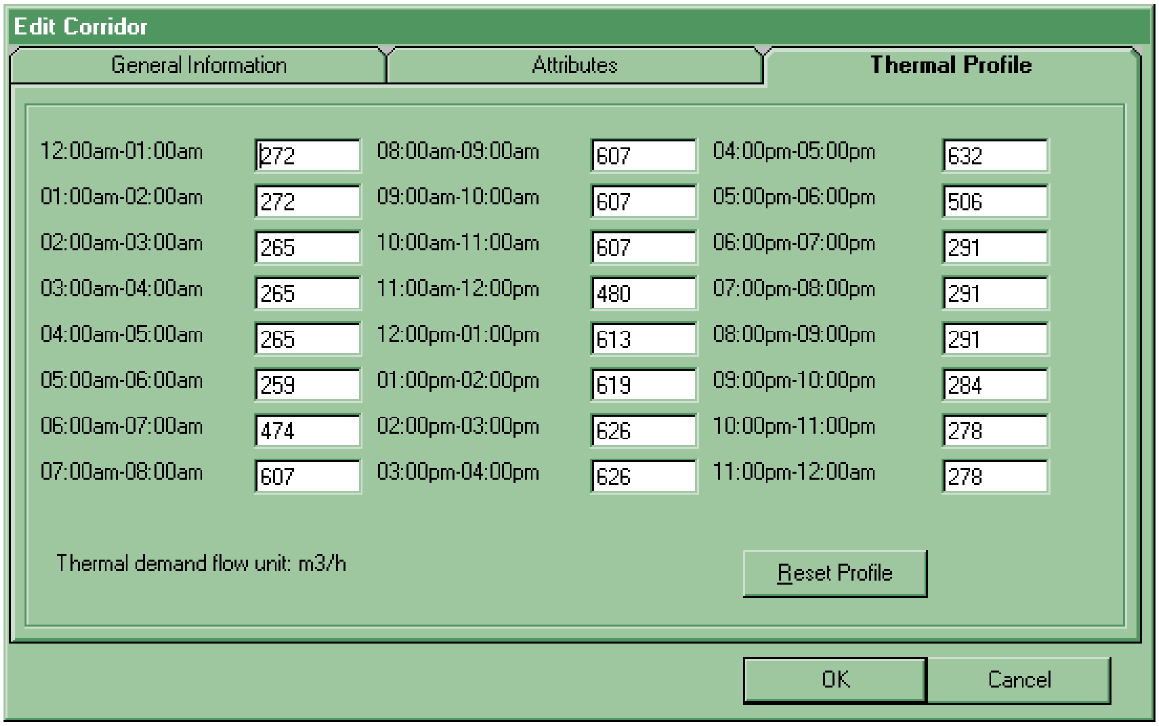

Figure 3-6c Edit Menu – Corridor – Add Corridor – Thermal Profile Tab

Table 3-30 Edit Menu - Corridor – Add Corridor – Thermal Profile Tab Selections

Click on:	And you can:
Thermal Demand Flow	Each hourly value represents a percentage of maximum cooling flow required for varying sensible and latent heat loads in a space. During a 24 hour period, a room will have varying cooling flow requirements as a result of the heat generated by people, lights, and equipment, as well as, building skin loads which are a function of geographic location. You may choose to use the default values by entering the geographic location, or override some or all of the displayed values based on a more detailed analysis of cooling requirements.

Edit Corridor

The Edit Corridor menu item allows you to edit previously created corridor-specific information.

Copy Corridor

The Copy Corridor menu item allows you to copy a previously created corridor.

Delete Corridor

The Delete Corridor menu item allows you to delete a corridor.

Edit-Exhaust Fan-Add Exhaust Fan Screen

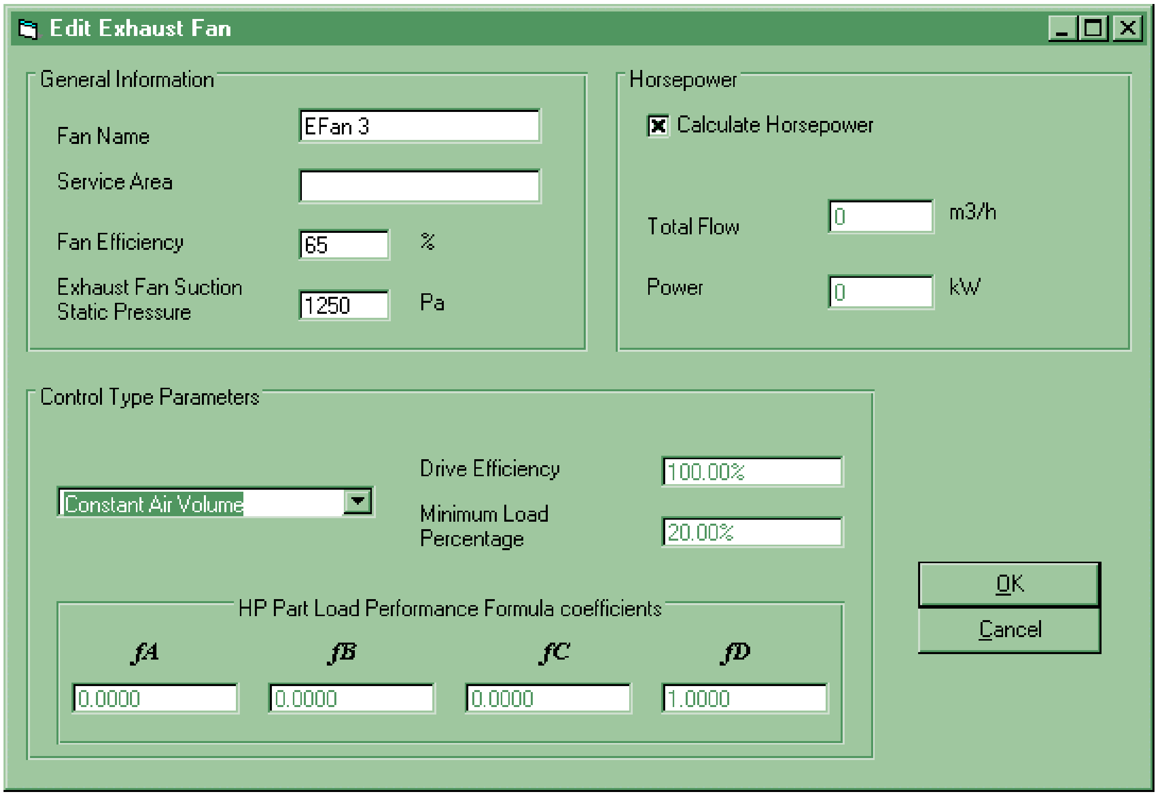

Figure 3-7 Edit Menu – Exhaust Fan – Add Exhaust Fan Screen

Table 3-31 Edit Menu – Exhaust Fan – Add Exhaust Fan Screen Selections

Click on:	And you can:
General Information – Fan Name	Enter a unique exhaust fan identifier in this field. You can use any combination of alphanumeric characters. If you use a number in a exhaust fan's name such as “EF 1” and you have more than ten exhaust fans, use a leading “0” before the single digits, (i.e., “EF 01" instead of “EF 1”) so that the exhaust fans will remain sequentially listed (i.e., “EF 01” will come before “EF 10”).
General Information – Service Area	Enter any combination of alphanumeric characters to name the pressurization zones that the exhaust fan serves.
General Information – Fan Efficiency	Enter a number for the default exhaust fan efficiency percentage.
General Information – Exhaust Fan Suction Pressure	Enter the value in inches of water (" wc) or Pascals (Pa) for the default suction static pressure measured in the ductwork at the inlet of the exhaust fan.
Horsepower – Calculate Horsepower	Click this button to have LabPro automatically sum the total exhaust CFM (or l/s or m^3/h) served by the selected fan and calculate the horsepower of the fan motor needed to drive the fan. If you do not select the Calculate Horsepower option, you must enter a value in the Power field.
Horsepower – Total Flow	LabPro totals all the exhaust air flow rates for all the rooms associated to the selected fan. LabPro displays the value in this field.

Table 3-31 Edit Menu – Exhaust Fan – Add Exhaust Fan Screen Selections

Click on:	And you can:
Horsepower – Power	Displays the motor horsepower (hp) required to drive the selected fan.
Control Type Parameters – Control Type	Select the default control type for the exhaust fans from the drop-down list: • Variable Frequency Drive • Constant Air Volume • Discharge Damper - Forward Curve Fan • Discharge Damper - Backward Incline Fan • Vane axial Fans • Inlet Vane Control - Airfoil • Inlet Vane Control - Forward Curve Fan

Control Type Parameters

Select the control type from the drop down list after checking with your local and federal regulatory standards and guidelines. The control types are described here:

Variable Frequency Drive

The exhaust fan operates at variable speed using a variable frequency drive. As the demand for airflow increases or decreases, a control signal is used to command the variable frequency drive to increase or decrease the speed of the fan resulting in increased/decreased airflow.

Constant Air Volume

The exhaust fan operates at a fixed fan speed regardless of airflow changes within the system.

Discharge Damper - Forward/Backward

The exhaust fan operates at a fixed fan speed. However, as the system demands less airflow flow rate, a discharge relief air damper is opened to maintain a constant flow rate of airflow to the inlet of the exhaust fan.

Vane axial Fan

The exhaust fan operates at a fixed fan speed. As the system demands less airflow flow rate, the pitch of the fan blade is changed while the fan is turning, restricting the flow rate of air that the fan is moving, resulting in variable volume operation.

Inlet Vane Control - Air Foil/Forward

The exhaust fan operates at a fixed fan speed. As the system demands less airflow flow rate, however, an inlet vane is modulated to restrict the flow rate of air to the inlet of the supply fan permitting variable volume operation.

Edit Exhaust Fan

The Edit Exhaust Fan menu item allows you to edit previously created exhaust fans.

Copy Exhaust Fan

The Copy Exhaust menu item allows you to copy a previously created exhaust fan.

Delete Exhaust Fan

The Delete Exhaust Fan menu item allows you to delete an exhaust fan.

Edit – Supply Fan – Add Supply Fan Screen

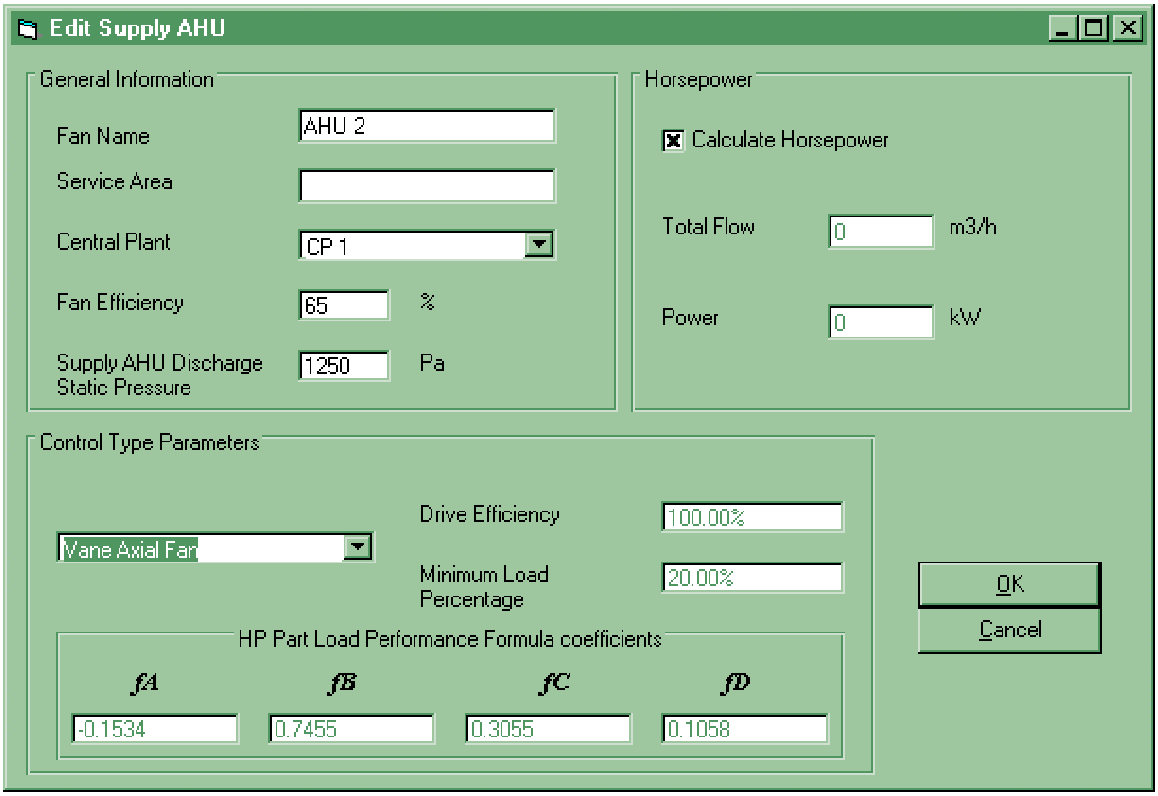

Figure 3-8 Edit Menu – Supply Fan – Add Supply Fan Screen

Table 3-32 Edit Menu – Supply Fan – Add Supply Fan Screen Selections

Click on:	And you can:
General Information – Fan Name	Enter a unique supply fan identifier in this field. You can use any combination of alphanumeric characters. If you use a number in a supply fan's name such as "SF 1" and you have more than ten supply fans, use a leading "0" before the single digits, (i.e., "SF 01" instead of "SF 1") so that the supply fans will remain sequentially listed (i.e., "SF 01" will come before "SF 10").
General Information – Service Area	Enter any combination of alphanumeric characters to name the pressurization zones that the supply fan serves.
General Information – Central Plant	Enter the name of the central plant that is associated with this fan.
General Information – Fan Efficiency	Enter a number for the default supply fan efficiency percentage.
General Information – Supply AHU Discharge Static Pressure	Enter the value in inches of water (" wc) or Pascals (Pa) for the default discharge static pressure measured in the ductwork at the outlet of the supply fan.
Horsepower – Calculate Horsepower	Click this button to have LabPro automatically sum the total supply CFM (or l/s or m^3/h) served by the selected fan and calculate the horsepower of the fan motor needed to drive the fan. If you do not select the Calculate Horsepower option, you must enter a value in the Power field.
Horsepower – Total Flow	LabPro totals all the supply air flow rates for all the rooms associated to the selected fan. LabPro displays the value in this field.

