Design and Implementation of Web-Based Tool for Space Cooling Load Calculations

GRADUATE PROJECT TECHNICAL REPORT

Submitted to the Faculty of
the Department of Computing and Mathematical Sciences
Texas A&M University-Corpus Christi
Corpus Christi, Texas

in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Computer Science

By

Carl J. Perales
Fall 2005

Committee Members

Dr. John Fernandez
Committee Chairperson

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ABSTRACT

There are various algorithms and steps used in performing HVAC (Heating, Ventilating, and Air-Conditioning) space cooling load calculations based on several Methods available. However, the basic concepts of heat transfer that must be understood by an engineer remain constant. Entry-level engineers are faced with the task of absorbing the large array of information associated with HVAC design and being able to put their newfound knowledge to use effectively. Thus, there is a need for a Web-based tool to provide basic concepts and establish relationships necessary to perform the procedures in determining the space cooling loads within a building. The goal of this project was to provide a step-by-step guide using interactive Web pages made available to all users via the company’s Intranet as well as the Internet. Based on user input, the system interacts with a database to provide and determine the required information necessary to complete the calculations being performed.
### TABLE OF CONTENTS

Abstract .................................................................................................................. ii

Table of Contents .................................................................................................... iii

List of Figures ......................................................................................................... vi

1. Introduction and Background .............................................................................. 1
   1.1 The Problem ..................................................................................................... 2
   1.2 The Tool – A Knowledge Based System ......................................................... 4
   1.3 The Solution ...................................................................................................... 6

2. Design and Implementation of Web-Based Tool for Space Cooling Load Calculations ….. 8
   2.1 Home Page ....................................................................................................... 9
   2.2 HVAC Matrix Map .......................................................................................... 11
       2.2.1 HVAC Matrix Map Legend ................................................................. 12
   2.3 HVAC Matrix Help ......................................................................................... 14
       2.3.1 About HVAC Matrix Map ................................................................. 15
       2.3.2 Space Cooling Load ........................................................................... 16
       2.3.3 Procedure for Calculating Space Cooling Load by CLTD Method ...... 17
       2.3.4 Sample Steps ....................................................................................... 19
   2.4 Step 1 – Project Documentation and Indoor Design Conditions ................ 20
   2.5 Step 2 – Project Documentation and Outdoor Design Conditions ............ 22
   2.6 Step 3 – CLTD Correction Factor and Enthalpy Values ................................ 22
   2.7 Step 4 – Glass Input ....................................................................................... 23
   2.8 Step 5 – Glass Output ..................................................................................... 23
   2.9 Step 6 – Wall and Roof Component Assembly ............................................. 25
2.10 Step 7 – Wall and Roof Input .................................................. 25
2.11 Step 8 - Wall and Roof Output ............................................. 26
2.12 Step 9 – Internal Heat Gain Input ........................................... 26
2.13 Step 10 – Internal Heat Gain Output ........................................ 26
2.14 Space Cooling Load Output .................................................... 27

3. System Design ........................................................................... 30
   3.1 Environment ............................................................................ 30
      3.1.1 System Components ......................................................... 30
      3.1.2 System Requirements ...................................................... 35
      3.1.3 Programming Languages ................................................ 35
   3.2 Procedure .............................................................................. 36
   3.3 Knowledge Definition .......................................................... 37
   3.4 Knowledge Design ............................................................... 49
   3.5 Database Design ................................................................. 50
   3.6 Website Design ................................................................. 55
      3.6.1 Site Definition ................................................................. 57
      3.6.2 Database Connection ...................................................... 60
      3.6.3 Web Page Layout ........................................................... 63
      3.6.4 PHP Scripts ................................................................. 66
      3.6.5 Form Development ......................................................... 68
   3.7 Visualization Design ............................................................. 69

4. Evaluation and Results .............................................................. 72
   4.1 User Interface Design .......................................................... 72
LIST OF FIGURES

Figure 1.1  Basic Concept of a Knowledge-Based System.................................4
Figure 1.2  Structure of a Knowledge-Based System........................................5
Figure 2.1   HVAC Matrix – Home.................................................................10
Figure 2.2   HVAC Matrix – Map.................................................................11
Figure 2.3   HVAC Matrix – Map Legend........................................................12
Figure 2.4   HVAC Matrix – Help.................................................................15
Figure 2.5   HVAC Matrix – About HVAC Matrix Map.....................................15
Figure 2.6   HVAC Matrix – Space Cooling Load.............................................16
Figure 2.7   HVAC Matrix – Procedure for Calculating Space Cooling Load by CLTD
Method........................................................................................................18
Figure 2.8   HVAC Matrix – Sample Steps......................................................19
Figure 2.9   HVAC Matrix – Step 1: Project Documentation and Indoor Design
Conditions....................................................................................................20
Figure 2.10  HVAC Matrix – Step 2: Project Documentation and Outdoor Design
Conditions....................................................................................................22
Figure 2.11  HVAC Matrix – Step 3: CLTD Correction Factor and Enthalpy Values…23
Figure 2.12  HVAC Matrix – Step 4: Glass Input..............................................23
Figure 2.13  HVAC Matrix – Step 5: Glass Output...........................................24
Figure 2.14  HVAC Matrix – Step 6: Wall and Roof Component Assembly...........25
Figure 2.15  HVAC Matrix – Step 7: Wall and Roof Input................................25
Figure 2.16  HVAC Matrix – Step 8: Wall and Roof Output...............................26
Figure 2.17  HVAC Matrix – Step 9: Internal Heat Gain Input............................27
Figure 2.18  HVAC Matrix – Step 10: Internal Heat Gain Output......................28
Figure 2.19  HVAC Matrix – Space Cooling Load Output................................28
1. INTRODUCTION AND BACKGROUND

HVAC is an initialism which stands for heating, ventilating, and air-conditioning. These three functions are closely interrelated, as they all change the temperature, humidity, and pressure of the air within a building. In modern building designs, the design, installation and control systems of these functions are integrated into what is known as an HVAC system. Modern buildings and their HVAC systems are required to be more energy efficient while still maintaining occupant comfort and minimizing the negative effects on the environment. “The most important financial aspect of the environmental performance of a building is of course heating or cooling necessary to maintain comfort” [Reffat 1994]. The HVAC space loads represent the amount of heat being transferred to/from the interior of a building. From these space loads, further calculations are performed to yield the heat that must be supplied to or removed from the interior of a building to maintain it at desired conditions.

HVAC design is a complex task requiring a variety of factors to be taken into consideration. Some of the steps required to complete the HVAC design for a building include building thermal analysis, equipment selection and simulation, and system design and sizing. Of these, the first step is commonly referred to as an HVAC load calculation and is the most critical since it is the foundation upon which the design is based. The objective of the system is to provide a guide for performing the space cooling load calculations. “Energy consumption in buildings accounts typically for over 30-40% of the national total annual energy consumption. HVAC systems are major energy users in buildings. Hence, both with respect to environmental impact and economics, the ability to
make sensible and well based decisions regarding the choice and design of HVAC systems, is of the utmost importance” [Hensen 1993].

Space cooling load calculations (SCLC) will ultimately determine the required size of equipment and ductwork necessary to condition a space. If the principles, procedures, and data on which the load calculation is based are flawed or incorrect, it will result in errors that have serious consequences including but not limited to: an inefficient system, ineffective conditioning of a space, loss of a client, and based on current events, will significantly increase the likelihood of being involved in a lawsuit. The concepts must be established and the procedures standardized to prevent these consequences from occurring. The data which is entered into the calculations should be centrally located and available to all users. A computer based tool in the form of a knowledge based system (KBS) is an effective and efficient application for training personnel in performing SCLCs. It is also useful for experienced HVAC engineers since it standardizes the procedures and minimizes the amount of deviations that can occur from the implementation of SCLCs from one engineer to another. The following subsections outline what the problem is, why a KBS was chosen, and what was used to perform the task.

1.1 The Problem

Small consulting firms are faced with the task of training and developing new staff with little overhead available, since they generally do not have the financial base to devote a department to in-house training. Most often there is only a short time set aside for training and no one in particular is assigned to guide new hires. Entry-level engineers are often involved almost immediately in project design and expected to produce the
same quality product as experienced engineers for the company’s clients. The thrown-
into-the-fire tactic is one training ideology used in many small firms because of 
economics. In these situations, this type of training can have a negative impact on an 
entry-level engineer’s knowledge base and his ability to make an informed decision. This 
can lead to an unstable foundation of knowledge and decision-making abilities since the 
development of staff, critical to maintaining a quality product for clients, is not a top 
priority. The role of a consulting firm is to continually produce a quality end product that 
is both feasible and cost-effective. The development of new staff is often overlooked due 
to the concentration of current staff in maintaining the quality of their own projects and 
meeting deadlines. This is in essence a catch-22 scenario.

The expected user, in this case an entry-level engineer, for this training system 
typically has an education in an engineering field but does not possess the specific 
knowledge of the procedures required to perform the space load calculations. The typical 
user possesses analytical skills and a general understanding of heat transfer but does not 
possess a combination of both with which to accurately and efficiently perform the task. 
There are training seminars available but these have several disadvantages and 
drawbacks. Included in these are the costs associated with outsourcing training, the 
unknown effectiveness of these seminars, and the lack of inclusion of company standards 
and heuristics, or rules of thumb.

Performing SCLCs is not an exact science. There are many methods that can be 
utilized to calculate a building’s space cooling load. Many of these methods have been 
published in handbooks written by the American Society of Heating, Refrigerating, and 
Air-Conditioning Engineers (ASHRAE). While a particular method may be published by
ASHRAE, the society does not endorse any third-party software product which bases its calculations on a particular ASHRAE recommended method [ASHRAE 2001]. Therefore, it is of significant importance that designers utilize an established procedure and incorporate rules of thumb that have been developed and approved by their company. The implementation of a KBS, defined in Section 1.2, is meant to minimize the deviations from these standards and heuristics and to inform, instruct, and implement a company-wide method with the ultimate goals of increasing employee knowledge and their ability to use it, eliminating errors made from reading tables in manuals, and reducing the overall amount of time required to perform an SCLC.

1.2 The Tool - a Knowledge-Based System

A knowledge-based system, by definition [Feigenbaum 1988], refers to programs whose competence at a task derives from knowledge about the task domain, or knowledge base. A knowledge base is a collection of knowledge expressed using some formal knowledge representation language. Furthermore, knowledge is the objects, concepts, and relationships that are assumed to exist in some area of interest. Figure 1.1 illustrates the basic concept of a KBS. The KBS consists of two main components. The knowledge base contains the knowledge with which the inference engine draws conclusions [Giarratono 1998]. These conclusions are the results of the user queries.

![Figure 1.1 Basic Concept of a Knowledge-Based System](image-url)
The elements of a KBS typically consist of the following [Giarratono 1998]: user interface – the mechanism by which the user and the system communicate; explanation facility – explains the reasoning of the system to a user; working memory – a global database; inference engine – makes inferences by deciding which step to execute; agenda – a prioritized list of actions created by the inference engine; and a knowledge acquisition facility – a way to allow the user to enter information into the system and is most often an optional feature in a KBS.

![Basic Structure of a Knowledge-Based System](image)

**Figure 1.2 Basic Structure of a Knowledge-Based System**

“The potential benefits of such a system are to bring expert knowledge within the reach of less experienced engineers, thus reducing the need for an experienced professional in this area to attend to every step of analysis. Also, this system would save considerable amount of man hours” [Reffat 1994]. There are many benefits that can be
attributed to the use of a KBS. These include improvements in productivity, preservation of knowledge, economical benefits, improved quality of goods and services, training, and job enrichment. Of these, training is the focus of the proposed system which inherently improves all other aspects. Improvements of training employees using a KBS are that it establishes a “consistency in decision-making…better compliance to organizational policies and procedures…reduces training time…quickly improves skills…and assists in the documentation of decision-making information for future use and training” [Martin 1996]. A KBS, when implemented, has the obvious potential to save money which traditionally is what drives product development.

The Web-based tool discussed in Section 2 is built upon on an engineering database of known facts, but the tool does not operate as a rule-based system. The tool uses information directly from the database to make space cooling load calculations so it does not rely on an inference engine. The information and steps provided to the user are primarily applicable to engineers who perform space cooling load calculations.

1.3 The Solution

The KBS, coupled with a graphical user interface (GUI) in the form of Web pages, provides all necessary components, facts and rules, to perform a space cooling load calculation. The strategy is to have a training system that is user friendly and allows the user to learn as he applies the procedures necessary to perform his work. Based on the author’s own background and experience in the HVAC field, the opportunity to develop and test this system in an actual company environment was conceived. The following section will focus on providing an external view of the system as it appears to the user. More precisely, the focus will be on the contents of the system that are presented
to the user via Web pages made available on the company’s intranet as well as on the Internet at the www.hvacmatrix.com website. Section 3 will focus on an internal view of the system by documenting each of the major components to show how the system was designed and implemented. This includes the programming languages and software applications used to develop the system. An evaluation of the system will be discussed in Section 4 followed by Section 5, which will identify additional work that can be done to improve the system. Finally, Section 6 will provide an overview of why this project was important, what it accomplished, how it accomplished it, and what future work is worth pursuing.
2. DESIGN AND IMPLEMENTATION OF WEB-BASED TOOL FOR SPACE COOLING LOAD CALCULATIONS

This system is a training tool for entry-level HVAC designers used to expedite their development and capability in performing space cooling load calculations. This is accomplished through visual and written aids throughout the Website which provides a foundation of the concepts and relationships involved while the user is performing the SCLC. This training tool is primarily aimed at improving the accuracy and efficiency of a designer in performing SCLCs. The system also reduced the amount of time required to perform a space cooling load calculation. The incorporation of this system has provided a more stable infrastructure and further established a foundation for more innovative and effective uses of information technology within the firm. In this regard, the system has fulfilled its functional requirements but also is keeping pace with the ongoing development of the company Intranet that is helping to distribute and enforce company-approved processes.

