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JUDUL: **USING ARTIFICIAL NEURAL NETWORK TO PREDICT POWER PLANT TURBINE HALL KEY COST DRIVERS**

SESI PENGAJIAN: 2006/2007

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Date : 11th. May 2007

USING ARTIFICIAL NEURAL NETWORK TO PREDICT POWER PLANT TURBINE HALL KEY COST DRIVERS

NG CHOO GEON

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Science (Construction Management)

Faculty of Civil Engineering
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MAY 2007

I declare that this thesis entitled "**Using Artificial Neural Network To Predict Power Plant Turbine Hall Key Cost Drivers** " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : NG CHOO GEON

Date : 11th May 2007.

To my beloved wife, Sau Lai

and my children

Phoebe Ng Yong Ci and Wilbur Ng Ji Chien

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ABSTRACT

The wave of sudden electricity shortage owing to the economic booms worldwide recently had resulted the tremendous time cut in power plant project development. The usual steps in project life cycle, like bidding time in the procurement process is one of them that have not been spared. Despite it has been recognised that the current traditional practice in cost estimation of power plant project is reliable but it is also very time consuming. As such, it is clearly imperative need to find alternate approach in preparation of bids, to meet the odds against time pressure. The study has been formulated to address such issue. The main aim of the study is to use Artificial Neural Network (ANN) as the faster alternative method in predicting key quantities for power plant project. However, the study will only focus on the construction of turbine hall section only. These key quantities normally will be priced by vendors in supply chain, subsequently compiled as latest price at bidding time. The 15 years old historical databases of photographs, drawings, as-built bill of quantities, and bids bill of quantities, from renown power plant constructors, have been used to enable the identification of key cost drivers and key parameters in estimating turbine hall and used to train ANN models. As a validation process, the results from the ANN model has been compared with the statistical method of Multi Level Regression (MLR). The result of the study has determined the ANN regression model is reliable and expected can be used by the contractor in the estimating process of turbine hall construction.

ABSTRAK

Kekurangan bekalan elektrik yang mengejut berpunca daripada peningkatan ekonomi seluruh dunia kebelakangan ini telah mengakibatkan keperluan untuk mengurangkan tempoh masa pembangunan loji elektrik secara mendadak. Pemendekan tempoh inin perlu dilakukan pada setiap fasa dalam kitaran hayat projek, seperti masa untuk pemprosesan tender. Kaedah anggaran kos yang diamalkan kini walaupun baik tetapi mengambil masa panjang. Justeru itu, satu kaedah lain yang lebih ringkas dan cepat dalam penyediaan tender sangat diperlukan. Kajian ini telah dijalankan sejajar dengan hasrat tersebut. Matlamat utama kajian in adalah untuk menggunakan rangkaian neural sebagai kaedah alternatif yang lebih cepat dalam meramal kuantiti utama untuk pembinaan loji letrik. Walau bagaimanapun kajian ini hanya ini hanya memfokuskan kepada proses menganggarkan kuantiti utama untuk pembinaan dewan turbin sahaja. Kuantiti-kuantiti utama yang diramalkan itu biasanya akan dihantarkan kepada pembekal-pembekal dalam rantaian bekalan untuk tujuan mendapatkan harga terbaru, dan selanjutnya dikumpulkan sebagai harga terkini pada masa tender. Pengkalan data dari firma yang terlibat dalam pembinaan eletrik loji yang terkenal dalam tempoh 15 tahun kos utama telah digunakan untuk sebagai asas menganggar pembinaan dewan turbin. Data tersebut telah digunakan untuk melatih dan membina model regressi rangkaian neural. Sebagai proses pengesahan keputusan model rangkaian neural telah dibandingkan dengan model Multi-layer Regression, (MLP). Keputusan kajian telah mengesahkan bahawa model regressi rangkaian neural yang dijana mempunyai ketepatan yang tinggi. Oleh itu ia diramal dapat digunakan oleh kontraktor untuk proses membuat anggaran dewan turbin dengan memuaskan.