Table 3-32 Edit Menu – Supply Fan – Add Supply Fan Screen Selections

Click on:	And you can:
Horsepower – Power	Displays the motor horsepower (hp) required to drive the selected fan.
Control Type Parameters – Control Type	Select the control type from the drop down list after checking with your local and federal regulatory standards and guidelines: • Variable Frequency Drive • Constant Air Volume • Discharge Damper - Forward Curve Fan • Discharge Damper - Backward Incline Fan • Vane axial Fans • Inlet Vane Control - Airfoil • Inlet Vane Control - Forward Curve Fan The selection made here controls the values displayed in the next two fields
Control Type Parameters – Drive Efficiency	Displays the number for the supply fan efficiency percentage for the selected control type.
Control Type Parameters – Minimum Load Percentage	Displays the number for the minimum load percentage for the selected control type.

Edit Supply Fan

The Edit Supply Fan menu item allows you to edit a previously created supply fan.

Copy Supply Fan

The Copy Supply menu item allows you to copy a previously created supply fan.

Delete Supply Fan

The Delete Supply Fan menu item allows you to delete a supply fan.

Edit-Central Plant – Add Central Plant Screen

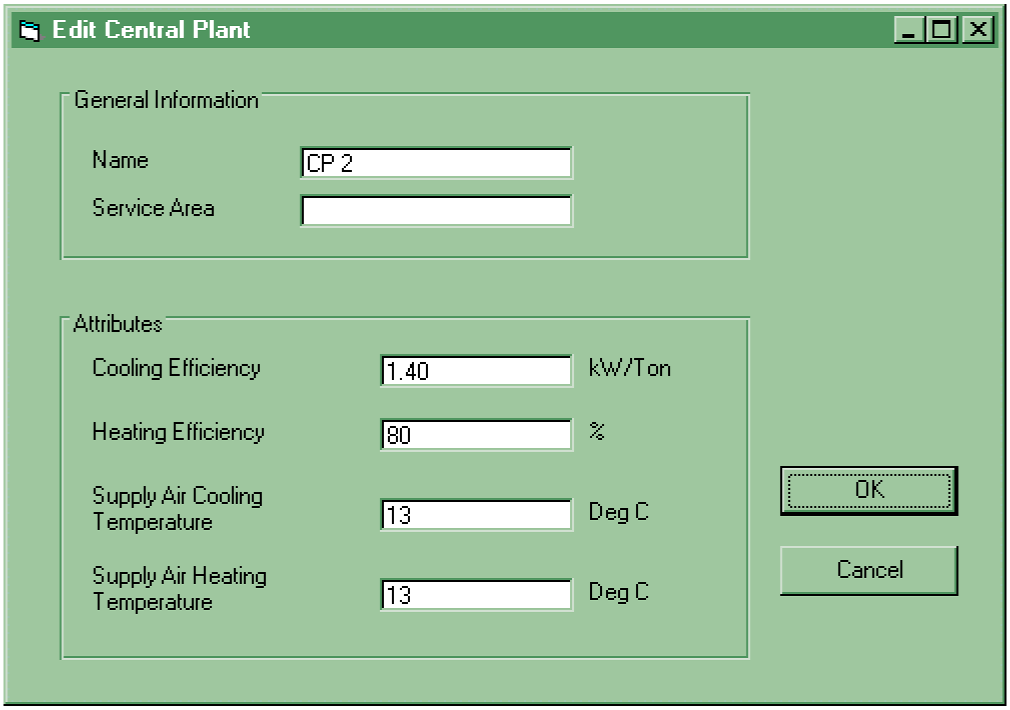

Figure 3-9 Edit Menu – Central Plant – Add Central Plant Screen

Table 3-33 Edit Menu – Central Plant – Add Central Plant Screen Selections

Click on:	And you can:
General Information –Name	Enter a unique name as the unique central plant identifier in this field. If you use a number in a central plant's name such as "CP 1" and you have more than ten central plants, use a leading "0" before the single digits, (i.e., "CP 01" instead of "CP 1") so that the supply fans will remain sequentially listed (i.e., "CP 02" will come before "CP 10").
General Information – Service Area	Enter any combination of alphanumeric characters to name the supply fans that the central plant serves. .
Attributes – Cooling Efficiency	Enter a value for the cooling efficiency of the complete central cooling plant, in kilowatts of power per ton of refrigeration.
Attributes – Heating Efficiency	Enter a value for the thermal efficiency of the complete central plant heating system as the ratio (expressed as a percentage) of total useful heat output versus the total energy input.
Attributes – Supply Air Cooling Temperature	Enter the value you want to be the default supply air temperature. This value represents the air temperature measured in degrees Fahrenheit or Celsius after the discharge of a pre-heater or cooling coil.
Attributes – Supply Air Heating Temperature	Enter the value you want to be the default supply air temperature. This value represents the air temperature measured in degrees Fahrenheit or Celsius after the discharge of a pre-heater or cooling coil.

Edit Central Plant

The Edit Central Plant menu item allows you to edit a previously created Central Plant.

Copy Central Plant

The Copy Central Plant menu item allows you to copy a previously created Central Plant.

Delete Central Plant

The Delete Central Plant menu item allows you to delete a Central Plant.

Chapter 4: Analysis and "What If"

Click on Analyze to bring up the Analyze menu; two choices are available.

Click on:	And LabPro will
Simulate project	Perform balancing, simulation, and cost calculations for the project.
What If	Examine the effect that changes in one or more variables have on up to three different design approaches.

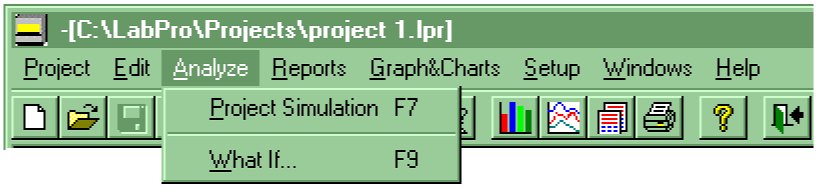

Figure 4-1 Analyze Menu

Analyze – Simulate Project

Simulate Project – Project Summary

Selecting Simulate Project displays the Project Summary screen, which shows the Total System flows and the Cost Summary information. The costs are calculated using the Edit Costs values and the Average and Design flows for a system. The system Flows section of the screen shows the Total Numbers (of rooms, lab hoods, fans, etc.) and the System Total Flows.

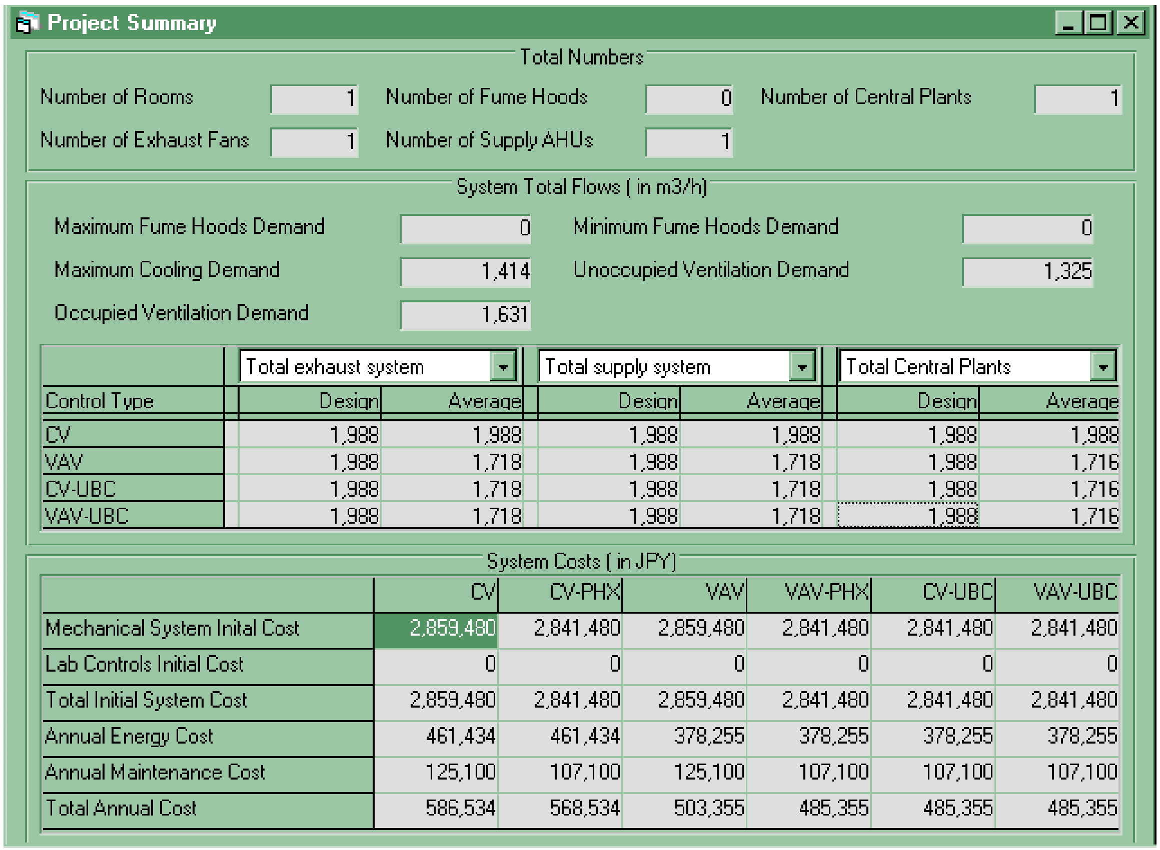

Figure 4-2 Analyze Menu – Simulate Project – Project Summary Screen

Table 4-1 Analyze Menu – Full Calculation – Project Summary Screen

Entry:	Is used to:
Total Numbers: Number of Rooms	Display the sum of all rooms created for a project.
Total Numbers: Number of Exhaust Fans	Display the sum of all Exhaust fans created for a project.
Total Numbers: Number of Fume Hoods	Display the sum of all fume hoods created for a project.
Total Numbers: Number of Supply AHUs	Display the sum of all Supply AHUs created for a project.
Total Numbers: Number of Central Plants	Display the sum of all central plants created for a project.
System Flows: Maximum Fume Hood Flow	Display the maximum exhaust flow required to operate all fume hoods simultaneously.
System Flows: Minimum Fume Hood Flow	Display the minimum exhaust flow required to operate all fume hoods simultaneously.
System Flows: Maximum Cooling Demand	Display the exhaust flow required to provide the necessary air exchange rate to provide maximum cooling.

Table 4-1 Analyze Menu – Full Calculation – Project Summary Screen

Entry:	Is used to:
System Flows: Total Occupied Ventilation Demand	Display the exhaust flow required to provide the necessary air exchange to provide occupied ventilation rates.
System Flows: Total Unoccupied Ventilation Demand	Display the exhaust flow required to provide the necessary air exchange to provide unoccupied ventilation rates.
System Flows: Average Flow: CV VAV CV UBC VAV UBC	Display the average flow of 24 hourly simulations so that total flow and corresponding energy calculations can be performed.
System Flows: Design Flow: CV VAV CV UBC VAV UBC	Display the maximum capacity that the system can perform to while remaining at the designers' specified confidence level.

System Costs

You can print a detailed cost comparison to view individual costs per item; see Chapter 5-Reports/Charts for more information.

