AN ENERGY RESPONSIVE BUILDING DESIGN GUIDELINE

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The ERB Design process is an organized design approach that responds to the need to consider the consequences of energy related concerns during the design process. It should be considered an integral part of the architectural design process. It consists of a series of separate but parallel procedures that impact the design solution just as other design considerations (such as MEP systems, structural systems, programming, budget, and so forth) impact the design.

The tasks that make up the ERB process reflect a series of concurrent activities and can impact the design as early as pre-design building programming. The level of ERB Design input becomes more detailed as the process moves from pre-design analysis through design development, and on to the construction document and construction phases. There are activities that correspond with the post-occupancy evaluation phase as well.

INTRODUCTION

Energy responsive buildings make positive use of the site, environment, and climate conditions. In the traditional building design process engineering solutions respond to architectural designs. In the ERB design process engineering concerns and concepts are explored far earlier in the design process than is traditional. Therefore, the ERB design process provides a framework to objectively consider a wide range of architectural and engineering concepts, but maintains a focus and direction for the effort because of the energy goals and issues that have been identified and must be addressed.

A fundamental goal of the Compaq corporate facilities program is to design and build energy efficient, cost effective buildings that meet Compaq's corporate needs and requirements.

The goal of this guideline is to provide Compaq and its consultants with a reference and design tool that can assist in the process of developing energy efficient, cost effective buildings.

The scope of the ERB design process encompasses all aspects of the overall building design process; from programming through post-occupancy evaluation.

The ERB design process establishes a framework for making energy related design decisions. During the early phases of the design process a set of energy goals, issues that respond to the goals, and design strategies that acknowledge the issues are established.

The ERB design process is just that; a process. There is no attempt to develop all the specific goals, issues or strategies relevant to all the possible building types, climate conditions, utility rate structures, and so forth. Goals, issues, and strategies are always project specific.

The process can be divided into 14 steps or tasks. The first 11 steps focus on design while the last 3 steps focus on implementing and evaluating the design. See Figure 1.

