HKIE(BS DIV)/ASHRAE HKC/CIBSE HKB Joint Function

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Technical Talk on:

Innovative Energy Efficient Pilot Projects carried out by EEO, EMSD

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Introduction

- In the interest of long-term sustainable development, the HKSAR Government has promulgated a no. of major policy objectives on improving the environment of HK.
- Energy Efficiency Office (EEO) of EMSD is actively exploring means to reduce energy consumption via series of initiatives.
- One of the initiatives is to investigate new and innovative energy efficient equipment and technologies for use in building services engineering.
- Investigation covers equipment and systems for lighting, air conditioning & vertical transportation, etc.

Introduction

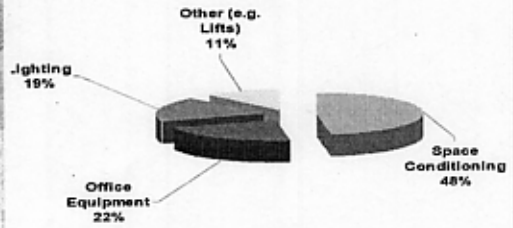
- In 1995, EEO obtained $6M to carry out a 3-year Pilot Energy Management Opportunities (EMO) Implementation Programme (Phase 1).
- Phase 1 programme completed in 1999 with successful implementation of electronic ballasts, variable speed drives, high efficient motors, demand control AC system, etc. in Government buildings.

Introduction

- Related project reports, application guides and information pamphlets for these equipment were published & some equipment were also included in DSM programme operating by the power companies.
- Phase 2 programme ($6M 1999-2001 and $3M 2001-2002) are in progress with focus on the application of innovative energy efficient equipment for pilot EMO projects in Government buildings

Introduction

Rough proportion of electricity consumption in a commercial building



Energy Saving Opportunities in Lighting

- Opportunities for energy saving in lighting include:
  - Use of more energy efficient light sources & lamps
  - Use of electronic ballasts instead of magnetic ballasts as lighting control gear
  - Use of more efficient luminaire reflectors and louvers
  - Dim down artificial lighting to optimise daylight utilization
  - Use of occupancy sensors to switch off or dim down lighting in unoccupied areas
  - Intelligent lighting control system, e.g. DALI

Energy Efficient Light Sources

Classification of Lamps:

- Incandescent Lamps - Tungsten Filament Lamps & Tungsten Halogen Lamps
- Gas Discharge Lamps - High Pressure Mercury Lamps, Low Pressure Mercury, High Pressure Sodium & Low Pressure Sodium
- Others: Induction, LED & Sulphur Lamps

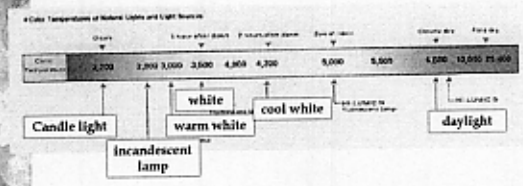
Energy Efficient Light Sources

Average efficacy (Lumens/Watt) of various light sources:

- Tungsten Lamp - 15 lm/W
- High Pressure Mercury Lamp - 40 to 60 lm/W
- Fluorescent Lamp - 64 to 100 lm/W
- Metal Halide - 70 to 90 lm/W
- High Pressure Sodium - 90 to 125 lm/W
- Low Pressure Sodium - 120 to 200 lm/W

Energy Efficient Light Sources

Colour Temperature of Lamps



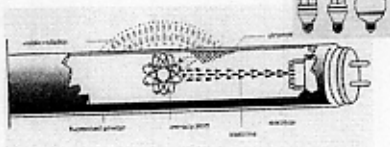
Energy Efficient Light Sources

Colour Rendering

The colour rendering index (Ra) represents colour rendition of the lamp. A value closer to 100 shows that a colour can be seen more naturally. Most commercial building use 80<Ra<90

Energy Efficient Light Sources

Fluorescent lamps are basically low pressure mercury lamps



Energy Efficient Light Sources

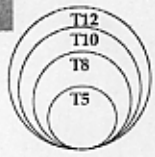
Lamp Labelling

F = Fluorescent

T = Tubular lamp shape

8 = lamp diameter in 1/8 inch increment

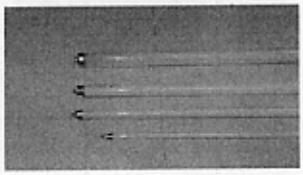
e.g. T5 = 5/8 inch = 16 mm
T8 = 8/8 inch = 1.0 inch = 26 mm
T10 = 10/8 inch = 1.25 inch
T12 = 12/8 inch = 1.5 inch = 38 mm



Energy Efficient Light Sources

Fluorescent lamps, T12, T10 & T8, have long be used as energy efficient lamps for general lighting

New generation of T5 fluorescent lamps with 16mm dia. & G5 base has recently been developed for improved efficient (100 lm/W) & performance



Energy Efficient Light Sources

Typical lamp wattage of T5 lamps is tabulated below as compared with their T12 & T8 counterparts

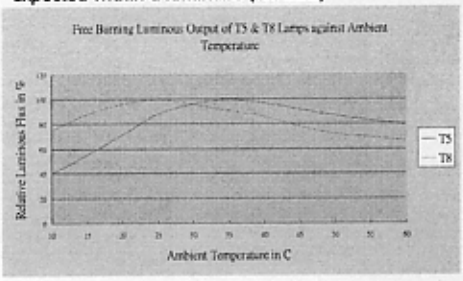
Nominal Lamp Leneth	T12	T8	T5 Standard (50mm Shorter)	T5 High Output Version
600mm	20W	18W	14W	24W
900mm	–	30W	21W	39W
1200mm	40W	36W	28W	54W
1500mm	65W	58W	35W	49W/80W
1800mm	75W	70W	–	–

Energy Efficient Light Sources

- Major Benefits of T5 Fluorescent Lamps:
  - Saving in power & energy consumption through improved efficacy (e.g. 28W T5 = 36W T8 = 40W T12)
  - Environmental Friendly - use less glass, less mercury & package material
  - Enables use of slimmer, neater luminaires to suit metric grid ceiling
  - Longer lamp life - over 15000 hours with electronic ballast
  - Reduce storage space & transportation costs

Energy Efficient Light Sources

T5 lamp is optimized for temperature conditions as expected within a luminaire (i.e. 35C)



Energy Efficient Light Sources

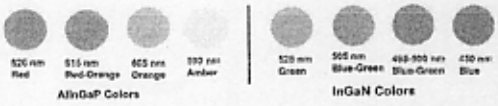
- Compact Fluorescent Lamps - The Development Trend is also toward miniaturisation.
- In Hong Kong, the control is under Energy Efficiency Labelling Scheme

Energy Efficient Light Sources

Electronic Light Source - Light Emitting Diode (LED)

- Efficacy of LED in 2001 (keep improving rapidly):

approx. 20 – 30 lm/W red /orange
approx. 3 – 5 lm/W blue
approx. 15 – 20 lm/W green
approx. 10 – 15 lm/W white