The system costs are displayed in a grid, with each control type assigned to a column and each of the following costs assigned to a row:

Cost Type:

Mechanical System Initial Cost
Laboratory Controls Cost
Total Initial System Cost
Annual Energy Costs
Annual Maintenance Costs
Total Annual Costs

Control Type

CV	Constant Volume
CV-PHX	Phoenix Controls Constant Volume
VAV	Variable Air Volume
VAV-PHX	Phoenix Controls Variable Air Volume
CV UBC	Phoenix Controls Constant Volume Usage Based Controls
VAV UBC	Phoenix Controls Variable Air Volume Usage Based Control

What If

Overview

The What If... feature is a decision making tool that allows you to instantly view the impact of your design decisions in terms of airflow, mechanical system first cost, energy costs, and operation and maintenance cost. What If comparisons are made on two screens.
You can change any of the values in the Set Parameters tab, but your changes will have no effect until you check each parameter's box and click on the Calculate button.
The Comparison tab shows these results for 3 control types; you can select any of the control types available from the currently defined project or values that you have edited.

Set Parameters Tab

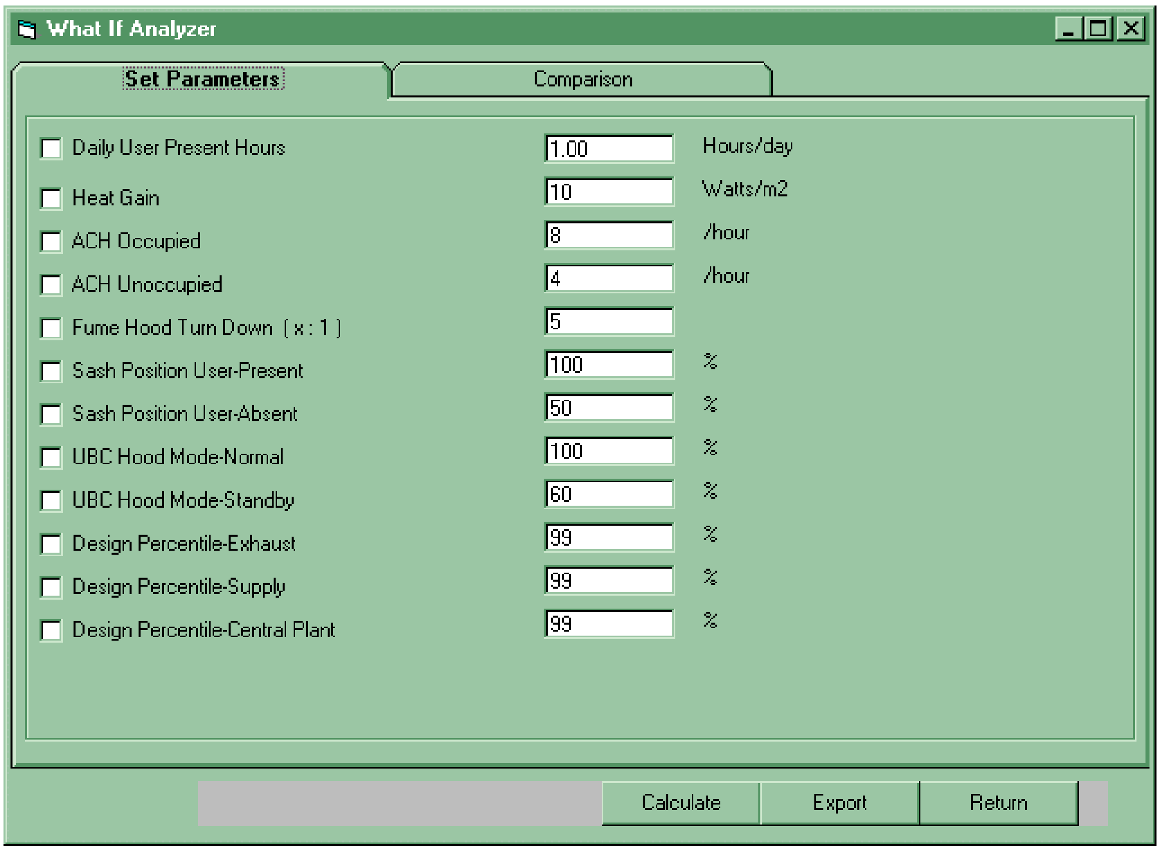

Figure 4-3 Analyze Menu – What If – Set Parameters Tab

Note: When analyzing the results, understand that the new value may or may not have an impact on the system sizing or operation. If you get unexpected results, perform a detailed analysis to completely understand the impact of the change.

Table 4-2 Analyze Menu – What If – Set Parameters Tab

Entry:	Is used to:
Daily User Present Hours	Enter the number of hours that a user is apt to be in front of their hood. This value cannot exceed the total number of the building's Occupied Hours.
Heat Gain	Represent the total heat gain in watts within a room divided by the total floor area of the room in square feet (or square meters). Total heat gain includes both sensible and latent heat from people, lighting, and equipment. Enter a value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.

Table 4-2 Analyze Menu – What If – Set Parameters Tab

Entry:	Is used to:
ACH Occupied	Indicates the air change rate for the building during the occupied hours. Air change rate is defined as the ventilation rate of a space divided by the total volume of a space. Air Changes per Hour (ACH) can be calculated by dividing the total exhaust rate (the volume of all air leaving the space per hour in cubic feet per hour (cfm x 60)), by the total volume of the space (in cubic feet). Enter a value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
ACH Unoccupied	Indicates the air change rate for the building during the unoccupied hours. Air change rate is defined as the ventilation rate of a space divided by the total volume of a space. Air Changes per Hour (ACH) can be calculated by dividing the total exhaust rate (the volume of all air leaving the space per hour in cubic feet per hour (cfm x 60)), by the total volume of the space (in cubic feet). Enter a value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
Fume Hood Turn Down	Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
Sash Position – User Present	Contains the expected sash position when an operator is in front of, or present at the hood. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
Sash Position – User Absent	Contains the expected sash position when an operator is away from, or absent from the hood. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
UBC Hood Mode – Normal	Represents what percentage of the hood exhaust design flow will be when an operator is present at the hood. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
UBC Hood Mode – Standby	Represents what percentage of the hood exhaust design flow will be when an operator is absent from the hood. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
Design Percentile – Exhaust	Represents what percentage of the "worst case design" the exhaust system has been designed to. The worst case design is based on the variable listed in the Set Parameters section. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
Design Percentile – Supply	This field represents what percentage of the "worst case design" the supply system has been designed to. The worst case design is based on the variable listed in the Set Parameters section. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.
Design Percentile – Central Plant	This field represents what percentage of the "worst case design" the cooling system and heating system have been designed to. The worst case design is based on the variable listed in the Set Parameters section. Enter a new value in this field and click on the Calculate button; LabPro will display the results on the Comparison tab.

Calculate

When you click on the Calculate button, LabPro recalculates the project totals based on the current system entries. For example, if the project has an average ACH rate of 20 when you begin your "What If" session, you can see the impact of an average of only 10 ACH. Simply enter 10 in the ACH edit box and click the Calculate button. LabPro will update the project flows, energy costs, first costs, and life cycle costs. You can see the effect of your change on all control types on the main What If... screen immediately. You can also view any control type with original or "What If" values.

Export

When you click this button, LabPro will export the What If… version of the *.lpr file to a new filename and that file can be opened like any *.lpr file.

Return

When you click this button, LabPro will return to the Main screen.

Comparison Tab

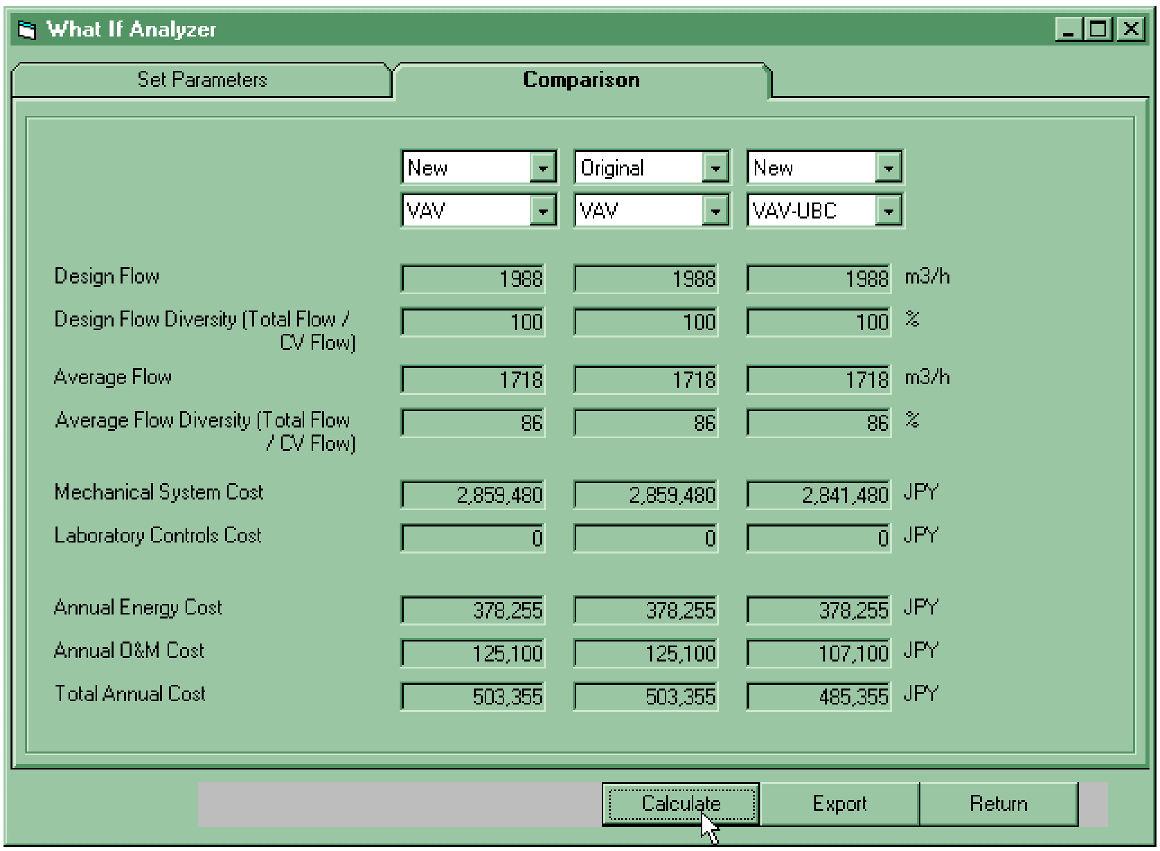

Figure 4-4 Analyze Menu – What If – Comparison Tab

Three different project configurations can be viewed at once. You can choose to view the User Input data as "Original" or the What If tab parameter changes as "New".

Control Types (drop-down box)

For each project configuration, you can select one of the following control types:

CV	Constant Volume
VAV	Variable Air Volume
VAV-PHX	Phoenix Controls Variable Air Volume
CV UBC	Phoenix Controls Constant Volume Usage Based Controls
VAV UBC	Phoenix Controls Variable Air Volume Usage Based Control

As the control types are selected, the relevant airflow and cost data are displayed for each type.

System Comparison

Entry:	Is used to:
Design Airflow Flow	Calculate the system design exhaust flow for this project. LabPro sums the system design exhaust flow for all the rooms and corridors in the project.
Average Flow	Calculate the system average exhaust flow for this project. LabPro sums the system average exhaust flow (based on 24 hours) for all the rooms and corridors in the project.
Design Diversity	Show the ratio of Design flow to the CV flow.
Average Diversity	Display the ratio of Average flow (i.e., 50% Design flow) to the CV flow.
Mechanical System Initial Cost	Calculate a summary cost of all mechanical costs associated with the air handling systems. LabPro sums the variables entered under the First Costs tab.
Lab Controls Initial Cost	Calculate a summary cost of all laboratory controls. LabPro calculates the value from the variables entered under the First Costs tab. These costs include the hood controls, the room controls, and the supply and exhaust airflow devices for both the room and the lab equipment.
Total Initial System Cost	Calculate the total initial cost for the project. LabPro calculates this value by summing the Mechanical System Initial Costs and the Lab Controls Initial Costs.
Annual Energy Costs	Calculate the annual energy cost. LabPro calculates this value from the variables entered under the Energy Tab. Variables under this tab include cooling fuel, heating fuel, reheat fuel and their associated costs per unit of fuel. Other variables include electricity cost per kWh, and central plant efficiency for the project.
Annual O & M Costs	Display a summary of the operation and maintenance costs. LabPro calculates this value from the variables entered under the Operating Costs tab. These are annual costs such as re-certification of the fume hoods, re-balancing the rooms, and regular equipment maintenance. Inflation and financing rates are also included in this calculation.
Total Annual Costs	Display the total annual cost. LabPro calculates this value by summing the Annual Energy Costs and the Annual O & M Costs.

