Energy Efficiency Experience with a Successful Performance Contract –
Island Place Shopping Centre

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ABSTRACT

In 2000, the Electrical and Mechanical Services Department (EMSD) of Hong Kong launched a pilot scheme allowing designated areas to use fresh water for evaporative cooling in air-conditioning systems. This energy saving measure is supported by the industry and is being implemented in many retrofit projects in Hong Kong. The use of fresh water for evaporative cooling would imply either the use of cooling towers and water-cooled chillers to replace air-cooled chillers, or cooling towers to replace air-cooled radiators. Energy savings with short payback period can be achieved.

The Island Place shopping centre at North Point Hong Kong was a project involving the changing of air-cooled chillers to water-cooled chillers with cooling towers. It was a performance contract which meant that the contractor used money from his own pocket to supply and install the retrofit project with guarantee on the system performance. In this project, the Contractor employed his in house Consultant to take care of the E&M and structural design package and take up the performance contract for the Client.

This performance contract was very successful and professional because the three parties involved trusted each other. Design analysis by the Consultant on the prediction of energy performance of the new system compared with the old one and other engineering studies should be precise and professional. Contract installation by the Contractor should be of good quality and reliable. The Client should be visionary, open and believe in partnership. High confidence in the Consultant and the Contractor with mutual trust and understanding from Client was believed to be the key to success of this performance contract.

This paper will take a holistic review of the project including professional design, optimum installation, performance contract management, experience and performance feedback.
一个成功的能源效益应用在表演合约
港运城购物中心

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摘 要

在二零零零年，香港政府机电工程署在特许区域推动一个把使用水作为蒸发性冷却空调系统的先头计划，这个节能计划获得香港各界广泛支持。使用水作蒸发性冷却是指把风冷冻机转为水冷冻机，或空气散热器转为水塔。短回报期的节能计划便容易达成。

香港北角港运城购物中心是采用把风冷冻机转为水冷冻机的工程。这是一份节能表演合约，承建商动用自己的资金去安装冷冻机提供了节能表演保证。本工程，承建商聘请他的顾问作机电及结构设计。

本节能表演合约非常成功及专业，主因是三方面都互相信任。设计由顾问担当，把预计的新能源表演与旧的比较，此分析必须精准及专业。承建商也必须富有高质素及可靠，业主必须有远见，开明及深信合作伙伴，成功之路便是业主的高度信任承建商及专业工作。

本论文内容包括专业设计，最佳效果的安装，节能表演合约管理，经验及表演反馈。

关键词：节能表演合约；计算流体学动力；量度及核实。
1. INTRODUCTION

In 2003, the chose to adopt a performance contract for this project. To implement performance contract, there are a lot of requirements in order to make it successful.

In this project, there were requirements and objectives that were well set out at the beginning of the contract. The Consultant had to be well experienced in energy analysis and their prediction should be of the highest degree of accuracy. The Contractor had to be well experienced with the objective of cost effectiveness with the selection of the highest energy efficient equipment. For the Client, they had to be professional in project management and contract administration. Also, they had to be open and believe in the concept of partnering.

2. HIGH PRECISION ANALYSIS ON PREDICTION OF ENERGY SAVINGS

To begin with, there were many methods available for energy analysis. The available software tools in the market did have a lot of weaknesses, such as too analytically focus, without making reference to the actual operation feedback, no correlations with the existing and predicted, variations at peak load and partial loads, etc. All these lead to unrealistic predictions. The analysis, methodology and tools carried out in the project were tailor made and designed by the Consultant. The following sections illustrate the approach and the important concept in design and prediction.

2.1 Methodology

To start the energy analysis, a lot of consultants quickly used the energy programmes. In fact, this kind of approach should be avoided. A proper analysis should follow a 20 steps systematic methodology. It was named SELAB by the author. This is presented in Fig. 1A & 1B. A better approach is to firstly carry out structural analysis after site visit, water chiller combination options and space planning. From past experience, structural constraint is the critical factor. With this, structural analysis had to go first before the energy analysis.
The feasibility study shall include the following step-by-step approach.

- Structural Analysis
- Electrical Distribution Assessment
- Noise Assessment
- Equipment Lifting Assessment
- Electrical Bills Analysis
- Energy Analysis
- Equipment Assessment
- Environmental (including Computational Fluid Dynamics) Analysis
- Additional Water Consumption Assessment
- Prediction Report

[Fig.1A - SELAB Methodology Flow Chart, Part 1 of 2]
By the end of the study, a professional report was produced with contents including plant descriptions, selection criteria, system schematic and layout, analyses of structural, electrical distribution, acoustic, environmental, equipment lifting, water, electrical bill, energy saving, assumptions, result, conversion costs, payback period, life cycle costing, joint venture partners, risk assessment and controls, etc.
2.2 Tool & Concept

The author used his software called BEMX for the energy analysis of the conversion from air-cooled chillers to water-cooled chillers. The software contained a huge database used for energy analysis for different building types such as office buildings, shopping malls, hotels, etc. The database is normalized for use with different building type application. The principle analysis of the software is diagrammatically given in Fig. 2A & 2B.