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CHAPTER 1

Introduction

1.1 Introduction

The power plant constructors are recently under tremendous pressure on the fast tracking of power development, at the same time facing steep price competition from the global players. In this chapter, the discussion on the background of this study in using Artificial Neural Network in estimation of Turbine Hall in Power Plant Project with hope that it can be used in near future to ease the pressing situation.

1.2 Background of Power Plant Procurement

Power Plant is basically a facility that generates electricity from fossil fuel or hydraulic potential of water dam. Recently the environmental friendly and more efficient modern gas turbine power plant has been chosen. In addition, it is providing the fast start-up in meeting peaking demand period.

The demand for electricity in the recent years has increase sharply owing to the extensive development of Information and Communication Technology (ICT) in various sectors. The wave of sudden electricity shortage owing to the economic boom worldwide recently has definitely exacerbated the already acute imbalance supply-demand equation. Such demand has resulted the need to fast-track power

plant construction; and it affects the whole spectrum of the project life-cycle activities in power plant development, and the procurement activities are not spared the time cut in each steps of its' processes. The key success factors in securing power plant project are the submission of best technical compliance and best price bid. The accuracy of the best price shall at the lowest possible of uncertainties or risks.

The time dependent in current practice in cost estimation of Power Plant Projects has inherited the traditional foolproof processes and dependent mainly on the manual search into historical databases; where it is then used to formulate the bill of quantities that will be issued for preliminary pricing. With globalization, more challenge and competition should be expected in bidding for power plant projects. As such, it is a clear imperative needs to find alternate approach in preparation of bids, to meet the odds against time pressure. In order to submit the best bid proposal with competitive price, successful best price sourcing through global supply chain management is important. Thus, the generation of bill of quantities at the shortest time is crucial to enable the global sourcing approach. The very much compact time schedule in bidding stage from the sudden demand, and coupled with this need in global sourcing, the need to find way or alternative to current estimation become apparent and crucial.

In the beginning of this new millennium, the wave of globalization has made competition in bidding Power Plant Project stiffer. And more crucial is the shorter and shorter bidding period for the power plant projects are not helping the situation at all. As such, it is essential for the investigation to more efficient estimating methods as to replace the current approaches in Power Plant Projects, which will address the need of speed, accuracy, reliability and cut down uncertainty to the minimum.

As such, this study is meant to investigate the alternative through the use of Artificial Neural Network (ANN) that is seen to be of great potential in supporting the estimation process of, Turbine Hall in particular, new power plant projects bid preparations. The focus on quantity estimate will address the elimination of risks that inherited within the unit rates uncertainties, like political situations, market demand

fluctuations, inflation, labour skills, the like; which changes with time and location of projects.

It is the aim of this research to systematically investigate into the real current practices, and the need of the power plant construction business to change. In addition, this research will instigate the need of alternate method in quantity estimation or prediction, and the key building where research can be meaningfully focus on. This research will attempt to use the artificial neural network modelling in the prediction estimation (Setyawati, et al, 2002) where historical data collected over the years is use to 'train' the model; and it is then to compare its accuracy and errors with statistical model.

1.3 The Current and Future of Estimating.

The traditional estimating is usually referred as rough and non-committed calculation of works, which is meant for the 'feel' of extent of work and used as rough indication of budget needed. In power plant business, the customer would usually request such estimate from the power generation companies/contractors for such price estimate for their budget preparation. Such estimate is commonly referred as 'Budgetary Price' submission by the power generation companies/contractors. And the time to submit Budgetary Price is given within 1 week, thus the 'rule of thumb' approach is used in the preliminary estimation.