Chapter 5 – Reports and Graphs

Reports

Project Summary

This report lists the total number of rooms, fume hoods, exhaust and supply fans, and central plants for the project along with the total demand, the total design and total average airflow requirements for the different control approaches along with specifying the different costs associated with each control approach.

Project Defaults

This report provides a summary of the project's defaults that have been entered while the user is in the project. The system defaults that are produced when you install LabPro onto a computer will be superceded for this project (and only this project) by any changes you made in the Edit Project screen.

Room Balance Report

This is a report that identifies the four critical conditions for room balance. The upper section of the report details the information from the room attributes screen.
Each equation illustrates how the supply into the room shall equal the exhaust out of the room, by identifying the flows of each supply and exhaust source. The two equations within each section are identified by and "A" and a "B." The "A" equation looks at the condition when the office and additional supplies are at their minimum flow rate, while the "B" equation looks at the condition when the office and additional supplies are at their maximum flow rate. The exhaust portion is then totaled for each line of equation.

Room Detail Report

This report provides a summary of all the attributes for an individual room.

Fume Hood Summary

This report provides a summary of all the fume hoods on the project. The summary lists numerically then alphabetically by Room Name. Within each room the hoods are listed alphabetically then numerically by hood name.

Corridor Detail Report

This report provides a summary of all the attributes and flows for an individual corridor.

Fan Systems Summary

This report provides a summary of all the fan systems and central plants on the project. The summary is listed alphabetically then numerically by system name.

System Summary

This report provides a summary of the total flows and systems costs for the system.

System Diversity Comparison

This report provides a diversity comparison for the different types of laboratory airflow control methods. It shows the design percent and flow requirements of each of the control methods for the exhaust system, supply system, and central plant.
This report also includes a summary of the three major system components (exhaust, supply and central plant).

System Cost Comparison

This report lists the initial, energy, and operation and maintenance costs of all major system components for the project based on the method of lab control being used.

Financial Analysis Comparison

This report provides key financial information to help analyze the financial benefits of different control approaches. The report compares two or three different control approaches. The report totals the annual benefits (savings) and provides a cumulative present value up to 15 years.

System Defaults

This report provides a summary of the system defaults that are produced when you install LabPro onto a computer. You can edit these defaults in the Edit Program Defaults Values screen and then store them as the program's new defaults for future projects.

Weather Data (Bin Weather Data)

This report lists the Bin Weather Data from United States Climatic Center's Engineering Weather Data for the location selected.

Default Fume Hood Type

This is a summary of fume hoods that have been predefined for use in a LabPro project file.

Graphs / Charts

LabPro can produce graphical representations of various aspects of your project. Graphs are available in the Reports menu.

Comparison Costs

Energy Costs Graph

The Energy Costs graph shows energy use for the current project based on control system type. For each stacked bar, supply air handler, exhaust fan, cooling, heating, and reheat costs are shown for the first year of operation.

Initial Mechanical System Costs Graph

The Initial Mechanical System Cost graph shows estimated first costs for the current project based on control system type. For each bar, Total Initial Cost is the sum of all related first costs as entered on the HVAC sub-screen of the Edit-Costs menu.

Life Cycle Costs Graph

The Life Cycle Costs graph shows estimated total cost of mechanical system ownership over the life of the building defined in the current project. For each stacked bar, the initial mechanical system cost is shown at the bottom of the bar; total operation and maintenance costs over the analysis period are shown on the top of the stacked bars. Total operation and maintenance costs include energy and non-energy related costs. The length of the analysis period, the inflation rate, and the hurdle rate are set for the current project in the Financial tab of the Edit Costs menu.

System Flows

Exhaust Systems Airflow Graph

This graph shows expected occupied and unoccupied exhaust system flows, by hour, based on project definition. Design exhaust airflow for Constant Volume, VAV, Constant Volume Usage Based Controls (CV UBC), and Variable Air Volume Usage Based Control (VAV UBC) controlled systems are shown along with minimum ventilation (ACH) flows and estimated maximum cooling flows.

Supply Systems Airflow Graph

This graph shows expected occupied and unoccupied exhaust system flows, by hour, based on project definition. Design supply airflow for Constant Volume, VAV, Constant Volume Usage Based Controls (CV UBC), and Variable Air Volume Usage Based Control (VAV UBC) controlled systems are shown along with minimum ventilation (ACH) flows and estimated maximum cooling flows.

Central Plants Airflow Graph

This graph shows expected occupied and unoccupied exhaust system flows, by hour, based on project definition. Design Central Plant airflow for Constant Volume, VAV, Constant Volume Usage Based Controls (CV UBC), and Variable Air Volume Usage Based Control (VAV UBC) controlled systems are shown along with minimum ventilation (ACH) flows and estimated maximum cooling flows.

Appendix A Calculations and Equations

This appendix has three sections:

1. *Calculation Overview:* provides a simple overview of LabPro's calculation methodology
2. *Calculation Procedure:* provides a detailed outline of LabPro's calculation methodology
3. *Equations:* lists all of LabPro's formulas

Calculation Overview

The following section describes LabPro's basic calculation sequence.

User Input

User input includes definition of:

- project information such as customer name, location, building occupancy hours;
- the number and type of supply fan systems used in this project;
- the number and type of exhaust fan systems used in this project;
- the corridors used in this project;
- the rooms and fume hoods/exhaust sources used in this project;
- energy types used for cooling, heating, and reheating the air required for this project, including appropriate rebate information;
- first cost information; and
- operating cost information including life cycle analysis information.

Room Flow Calculations

LabPro calculates room airflow data using the room balance method described in the Phoenix Controls Laboratory Engineering Guide. This includes offset flow, maximum and minimum supply air flow, and maximum and minimum general exhaust flow. LabPro also calculates the total maximum and minimum room exhaust flow along with maximum and minimum flows associated with all the fume exhaust sources in each room.

Corridor Flow Calculations

LabPro calculates corridor airflow data including total room offset flow for each room that is adjacent to the corridor, maximum and minimum corridor supply air flow, and maximum and minimum corridor exhaust flow.

Exhaust Systems Calculations

LabPro calculates exhaust system data by summing maximum and minimum exhaust requirements from all the corridors and rooms that are associated with each exhaust fan. It also updates horsepower and annual kWh at this time.

Supply Systems Calculations

LabPro calculates supply system data by summing maximum and minimum supply requirements from all the corridors and rooms that are associated with each supply fan. It also updates horsepower and annual kWh at this time.

Central Plant Systems Calculations

LabPro calculates central plant system flows by summing maximum and minimum supply requirements from all the corridors and rooms for the entire system. LabPro assumes that each project will have one central plant, so all rooms, fume hoods, and corridors are included for these calculations.

Diversity Based Airflow Calculations

LabPro calculates design flows based on laboratory control type using Phoenix Controls' methodology for calculating system diversity as described in the Methodology section. Design flows represent an expected worst case for exhaust or supply flow based on your input.

Energy Use and Cost Calculations

LabPro calculates estimated energy use and costs based on average flows by control system type. It uses the ASHRAE simplified bin method to calculate primary cooling and heating energy use. LabPro uses the average flow for each system type because cooling and heating energy calculations are linear. It also calculates fan energy hourly based on flow requirements and calculates reheat energy hourly using the difference between actual flow and required cooling flow. (See *ASHRAE Fundamentals 1994* for more details on the simplified bin method.)

First Cost Calculations

LabPro estimates mechanical system initial costs based on design flows by control system type and cost inputs. It calculates system design flows based on your input. You also enter information about the estimated cost of each system component, typically based on flow requirements. LabPro then combines these two pieces of information to produce an estimated mechanical system initial cost.

Life Cycle Cost Calculations

LabPro calculates life cycle cost for selected control system options. On the Operating Costs tab of the System Default screen, you select three laboratory control system types as options for comparison. Enter an expected inflation rate, a number of years for the analysis period, and the customer's hurdle rate for investments. LabPro will calculate the total first costs, first year energy costs, first year non-energy operating costs, and the total operating and maintenance costs for the analysis period. Net Present Value, Internal Rate of Return, and Payback will be calculated. LabPro will show a comparison of the Base system with its associated control type to Option 1 and Option 2, and also show a comparison of Option 1 against Option 2.

Calculation Procedure

Calculate Project

1. Calculate total occupied and unoccupied hours per day (Labsim)
2. Calculate individual room flows:
    A. Estimate room offset
    B. Solve for unoccupied ventilation demand
    C. Solve for occupied ventilation demand
    D. Solve for thermal demand
    E. Size general exhaust valves
    F. Solve for hood demand
    G. Size supply valves
    H. Validate room flows
    I. Validate room offset
3. Calculate individual corridor flows:
    A. Calculate corridor offset (Eq. 2.5)
    B. Size supply and exhaust valves (Eq. 2.6, 2.7, 2.8, 2.9, 2.10, 2.11)
4. Calculate individual exhaust fan flow data:
    A. Sum exhaust fan room data for associated rooms and corridors
        1. Sum individual room total exhaust flows (Eq. 5.1 and 5.2)
        2. Sum maximum hood and corridor exhaust flows (Eq. 5.3)
        3. Sum minimum hood and corridor exhaust flows (Eq. 5.4)
        4. Sum fan maximum flow (Eq. 5.5)

    5. Sum room and corridor ACH flows (Eq. 5.6)
  B. Sum exhaust fan hood data
    1. Sum hood count (Eq. 5.7)
    2. Sum maximum hood flows (Eq. 5.7.1)
    3. Sum minimum hood flows (Eq. 5.7.2)
  C. Calculate design and average hood presence probability (Eq. 5.10 and 5.11)
  D. Run Simulation to determine Occ or UnOcc for each hood. (See Labsim methodology)
  E. Calculate VAV hood flows
    1. Calculate VAV occupied hood flow
    2. Calculate VAV unoccupied hood flow
  F. Calculate CV UBC hood flows
    1. Calculate CV UBC occupied hood flow
    2. Calculate CV UBC unoccupied hood flow
  G. Calculate VAV UBC hood flows
    1. Calculate VAV UBC occupied hood flow
    2. Calculate VAV UBC unoccupied hood flow
  H. Calculate CV horsepower (if requested)(Eq. 9.1)

5. Calculate individual supply air handler flow
  A. Sum supply air handler room data for associated rooms and corridors
    1. Sum individual room and corridor maximum supply flows (Eq. 5.6)
    2. Sum individual room and corridor minimum supply flows
    3. Sum individual room and corridor occupied ACH supply flows (Eq. 5.6)
    4. Sum individual room and corridor unoccupied ACH supply flows (Eq. 5.6)
    5. Sum individual room and corridor fume hood demand flows (See Labsim methodology)

6. Calculate Central Plant flow data
  A. Sum exhaust fan room data
    1. Sum individual room total exhaust flows (Eq. 5.1 and 5.2)
    2. Sum maximum hood and corridor exhaust flows (Eq. 5.3)
    3. Sum minimum hood and corridor exhaust flows (Eq. 5.4)
    4. Sum room and corridor ACH flows (Eq. 5.6)
  B. Sum exhaust fan hood data
  C. Calculate CV horsepower (if requested)(Eq. 9.1)

7. Calculate Project Totals
  A. Sum project hood data
    1. Sum CV exhaust flows
    2. Sum total number of hoods
    5. Sum hood maximum flows
    6. Sum hood minimum flows
    7. Sum CV UBC design flows

8. Sum VAV design flows
9. Sum VAV UBC design flows
10. Sum CV UBC average flows
11. Sum VAV average flows
12. Sum VAV UBC average flows
13. Sum CV UBC night flows
14. Sum VAV night flows
15. Sum VAV UBC night flows

B. Sum project corridor data
   1. Sum corridor volumes
   2. Sum corridor areas
   3. Sum corridor maximum cooling flows
   4. Sum corridor minimum heating flows
   5. Sum corridor ACH flows
   6. Sum 24 hour cooling profiles by hour
   7. Calculate average corridor watts per square foot (or per square meter)
   8. Calculate average corridor temperature

C. Sum project room data
   1. Sum total number of rooms
   2. Sum room volumes
   3. Sum room areas
   4. Sum room maximum cooling flows
   5. Sum room occupied and unoccupied ACH flows
   6. Sum room hood minimum flows
   7. Sum room hood maximum flows
   8. Sum 24 hour cooling profiles by hour
   9. Calculate (average) room watts per square foot
   10. Calculate (average) room temperature

D. Sum project exhaust fan data
   1. Sum exhaust fan CV flows
   2. Sum total number of hoods
   3. Sum hood maximum flows
   4. Sum hood minimum flows
   5. Sum CV UBC design flows
   6. Sum VAV design flows
   7. Sum VAV UBC design flows
   8. Sum CV UBC average flows
   9. Sum VAV average hood flows
   10. Sum VAV UBC average flows