The following sections each cover a page and/or step that is contained within the www.hvacmatrix.com website, where the system is currently hosted. Each page will be discussed primarily using a screenshot image along with keyed notes to point out specific aspects. Keyed notes are denoted by the symbol # where the # represents a specific number and an arrow associates each symbol with its respective item. Where common occurrences are present, such as the top navigation bar on each page, these aspects will only be highlighted once unless further discussion is deemed necessary. In certain instances, the header of a page was eliminated from the screenshot to simplify the content shown throughout this section. Of note, the only page not following the overall theme of the site is the site map itself, which is discussed in greater detail in Section 2.2.
2.1 Home

The first step in preparing the user to utilize the training system was to establish the look and feel of the site. Hence, a simple, easy to follow and functional design was the key requirement in creating the Home page (Figure 2.1), which would set the tone for the whole site. Keyed note 1 identifies the top navigation bar that is present on each page of the site (excluding the site map). The top navigation bar contains three links. ‘HVAC Matrix Home’ is the link to the Home page, ‘HVAC Matrix Map’ is the link to the interactive site map, and ‘HVAC Matrix Help’ is the link to the Help page. Keyed note 2 identifies the left navigation bar, which is a dynamic link in that as the user progresses through the steps, the links change to different samples that are in alignment with the step(s) being performed. These samples are screenshots of the steps that have been completed so that the user can visually see an example of the current and next steps. The ‘Sample Step Info’ link on the Home page is an explanation of this feature. Keyed note 3 indicates the submit button common to each step which is used to advance the user to the next step once all fields have been completed. The items denoted by keyed note 4 are in essence redundant links but serve to indicate how links located within the body of a page are formatted, with the color being a different blue, having a bold font and are underlined. The GPM Engineering image, keyed note 4, is a .gif image, with a defined area that also links to the Home page when clicked.

Further formatting of the pages includes use of font type, size, color, and weight. Where pages of the site are not actual steps in the SCLC, they are denoted with red page titles within the body of the page, as indicated by keyed note 6. Keyed note 7 shows the font characteristics of typical body text, while keyed note 8 identifies the disclaimer that
is only present on the home page, therefore shown in italics. The disclaimer provides the user with a quick description of the knowledge base and its limitations, the method utilized, and the ability to e-mail the site administrator to request help. The left menu designated by keyed note 9, identifies the company contact information and is common to all pages. While often provided through a link, it was deemed appropriate to have the contact information as a static entity on each page.

In summary, features identified by keyed notes 1, 4, 5, 7, and 9 are common to all pages of the site. Keyed item 6 is common to non-step pages, keyed item 8 is unique to the Home page, while items identified by keyed notes 2 and 3 are universal features of the step pages.

Figure 2.1 HVAC Matrix - Home
2.2 HVAC Matrix Map

A star tree as depicted in Figure 2.2 represents the HVAC Matrix Map. Inxight Star Tree™ technology is Inxight's patented, proven technique for navigating and visualizing Web sites and other hierarchical information collections. Inxight StarTree software allows users to generate a hyperbolic tree to navigate and explore hierarchical relationships and drill-down to information of interest. Using StarTree technology, hierarchies were laid out in a uniform way on a hyperbolic plane, which was mapped onto a circular display region. This supports a smooth blending between focus and context, as well as continuous redirection of the focus. Manipulating the focus can be achieved through pointer clicks as well as interactive dragging. Features also include spotlighting, the ability to include icons, and a variety of other controls [Inxight 2005].

Figure 2.2 HVAC Matrix – Map
As mentioned previously, the HVAC Matrix Map page is unique to all other pages within the site. This page is an interactive site map, containing nodes that are linked directly to non-step pages as well as linked to samples of all the step pages. The Center Star Tree button denoted by keyed note 1 (Figure 2.2) can be clicked to re-center the star tree on the root node. The text field, keyed note 2, allows the user to enter a term to search. Once typed, the binocular button can be clicked to search the tree for the text. If search term is not found, ‘None found’ is displayed. If the term is found, the node containing it will be highlighted with an arrow and the menu bar will display: ‘Found: # of #’. When multiple nodes are found with the same term, the user can toggle to each one by using the arrow buttons. This gives the user a better idea of how prevalent a certain term is within the site, thus more matches indicate greater importance. Maintaining reference to Figure 2.2, Inxight provides its own help page which is accessed when the ? button, keyed note 3, is clicked. Keyed note 4 identifies the Inxight image, which targets Inxight’s own home page. Keyed note 5 denotes the reference to Inxight Star Tree Studio™ which was the software used to generate the star tree. The actual star tree itself is identified by keyed note 6, consisting of a root node connected to parent and child nodes, known as branches. Hence, the visual image created by the nodes with a centrally located root node simulating attributes of a star, with nodes connected by lines forming branches, simulating the attributes of a tree.

2.2.1 HVAC Matrix Map Legend

The HVAC Matrix Map was designed as a traditional site map yet having more interactive features. These features are identified in Figure 2.3, with the following numbered list referencing the keyed notes shown:
Figure 2.3 HVAC Matrix – Map Legend

1. The root node of the star tree. Representing the home page of the site and color-coded in green to indicate its uniqueness. Double clicking this node takes the user to the Home page. In this instance the text in the node represents the site name.

2. The first nodes encountered from the root node, are the Step nodes. These nodes represent each step the user will encounter. Double clicking these nodes take the user to each respective sample step. In this instance, the text in the node represents the step and the # is for the step number. These nodes are color-coded in red to indicate being step nodes. The only variation to this format is for the node representing the Help pages, which is a branch of the star tree that is linked directly to the Help pages.

3. The first child of the Step nodes is the Step title. These nodes provide a link to page that provides a written description of the step and are color-coded orange.
4. Then next child following the Step title is either the title of a sub-step or a field that is found within the actual contents of the Step pages. If a step has more than one major feature, a sub-step title will be shown that will link to a page with a description of that sub-step. If not, this node will be a field name contained within the step and will link to a page with a description of the field and its purpose.

5. The minus (-) symbol located in the bottom right corner of a node indicates that all its child nodes are currently displayed. The primary function of this feature is to allow the user to expand or contract nodes to show the information of interest. If a plus (+) symbol is shown in this location, it indicates that the node is a parent and has one or more children not currently shown on the screen.

6. This is the last child node of the tree also known as a leaf node and is color-coded violet to signify the end of the branch. These nodes are labeled with variable of field names that are found within the context of their respective Step node. Selecting these nodes will bring a page that describes the variable or field.

7. This is the tool tip feature that pops up when the user moves the mouse over a node. A short description and/or an instruction will be shown in the tool tip.

8. This is known as the link and refers to the connection between two nodes. It is indicated simply be a line connecting two nodes is dynamic in that it contracts and stretches to match the users manipulation of the tree while still maintaining order.

2.3 HVAC Matrix Help

Clicking the ‘HVAC Matrix Help’ link located in the right hand side of the top navigation bar accesses the HVAC Matrix Help feature. By selecting this link, the user is taken to the ‘HVAC Matrix Help Page’ as shown in Figure 2.4. This page contains links
to four specific areas of information as indicated by keyed note 1 that the user should familiarize himself with prior to performing the steps in the SCLC. Each of these links is described in the following subsections. At some point the user may be going back and forth to this Help page while exploring the help features and is given the opportunity to go to step 1 (keyed note 2) through a submit button.

Figure 2.4 HVAC Matrix – Help

2.3.1 About HVAC Matrix Map

The About HVAC Matrix Map page shown in Figure 2.5 gives a brief description of what the map is and how it can be utilized (keyed note 2). A redundant link (keyed note 1) is provided as the end of the description to further encourage the user to explore the HVAC Matrix Map.

Figure 2.5 HVAC Matrix – About HVAC Matrix Map
2.3.2 Space Cooling Load

The Space Cooling Load page shown in Figure 2.6 defines a space cooling load so that the user understands the concepts being applied. Space cooling load is the rate at which heat must be removed from the space to maintain room air temperature at a constant value. Space heat gain is the amount of heat entering a space. This heat is transferred to the space by radiation and conduction. Heat gain occurs in several forms. The major modes of entry include (1) solar radiation through transparent surfaces such as glass; (2) heat conduction through exterior glass, walls and roofs; and (3) heat generated in the space by people, lights, and equipment.

Figure 2.6 HVAC Matrix – Space Cooling Load

The space cooling load calculation technique utilized in this system is the CLTD method which uses cooling load temperature differential (CLTD) data for one step calculations of cooling load from conduction heat gain through sunlit walls and roofs and conduction through glass exposures. CLTDs include the effect of (1) time lag in conductive heat gain through opaque exterior surfaces and (2) time delay by thermal storage in converting radiant heat gain to cooling load. This simplification allows cooling loads to be calculated manually; thus, when data are available and appropriately used, the results are consistent with other methods that require complex calculations and cannot be
hand calculated, therefore making this method a popular choice for both instruction and
use. The procedure for performing in the SCLC is outlined in the following section.

2.3.3 Procedure for Calculating Space Cooling Load by CLTD Method

There are two main components of a space cooling load calculation. External cooling
load accounts for all the heat transfer that occurs through what is known as the building
envelope, namely the glass, walls, and roof. Internal cooling load accounts for all the heat
transfer that occurs within the building, consisting of heat generated by people, lights,
and equipment. Outlined below is the format of this page as indicated by the keyed notes
shown in Figure 2.7.

1. External Cooling Load: The first of the two major components designated in bold
   blue text. The second major component is also identified in the same font style.

2. Conduction through glass, walls, and roof: A subcategory of an external cooling
   load indicated by italicized red text. Other subcategories are similarly identified.

3. Equation: The equation that is applied to determine the value of the subcategory
   and color-coded using green text. Simple arithmetic equation utilizing
   multiplication of different variables and constants.

4. Variable and Constants: Definitions of variables and constants using blue body
   text while maintaining green color-coding of parameters being defined.

5. Submit Button: Provided at bottom of page to allow user to go to Step 1.

The actual implementation and derivation of the equations involved will be described in
detail in Section 3. For simplicity, this page did not contain links to separate pages
containing definitions or additional information so that the user is once again further
encouraged to explore the HVAC Matrix Map.
Procedure for Calculating Space Cooling Load by CLTD Method

There are two main components of a space cooling load: External cooling load accounts for all the heat transfer that occurs through what is known as the building envelope, namely the glass, walls, and roof. Internal cooling load accounts for all the heat transfer that occurs within the building, consisting of heat generated by people, lights, and equipment. Outlined below is a breakdown of these two components along with the equations that are involved.

**External Cooling Load**

- Conduction through glass, walls, and roofs
  \[ q = U \cdot A \cdot (CLTD) \]
  where
  \[ U = \text{design heat transfer coefficient from } U \text{ value table from database based on glass, roof, or wall type} \]
  \[ A = \text{area of glass, roof, or wall calculated from building plans} \]
  \[ CLTD = \text{cooling load temperature difference based on time of day and adjusted for location of project} \]

**Solar Load through glass**

- \[ q = A \cdot (SC) \cdot (SF) \]
  where
  \[ q = \text{cooling load in Btuh (rate of heat gain)} \]
  \[ A = \text{area of glass calculated from building plans} \]
  \[ SC = \text{Solar Coefficient selected from database based on glass type} \]
  \[ SF = \text{Solar Factor selected from database based on building location and time of day} \]

**Internal Cooling Load**

- People
  \[ q = N \cdot (HG) \]
  where
  \[ q = \text{cooling load in Btuh (rate of heat gain)} \]
  \[ N = \text{number of people in space based on building type} \]
  \[ HG = \text{Heat Gain selected from database based on degree of activity} \]

- Lights
  \[ q = 3.414 \cdot W \]
  where
  \[ q = \text{cooling load in Btuh (rate of heat gain)} \]
  \[ 3.414 = \text{the conversion factor between watts and btuh} \]
  \[ W = \text{watts input from electrical plans or lighting fixture data} \]

- Equipment
  \[ q = N \cdot (HG) \cdot (Usage) \]
  where
  \[ q = \text{cooling load in Btuh (rate of heat gain)} \]
  \[ HG = \text{Heat Gain from database based on type of equipment} \]
  \[ Usage = \text{factor which estimates percentage of time equipment is in use} \]
2.3.4 Sample Steps Page

The Sample Steps Page (Figure 2.8) is a page containing links to samples of all the steps the user will encounter in performing the SCLC. The format of this page is simply a listing that contains hyperlinks to each page, images of completed steps for the user to reference, along with the title of the step. The intent of this page is to give the user quick access to all the sample steps. For example, by selecting the ‘Sample Step 1’ link, the user will be taken to a sample page similar to the one shown in Figure 2.9. These links point to the same target as the Step # nodes that are located in the HVAC Matrix Map. A minor inconvenience of the map is the time required to load the Java™ applet used to generate the star tree; thereby, further enforcing the reason for creating this page.
2.4 Step 1 – Project Documentation and Indoor Design Conditions

The first step the user encounters in the procedure is ‘Project Documentation and Indoor Design Conditions’ (Figure 2.9) will be to direct the user to apply the steps learned from the Step 1 node of the star tree. The objective of this step is to properly document the procedure and help the user establish the indoor design conditions. Unless referenced in a list format, keyed notes referenced within body of this text will be denoted by (**) where * denotes the keyed note number.

![Figure 2.9 HVAC Matrix - Step 1: Project Documentation and Indoor Design Conditions](image)

The first three fields are for filing and tracking purposes so that the file may be retrieved at a later date. **Project Number** should be entered in as a 6-digit number based on the job number assigned to the project. i.e., 040001 if the project was started in the year 2004 and was essentially assigned the job number 1. **Project Name** should be entered in as the official name of the project. Furthermore, in the **Project Description** the designer should designate the project type, e.g., New Construction, Remodel, Addition, etc. **Project Notes** can be used to record any significant information which may not be stored elsewhere or which may be needed to refer to at a later date. This can include project contact information, sub-contractor information, the mechanical code which the project is being designed under, etc.

This step allows the designer to choose the **City** in which the project is located. This will establish several values for parameters that will be used later in this procedure. Once the city has been selected, the designer will need to determine what indoor design conditions are required for the project. Currently, our office standards are the following:

- **Summer Indoor Dry Bulb**: 75 degrees
- **Summer Indoor Relative Humidity**: 50%
- **Winter Indoor Dry Bulb**: 70 degrees

Unless otherwise directed, these parameters shall be selected for the project's indoor design conditions.

**Input/Output Format:** The required inputs for all steps are shown by **field** labeled in green. Furthermore, the input data will yield green **text** as information is entered. The outputs for all steps are shown by **field** and **text** in red and should not be modified. Final results are indicated in purple **text**.