Energy Efficient Light Sources

White LED for general lighting – 2 solutions

- colour conversion:
  - Based on blue LED (similar to FL)
  - Ra: 75 – 80
  - Colour Temp.: 4000K
- RGB (Red/Green/Blue)
  - Ra: 50 – 55
  - lower costs

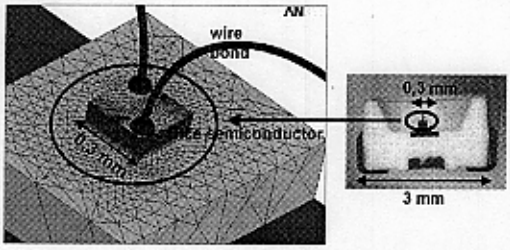
Energy Efficient Light Sources

LED – types:

- Wired LED
- SMD (Surface Mounted Diode) LED
- COB (Chip on Board)

Energy Efficient Light Sources

- COB LED Technology – dice assembled directly on the PC-board (More light on small area, longer life & higher efficiency via lower temperature)



Energy Efficient Light Sources

- LED will enter lighting market soon because of specific benefits.
  - Long life, maintenance free (up to 100,000 hours)
  - Operates on safety extra-low voltage (12V & 24V)
  - Mercury free, no UV or IR radiation
  - Resistance against vibrations
  - Point sources – flexible design
  - Flat light source (SMD, COB)
  - Full Dimming
  - Range of Colours

Energy Efficient Light Sources

- Market segments in LED lighting (EEO will investigate closely for possible pilot projects):
  - General lighting for commercial & residential
    - Effect lighting (colours, dimming)
    - Special luminaires (maintenance free, safety)
    - Flat fittings (surface-mounted, furniture...)
  - Signalling
    - Traffic lights
    - Displays, advertising
    - Direction Signs
  - Emergency lighting

Energy Efficient Lighting Ballasts

Electromagnetic

⇩

Electronic

⇩

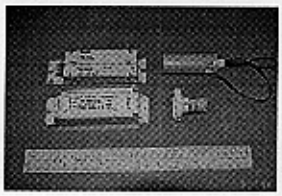
Digital Dimmable

Energy Efficient Lighting Ballasts

- Functions of Ballast for Fluorescent Lamps
  - Supplies controlled power to heat lamp electrodes
  - Supplies starting voltage to ionise lamp gas and create electron discharge stream between electrodes
  - Limits current and controls power to the lamp for proper operation

Energy Efficient Lighting Ballasts

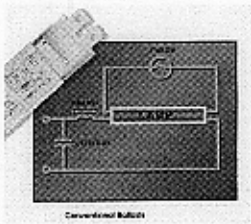
Conventional control gear for fluorescent lamp includes magnetic ballast, starter switch & power factor correction capacitor, and consumes high portion of power to operate (typical @ 11W)



Energy Efficient Lighting Ballasts

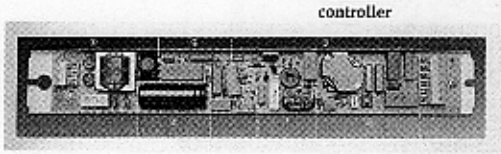
Conventional Ballast Circuit

- Normally, 1 conventional ballast is used for 1 lamp only
- 2 x 18W T8 lamps could be operated in series via 36W conventional ballast



Energy Efficient Lighting Ballasts

Electronic Ballasts

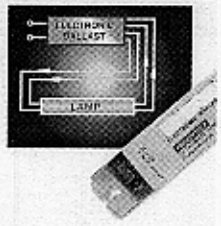


Energy Efficient Lighting Ballasts

Electronic Ballast Circuit

♦Sample shows one ballast for 1 lamp

♦Circuit could be one ballast for 1 lamp, 2 lamps, 3 lamps or even 4 lamps



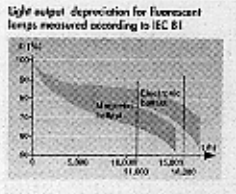
Energy Efficient Lighting Ballasts

Electronic Ballasts

High frequency operation of lamp increases lamp life by:

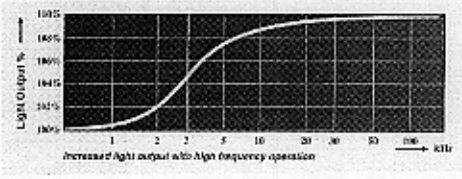
♦reducing load on lamp electrodes (less blackening)

♦reducing greying of fluorescent material



Energy Efficient Lighting Ballasts

Lumen Output as Function of Frequency



Energy Efficient Lighting Ballasts

Electronic Ballasts

Electronic ballast designed to IEC 60928 & 60929 are well developed nowadays & have widely been used for replacing conventional ballasts in fluorescent luminaires

Basic Requirements for High Performance Criteria :

- No visible flicker
- Low lamp current crest factor (LCCF)
- Low total harmonic distortion (THD)
- High power factor

Energy Efficient Lighting Ballasts

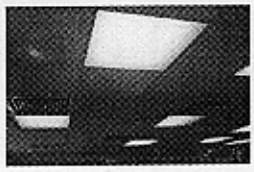
- Other Types of Electronic Ballasts Available:
  - Dimmable electronic ballasts using 0 - 10 V d.c. analogue signal
  - Digital dimmable & DALI electronic ballasts
  - Electronic ballasts for non-integrated Compact Fluorescent Lamps (CFL)
  - Electronic ballasts for High Intensity Discharge (HID) lamps
  - Integrated Electronic Ballast with Emergency Power Pack

Energy Efficient Luminaires

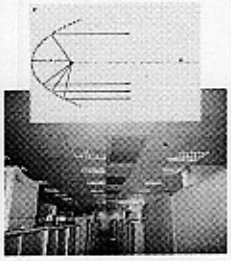
- Basic Luminaire Design:
  - Optical control is an important element in efficient luminaire design
  - Purpose of optical design is to redirect light from bare lamp to area in needed & to reduce glare
  - Common types of optical control include opal diffusers, prismatic controllers & parabolic reflectors
  - In modern offices, luminaires designed to CIBSE LG3 Cat. 2 are normally specified to minimize reflective glare on computer monitors

Energy Efficient Luminaires

Luminaires with Prismatic Controllers

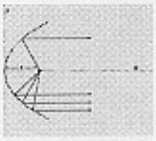


Parabolic Reflector & Cat. II Luminaire



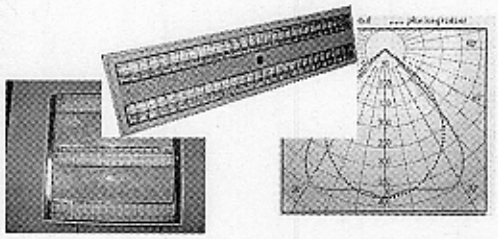
Energy Efficient Luminaires

- For T5 luminaire, the most effective means of optical control is parabolic reflection
- As T5 lamp is much closer to a linear line source, optical control in parabolic reflector is more precise and efficient
- In modern offices, luminaires designed to CIBSE LG3 Cat. 2 are normally specified to minimize reflective glare on computer monitors