    11. Sum CV UBC unoccupied flows
    12. Sum VAV unoccupied flows
    13. Sum VAV UBC unoccupied flows

E. Sum project supply air handler data

    1. Sum supply fan CV flows
    2. Sum total number of hoods
    3. Sum hood maximum flows
    4. Sum hood minimum flows
    5. Sum CV UBC design flows
    6. Sum VAV design flows
    7. Sum VAV UBC design flows
    8. Sum CV UBC average flows
    9. Sum VAV average flows
    10. Sum VAV UBC average flows
    11. Sum CV UBC unoccupied flows
    12. Sum VAV unoccupied flows
    13. Sum VAV UBC unoccupied flows

F. Sum project central plant data

    1. Sum central plant CV flows
    2. Sum total number of hoods
    3. Sum hood maximum flows
    4. Sum hood minimum flows
    5. Sum CV UBC design flows
    6. Sum VAV design flows
    7. Sum VAV UBC design flows
    8. Sum CV UBC average flows
    9. Sum VAV UBC average flows
    10. Sum VAV average flows
    11. Sum CV UBC unoccupied flows
    12. Sum VAV unoccupied flows
    13. Sum VAV UBC unoccupied flows

8. Construct flow grid. The flow grid is an hour by hour comparison of project flows that were obtained in the previous calculations. For each hour LabPro will insert the following values:

- CV exhaust flow
- CV supply flow
- CV central plant flow
- Occupied ACH flow
- Minimum supply system heatin flow
- Minimum central plant heating flow
- VAV exhaust system design hoc flow
- VAV exhaust system average ho flow
- CV UBC supply system average hood flow
- CV UBC supply system unoccu hood flow
- CV UBC central plant design h flow
- CV UBC central plant average hood flow

- Unoccupied ACH flow
- VAV exhaust system minimum hood flow
- VAV supply system minimum h flow
- VAV central plant minimum hc flow
- CV UBC exhaust system minim hood flow
- CV UBC supply system minimu hood flow
- CV UBC central plant minimu hood flow
- Maximum exhaust system cooli flow
- Maximum supply system coolin flow
- Maximum central plant cooling flow
- Minimum exhaust system heati flow
- VAV exhaust system unoccupie hood flow
- VAV supply system design hooc flow
- VAV supply system average hoc flow
- VAV supply system unoccupied hood flow
- VAV central plant design hood
- VAV central plant average hooc flow
- VAV central plant unoccupied hood flow
- CV UBC exhaust system design hood flow
- CV UBC exhaust system averag hood flow
- CV UBC exhaust system unoccupied hood flow
- CV UBC supply system design hood flow
- CV UBC central plant unoccup hood flow
- VAV UBC exhaust system desig hood flow
- VAV UBC exhaust system avera hood flow
- VAV UBC exhaust system unoccupied hood flow
- VAV UBC supply system desigi hood flow
- VAV UBC supply system averag hood flow
- VAV UBC supply system unoccupied hood flow
- VAV UBC central plant design hood flow
- VAV UBC central plant average hood flow
- VAV UBC central plant unoccupied hood flow

9. Calculate hourly design and average flow for each system by control option:
   A. System Design Flow = Greater of: Design Hood flow, ACH Flow, Maximum Cooling Flow, Minimum Hood Flow.
   B. System Average Flow = Greater of: Average Hood Flow, ACH Flow, Maximum Cooling Flow, Minimum Hood Flow.
10. Calculate hourly kW for each fan system by control option
    A. Calculate CV exhaust fan hourly kW (Eq. 9.10)
    B. Calculate CV UBC exhaust fan hourly kW (Eq. 9.11)
    C. Calculate VAV UBC exhaust fan hourly kW (Eq. 9.11)
    D. Calculate VAV exhaust fan hourly kW (Eq. 9.11)
    E. Calculate CV supply fan hourly kW (Eq. 9.10)
    F. Calculate CV UBC supply fan hourly kW (Eq. 9.11)
    G. Calculate VAV UBC supply fan hourly kW (Eq. 9.11)
    H. Calculate VAV supply fan hourly kW (Eq. 9.11)
11. Calculate hourly design and average reheat BTUs by control option
    A. Calculate CV hourly design reheat BTUs (Eq. 8.8)
    B. Calculate CV UBC hourly design reheat BTUs (Eq. 8.8)
    C. Calculate VAV UBC hourly design reheat BTUs (Eq. 8.8)
    D. Calculate VAV hourly design reheat BTUs (Eq. 8.8)
    E. Calculate CV hourly average reheat BTUs (Eq. 8.8)
    F. Calculate CV UBC hourly average reheat BTUs (Eq. 8.8)
    G. Calculate VAV UBC hourly average reheat BTUs (Eq. 8.8)
    H. Calculate VAV hourly average reheat BTUs (Eq. 8.8)

12. Calculate project cooling energy costs for each bin and control option
    A. Calculate bin CV cooling tons (Eq. 8.2)
    B. Calculate bin CV cooling BTUs (cooling tons x 12,000 BTU/cooling ton)
    C. Calculate bin CV cooling energy costs (Eq. 8.4)
    D. Select hottest bin to determine CV design cooling tonnage
    E. Calculate bin CV UBC cooling tons (Eq. 8.2)
    F. Calculate bin CV UBC cooling BTUs (cooling tons x 12,000 BTU/cooling ton)
    G. Calculate bin CV UBC cooling energy costs (Eq. 8.4)
    H. Select hottest bin to determine CV UBC design cooling tonnage
    I. Calculate bin VAV UBC cooling tons (Eq. 8.2)
    J. Calculate bin VAV UBC cooling BTUs (cooling tons x 12,000 BTU/cooling ton)
    K. Calculate bin VAV UBC cooling energy costs (Eq. 8.4)
    L. Select hottest bin to determine VAV UBC design cooling tonnage
    M. Calculate bin VAV cooling tons (Eq. 8.2)
    N. Calculate bin VAV cooling BTUs (cooling tons x 12,000 BTU/cooling ton)
    O. Calculate bin VAV cooling energy costs (Eq. 8.4)
    P. Select hottest bin to determine VAV design cooling tonnage
13. Calculate project reheat energy costs for each bin and control option.
    A. Calculate bin CV heating BTUs (Eq. 8.8)
    B. Calculate bin CV heating energy costs (Eq. 8.10)
    C. Select coolest bin to determine CV design heating BTUs
    D. Calculate bin CV UBC heating BTUs (Eq. 8.8)
    E. Calculate bin CV UBC heating energy costs (Eq. 8.10)
    F. Select coolest bin to determine CV UBC design heating BTUs
    G. Calculate bin VAV heating BTUs (Eq. 8.8)
    H. Calculate bin VAV heating energy costs (Eq. 8.10)
    I. Select coolest bin to determine VAV design heating BTUs
    J. Calculate bin VAV UBC heating BTUs (Eq. 8.8)
    K. Calculate bin VAV UBC heating energy costs (Eq. 8.10)
    L. Select coolest bin to determine VAV design heating BTUs
14. Calculate project heating energy costs for each bin and control option.
    A. Calculate bin CV heating BTUs (Eq. 8.5)
    B. Calculate bin CV heating energy costs (Eq. 8.7)
    C. Select coolest bin to determine CV design heating BTUs
    D. Calculate bin CV UBC heating BTUs (Eq. 8.5)
    E. Calculate bin CV UBC heating energy costs (Eq. 8.7)
    F. Select coolest bin to determine CV UBC design heating BTUs
    G. Calculate bin VAV heating BTUs (Eq. 8.5)
    H. Calculate bin VAV heating energy costs (Eq. 8.7)

I. Select coolest bin to determine VAV design heating BTUs

J. Calculate bin VAV UBC heating BTUs (Eq. 8.5)

K. Calculate bin VAV UBC heating energy costs (Eq. 8.7)

L. Select coolest bin to determine VAV design heating BTUs

15. Sum total energy usage and energy costs from each bin to determine energy use and energy cost by control option.

16. Sum cooling energy cost, heating energy cost, reheat energy cost, supply air handler energy cost, and exhaust fan energy cost to determine total energy cost for each control option.

17. Calculate project first costs by control option

A. Calculate CV cooling system first costs (Eq. 10.1)

B. Calculate CV heating system first costs (Eq. 10.2)

C. Calculate CV reheat system first costs (Eq. 10.3)

D. Calculate CV duct system first costs (Eq. 10.4)

E. Calculate CV supply air handler first costs (Eq. 10.5)

F. Calculate CV exhaust fan first costs (Eq. 10.6)

G. Calculate CV variable frequency drive first costs (Eq. 10.7)

H. Calculate CV automatic temperature control first costs (Eq. 10.9)

I. Calculate CV automatic temperature control interface first costs (Eq. 10.10)

J. Calculate CV lab controls first costs (Eq. 10.12)

K. Calculate CV-PHX lab controls first costs (Eq. 10.11)

L. Calculate CV balancing costs (Eq. 10.18)

M. Calculate CV-PHX balancing costs (Eq. 10.17)

L. Calculate CV hood certification costs (Eq. 10.20)

M. Calculate CV-PHX hood certification (Eq. 10.19)

18. Calculate project first costs for each control option

A. Calculate CV-PHX cooling system first costs (Eq. 10.1)

B. Calculate CV-PHX heating system first costs (Eq. 10.2)

C. Calculate CV-PHX reheat system first costs (Eq. 10.3)

D. Calculate CV-PHX duct system first costs (Eq. 10.4)

E. Calculate CV-PHX supply air handler first costs (Eq. 10.5)

F. Calculate CV-PHX exhaust fan first costs (Eq. 10.6)

G. Calculate CV-PHX variable frequency drive first costs (Eq. 10.7)

H. Calculate CV-PHX automatic temperature control first costs (Eq. 10.9)

I. Calculate CV-PHX automatic temperature control interface first costs (Eq. 10.10)

J. Calculate CV-PHX lab controls first costs (Eq. 10.12)

K. Calculate CV-PHX lab controls first costs (Eq. 10.11)

L. Calculate CV-PHX balancing costs (Eq. 10.18)

M. Calculate CV-PHX balancing costs (Eq. 10.17)

N. Calculate CV-PHX hood certification costs (Eq. 10.20)

O. Calculate CV-PHX hood certification (Eq. 10.19)
P. Calculate CV UBC cooling system first costs (Eq. 10.1)
Q. Calculate CV UBC heating system first costs (Eq. 10.2)
R. Calculate CV UBC reheat system first costs (Eq. 10.3)
S. Calculate CV UBC duct system first costs (Eq. 10.4)
T. Calculate CV UBC supply air handler first costs (Eq. 10.5)
U. Calculate CV UBC exhaust fan first costs (Eq. 10.6)
V. Calculate CV UBC variable frequency drive first costs (Eq. 10.7)
W. Calculate CV UBC automatic temperature control first costs (Eq. 10.9)
X. Calculate CV UBC automatic temperature control interface first costs (Eq. 10.10)
Y. Calculate CV UBC lab controls first costs (Eq. 10.15)
Z. Calculate CV UBC balancing costs (Eq. 10.17)
AA. Calculate CV UBC hood certification costs (Eq. 10.19)
AB. Calculate VAV UBC cooling system first costs (Eq. 10.1)
AC. Calculate VAV UBC heating system first costs (Eq. 10.2)
AD. Calculate VAV UBC reheat system first costs (Eq. 10.3)
AE. Calculate VAV UBC duct system first costs (Eq. 10.4)
AF. Calculate VAV UBC supply air handler first costs (Eq. 10.5)
AG. Calculate VAV UBC exhaust fan first costs (Eq. 10.6)
AH. Calculate VAV UBC variable frequency drive first costs (Eq. 10.7)
AI. Calculate VAV UBC automatic temperature control first costs (Eq. 10.9)
AJ. Calculate VAV UBC automatic temperature control interface first costs (Eq. 10.10)
AK. Calculate VAV UBC lab controls first costs (Eq. 10.16)
AL. Calculate VAV UBC balancing costs (Eq. 10.17)
AM. Calculate VAV UBC hood certification costs (Eq. 10.19)
AN. Calculate VAV cooling system first costs (Eq. 10.1)
AO. Calculate VAV heating system first costs (Eq. 10.2)
AP. Calculate VAV reheat system first costs (Eq. 10.3)
AQ. Calculate VAV duct system first costs (Eq. 10.4)
AR. Calculate VAV supply air handler first costs (Eq. 10.5)
AS. Calculate VAV exhaust fan first costs (Eq. 10.6)
AT. Calculate VAV variable frequency drive first costs (Eq. 10.7)
AU. Calculate VAV automatic temperature control first costs (Eq. 10.9)
AV. Calculate VAV automatic temperature control interface first costs (Eq. 10.10)
AW. Calculate VAV lab controls first costs (Eq. 10.14)
AX. Calculate VAV-PHX lab controls first costs (Eq. 10.13)
AY. Calculate VAV balancing costs (Eq. 10.18)
AZ. Calculate VAV-PHX balancing costs (Eq. 10.17)
BA. Calculate VAV hood certification costs (Eq. 10.20)

   BB. Calculate VAV-PHX hood certification (Eq. 10.19)

