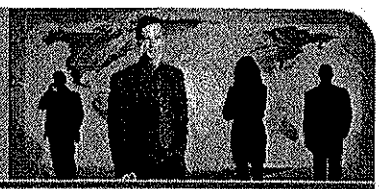
The Lifecycle Agenda in Sustainable Facilities Management



Presented by;

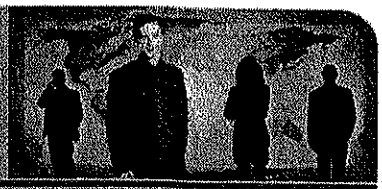
Martin Lim
Metropolitan Green Design and Technology

Topics



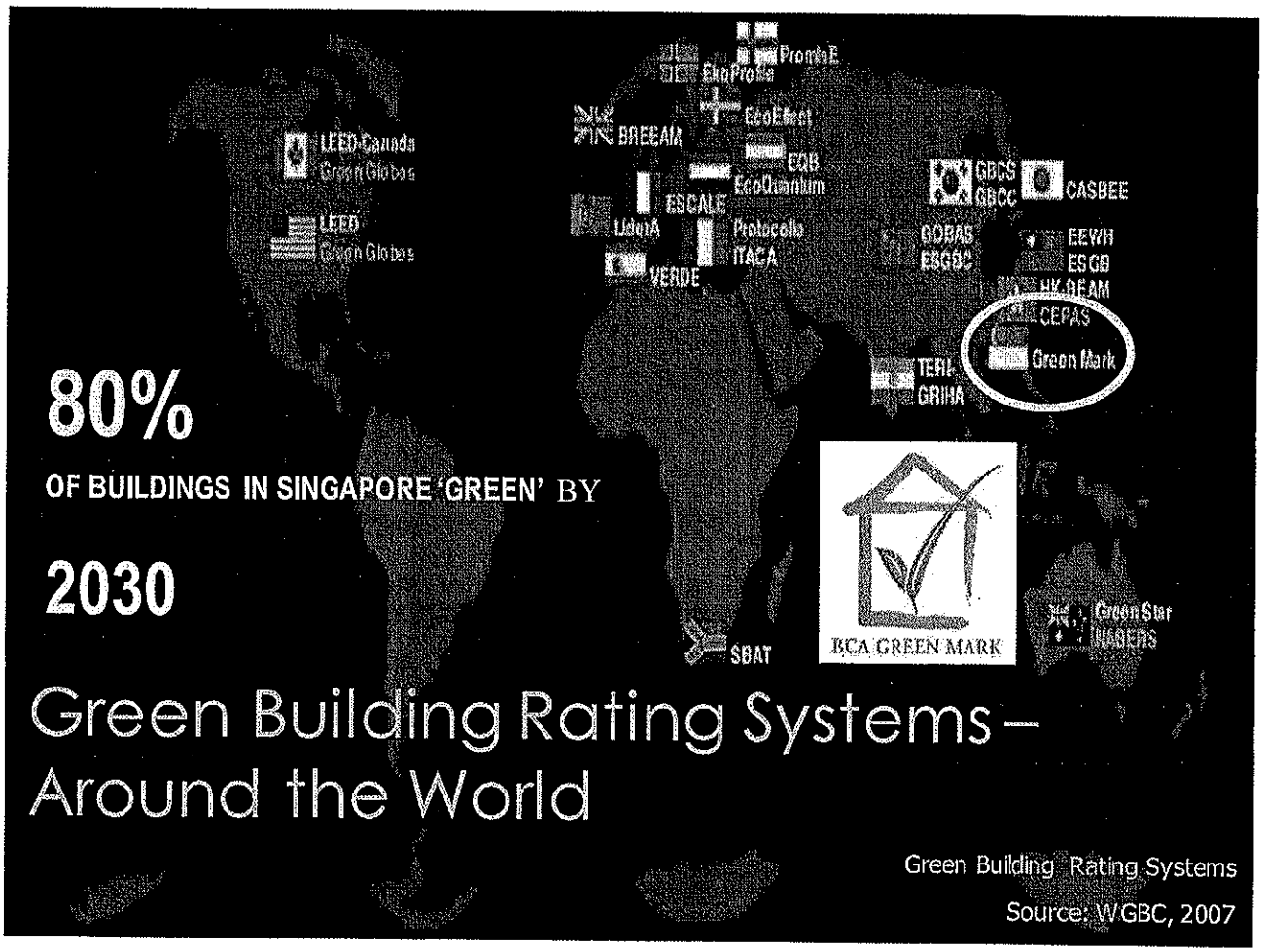
- Introduction
- Typical organisational structure
- Examples of green buildings
- Strategic FM considerations
- General objectives to FM
- Defining lifecycle investments
- Lifecycle priorities
- Integrating lifecycle in the procurement process
- Designing and building for maintainability
- Applicability of lifecycle to operations & maintenance
- Financial models for lifecycle cost analysis
- Data sources for lifecycle costing
- Sustainability considerations
- Lifecycle benefits
- LCC implementation

Characteristics of Green Buildings



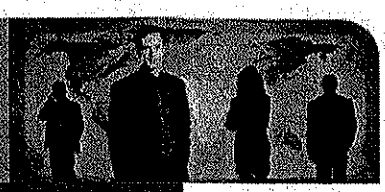


- Optimal environmental and economic performance
- Increased efficiencies saving energy and resources
- Satisfying, productive, quality indoor spaces
- Whole-building design, construction and operation over entire life cycle
- Fully integrated approach – teams, processes, systems



Green Building Rating Systems – Around the World

Recognition and differentiation of "Green Buildings".









BCA GREEN MARK

- **Value enhancement by owners to their tenants**
- **Sharing of best practices among owners of Green Mark Buildings**
- Image branding which promotes enhanced perception with consumers
- Protects Brand Reputation as a leader in sustainability
- **Cost savings in lifecycle approach for operations and maintenance**
- Studies in the US have shown potential savings of **20-50%** in **energy consumption**
- Savings in **water consumption** of up to **30%**
- Better indoor environment can lead to **reduced health care costs** of up to **25%**
- Reduces absenteeism by 45% and increasing productivity up to 16%
- **Higher Valuation of Building** - Up to $4 increased valuation for every $1 spent (USA)
- **Reduced Insurance & Risk of Liability**

