Energy Efficient Technologies

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Energy and the Environment

- **Energy production causes particulate emission, acid rain and global warming**
- **Energy efficient technologies help the environment & are cost effective**
- **Other green initiatives may not be cost effective but have intangible benefits and improve corporate image, e.g. renewable energy**

Energy and the Environment

- **Energy efficiency of a country should be considered under 3 issues:**
  1. **Economic efficiency is a measure of the energy required to support economic activities (MW/GDP)**
  2. **Societal efficiency is a measure of the amount of energy used by each citizen (MW/GDP)**
  3. **Environmental efficiency is a measure of the amount of emission to produce unit energy (CO^2 emission per MW)**

Energy Efficiency in Buildings

- Architectural measures
- Lighting
- Air-conditioning
- Electrical
- Lifts and escalators
- Plumbing & drainage

Architectural Measures

- Building orientation to enhance natural ventilation and natural lighting and to reduce solar gains
- Sun shading devices
- Central location of plant rooms to minimize losses
- Stacking of plant rooms on different floors
- Improving OTTV (overall thermal transfer value)
- Better glazing: low-E & reflective glass
- Green roof
- Better insulation of external facade
- Reduce infiltration

Lighting

Lamp type	**Luminous efficiency**	**Lamp life**
Incandescent	8 – 21 Lm/W	750 to 2,500 hours
Tungsten-halogen	18 - 24	4,000
Mercury vapour	26 - 50	24,000
Metal halide	61 – 100	7,000 to 20,000
Fluorescent	70 – 100	9,000 to 20,000
High pressure sodium	57 – 125	16,000 to 24,000
Low pressure sodium	150	18,000
Induction lamp	70 - 80	60,000 to 100,000

Lighting

- T8 with electronic ballast
- High efficiency T5 (T5 HE)
- High output T5 (T5 HO)
- Induction lamp
- Self luminous exit sign
- Compact fluorescent lamp
- Dimmable electronic ballast
- Occupancy sensor
- LED lighting

T8 & T5 (1200 mm)

- T5 HE 28W -2900 lm, 104/91 (including ballast loss) lm/W (35^0C ambient)
- T8 32W (Electronic) -2900 lm, 94/83 lm/W (25^0C ambient)
- T8 36 W (Magnetic) -3000 lm, 86/65 lm/W

T5 HE & T5 HO

- Lumen output: 2900 lm Vs 5000 lm
- Lamp power: 28W Vs 54W
- Efficacy: 104 lm/W Vs 93lm/W
- Maintenance at 10000hr: both 92%
- Rated Life: both 20000 hr
- T5 HE lamps are suitable for replacing T8 lamps
- Plug & enhance adaptor is available for installing T5 tube directly into a T8 fitting
- T5 HO lamps are suitable for space with high ceiling

Advantage of T5

- Energy efficient with pay back within 2 years
- Fits exactly into ceiling grid
- Suitable for viewing computer monitor
- Better lumen maintenance and longer lamp life
- Optimum performance at 35^0C
- T5 fitting is only 50 mm deep and can suit congested ceiling space
- More environmental friendly due to less mercury, material in production and packaging (1xT8=2.5T5)

Induction Lamp

(Currently used in Tsing Ma Bridge)

- Florescent lamp without electrode
- Energy transmission by magnetism
- Mercury as secondary coil
- 2.65 MHz (40-100 kHz for T5)
- Rated Life: 60,000 hr (up to 100,000 hr)
- 70 lm/W (80 for external coil)
- Case study in a squash court:
  - -150W induction Vs 250W metal halide
  - - 24% energy saving, 5 years payback
  - - 9% brighter

Self luminous exit sign

- Beta ray on fluorescent coating
- Rated life: 15 years
- Radioactive tritium gas in glass tube
- Payback less than 2 years if licensing fee is excluded
- Eliminates power supply & wiring
- Eliminates maintenance on battery
- Approved for use by FSD
- Requires licensing by EPD (Radioactive)

Compact Fluorescent Lamp

- The principles of operation of CFL are similar to fluorescent lamp
- CFL is designed as substitute for incandescent lamp
- A 20W CFL is as bright as a 100W incandescent lamp i.e. saves 80% energy
- Pay back period is less than a year
- It has a longer lamp life than incandescent lamp

Dimmable electronic ballasts

- Conventional electro-magnetic ballasts for fluorescent lamp do not provide dimming function
- Due to advances in electronic circuitry, electronic ballasts are now dimmable
- It provides better lighting effect for different uses of a space
- It is energy efficient as well

Occupancy sensor

- Occupancy sensors are installed to switch off lighting when the occupants have left the room
- It can be a CO_2 sensor (detects occupant) or a infrared sensor (detects motion)
- It can save more than 20% energy

LED Lighting

- Very energy efficiency but high initial cost
- Cost effective for longer operational hours, e.g. exit sign and for spot lighting
- Currently not cost effective as replacement of T5 for office although it can save about 10 to 20% energy