19. Calculate total system first cost for each control option (Eq. 10.21)
20. Calculate project first-year maintenance costs for each control option
    A. Calculate first-year CV maintenance costs (Eq. 11.3)
    B. Calculate first-year CV-PHX maintenance costs (Eq. 11.2)
    C. Calculate first-year CV UBC maintenance costs (Eq. 11.2)
    D. Calculate first-year VAV UBC maintenance costs (Eq. 11.4)
    E. Calculate first-year VAV maintenance costs (Eq. 11.5)
    F. Calculate first-year VAV-PHX VAV maintenance costs (Eq. 11.4)
    G. Calculate first-year ATC maintenance costs (Eq. 11.1)
21. Calculate project first-year downtime hours and costs
    A. Calculate first year CV downtime hours (Eq. 11.7)
    B. Calculate first year CV-PHX downtime hours (Eq. 11.6)
    C. Calculate first year CV UBC downtime hours (Eq. 11.10)
    D. Calculate first year VAV UBC downtime hours (Eq. 11.11)
    E. Calculate first year VAV downtime hour (Eq. 11.9)
    F. Calculate first year VAV-PHX downtime hours (Eq. 11.8)
    G. Calculate laboratory first year downtime costs (Eq. 11.12)
22. Calculate project total first year non-energy O&M costs
    A. Calculate total first-year CV non-energy O&M costs (Eq. 11.15)
    B. Calculate total first-year CV-PHX non-energy O&M costs (Eq. 11.13)
    C. Calculate total first-year CV UBC non-energy O&M costs (Eq. 11.18)
    D. Calculate total first-year VAV UBC non-energy O&M costs (Eq. 11.19)
    E. Calculate total first-year VAV non-energy O&M costs (Eq. 11.17)
    F. Calculate total first-year VAV-PHX non-energy O&M costs (Eq. 11.16)
23. Calculate project life cycle costs
    A. Calculate total energy costs (Eq. 12.2)
    B. Calculate total non-energy O&M costs (Eq. 12.3)
    C. Calculate total O&M costs (Eq. 12.4)
    D. Calculate total life cycle costs (Eq. 12.5)
    E. Calculate annual cost of ownership (Eq. 12.6)
    F. Calculate series of periodic cost differences for period of analysis (Eq. 12.7, 12.8, and 12.9)
24. Calculate Project in the What If... Mode
    A. Re-calculate project with user modified What If... parameters (see *Calculate Project*)

Equations

General Equations

(1.1) $\text{Barometric Pressure} = \left(\left[1 - .0000068745 \times \text{Altitude}\right]^{5.2559}\right) \times 14.696 \times 2.036$

(1.2) $\text{Altitude Correction Factor} = \dfrac{\text{Barometric Pressure}}{29.921}$

Corridor Data Calculations

Corridor Air Changes per Hour (ACH) Data

(2.1) $\text{Corridor Volume} = \text{Corridor Area} \times \text{Corridor Ceiling Height}$

(2.2) $\text{ACH} = \text{ACH Flow} \times \dfrac{60}{\text{Corridor Volume}}$

(2.3) $\text{ACH Flow} = \text{Corridor Volume} \times \dfrac{\text{ACH}}{60}$

Corridor Maximum Cooling Flow

(2.4) $\text{Corridor Max. Cooling Flow} = \dfrac{\text{Watts per Square Foot} \times \text{Corridor Area} \times 3.413}{1.08 \times (\text{Corridor Temperature} - \text{Supply Air Temperature})}$

Corridor Offset Flow

(2.5) $\text{Corridor Offset Flow} = \sum_{1}^{n} \text{Room Offset Flow}_{n}$ for each corridor

Corridor Supply Maximum Flow

(2.6) Maximum value of: Corridor ACH Flow, Corridor maximum cooling Flow, Corridor Room Offset Flow

Corridor Supply Valve Minimum Flow

(2.7) Lookup based on Corridor Supply Maximum

Corridor Supply Minimum Flow

(2.8) Maximum value of: Corridor ACH Flow, Corridor Room Offset Flow

Corridor Exhaust Maximum Flow

(2.9) Corridor Supply Maximum Flow - Corridor Room Offset Flow

Corridor Exhaust Valve Minimum Flow

(2.10) Lookup based on Corridor Exhaust Maximum Flow

Corridor Exhaust Minimum Flow

(2.11) Corridor Supply Minimum Flow - Corridor Room Offset Flow

Room Data Calculations

ACH Data

(3.1) $\text{Room Volume} = \text{Room Area} \times \text{Room Ceiling Height}$

(3.2) $\text{ACH} = \text{ACH Flow} \times \dfrac{60}{\text{Room Volume}}$

$$(3.3)\quad \text{ACH Flow} = \text{Room Volume} \times \frac{\text{ACH}}{60}$$

Room Maximum Cooling Flow

$$(3.4)\quad \text{Room Max. Cooling Flow} = \frac{\text{Watts per Square Foot(or Square Meter)} \times \text{Room Area} \times 3.413}{1.08 \text{ x (Room Temperature} - \text{Supply Air Temperature)}}$$

Room Zone Balance

(including Room Supply Maximum Flow, Supply Minimum Flow, General Exhaust Maximum Flow, General Exhaust Minimum Flow, Room Offset Flow

Laboratory Zone Balancing Worksheet Instructions

Refer to the Laboratory Engineering Guide for instructions on completing a Room Balance Worksheet.

Calculate Fan System Flow

Calculate Maximum and Minimum Constant Volume Exhaust Fan Flows per fan system

$$(5.1)\quad \text{Fan Max. Flow} = \sum_{1}^{n} \text{Maximum Room Flow}_n + \sum_{1}^{m} \text{Maximum Corridor Flow}_m$$

$$(5.2)\quad \text{Fan Min.} = \sum_{1}^{n} \text{Minimum Room Flow}_n + \sum_{1}^{m} \text{Minimum Corridor Flow}_m$$

Sum all Maximum Hood and Corridor exhaust flows per fan system

$$(5.3)\quad \text{Fan Hood Max. Flow} = \sum_{1}^{n} \text{Max. Hood Flow}_n + \sum_{1}^{m} \text{Max. Corridor Exhaust Flow}_m$$

Sum all Minimum Hood and Corridor exhaust flows per fan system

$$(5.4)\quad \text{Fan Hood Min. Flow} = \sum_{1}^{n} \text{Min. Hood Flow}_n + \sum_{1}^{m} \text{Min. Corridor Exhaust Flow}_m$$

Sum all Room and Corridor Total Supply Maximum Flows for each fan system

$$(5.5)\quad \text{Max. Fan Supply Flow} = \sum_{1}^{n} \text{Max. Room Supply Flow}_n + \sum_{1}^{m} \text{Max. Corridor Supply Flow}_m$$

Sum all room and corridor ACH flows (occupied and unoccupied)

$$(5.6)\quad \text{Fan ACH Flow} = \sum_{1}^{n} \text{Room ACH Flow}_n + \sum_{1}^{m} \text{Corridor ACH Flow}_m$$

Calculate the number of hoods per fan system

$$(5.7)\quad \text{Fan Hood Count} = \sum_{1}^{n} \text{Room Hood Count}_n$$

Calculate the maximum hood flow

$$(5.7.1)\quad \text{Max Hood Flow} = \sum_{1}^{n} \text{Max Hood Flow}_n$$

Calculate the minimum hood flow

$$(5.7.2)\quad \text{Min Hood Flow} = \sum_{1}^{n} \text{Min Hood Flow}_n$$

Project Simulation Algorithm

Hood Subroutine

1. Calculate Hood Occupied Flow
   - CV Hood Occupied Flow = (Hood Max. Flow)
   - VAV Hood Occupied Flow = Max2((Hood Max. Flow * Hood Occupied Sash Position), Hood Min. Flow)
   - CV UBC Hood Occupied Flow = Max2((Hood Max. Flow * UBC Normal Mode %), Hood Min. Flow)
   - VAV UBC Hood Occupied Flow = Max2((Hood Max. Flow * UBC Normal Mode % * Hood Occupied Sash Position), Hood Min. Flow)
2. Calculate Hood Unoccupied Flow
   - CV Hood Unoccupied Flow = (Hood Max. Flow)
   - VAV Hood Unoccupied Flow = Max2((Hood Max. Flow * Hood Unoccupied Sash Position), Hood Min. Flow)
   - CV UBC Hood Unoccupied Flow = Max2((Hood Max. Flow * UBC Stand-By Mode %), Hood Min. Flow)
   - VAV UBC Hood Unoccupied Flow = Max2((Hood Max. Flow * UBC Stand-By Mode % * Hood Unoccupied Sash Position), Hood Min. Flow)

Room Subroutine

1. Run Hood Subroutine
2. Sum Hood Data
   - Hood Count = Hoodcount
   - Hood Max Flow = HoodMaxFlow
   - Hood Min Flow = HoodMinFlow
   - CV Hood Occupied Flow = CVHoodOccupiedFlow
   - VAV Hood Occupied Flow = VAVHoodOccupiedFlow
   - CV UBC Hood Occupied Flow = CV UBCHoodOccupiedFlow
   - VAV UBC Hood Occupied Flow = VAV UBCHoodOccupiedFlow
   - CV Hood Unoccupied Flow = CVHoodOccupiedFlow
   - VAV Hood Unoccupied Flow = VAVHoodUnoccupiedFlow
   - CV UBC Hood Unoccupied Flow = CV UBCHoodUnoccupiedFlow
   - VAV UBC Hood Unoccupied Flow = VAV UBCHoodUnoccupiedFlow
3. Take snap shot of each hood
   - CV Hood Occupied Flow
   - VAV Hood Occupied Flow
   - CV UBC Hood Occupied Flow
   - VAV UBC Hood Occupied Flow
   - CV Hood Unoccupied Flow
   - VAV Hood Unoccupied Flow
   - CV UBC Hood Unoccupied Flow
   - VAV UBC Hood Unoccupied Flow
4. Run all Room Balance subroutines
5. Calculate Design Hoods Presence Probability.
   - Design Hood Presence Probability = Hood Usage Hours/Building Occupied Hours
6. Calculate Average Hoods Presence Probability.
   - Average Hood Presence Probability = Hood Usage Hours/24 Hours
7. Calculate Room Other Exhaust Flow
   - CV Room Other Exhaust Flow = CV Gex + Other CV Exhaust Max. + Gex Valve Min. Flow
   - Room Other Exhaust Flow = CV Gex + Other CV Exhaust Max. + Gex Valve Min. Flow
8. Calculate Room Occupied Exhaust Flow
   - CV Room Occupied Exhaust Flow = CV Hood Occupied Flow + CV Room Other Exhaust Flow

- VAV Room Occupied Exhaust Flow = VAV Hood Occupied Flow + Room Other Exhaust Flow
- CV UBC Room Occupied Exhaust Flow = CV UBC Hood Occupied Flow + Room Other Exhaust Flow
- VAV UBC Room Occupied Exhaust Flow = VAV UBC Hood Occupied Flow + Room Other Exhaust Flow

9. Calculate Room Unoccupied Exhaust Flow
   - CV Room Unoccupied Exhaust Flow = CV Hood UnoccupiedFlow + CV Room Other Exhaust Flow
   - VAV Room Unoccupied Exhaust Flow = VAV Hood Unoccupied Flow + Room Other Exhaust Flow
   - CV UBC Room Unoccupied Exhaust Flow = CV UBC Hood Unoccupied Flow + Room Other Exhaust Flow
   - VAV UBC Room Unoccupied Exhaust Flow = VAV UBC Hood Unoccupied Flow + Room Other Exhaust Flow

Begin Loop

1. Calculate Average Flow for each hour in flow grid Setting the vent demand equal to corresponding occupied or unoccupied value and the Max Cooling Flow equal to the corresponding hour in the room profile. (store results in Room Table)

- Calculate Ventilation Demand Flow
  - ⇒ If Room is Negative Then
  - ⇒ Occupied Vent Demand Flow = ACH Occupied Flow
  - ⇒ Unoccupied Vent Demand Flow = ACH Unoccupied Flow
  - ⇒ Else
  - ⇒ Occupied Vent Demand Flow = ACH Occupied Flow + Offset
  - ⇒ Unoccupied Vent Demand Flow = ACH Unoccupied Flow + Offset
- Calculate Supply Minimum Flow
  - ⇒ CV Supply Min Flow = CV Supply + VAV Supply Valve Min. + Offset + Additional Supply Valve Max. +. Office Supply Valve Max.
  - ⇒ Supply Min Flow = CV Supply + VAV Supply Valve Min. + Offset + Additional Supply Valve Max. + Office Supply Valve Max.
- Calculate Max Cooling Demand Flow
  - ⇒ CV Max Cooling Demand Flow = Max. Cooling Flow + Offset + Office Supply Valve Max. + Additional Supply Valve Max.
  - ⇒ Max Cooling Demand Flow = Max. Cooling Flow + Offset + Office Supply Valve Max. + Additional Supply Valve Max.
- Compare Room Occupied Exhaust Flow to Vent Demand Flow (Occupied or Unoccupied), Max Cooling Demand Flow, Min. Supply Flow.
  - ⇒ If Max3 (Vent Demand Flow, CV Max. Cooling Demand Flow, CV Min. Supply Flow) > CV Room Occupied Exhaust Flow