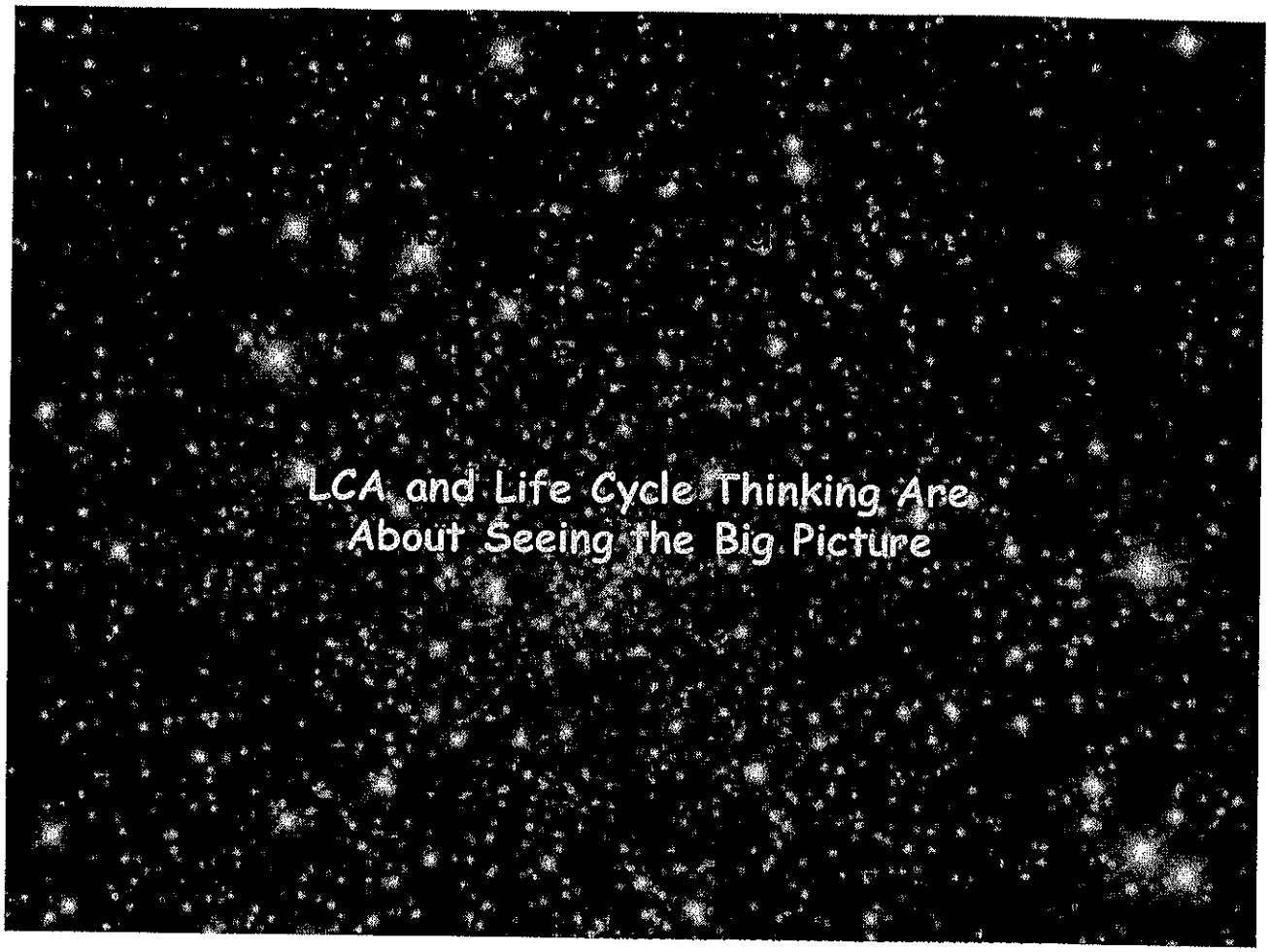
Is there a real business case for green buildings?



BCA GREEN MARK AWARD TYPE	GREEN COST PREMIUM (%)	Payback period (years)
Platinum	2% to 8%	2 to 8 years
Gold plus	1% to 3%	2 to 6 years
Gold	1% to 2%	2 to 6 years
Certified	0.3% to 1%	2 to 5 years

Source : Building and Construction Authority, May 2011, Green Mark for Facilities Managers course

Green buildings usually have a higher upfront cost which is estimated to be an additional 2% to 8% of the construction cost depending on desired green design score. The resulting benefit is an average lifecycle savings of 20% for a savings of ten times the initial investment



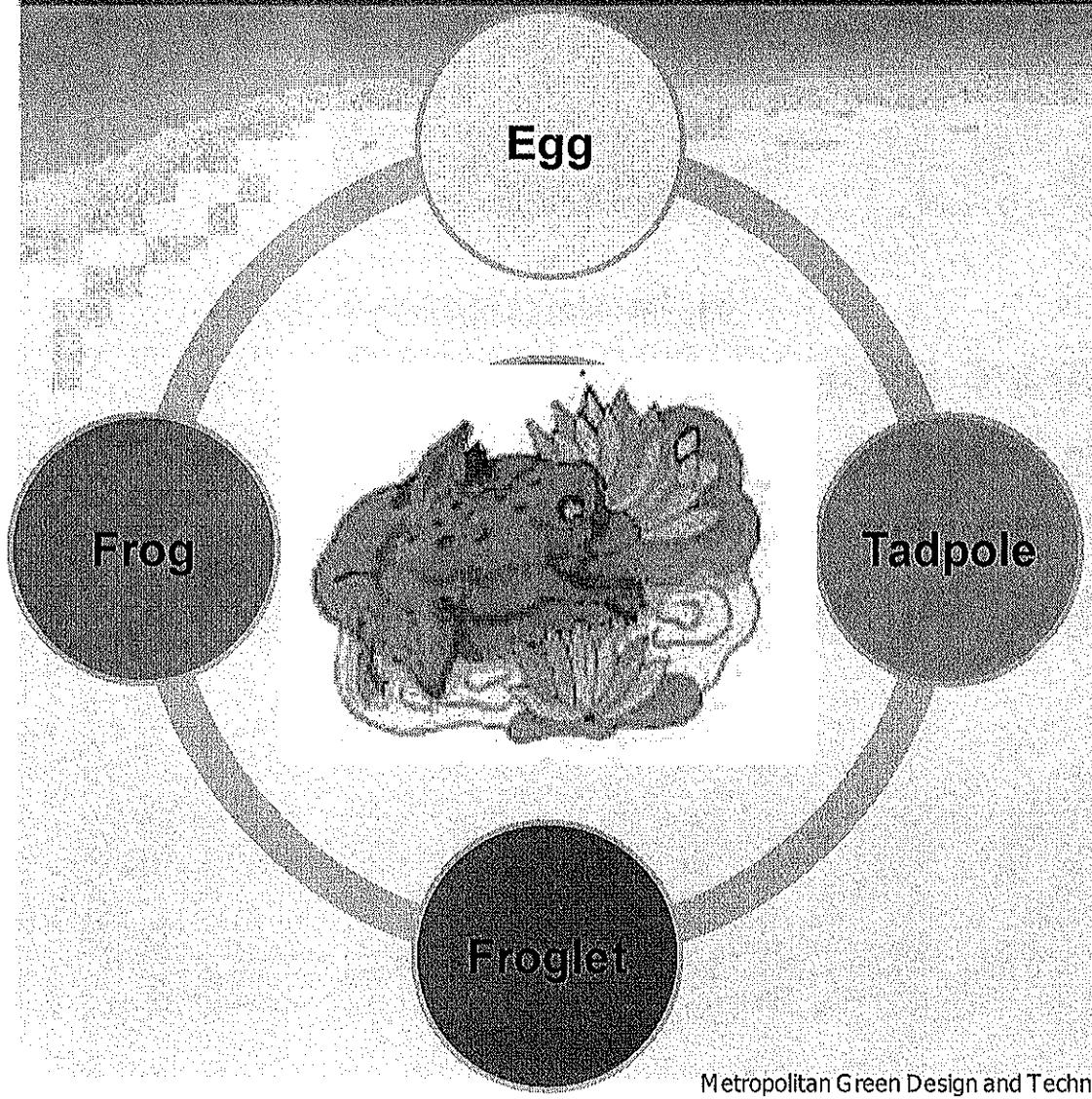
Introduction



- Life Cycle Management (LCM) has been practiced for many years in various forms by Hotels, Manufacturing, Petro Chemical and Medical
- With Sustainability practices, Green Mark & Green Environment gradually mandated by BCA, the lifecycle impact on O&M of commercial, industrial buildings, mission-critical buildings become more apparent in the future
- LCM is a tool to protect the higher than usual investment cost & complex equipment in the maintenance processes

What is lifecycle?





Stages in a Frog's Life

Egg

Females lay a clump of as many as four thousand to six thousand eggs. Once the eggs are fertilized, it takes about ten days (varies between species) for them to hatch into tadpoles.

Tadpole

For about five weeks, the tadpole breaths through gills and swims like a fish. A week after developing back legs, the tadpole develops lungs and breaths air. After about ten to eleven weeks, front legs can also be seen on the tadpole.

Froglet

At the age of twelve weeks, the tadpole has lost most of its tail and has functional front and back legs. It is now called a froglet and is able to go onto land.

