

## **Assignment (2003-2004)**

**Instructions:** Your assignment report should not be more than twenty (20) A4 pages. You may use charts, diagrams, tables, graphics, etc. to help explain your ideas. You are encouraged to use your own words for the writing. Any information taken from other sources must be fully referenced. The assignment might be submitted via e-mail and an acknowledgement by a reply e-mail will be sent to the student for confirmation.

1. Briefly explain how the following factors affect energy efficiency in buildings and suggest strategies to ensure good energy performance in building design.

- i) Climate
- ii) Building envelope
- iii) Building services systems
- iv) Human factors

(4 marks)

### Solution outline 1.:

[Shall explain the factors clearly and concisely using short sentences and key points. Use your own words if possible and DO NOT copy directly from reference text. Bonus will be given to answers with original thinking and info.]

#### (a) Climate

- Effect of climate on building thermal and energy performance
- Response of a building to climate:
  - i. Thermal response of building structure
  - ii. Response of HVAC and lighting systems
- Building design must “fit” its climate
  - i. Human comfort and bioclimatic design

#### (b) Building envelope

- Building skin, such as walls, roofs, windows, skylights
- Design parameters: area, thermal properties, thermal mass, shading
- Good design shall:
  - i. Consider & respond to local climate
  - ii. Good thermal performance
  - iii. Appropriate window areas
  - iv. Proper solar control
- Need to balance with other requirements e.g. aesthetics and view

#### (c) Building services systems

- Main energy users in buildings including
  - i. Air-conditioning
  - ii. Lighting
  - iii. Electrical services
  - iv. Lifts & escalators
  - v. Plumbing & drainage
  - vi. Town gas supply
  - vii. Building management
- Design strategies:
  - i. Thermal comfort criteria: proper design temperature, humidity
  - ii. System characteristics: types, energy efficiency ratios, operation & control
  - iii. Equipment and plant operation: during partload conditions
  - iv. Effective zoning and space design

- v. Effective distribution network
- vi. Correct sizing and selection of equipment
- vii. Proper operation and maintenance
- viii. Better control and monitoring
- ix. Energy awareness of occupants/building managers
- x. Good house-keeping and education
- xi. Energy efficient appliances

(d) Human factors

- Comfort requirements
  - i. Thermal comfort
  - ii. Visual comfort
  - iii. Noise control
- Occupant behaviours
  - i. Patterns of use
  - ii. Periods of occupation
    - Management issues
  - i. Building use, operation & maintenance

2. Building energy standards and codes is an important policy measure for promoting energy efficiency and assessing energy performance of buildings. Briefly describe the following documents and comment on their significance in the respective society.

- i) EU Directive on Energy Performance of Buildings
- ii) The building energy codes in Hong Kong

(3 marks)

Solution outline 2.:

[Use your own words if possible to show your understanding. Bonus will be given to answers with original thinking and critical evaluation of the two sets of documents.]

i) EU Directive on Energy Performance of Buildings

[\* Study the EU Directive document and the CIBSE briefings. Provide a brief summary of the major requirements and comment on the significance in Europe and to the world.]

ii) Building energy codes in Hong Kong

[\* Briefly describe each of the codes and comment on their significance, stringency and effectiveness.]

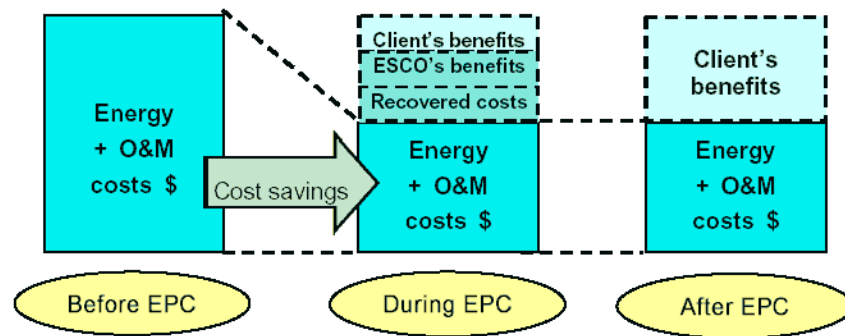
- OTTV code (mandatory)
- Lighting code
- Air-conditioning code
- Electrical code
- Lifts & escalators code
- Performance-based building energy code

3. What is energy performance contracting (EPC)? Briefly discuss the benefits of it and the barriers affecting its development in Hong Kong.

(3 marks)

Solution outline 3.:

Energy performance contracting (EPC), also known as energy savings performance contracting, is a financing technique to raise money for energy efficiency investments based on future savings. Usually, the energy services companies (ESCO) offer the EPC services, without upfront capital on building owners.



The benefits of EPC are: [\* shall discuss each point to show your own understanding. Other suggested points are also possible.]

- Reduced risk (contractor guarantees)
- Turnkey services (contractor provides all services)
- The business needs less internal expertise
- Project financing can be 'off balance sheet'
- Advanced products & services can be used
- Savings can be much higher than done by itself
- Additional improvements to built environment

The barriers affecting EPC development in Hong Kong: [\* shall discuss each point to show your own understanding. Other suggested points are also possible.]

- Weak awareness & experience
- Complex legal & contractual issues
- Problems with conventional procurement process
- Problems with measurement & verification

4. Briefly describe the major elements of building energy simulation and the typical procedure for carrying out the simulation analysis.