Air-conditioning

- Variable speed drive
- High efficiency motor
- Heat pump
- Heat recovery
- Free cooling
- VAV (variable air volume)
- Variable water flow
- VRV (variable refrigerant volume)
- Water-cooled condenser
- Automatic condenser tube cleaning device
- District cooling
- Occupancy sensor
- CCMS (central control & monitoring system)

Variable Speed Drive (VSD)

- VSD saves energy by changing the speed of the motor to suit variable loading conditions. The saving is greater than that might initially be expected. As the speed of the fan/pump is reduced, the flow will be reduce proportionally, while the power required will reduce with the cube of the speed. For example, if the speed reduction is 80%, the power required is only 51.2%
- Most VSD works on the principle of varying frequency by electronic circuitry
- The pay back period is around 2 to 4 years
- VSD is suitable for pump, fan motor, chiller motor & compressor
- VSD can generate excessive harmonic distortion and requires harmonic filter

High Efficiency Motor

- The higher the efficiency of the motor, the less is its power consumption.
- Manufacturer will normally produce a series of similar equipment that have motors of different efficiency. The more expensive equipment will have high efficiency motor incorporated.
- It is worthwhile to consider the life-cycle costing of different options. It is quite normal for a more expensive equipment to achieve lower life-cycle cost.

Heat Pump

- Heat pump works as a revered cycle refrigeration unit
- Heating provided by the heat pump is the heat rejection from the condenser
- The co-efficient of performance of the condenser is higher than that of the evaporator and can be more than 5
- If cooling is also required, the efficiency of the heat pump will be even higher

Heat Recovery Unit

- Heat recovery system recovers the cooling effect of the exhaust air or the condensate from cooling coils
- Exhaust air are collected and ducted to a heat wheel where its cooling effect is harvested and transferred to the incoming fresh air in order to save energy.
- Condensate from cooling coils can also be collected and passed through heat exchanger where the cooling effect is transferred to the make-up water.
- The cost effectiveness of heat recovery unit depends on the ease with which the exhaust air or condensate can be collected. In many cases it can be pay back within reasonable time e.g. 4 to 5 years

Free Cooling

- If provisions are properly allowed, free cooling saves substantial energy during fall and winter
- Fresh air (FA) that is low in temperature and humidity is used to provide cooling of the space without the help of the cooling coil
- Areas of the FA intakes, FA ducts and FA dampers should be large enough for the amount of FA required for free cooling
- For free cooling to be effective, it is necessary to evaluate the comfort conditions of the space

VAV

- VAV system is most suitable for space with variable load conditions, e.g. east or west external zones, conference room with variable occupancy.
- The motor of the VAV air handling unit is served by a variable speed drive (VSD)
- VAV system can save up to 30% of the fan power
- The supply air to a room is delivered by a VAV box that supplies variable volume of air to suit the loading requirement. If the air required is reduced during part load, the pressure within the main supply air duct will be increased and this signal is detected by a pressure sensor and transmitted to the VSD controller to cause the fan to reduce its speed.

Variable Water Flow System

- Variable water flow system is most suitable for supplying different quantity of chilled water to space with variable load conditions
- The motor of the chilled water pump is served by a variable speed drive (VSD)
- VAV system can save up to 30% of the pump power
- The supply water to AHUs and fan coil units is controlled by regulating valves that supplies variable quantity of water to suit the loading requirement. If the water required is reduced during part load, the pressure in the main water pipe duct will be increased and this signal is detected by a pressure sensor and transmitted to the VSD controller to cause the pump to reduce its speed.

VRV

- Variable refrigerant flow is not possible in the past. Any reduction in the system resistance to control flow would lead to evaporation of refrigerant
- Due to the advance in computer technologies, it is now possible to deliver increased/reduced amount of refrigerant to any load centre to suit requirement by a central computer without the evaporation of refrigerant.
- VRV is energy efficient as the refrigerant evaporates at the DX coil of the AHU producing much larger cooling effect than chilled water
- VRV chiller is normally of modular design. Larger plant is comprised of more modular units.
- Design of the refrigeration system is normally by the supplier.
- VRV is expensive and not widely used in HK

Water-cooled Condenser

- Water-cooled condenser is more efficient than air-cooled condenser due to lower condensing temperature
- If sea water is available, direct sea water cooled condenser is used. The used sea water is returned back to the sea. It is about 30% more efficiency than air-cooled system.
- In order to promote energy efficiency, the Government allowed the use of fresh water for cooling towers in designated pilot areas. The water cooled condenser is about 20% more efficiency than air-cooled condenser. Condenser water needs water treatment to prevent legionnaires disease.
- Water-cooled condensers are installed inside building and have lower noise and thermal pollution.
- Water cooled condensers have larger unit sizes.

