MEBS6016 Energy Performance of Buildings

http://www.hku.hk/bse/MEBS6016/

Self-evaluation Exercise (2010-2011) (Suggested Solutions)

(* Outline of the solution only)

1. (a)

Possible benefits of energy efficiency:

- Improved building design and operation
- Better working environments
- Life-cycle cost savings
- Added market value of buildings
- Reduced CO_2 emissions and consumption of finite fossil fuels
- Reduced capital cost by better integration of building fabric and systems

Key strategies to achieve energy efficiency for new buildings and existing buildings (w/ brief discussions for each):

- For new buildings
  - Designing the building
    - Design strategy
    - Control strategies
    - Commissioning
- For existing buildings
  - Operating and upgrading the building
    - Building management
    - Refurbishment/renovation/retrofitting
    - Maintenance and monitoring

1. (b)

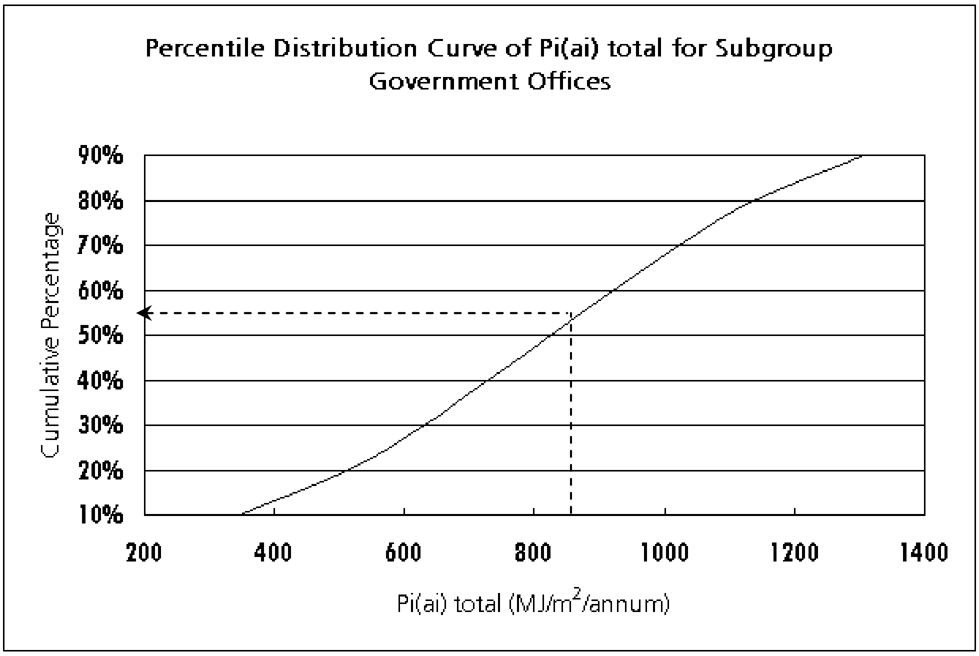
Average cost of electricity = $3.5 x 10^6 / 3.2 x 10^6 kWh = **<u>$1.09 per kWh</u>**

Net floor area = 0.7 x Gross floor area = 0.7 x 20,000 = 14,000 m^2
Energy charge = annual electricity cost x (1 – 15%)

i) Energy utilization index, based on net floor area is:
3.2 x 10^6 / 14,000 = **<u>228.6 kWh/m²/year</u>** (or 823 MJ/m^2/year)

ii) Energy cost index, based on net floor area is:
$3.5 x 10^6 x (1 – 15%) / 14,000 = **<u>$212.5 /m²/year</u>**

From the given energy benchmark graph, at 823 MJ/m^2/year the percentile is about 54%. That means, 46% of the building population in this group is having energy consumption level higher than this building while 54% of the building population is having energy consumption level lower than it. This building is close to the average in the group.



2. (a)

The EU directive, came into force on 4 Jan 2003, is an important move by the European Union and will contribute to reducing carbon dioxide emissions under the Kyoto protocol (Europe overall -8% emission). It will also set out a trend for promotion & assessment of building energy performance in the world.