The literature of modern estimating has put effort and importance in stressing on the 'accuracy' and 'certainty' of the estimate, as to improve hit rate in submission of bids. This is becoming evident, owing to the nature of very competitive market situation which is very open and global, particularly in Power Plant Projects. The world key players from America like General Electrics, European like Alstom and Siemens, and Asian like Japanese's Mitsubishi and the Koreans, are very aggressive in submitting the 'Firm Price' to win projects. The commitment of 'Firm Price' by

the bidding parties will usually form the contract price after several of negotiations. The turnover period for 'Firm Price' submission was about 12 weeks in the 90s and become 8 to 10 weeks at the start of this recent new millennium, and the trend of much reduced tendering period is adamant in very near future. Thus, the need of a revolutionary approach with greater efficiency, quicker speed and higher accuracy in estimating is seriously in need in very near future.

The latest key phrase for addressing the efficiency aspect is the use of Information Technology, where we can see how the market is becoming flooded with simple to complicated software. Estimating software is usually developed by the traditional sequence of work to an estimator or a quantity surveyor approach of training. The input would require feeding the fundamental dimensional and unit rate information to assist the taking off process, which the software would be performing the basic computation to form the quantities with the corresponding amount for bringing to total value of the cost. The more sophisticated software would trigger the evaluation process after several unit rates being input; and then follow selection and functions to continue post contract follow-up to final account. Generally, the software would seem act as calculator with systematic filing system that replaces the manual tedious and laborious work. The crucial analyses and rationalization of the estimate is the estimator or quantity surveyor (QS). Thus strictly speaking the software so far wound need the, so to speak, 'intelligence' to compliment the 'thinking' processes to come out with final and rationalized estimate.

The intelligence that enables the thinking in human being will be experiences gathered through the years of number crunching and result of trial and error corrections. And such experiences will not be easily past on to the next person overnight, which discuss in length by Koh (2005) in his knowledge transfer study in cost estimation; whereby time still a critical factor. The challenge now, then, is how to have the computer to perform the 'thinking' part of the estimating process. And how to make the computer 'experienced' enough to 'think' in the estimating.

The emulation of thinking process as in neuron in the use of Artificial Neural Network (ANN) for estimation (Setyawati, et al, 2002) which can 'train' using the

historical data collected over the year, will complement the shortcoming referred. The input and output of the historical data will be used to train the ANN model to make it 'experienced' enough for the 'estimating' based on the corresponding new input. Basically the historical input and output data will enable the ANN model to formulate regularized patterns of the input and output. The formulated patterns are then used to predict the output of the corresponding input, whereby it is similar to the estimate done through human being's rationale thinking process.

1.4 Fundamental of Cost Estimation in Relation to Uncertainties.

Through the examination of several key elements that usually affecting a successful the price level of project, it can be noted the elements of quantities (design), unit rates, risks and market uncertainties. By observation, it can be noted that the last three elements, unit rates, risks and market uncertainties, are very much variables which dependent on the market forces. They are usually uncontrollable or not easy controllable by a firm. Such market variability usually requires input almost on real-time information input together with the adjustment using risk analyses approaches. The input can be fairly obtained accurate or sought in market through the established sub suppliers, giving sufficient time. As such, the uncertainties that are timing and market driven will be very much mitigated. Through the removal of elements related to time and market sentiment mentioned, it is now left with quantities of works, which are very much controllable element. The historical databases of quantities are very much archive of information that can be reused, and the logical relationship of the quantities with key parameters of power plant will be a good estimate or prediction to the power plant in different configuration. Such immediate and quick prediction can save time when compare to generating quantities from engineering process concept up to engineering drawings by painstaking and time-consuming quantity take-off.

The above prelude to this study had indicated the use of ANN to predict or estimate quantities for power plant project is very clear of its advantage and

importance, towards the contribution for winning projects. It is crucial to collect data for the training of the ANN model, to enable the estimating of quantities; which is specifically the focus for this study. It is where a lot of input on thinking patterns can be established for setting the 'thinking' course of the ANN model, which the computer can take over.

1.5 Problem Statement

The key factor the trigger the need of the study is the time constraints faced recently, which will be more demanding in the future. The time frame for tendering Power Plant project has becoming shorter and call for more competitive price submission. In order to allow for more time to get better and latest market unit rate, the conventional tedious and time-consuming preparation of bill of quantity, is in need to find effective alternative to generate bill of quantities.