Energy Efficient Luminaires

Typical T5 Luminaire designed to CIBSE LG3 Cat. II with 65 degree cut off angle



Energy Efficient Lighting Control

- Automatic dimming control of fluorescent lamp using analogue technology and electronic ballast has long been used in commercial lighting
- It was not popular because of high equipment cost (separate sensors, controllers & lighting control modules) & wiring cost (dc control cables)
- New development in digital control technology has greatly reduced equipment & wiring cost
- Intelligent digital lighting control with integrated sensors to detect daylight and occupancy is also available to enhance energy saving in T5 lighting system

Energy Efficient Lighting Control

- Analogue Dimming
  - Phase control was the earliest form of dimming fluorescent lamps by reducing input/output power of ballasts (magnetic type)
  - With the evolution of HF electronic ballasts, analogue dimming was the first attempt to dim lamps more accurately by using an independent bus line
  - A 1-10V DC signal sent along a ELV bus to ballast changed its output frequency to lamp for dimming
  - Potentiometer could also be placed into the circuit & vary output signal generated by ballast
  - Analogue dimming became popular during late 80' and early 90', but was limited in accuracy & applications

Energy Efficient Lighting Control

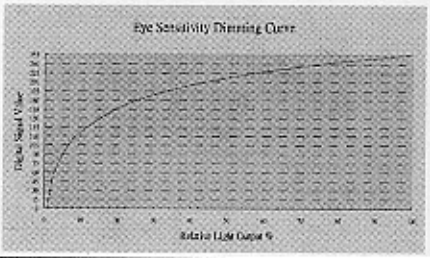
- Analogue Dimming: 1-10V System
  - Imprecise 0.1V = 1% (Minimum level normally 10%)
  - Voltage drop over long distance makes inaccuracies
  - Proportional scale not reflecting true sensitivity of human eye human

Energy Efficient Lighting Control

- Digital Dimming
  - Micro-processors nowadays evolved into computers to perform many function at tremendous speed
  - The increase use of network languages such as LON, EIB, C-bus etc., all made use of the power of processors
  - Analogue technology in lighting control is to send a signal to switch or a voltage to regulate lighting level
  - Digital works on numbers, send the data bit for the level required more accurately & ON/OFF commend if necessary

Energy Efficient Lighting Control

- To achieve smooth dimming, a logarithmic scale (127log(%)+1) is used in digital dimming to reflect true sensitivity of human eye

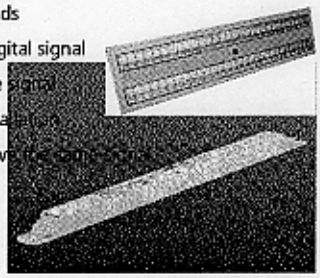


Energy Efficient Lighting Control

- Digital Dimming
  - Data is biased towards the lower end of the scale to improve perceived dimming quality
  - Digital signal simply gives the lighting level (1 to 255) required & it is up to the controllable ballast to interpret the signal which is able to do
  - Control of ballasts is by a 2 wire bus
  - Multi-point control anywhere along the bus
  - Bus voltage is 12V & universal polarity

Energy Efficient Lighting Control

- Digital Dimmable Ballast
  - Precise commands
  - Switching via digital signal
  - Disturbance free signal
  - Polarity free installation
  - All ballasts receive the same signal



Energy Efficient Lighting Control

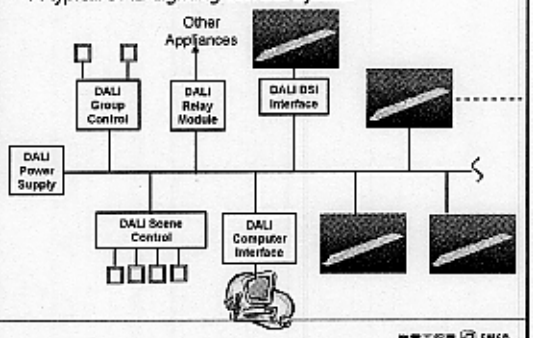
Typical equipment for intelligent digital control using Digital Serial Interface (DSI) (數碼串行接口程序)

Energy Efficient Lighting Control

- DALI (數碼可編址照明接口程序) is a new industrial standard to lighting control system
- DALI protocol (amendment to IEC929) has been adopted as new standard by major ballast manufacturers (Helvar, Philips, Osram, Tridonic, Trilux, VS etc.)
- As dedicated communication interface for control of lighting system, DALI enables sophisticated control with increased flexibility and reduced installation costs
- DALI digital control signal used to control electronic ballasts, relays & sensors belonging to the system
- Each system components has its own device-specific address for individual device control

Energy Efficient Lighting Control

A typical DALI Lighting Control System



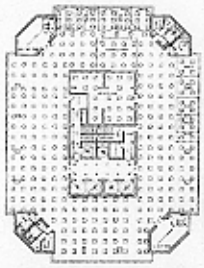
Energy Efficient Lighting Control

- Main differences between DALI & building automation buses:
  - DALI system has a limited system size (64 addresses)
  - DALI is meant only for communication in lighting systems and BMS includes other functional control as well (HVAC, security, fire services, etc.)
  - BMS normally has unlimited expansion possibilities, which DALI does not have
  - DALI system is not competing against BMS, it is only complementing them through an interface

Pilot Energy Efficient Lighting Projects

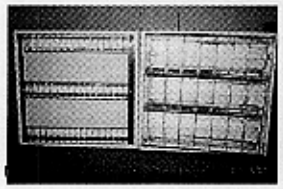
- Pilot T5 Lighting Project at Arsenal House
  - Arsenal House is the 1st T5 pilot lighting project of EEO in early 2000
  - The project involved replacement of 320 sets 3x18W T8 luminaires (with magnetic ballasts) with new 3x14W T5 luminaires at 27/F
  - New luminaire complete with 3x14W electronic ballast & double parabolic reflectors designed to CIBSE LG3 Cat.II

Pilot Energy Efficient Lighting Projects



Lighting Layout at 27/F, Arsenal House

Old 3x18W T8 Luminaire



Pilot Energy Efficient Lighting Projects

Electrical parameters of the old 3x18W T8 luminaire

			Voltage	Current
Frequency	49.99	RMS	223.4	0.754
Power		Peak	312.7	1.095
W	90	DC Offset	0.2	-0.02
VA	168	C. F.	1.4	1.45
var	142	THD Rms	2.23	8.80
Peak W	244	THD Fund	2.23	8.84
Phase	58°lag	HRMS	5.0	0.66
Total PF	0.53	KFactor		1.51
DPF	0.53			

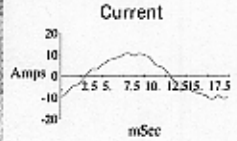
Pilot Energy Efficient Lighting Projects