  Then Set CV Average Flow = Max3 (Vent Demand Flow, Max. Cooling Demand Flow, CV Min. Supply Flow)

  Else Proceed To next step
  - ⇒ If Max3 (Vent Demand Flow, Max. Cooling Demand Flow, Min. Supply Flow) > VAV Room Occupied Exhaust Flow

  Then Set VAV Average Flow = Max3 (Vent Demand Flow, Max. Cooling Demand Flow, Min. Supply Flow)

  Else Proceed To next step
  - ⇒ If Max3 (Vent Demand Flow, Max. Cooling Demand Flow, Min. Supply Flow) > CV UBC Room Occupied Exhaust Flow

  Then Set CV UBC Average Flow = Max3 (Vent Demand Flow, Max. Cooling Demand Flow, Min. Supply Flow)

  Else Proceed To next step
  - ⇒ If Max3 (Vent Demand Flow, Max. Cooling Demand Flow, Min. Supply Flow) > VAV UBC Room Occupied Exhaust Flow

Then Set VAV UBC Average Flow = Max3 (Vent Demand Flow, Max. Cooling Demand Flow, Min. Supply Flow)
Else Proceed To next step

- If Vent Demand Flow, Max. Cooling Demand Flow, and Min. Supply Flow, equal values from previous hour or Vent Demand Flow and Min Supply Flow equal values from previous hour and Vent Demand Flow, Flow or Min Supply Flow > Max. Cooling Demand set average flow for this hour equal to values from previous hour. If they are true, return to item 10 (Begin Loop).
- If Vent Demand Flow(Occupied or Unoccupied), Max Cooling Demand Flow, and Min. Supply Flow are < Room Occupied Exhaust Flow and Vent Demand Flow (Occupied or Unoccupied), Max. Cooling Demand Flow, and Min. Supply Flow are > Room Unoccupied Exhaust Flow, then

A. Select a random number between 0 and 1

B. Compare the random number to the Average Hood Presence Probability.

1. If the Random Number is less than or equal to the Average Hood Presence Probability set the Hood Flow
   - CV Hood Flow = CV Hood Occupied Flow
   - VAV Hood Flow = VAV Hood Occupied Flow
   - CV UBC Hood Flow = CV UBC Hood Occupied Flow
   - VAV UBC Hood Flow = VAV UBC Hood Occupied Flow
2. If the Random Number is greater than the Design Hood Presence Probability set the Hood Flow
   - CV Hood Flow = CV Hood Unoccupied Flow
   - VAV Hood Flow = VAV Hood Unoccupied Flow
   - CV UBC Hood Flow = CV UBC Hood Unoccupied Flow
   - VAV UBC Hood Flow = VAV UBC Hood Unoccupied Flow

C. Run A & B on next hood in room (Hood Flow) and add to the Room Hood Flow

- CV Room Hood Flow = CV Room Hood Flow + CV Hood Flow
- VAV Room Hood Flow = VAV Room Hood Flow + VAV Hood Flow
- CV UBC Room Hood Flow = CV UBC Room Hood Flow + CV UBC Hood Flow)
- VAV UBC Room Hood Flow = VAV UBC Room Hood Flow + VAV UBC Hood Flow

D. Run A through C on remaining hoods in the room each time adding the result to the Room Hood Flow

- CV Room Hood Flow = CV Room Hood Flow + CV Hood Flow
- AV Room Hood Flow = VAV Room Hood Flow + VAV Hood Flow
- CV UBC Room Hood Flow = CV UBC Room Hood Flow + CV UBC Hood Flow
- VAV UBC Room Hood Flow = VAV UBC Room Hood Flow + VAV UBC Hood Flow

E. Calculate Total Room Demand Flow

- CV Total Room Demand = Max4((CV Room Flow + CV Room Other Exhaust Flow), Vent Demand Flow, CV Max. Cooling Demand Flow, CV Supply Min. Flow)
- VAV Total Room Demand = Max4((VAV Room Flow + VAV Room Other Exhaust Flow), Vent Demand Flow, Max. Cooling Demand Flow, Supply Min. Flow)
- CV UBC Total Room Demand = Max4((CV UBC Room Flow + CV UBC Room Other Exhaust Flow), Vent Demand Flow, Max. Cooling Demand Flow, Supply Min. Flow)
- VAV UBC Total Room Demand = Max4((VAV UBC Room Flow + VAV UBC Room Other Exhaust Flow), Vent Demand Flow, Max. Cooling Demand Flow, Supply Min. Flow)

F. Add Total Room Demand to Average Flow

- CV Average Flow = CV Average Flow + CV Total Room Demand
- VAV Average Flow = VAV Average Flow + VAV Total Room Demand
- CV UBC Average Flow = CV UBC Average Flow + CV UBC Total Room Demand
- VAV UBC Average Flow = VAV UBC Average Flow + VAV UBC Total Room Demand

G. Repeat A through F 300 to 500 times, each time adding to the final Average Flow

H. Set Average Flow

- CV Average Flow = CV Average Flow/Number of trials

- VAV Average Flow = VAV Average Flow/Number of trials
- CV UBC Average Flow = CV UBC Average Flow/Number of trials
- VAV UBC Average Flow = VAV UBC Average Flow/Number of trials

I. Set Average Flow equal to corresponding Bin Hour Flow

11. Complete Flow Grid for each Hour (Go back to number 10, Begin Loop)

End of loop

Calculate Project Totals Subroutine

1. If all Standard Cooling Profile boxes are checked, then
   - Thermal Demand = Sum of Max Cooling for each room on manifold. (Complete for each manifold
   - Else
   - Compare each room profile
   - If Max hour is equal for all Rooms, then
   - Thermal Demand = Sum of Mac Cooling for each room on manifold. (Complete for each manifold
   - Else
   - Run complete subroutine for each occupied hour, each time calculating Thermal Demand
   - Thermal Demand = Sum of Mac Cooling for each occupied hour for each room on manifold. (Complete for each manifold)
2. Calculate Cooling Demand for each exhaust, supply and temperature control manifold
   - Cooling Demand Flow = Max. Thermal Demand Flow + Offset + Office Supply Valve Max. + Additional
3. Calculate Limit Term of each manifold
   - CV Limit Term = Max3(Occupied Vent Demand, Cooling Demand Flow, CV Supply Min. Flow)
   - Limit Term = Max3(Occupied Vent Demand, Cooling Demand Flow, Supply Min. Flow)
   - Places values in room table
4. Merge hood and room tables and transfer data to C.DLL
5. Creating temporary holding values for each exhaust, supply and temp control manifold
6. Set Random Number equal to 1 and maker first pass steps 13 through 17. Set value equal to bin max for each manifold. Also set CV UBC value equal to CV design Flow
7. Set Random Number equal to 0 and make second pass steps 13 through 17. Set value equal to bin min for each manifold
8. When complete with first two passes set up storage bins Add result from 6 and 7 and divide by 200.
9. Establish Bin tables for each manifold
10. Select a random number between 0 and 1
11. Compare the random number to the Design Hood Presence Probability.
    - If the Random Number is less than or equal to the Design Hood Presence Probability set the Hood Flow
      VAV Hood Flow = VAV Hood Occupied Flow
      CV UBC Hood Flow = CV UBC Hood Occupied Flow
      VAV UBC Hood Flow = VAV UBC Hood Occupied Flow
    - If the Random Number is greater than the Design Hood Presence Probability set the Hood Flow
      VAV Hood Flow = VAV Hood Unoccupied Flow
      CV UBC Hood Flow = CV UBC Hood Unoccupied Flow
      VAV UBC Hood Flow = VAV UBC Hood Unoccupied Flow

1. Run 10 & 11 on next hood in room (Hood Flow) and add to the Room Hood Flow.
   - VAV Room Hood Flow = VAV Room Hood Flow + VAV Hood Flow
   - CV UBC Room Hood Flow = CV UBC Room Hood Flow + CV UBC Hood Flow
   - VAV UBC Room Hood Flow = VAV UBC Room Hood Flow + VAV UBC Hood Flow
2. Run 11 through 12 on remaining hoods in the room each time adding the result to the Room Hood Flow
   - VAV Room Hood Flow = VAV Room Hood Flow + VAV Hood Flow
   - CV UBC Room Hood Flow = CV UBC Room Hood Flow + CV UBC Hood Flow
   - VAV UBC Room Hood Flow = VAV UBC Room Hood Flow + VAV UBC Hood Flow
3. Calculate Total Room Exhaust Flow

- VAV Total Room Demand = Max2(VAV Total Room Exhaust Flow, Limit Term)
- CV UBC Total Room Demand = Max2(CV UBC Total Room Exhaust Flow, Limit Term)
- VAV UBC Total Room Demand = Max2(VAV UBC Total Room Exhaust Flow, Limit Term)

4. Place value in temp hold variable corresponding to appropriate manifold.
5. Repeat number 8 - 13 for each room
6. Add Total Room Exhaust to Design Flow
   - VAV Design Flow = VAV Design Flow + VAV Total Room Exhaust
   - CV UBC Design Flow = CV UBC Design Flow + CV UBC Total Room Exhaust
   - VAV UBC Design Flow = VAV UBC Design Flow + VAV UBC Total Room Exhaust
7. When complete with all room add 1 to the Manifold Bin that corresponds to the Design Flow
8. If VAV, CV UBC or VAV UBC, then loop through process 10,000 times and stop
9. When complete select the design percentile Flow that corresponds to the bin that equals the design percentile. Complete for each bin. If the design percentile is greater than the previous run then Transfer each manifold bin and design percentile to access database.
10. Else process to number 1 if you are running process of multiple profile hours or end subroutine.
11. Add each corridor GEX Max. Flow and Room Other Exhaust Flow to Design Flow
    - VAV Design Flow = VAV Design Flow + CV Room Other Exhaust Flow + Corridor GEX Max. Flow + ... Corridor GEX Max. Flow
    - CV UBC Design Flow = CV UBC Design Flow + Room Other Exhaust Flow + Corridor GEX Max. Flow + ... Corridor GEX Max. Flow
    - VAV UBC Design Flow = VAV UBC Design Flow + Room Other Exhaust Flow + Corridor GEX Max. Flow + ... Corridor GEX Max. Flow

END

Calculate Cooling Energy Costs

General Equations

LabPro uses Simplified Bin Weather Data Calculations to calculate cooling and heating energy use. In the Bin Cooling Tons equations, the Flow is dependent on the control system used and the subsequent design and average cfm. Since all of the cooling equations are linear, the average flow represents a good approximation for the energy use calculations.

SAT = Supply Air Temperature
ACF = Altitude Correction Factor
OSAH = Outside Air Humidity (Gr/lb.)
LCH = Leaving Coil Humidity (Gr/lb.)

$$\text{(8.1)}\ \ \text{Outside Air Temperature (OSAT)} = \frac{\text{Bin Min. Temperature} + \text{Bin Max. Temperature}}{2}$$

$$\text{(8.2)}\ \ \text{Bin Cooling Tons} = \left(\frac{1.08 \times \text{Hourly Flow} \times \text{ACF} \times (\text{OSAT - SAT})}{12{,}000}\right) + \left(\frac{.68 \times \text{HourlyFlow} \times (\text{OSAH} - \text{LCH}) \times \text{ACF}}{12{,}000}\right)$$

$$\text{(8.3)}\ \ \text{Kwh} = \text{Bin Cooling Tons} \times \text{Annual Hours of Operation} \times 3.52 \times \left(\frac{1}{\text{COP}}\right) \text{ where } \text{COP} = \frac{\text{1ton (Refrigerant)}}{\text{kW (Input Power)}}$$

$$\text{(8.4)}\ \ \text{Cooling Energy Cost} = \text{kWh} \times \frac{\text{Cost}}{\text{kWh}}$$

Calculate Heating Energy Costs

General Equations

$$\text{(8.5)}\ \ \text{Bin Heating BTUs per Hour} = 1.08 \times \text{Flow} \times \text{ACF} \times (\text{SAT - OSAT})$$

$$\text{(8.6)}\ \ \text{Bin Heating BTUs} = \frac{\text{Bin Heating BTUs per Hour} \times \text{Annual Hours of Operation}}{\text{Heating Efficiency}}$$

$$\text{(8.7)}\ \ \text{Heating Energy Cost} = \frac{\text{Bin Heating BTUs} \times \text{Heating Fuel Cost per Unit}}{\text{Heating Fuel BTU per Unit}}$$

Calculate Reheat Energy Costs

General Equations

(8.8) $$\text{Reheat BTUs per Hour} = \frac{(\text{Hourly Flow - Cooling Demand Flow}) \times 1.08 \times (\text{Room Temp - Supply Air Temp})}{\text{Heating efficiency}}$$