The problem with the current situation had been due to the various aspects of the time dependent practices. The very demanding requirements from the customers by giving short duration on response time. In addition, the fast moving business environment in term of globalization of supply chain, and more importantly the technological advancement in various media and tools, had made lots of old practices obsolesces.

One key area has been the written work process, which is foolproof in nature, for preparing bid submission is rather long winded and require time. The use of historical databases in helping the estimation for bid preparation through manually cut-and-paste, will have vast opportunity and potential of improvement in this digital age. The approach of estimation, especially with quantity estimation, which requires to wait for a lot of engineering input to complete before the material take off can commence. The historical database of other locations in various countries may not be

immediately useable when cost had been the main component archived, owing to currency differences and exchange rate differences with time.

Practices from various countries, which differed from one to another, underlined one fundamental difference in quantity take-off or more commonly known as method of measurement. The commonwealth country would more use the mainly Standard Method of Measurement (SMM) or Civil Engineer Standard Method of Measurement (CESMM). The non-commonwealth country like Vietnam, Thailand, and Philippines will have their own method of measurement that made them having an underlying unique set of variability. The more advance country like Australia has their own standard method of measurement. Bill of quantity prepared by various locations may not be comparable or compatible, in term of the grouping and breakdown. It is one of the recommendation points to use a standardized data archiving format for the quantities, with same measurement preambles.

The research probes into the current practices and satisfaction level of the expert panels. Various aspects of the current practice in facing future challenges are being investigated in order to verify the need of alternate tool for bid preparation as the main reason for this research. Literature review into the estimating process referred in Hendrickson(2000), and literature review and guidance from previous researchers, of the software applications used in this research is established, for computation and verification of models in under study.

1.6 Objective of the Research.

The main aim of this master project is to develop Artificial Neural Network model to predict quantities of work for turbine hall construction; to achieve the above aim the following objective has been determined:

1. To investigate into the need of alternate quantity estimation/prediction in power industry and establishment on area of study.

2. To establish key parameters and key cost drivers in the main building in power plant.
3. To use ANN to develop model for predicting key cost drivers of main building in power plant.

1.7 The Significance of this Study.

The importance of this study is to address the future trend of shorter tendering period, especially in Power Plant Projects. It is clearly a crucial need to seek alternative methods in which give fast, reliable, accurate and quick estimate for establishing sets of quantities for pricing Gas Fired Power Plant. The research is focus on main building in power island to see the capability of the alternate estimation approach.

It has been the current practice that as-built data from the projects are being cut-and-paste to formulate the quantities for a new project proposal. Items where the historical data non-existence, will be usually obtained through the development of corresponding drawings/sketches follow by the quantity taking off process that will allow the generation of Bill of quantities.

The usage of ANN is being studied for the rational prediction of quantities based on sets of historical data. This research will see the use of ANN model to shorten the generation of quantities. It will be the scientific option to traditional the time-consuming and laborious material take-off estimating approach, which is being practiced currently.

The study of ANN use in cost estimation is not a new topic. There had been many studies like Onuegbu and Mohan (2004), Murat and Zeynep (2004), Setyawati et al (2002), Pearce (1997), and Creese (1995), to suggest the method is the way to

proceed in the future to come. The methodology similar to Creese (1995) in his paper on Timber Bridges has been adopted in this research, especially application of ANN when the number of data available is scarce. The availability of information or data, which is key crucial attribute of ANN can then be fulfilled with database establish over years of computerized system in data management.

1.8 Scope and Limitation of the Research.

The area, which will be covered under this study would be within the following framework:

(i) The quantities in the study limits to Civil and Structure works.

(ii) The area shall limit to Turbine Hall of Power Plant Design in Gas Fuel related plant in South Asia Pacific region, and data available in power plant constructors hubs in Kuala Lumpur office.

(iii) This study will use the Multi Level Perceptron (MLP) Method of Neural Network Model and check by Multi Level Regression (MLR) .