Electrical parameters of the new 3x14W T5 luminaire

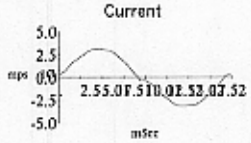
			Voltage	Current
Frequency	49.94	RMS	221.8	0.22
Power		Peak	308.5	0.316
W	48	DC Offset	0.0	-0.03
VA	49	Crest	1.39	1.44
var	7	THD Rms	2.30	8.60
Peak W	98	THD Fund	2.30	8.63
Phase	8°lead	HRMS	5.1	0.19
Total PF	0.99	KFactor		1.19
DPF	0.99			

Pilot Energy Efficient Lighting Projects

Current waveform of old 3x18W T8 luminaire



Current waveform of new 3x14W T5 luminaire



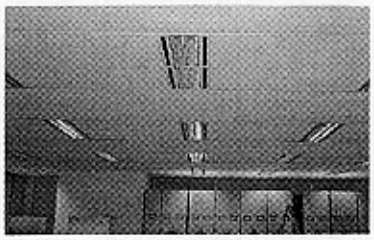
Pilot Energy Efficient Lighting Projects

Summary Table of the T5 Lighting Retrofit

	Existing T8 Lighting System	New T5 Lighting System	% Change
Active Power (kW)	28 kW	16 kW	- 42%
Power Factor.	0.53	0.99	+ 87%
T.H.D.	11%	8.6%	- 21.8%
Apparent Power (kVA)	52.8 kVA	16.2 kVA	- 69%
Average Illuminance	450 lux	600 lux	+33%
Lighting Power Density	30 W/m²	18 W/m²	-40%

Pilot Energy Efficient Lighting Projects

New 2x28W T5 Luminaires installed at EFB Offices at Citibank Plaza



Pilot Energy Efficient Lighting Projects

- The new HQ for Environmental & Food Bureau (EFB) was selected for the 2nd pilot project for T5 lighting
- The project involved replacement of about 600 sets 2x36W T8 luminaires (with magnetic ballasts) with new 2x28W T5 luminaires
- The new air-handling luminaire completed with 2x28W electronic ballast & double parabolic reflectors designed to CIBSE LG3 Cat.II
- Electronic ballasts used were fixed type for open plan office and dimmable type with integrated sensors for executive offices at perimeter zones

Pilot Energy Efficient Lighting Projects

Electrical parameters of the old 2x36W T8 luminaire

			Voltage	Current
Frequency	49.94	RMS	225.6	0.488
Power		Peak	314.0	0.686
W	98	DC Offset	0.0	-0.03
VA	110	Crest	1.39	1.41
var	46	THD Rms	2.67	22.46
Peak W	213	THD Fund	2.67	23.04
Phase	25°lng	HRMS	6.0	1.10
Total PF	0.89	KFactor		3.53
DPF	0.90			

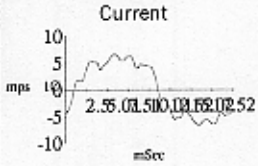
Pilot Energy Efficient Lighting Projects

Electrical parameters of the new 2x28W T5 luminaire

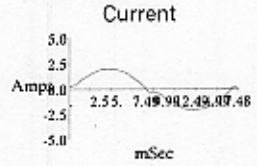
			Voltage	Current
Frequency	50.13	RMS	225.8	0.284
Power		Peak	316.0	0.434
W	60	DC Offset	-0.1	-0.03
VA	64	Crest	1.4	1.53
var	20	THD Rms	2.71	13.70
Peak W	134	THD Fund	2.71	13.83
Phase	18°lead	HRMS	6.1	0.19
Total PF	0.95	KFactor		1.52
DPF	0.95			

Pilot Energy Efficient Lighting Projects

Current waveform of old 2x36W T8 luminaire



Current waveform of new 2x28W T5 luminaire



Pilot Energy Efficient Lighting Projects

Summary table for the pilot project

	Existing T8 Lighting System	New T5 Lighting System	% Change
Active Power (kW)	34 kW	23 kW	- 32%
Power Factor.	0.89	0.99	+ 11%
T.H.D.	23%	10%	- 56%
Apparent Power (kVA)	38 kVA	23 kVA	- 39%
Average Illuminance	500 lux	700 lux	+40%
Lighting Power Density	27 W/m²	17 W/m²	-37%

Pilot Energy Efficient Lighting Projects

- The ArchSD offices at 35/F, QGO was selected for the 3nd pilot project for T5 lighting with intelligent lighting control
- The project involved replacement of 500 sets 1x36W T8 luminaires with new 1x28W T5 luminaires (digital dimmable electronic ballast)
- The optical control of the new luminaire uses anodised aluminum parabolic reflectors designed to CIBSE LG3 Cat.II
- Luminaires were grouped in 4 for linking to an integrated detector for daylight & occupancy sensing
- Illuminance can also be programmed to suit individual requirement at each work station

Pilot Energy Efficient Lighting Projects

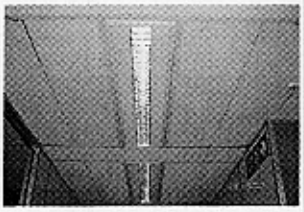
The existing 1x36W T8 300mmx1200mm recessed luminaire installed at QGO.

Lamp was operated by magnetic ballast

Pilot Energy Efficient Lighting Projects

The new 1x28W T5 300mmx1200mm Cat. II recessed luminaire installed at QGO.

Lamp was operated by dimmable electronic ballast



Pilot Energy Efficient Lighting Projects

Electrical parameters of the old 1x36W T8 luminaire

			Voltage	Current
Frequency	49.94	RMS	225.6	0.244
Power		Peak	314.0	0.343
W	49	DC Offset	0.0	-0.03
VA	55	Crest	1.39	1.41
var	23	THD Rms	2.67	22.46
Peak W	107	THD Fund	2.67	23.04
Phase	25°lag	HRMS	6.0	1.10
Total PF	0.89	KFactor		3.53
DPF	0.90			

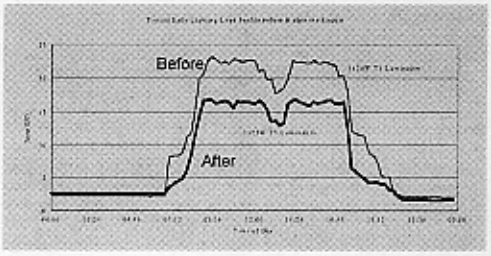
Pilot Energy Efficient Lighting Projects

Electrical parameters of the new 1x28W T5 luminaire

			Voltage	Current
Frequency	50.13	RMS	225.8	0.142
Power		Peak	316.0	0.217
W	30	DC Offset	-0.1	-0.03
VA	32	Crest	1.4	1.53
Var	10	THD Rms	2.71	13.70
Peak W	67	THD Fund	2.71	13.83
Phase	18°lead	HRMS	6.1	0.19
Total PF	0.95	KFactor		1.52
DPF	0.95			