(8.9) $$\text{Reheat BTUs} = \text{Hours of Operation} \times \text{Reheat BTUs per Hour}$$

(8.10) $$\text{Reheat Energy Cost} = \text{Heating Fuel Cost per Unit} \times \frac{\text{Reheat BTUs}}{\text{Heating Fuel BTUs per Unit}}$$

Calculate Fan Energy Costs

Calculate Constant Volume Fan Horsepower

(9.1) $$\text{Fan Horsepower} = \frac{\text{Hourly Flow} \times \text{Duct Static Pressure}}{6356 \times \text{Fan Efficiency} \times \text{Altitude Correction Factor}}$$

Calculate Fan Horsepower for Part Load Performance

Fan part load performance curves are calculated using the general equation

(9.2) $$Y = AX + BX^2 + CX^3 + D$$

Where:

Y = Fan Percent Horsepower

X = % Flow required

Constant Air Volume Fan Percent Horsepower

(9.3) $$Y = 1$$

Backward Incline Fan with Discharge Dampers Percent Horsepower

(9.4) $$Y = .94868X + .12381X^2 - .26418X^3 + .19355$$

Air Foil with Inlet Guide Vanes Percent Horsepower

(9.5) $$Y = .22663X - .25530X^2 + .51261X^3 + .51311$$

Forward Curve Fan with Discharge Dampers Percent Horsepower

(9.6) $$Y = .66992X + .07037X^2 + .17926X^3 + .08$$

Forward Curve Fan with Inlet Guide Vanes Percent Horsepower

(9.7) $$Y = -.39225X + .90543X^2 + .25487X^3 + .23174$$

VAV with Vane Axial Fan Percent Horsepower

(9.8) $$Y = -.15342X + .74548X^2 + .30553X^3 + .10578$$

VAV with Variable Frequency Drive (VFD) Fan Percent Horsepower

(9.9) $$Y = X^3$$

The minimum % flows = 50% for Backward Incline Fan with Discharge Dampers; 20% for all other VAV type
Minimums kW is 20% of full flow kW for all fan types.
Drive efficiency is .97 for VFD applications only; 1.00 for all others.

(9.10) $$\text{Constant Air Volume Fan kW} = \frac{\text{Fan Horsepower} \times 0.746}{\text{Fan Efficiency}}$$

(9.11) $$\text{Variable Air Volume Fan kW} = \frac{\text{Fan Horsepower} \times 0.746}{\text{Fan Efficiency} \times \text{Drive Efficiency}}$$

(9.12) $$\text{kWh} = \text{kW} \times \text{Hours}$$

(9.13) $\text{Fan Energy Cost} = \text{kWh} \times \dfrac{\text{Cost}}{\text{kWh}}$

Calculate Mechanical Equipment Initial Costs

(10.1) $\text{Cooling Plant Equipment Costs} = \text{Design Cooling Tons} \times \text{Cost per Ton}$

(10.2) $\text{Heating Plant Euipment Costs} = \text{Design unit of flow} \times \text{Heating System Cost per unit of flow}$

(10.3) $\text{Reheat System Euipment Costs} = \text{Design unit of flow} \times \text{Reheat System Cost per unit of flow}$

(10.4) $\text{Supply and Exhaust Air Duct Costs} = \text{Design unit of flow} \times \text{Duct Cost per unit of flow}$

(10.5) $\text{Supply Air Handler Costs} = \text{Design unit of flow} \times \text{Supply Air Handler Cost per unit of flow}$

(10.6) $\text{Exhaust Fan Costs} = \text{Design unit of flow} \times \text{Exhaust Fan Cost per unit of flow}$

(10.7) $\text{Variable Frequency Drive Costs} = \text{Design Horsepower} \times \text{VFD Cost per Horsepower}$

(10.8) $\text{Filter Costs} = \text{Design unit of flow} \times \text{Filter Cost per unit of flow}$

(10.9) $\text{ATC Cost} = (\text{Number of Rooms} + \text{Number of Corridors}) \times \text{ATC Cost per Room}$

(10.10) $\text{ATC Interface Cost} = \text{Number of Rooms} \times \text{Interface Cost per Room}$

(10.11) $\text{Phoenix CV Controls Costs} = \text{Number of Fume Hoods} \times \text{Phoenix CV Cost per Hood}$

(10.12) $\text{Other CV Controls Costs} = \text{Number of Fume Hoods} \times \text{Other CV Cost per Hood}$

(10.13) $\text{Phoenix VAV Controls Costs} = \text{Number of Fume Hoods} \times \text{Phoenix VAV Cost per Hood}$

(10.14) $\text{Other VAV Controls Costs} = \text{Number of Fume Hoods} \times \text{Other VAV Cost per Hood}$

(10.15) $\text{Phoenix ACV Controls Costs} = \text{Number of Fume Hoods} \times \text{Phoenix ACV Cost per Hood}$

(10.16) $\text{Phoenix AFV Controls Costs} = \text{Number of Fume Hoods} \times \text{Phoenix AFV Cost per Hood}$

(10.17) $\text{Phoenix System Balance Cost} = \text{Number of Rooms} \times \text{Phoenix System Balancing Cost per Room}$

(10.18) $\text{Other System Balance Cost} = \text{Number of Rooms} \times \text{Other System Balancing Cost per Room}$

(10.19) $\text{Phoenix System Hood Certification Cost} = \text{Number of Rooms} \times \text{Phoenix System Hood CertificationCost per Room}$

(10.20) $\text{Other System Hood Certification Cost} = \text{Number of Rooms} \times \text{Other System Hood Certification Cost per Room}$

You enter the Rebate amount on the Initial Costs tab in the main Project screen.

(10.21) Total First Cost = Cooling Plant Equipment Costs + Heating Plant Equipment Costs + Reheat System Equipment Costs + Duct Costs + Supply AHU Costs + Exhaust Fan Costs + VFD Costs + Filter Costs + ATC Cost + ATC Interface Cost + Lab Controls Costs + System Balance Costs + Hood Certification Costs - Rebate Amount

Calculate Total Annual Maintenance Costs

(11.1) $\text{ATC Maintenance Cost} = \text{Number of Rooms} \times \text{ATC Maintenance Cost per Room}$

(11.2) $\text{Phoenix CV Maintenance Cost} = \text{Number of Hoods} \times \text{Phoenix CV Maintenance Cost per Hood}$

(11.3) $\text{Other CV Maintenance Cost} = \text{Number of Hoods} \times \text{Other CV Maintenance Cost per Hood}$

(11.4) $\text{Phoenix VAV Maintenance Cost} = \text{Number of Hoods} \times \text{Phoenix VAV Maintenance Cost per Hood}$

(11.5) $\text{Other VAV Maintenance Cost} = \text{Number of Hoods} \times \text{Other VAV Maintenance Cost per Hood}$

(11.6) CV-PHX Downtime Hours = CV-PHX Maintenance Cost / 100

(11.7) Other CV Downtime Hours = Other CV Maintenance Cost / 100

(11.8) VAV-PHX Downtime Hours = VAV-PHX Maintenance Cost / 100

(11.9) Other VAV Downtime Hours = Other VAV Maintenance Cost / 100

(11.10) CV-PHX UBC Downtime Hours = CV-PHX UBC Maintenance Cost / 100

(11.11) VAV-PHX UBC Downtime Hours = VAV-PHX UBC Maintenance Cost / 100

(11.12) $\text{Laboratory Downtime Costs} = \text{Number of Hours of Maintenance} \times \text{Downtime Cost per Hour}$

(11.13) CV-PHX Maintenance Cost = Phoenix Hood Certification Cost + Phoenix Balance Cost + ATC maintenance Cost + CV-PHX Lab Controls Maintenance Cost + CV Filter Cost + CV-PHX Downtime Costs

(11.15) Annual Other CV Maintenance Cost = Other Hood Certification Cost + Other Balance Cost + ATC maintenance Cost + Other CV Lab Controls Maintenance Cost + CV Filter Cost + Other CV Downtime Costs

(11.16) Annual VAV-PHX Maintenance Cost = Phoenix Hood Certification Cost + Phoenix Balance Cost + ATC maintenance Cost + VAV-PHX Lab Controls Maintenance Cost + VAV Filter Cost + VAV-PHX Downtime Costs

(11.17) Annual Other VAV Maintenance Cost = Phoenix Hood Certification Cost + Phoenix Balance Cost + ATC maintenance Cost + Other VAV Lab Controls Maintenance Cost + VAV Filter Cost + Other VAV Downtime Costs

(11.18) Annual CV-PHX UBC Maintenance Cost = Phoenix Hood Certification Cost + Phoenix Balance Cost + ATC maintenance Cost + CV-PHX UBC Lab Controls Maintenance Cost + CV UBC Filter Cost + CV UBC Downtime Costs

(11.19) Annual VAV-PHX UBC Maintenance Cost = Phoenix Hood Certification Cost + Phoenix Balance Cost + ATC maintenance Cost + VAV-PHX UBC Lab Controls Maintenance Cost + VAV UBC Filter Cost + VAV UBC Downtime Costs

Calculate Life Cycle Costs

For each Life Cycle Analysis control option

- Get the first cost
- Get the first year energy cost
- Get the first year non-energy O&M cost

Calculate the total energy costs over the life of the analysis using the inflation rate and number of years that were input on the Operating Costs tab of the main project screen.

(12.2) $$\text{Total Energy Costs} = \text{First Year Energy Cost} + \sum_{y=2}^{n} \text{Energy Cost}_{y-1} \times (1 + \text{Inflation Rate})$$

Calculate the total non-energy operation and maintenance costs over the life of the analysis using the inflation rate and number of years that were input on the Operating Costs tab of the main project screen.

(12.3) $$\text{Total Non-Energy O\&M Costs} = \left(\text{First Year Non-Energy O\&M Cost} + \sum_{y=2}^{n} \text{Non-Energy O\&M Cost}_{y-1} \right) \times (1 + \text{Inflation Rate})$$

(12.4) $\text{Total O\&M Costs} = \text{Total Energy Costs} + \text{Total Non-Energy O\&M Costs for the Analysis Period}$

Calculate the total life cycle cost

(12.5) $\text{Total Life Cycle Cost} = \text{Initial System Cost} + \text{Total O\&M Costs for the Analysis Period}$

Calculate the annual cost of ownership.

(12.6) $\text{Annual Cost of Ownership} = \dfrac{\text{Option Total Life Cycle Cost}}{\text{Years of Analysis Period}}$

Calculate the series of periodic cost differences for the period of the analysis

(12.7) $\text{Periodic Difference}_0 = \text{Option Y First Cost} - \text{Option X First Cost}$

(12.8) $\text{Periodic Difference}_1 = \text{Option Y First Year O\&M Cost} - \text{Option X First Year O\&M Cost}$

(12.9) $\text{Periodic Difference}_n = \text{Periodic Difference}_{n\text{-}1} \times (1 + \text{Inflation Rate})$

(12.10) If the First Cost Difference is less than or equal to 0, the Simple Payback equals 0

Otherwise the Simple Payback equals the First Cost Difference divided by the First Year O&M Cost Difference

Net Present Value and Internal Rate of Return are calculated for the analysis period with the user input analysis period, inflation rate, and hurdle rate using standard functions. The series of periodic cash flows are from Periodic Difference$_n$ calculated above.

Exhaust Fan Attributes

Fan Motor Efficiency %

You can calculate the value using the formula:

$$(13.1)\quad \text{Efficiency} = \frac{\text{power output (kW)} \times 100}{\text{power input (kW)}}$$

Calculate Horsepower

LabPro calculates the value using the formula:

$$(13.2)\quad \text{Motor Horsepower} = \frac{\text{Design Flow} \times \text{Static Pressure}}{6356 \times \text{Fan Efficiency} \times \text{Altitude Correction Factor}}$$

Corridor Tab

Calculate Cooling CFM

LabPro calculates this value using the formula:

$$(13.3)\quad \text{Cooling Flow} = \frac{\text{watts/(sq.ft. or sq. meter)} \times \text{corr. area (sq. ft. or sq. meter)} \times 3.413}{1.08 \times \Delta\text{T (Supply Air Temp. - Corridor Temp.)}}$$

Calculate Maximum Cooling Flow

LabPro uses the equation:

$$(13.4)\quad \text{Max Cooling Flow} = \frac{\text{watts /(sq. ft. or sq. meter)} \times \text{corr. area (sq. ft. or sq. meter)} \times 3.413}{1.08 \times \quad \text{T (Supply Air Temp. - Corridor Temp.)}}$$

Room Tab

Calculate Maximum Cooling Flow

LabPro uses the equation:

$$(15.1)\quad \text{Max Cooling Flow} = \frac{\text{watts/(sq. ft. or sq. meter)} \times \text{room area (sq. ft. or sq. meter)} \times 3.413}{1.08 \times \quad \text{T (Supply Air Temp. - Room Air Temp.)}}$$

to automatically fill in the Maximum Cooling Flow field in the Thermal Information portion of the Edit Room Attributes section of the Room tab.