**Project Number:** 050001

**Project Name:** Cimmeria Coffee Shop

**Project Description:** New Construction

**Project Notes:**
- **Stand alone building located in Corpus Christi, TX**
- **2003 International Mechanical Code**
- **2003 International Energy Conservation Code**
- **Building Area: 2000 sf**
- **Engineer: Carl J. Perales**

**City:** Corpus Christi

**Summer Indoor Dry Bulb:** 75

**Summer Indoor Relative Humidity:** 50%

**Winter Indoor Dry Bulb:** 70

**Go to Step 2**

Figure 2.9 HVAC Matrix - Step 1: Project Documentation and Indoor Design Conditions

The first step is used to establish most of the formatting criteria used throughout all the step pages the user will encounter. The following list references the keyed notes shown in Figure 2.9:
1. Input/Output Format: Establishes the input/output titles and text fields as a color-coded system where green signifies required input and red indicates output. The SCLC final results are designated as purple text, the only purple text within the entire site.

2. Input titles: Examples of titles that preface text fields requiring user input.

3. Text field: Green text help to confirm that the field is indeed an input field. These fields are empty of course but the figure shown in a sample for illustration.

4. Text area: Multi-line text area will expand to allow the user to input whatever project notes are deemed important.

5. Lists: In many instances the user will encounter list fields where valid input choices have been provided, where the lists are associated to a database table.

6. Submit Button: Provided at bottom of page to allow user to go to next step. The submit button is common to all the step pages.

7. Step Title: Pages of the site that are actual steps in the SCLC are denoted with blue page titles within the body of the page.

8. Quick Connects: Links to samples of the current and next step for quick reference. These links are dynamic in that they change to match the progress of the user and are common to all the step pages.

9. Body text: The area immediately below the Step title generally contains a description of the step along with any pertinent instructions for the step. Key words are indicated by bold font.

2.5 Step 2 – Project Documentation and Outdoor Design Conditions

The second step (Figure 2.10) is used to provide a copy of the project documentation submitted in Step 1 and allow the user to hit the back button should they wish to make a change before submitting the data, which will be saved to the database. Output titles (1) are displayed in red text to indicate to the user that the associated fields (3) are output data. Once again, input titles (2) and fields (4) are displayed in green text.

Figure 2.10 HVAC Matrix - Step 2: Project Documentation and Outdoor Design Conditions

2.6 Step 3 – CLTD Correction Factor and Enthalpy Values

Step 3 (Figure 2.11) follows suit in formatting style of the previous two steps. Unique items to this step include: (1) a message to the user that the inputs submitted have been successfully saved to the database; (2) identification of an output
items that are not part of this SCLC yet have important significance for future work; and (3) text fields that are used to generate specific quantities of input fields in the next step.

Figure 2.11 HVAC Matrix – Step 3: CLTD Correction Factor and Enthalpy Values

2.7 Step 4 – Glass Input

Step 4 (Figure 2.12) has input title (1), field (2) and list (3, 4, 5) quantities generated by input taken from the Step 3. The orientation of the fields and lists match the equations being processed in the step. Text field (6) is an output item derived from Step 3 and applied in this step. A variable derived in one step is commonly applied in an equation occurring in the next step.

2.8 Step 5 – Glass Output

Step 5 (Figure 2.13) contains output titles and fields designated by (1) and input fields (2) that are passed to the next step once the submit button is clicked. Titles in bright blue font (3) help to delineate each section of the step where an equation is being applied. In this case, there are two equations that have been processed.
Figure 2.12 HVAC Matrix – Glass Input

Step 4: Glass Input

This step in the procedure allows the user to enter the glass area, direction, and type of glass used to determine the glass solar heat gain. The glass solar heat gain equation involves the direction which the glass faces since solar heat gain is dependent on the location of the sun. The glass transmission heat gain also uses the glass area and type of glass. However, the difference is that the CLTD is multiplied since heat transmission involves temperature differences.

Glass Solar Heat Gain
Exposures Glass Area, Ft² Direction Type of Glass
Exposure 1 40 N Insulating Glass -> Heat Absorbing Out, Clear In - 1/4 inch
Exposure 2 120 S Insulating Glass -> Heat Absorbing Out, Clear In - 1/4 inch
Exposure 3 80 E Insulating Glass -> Heat Absorbing Out, Clear In - 1/4 inch
Exposure 4 80 W Insulating Glass -> Heat Absorbing Out, Clear In - 1/4 inch

Glass Transmission Heat Gain/Loss
Exposures Gross Window Area, Ft² CLTD Corrected Type of Glass
Exposure 1 15.75 Insulating Glass: Double -> 1/2 inch air space with 1/4 inch glass
Exposure 2 15.75 Insulating Glass: Double -> 1/2 inch air space with 1/4 inch glass
Exposure 3 15.75 Insulating Glass: Double -> 1/2 inch air space with 1/4 inch glass
Exposure 4 15.75 Insulating Glass: Double -> 1/2 inch air space with 1/4 inch glass

Figure 2.13 HVAC Matrix – Glass Output

Step 5: Glass Output

This page contains the glass solar heat and transmission heat gains based on the information provided and values derived from the database. The number of wall components should include the inside and outside air resistances since they offer resistance to heat gain. The user should refer to an architectural wall section to determine the different amount of materials which make up the wall. The number of roof components should also account for the inside and outside air resistances. Often air spaces are used in roof and wall construction and these should be counted as a component since air space also provides resistance.

Glass Solar Heat Gain
Exposures Glass Area, Ft² Solar Factor, Btu/Ft² Solar Coefficient Solar Heat Gain, Btu
Exposure 1 40 27.53 0.55 105.66
Exposure 2 120 42.48 0.55 203.68
Exposure 3 80 57 0.55 150.00
Exposure 4 57 113 0.55 484.00
Total Solar Heat Gain, Btu: 1076.74

Glass Transmission Heat Gain/Loss
Exposures Gross Window Area, Ft² CLTD Corrected, F U Value, Btu/Ft²/F Transmission Heat Gain, Btu
Exposure 1 44 15.75 0.56 388.08
Exposure 2 132 15.75 0.56 1164.24
Exposure 3 88 15.75 0.56 796.16
Exposure 4 88 15.75 0.56 796.16
Total Transmission Heat Gain, Btu: 3104.64

Enter number of wall components: 5
Enter number of roof components: 5

Go to Step 5
2.9  **Step 6 – Wall and Roof Component Assembly**

Step 6 (Figure 2.14) consists entirely of input lists (1, 2, 4, 5) and input field (3).

![Figure 2.14 HVAC Matrix - Step 6: Wall and Roof Component Assembly](image)

**2.10  Step 7 – Wall and Roof Input**

Step 7 (Figure 2.15) shown below, consists of a mixture of input fields (1), input lists (2), and output fields (3) that are used to derive the output shown in Step 8.

![Figure 2.15 HVAC Matrix - Step 7: Wall and Roof Input](image)
2.11 Step 8 – Wall and Roof Output

Step 8 (Figure 2.16) consists of output titles and fields (1) and input fields (2) used to establish input field quantities in Step 9 (Figure 2.17).

![Figure 2.16 HVAC Matrix - Step 8: Wall and Roof Output](image)

2.12 Step 9 – Internal Heat Gain Input

Step 9 consists entirely of input fields (1, 2, 3) and lists (4, 5, 6, 7) that are used to determine the 3 forms (8) of internal heat gain. Once all fields have been entered and the appropriate selections are made from the lists, the user proceeds to the final step.

2.13 Step 10 – Internal Heat Gain Output

Step 10 (Figure 2.18) is the final step of the SCLC and is really just an output summary for the internal heat gains from people, equipment, and lights so that the user has a chance to see the derived quantities in greater detail.
2.14 Space Cooling Load Output

The Space Cooling Load Output page (Figure 2.19) shows the user all the output fields (1) indicating the heat gain totals expressed in two units of heat transfer as well as a percentage of the total heat gain. The total heat gain total (2) is also expressed in the two common units of heat transfer. The submit button (3) is placed as added indication that the SCLC has been completed given the text, ‘Go Home’. The final feature of the SCLC was to provide a print report option (4) for the user that transfers all meaningful data to a new page with a white background, suitable for printing, as shown in Figure 2.20.
### Figure 2.18 HVAC Matrix - Step 10: Internal Heat Gain Output

**Step 10: Internal Heat Gain Output**

This page contains a recapitulation of the information you have inputted/selected so far.

#### People Heat Gain

<table>
<thead>
<tr>
<th>Group</th>
<th>Quantity (People)</th>
<th>Activity, Btu/Hr/Person</th>
<th>Activity Heat Gain, Btu/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>1</td>
<td>710</td>
<td>710</td>
</tr>
<tr>
<td>Type 2</td>
<td>1</td>
<td>710</td>
<td>710</td>
</tr>
<tr>
<td>Type 3</td>
<td>20</td>
<td>710</td>
<td>14200</td>
</tr>
</tbody>
</table>

#### Equipment Heat Gain

<table>
<thead>
<tr>
<th>Group</th>
<th>Quantity (Equipment)</th>
<th>Equipment Heat Gain, Btu/Unit</th>
<th>Equipment Heat Gain, Btu/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>0.5</td>
<td>2</td>
<td>3750</td>
</tr>
<tr>
<td>Type 2</td>
<td>0.5</td>
<td>1</td>
<td>1910</td>
</tr>
<tr>
<td>Type 3</td>
<td>0.5</td>
<td>1</td>
<td>1910</td>
</tr>
<tr>
<td>Type 4</td>
<td>0.5</td>
<td>1</td>
<td>1090</td>
</tr>
</tbody>
</table>

**Total Equipment Heat Gain, Btu/h:** 5250

#### Light Heat Gain

<table>
<thead>
<tr>
<th>Group</th>
<th>Quantity (Lights)</th>
<th>Wattage, Watts</th>
<th>Conversion Factor, Btu/Watt</th>
<th>Light Heat Gain, Btu/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>6</td>
<td>50</td>
<td>3.414</td>
<td>10242</td>
</tr>
<tr>
<td>Type 2</td>
<td>34</td>
<td>120</td>
<td>3.414</td>
<td>10291.2</td>
</tr>
</tbody>
</table>

**Total Light Heat Gain, Btu/h:** 14953.32

### Figure 2.19 HVAC Matrix - Space Cooling Load Output

**SPACE COOLING LOAD OUTPUT**

The first three fields are for filing and tracking purposes so that the file may be retrieved at a later date. **Project Number** should be entered in as a 5-digit number based on the job number assigned to the project, i.e., 04001 if the project was started in the year 2004 and was essentially assigned the job number 1. **Project Name** should be entered in as the official name of the project. Furthermore, in the **Project Description** the designer should designate the project type, e.g., New Construction, Remodel, Addition, etc. **Project Notes** can be used to record any significant information which may not be stored elsewhere or which may be needed to refer to at a later date. This can include project contact information, city department information, the mechanical code which the project is being designed under, etc.

#### External Heat Gains:

- **Glass Solar Heat Gain:** 10757.34
- **Glass Transmission Heat Gain:** 3104.64
- **Wall Heat Gain:** 3305.013869.3659
- **Roof Heat Gain:** 2650.000000001
- **External Heat Gain Total:** 43418.016865367

#### Internal Heat Gains:

- **People Heat Gain:** 17750
- **Equipment Heat Gain:** 5250
- **Light Heat Gain:** 14953.32
- **Internal Heat Gain Total:** 37953.32

**Total Heat Gain:** 81371.336585367 Btu/h

**Heat Gain, tons:** 0.896445

**% of Total Heat Gain:** 13.22006580810

**1935.397575305

**2.9550034878049

**2.87508000001

**3.6181680487006

**53.35785644352

**1.47916666666667

**0.4375

**1.24831

**3.16276666666667

**46.642124355648
### External Heat Gains

<table>
<thead>
<tr>
<th>Description</th>
<th>Heat Gain</th>
<th>tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Solar Heat Gain</td>
<td>10,791.33 Btuh</td>
<td>0.90</td>
</tr>
<tr>
<td>Glass Transmission Heat Gain</td>
<td>3,142.13 Btuh</td>
<td>0.26</td>
</tr>
<tr>
<td>Wall Transmission Heat Gain</td>
<td>11,029.95 Btuh</td>
<td>0.92</td>
</tr>
<tr>
<td>Roof Transmission Heat Gain</td>
<td>17,471.59 Btuh</td>
<td>1.46</td>
</tr>
<tr>
<td>External Heat gain Total</td>
<td>42435 Btuh</td>
<td>3.53625</td>
</tr>
</tbody>
</table>

### Internal Heat Gains

<table>
<thead>
<tr>
<th>Description</th>
<th>Heat Gain</th>
<th>tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>People Transmission Heat Gain</td>
<td>5,070.00 Btuh</td>
<td>0.42</td>
</tr>
<tr>
<td>Equipment Transmission Heat Gain</td>
<td>17,338.80 Btuh</td>
<td>1.44</td>
</tr>
<tr>
<td>Light Transmission Heat Gain</td>
<td>10,952.11 Btuh</td>
<td>0.91</td>
</tr>
<tr>
<td>Internal Heat Total</td>
<td>33360.9 Btuh</td>
<td>2.78008</td>
</tr>
<tr>
<td>Space Cooling Load Total</td>
<td>75,795.91 Btuh</td>
<td>6.32</td>
</tr>
</tbody>
</table>
3. SYSTEM DESIGN

3.1 Environment

The HVAC Matrix system was originally implemented in a Web page format for use on the company’s Intranet. It can be accessed from any workstation connected to the local area network (LAN) that has a Web browser installed. The system is capable of being viewed on the two major Web browsers in use today, Microsoft Internet Explorer and Netscape Navigator. The system was originally developed on a Windows NT 4.0 workstation running the Apache HTTP Server Version 2.0.53 as the Web server. As the system design progressed and time passed, the operating system used to test the system was upgraded to Windows XP Professional. Over time, it was found that the system has no known performance issues by running on Windows NT, 95, 98, 2000, and/or XP operating systems. As an aside, while this project was developed for use on a Windows system, it is a cross-platform Web application. Essentially, this means that while this system was developed in Windows it can serve on a Unix platform. Ultimately, the system was published to a live Website at www.hvacmatrix.com to enhance access to and use of the knowledge base. For the purposes of further discussion, references to the system will consider the entire HVAC Matrix Website; inclusive of all components involved in its design and implementation.