Pilot Energy Efficient Lighting Projects

Typical daily lighting load profile before & after the retrofit



Pilot Energy Efficient Lighting Projects

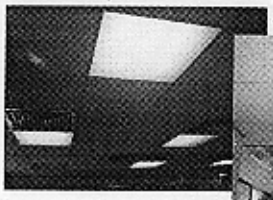
Summary table for the pilot T5 project at QGO

	Existing T8 Lighting System	New T5 Lighting System	% Change
Active Power (kW)	24 kW	16 kW (Max.)	- 33%
Power Factor.	0.89	0.95	+ 6.7%
T.H.D.	23%	14%	- 39%
Apparent Power (kVA)	27 kVA	17 kVA	- 37%
Average Illuminance	460 lux	730 lux	+59%
Lighting Power Density	22 W/m²	13 W/m² (Max.)	-41%

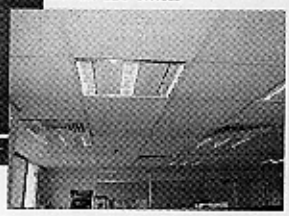
Pilot Energy Efficient Lighting Projects

T5 Lighting Retrofit at EEO New Offices:

Existing 3x18W T8 luminaires at EEO office expansion

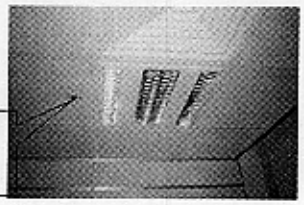


New 3x14W T5 luminaires installed at new EEO offices



Pilot Energy Efficient Lighting Projects

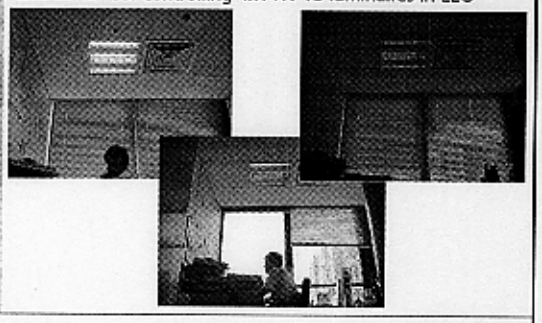
- Integrated SMART sensors were used in EEO for automatic lighting control
- They were used in Barrack Block Airport Police Station for both lighting & FCU control



Integrated sensor for daylight & occupancy detection

Pilot Energy Efficient Lighting Projects

SMART sensor controlling 4x14W T5 luminaires in EEO

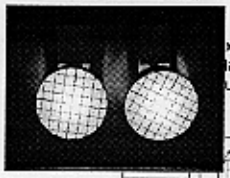


Pilot Energy Efficient Lighting Projects

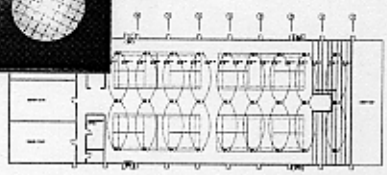
2x28W T5 luminaires installed at GPO

Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall

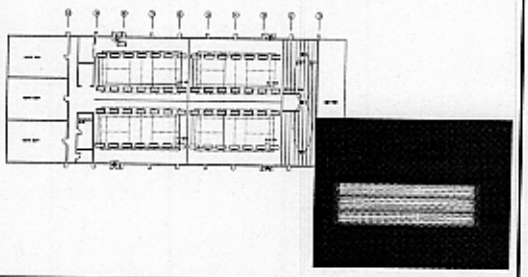


xisting 48 nos. 400W Metal alide & 250W SON High Bay uminaires



Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall



Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall

New 3x49W T5 Lighting System

Existing 400W Metal Halide & 250W SON High Bay Lighting System

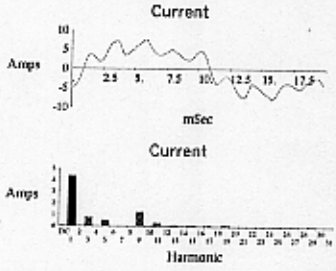
Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall: Measured Data of 400W Metal Halide Lamp

			Voltage	Current
Frequency	50 Hz	RMS	220.4V	2.29A
Power:		Peak	306.5V	3.82A
W	460W	DC Offset	0.0	-0.03
VA	505VA	Crest Factor	1.39	1.67
var	122var	THD Rms	2.30%	34.45%
Peak W	98	THD Fund	2.30%	36.70%
Phase	14°lag	HRMS	5.1V	0.84A
Total PF	0.91	KFactor		8.96
DPF	0.97			

Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall: Current Waveform & Harmonics of 400W Metal Halide Lamp



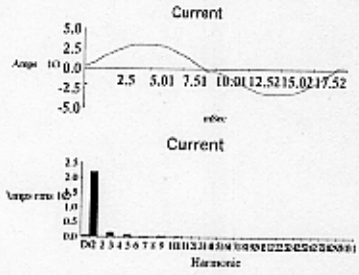
Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall: Measured Data of 3x49W T5 Luminaire

			Voltage	Current
Frequency	50Hz	RMS	220.4V	0.72A
Power:		Peak	308.5V	1.04A
W	156W	DC Offset	0.0V	-0.03A
VA	158VA	Crest Factor	1.39	1.44
var	22var	THD Rms	2.30%	4.60%
Peak W	98W	THD Fund	2.30%	4.70%
Phase	8°lead	HRMS	5.1V	0.03A
Total PF	0.99	KFactor		1.19
DPF	0.99			

Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall: Current Waveform & Harmonics of New 3x49W T5 Luminaire



Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall: Energy performance of Existing HID & T5 Lighting Systems

	Existing HID Lighting System	New T5 Lighting System	% difference
Active Power (kW)	17.2 kW	8.7 kW	- 49%
Power Factor.	0.97	0.99	+ 2%
Current THD	23.6%	4.7%	- 80%
Lighting Power Density	26.3 W/m²	13.3 W/m²	- 49%
Average Illuminance	479 lux	760 lux	+59%

Pilot Energy Efficient Lighting Projects

High Output T5 Lighting System at East Kai Tak Indoor Games Hall (Other Benefits):

- Instant start up and restrict
- Flexible switching to suite games hall booking
- Less light depreciation
- Better colour temperature (closer to daylight)
- Better colour rendering index (Ra > 80)
- Do not affect by voltage fluctuation
- Suitable for emergency lighting with power pack

Pilot Energy Efficient Lighting Projects

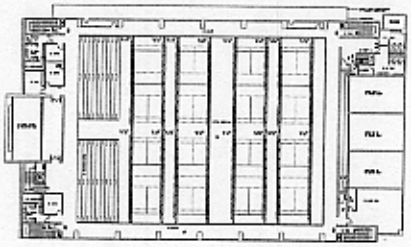
New 2x80W High Output T5 Lighting System at Kowloon Bay Indoor Games Hall (Existing HID Lighting)

Pilot Energy Efficient Lighting Projects

- New Design of 2x80W High Output T5 Lighting System at Kowloon Bay Indoor Games Hall (KBIGH) to suit various functions:
  - Lighting Class I: 750 lux for top-level competition & training at international & national standard
  - Lighting Class II: 500 lux for mid-level competition or high-level training at regional level
  - Lighting Class III: 300 lux for low-level competition, general training & recreation activities, etc.