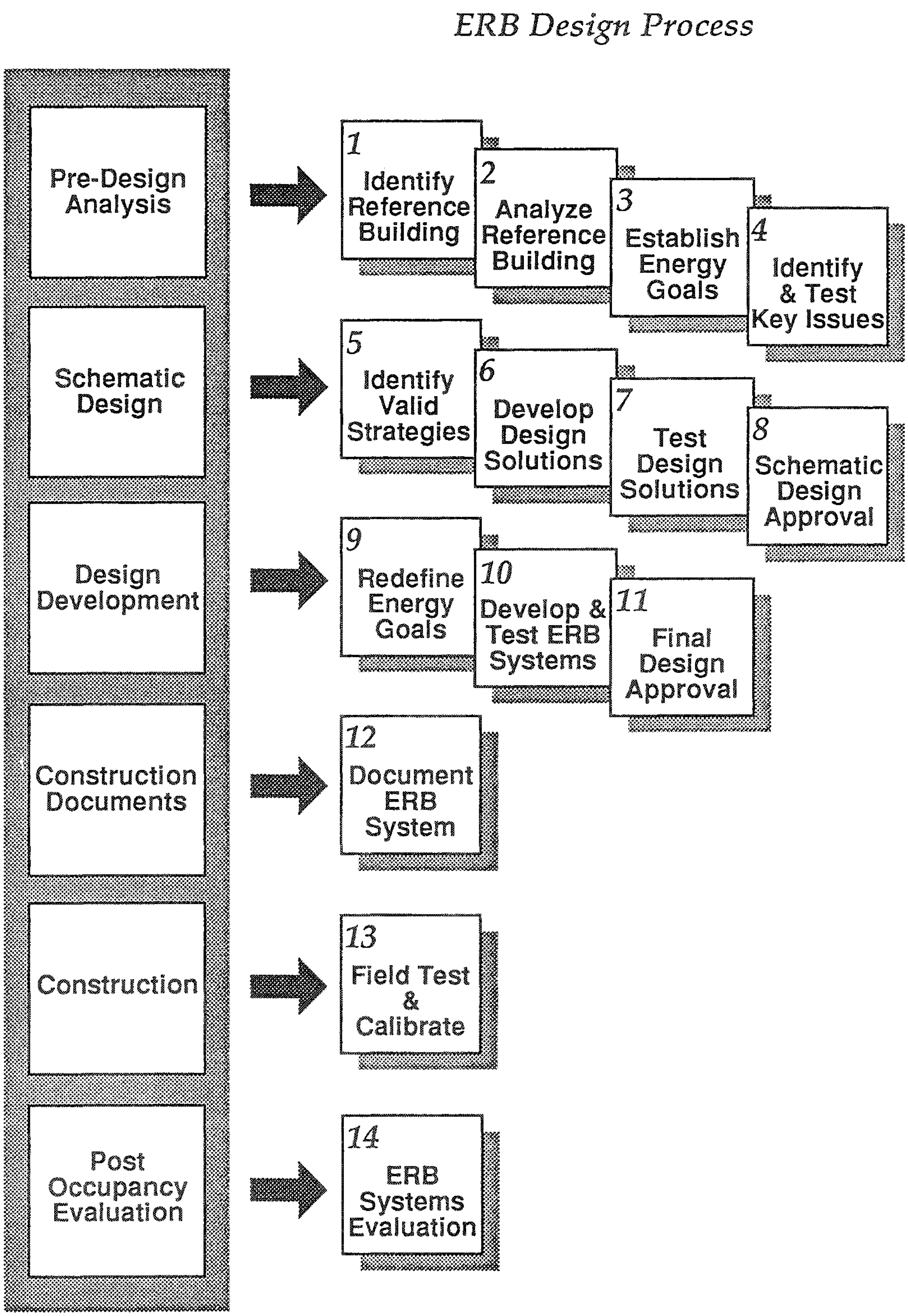

Figure 1. Architectural Design Process

PRE DESIGN ANALYSIS

Steps 1-4 should be coordinated with the programming phase of the architectural design process. During PDA, the ERB Design process focuses on establishing important background energy information about the site, climate, utility, and building program. The ERB process is at the same level of detail as the building program. Therefore, these steps do not provide information on a specific design solution, but are used to establish the reference building, project energy goals, and identify issues to be considered later during schematic design.

Since no architectural design solutions have been formulated at this point in the ERB process, it is unrealistic to expect the ERB pre-design analysis process to do any more than provide guidelines for conceptual consideration of energy concerns during the schematic design phase.

Step 1 Identify Reference Building

The purpose of this task is to establish of the information needed to begin the analysis process. Key tasks include, but are not limited to: (1) establishing a reference building, (2) preparing any site and locale climate data, (3) determining the appropriate utility rate tariffs that will be applied to the project.

Step 2 Analyze Reference Building

Dynamic computer simulation, which consists of parametric analysis and sensitivity analysis, is used to determine the energy characteristics of the reference building. Dynamic simulation is a technique that determines the energy use, energy cost, and peak demand attributes of the reference building for each hour of the year; a total of 8760 hours, or calculation loops.

Two forms of detailed analysis are used to establish the pattern of energy usage for the reference building. These are: (a) parametric analysis, and (b) sensitivity analysis. Parametric analysis is used to determine the cause of the energy use and the range of possible performance. Sensitivity analysis is used to establish the seasonal and day/night (diurnal) performance boundaries of the reference building.

Step 3 Identify Energy Goals

Energy goals represent the various performance targets for a particular building. These performance targets represent achievable energy conservation levels for the project. Three forms of energy goals can be established: (a) peak demand reduction goals, (b) energy cost reduction goals, and (c) energy conservation goals. Combined these are called PDQ goals.

At this phase of the project the goals represent overall building performance criteria. More detailed goals may evolve during design development.

Step 4 Identify and Test Key Issues

Issues are specific areas of concern, such as heating, lighting, or equipment that require individual strategy responses in order to insure that the total ERB Design achieves the identified PDQ goals.

Issues identify the necessary actions required to respond to energy goals. For example, establishing a goal to reduce energy use and peak demand may be achieved by a set of required actions: as identified by a set of issues. To reduce energy use the issue might be attack daytime cooling, daytime lighting, or nighttime heating, or all three of these combined. To reduce peak demand the issue may be to attack all coincident daytime electric loads.

Studying operating schedules, time of day of specific energy end-uses, and so forth, leads to the determination of the issues. See Figure 2.

SCHEMATIC DESIGN

Steps 5-8 sorts out and conceptualizes the information developed during PDA into design possibilities that address key areas of concern. Whenever possible, an ERB Design concept will attack more than one energy issue. Although individual concepts are analyzed, it is the effective combination of sets of ERB concepts that are being sought out as part of the SD process.