Frog

After about sixteen weeks, the froglet loses its tail completely and becomes a frog. It can begin mating, starting the lifecycle over again.

***The frog in the book is a bullfrog, which can take two years to go from a tadpole to a frog. Other species can take as little as two weeks.

What are Green Buildings?

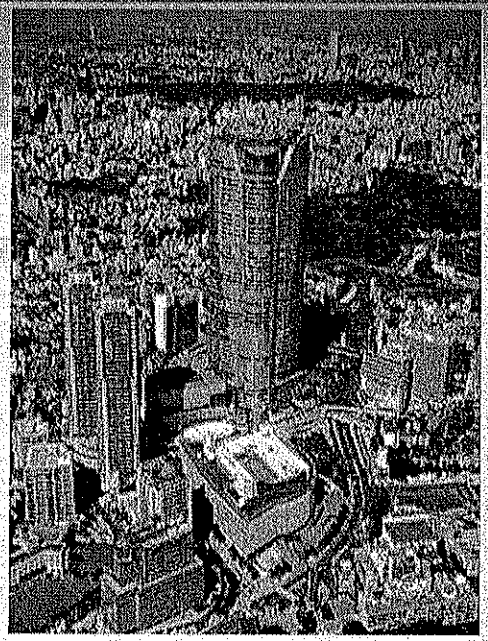


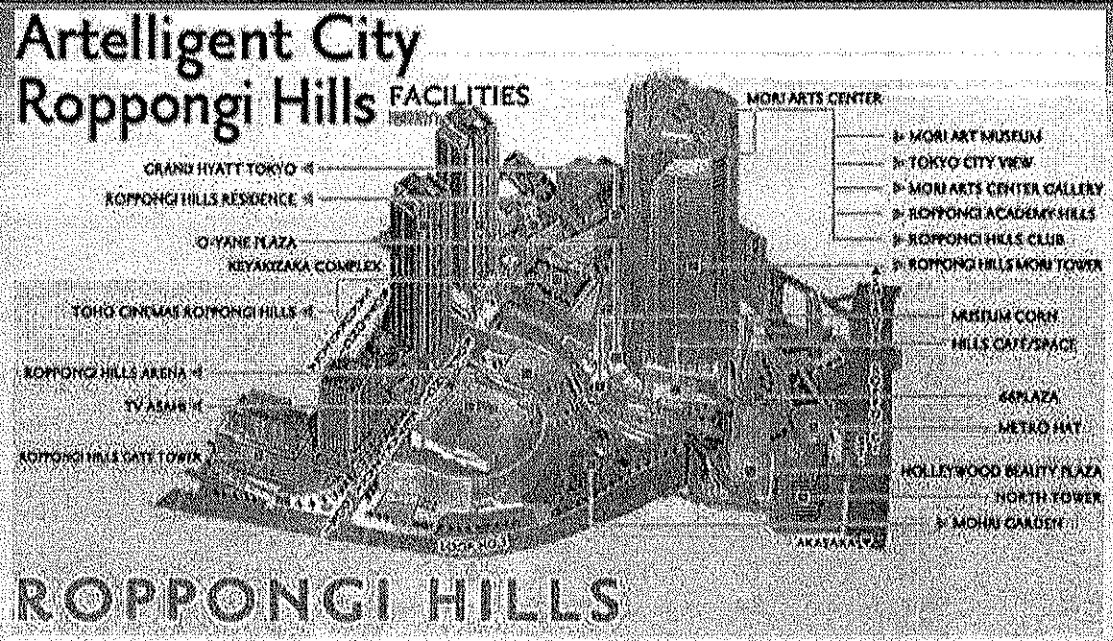
Green buildings **conserve** the **earth's natural resources** through the efficient and intelligent use of **energy**, **materials**, **water** and the **building site**. They provide their occupants with **comfortable surroundings** and **healthy indoor environments**.



Green buildings in Japan





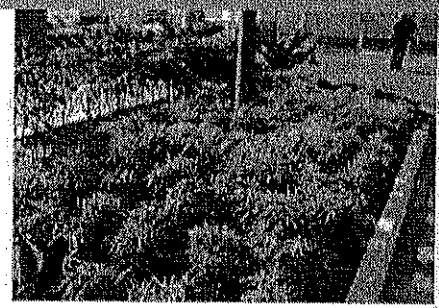


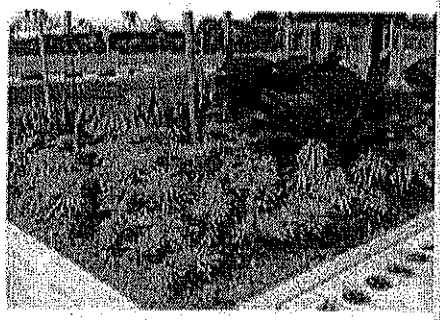
- **Increasing interest in "green buildings" worldwide in the past few years.**
- **Growing global concern on sustainability and the environment.**
- **USA, UK, Australia Japan and South Korea where green building assessment has been established.**
- **China, Taiwan, Malaysia & recently Singapore**

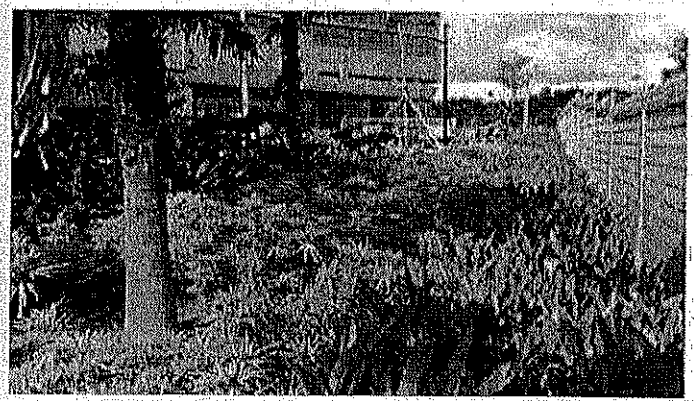
Seagate W3 – Green Eco-Friendly Disk Media Manufacturing Plant