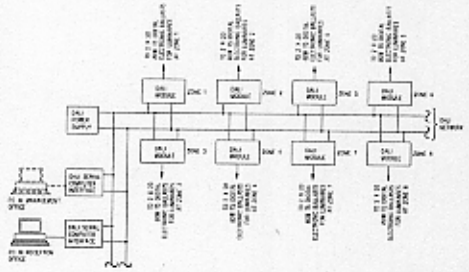
Pilot Energy Efficient Lighting Projects

New 2x80W High Output T5 Lighting System at Kowloon Bay Indoor Games Hall (New Lighting Layout)



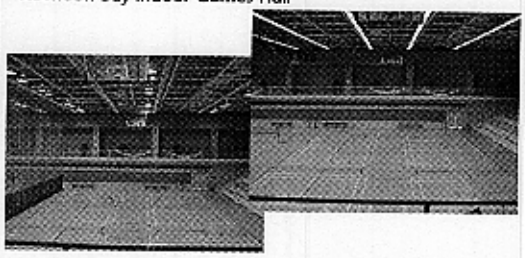
Pilot Energy Efficient Lighting Projects

New High Output T5 Lighting System at Kowloon Bay Indoor Games Hall (DALI Lighting Control Schematic)



Pilot Energy Efficient Lighting Projects

Comparison of visual environment between existing HID and new High Output T5 Lighting System at Kowloon Bay Indoor Games Hall



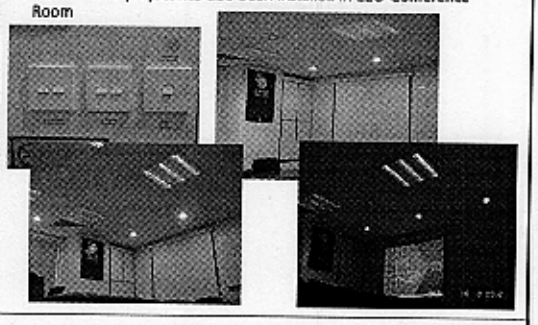
Pilot Energy Efficient Lighting Projects

Lighting Control using Digital Addressable Lighting Interface (DALI) :

Switching group & different scenes setting are set by computer & operate by simple push buttons

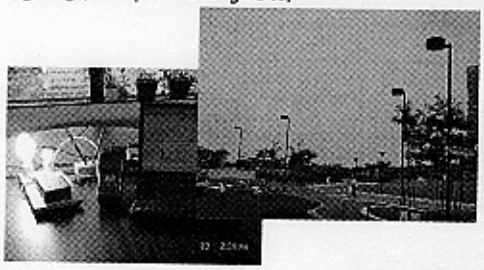
Pilot Energy Efficient Lighting Projects

- The 2nd DALI project has also been installed in EEO Conference Room



Pilot Energy Efficient Lighting Projects

- Proposed electronic ballasts application for HID park lighting (Anticipated saving 15%)

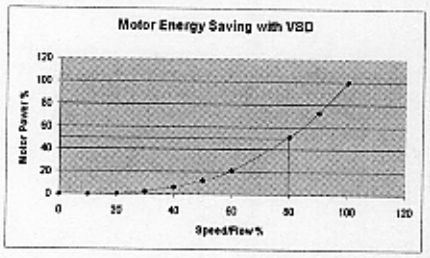


Energy Efficient HVAC Equipment & Systems

- In Hong Kong, most 3-phase induction motors used in buildings are fitted to drive fans and pumps.
- Air or water flow is either constant volume or regulate by mechanical means, e.g. air vanes/dampers, water by-pass valve, etc.
- Mechanical volume control adds loss in the system and is energy inefficient.
- As power required by fan or pump reduced proportionally to the cube of the motor speed, the application of VSD in volume flow control is more energy efficient, e.g. 20% speed reduction in motor need 51% of the original power.

Energy Efficient HVAC Equipment & Systems

Fan/Pump Cube Law

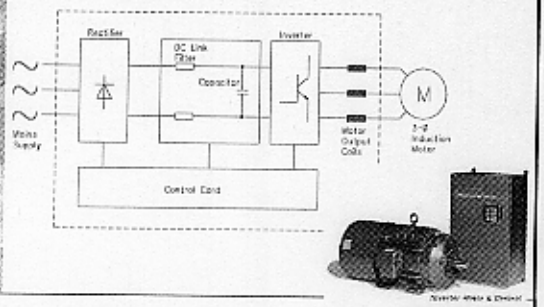


Energy Efficient HVAC Equipment & Systems

- VSD is actually a frequency converter rectifying ac to dc and then modifies dc into ac with variable amplitude and frequency.

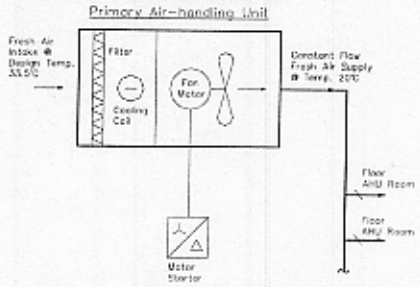
Energy Efficient HVAC Equipment & Systems

Schematic Diagram of VSD



Energy Efficient HVAC Equipment & Systems

Conventional Constant Flow PAU

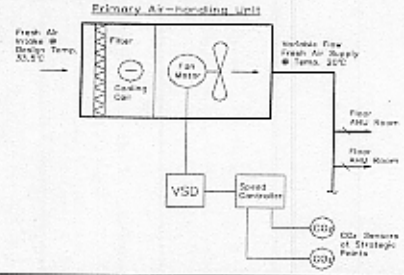


Energy Efficient HVAC Equipment & Systems

- Conventional fresh air supply in building is normally fed via PAU at constant air volume at a rate of 10 litres/s per person.
- PAU pre-treats & cools outdoor air from designed temperature of 33.5C to 20-25C.
- Constant FA disregarding the actual demand required is a great waste of energy.
- Demand control on PAU using CO2 sensor & VSD offer good opportunity to save energy in AC spaces with variable or intermittent occupancy.
- CO2 content of 1000 ppm is considered ideal according to ASHRAE standard for IAQ

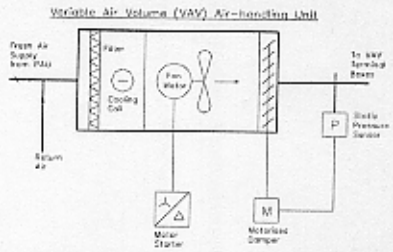
Energy Efficient HVAC Equipment & Systems

Typical Arrangement of variable flow PAU using VSD & CO2 sensors



Energy Efficient HVAC Equipment & Systems

Conventional Variable Air Volume (VAV) System using Inlet Guide Vanes or Outlet Damper

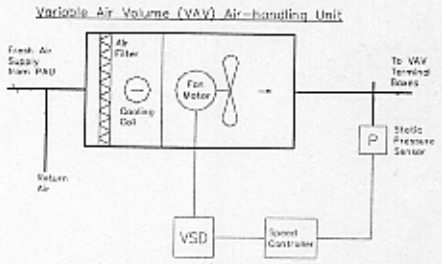


Energy Efficient HVAC Equipment & Systems

- Common AC systems in commercial building are Variable Air Volume and Fan Coil Unit (FCU).
- VAV system consists Air Handling Unit, air duct and VAV Boxes.
- Air volume flow depends on demand of cooling load required via zone temperature sensor & VAV box damper.
- Pressure in air duct is used to regulate air volume flow.
- Traditionally, inlet guide vanes or outlet damper in AHU is used for volume control.
- Instead, VSD could be employed to control flow more economically to save energy.