How does the EU directive work? It facilitated requirements to measure building energy use by:

- Introducing agreed measurements of relative energy performance
- Regular inspections and re-evaluations
- Requiring higher standards for upgrading larger buildings
- Improving standards for new buildings

Four major requirements of the directive and their implications (w/ brief description):

1. Methodology for integrated buildings energy performance standards
2. Application of these standards on new and existing buildings
3. Certification schemes for all buildings
4. Inspection & assessment of boilers/heating and cooling installations

2. (b)

Annual energy cost savings in dollars:

Option A = [(360,000 – 180,000) / 3.6] x ($1/kWh) = **$50,000**
Option B = [(360,000 – 252,000) / 3.6] x ($1/kWh) = **$30,000**

Simple payback (SPB):

Option A = $200,000 / $50,000 = **4 years**
Option B = $100,000 / $30,000 = **3.3 years**

Return on investment (ROI):

Option A = $50,000 / $200,000 x 100% = **25%**
Option B = $30,000 / $100,000 x 100% = **30%**

With interest rate 10% and the study period 10 years, present worth factor is:

PWF = [1 – 1/(1 + 0.1)10]/0.1 = 6.145

Net present value (NPV):

Option A = -$200,000 + $50,000 x 6.145 = **$107,250**

Option B = -$100,000 + $30,000 x 6.145 = **$84,350**

Since Option A has a higher NPV, it is preferred.

3. (a)

Prescriptive approach:

- Advantages:
  - Simple to use & follow
  - Easy to check & enforce
- Drawbacks:
  - Rather restrictive
  - Barrier to innovation & performance optimization
  - Hinder cross-country product trading

Performance approach:

- Advantages:
  - More clearly explains what the code intends
  - Permits innovation & alternative solutions
  - More flexible regulatory environment, easily updated
  - Encourage building/technology research
- Drawbacks:
  - Often more efforts are needed for analysis/compliance
  - Can be very complex & require energy expertise

Four situations where simulation method is not recommended:

- If it can't answer the design question (such as airflow & occupant behaviours)
- If the design has proceeded too far (unlikely anything can be changed)
- If project is too small or time is too tight (not economical to carry out simulation)
- If you do not understand the benefits & limitations of the simulation

3. (b)

From the pump law, estimated new annual energy consumption is:

(8,000 kWh) x (70/100)3 = 2,744 kWh

Therefore, Estimated annual energy savings = (8,000 – 2,744) = **5,526 kWh**

Estimated annual energy cost savings = (5,526 kWh) x ($1/kWh) = $5,256

Net annual cost saving = $5,256 - $200 = **$5,056**

Simple payback = $20,000 / $5,056 = **3.96 years**

Discount factor = $(1 + r)^{-n} = (1 + 8\%)^{-n}$

Thus, cash flow analysis for a study period of 10 years is:

Year	Initial cost	Energy savings	Additional maint. cost	Net cost savings	Discount factor	Present value
0	-$20,000				1.000	-$20,000
1		$5,256	-$200	$5,056	0.926	$4,682
2		$5,256	-$200	$5,056	0.857	$4,333
3		$5,256	-$200	$5,056	0.794	$4,014
4		$5,256	-$200	$5,056	0.735	$3,716
5		$5,256	-$200	$5,056	0.681	$3,443
6		$5,256	-$200	$5,056	0.630	$3,185
7		$5,256	-$200	$5,056	0.583	$2,948
8		$5,256	-$200	$5,056	0.540	$2,730
9		$5,256	-$200	$5,056	0.500	$2,528
10		$5,256	-$200	$5,056	0.463	$2,341
			Total =	**$50,560**		**$13,926**

Total life cycle cost = -$20,000 + $33,926 = $13,926

Or, with interest rate 8% and the study period 10 years, present worth factor is:

$PWF = [1 – 1/(1 + 0.08)^{10}]/0.08 = 6.71$

Total life cycle cost = -$20,000 + $5,056 x 6.71 = $13,926