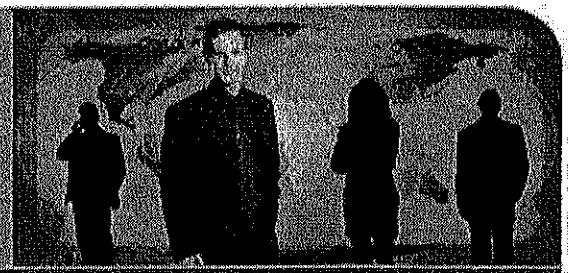








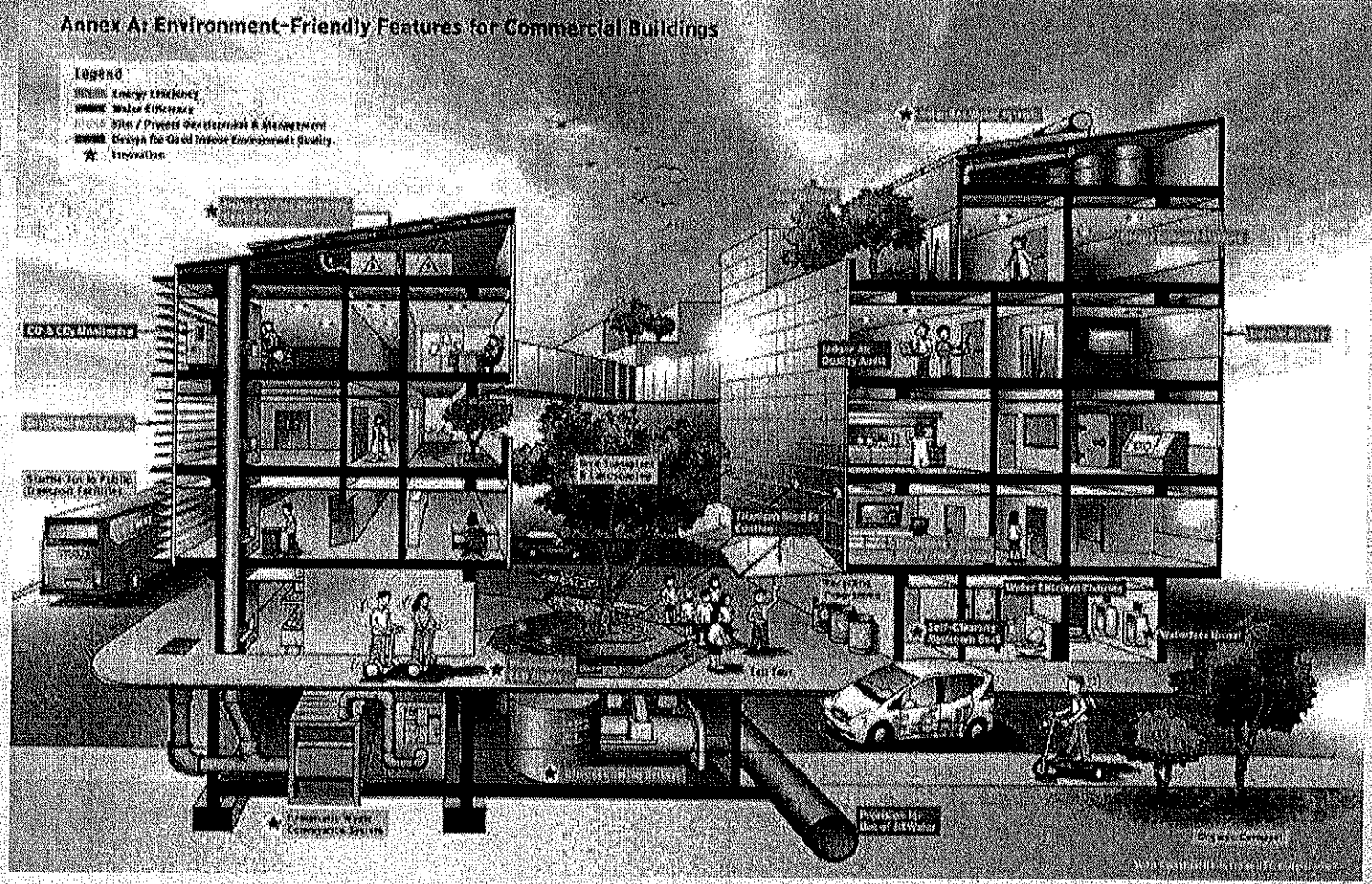
Seagate's Innovative green features



- **On-site Generation of N2 (gaseous nitrogen)**
- **Fuel Cells for green power-back-up**
- **Comprehensive Water Conservation Strategies (Reverse Osmosis / DI Reclaim** /Condensate Recovery /Newater for process manufacturing / Grey Water for cooling towers)
- **Advanced Variable FFUs (Fan Filter Units)**
- **Zero Loss Dryers**
- **Germicidal UVC Emitter System at all AHUs and FCUs**
- **Photovoltaic System**
- **T5 Fluorescent Lamps / LED Lamps**
- **Titanium Dioxide (Photocatalyst) Treatment of all Toilets and Canteen**
- **Rain Sensor and Weather Programme**
- **Photocells and Daylight Harvesting**
- **Power Quality Monitoring System**
- **Central Wet and Dry Vacuuming System**
- **Green Cooling Towers**
- **Exhaust Air Scrubber System**
- **Green Furniture, Carpets, Ceilings and Fibreboards**
- **ETTV of 38.18 W/m² resulting from a façade design which minimizes window areas on the** West and East facings to reduce solar heat gain.

Building Infrastructure Trends





Project Sustainability Overview
313 Somerset



End to End Sustainability: Key Initiatives

Solar panels for Renewable Energy

Highly efficient airconditioning systems with optimised Chiller, VSD and Low Flow Design

Cogeneration system run from tenant waste cooking oil/ biodiesel to produce electricity and hot water.

Glass/Void/Metal hybrid roof for carpark natural ventilation and day lighting

Rain Water Collection Tank at roof level for toilet flush and irrigation

Tenants in the mall comply with green lease conditions and are assisted by our Retail Design Managers with sustainability tools: retail services calculator, sustainable materials guide. Power consumption limit for tenants to be agreed with incentivised electricity rates

Light Sensors save energy in areas with natural daylighting, ie top-level Carpark and Atrium Corridors.

Vertical Greening in Sky Terraces and Landscape along Discovery Walk is fed by collected rain water

Energy-saving Standby speed escalators

Intelligent Lighting Controls via BMS for Common Area

Jet Fans in Thru-block Link reduces energy consumption for ventilation at night.

Direct connection to MRT at B2 to promote public transport

Basement Sprinkler Tank doubles up as Thermal Energy Storage Bank

Odour-free Mechanical Grease Separation System located underground with auto-extraction, self-cleaning improves IEQ

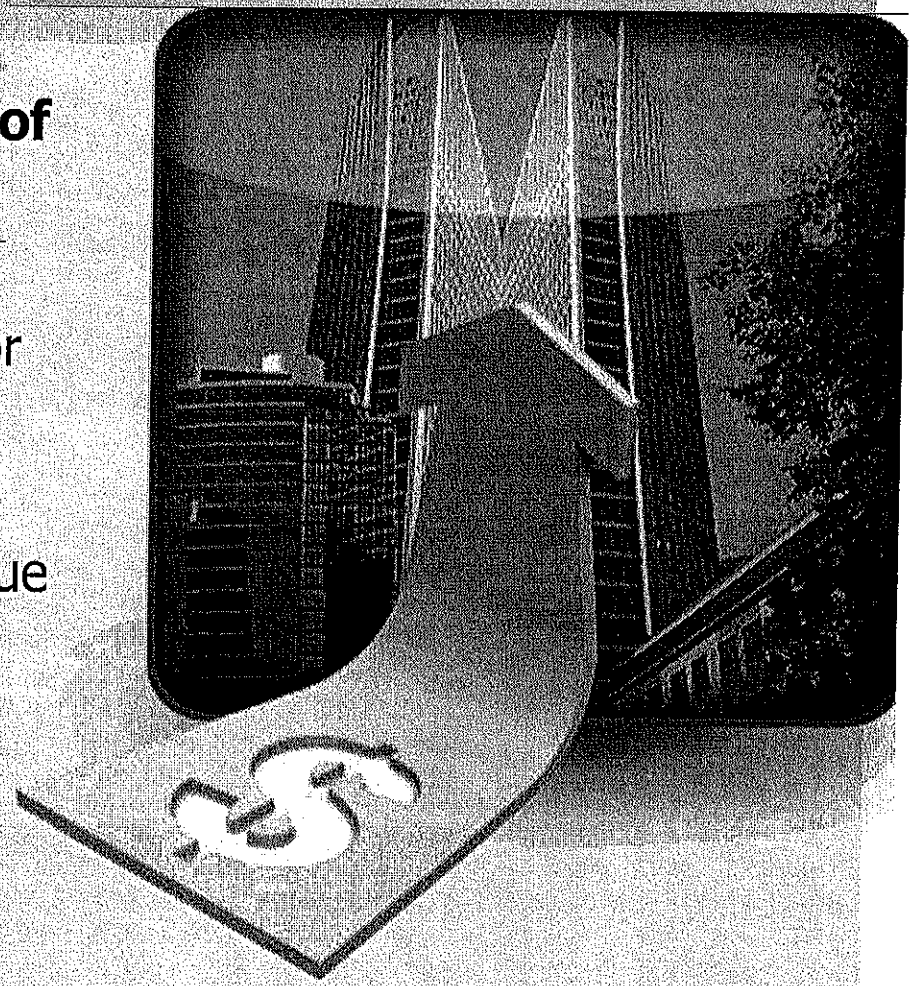
Eco Tour to educate and share with tenants, shoppers, professionals, youths and public- presentation and tour