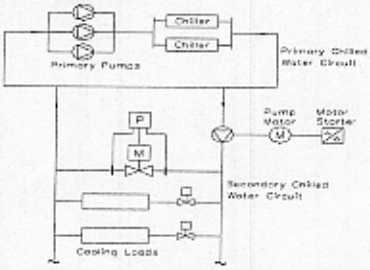
Energy Efficient HVAC Equipment & Systems

Typical Arrangement of VAV AHU using VSD & Pressure Sensors



Energy Efficient HVAC Equipment & Systems

Conventional Variable Chilled Water Flow System using By-pass Valve

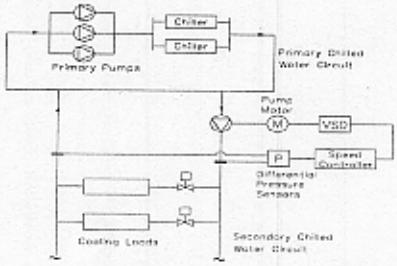


Energy Efficient HVAC Equipment & Systems

- Pumps for secondary chilled water circuit is normally sized to circulate chilled water at full capacity.
- Pump motor is running at full speed without speed control.
- Chilled water flow to loads is normally regulated through by-pass valve controlled by differential pressure sensors.
- VSD could be used instead to control chilled water flow by varying speed of pump motor.
- The same differential pressure sensors in flow and return chilled water circuits could be used to control VSD.

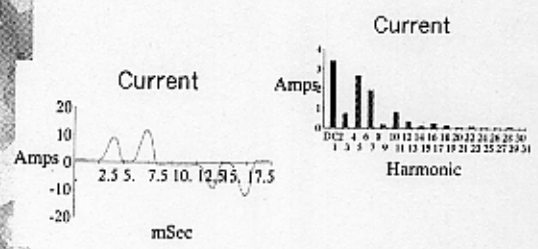
Energy Efficient HVAC Equipment & Systems

Variable Chilled Water Flow System using VSD



Energy Efficient HVAC Equipment & Systems

Typical Current Harmonic Distortion in VSD without filtering (THD = 100%)

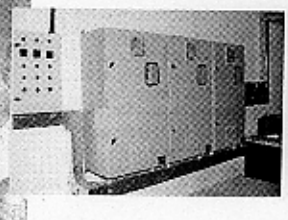


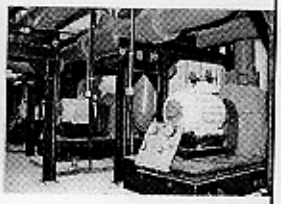
Energy Efficient HVAC Equipment & Systems

- Energy Efficiency Office carried out Variable Speed Drives (VSD) pilot projects in the following government buildings:
  - Queensway G.O. – Primary Air-handling Unit (PAU) and Chilled Water Circuit
  - Mong Kok G.O. – PAU and Variable Air Volume (VAV)
  - Southorn Centre - PAU
  - Harbour Building – PAU and VAV
  - Tuen Mun G.O. - VAV
  - Revenue Tower – VAV
  - Shatin Town Hall – VSD Chiller

Energy Efficient HVAC Equipment & Systems

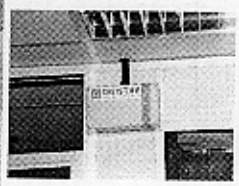
Queensway G.O. - VSD installations for 3 nos. 37 kW secondary chilled water pumps





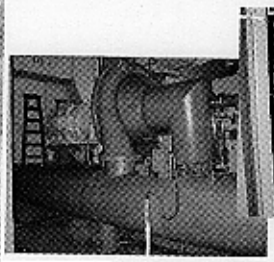
Energy Efficient HVAC Equipment & Systems

Southorn Centre - Carbon Dioxide Detector to control VSD speed of Primary Fresh Air Handling Units (PAU)



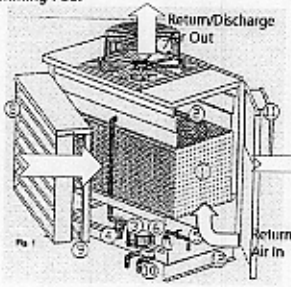
Energy Efficient HVAC Equipment & Systems

Shatin Town Hall – 400 RT water-cooled chiller to be retrofitted with VSD to improve its part-load performance



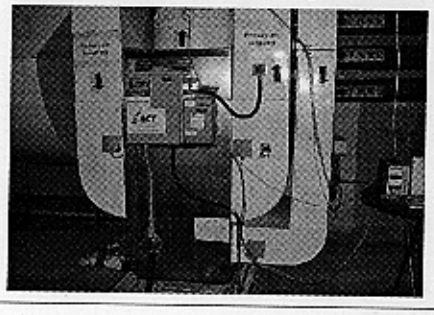
Energy Efficient HVAC Equipment & Systems

Indirect Evaporating Pre-cooling of Primary Air at Kowloon Park Swimming Pool



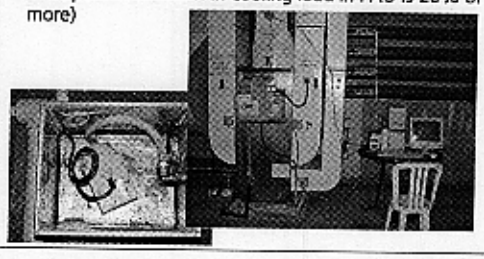
Energy Efficient HVAC Equipment & Systems

Indirect Evaporating Pre-cooling of Primary Air: Module Unit



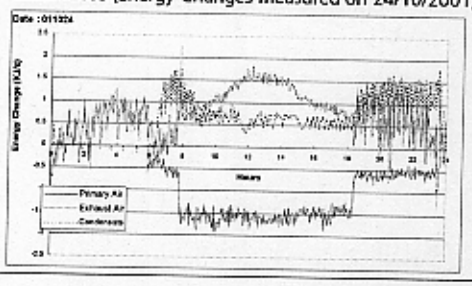
Energy Efficient HVAC Equipment & Systems

- Indirect evaporating pre-cooling of primary air at Kowloon Park Swimming Pool using condensate water from AHUs (Data are still being collected on site. The anticipated reduction in cooling load in PAU is 20% or more)