The advantage of this analysis is based on actual electrical bills. It always makes use of the PEAK running & part load characteristics which results in better prediction of results. It also uses a procedure: from KWh (Existing) “to” Cooling Load “to” KWh (New) employing the simple concept and the first principles in HVAC. The software had been trial tested for many years and the results were consistent and of high precise predictions.
2.3 Computational Fluid Dynamics (CFD)

There were concerns of the nuisance generated from the cooling tower exhaust after installation to the surroundings. The parameters to be investigated were air flow velocity, air temperature and moisture content. The new cooling tower exhaust would be compared with the existing air-cooled chiller exhaust. An analysis would be necessary to predict the three parameters at the nearest residential receiver point. To accurately predict the result, a computational fluid dynamic study was carried out. It was found that there was not adverse effect on the resultant air flow at the nearest residential receiver. The result is given in Fig.3.
3. IMPLEMENTATION OF SYSTEMS

3.1 Contract

The contract arrangement was a design and built contract with performance guarantee. The contractor was responsible for the design, supply and installation of the new water cooled chiller plant. The contractor did not only include the E&M design, but also the structural, acoustical and environmental analysis and evaluation. In this project, the contractor employed his consultant to take up the task. The contractor needed to calculate the estimated electrical savings based on the cooling load profile (Methodology was referred to Section 2.1) and performance of new equipment. Comparing with the overall capital costs and interest charge, the payback period could be calculated. Once the payback period had been confirmed, the contractor could only be paid from the savings of electrical consumption/bills within this payback period. The owner of the building would pay the ‘same’ amount of money stated in the benchmark of annual electrical bills throughout the agreed payback period. However, if the operating parameters were changed, there would be some formulae to adjust the benchmarking annual electrical bills.
Strategically, the contractor made the most cost effective design of the system to bring the best value to the stakeholders. Conversely, all options that could improve the efficiency of the system were considered. A very important factor that needed to be addressed was the reliability of the system. If the system broke down during the payback period, the savings would be affected and no extension of payback period was granted because of this situation. Therefore, making the system to be the most efficient, robust and reliable at the optimum costs would be the key success factor of this project.

All equipment and associated accessories used in this project had to be approved by the client. A proposed list of equipment was submitted during the tender stage. The client compared the scope of supply amongst the tenderers together with the relevant payback periods.

### 3.2 Installation

The replacement schedule was chosen from end of the year to the period before the hot summer of the following year. To maintain the continual operation of the plant, the installation was divided into 2 phases. Project meetings were arranged regularly to review the design, progress and approval. Everything was discussed during the project meetings and prompt decisions were made. This could totally shorten the time for approval and communication. The client and the contractor somehow developed the trust and applied win-win strategy in the discussion of all disputes and arguments. Fairness and reasonableness were always the pillars of the negotiation.

After the completion of the installation of the phase 1, the contract allowed 2-3 weeks for trial run and fine tuning of the system. Once the system was smoothly operated, the installation of phase 2 started. The savings of electrical charge from phase 1 was also recorded until the practical completion of the whole project. These savings were put into a pool for the expenses of variation of orders. The payout was agreed by the client and contractor together. The surplus was kept by the client and shared by two parties once the practical completion was confirmed.

When everything was in the stable conditions, the payback period started and the data base of the electrical consumptions and savings were orderly recorded for comparison.
3.3 Performance Indicators

The performance indicators were definitely the savings in electrical bills. If the savings exceeded the previous estimation, then the overall performance was good. However, the client would also look at the design of the chiller plant, the quality of the installation works and the project management of the contractor. The reliability of the system was another indirect performance indicator. In addition, good after sales service and maintenance service of the contract were part of the performance.

The performance indicators were also related to the number of outstanding defects or arguments. If the project was running smoothly without too much unsolved issues, then the client was happy and the customer satisfaction was high. This was very important to this kind of performance contract because it would last for 5 ~ 6 years for collection of money from savings of electrical bills. Keeping good and harmonized working relationship with the client or the property management company was essential.

There were many operating parameters that would affect the electrical consumption. Formulae had pre-set and agreed during the tender stage and stated clearly in exhibits. All variances in operating parameters were anticipated in the contract early stage and be calculated from the formulae and be adjusted as necessary. This arrangement reduced a lot of arguments in future and enhanced the greatest harmony.

3.4 Buffers & Others

Putting buffers in capital cost or payback period could allow variances in installation works and operating parameters during the installation and operation stages respectively. When the contractor submitted the proposal at tender stage, the design of the system was not fully considered in details especially in the change over stage of the system. Once the tender was awarded, the contractor would start the detailed design. The client would also give suggestions and expectations to the design of the system because they were the end users of the system. Although there were demands in increasing the standard of the installation works, the system would perform better and the end user felt satisfactory.
The buffer was used to meet the end user’s expectations that could improve the performance of the system. It was important that the client should not ask for unreasonable requirements.