3.1.1 System Components

The system includes the following six major components: a Web server, a Web browser, an HTML editor, a database, a database management tool, and a system visualization tool. The Web server originally chosen to implement this project was the
Apache HTTP Server running locally on a Windows workstation. Once the site was chosen to be developed as a live Website, the system was moved to a Web host which utilized Apache as its Web server. A Web host is simply a business that provides the Web server and space to store all the necessary files so that users can access the Web site. The Apache Web Server was developed for use as an open-source HTTP server for modern operating systems including UNIX and Windows. Apache has been the most popular Web server on the Internet since April 1996. The October 2003 Netcraft Web Server Survey found that more than 64% of the Web sites on the Internet are using Apache, thus making it more widely used than all other Web servers combined [Apache 2004]. A Web browser is a software program that allows you to access Web pages on the Internet, an Intranet, or an Extranet. It can also be considered an application program that interprets HTML (Hypertext Markup Language) and presents the final Web page to the user. In this case, the Web browser was used to access and display Web pages on an Intranet as well as the Internet. Web browsers provide a graphical interface that lets users click buttons, icons, and menu options to view and navigate Web pages. The two most popular browsers are Microsoft's Internet Explorer and Netscape Navigator.

The HTML editor used for this project was Macromedia Dreamweaver MX 2004. Macromedia Dreamweaver MX 2004 is a professional HTML editor for designing, coding, and developing Websites, Web pages, and Web applications. Dreamweaver was used to help build the dynamic database-backed Web application using the server language PHP. One of the many useful features of Dreamweaver was the ability to see both (1) code and (2) design views (Figure 3.1) giving relatively instant changes with the addition and modification of HTML code and PHP scripts.
The database type chosen was MySQL Server 4.1. MySQL is a small, compact database server which supports standard SQL (ANSI) but also compiles on a number of platforms and has multithreading abilities on Unix servers. For non-Unix applications, MySQL can be run as a service on Windows NT and as a normal process in Windows 95/98/2000/XP machines. The MySQL database server is currently the world’s most popular open source database [Mysql 2004]. While MySQL is a powerful and highly reliable database management software, it was not feasible for the author to create, maintain, and manage the database from a command line prompt. Therefore, a software tool with a GUI was necessary to expedite constructing the database. The database management tool chosen was phpMyAdmin 2.6.0 which is “a tool written in PHP intended to handle the administration of MySQL over the Web. Currently it can create
and drop databases, create/drop/alter tables, delete/edit/add fields, execute any SQL statement, manage keys on fields, manage privileges, and export data into various formats” [PhpMyAdmin 2004]. Fortunately, this tool (Figure 3.2) was available as a service from the Web host provider.

![Image of phpMyAdmin tool](image.png)

**Figure 3.2 phpMyAdmin**

The phpMyAdmin tool shown above gives an overall view of how the database was constructed. The left menu (1) contains all fifteen tables that were created in the database. The main window provides a listing of the tables along with a variety of actions (2) to choose from ranging from defining the table structure, dumping data, or even deleting the entire table. Table information (3) is also displayed including the number of records contained, the table type, and the table size (storage). A few other features (4)
include printing a listing of the database tables, viewing the data dictionary of each table, and of the option to create new tables with just a table name and the number of fields.

The visualization tool used to represent the system was Inxight Star Tree™ Studio (Figure 3.3). This software technology is Inxight's patented, proven technique for navigating and visualizing Web sites and other hierarchical information collections. The goal was to provide the user with an overview of the system as well as an explanation of the steps required to complete the calculations. This information was laid out in a uniform way on a hyperbolic plane, which is mapped onto a circular display region, known as a star tree. Key features of this software included the ability to (1) apply global properties to nodes making up the star tree, (2) set specific nodal properties, as well as (3) specify caption properties of the text displayed on the nodes.

Figure 3.3 Inxight Star Tree™ Studio
3.1.2 System Requirements

The following hardware and software were required to run the system. These requirements were based largely on Macromedia Dreamweaver’s required specifications to install and run their software. An Intel Pentium II Processor or equivalent, 300 MHz or faster; a Windows 98, Windows 2000, Windows NT (with Service Pack 3 or later), Windows ME, or Windows XP operating system; Version 4.0 or later of Netscape Navigator or Microsoft Internet Explorer for a Web browser; 96 MB of available random-access memory (RAM); 275 MB of available disk space; and a 256-color monitor capable of 800 x 600 pixel resolution. Inxight Startree required a Java compiler compatible with JDK (Java Development Kit) 1.1 and above. Java Virtual Machine was required to be installed on the local computer being used to view the star tree page.

3.1.3 Programming Languages

This project utilized a combination of HTML and PHP. HTML is simply a language used to create Web pages. PHP (recursive acronym for "PHP: Hypertext Preprocessor") is an open source general-purpose scripting language that is especially suited for Web development and can be embedded into HTML [Php 2004]. PHP is a server-side scripting language. PHP script is processed by the Web server. After the server interprets the PHP code, it returns HTML back to the browser. What distinguishes PHP from something like client-side JavaScript is that the code is executed on the server. For this project, Apache was configured to process all the HTML files with PHP, so that users only see the results of the PHP coding.
3.2 Procedure

The following steps were followed in the development of this system. First, the relevant data were collected regarding the components of a space cooling load calculation. Secondly, this information was structured and organized into tables using the phpMyAdmin database manager. Finally, the system was developed in Macromedia Dreamweaver MX using PHP code to create the functions required to interact with the MySQL database with HTML code to generate the majority of the Web page layout. The methodology used to create the system was prototype development. The overall concept of the steps used to develop the system can be seen in Figure 3.5.

Figure 3.4 System Development Process
3.3 Knowledge Definition

The objective of the knowledge definition stage is to define the knowledge requirements of the system. The knowledge definition stage consists of two main tasks: knowledge source identification and selection and knowledge acquisition, analysis, and extraction [Giarratano 1998]. The main objective of these tasks is to produce and verify the knowledge required by the system in preparation for the next stage of knowledge design. The main source of knowledge acquisition was through the use of the ASHRAE Fundamentals handbook [ASHRAE 2001] to establish the procedure used, in this the CLTD Method, as well as to assemble the data. This source is recognized as the international industry standard in the HVAC field and is updated once every four years. The final source was through five years of the author’s work knowledge in the HVAC industry.

The equations involved in performing the CLTD method for a SCLC were taken from the ASHRAE Fundamentals handbook and were utilized in the PHP scripts to process data. Eq. (3.1) is the first equation that must be processed in order to ensure that the results are precise. This equation establishes the correction factor that must be added to each CLTD factor when applying Eq. (3.2)

\[
\text{CLTD Correction} = \text{TD} - \frac{(\text{DR} + 14)}{2}
\]  

where

\(\text{TD} = \) temperature difference between indoor and outdoor design conditions utilizing the following parameters based on user input: \(\text{coolingDryBulb} - \text{IndoorDryBulb}\)

\(\text{coolingDryBulb}\) represents the outdoor design condition specified by the user and extracted from the \text{hvacdata} database table 1_climatic_conditions_texas; code shown in
Figure 3.5 creates a dynamic list that is displayed to the user so that he can choose the outdoor design conditions.

$sIndoorDryBulb$ represents the indoor design condition specified by the user by selecting from the static list provided in the drop down menu using the code shown in Figure 3.6.

$DR = \text{Daily Range}$ obtained by matching the city selected by user and extracting the $DailyRange$ field (Figure 3.7) from the $hvacdata$ table $1\text{climatic_conditions_texas}$

```html
<tr>
  <td class="fieldtitle">Cooling Dry Bulb/Cooling Wet Bulb:</td>
  <td>
    <select name="coolingDryBulb" class="style4">
      <option value=""><?php echo $Cooling_DryBulb1 ?></option>
      <option value=""><?php echo $Cooling_DryBulb2 ?></option>
      <option value=""><?php echo $Cooling_DryBulb3 ?></option>
    </select>
  </td>
</tr>
```

**Figure 3.5 Eq. (3.1): Selecting $coolingDryBulb$**

```html
<tr>
  <td width="174" class="fieldtitle">Summer Indoor Dry Bulb:</td>
  <td>
    <select name="sIndoorDryBulb" class="style4">
      <option>65</option>
      <option>66</option>
      <option>67</option>
      <option>68</option>
      <option>69</option>
      <option>70</option>
      <option>71</option>
      <option>72</option>
      <option>73</option>
      <option>74</option>
      <option>75</option>
      <option>76</option>
      <option>77</option>
      <option>78</option>
      <option>79</option>
      <option>80</option>
    </select>
  </td>
</tr>
```

**Figure 3.6 Eq. (3.1): Selecting $sIndoorDryBulb$**
Transmission heat gain through glass, wall, and roof is calculated using Eq. (3.2).

It consists of the three main components as described below.

$$q = U \times A \times (\text{CLTD})$$

where

$q =$ cooling load in Btu/h (rate of heat gain)

$U =$ design heat transfer coefficient from $U$ value table (glass) from database or derived from $R$ value tables (wall and roof) from database based on building components selected

$A =$ Area of glass, wall, or roof calculated from building plans

$\text{CLTD} =$ Cooling Load Temperature Difference based on time of day and adjusted for location of project by including the $\text{CLTD Correction}$ value.
In Figure 3.8, the first step in processing Eq. (3.2) is shown. The PHP code creates the recordsets that will be referenced when creating dynamic lists. Figure 3.9 shows the specific PHP code which is taken from Step 6 of the SCLC that displays the dynamic list of roof components to user. Each component has an R value associated with it. While not shown in the figures below, the application of Eq. (3.2) is identical when applied to walls. The only difference when applying the equation to glass is that the U value is directly related to the glass type and is generally provided by the manufacturer of the glass.

The relationship between the U value and R values when applying Eq. (3.2) to walls and roofs is as follows: 

\[
U = \frac{1}{R_{total}}
\]

where \( R_{total} \) is equal to the summation of all R values. This intermediate step (Figure 3.10) must be calculated when applying Eq. (3.2) to walls and roofs. This calculation occurs in Step 7.

```php
3  # mysql query to create rWalls recordset of all fields from 8_r_walls table
4  mysql_select_db($database_hvacData, $hvacData);
5  $query_rWalls = "SELECT * FROM `8_r_walls` ORDER BY Material ASC";
6  $rWalls = mysql_query($query_rWalls, $hvacData) or die(mysql_error());
7  $row_rWalls = mysql_fetch_assoc($rWalls);
8  $totalRows_rWalls = mysql_num_rows($rWalls);
9  # mysql query to create rRoofs recordset of all fields from 9_r_roofs table
10 mysql_select_db($database_hvacData, $hvacData);
11 $query_rRoofs = "SELECT * FROM `9_r_roofs` ORDER BY Material ASC";
12 $rRoofs = mysql_query($query_rRoofs, $hvacData) or die(mysql_error());
13 $row_rRoofs = mysql_fetch_assoc($rRoofs);
14 $totalRows_rRoofs = mysql_num_rows($rRoofs);
15 # mysql query to create wallType recordset of all fields from 10_group_walls table
16 mysql_select_db($database_hvacData, $hvacData);
17 $query_wallType = "SELECT * FROM `10_group_walls`";
18 $row_wallType = mysql_fetch_assoc($WallType);
19 $totalRows_wallType = mysql_num_rows($wallType);
20 # mysql query to create roofType recordset of all fields from 11_group_roofs table
21 mysql_select_db($database_hvacData, $hvacData);
22 $query_roofType = "SELECT * FROM `11_group_roofs`";
23 $row_roofType = mysql_fetch_assoc($roofType);
24 $totalRows_roofType = mysql_num_rows($roofType);

Figure 3.8 Eq. (3.2): Recordsets of R values, Wall and Roof Types
Figure 3.9 Eq. (3.2): Dynamic List of R values for Roof Components

```php
<?
for ($i = 0; $i < $trootComponents; $i++) {
    echo "Component ", $i;
}<?

<?
<select name="tRoots[]" class="style4a">
<?
for ($i = 0; $i < $tRoots; $i++) {
    $r = $tRoots[$i];
    echo "Component ", $r;
}<??></select>

<?php do { ?>
    <!-- displays the material list and assigns the R value to the variable tRoot for Step 7 -->
    <option value=""<?php echo $tRoots[$tRoot];?>"><?php echo $tRoots[$Material];?></option>
<?php } while ($row_roofs = mysql_fetch_assoc($tRoots));
        $rows = mysql_num_rows($tRoots);
        if ($rows > 0) {
            mysql_data_seek($tRoots, 0);
            $row_roofs = mysql_fetch_assoc($tRoots);
        }
    ?>
</select> <!-- end of list -->
</td></tr>
<?php } ?> <!-- end of for loop -->
```

Figure 3.10 Eq. (3.2): Calculating the U value of Roof

```
# for loop to sum up all R values to calculate U value of roof
for ($x = 0; $x < $troofComponents; $x++) {
    global $rRoof, $rRoot;
    // Test for variable tRoofs: echo "roof R is: ", $xRoofs[$x]."<br>";
    $rRoof += $xRoofs[$x];
    $rRoot = 1/$rRoof;
}
```

Figure 3.11 indicates the PHP code required to process the three main components of Eq. (3.2). The roofCLTD recordset is created by matching the roof type selected by the user in Step 7. This recordset (code lines 50-55) extracts the CLTD value based on the roof type and the CLTD Correction value is added (code line 58). The U value of the roof, calculated in Step 7, is multiplied by the roof area, obtained as user input in Step 6, then multiplied by the roof CLTD value (code line 68) to obtain the transmission heat gain through the roof.
Solar heat gain through glass is calculated using Eq. (3.3). The only building envelope component that this equation applies to is glass, since it is the only component allowing solar transmission.

\[ q = A \times (SC) \times (SF) \]  

where

- \( q \) = cooling load in Btu/h (rate of heat gain)
- \( A \) = Area of the glass exposed to sunlight as determined from building plans; obtained from PHP code occurring in Step 4 as indicated in Figure 3.12 below.
- \( SC \) = Solar Coefficient extracted from database based on glass type selected by user; obtained from PHP code occurring in Step 5 as indicated in Figure 3.13.
- \( SF \) = Solar Factor derived from database based on city location and time of day
The SF variable of Eq. (3.3) requires 3 components to derive. These components are the direction in which the glass is facing (Figure 3.14), the city in which the building is located (Figure 3.15), and the time of day in which the solar transmission is occurring. For the purposes of this system, the time of day chosen was 4 pm since it is historically the time at which maximum solar transmission occurs and is accepted as the industry standard when applying the CLTD method. The solarFactor recordset that is generated in Step 5 of the SCLC (Figure 3.15) using code lines 20-25, requires matching the glass direction and city location to derive the solar factor. Eq. (3.3) is processed in its entirety in code line 35. The equation involves utilizing a mixture of information including direct user input as well as requiring multiple database queries and transactions.
The rate of heat gain produced by the people occupying a space is calculated using Eq. (3.4). It requires that the user identify the type of occupancy which generally determines the expected quantity of people based on a square footage factor per code.

\[ q = N \times (HG) \quad (3.4) \]

\( q \) = cooling load in Btu/h (rate of heat gain)

\( N \) = number of people in space based on building type indicated on plans

\( HG \) = Heat Gain from people selected from database based on activity; Figure 3.16 indicates Activity recordset (code lines 11-15) created to provide user with a choice of activities. This recordset includes the associate heat gain value for each type of activity.
The rate of heat gain produced by equipment is calculated using Eq. (3.5). It requires that the user determine the approximate usage of each piece of equipment.

\[ q = N \times (HG) \times (Usage) \]  

\( q \) = cooling load in Btu/h (rate of heat gain)  
\( N \) = quantity of equipment as indicated on building plans  
\( HG \) = Heat Gain from equipment based on equipment type and extracted from database;  
Figure 3.16 indicates the equipment recordset created to provide user with dynamic list  
\( Usage \) = factor which estimates the percentage of time equipment is in use

The rate of heat gain produced by lights in a space is calculated using Eq. (3.6).

\[ q = N \times 3.414 \times W \]  

\( q \) = cooling load in Btu/h (rate of heat gain)  
\( N \) = quantity of light fixtures as indicated on building plans  
3.414 is the conversion factor between watts and Btu/h  
\( W \) = Watts; derived by user selecting type of light fixture shown on building plans;  
Figure 3.16 indicates the watts recordset used to later provide user with a dynamic list