Source : Lend Lease GMFM course

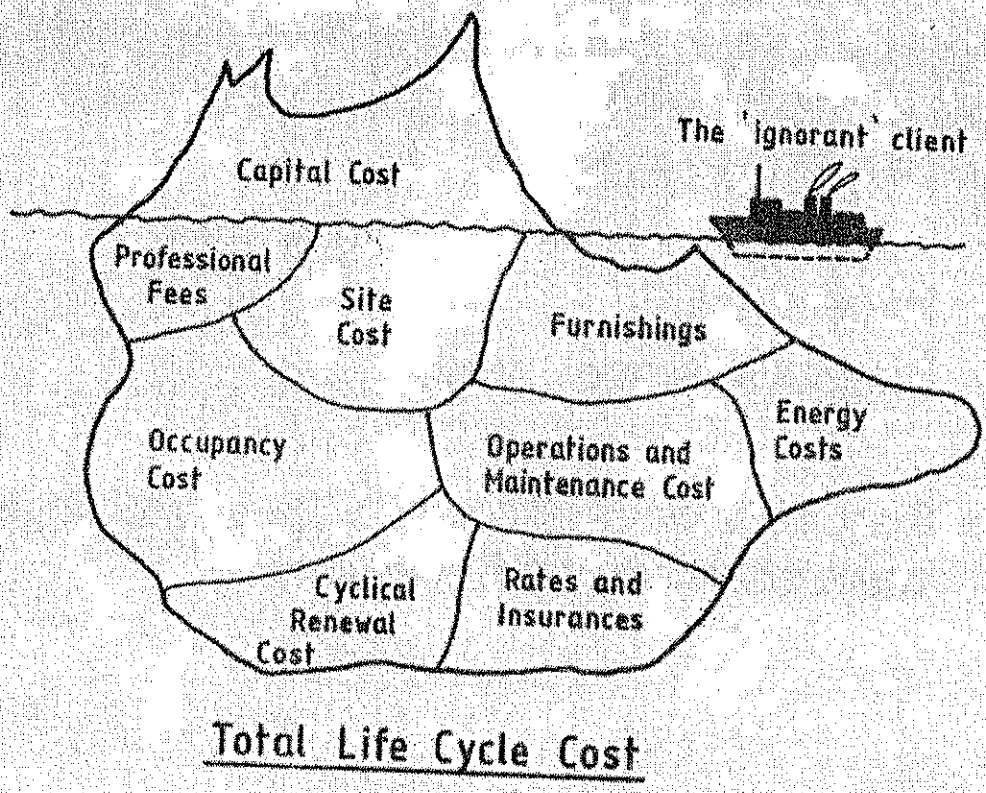
Objectives of sustainable FM



- Promote **awareness & benefits of Sustainable FM** to Stake Holders the **of buildings**.
- Identify & Adopt **best practices** in maintenance management of existing or green buildings focusing on designs, modification, spares & materials used
- **Maximization of Investment** by Value Enhancement program, Life Cycle Management



The ice-berg principle



Total Life Cycle Cost

Illustration 1 9/13/6

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Relative costs of owning a building



Cost component description	Percentage (%)
Design services	3.0
Construction	16.0
Operations and Maintenance	40.0
Repairs	30.0
Periodic refurbishment	10.0
Demolition/disposal	1.0
Total cost of ownership	100.0

Source: Royal Academy of Engineering, 1998

Application of whole life costing

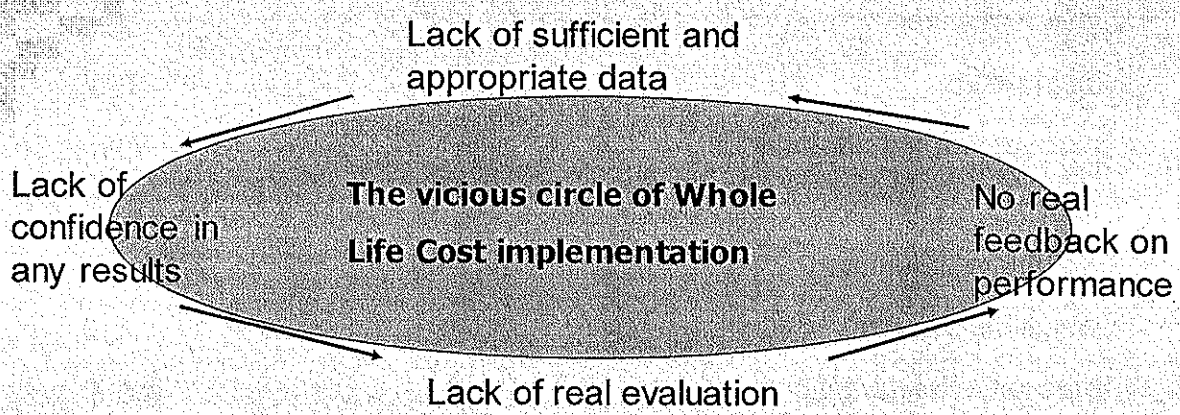


- PPP/PFI projects
- Public sector projects using private investment
- Hospitals, school, roads

- Require a whole life cost > 25 years, since costs often extend for 25 years+

Common difficulties of lifecycle





Source : University of Salford, UK

Issues to consider in buildings



- Building's life
  - Is this properly considered during design?

- Depends upon:
  - Type of building
  - Construction methods
  - Maintenance policies
  - Changes in demand and use
  - Management policies

Typical Building lifespan



• Offices	50 years
• School	60 years
• House	100 years
• Cathedral	300 years
• Information technology	3 years
• Motor car	10 years
• Engineering services	15 years

Data from : University of Salford, UK

Indicative renewal periods



• International fast food outlet	5 years
• Car production factory	10 years
• Office development	20 years
• Local authority school	30 years
• Prison	60 years

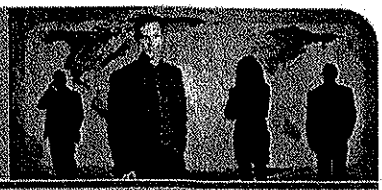
Source: University of Salford, UK

Types of Obsolescence



- Technological
- Function
- Economic
- Social
- Legal
- Aesthetic

Component lifespan



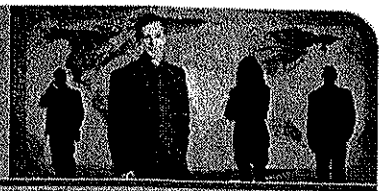
- Factors in determining the length of component lives:
  - original specification of the component
  - its appropriate installation within the building interaction with adjacent materials
  - use and abuse
  - frequency and standards of maintenance
  - local conditions
  - acceptable level of actual performance by the user
  - management policies used by owners or occupiers.

Sources of data for resource



- Product manufacturers
- Building Cost Information Service
- Building maintenance information
- Research organisations
- Personal records and anecdotal data

Predicting future component life cycles



- Components that fail due to ageing and predictable wear and tear (replacement predictable)
- Risk of accidental damage such as storm, vandalism and misuse where prediction is only possible on the basis of probability
- The effect of delaying maintenance which may be indicated by a partial failure of components.