The ERB Design process is interactive. That is, there is considerable interplay between the development of ERB concepts and the development of architectural and engineering concepts. The ERB Design process provides unique solutions to each

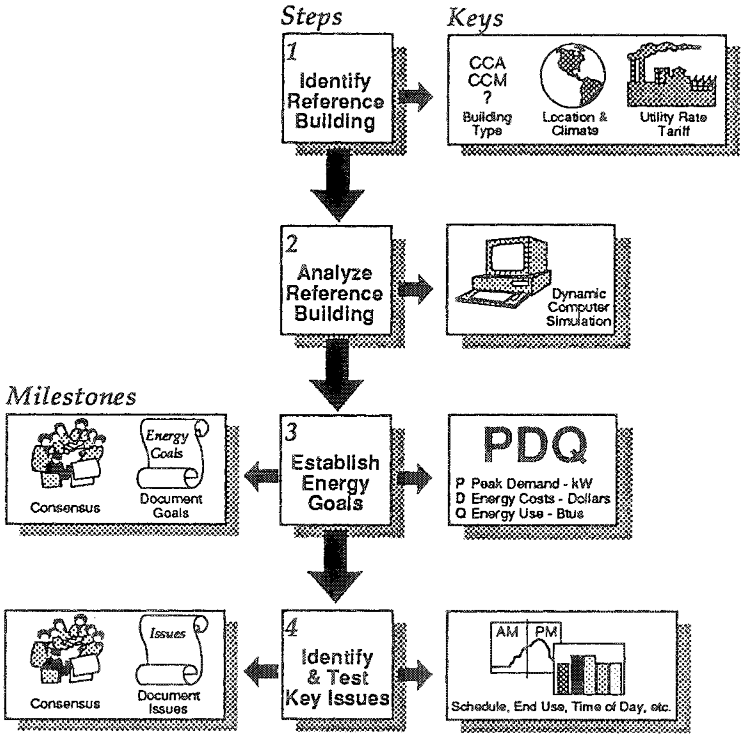

Figure 2. Pre-Design Analysis and Programming

schematic concept. The analysis of these designs leads to the discovery of the best combination of energy concepts. It should always be remembered that the purpose of schematic design is to be exploratory, and the ERB Design process attempts to encourage exploration with respect to energy conservation.

The major milestone of this effort is to produce the optimum design solution for approval.

Step 5 Identify Valid Strategies

Strategy analysis is used to determine the most valid set of strategies that match a given schematic design. Different strategies may be appropriate for different schematic design concepts.

This step will investigate possible building forms, construction materials, space relationships, MEP systems, building systems, components, and so forth, to determine alternatives to identified issues.

Step 6 Develop Design Solutions

Once individual strategies have been identified they can be combined to establish the most effective design solution. It is important to combine groups of strategies because their performance characteristics vary when analyzed as part of a group as compared with when each strategy is analyzed individually.

ERB Design concepts are based on the preliminary PDA analysis. This step will require the development of architectural solutions that will respond to identified strategies.

Step 7 Test Design Solutions

Design solutions should be tested to establish their ability to meet ERB Design requirements as well as all other programming requirements. Energy analysis should be performed on all schematic design solutions to determine the scheme that provides the optimum performance of the PDQ elements.

Step 8 Schematic Design Approval

The architectural solution that meets ERB Design requirements as well as other programming requirements should be selected and presented to Compaq for approval. See Figure 3.

DESIGN DEVELOPMENT (DD)

Steps 9-11 take the concepts developed in SD and develop them into energy systems.

However, the first step of DD, Step 9, is to re-evaluate the goals established during pre-design analysis to confirm that they continue to be realistic and attainable. This evaluation is necessary because the schematic design concept approved for design development may not be capable of meeting all of the energy goals established during PDA. Stated another way, since the concept taken into DD must meet all of the requirements and constraints of the project, not just the ERB Design goals, it is very probable that the concept approved for DD is not the most energy efficient building concept studied in SD. Therefore, goals are re-focused at the beginning of the DD process. The revised goals established during DD are used as a basis for reviewing and testing the building during build-out and post-occupancy evaluation.

Materials, sizes, manufacturers, and so forth, are selected for development and testing during design development. This phase is completed with the approval of the final design.

Step 9 Redefine Energy Goals

It is important that realistic and attainable goals are set. Realistic goals help in evaluating the true effectiveness of the ERB Design. Therefore, it is also equally important to understand that the schematic design approved may be the consensus solution for all programming and design requirements, but it may not necessarily be the optimum solution for ERB requirements. Because it may not be the optimum ERB Design, it may not be capable of meeting the original PDQ goals. Therefore, goals should be redefined relative to the approved design.