(iv) The selection and verification of the best model will base on the highest accuracy value or the smallest deviation percentile in the Study.

(v) Each model will use same set of data for the comparison purposes.

The application ANN package(s), similar to Neural Connection Release 1.0 used by Yahya (2002) in his study, would be used for neural network model study, whereas SPSS application will be used for analyses and the formation of regression model collected.

With the above limitation of study, it is the aim for the continual upgrade of the study to enable a more accurate and reliable estimate to be achieved for the Turbine Hall of Power Plant project estimate. And this model of study may be used as springboard to wider construction industry in construction management.

1.9 Brief of Research Methodology.

The following methodology is adopted in this research based on the different objectives set out earlier.

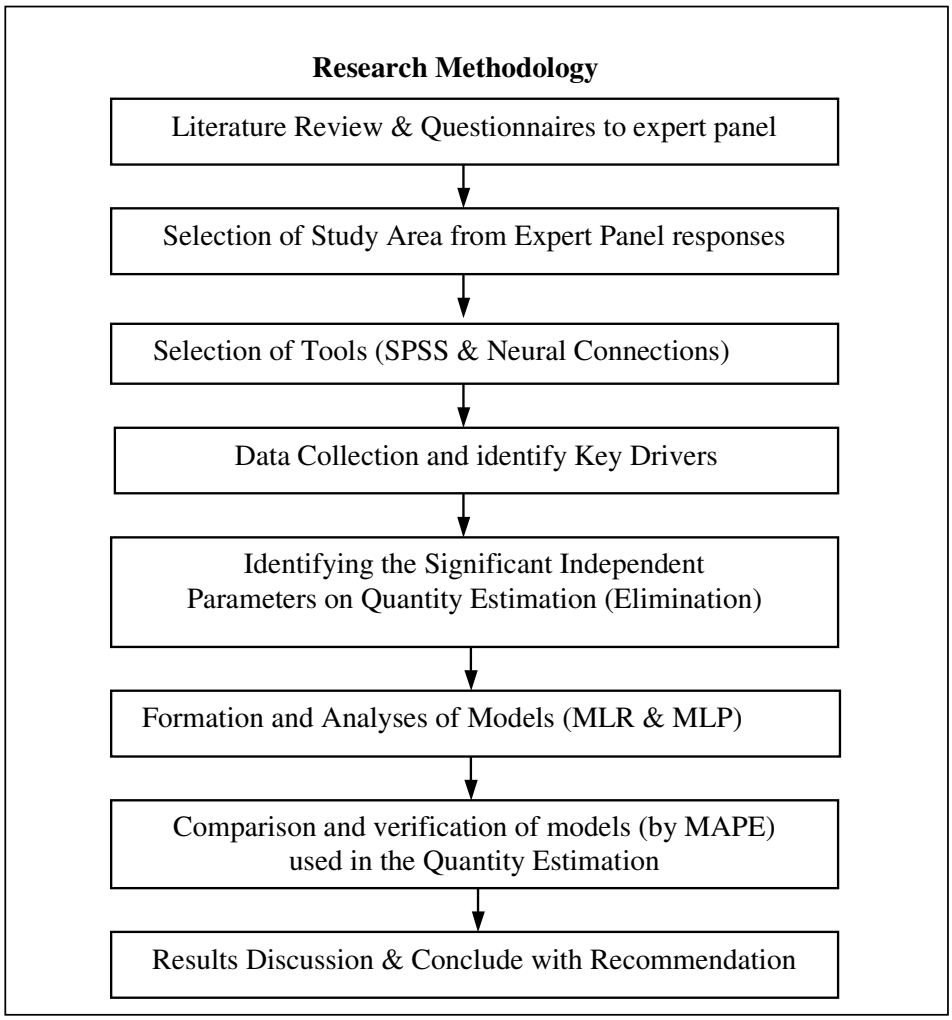

Figure 1.1: Brief Methodology of the Study.