```php
// mysql query to create Activity recordset of all fields from 12_people table
mysql_select_db("database_hvacData", $hvacData);
$query_Activity = "SELECT * FROM '12_people' ORDER BY Activity ASC";
$Activity = mysql_query($query_Activity, $hvacData) or die(mysql_error());
$row_Activity = mysql_fetch_assoc($Activity);
$totalRows_Activity = mysql_num_rows($Activity);

// mysql query to create equipment recordset of all fields from 13_equipment table
mysql_select_db("database_hvacData", $hvacData);
$query_equipment = "SELECT * FROM '13_equipment'";
$equipment = mysql_query($query_equipment, $hvacData) or die(mysql_error());
$row_equipment = mysql_fetch_assoc($equipment);
$totalRows_equipment = mysql_num_rows($equipment);

// mysql query to create watts recordset of all fields from 14_lights table
mysql_select_db("database_hvacData", $hvacData);
$query_watts = "SELECT * FROM '14_lights'";
$watts = mysql_query($query_watts, $hvacData) or die(mysql_error());
$row_watts = mysql_fetch_assoc($watts);
$totalRows_watts = mysql_num_rows($watts);
```

Figure 3.16 Eq. (3.4, 3.5, 3.6): Defining Recordsets
In Figure 3.17, Eqs. (3.4) and (3.5) are processed in Step 9 of the SCLC. In this step, the user is required to enter quantities of people and equipment, both obtained by using input text fields that are subsequently passed onto Step 10. Additionally, dynamic lists are generated using the recordsets defined in Figure 3.16.

```php
<?php do { ?>
    <option value="$row_activity['Name']">$row_activity['Name']</option>
<?php } while ($row_activity = mysql_fetch_assoc($query));

<?php do { ?>
    <option value="$row_equipment['Name']">$row_equipment['Name']</option>
<?php } while ($row_equipment = mysql_fetch_assoc($query));

for ($i = 0; $i < $activities; $i++) {
    echo "<select name="Activity" class="style4">
    <option value="">Select Activity...</option>
    " . $row_activity['Name'] . "</option>
</select>
</td>

for ($i = 0; $i < $appliances; $i++) {
    echo "<select name="Appliance" class="style4">
    <option value="">Select Appliance...</option>
    " . $row_equipment['Name'] . "</option>
</select>
</td>
```

Figure 3.17 Eq. (3.4, 3.5): User Input and Dynamic Lists
Finally, the PHP code shown below in Figure 3.18 is processed prior to any HTML code being executed in Step 10 of the SCLC. The code listed below handles all three of the equations involving internal heat gains. The format to process each equation involves applying a for loop to cycle through each quantity and type, calculating results for each, and finally adding each of the results to a global variable to hold the total value. These values were used to display the output within Step 10 as well as on the Space Cooling Load Output page of the SCLC.

```
# for loop to process each quantity and type of activity
for ($i = 0; $i < $activities; $i++) {
    // Testing variable: echo "activity is: ".Activity[$i]."<br>";
    # Calculating equation q = N * H0 for people
    $peopleResult[$i] = $Quantity1[$i] * Activity[$i];
    // Testing - echo "result is: ".$peopleResult[$i]."<br>";
    $peopleTotal += $peopleResult[$i];
}

# for loop to process each quantity and type of equipment
for ($i = 0; $i < $appliances; $i++) {
    /* Testing output of variables
    echo "equipment is: ".Equipment[$i]."<br>";
    echo "quantity is: ".$Quantity2[$i]."<br>";
    echo "usage is: ".Usage[$i]."<br>";
    */
    # Calculating equation q = N * H0 * Usage for equipment
    $equipmentResult[$i] = $Quantity2[$i] * Equipment[$i] * Usage[$i];
    // Testing variable: echo "result is: ".$equipmentResult[$i]."<br>";
    $equipmentTotal += $equipmentResult[$i];
}

# for loop to process each quantity and type of light fixture
for ($i = 0; $i < $fixtures; $i++) {
    /* Testing output of variables
    echo "light is: ".$Watts[$i]."<br>";
    echo "quantity is: ".$Quantity3[$i]."<br>";
    */
    # Calculating equation q = N * 3.414 * Watts
    $lightResult[$i] = $Quantity3[$i] * conversion * Light[$i];
    // Testing variable: echo "result is: ".$lightResult[$i]."<br>";
    $lightTotal += $lightResult[$i];
}
```

**Figure 3.18 Eq. (3.4, 3.5, 3.6): Processing equations**
The equations involved in performing the CLTD method for a SCLC were taken from the ASHRAE Fundamentals handbook and were utilized in the PHP scripts to process data. Many of these equations required data from various tables in the handbook. These data were extracted from the handbook from tables such as Table 2, p. 30.5 (Table 3.1) of the handbook [ASHRAE 2001]. These data were entered into Microsoft Excel (Figure 3.19) and saved in comma-delimited format, or .csv files. These files were then used to insert data, using the text file function, of the tables that were created using phpMyAdmin. For a further discussion on how the tables were created in phpMyAdmin, please see Section 3.5. This process was repeated over and over to create the tables that make up the MySQL database. See Section 3.6 for a discussion on how a database connection was made to the MySQL database in Dreamweaver.

### Table 3.1 ASHRAE Fundamentals Handbook - Light Fixture Table

<table>
<thead>
<tr>
<th>Description</th>
<th>Ballast</th>
<th>Watts/Lamp</th>
<th>Lamp Watts</th>
<th>Fixture Watts</th>
<th>Special Notes</th>
<th>Distance Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compact Fluorescent Fixtures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twin, (1) 5 W lamp</td>
<td>Mag-Std</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>1.60</td>
</tr>
<tr>
<td>Twin, (1) 7 W lamp</td>
<td>Mag-Std</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>10</td>
<td>1.43</td>
</tr>
<tr>
<td>Twin, (1) 9 W lamp</td>
<td>Mag-Std</td>
<td>9</td>
<td>1</td>
<td>9</td>
<td>11</td>
<td>1.22</td>
</tr>
<tr>
<td>Quad, (1) 13 W lamp</td>
<td>Mag-Std</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>17</td>
<td>1.31</td>
</tr>
<tr>
<td>Quad, (2) 26 W lamp</td>
<td>Mag-Std</td>
<td>18</td>
<td>2</td>
<td>36</td>
<td>45</td>
<td>1.25</td>
</tr>
<tr>
<td>Quad, (2) 26 W lamp</td>
<td>Mag-Std</td>
<td>22</td>
<td>2</td>
<td>44</td>
<td>48</td>
<td>1.09</td>
</tr>
<tr>
<td><strong>Fluorescent Fixtures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>15</td>
<td>1</td>
<td>15</td>
<td>19</td>
<td>1.27</td>
</tr>
<tr>
<td>(1) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>15</td>
<td>1</td>
<td>15</td>
<td>19</td>
<td>1.27</td>
</tr>
<tr>
<td>(2) 38 in., T8 lamp</td>
<td>Mag-Std</td>
<td>15</td>
<td>2</td>
<td>30</td>
<td>36</td>
<td>1.20</td>
</tr>
<tr>
<td>(2) 38 in., T12 lamp</td>
<td>Mag-Std</td>
<td>15</td>
<td>2</td>
<td>30</td>
<td>36</td>
<td>1.20</td>
</tr>
<tr>
<td>(1) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>20</td>
<td>1</td>
<td>20</td>
<td>28</td>
<td>1.40</td>
</tr>
<tr>
<td>(2) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>20</td>
<td>2</td>
<td>40</td>
<td>56</td>
<td>1.40</td>
</tr>
<tr>
<td>(2) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>20</td>
<td>2</td>
<td>40</td>
<td>56</td>
<td>1.40</td>
</tr>
<tr>
<td>(1) 24 in., T12 HO lamp</td>
<td>Mag-Std</td>
<td>35</td>
<td>1</td>
<td>35</td>
<td>62</td>
<td>1.77</td>
</tr>
<tr>
<td>(2) 24 in., T12 HO lamp</td>
<td>Mag-Std</td>
<td>35</td>
<td>2</td>
<td>70</td>
<td>90</td>
<td>1.29</td>
</tr>
<tr>
<td>(1) 24 in., T8 lamp</td>
<td>Electronic</td>
<td>17</td>
<td>1</td>
<td>17</td>
<td>16</td>
<td>0.94</td>
</tr>
<tr>
<td>(2) 24 in., T8 lamp</td>
<td>Electronic</td>
<td>17</td>
<td>2</td>
<td>34</td>
<td>31</td>
<td>0.91</td>
</tr>
<tr>
<td>(1) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>30</td>
<td>1</td>
<td>30</td>
<td>46</td>
<td>1.55</td>
</tr>
<tr>
<td>(2) 24 in., T12 lamp</td>
<td>Mag-Std</td>
<td>30</td>
<td>2</td>
<td>60</td>
<td>81</td>
<td>1.35</td>
</tr>
<tr>
<td>(1) 36 in., T12 ES lamp</td>
<td>Mag-Std</td>
<td>25</td>
<td>1</td>
<td>25</td>
<td>42</td>
<td>1.68</td>
</tr>
<tr>
<td>(2) 36 in., T12 ES lamp</td>
<td>Mag-Std</td>
<td>25</td>
<td>2</td>
<td>50</td>
<td>73</td>
<td>1.46</td>
</tr>
<tr>
<td>(1) 36 in., T12 HO lamp</td>
<td>Mag-Std</td>
<td>50</td>
<td>1</td>
<td>50</td>
<td>70</td>
<td>1.40</td>
</tr>
<tr>
<td>(2) 36 in., T12 HO lamp</td>
<td>Mag-Std</td>
<td>50</td>
<td>2</td>
<td>100</td>
<td>114</td>
<td>1.14</td>
</tr>
<tr>
<td>(2) 36 in., T12 lamp</td>
<td>Mag-ES</td>
<td>30</td>
<td>2</td>
<td>60</td>
<td>74</td>
<td>1.25</td>
</tr>
<tr>
<td>(2) 36 in., T12 ES lamp</td>
<td>Mag-ES</td>
<td>25</td>
<td>2</td>
<td>50</td>
<td>66</td>
<td>1.32</td>
</tr>
<tr>
<td>(1) 36 in., T12 lamp</td>
<td>Electronic</td>
<td>30</td>
<td>1</td>
<td>30</td>
<td>31</td>
<td>1.03</td>
</tr>
<tr>
<td>(1) 36 in., T12 ES lamp</td>
<td>Electronic</td>
<td>25</td>
<td>1</td>
<td>25</td>
<td>26</td>
<td>1.04</td>
</tr>
<tr>
<td>(1) 36 in., T12 ES lamp</td>
<td>Electronic</td>
<td>25</td>
<td>1</td>
<td>25</td>
<td>24</td>
<td>0.96</td>
</tr>
<tr>
<td>(2) 36 in., T12 lamp</td>
<td>Electronic</td>
<td>30</td>
<td>2</td>
<td>60</td>
<td>58</td>
<td>0.97</td>
</tr>
</tbody>
</table>
3.4 Knowledge Design

The objective of the knowledge design stage was to produce the detailed design for the system. There are two main tasks within this stage: defining the knowledge-based system and utilizing knowledge base system tools. The knowledge-based system task involved choosing the platform most suitable to accessing the knowledge base. A Website format was chosen for its widespread use and familiarity among target users. Initially, it was chosen to make the Web pages available on the company Intranet, but in the end it made the most sense to establish a live Website.

The next task was to identify the tools necessary to design the knowledge base. The first tool chosen was phpMyAdmin. It was used to represent the knowledge in the form of a MySQL database. The tables making up the database were used to organize the data needed for the different steps in the SCLC procedure. The information they contained was extracted during various steps of the SCLC and used in the various
calculations involved. The knowledge-based system tool used to create the functions and GUI features within the Website necessary to interact with the database was Macromedia Dreamweaver. Finally, it was deemed necessary to provide the user with an interactive graphical representation of the domain knowledge within the system to show how the steps in an SCLC are interrelated. The tool chosen to perform this portion of the task was Star Tree™ Studio. The star tree format offered a fluid entity representing the site map. Instead of a static list of links to the Web pages within the Website, the star tree had the benefits of being dragged around with a mouse while still maintaining its structure. This feature allowed the user to focus on certain areas of the site, while also having the traditional site map ability of expanding and/or contracting various areas of the site map.

3.5 Database Design

The database design was initiated by extracting data from tables found in the ASHRAE Fundamentals Handbook and other industry handbooks as discussed in Section 3.3. From here, the data had to be defined in a database format that could be readily accessed from a Web page design. One of the most widely used database servers is MySQL. The initial problem was the lack of a user-friendly interface to create the database. Hence, phpMyAdmin was chosen as the database management tool to handle the administration of the MySQL database.

Once logged into the phpMyAdmin tool provided by the Web host for the HVAC Matrix site, the MySQL database was created (Figure 3.20) and database tables (e.g. Figure 3.21) were created to hold data extracted from ASHRAE tables such as Table 3.1.
After the database table was created, its structure had to be defined. As can be seen in Figure 3.22, this involved naming the fields, defining the type of variable each field contained, and establishing a length if dealing with a character string. This step also involved table comments to be entered and the table type defined.
Once the table structure was saved, there were a variety of table options (Figure 3.23) to choose from. The next step was to insert the data in the .csv file into the database table using the (1) *Insert data from text file into the table* option. Once this option was selected, the window shown in Figure 3.24 was activated within phpMyAdmin. The data was loaded by defining the (1) location of the text file and (2) defining the “,” character to be field terminator since the text file involved was in a comma-delimited format. Once the information was (3) submitted and the insertion was successful, the table data (Figure 3.25) could be viewed by clicking the Browse command in phpMyAdmin.

Figure 3.23 phpMyAdmin – Database Table Options

The aforementioned steps and associated figures comprise the bulk of the operations used in phpMyAdmin for all database tables created for access in the HVAC Matrix Website. Additional operations as shown in Figure 3.26 were also available.
Figure 3.24 phpMyAdmin – Database Table Data File

Figure 3.25 phpMyAdmin – Database Table Data View
3.6 Website Design

The Website design was developed and tested using Macromedia’s Dreamweaver MX 2004 software. The Website design consisted of many aspects including but not limited to: defining the Website for local and remote access as well as testing, connecting to the MySQL database, establishing the Web page layout, coding PHP scripts to define recordsets and dynamic lists within Web pages, and developing HTML forms to handle the input and output functions required to process database transactions necessary to perform the SCLC. The various folders and files located within the HVAC Matrix Website are shown in Figure 3.27.
Figure 3.27 Dreamweaver – File Listing

The Website assets are shown in Figure 3.28. Assets include a variety of elements that are stored in the Website, such as an image or movie file. In this case, the Website’s
assets consist of image files used in different Webpages such as the company logo and sample step images. In Figure 3.28, the highlighted asset is the logo.gif file and Macromedia provides a preview of this image. These image files were created by taking screenshots using the Ctrl-Print Screen keys on a standard keyboard and using IrfanView software to edit and crop the images. IrfanView is a very fast, small, compact and innovative freeware (for non-commercial use) graphic viewer that is compatible with Windows 9x/ME/NT/2000/XP/2003. These screenshots were saved as jpeg files and saved to the images folder within the root folder.

![Figure 3.28 Dreamweaver – Asset Listing](image)

### 3.6.1 Site Definition

In order to utilize Dreamweaver to build the dynamic database-backed Web application using the server language PHP, it first had to be properly defined. Figure 3.29 contains the site definition for the HVAC Matrix Website. Item (1) indicates the site name assigned for this design, (2) defines the local root folder where all files that are
affiliated with the site must be located, and finally (3) establishes the location of the images folder for which the Website assets are located.

![Site Definition for hvacmatrix](image)

**Figure 3.29 Dreamweaver – Site Definition (Local Info)**

The following step (Figure 3.30) required the remote information to be defined for the Website. This included the (1) type of access to be used to upload files, (2) the name of the File Transfer Protocol (FTP) host, as well as (3) the name of the host directory. The FTP host name and host directory were determined by the Web host provider, which provides an FTP server or host for transferring files. Item (4), which contains the login and password information, is also directly associated with how the
Web host was set up. For a successful definition, all items had to match the information provided by the Web host provider.

Figure 3.30 Dreamweaver – Site Definition (Remote Info)

The final step (Figure 3.31) involved specifying the criteria used for the testing server which allowed the files to be uploaded to the Website. The (1) server model was defined appropriately as PHP MySQL, (2) access was set as FTP, (3) FTP host set to match the location provided by Web host, and the (4) URL prefix defined as the location of the site’s root folder on the testing server.
3.6.2 Database Connection

Section 3.5 discussed how the MySQL database was created using phpMyAdmin. The final step of the setup process of the HVAC Matrix site within Dreamweaver was to create a connection to the database. Dreamweaver contained the following instructions in their help menu to create a database connection:

1. Open a new PHP page in Dreamweaver and then open the Databases panel.
2. Click the Plus (+) button on the panel and select MySQL Connection from the pop-up menu. The MySQL Connection dialog box appears.
3. Enter the connection name.

4. In the MySQL Server text box, specify the computer hosting MySQL. Enter an IP address or a server name. If MySQL is running on the same computer as Dreamweaver, enter localhost.

5. Enter your MySQL user name and password. If you didn’t define a user name while configuring your MySQL installation, enter root in the Username text box. If you don’t have a password, leave the Password text box blank.

6. In the Database text box, enter the database name, or click Select and select from the list of MySQL databases.

7. Click Test.

8. Click OK.

Instead of presenting screenshots of the steps involved to accomplish this task, the PHP file which was generated to create the database connection by following the steps listed is shown in Figure 3.32 below. The new hvacdata database connection shows up in the (1) Application panel under the Databases tab as well as the (2) hvacdata PHP file used to create this connection as indicated in Figure 3.33. The Application tab shows other databases that are a part of the GPM Intranet. Their respective PHP files are also indicated in the Files listing. While not a part of the HVAC Matrix, these database connections and files served to provide an example of how to accomplish this task.

Although acknowledgements are usually reserved for an acknowledgement section, the author would like to acknowledge the contributions of Albert Garza, co-worker at GPM Engineering, plumbing designer by occupation as well as web designer of the GPM Intranet, who provided an abundance of information regarding PHP and MySQL.
Figure 3.32 Dreamweaver – MySQL Database Connection PHP file

Figure 3.33 Dreamweaver – Database Connection Panel View
3.6.3 Web Page Layout

One of the most important aspects of the Website design was the Web page layout, since this established the look and feel of the site. The HVAC Matrix home page, or index.php file, will be used for illustrating the Web page layout. It is the initial page viewed by all users and its layout is indicative of all other pages located in the Website. The following figures will show the combination of HTML and PHP coding used to generate the Web pages along with the resulting Design view seen in Dreamweaver.

Figure 3.34 contains the coding which defines the Page title, links to the CSS Style Sheet, includes the header file, and defines the main tables of the Web page.