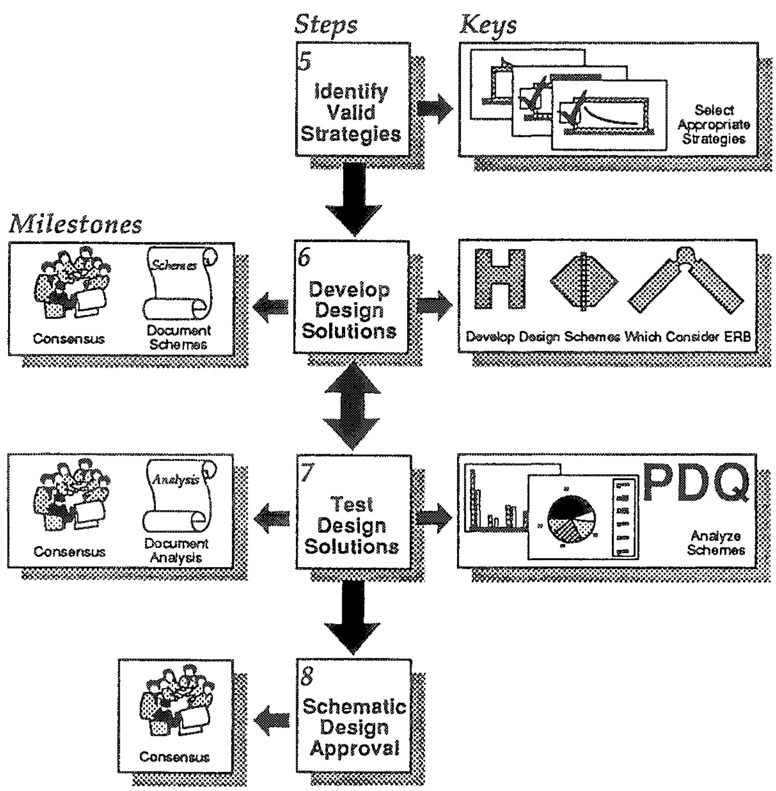

Figure 3. Schematic Design

Step 10 Develop and Test ERB Systems

Schematic design strategies should be developed into detailed ERB Design systems during this step of the process. Specific material selections, sizes, and so forth, should be reviewed and tested to optimize their effectiveness as design strategies.

Step 11 Final Design Approval

The ERB systems should be incorporated into the design and submitted to Compaq for final design approval as part of the architectural design submittal. See Figure 4.

CONSTRUCTION DOCUMENTS

Step 12 incorporates all ERB systems into the construction document package in a format acceptable for construction of those systems. This includes all plans, elevations, sections, details, and specifications necessary to show how the ERB systems interface with other building systems for construction purposes.

Step 12 Document ERB Systems

Once the final design is approved the ERB systems should be developed for construction and included in the construction documents. Most of this work will be done by the architects and mechanical/ electrical engineers. The energy consultant will provide documentation as requested by other members of the design team. See Figure 5.

CONSTRUCTION

The construction phase of the ERB Design process encompasses two distinct areas: (1) field testing and calibration of specified equipment, and (2) build-out.

Field testing and calibration insures proper installation and operation of all ERB systems. If needed, the monitoring protocol and commissioning reports are prepared during this stage of the process.

Build-out is a critical element in the ERB Design process. Once the shell is completed the interior build-out begins. Build-out goes through the same methodology as outlined in steps 1-12 of the ERB process that has previously been applied to the overall design. The primary difference is that each floor of the building is considered as a separate entity and the energy goals established during DD are used as the base-line for any analysis. In this way the goals established for the building can be carried through to the final construction of each floor.

Step 13 Construction

Step 13 has two distinct phases: (a) construction observation and field testing and calibration of equipment, and (b) interior build-out. Construction observation, testing, and calibration are used to monitor the installation of ERB systems during the construction process. Clarification of correct installation procedures or approval of substitutions may be necessary. Field testing and calibration is performed to insure that ERB systems are installed to provide the maximum benefit.

Build-out is the phase of the project where the interior is finished to user specifications. The ERB process is applied to each floor of the building to insure that goals finalized during design development are followed during the final stages of construction. See Figure 6.