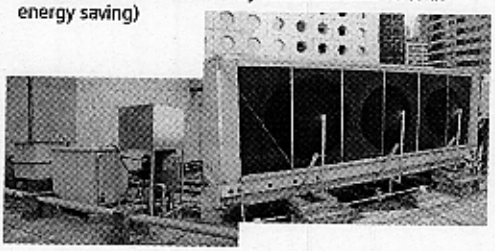
Energy Efficient HVAC Equipment & Systems

- Indirect evaporating pre-cooling of primary air at Kowloon Park Swimming Pool using condensate water from AHUs (Energy Changes measured on 24/10/2001)



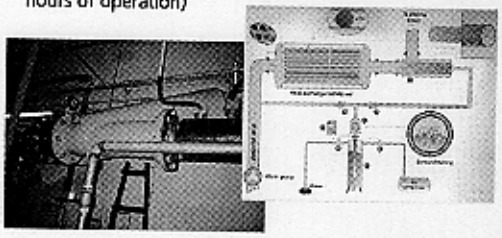
Energy Efficient HVAC Equipment & Systems

- Evaporating cooling for air-cooled chillers at GPO and Yeung Uk Road Indoor Games Hall (Data are still being collected on site. Preliminary result showed 15% in energy saving)

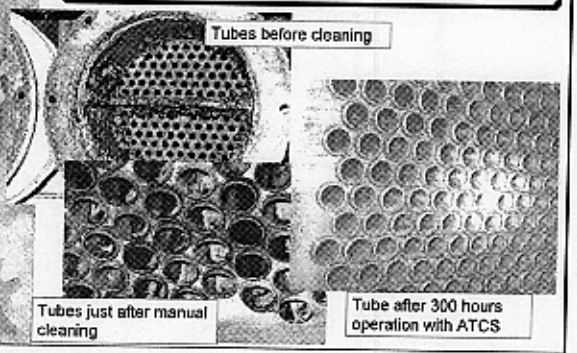


Energy Efficient HVAC Equipment & Systems

- Automatic tube cleaning for seawater-cooled chiller at China Ferry terminal (Preliminary energy saving of 2.4% was found. Tubes were found clean & shiny after 1000 hours of operation)

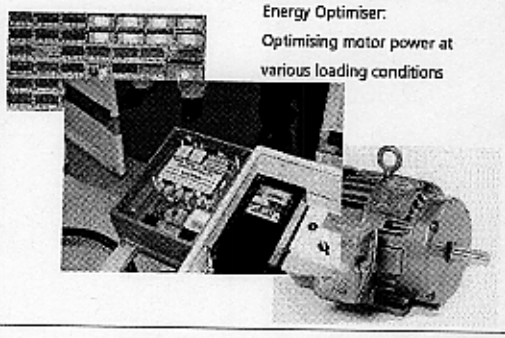


Energy Efficient HVAC Equipment & Systems



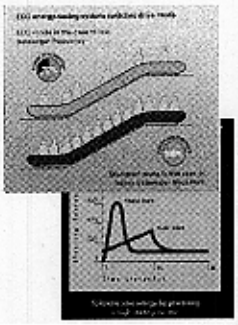
EE Equipment for Lift & Escalator

Energy Optimiser:
Optimising motor power at various loading conditions



EE Equipment for Lift & Escalator

- Energy Optimiser is a solid-state voltage controller that reduces losses in induction motor by means of voltage reduction and soft starting
- Motor running at low load are inefficient with full voltage as its iron loss is proportional to its voltage squared
- Motor operating at variable voltage to suit various loads results in power factor improvement and loss reduction



EE Equipment for Lift & Escalator

- The UP escalator from G/F to 1/F at North Point GO was selected for trial
- The escalator was driven by a 7.5kW 3-phase motor with a direct-on-line starter
- The escalator operated from 8 am to 6 pm every working day and was not always loaded
- A 7.5kW energy optimiser was installed in the service pit together with changeover contactors, kWh meter and hour meter
- The escalator was tested with optimiser ON & OFF alternatively every week and measured data were collected for performance analysis

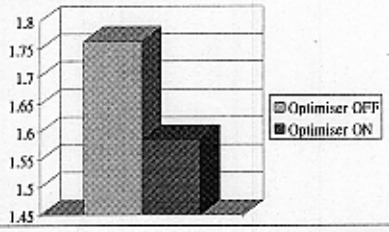
EE Equipment for Lift & Escalator

Summary of measured data recorded from Jan to March 2000:

Average kWh per hour of operation with optimiser OFF = 1.763

Average kWh per hour of operation with optimiser ON = 1.586

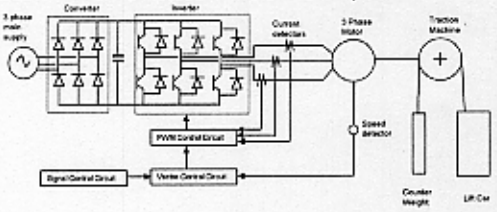
Average Energy Saving = 10%



EE Equipment for Lift & Escalator

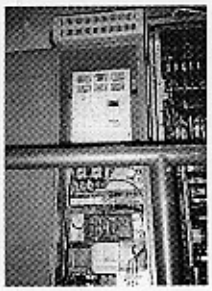
Traction Lift:

Use VVVF drive instead of DC or AC 2-Speed



EE Equipment for Lift & Escalator

Pilot Projects for converting AC 2-speed motor drive systems to Variable Voltage Variable Frequency (VVVF) have been carried out in Po On Market & WSD Staff Quarters at Kwai Fong. The measured energy saving is over 40%. Noise & riding comfort have also be improved as well.



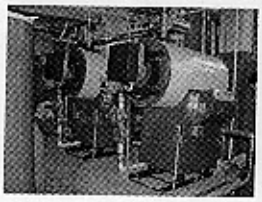
Other Potential EE Equipment/Materials

- New solar control window film declared to achieve:
  - 73% visible light transmission
  - 94% infra red reflection
  - 99 ultra-violet rejection
  - 0.5 shading coefficient

Solar film being installed at EPD HQs for trial

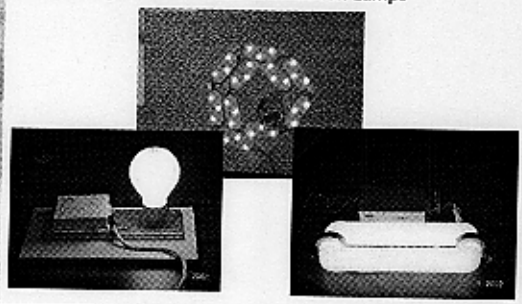
Other Potential EE Equipment/Materials

- Water to air heat pump for hot water system (to replace gas boiler or electric storage heater and suitable for buildings with demand of hot water and cool air at the same time



Other Potential EE Equipment/Materials

- New Light Sources: LED & Induction Lamps



Other Potential EE Equipment/Materials

- New and Renewable Energy

For any further information please contact

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