Automatic Condenser Tube Cleaning Device

- Scales are formed on the inner surface of the condenser water tubes due to chemicals used in water treatment and other impurities in the water.
- Periodical cleaning of the condenser tube can improve heat transfer efficiency and saves about 10% of energy.
- Cleaning can be done manually in which case sufficient maintenance space is required at one end of the condenser.
- Automatic condenser tube cleaning device is more desirable. It consists of cleaning balls usually of metal that is stored in vessel in a by-pass pipe-work. It will be used during the cleaning cycle by reversing the flow direction through the condenser.

District Cooling

- A district cooling scheme (DCS) consists of a central plant room normally near the sea or a river. The main water-cooled chillers are very large and can have a total capacity in excess of 100,000 kW. Chilled water is distributed to premises by underground pipelines.
- If a DCS is available in your area, it is preferable to join the scheme.
- It is very energy efficient due to the improved efficiency of large plants and the ability to reduce the total plant size as a result of diversity.
- The other main benefits are saving of plant spaces, less maintenance requirements, saving of operation costs and less environmental problems.

Occupancy Sensor

- Occupancy sensors are installed to switch off AC when the occupants have left the room
- It can be a CO2 sensor (detects occupant) or a infrared sensor (detects motion)
- It can save more than 20% energy

CCMS

- The CCMS is usually part of a building management system (BMS) which provides computerized control of the various systems of a building.
- With good computer hard-wares and soft-wares, the CCMS enables the AC systems to operate as designed and at the optimum efficiency level.
- Examples of the functions of a CCMS are:
  1. Closer control and monitoring of equipment and systems
  2. Optimum starting of chillers and other main plants
  3. Scheduling of plant operation
  4. Remote operation of systems in various buildings from a central control room
  5. **Exceptional reports for preventive maintenance**
- The CCMS can provide a potential savings of 10 to 25%.

Electrical

- Energy efficient office equipment
- High efficiency transformer and motors
- Energy efficient cabling system
- Review of tariff, power factor and quality

Energy Efficient Office Equipment

- The energy consumption of office equipment (telephone, fax, photocopier, computer, monitor, etc.) increases every year and has exceeded that used by lighting.
- Energy efficient office equipment has low standby power consumption. The poor equipment can have standby power several times that of an efficient equipment.
- It always pays to use office equipment with highly rated energy efficiency label.
- Set office equipment to energy saving mode.

High Efficiency Transformer & Motor

- Distribution transformer should have efficiency in excess of 98%.
- The full load efficiency for small motors should be at least 85% and for larger motors it should be at least 90%.
- Avoid over-sizing of motors. It is preferable to size motor by not more than 125% of the anticipated system load.
- Soft starter is recommended to limit starting current.

Energy Efficient Cabling System

- The Government promoted the use energy efficient cabling system that will reduce energy consumption through lower copper losses and improve safety through better power quality at the same time.
- The location of the transformer room and main switch room should be immediately adjacent to, above or below each other.
- The copper losses should not exceed 0.5% of the total active power transmitted along the circuit conductors at the rated circuit current.
- The design of the system can be found in the COP for Energy Efficiency of Electrical Installations

Review of Tariff, Power Factor and Quality

- Conduct tariff review and apply to supply company for a special charge rate other than general tariff
- Power factor should be improved to not less than 0.85
- Power factor correction capacitor bank must be designed to avoid over current and resonance in the supply network with high contents of harmonics
- The total harmonic distortion (THD) of current should not exceed the control figures required by the supply company (ranging from 5% for current above 2000A to 20% for current below 40A).
- THD filters (passive or active filter) may be required at appropriate location, preferably near the sources.

Lifts and Escalators

- High efficiency driving system
- Intelligent lift grouping and control system

High Efficiency Driving System

- ACVV or VVVF driving system should be employed.
- The system should also be designed with more concern for the possible impact on polluting the power quality of the building supply system.
- Dedicated feeders should be provided for the lifts and escalators circuits to facilitate future energy management and auditing purposes.

Intelligent Lift Grouping & Control

- Energy efficiency can be achieved by intelligent control of lifts and escalators.
- Good lift zoning, grouping and response method can improve waiting time and provide opportunity for dispatch of lift with energy efficiency as the first consideration.
- Energy efficient mode for lifts during no load condition can be designed to suit the management.
- Escalators can be controlled to provide reduced speed during no load operation.

Plumbing & Drainage

Energy efficiency in P&D systems aims at reducing the consumption or wastage of water. Examples are:

- Self-closing taps
- Taps with sensor control
- Automatic flushing cisterns with sensor control
- Low flow WC

Useful references

- Codes of Practice for Energy Efficiency of Lighting, Air Conditioning, Electrical and Lifts & Escalators Installations
- Guidelines on Energy Efficiency of Lighting, Air Conditioning, Electrical and Lifts & Escalators Installations
- Performance-based Building Energy Code
- Guidelines on Performance-based Building Energy Code