(2 marks)

Solution outline 4.:

[Shall describe each element and steps using your own words. Bonus will be given to answers with original thinking and info.]

Major elements of building energy simulation include:

(a) Input:

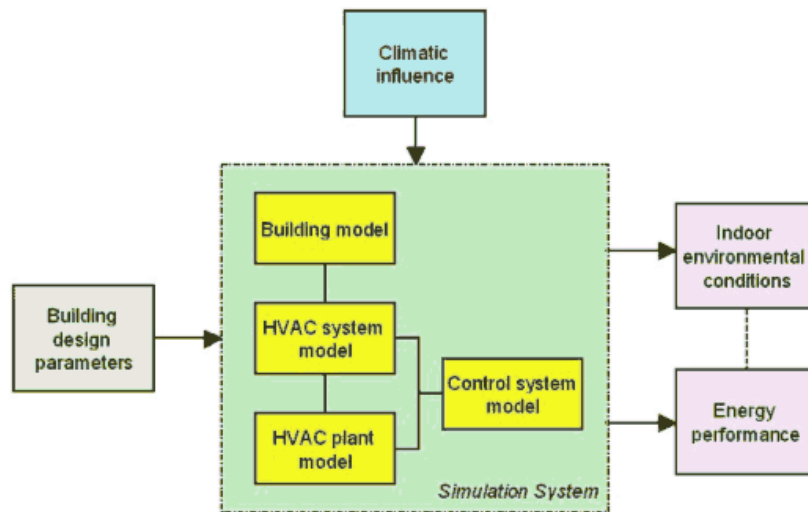
- Building design parameters
- Climatic influence (weather data & file)

(b) Simulation system:

- Building model
- HVAC system model
- HVAC plant model
- Control system model

(c) Output:

- Energy performance
- Indoor environmental conditions



Typical procedure for carrying out the simulation analysis:

- Input/Prepare building description (from thermal design viewpoints; as simple as possible)
- Develop reference/base case
- Develop low-energy case, or parametric study
- Size HVAC systems (by simulation or calculation)
- Run simulation (e.g. for all 8,760 hours)
- Interpret results and reporting

5. What are the common methods for building economic and financial analysis? Briefly explain the principle of life cycle costing (LCC) and its application to building energy analysis and study. (2 marks)

Solution outline 5.:

[Use your own words if possible and DO NOT copy directly from reference text. Bonus will be given to answers with concise description of the methods and showing good understanding of LCC.]

Common methods for building economic and financial analysis include:

- (a) Building energy consumption and cost analysis
  - Building energy consumption analysis (e.g. through energy audit & modelling)
  - Analysis of energy demand and costs
- (b) Payback analysis
  - Simple payback
  - Discount payback
  - Return-on-investment (ROI)
- (c) Life cycle cost (LCC) analysis
- (d) Finance and investment appraisal
  - Review financial energy management matrix
  - Evaluate cash flow and investments
  - Initial screening (e.g. using payback period and other indices)
  - Detailed assessment (e.g. using LCC and net present value)
  - Evaluate financing options (e.g. cash, bonds, performance contracts)

Principle of life cycle costing (LCC):

LCC is quite broad and encompasses all those techniques that take into account both initial costs and future

costs and benefits (savings) of an investment over some period of time. The basic LCC equation looks like this:

$$\text{LCC} = I + \text{Repl} - \text{Res} + E + W + \text{OM\&R}$$

LCC is an economic method of project evaluation in which all costs, from operating, maintaining & repair (OM&R), energy (E), water (W), replacement (Repl), residual (Res) and disposing are considered over a given study period. LCC can be used to compare two or more mutually exclusive design alternatives that perform the same function in order to choose the single most cost effective option. It is believed that LCC analysis provides a better assessment of the long-term cost effectiveness of a project compared with other cost analysis methods such as the payback methods.

Application to building energy analysis and study:

LCC can be applied to building energy analysis to help make informed decisions on design alternatives or purchase of products or investment on projects. It is particularly useful for optimising building design and retrofits, evaluating energy conservation measures, and assessing the impact of building energy codes.

6. Energy Audit for Your Home

Carry out an energy audit to study the energy consumption at your home and evaluate the major factors affecting the energy performance. A typical process looks like this:

- Collect information about the energy use and survey the energy systems and equipment
- Examine the utility bills (including electricity, town gas and other fuels) to assess the consumption levels and patterns (preferably over one year)
  - Estimate the energy use indicators such as average energy use per person and per floor area
  - Assess the important factors affecting the energy consumption
  - Identify potential areas for applying energy saving measures
  - Prepare a summary report for the energy audit

The following websites contain useful information and may be used during your study:

- <http://www.hec.com.hk/hec/customer/using.asp>
- <http://www.chinalightandpower.com.hk/clpgroup/home/efficientTips/?lang=en>
- [http://www.emsd.gov.hk/emsd/eng\\_source/pee/em\\_pub\\_codes.htm](http://www.emsd.gov.hk/emsd/eng_source/pee/em_pub_codes.htm)

(6 marks)

Solution outline 6.:

[\* This question has NO standard solution. The assessment is based on logical thinking, info organisation, data presentation, use of references, analysis methods, understanding of the situation, and creativity. Clear report layout, use of graphs and tables, discussion of the limitations will be helpful.]