```html
1. <DOCTYP HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
2. <html> <!-- Beginning of the html code -->
3. <head>
4. <!-- Define the Page title displayed in the browser -->
5. <title> HVAC Matrix - Home </title>
6. <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
7. <!-- Establish the CSS Styles to be used for the page -->
8. <link href="example.css" rel="stylesheet" type="text/css">
9. </head>
10. <!-- Sets the background of the page using the bg_main.gif asset located in the images folder -->
11. <body background="images/bg_main.gif" leftmargin="0" topmargin="0">
12. <!-- Includes the header file containing the PHP logo and the top navigation bar -->
13. <php include_once("includes/header.php");>
14. <!-- Define table size consisting of a left menu bar for contact information and a main body -->
15. <table width="384" height="1008" border="0" align="center" cellspacing="0" cellpadding="0"bgcolor="#FFFFFF" style="border-bottom: 1px solid black; border-right: 1px solid black; border-left: 1px solid black">
16. <tr><td align="top" bgcolor="#D0D0D0" width="1004" height="1004" border="0" cellspacing="0" cellpadding="0">
17. <td width="150" align="top" bgcolor="#396D85" class="boldtitle" style="border-right: 1px solid white">
18. <table border="0" cellspacing="0" cellpadding="4">
19. <tr><td width="151" <span class="title">Mechanical and/or<br>Electrical Consultant(s):<br>1440 Old Brownsville Rd.<br>Corpus Christi, TX 78417</span></td>
20. <td width="151" 351.852.2342 vox<br>351.852.2343 fax</td>
21. <td width="151" 214 Beverley Ave., Ste 202<br>San Antonio, TX 78204</td>
22. <td width="151" 210.222.1522 vox<br>210.222.1540 fax</td>
23. </tr></table>
24. </td>
25. </body></html>
```

Figure 3.34 Dreamweaver – HVAC Matrix Home Page Code View (1)
In Figure 3.35 below, more table definitions are used to format the Web page. The code also includes defining the Page heading, assigning the location of body text, defining an HTML form, including the footer file, and finally ending the HTML code. This yields the Dreamweaver design view as shown in Figure 3.36.
Figure 3.36 Dreamweaver – HVAC Matrix Home Page Design View

The following list references the various aspects of the Page Design View above.

1. Symbol represents PHP code is located within the HTML code.
2. The PHP code yields the header file containing logo and links.
3. Left menu created with contact information.
4. Hyperlink created in the left menu.
5. Page Heading defined within the main body of Web page.
6. Body text including bold font and hyperlinks underlined.
7. Simple HTML form contains submit button to allow user to proceed to Step 1.
8. Notice to User text displayed in italic font with hyperlink to e-mail address.
9. The PHP code yields the footer file which contains copyright information.

The overall layout of the home page was used as the structure to create all other Web pages within the Website to establish a uniform look and feel.
3.6.4 PHP Scripts

Throughout the HVAC Matrix Website development, HTML and PHP code were combined to create the majority of the Web pages. This was done because it was necessary to include form-parsing code on the same page as a hard-coded HTML form. PHP code used to accomplish specific tasks will be referred to as a PHP script. For the present discussion, HTML forms will be viewed as the principal means by which substantial amounts of information was passed from the user to the server. PHP is designed to acquire and work with information submitted via HTML forms [Zandstra 2002]. HTML forms will be discussed in detail in Section 3.6.5.

The two most common PHP scripts in the Web page design are used to define recordsets and dynamic lists. When using a database as a content source for a dynamic Web page, you must first create a recordset in which to store the retrieved data. Recordsets serve as an intermediary between the database storing the content and the application server generating the page. Recordsets consist of the data returned by a database query, and are temporarily stored in the application server’s memory for faster data retrieval. The server discards the recordset when it is no longer needed. The recordset itself is a collection of data retrieved from a specified database. It can include an entire database table, or a subset of the table’s rows and columns. These rows and columns are retrieved by means of a database query that is defined in the recordset. These database queries (1, 2) were written in MySQL and the resulting recordsets (3) are displayed in the Database panel of Dreamweaver under the Bindings tab (Refer to Figure 3.37). These PHP scripts are defined prior to any HTML code since they must be
available for use in the HTML form. It’s equivalent to defining an entity within a program prior to using it.

**Figure 3.37 Dreamweaver – Recordset**

A dynamic list is simply a list of values made available to the user on a Web page that are linked to a recordset. The dynamic list definition occurs within the HTML form. In lines 134 through 149 of the code shown in Figure 3.38, the glassType[] dynamic list (1) is defined utilizing a PHP script to dynamically link it to the shadingCoefficient recordset. The result (2) of the code can be seen in Dreamweaver’s Application Panel under the Server Behaviors tab.

**Figure 3.38 Dreamweaver – Dynamic List**
3.6.5 Form Development

Forms allow information to be provided and gathered from visitors to the Website. Users enter information using form objects such as text fields or areas and then click a button to submit the information. A dynamic form object is a form object whose initial state is determined by the server when the page is requested from the server, not by the form designer at design time. For example, when a user requests a PHP page containing a form with a menu such as in Figure 3.38, a PHP script in the page (code lines 138-151) automatically populates the menu with values stored in the HVAC\textit{data} database. The server then sends the completed page to the user’s browser. Making form objects dynamic simplify site maintenance. The HVAC Matrix Website uses menus to present users with a set of options. If the menu is dynamic, the administrator can add, remove, or change menu items in a single place—the database table in which the items are stored—to update all instances of the same menu on the site.

Other features of HTML forms (refer to Figure 3.39) include inserting a table to format the display (code line 111), creating rows and columns with text headings (code lines 112-120), and displaying static lists (code lines 126-136) which contain the information to be displayed on the Web page in the actual HTML code. Figure 3.40 shows the remainder of the form code and shows one additional feature. This feature involves the passing of variables and their values using hidden fields (code lines 189-193).

The result of the form coding can be seen by viewing Figure 3.39 which is the respective design view of the coding contained within Figures 3.39 and 3.40. The list below Figure 3.41 contains a description of important aspects of the design view code.
<?php
    $form = '<form name="glass" method="post" action="step5.php">'

    '<table border="0" cellspacing="0" cellpadding="4">

    '<tr>
    '<td colspan="4" class="style2">Glass Solar Heat Gain</td>
    '</tr>

    '<tr class="flextile"> <!-- Defines the column headings -->
    '<td>Exposures</td>
    '<td>Glass Area ft^2</td>
    '<td>Direction</td>
    '<td>Type of Glass</td>
    '</tr>

    '<tr>
    '<td>/* For (i = 0; i < $numExposures; i++) { // loop starts here */</td>
    '</tr>

    '<tr>
    '<td class="styled">i = $i+1; echo "Exposure ": $i; // Used to generate correct amount of rows */</td>
    '</tr>

    '<tr>
    '<td class="styled">-- input text field created to hold the glass area --></td>
    '</tr>

    '<tr>
    '<td class="styled">-- Static list created for the Direction column --></td>
    '</tr>

    '<tr>
    '<td class="styled">-- Dynamic list created for the type of glass using the shadingCoefficient recordset --></td>
    '</tr>

    '</tr>

    '<tr>
    '<td class="styled">-- Hidden fields used to transfer input from this page to next page --></td>
    '</tr>

    '<tr>
    '<td colspan="4" class="inputr"> submit</td>
    '</tr>

    '</table>

    '</form>

    <!-- Figure 3.39 Dreamweaver – Glass Input Form Code View (1) -->

    <!-- Figure 3.40 Dreamweaver – Glass Input Form Code View (2) -->

    <!-- Figure 3.39 Dreamweaver – Glass Input Form Code View (1) -->

    <!-- Figure 3.40 Dreamweaver – Glass Input Form Code View (2) -->

    76
1. PHP symbol indicating script which executes is a loop within the code.

2. Input text field for user to enter the glass area.

3. Static list of standard directions for user to choose from.

4. Dynamic list which is linked to the shadingCoefficient recordset

5. PHP symbol indicating script which executes is a loop within the code.

6. Input text field for user to enter the gross window area.

7. Output text field from previous step. Utilizes echo command to display data.

8. Dynamic list that is linked to the uValueglass recordset

9. Hidden input text fields used to transfer data from this step to next step.

10. Submit button associated with the HTML and used to process the operations.

3.7 Visualization Design

The final major design of the Website involved the formulation of an interactive and informative visual aid that really was a useful tool for the user. The tool used to generate this visual aid was Inxight Star Tree™ Studio. The design view is shown in
Figure 3.3 and is discussed in sufficient detail in Section 2.2. Figures 3.42 and 3.43 show the two-step process used to publish the HVAC Matrix Map to the Website.
The remote view of the site (Figure 3.44) shows the `public_html` folder where the star tree files were published. Star Tree Studio generates the (1) `startree.html` file, which in turn loads the (2) `startree.stz` file using either the (3) `StarTree30.jar` executable file for Microsoft Internet Explorer or (4) `StarTreeStudio30netmac.jar` or Netscape Navigator.

<table>
<thead>
<tr>
<th>Remote Site</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>public_html/</code></td>
<td></td>
</tr>
<tr>
<td><code>cgi-bin</code></td>
<td>3/3/2005 12:00 AM</td>
</tr>
<tr>
<td><code>Connections</code></td>
<td>10/17/2005 2:45 AM</td>
</tr>
<tr>
<td><code>help</code></td>
<td>10/28/2005 4:14 AM</td>
</tr>
<tr>
<td><code>images</code></td>
<td>10/28/2005 4:16 AM</td>
</tr>
<tr>
<td><code>includes</code></td>
<td>10/28/2005 4:16 AM</td>
</tr>
<tr>
<td><code>phpmyadmin</code></td>
<td>3/24/2005 12:00 AM</td>
</tr>
<tr>
<td><code>samples</code></td>
<td>10/28/2005 4:14 AM</td>
</tr>
<tr>
<td><code>.htaccess</code></td>
<td>3/4/2005 12:00 AM</td>
</tr>
<tr>
<td><code>gpmstyle.css</code></td>
<td>10/17/2005 2:03 AM</td>
</tr>
<tr>
<td><code>index.php</code></td>
<td>10/17/2005 2:09 AM</td>
</tr>
<tr>
<td><code>results.php</code></td>
<td>9/28/2005 7:15 AM</td>
</tr>
<tr>
<td><code>startree.html</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
<tr>
<td><code>startree.stz</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
<tr>
<td><code>startree30license.txt</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
<tr>
<td><code>startree_frameset.html</code></td>
<td>7/12/2005 3:52 AM</td>
</tr>
<tr>
<td><code>startree_netmac.html</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
<tr>
<td><code>startree_readme.txt</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
<tr>
<td><code>StarTreeStudio30.jar</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
<tr>
<td><code>StarTreeStudio30netmac.jar</code></td>
<td>10/25/2005 7:52 AM</td>
</tr>
</tbody>
</table>

**Figure 3.44 Dreamweaver – Remote Directory**

This section has presented the methodology that was used to develop the system as well as specific examples of how the system was implemented. The next section will cover the final step in the system development process that is often referred to as verification, validation, and evaluation (VVE). In this case, the system was evaluated by users to validate if the training system is effective.
4. EVALUATION AND RESULTS

The user interface design was developed based on prevalent human-computer interaction (HCI) techniques as well as a common-sense approach to implementing the tasks required to perform a SCLC. This development and the techniques implemented are discussed in Section 4.1. In addition, the usability testing evaluations necessary to validate the system’s performance were conducted using a mixture of users. These included users who were experienced HVAC designers at a consulting engineering firm to users with no knowledge of HVAC design. The user reaction survey form and results are discussed in the Section 4.2

4.1 User Interface Design

There were a number of principles incorporated into the system to create an effective GUI for the KBS. The first was to understand the users who are going to be using the product. Most users like things to be simple. In consideration that the target users would be entry-level designers, it made the most sense to use a Website format since most people are able to intuitively use this interface.

The next issue is the interface clarity. To be a successful interface, the system had to be clear. This meant that the instructions to the user should only present the information needed and be as concise as possible. This concept was incorporated into each step of the SCLC. Only the information required for the current step as well as the next step were displayed on each respective Web page. Instead of overloading each Web page with excessive or redundant information, the instructions were limited to the immediate tasks at hand. This falls under the user interface design component of presentation, where the appearance of the input and output and is clearly made to the user.
from the beginning of the SCLC [Dix 2004]. The user was provided with an input/output format utilized in all the steps and this format was maintained throughout all Web pages.

In addition, the system should not confuse the user but the user should always feel familiar with every part of the system. This concept was incorporated into the design of all Web pages. Features that were designed into the site included the ability of users to see where they are. Each Web page was titled within the Web browser with the step number and a brief description of the step. Each Submit button used to process the current step was labeled with the number of the next step. The links to the sample steps changed as the user progressed through the steps to match the current and next steps, respectively.

Another concept adhered to in the development was that the user should always know where he is going and how the system will behave before any action is taken. The SCLC is linear in nature. By visiting the help pages, the user can see an overview of the SCLC procedure and all the steps involved. He can also browse through a listing of links to all the sample steps, which as mentioned previously, were also included on the Step pages. Among the tools made available to the user was the use of an interactive site map. This map, known as a star tree, represents the entire HVAC Matrix Website, including breakdowns of the equations utilized within the SCLC along with descriptions of all the components making up those equations.

4.2 Usability Testing

Validation is the process to determine whether a KBS is an effective encoding and distribution of knowledge. The best validation method used for the KBS is usability testing. Users performed the testing and feedback was obtained through the use of survey questionnaires. This included the ability to rate the system on several usability factors as
indicated in the form shown in Figure 4.1. Ultimately, since users expressed an interest in utilizing and recommending the Website, the goal of the system was satisfied.

User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: _________________________________  Date: ________________
Occupation: _____________________________  HVAC Design Experience: Yes / No
If Yes, please list the amount of experience you have: ___Years ____Months
Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?

7. What two things did you like least and why?

8. What would you suggest as changes to the design?

Figure 4.1 User Reaction Survey Form