POST OCCUPANCY EVALUATION

It is important that the ERB Design established for a given building is evaluated to help direct the ERB Design process during the design of the next project. Post-occupancy evaluation consists of analysis and monitoring of both start-up and ongoing "normal" operations. Start-up analysis helps insure that the building is performing as designed. On-going analysis is used to study the normal operation of the building. It provides a base-line for establishing an operation and maintenance schedule for the building and assists the facilities staff in understanding the expected ongoing performance of the building.

Each step of the process can include both key tasks and milestones. The key tasks describe the critical elements that must be completed as part of the step. Milestones describe deliverables and control points. Not all steps include both keys and milestones.

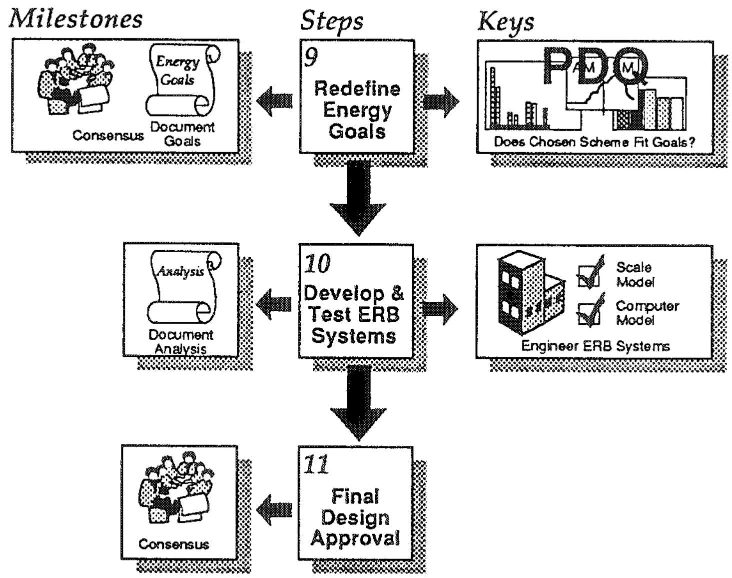

Figure 4. Design Development

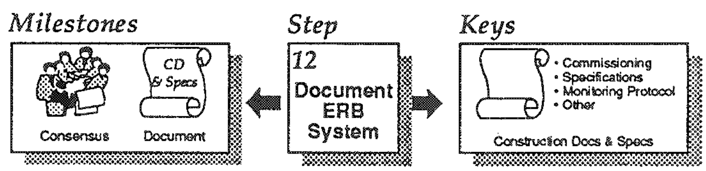

Figure 5. Construction Documents

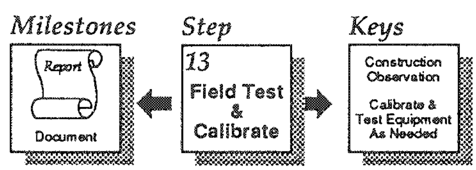

Figure 6. Construction

Step 14 Post Occupancy Evaluation

Energy performance, peak demand, and energy costs are measured and calculated after the building is occupied to establish criteria and guidelines for future projects.

Post occupancy evaluation occurs in two stages: (a) start-up, and (b) normal operation. Start-up is the initial staging of the building before it is fully occupied and before the use pattern has been established. It is important to understand the start-up pattern in order to forecast utility usage and cost during this phase of operation.

Normal operation occurs after the building is fully occupied and all of the systems have been tested and approved.

Post occupancy evaluation can include monitoring, commissioning, and detailed energy analysis. See Figure 7.

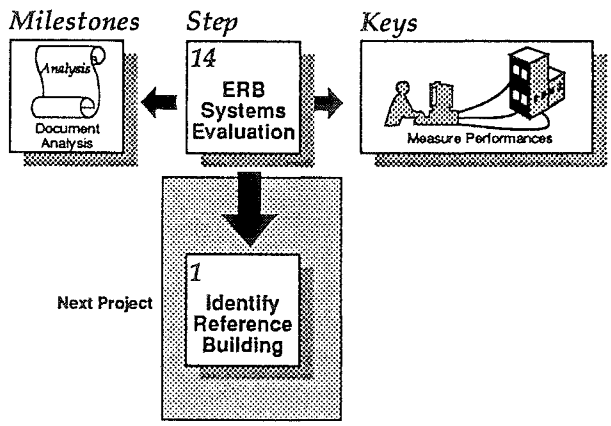

Figure 7. Post Occupancy Evaluation

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