Targeting major cost components



CATEGORY	Commercial %	Recreation %	Educational %	Residential %
Utilities and energy	35	22	32	22
Overheads	24	19	23	13
Administration	12	29	14	20
Cleaning	12	13	16	25
Building fabric maintenance	9	6	5	6
Services maintenance	5	7	7	6
Decorations	3	4	3	8
TOTAL	100	100	100	100

Source: The Construction Best Practice Programme

Issues and Considerations



- The earlier that whole life costing is considered, the greater are the potential benefits.
- Lower capital costs, reflecting a more efficient design, can result in lower whole life costs.
- Buildings with low in-built running costs will have a lower impact on the building owner's or occupier's business.
- Buildings whose performance can be readily and economically maintained will benefit the occupants and help to improve their productivity
- The use of discounting for the time value of money
- Accounting for uncertainty
- Mathematical modelling

Advantages of applying whole life costing



- The emphasis is on whole cost rather than concentrating only on the initial costs
- A more effective choice made between competing proposals
- Whole life costs considers all costs over the lifetime of the asset
- It is an asset management tool that allows the operating costs of premises to be evaluated at frequent intervals
- It enables these costs to be correlated with changes in working practice such as hours of operation, the introduction of new plant or machinery
- Whole-life costing can be used throughout the different phases of the building's life.

Benefits of Lifecycle Management



- **Option Evaluation**
  Allows evaluation of competing proposals on the basis of through life cost & is relevant to most service contracts and equipment purchasing decisions

- **Improved Awareness**
  Provides management with an improved awareness of the factors that drive cost and the resources required by the purchase.

- **Improved Forecasting**
  Allows the full cost associated with a procurement to be estimated more accurately leading to improved decision making at all levels, for example major investment decisions, or the establishment of cost effective support policies. Additionally allows more accurate forecasting of future expenditure.

- **Performance Trade-off Against Cost**
  There are other factors such as the overall fit against the requirement and the quality of the goods and the levels of service to be provided.

Applying LCM to Predict the future



Whole life costing can be used for making intelligent decisions pertaining to;

- Technological change
- Fashion changes
- Cost and value changes
- Policy-making and decision-making changes
- Historical perspectives

Lifecycle cost as part of construction cost



Table 1.1: Estimated Life Cycle Cost of Construction Cost*

Country	Total Value of Construction Projects* US$bn	Estimated Life Cycle Cost FM Component** US$bn	Total Life Cycle*** Cost of Projects US$bn
UAE	176	704	880
KSA	24	96	120
Qatar	23	92	115
Total	**223**	**892**	**1,115**

Source: MEED and Middle East Strategy Advisors (MESA) research

** Excludes oil & gas construction projects*

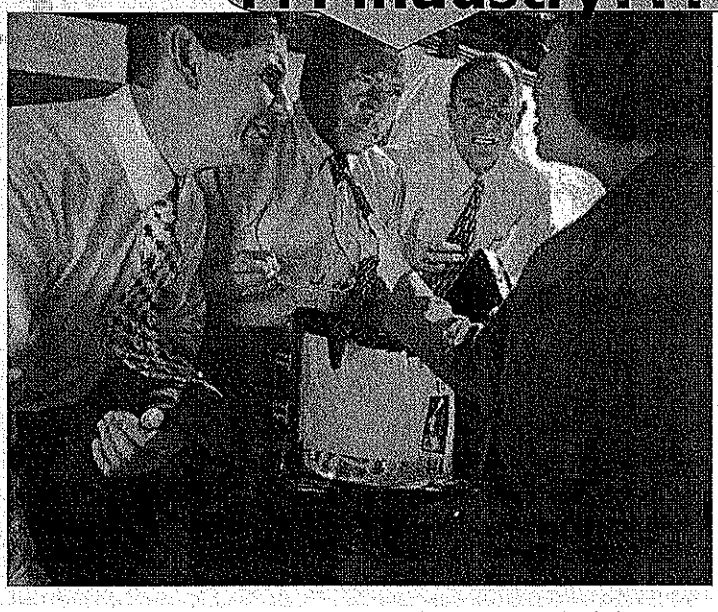
*** Based on the assumption that the initial investment (development cost) of a development is only 20% of the total money spent across the lifetime of a building; and that facilities management captures the remaining 80% over a 25-year period*

**** Over a 25-year period*

Excludes existing building, infrastructure and residential communities.

Good stuff! But, How does this apply to us in the FM industry???





Typical FM Organization Scope



Strategic Plan

FM / Prop Mgr

CAPEX
Eva / Selection

Mgmt Level

FE / Prop Exe / Snr Egr

OPEX / Proposal
Evaluation

Ops Level

ACMV	MEC	ELEC	BLDG
[redacted]	Ops Optimisation Water management Equipment Conditioning	Ops Optimisation Light Conditioning Equipment Conditioning	Bldg Cond Enviro Quality Space Use EHS Waste mgmt

Goals of LCM in Strategic FM

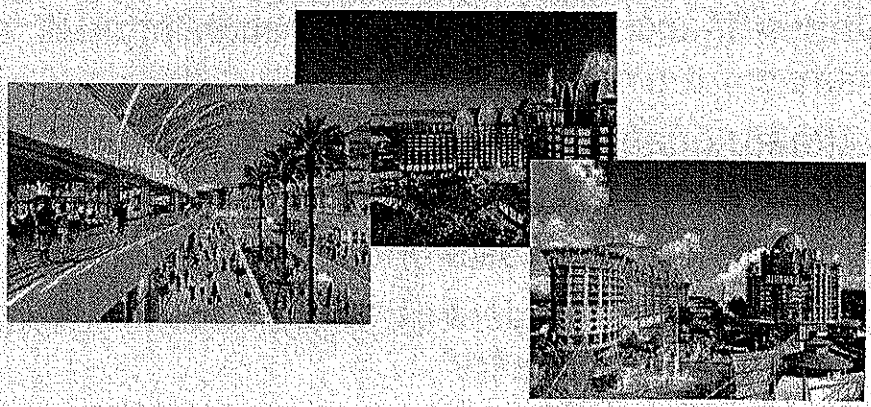


- Protect Investment
- Maximize Productive Lifespan
- Optimize Operating Cost by Real Value Add
- Reduction of Unnecessary Consumption and thereby less wastage
- Protect natural resources for future, including HR

Importance of LCM in Sustainable FM for New & Complex development



- 25 yrs to recover investment : CAPEX
- 25 yrs of Ops Cost : OPEX
- 10-15 yrs of Re-investment : CAPEX



Tool or chore?



- Used as evaluating option to choose between competing options (building, components, materials, finishes)
- Management tool to ensure that the facility is being used effectively and that returns on investment (ROI) is maximised
- As a basis for forecasting future operating expenditure
- As a means for total cost consideration not just CAPEX

Where can LCC be effectively applied?



- Estimate, Upgrading, Renovation, Overhauling, Refurbishing, A&A or building construction cost using most accurate info
- Estimate annual consumption of energy, water, oil costs (validate with energy modeling whenever possible)
- Gather financial data (inflation rates, interest rates, financing terms, etc)
- Estimate operation and maintenance, replacement costs and service life
- Calculate lifecycle costs present & future
- Compare the lifecycle cost for each alternative and select best option for investor