The User Reaction Survey Form proved to be an effective way to rate the Website and gather constructive feedback. The goal of the author was to obtain an overall average rating of 4.0 on a scale of 1 to 5, where 1 is the lowest rating and 5 is the highest rating the user could rate the Website. Each of the five statements shown in Figure 4.1 was evaluated individually, and then as a whole to determine the overall user reaction to the Website. The usability testing results discussed below are based on seventeen User Reaction Survey Forms that can be found in Appendix C. Of the seventeen users surveyed, more than one third had HVAC design experience. This type of usability testing is known as evaluation through user participation. “If participants are not actual users, they [were] chosen to be of a similar age and level of education as the intended user group.” [Dix 2004]. In this case, all users without HVAC design experience had either an engineering or computer science background. For the purposes of discussion, the averages calculated from the forms are rounded to the nearest tenth.

In statement 1 regarding the user’s opinion of browsing the Website, the average user rating was a 3.9. While this score was slightly lower than the overall rating of a 4.0, it was well within the range of being considered an acceptable score. Statement 2 focused on the user’s opinion of the menus and navigation approaches used in the Website design. The average user rating was a 4.3, substantiating the goal of providing an easy-to-use interface. The major validation issue was covered in statement 3. The average user rating when asked if it was easy to complete the steps for the SCLC was a 4.2. The reason this statement is considered the major issue is that the Website was designed for everyday use to perform SCLC’s. Once a user becomes familiar with the Website, using the help pages, and exploring the site map, these features would become somewhat obsolete and
only the ten steps of the SCLC would be visited with the greatest frequency. This does not preclude that the help pages would be improved or that the site map would be updated over time. Simply put, the ten steps of the SCLC are considered the focus of the Website.

Statement 4 covered the topic involving the user’s opinion of the colors and graphics used within the Website. Not surprisingly, this topic ranked the lowest with an average user rating of 3.1, receiving scores of 2 on three occasions. This was actually an expected opinion since in the author’s opinion many users would base their opinion of these characteristics on entertainment Websites. Since the goal of this project was not focused on visual appeal, this is considered an item of future work.

Finally, statement 5 was used to gauge the overall opinion of the Website in its entirety. The average user rating of this topic was a 4.2, tying with statement 3’s rating for the second highest average rank of all 5 topics. Statement 5 is considered to be the second most important aspect rated by the users in substantiating the goals of this project. Since the users surveyed had vastly different occupations, the affirmation that all but one user either agreed or strongly agreed that they would use and recommend the Website to others is a strong indicator for a successful product.
5. CONCLUSION

Consulting engineers perform procedures to solve problems everyday. Each engineer may have developed his own techniques and justifications for solving a particular problem making his evaluation unique to the company as a whole. What occurs is often a chaotic and unstable approach to performing everyday tasks since each individual has meshed knowledge gained from peers, literature, and their own experience. There are several commercial programs available for use to perform space cooling load calculations. However, “these individuals who may have the knowledge to input data to the programs, but do not have the required criteria to know if the data, the path followed within the programs and the results, are correct” [de Buen 1998]. What is important is that each engineer within the company follows an established procedure and that the procedures can be implemented efficiently and the steps necessary to carry them out are communicated effectively. Thus, the need for a knowledge-based system to learn, apply, and consult procedures.

The system is designed to provide support to the consulting engineer in a variety of ways. The system gives the user the opportunity to learn the steps in the procedure, to apply the knowledge gained to his specific project, and to consult or find specific information about any step in the procedure prior to having to perform it.

The proposed system is implemented using a Web page format since it provides the best tools to produce a GUI interface that is user friendly. The inference engine of the KBS is integrated with a MySQL databases. MySQL queries are utilized to access all database files. PHP scripts are used to process the equations and PHP and HTML files were used to generate the Web pages.
The system was evaluated based on its effectiveness as conveyed by a variety of users. Essentially, the users were allowed to offer recommendations and comments during the development stages of the Website design. Some of these recommendations and comments were incorporated into the final design of the HVAC Matrix Website. The desired end result is a system that not only is functional but that also implemented the subtleties of the intended users.
6. FUTURE WORK

This project provided the necessary tools to perform a SCLC. The next in the HVAC design of a building would be to calculate the required size of HVAC equipment necessary to condition a space. The SCLC output is used to determine the equipment size. Therefore, it makes logical sense that the focus of any future work would be to take the results of the SCLC and process it along with the additional procedures to size the equipment.

Another important feature that could be incorporated into the Website design would be allowing database entry by the users. This would have to be approved by the administrator but this feature would be in stride with the whole concept of a knowledge-based system; to obtain knowledge from the users. This could be in the form of adding glass types to choose from when calculating the solar and transmission heat gains through glass, to expanding the list of available equipment to choose from in the project design.

Other items of possible future work were derived from the feedback provided by users in the User Reaction Surveys. These include providing a save file feature so that the user does not have to complete all steps all in one session. This would require saving the input to a database and allowing it to be retrieved at a later time. At the time of development, the intent was for users to only enter numerical values in the input fields. Any other input resulted in an error with an appropriate description of the error provided in an error page. These error messages could be improved upon. Another minor area of future work lies in selecting better colors and graphics to use on the Web pages. While users expressed satisfaction with the menus and navigation, or the Web page layout, the colors and graphics scored the lowest among all aspects rated by the user.
BIBLIOGRAPHY AND REFERENCES


Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: ___Josh Mueller__________________________ Date: ___October 30, 2005___

Occupation: ___Student (Computer Science Major)___ HVAC Design Experience: Yes / No

If Yes, please list the amount of experience you have: ___Years ____Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

_____________________________________________________________________________

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?
   The software was easily used because of the information provided. Each step contained in depth information on choices the user was making.
   The WEB site itself was very neat/clean and user-friendly.

7. What two things did you like least and why?
   The contrast between the grey and light blue, it was difficult to read.
   No message boxes (WARNING MESSAGES). If the user forgot to fill in or check something, how would they know it? Maybe, if certain objects needed to be answered it would have something to notify the user.

8. What would you suggest as changes to the design?
   Change the background color or change the font’s color.
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: Nancy Shindler  Date: 10/30/05
Occupation: Quality Engineer  HVAC Design Experience: No
If Yes, please list the amount of experience you have: N/A_Years N/A_Months
Do you have an engineering background: Yes; If Yes, please describe briefly below (e.g. BSME):
Bachelor of Science In Electrical Engineering

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (X) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (X) Agree  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (X) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (X) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (X) Agree  (5) Strongly Agree

6. What two things did you like best and why?
   I like the fact that you can see the sample pages as you go through the steps. It helps the user.
   I like the matrix map. I like that you can view each phase.

7. What two things did you like least and why?
   ➢ Sample page 7-10 and Sample Results were not available.

8. What would you suggest as changes to the design?
   ➢ Is there a way for the user to save the results and come back to it later in case they do not remember their project #?
   ➢ What if they realize they made a mistake and need to make a different entry, will they have to go through all the steps again?
   ➢ No “Back” button but I guess you can use the browser.
Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: __Tommy Shindler_______________  Date: __10/30/2005______  
Occupation: __Software Developer_________  HVAC Design Experience: Yes / No

If Yes, please list the amount of experience you have: ___Years ____Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):
__Bachelor of Science in Mechanical Engineering, Masters of Science in Computer Science_________

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?
   1. Matrix map is awesome!  
   2. Samples available at each step were helpful.

7. What two things did you like least and why?
   1. No error handling, (IE: Null of nonnumeric values accepted.)
   2. No mechanism for “saving” job.

8. What would you suggest as changes to the design?
   In addition to the items mentioned in 7, and perhaps an alternative to “saving” a job, have you considered options such as print or export (IE: spreadsheet). These are really minor, however, and probably do not fall within the scope of intended use of the product.
Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: Daniel Lara                    Date: October 31, 2005
Occupation: Mechanical Engineer               HVAC Design Experience: Yes

If Yes, please list the amount of experience you have: 3 Years 6 Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

Yes, Bachelor of Science in Electrical Engineering (BSEE)

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.  
   (3) Neutral

2. It was very easy to use the menus and navigation approaches used in the Website design.  
   (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.  
   (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.  
   (2) Disagree

5. If this software product were available to me, I would use it and recommend it to others.  
   (3) Neutral

6. What two things did you like best and why?

   (1) The program is easy to follow and has most of the information you need to perform HVAC load calculation on the screen.
   (2) Pull down menus make the process quick to complete.

7. What two things did you like least and why?

   (1) It does not complete the HVAC calculation in terms of being able to selection equipment. It only gives the heat load output.
   (2) The colors used on the website are not eye catching. There is a dull/boring feeling given off by the gray and blue colors.

8. What would you suggest as changes to the design?

   (1) Give a description of what wall/roof components are and how they affect the heat load, similar to what is done with the glass.
   (2) Round output numbers to 1 or 2 decimal places.
   (3) Provide a description or interpretation of what the output means.
   (4) Add horizontal/skylight glass to the glass heat load portion.
   (5) Area for calculating Glass Transmission Heat Gain is equal to the summation of glass area for Glass Solar Heat Gain. Provide a note to this effect or automatically calculate the summation based on the first inputs.
Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: Carlos Castañeda Date: 10/31/05

Occupation: Field Engineer HVAC Design Experience: No

If Yes, please list the amount of experience you have: ___ Years ___ Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

BSME, field engineer for an oil field company

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.

   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.

   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.

   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.

   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.

   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why? I liked the simplicity. The sight is very informative and easy to navigate.

7. What two things did you like least and why?

   1. The sight does not mention anything regarding the possibility of errors in the design. During step 3 I received an error regarding a duplicate project number. I was not sure what that meant. Eventually I figured it out.

   2. I had a hard time loading sample step 9 and 10. Not sure why, but it could have been that the server was busy.

8. What would you suggest as changes to the design?

   Expand HVAC Matrix help section to include possible errors a user may see during the 10 step process.
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: ___Juan Pena__________________________  Date: ___10/31/05__________
Occupation: ___Engineer___________________                      HVAC Design Experience:  No
If Yes, please list the amount of experience you have: ___Years ____Months
Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):
______Yes, BSME_________________________________________________________________

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree-X  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree-X  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree - X  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree -X

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree -X

6. What two things did you like best and why?
   User Interface, Display
   The program was easy to use and the instructions were detailed and specific. The layout was appealing and user friendly.

7. What two things did you like least and why?
   There was not one item I disliked.

8. What would you suggest as changes to the design?
   The only item that was confusing but justifiable was the project number error. The program would not let me continue since the project number had already been used. I’m sure this problem arose only because various people were testing the software. In a structured daily use of the program, this would not happen.
Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: _____Shizuko Carson____________________  Date: __10/31/2005________
Occupation: __Mechanical Design Engineer ______                      HVAC Design Experience: No

If Yes, please list the amount of experience you have: ___Years ____Months

Do you have an engineering background: Yes ; If Yes, please describe briefly below (e.g. BSME):
BSME – Electro-Mechanical packaging design, thermal design of high power telecom equipment, heatsink design, fan tray design, outdoor cabinet design for telecom equipment

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

6. What two things did you like best and why?
   Pull down menus… easy to use
   Output. Simple

7. What two things did you like least and why?
   Menu selection. Did not cover enough.
   Instruction. Does not provide enough instruction for some input.

8. What would you suggest as changes to the design?
   More diagrams and pictures maybe helpful. More thorough instruction needed.
