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SCIENCE DIRECT
Building and Environment 40 (2005) 1153–1163
BUILDING AND ENVIRONMENT
www.elsevier.com/locate/buildenv

Investigation into capital costs of HVAC systems

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Received 28 November 2002; accepted 12 November 2004

Abstract

The initial capital outlay is one of the largest expenses of any HVAC system. Estimating these costs accurately is crucial to any HVAC economic analysis. In this article, initial cost models are investigated.

A literature study reveals different methods for estimating initial costs. None of these are suitable for use during the conceptual design stage. They are either too simplified or require too detailed inputs. The use of ''Pareto's Principle'' to develop a suitable model is investigated in this paper.

''Pareto's Principle'' can be formulated to state that 20% of the equipment makes up 80% of the cost. This principle is tested by analysing some tender estimates. Although it appears to hold true, it is also evident that items like piping and ducting contribute significantly to installation costs. Accurate estimates can thus only be obtained by pricing each sub-system separately.

Models are proposed for each subsystem of a typical HVAC system. All the proposed models are suitable for integration with *QUICKcontrol* and are applicable to a wide range of different HVAC systems.

Estimating the costs of both the major capital equipment as well as the smaller sub-systems, is relatively simple. Air and water distribution systems are more problematic due to the number of variables. Without a fairly detailed design and costing model, no accurate cost predictions can be made.

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Keywords: HVAC system; Initial costs; Economic analysis

1. Introduction

Initial cost is one of the major expenses during the life-cycle of HVAC systems. It must form part of any HVAC economic analysis [1–3]. Initial cost is especially important in short- and medium-term economic analyses. Even in long-term analyses it has a 20–50% contribution to the life-cycle cost.

It is commonly believed that the largest life-cycle savings can be realised during the conceptual design of the system [4]. Performance simulation programs must be used to realise these savings through quick and accurate energy use simulations. For this study the performance simulation tool, *QUICKcontrol,* developed by Mathews and Rousseau [5] is used.

Together with the performance simulation results, the designer also requires the initial cost of the system. However, it is often difficult to estimate the initial cost of different conceptual designs. Good prediction models for initial costs would greatly facilitate economic analyses at the design stage.

It is useful to investigate the methods currently applied in practice. Analysing tender results can give us an insight into the accuracy of initial cost estimates. The application of Pareto's Law to simplify the initial cost estimating is evaluated in this paper. Based on the results, recommendations are made for the development of suitable initial cost models and procedures. However, it will require extensive future work to develop these models further.

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0360-1323/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.buildenv.2004.11.011

2. Accuracy

Not all estimating methods and cost models have the same accuracy. Understandably, the more detailed methods give better results. The question, which needs to be answered is: "How accurate does the initial cost estimate *have* to be?" Perhaps a more relevant question is: "How accurate *can* it be?" In this regard one can learn a lot by examining actual tender results.

In practice, even though tenders are based on the same detailed specifications, the tender prices often vary significantly. The submitted prices for seventeen tenders were evaluated in this study. Fig. 1 shows the spread of the actual tender prices for each tender. (All of these tenders were submitted during the year 2000.)

From the graph, it can be seen that the tender values vary by between 15% and 40%. The smaller percentage variations occur on the larger projects. One must accept that the detail of the tender specifications and drawings can influence the variance of the tender results. Other influencing factors are the work load, profit margins and overhead structures of different companies. Clearly, any initial cost model can only give approximate answers. A model cannot be more accurate than detailed tender prices.

3. Cost estimating in practice

During the design process, initial costs have to be determined for the different concept designs. The designer normally relies on "rules of thumb" and cost factors based on experience.

A good example of a cost factor is the cost per floor area rates often used in the HVAC industry. Some analysts reckon that *cost per floor area factors* are no longer acceptable [6]. In most instances, the only accurate method is to compile a priced Bill of Quantities. This is only possible if the design specifications and drawings are available.

To compile this information solely for the purpose of comparing different conceptual designs, is not cost effective. Even if a design office has the *manpower* to do this, they normally do not have the *estimating* capabilities, since they often rely on the services of HVAC contractors for the costing function.

However, contractors are often unwilling to estimate the costs of conceptual designs because of the costs involved for them. Furthermore, contractors have no incentive to help the engineer design cheaper systems, as in most instances this means a reduced income for them.

For the economic analysis of conceptual designs, designers need faster, more accurate ways to estimate initial costs. Therefore, the engineer has to have some means of estimating initial costs.

3.1. Cost factors

Discussions with HVAC consultants reveal that they still use *cost per floor area* or capacity models for conceptual estimates. Raftery [7] has found the same tendency in the construction industry. There is also evidence that cost factors are used for computer modelling of HVAC systems [8].

These cost factors are not always very accurate. They are only reliable if used for specific building types, HVAC systems and climates. They do not work well at all when a system, or building, out of the norm is encountered.

3.1.1. Cost per floor area

The use of standard cost factors is by far the most favoured estimate model for conceptual design estimates. In some of the estimating manuals *cost per floor*

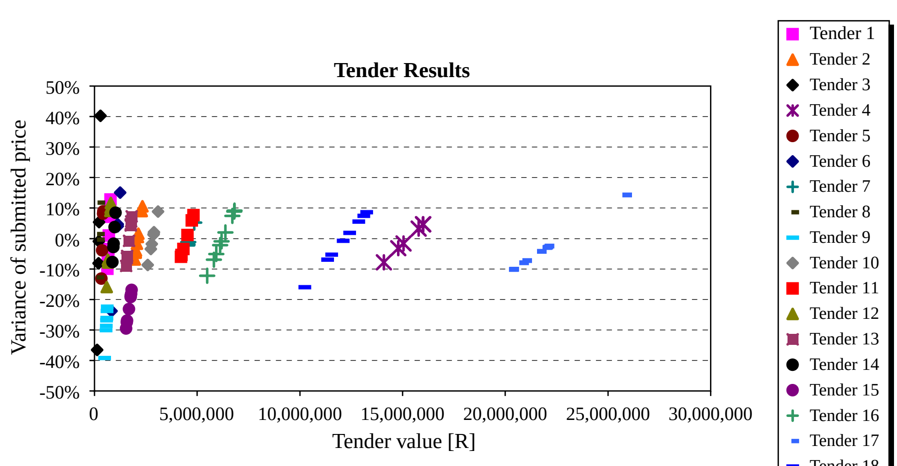

Fig. 1. Spread of tender results.

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