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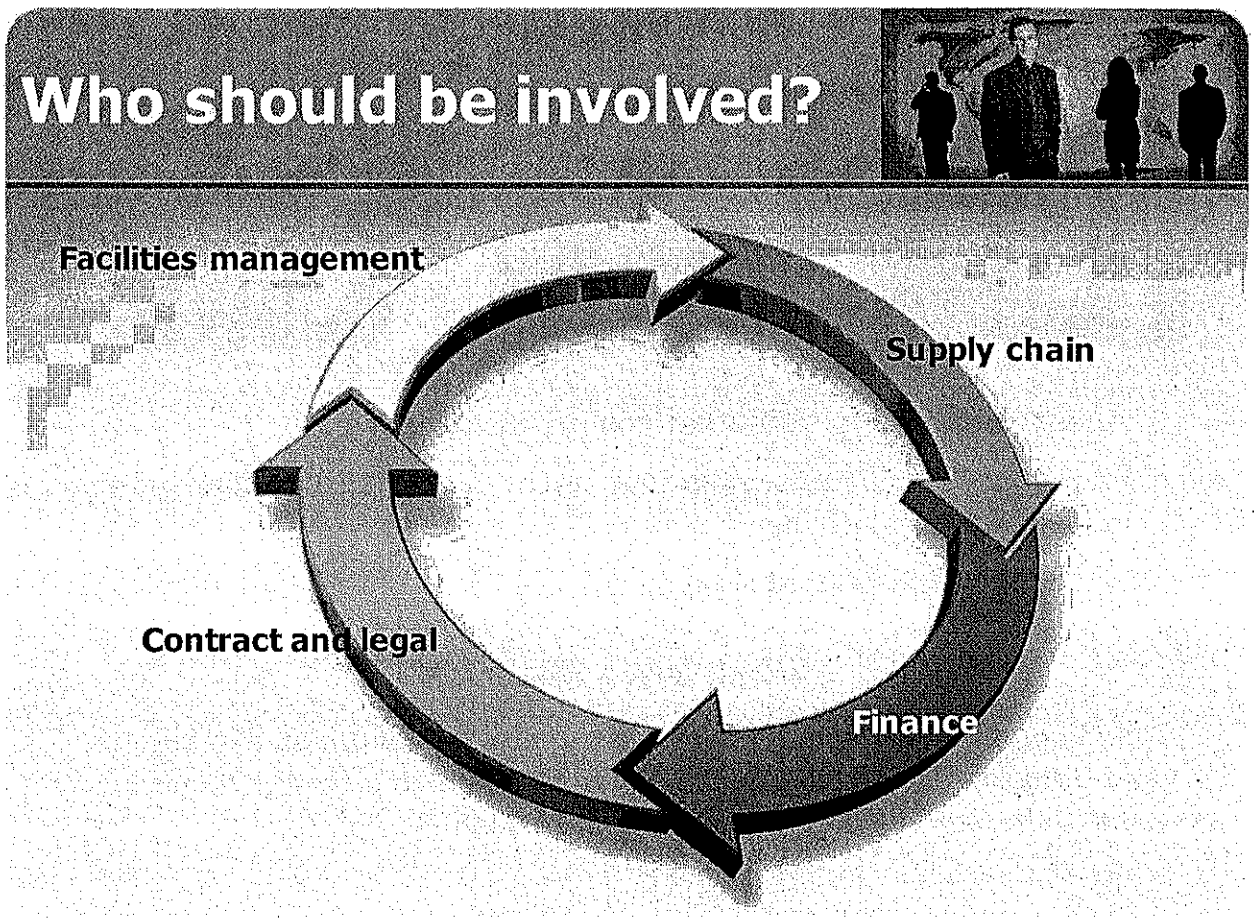

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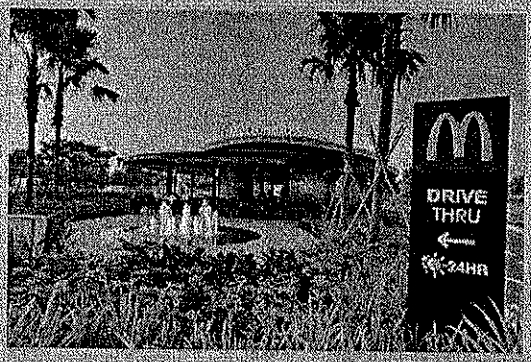
CASE STUDY :

McDonald's @ Jurong Central Park

CREATING A WORLD-CLASS ECO-FRIENDLY GREEN RESTAURANT

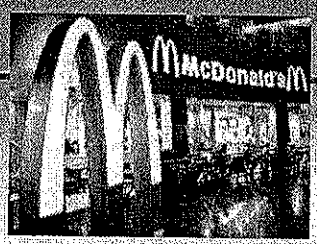


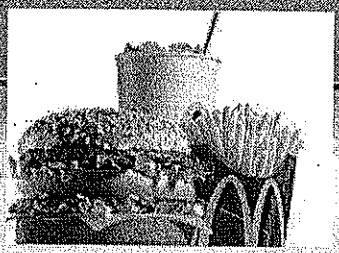


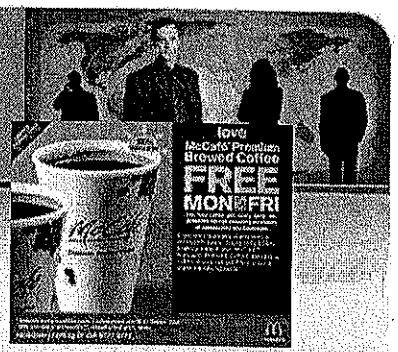
ESD Consultant: Metropolitan Green Design and Technology & GETC Asia

Crafting Eco-Friendly Solutions for a World-Class Green Restaurant

Getting to Know McDonald's







- Largest Quick Service restaurant chain in the world.
- More than **32,000 local restaurants** serving more than **64 million people** in **117 countries** each day.
- **1.7 million employees** worldwide.

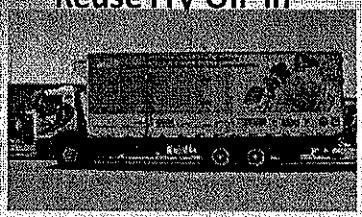
What We're Made Of

Continuous improvement...growth opportunity...commitment to doing the right thing for our customers, our communities and the planet... these are some of the ingredients McDonald's as a company is made of.

Working Towards a Greener Future Around the World
Harnessing Green Energy



McDonald's UK Reuse Fry Oil in



Frying oil from around **900 McDonald's restaurants** will be used to fuel the **155-strong delivery fleet** .

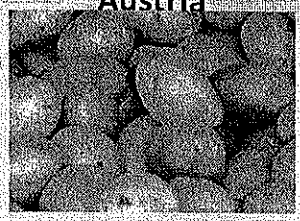
McDonald's expects to cut **carbon emissions by 1,675 tonnes** a year through the project.

Harnessing the Wind in UK



McDonald's supplier McCain Foods uses **wind turbines** at a French fry factory to provide up to 60 % of the annual electrical power required to operate the plant annually, **reducing CO2 emissions by 10,000 tons** in 2009.

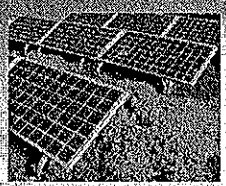
Potato Energy in Austria



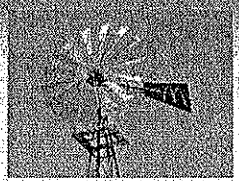
In Austria, McDonald's supplier Frisch and Frost takes the **solid by-product from potatoes** and converts it into **gas**, and the **residue from that process** is delivered to farmers who use it as a **natural fertilizer.**

Working Towards a Greener Future Around the World
Green Restaurants

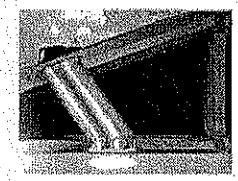




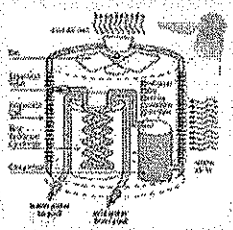
Photovoltaic Panels



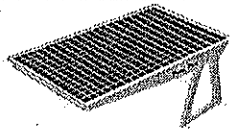
Windmill



Solar Light Tube



Heat Pump Heat Recovery System





McCharge on the Menu for Electric Vehicles

McDonald's Europe's many green initiatives include the installation of **solar panels, windmills, heat recovery systems** and **recyclable building materials**

Some **water-conservation technologies** in use at **McDonald's Australia** restaurants include **low-flow spray nozzles, dual-flush toilets, extensive native landscaping** and **smart irrigation practices.**

McDonald's in **Cary in North Carolina** uses **solar tubes** to pipe natural light into the premises, **sunflower-seed board** and **bamboo fittings** and a **re-charging facility** for the drivers of **electric vehicles.**

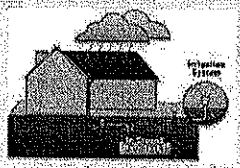
Major Green Highlights ; Jurong Central Park





Green Roof

- **Green roof** to improve building thermal performance, storm water management and aesthetics.