   More complete menu choices needed (especially for equipment list)
   Interpretation of result maybe helpful (not just numbers)
For HVAC Matrix: [http://www.hvacmatrix.com](http://www.hvacmatrix.com)

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: ___ Jessica V. Salinas  D a t e :  _ _ 1 0 / 3 1 / 0 5 _ _ _ _ _ _

Occupation: ____ Engineering Supervisor  HVAC Design Experience: No

If Yes, please list the amount of experience you have: ___Years ___Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

____ BSME – currently working in Natural Gas Industry

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

6. What two things did you like best and why?
   The process was very easy to follow by using the “step” method. The menu options were also very helpful and in alphabetical order.

7. What two things did you like least and why?
   The only thing that I liked least was all the steps and fields to be filled. I believe that this is lack of training on the users part.

8. What would you suggest as changes to the design?
   The only suggestion would be a page of examples with solutions/results. Maybe more photos/charts………just my 2 cents. Overall, the content was very impressive!!!!! Good Job!
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: ______ R. G. Gallardo___________________________  Date: ____10-31-05_____
Occupation: __IV&V Analyst________________                      HVAC Design Experience: Yes / No

If Yes, please list the amount of experience you have: ___Years ____Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):
BS Computer Science, 2 yrs development of Space Systems, 2.5 yrs IV&V Analyst for Space Systems

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral X  (4) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree X  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree X  (3) Neutral  (4) Agree  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree X  (3) Neutral  (4) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree (5) Strongly Agree X

6. What two things did you like best and why?
   The developer took advantage of the use of space on each page, all data was conveyed without the user having to scour the text.

7. What two things did you like least and why?
   1) The use of ‘red’ text on the website was distracting and difficult to see.
   2) The use of ‘gray’ as the background color; stronger text colors could have probably been used in this case.

8. What would you suggest as changes to the design?
   Place all ‘Sample Step’ links to the left of each ‘Step’ page (all Sample Steps 1-10/Results) and leave it to the user’s discretion to navigate, rather than have only the next ‘Sample Step’ link that correlates with the ‘Step’ page. Also placing the ‘help’ link underneath the ‘Sample Step’ links would cut some time, preventing the user from roving the web page looking for the ‘help’ link. In the web pages that contain form fills, aligning the forms closer to the corresponding text (Ex. Pages 2, 6, 8) prevents ambiguity.
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: Valdemar Cantu     Date: 10.31.05
Occupation: Sr. Plumbing Designer/Draftsman     HVAC Design Experience: Yes / No
If Yes, please list the amount of experience you have: ___Years ____Months
Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree   (2) Disagree   (3) Neutral   (4) Agree   (5) Strongly Agree

6. What two things did you like best and why?
   I liked all the samples you provided. A lot of times websites do not offer to much information for there applications and assume the person using the site is aware of what is going on.

7. What two things did you like least and why?
   I don’t know much about HVAC so I would have to say I really disliked the color scheme and lack of graphics used.

8. What would you suggest as changes to the design?
   If I forget to enter information for a table, the table should be highlighted or have a star next to let me know that I forgot to enter an item rather than give me “Duplicate entry “ for key 2”. 
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: Albert Garza ______________________________ Date: 10/31/05 ___________
Occupation: Plumbing Designer _________________ HVAC Design Experience: Yes / No
If Yes, please list the amount of experience you have: ___Years ____Months
Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

_________________________________________________________________________________

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?
   I like that fact that you don’t need to look up data in a handbook or enter values in an equation to get a solution. Also the HVAC matrix really helps to see the structure of how everything comes together.

7. What two things did you like least and why?
   My least thing would be the long names on some of the drop boxes… they become a bit long and generate a horizontal scroll bar on your browser.

8. What would you suggest as changes to the design?
   Suggest change the color of the visited links on side bar to a darker color. Too hard to read when both the background and the link are shades of blue.
Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: __Sean Rodriguez______ Date: __11-1-2005____
Occupation: __Mechanical Engineer___ HVAC Design Experience: Yes
If Yes, please list the amount of experience you have: __9_Years ____Months
Do you have an engineering background: Yes ; If Yes, please describe briefly below (e.g. BSME):
BSME from TAMU College Station___________________________________________________

Please respond to the following items by circling the opinion that best corresponds to your own:

6. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

7. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

8. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

9. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

10. If this software product were available to me, I would use it and recommend it to others.
    (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?
   a. It was easy to follow and understand.
   b. Large text made it easy to read

7. What two things did you like least and why?
   a. In step 3 you have a CLTD correction number, but this correction number does not appear to be used in any of the formula’s. The CLTD is different for Roofs, walls, and glass.
   b. There was no back button to change the data entered and the sample buttons did not work.
   c. Program does not let you enter in your own U-values.

8. What would you suggest as changes to the design?
   a. Add a psychrometric analysis
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: David Flores
Date: 11/01/05
Occupation: Production Engineer
HVAC Design Experience: Yes/No
If Yes, please list the amount of experience you have: 3 Years
Do you have an engineering background: Yes/No; If Yes, please describe briefly below (e.g. BSME): BSME

Please respond to the following items by circling the opinion that best corresponds to your own:

11. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

12. It was very easy to use the menus and navigation approaches used in the Website design.
(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

13. It was easy to complete the steps for the SCLC provided in the site.
(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

14. The colors and graphics were pleasing to the eye.
(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

15. If this software product were available to me, I would use it and recommend it to others.
(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?
It is user friendly and easy to understand.

7. What two things did you like least and why?
The amount of steps needed to complete the calculation.

8. What would you suggest as changes to the design?
More graphics and combine some of the steps.
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: __Travis McLeod______________________________ Date: ____11/1/05_________
Occupation: __Mechanical Engineering / Sales____                      HVAC Design Experience: Yes
If Yes, please list the amount of experience you have: _12__Years __6__Months
Do you have an engineering background: Yes    ; If Yes, please describe briefly below (e.g. BSME):
BSME in Mechanical Engineering with 5 years experience in consulting; 7.5 years in HVAC Sales/Design

Please respond to the following items by circling the opinion that best corresponds to your own:

16. Browsing the software product was as comfortable as the best tutorial Websites I have visited.

(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

17. It was very easy to use the menus and navigation approaches used in the Website design.

(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

18. It was easy to complete the steps for the SCLC provided in the site.

(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

19. The colors and graphics were pleasing to the eye.

(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

20. If this software product were available to me, I would use it and recommend it to others.

(1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

6. What two things did you like best and why?
The steps required to complete the tutorial were easy and to the point.
When it came time to select various options, there were many available to select.

7. What two things did you like least and why?
The overall color/layout design was a bit bland, but hey, that’s why you are an engineer and not a graphic designer. I don’t care for answers that carry out to the 4th and 5th decimal points. In the HVAC world, I expect to see no more than two decimal places (ie. 105.24 btuh vs. 105.2456731 btuh)

8. What would you suggest as changes to the design?
Carl – Overall, I think you did a GREAT job. I’m very impressed. I really think the only thing that I would change would be the description on the first few pages. When you start up the tutorial, you are hit with a very large paragraph of words and descriptions. I found it to be almost too much to read up front. Break up the paragraphs into smaller chunks. It could be just ME, but when I’m hit with a very large paragraph, I get anxious and want to skim thru it. Which, of course, causes me to skip over things. Otherwise, again, you did a GREAT job. The Site Matrix was a cool feature by the way.
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: ______ Pete Castillo ____________ Date: _____11/1/05____

Occupation: ___Mechanical Engineer_____                      HVAC Design Experience: Yes

If Yes, please list the amount of experience you have: _4_Years __1_Months

Do you have an engineering background: Yes; If Yes, please describe briefly below (e.g. BSME):

____________________________________BS ME________________________________________

Please respond to the following items by circling the opinion that best corresponds to your own:

21. Browsing the software product was as comfortable as the best tutorial Websites I have visited.

(4) Agree

22. It was very easy to use the menus and navigation approaches used in the Website design.

(3) Neutral

23. It was easy to complete the steps for the SCLC provided in the site.

(4) Agree

24. The colors and graphics were pleasing to the eye.

(3) Neutral

25. If this software product were available to me, I would use it and recommend it to others.

(4) Agree

6. What two things did you like best and why?

I like the details of each description for the lighting, roof, walls and glass type. I also like the orientation (North, South, West, East).

7. What two things did you like least and why?

You can add small graphics/pictures help for those who don't have any know to use these calculations.

The least about the program it can only be use for commercial and possible residential fields.

8. What would you suggest as changes to the design?

You can add or divide into sections. (for example: Residential, Industrial, Commercial)
Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC), we would like to know some of your reactions, both in general and to specific features of the system.

Name: Mark Valdez Date: November 2, 2005

Occupation: Reliability Engineer HVAC Design Experience: Yes / No

If Yes, please list the amount of experience you have: ___ Years ___ Months

Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):

Yes - BSME

Please respond to the following items by circling the opinion that best corresponds to your own:

1. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
2. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
3. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
4. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
5. If this software product were available to me, I would use it and recommend it to others.
   (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
6. What two things did you like best and why?

The HVAC matrix help page was very helpful. I liked the procedure for calculating the space cooling load. The procedure explained fully which loads were necessary and how to calculate them. I liked that each variable in each equation was explained fully. This section is especially useful for those who have no experience in HVAC calculations. The sample steps were very helpful. An inexperienced user could study these and use them as a guide before delving into an actual calculation.

7. What two things did you like least and why?

The actual Star Tree matrix map was a little confusing at times. It was hard to read and takes a while to get used to.

8. What would you suggest as changes to the design?

The one suggestion that I would make is in Step 1. The information that one needs to input for each of the fields is explained in the paragraph above the fields. I would recommend that the information be available when the cursor is moved over that field. A small comment box could pop up with the information for the particular field. That would make it much easier that having to scroll back up to read the paragraph.
User Reaction Survey
For HVAC Matrix: http://www.hvacmatrix.com

__________________________________________________________________

Now that you have browsed the Website and completed the Space Cooling Load Calculation (SCLC),
we would like to know some of your reactions, both in general and to specific features of the system.

Name: _Denise Salinas____________________  Date: _11/4/05_______
Occupation: __Plant Engineer_______________                 HVAC Design Experience: YES
If Yes, please list the amount of experience you have: _2_Years _8__Months
Do you have an engineering background: Yes / No; If Yes, please describe briefly below (e.g. BSME):
__Yes-BSME___________________________

Please respond to the following items by circling the opinion that best corresponds to your own:

6. Browsing the software product was as comfortable as the best tutorial Websites I have visited.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

7. It was very easy to use the menus and navigation approaches used in the Website design.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

8. It was easy to complete the steps for the SCLC provided in the site.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

9. The colors and graphics were pleasing to the eye.
   (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

10. If this software product were available to me, I would use it and recommend it to others.
    (1) Strongly Disagree  (2) Disagree  (3) Neutral  (4) Agree  (5) Strongly Agree

11. What two things did you like best and why?

    Very simple, easy to input data

12. What two things did you like least and why?

    My screen did not allow full view of web pages and often I had to horizontally scroll.

       Adding notes...If the selected equipment/lighting is similar to my situation, how could i note that it is not exactly like the selection made, but very similar.

8. What would you suggest as changes to the design?

    I loved the site, but not very eye appealing. GREAT JOB!
APPENDIX B – WEBSITE FILES

The digital media of this appendix are contained in the disk provided.
APPENDIX C – DATABASE FILES

The digital media of this appendix are contained in the disk provided.
APPENDIX D – DIGITAL MEDIA

A copy of the source document for the technical report in Microsoft Word format, a printable version of the technical report in Adobe pdf format, and the technical report presentation in Microsoft PowerPoint format are contained in the disk provided.