There were many performance contracts done by other contractors. However, most of them did not achieve a happy ending. The contractor wanted to earn as much money as possible. The owner also wanted to have the highest standard. With this in mind, there were conflicts already in the business point of view. If everything could state clearly well before hand, then conflicts would be reduced to a practical minimum. By nature, performance contracts do not wish to lead to unhappy endings. That is why setting the buffer was so important to reduce these conflicts. With such, it would slightly extend the payback period to longer time but still at reasonable acceptance. The most important thing for performance contract to succeed was to build up the mutual trust and communication in the project team. Everybody worked on the same target but not on their personal issues. Choosing the right customer was the success of the first step.

4. A REVIEW ON PERFORMANCE CONTRACTS

Energy Performance Contracting (EPC) has been adopted in the western world for a long time already, however the take-up rate in Hong Kong has remained low. The principle of EPC is for contractor to enter into a performance contract with a client. The project will usually involve either new installations or modification works which can generate long term savings to the client. The contractor will guarantee the savings and get back the investment and their profit through savings within an agreed time period.

4.1 Prerequisites

In theory, a client will only be interested in adopting an EPC if they perceive that there is a net benefit out of an EPC. This includes both competitive advantages of the contractor over the client and comparative advantages of the client’s limited resources. The obvious ones are listed below:

- Resources which include the particular technical knowledge and internal expertise which would be less cost effective for the client to acquire.
- Better risk management as a result of the particular technical knowledge and
experience of the contractor. Risk can hence be better assessed and managed.

- Lower financial cost obtained by the contractor. Sometimes, the client may even have difficulties in seeking funding for the project such as in multi-ownership buildings.

That is, if the client knows the technology, knows the chances of success of the project and has the funding and other associated resources available that can give a better return over other opportunities, there would not be an interest for the client to adopt EPC.

4.2 Barriers to EPC

While availabilities of technical resources and financial cost are easy to determine, the risk management is a more subjective and complicated matter which becomes the major barriers to EPC.

The followings will cause risks to a client or contractor which are difficult for the either parties to assess and manage.

- Complex and rigid contractual term and conditions.
- Difficulties in the measurement and verification (M & V) of performance as a result in the changing parameters.
- Trust between client and contractor.

As a result of the above, clients are reluctant to adopt EPC and/or contractors need to add on a high premium to offset the risk. This will also incur added insurance and financial costs. Both parties will need substantial administrative efforts to manage the contract and the extensive measurement and verification requirements.

If the contract can be established so that the risks can be reduced, there are more chances that the client will adopt EPC and the contract can be carried out more cost effectively.

4.3 The Contract Management for the Project

The EPC is established with a mind to address for the above mentioned
problems.

(a) Contract Awarding Process

(b) Invitation for Proposal and Selection of Contractor.

A few contractors were requested to submit a proposal for the project. The document given to the contractor includes:

- Detailed requirements: giving the contractors the contract constraints and performance that the contract needs to work within. At the same time, contractors are given the flexibilities to propose options that can give the best value to the client.

- Submission / criteria for selection

Requirements for submissions are listed out which includes:

- System design drawings
- Estimated energy consumption profile and savings with detailed calculations.
- Assumptions for all calculations.
- Performance characteristics of chillier including part load performance under various conditions.
- Plant optimization, control and operation strategies.
- Estimated cost with detailed breakdown, payback period and life cycle cost.
- Risk assessment and control, etc.

The criteria for selection are also spelt out in the document so that the contractors can better formulate their strategy and proposal.
Information to contractors

To allow contractors to better estimate the savings, the vendors were given
the existing chiller plant operation methods, one year operating data and
electricity bill record for the past two years.

(c) Establishing of Contract Details and M&V Methods

The contract details and M&V methods are established jointly with the
contractor. This is to ensure that both sides understand the details in full and
those agreed are practical and cost effective to both parties. The performance is
benchmarked with a reference year with 8 operation parameters including set
point of leaving water temperature, daily operation hours, the situation to run
air-cooled chillers, set point of indoor temperature, building usage, occupancy
rate, maintenance hours of air-cooled chillers, and the unit rate of electricity
charge.

An allowable variance to each parameter is stated so as to reduce the M&V
efforts in tracing the changes in the operation parameters. Should the operation
parameter falls outside of the stated allowable variance, simple formulae for
calculation of additional costs were agreed.

4.4 Result

On the whole, the contract was implemented smoothly. Little effort were spent
by both parties on M&V as a result of a well thought through and simple contract
details and M&V methods established jointly between the two parties. One critical
success factor is the trust between the client and the contractor and the demonstration
of expertise and professionalism during the whole process.

5. CONCLUSION

The key to success of this performance contract demands a number of professional
and contractual factors. These factors had to be performed at high standards,
otherwise there will be no chance to succeed. Strong technical analysis in
methodology and programming tools leads to high precision on prediction report.
Well experienced installation work with the objective of cost effectiveness and the
selection for the highest energy efficient equipment is absolutely needed.
Contract buffers implementation into the contract to eliminate all possible arguments is extremely important. The client has to be open, strong belief in partnership and high capability in contract administration. Finally, the highest mutual trust and understanding between the parties concerned are the key to succeed.

6. REFERENCE


7. AUTHORS

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