Rain Water Harvesting System

- **Rain water harvesting system** to collect rain water for plant irrigation. Use of **moisture sensor** to initiate watering.



Heat Pump system

- **Heat pump system** for heat recovery for free generation of hot water for dish washing.



UVC Emitter System

- **UVC emitters** for HVAC system to enhance IAQ and simplify HVAC maintenance.
- **Titanium dioxide photocatalyst** application in toilets to improve air quality and sanitation standard.

Major Green Highlights ; Jurong Central Park





Negative Kitchen Pressurization System

- **Negative kitchen pressurization system** to prevent ingress of odours from the kitchen into the dining areas.



LED Lighting

- **Smart thermostat** with time-based temperature set- points conserves energy by preventing over-cooling.
- **LED lighting** and **signages.**



LOV Fryer

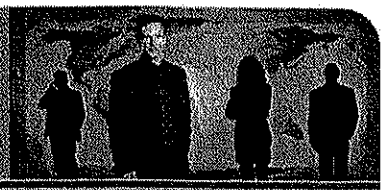
- **Efficient kitchen equipment** with Energy Star rating.
- **Low Oil Volume (LOV) Fryer**, the next generation fryer, improves cooking efficiency, simplifies filtering and cleaning, and provides enhanced environmental benefits.



Recycled Concrete Aggregate

- **Sustainable building materials:** recycled ceiling boards, green paint, recycled concrete aggregate for road foundation and drains made from recycled concrete.

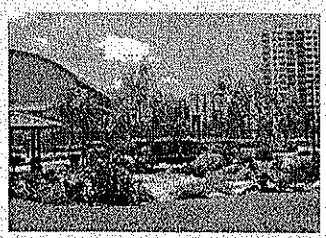
Key initiatives with lifecycle considerations

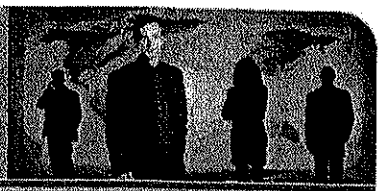


Initiatives	Incremental cost (RM)	Savings (RM/year)	Payback (Years)	Deployment status
Heat recovery system	?	15% of annual energy consumption	1.1	Under investigation
Rain water harvesting system	?	(estimated at 10% of water supply usage)	50	Under investigation
LED lighting (interior, pylons, lamp posts and signages	?	8% of annual energy consumption	<3.0	Study in progress
Air-con with high COP of 3.5 and smart thermostat	?	20% of annual energy consumption	?	Study in progress
High efficiency kitchen equipment	?	3-10% of annual energy consumption	?	Study in progress
Recycled building material	?	NA	NA	For new development



Applicability of LCM to operations and maintenance for the GMFM





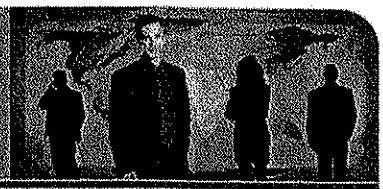
Examples of LCM application in everyday work

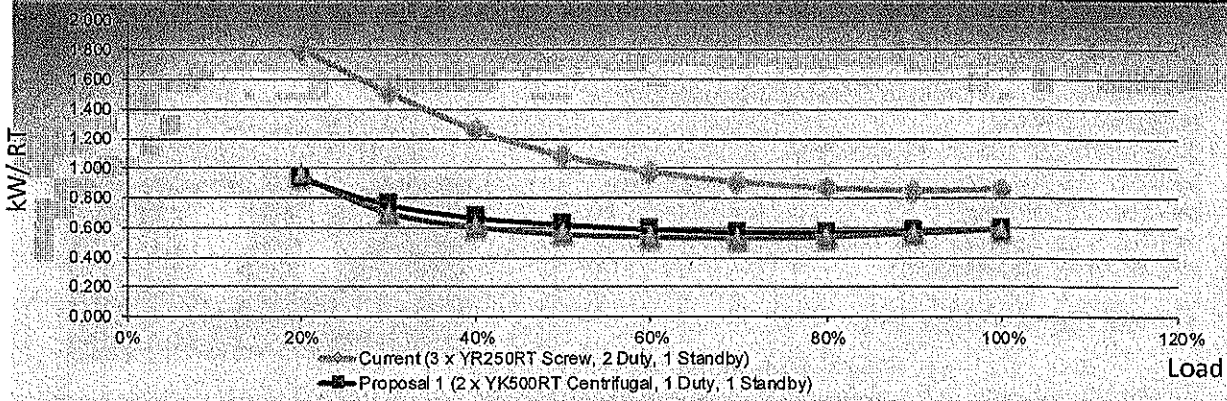
Lifecycle examples in energy efficiency computation for green buildings



Item	Criteria	Max Pts	Present Statement	Current Points	Proposed Value	Target Pts	Additional Investment ($'S)	Annual Savings ($'S)
1-1	ETTV	12	50 W/m²	0.0	42 W/m²	9.6	$ 520,000	$ 76,000
1-2	Air-Conditioning System	30	DSE of 0.862 kW/RT	0.0	0.572 kW/RT	29.0	$ 450,000	$ 119,790
1-3	Building Envelope	35		N.A. (<10% Non-AC Space)				-
1-4	Natural Ventilation	20		N.A. (<10% Non-AC Space)				-
1-5	Day lighting	6		0		0	-	-
1-6	Artificial Lighting	12	Conventional (15W/m²)	0	T5 Lighting (9.1W/m²)	12.0	$ 100,000	$56,850
1-7	Ventilation in Carpark	4	80% Above ground/20% Basement	0	Install Jet Fans, CO2 Sensor	3.6	$20,000	-
1-8	Ventil. in Com. Areas	5		1	-	2	-	-
1-9	Lifts and Escalators	2	VVVF, Sleep Mode	2	-	2	-	-
1-10	Energy Efficient Practices & Features	12	Heat Recovery for Hot Water	1	Compute EEI	2	-	-
1-11	Renewable Energy	20	NIL	0.0	-	0.0	-	-
	TOTAL	103		4	ROI = 5.2 yr	53.7	$1,110,000	$ 214,640

Chiller Plant efficiency - example





Option	Chiller Configuration	DSE (kW/RT)	Duty	Standby	Annual Operating Energy Consumption (kWh)	Annual Operating Cost (S$)	Annual Operating Cost Saving (S$)	Additional Investment (S$)	Payback (Years)	ROI	Green Mark Points
Current	3 x YR250RT Screw	0.862	2 x 250RT	1 x 250RT	916,250	$229,063					-
Proposal 1	2 x YK500RT Centrifugal	0.572	1 x 500RT	1 x 500RT	608,125	$152,031	$77,031	$250,000	3.2	30.8%	20
Proposal 2	2 x YMCC500RT Magnetic Centrifugal	0.554	1 x 500RT	1 x 500RT	588,125	$147,031	$82,031	$850,000	4.3	23.4%	20

Artificial lighting - example

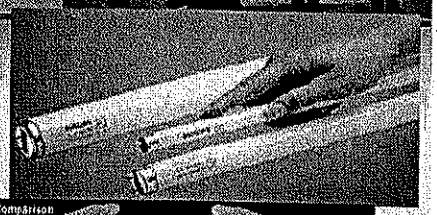


	Location	Floor Area (m2) (A)	Fitting Type	Power Consumption per fitting	Ballast Loss (W) (D)	No of fittings (E)	Total Power consumption based on light fitting type (W) (C+D)xE	Design (W/m2)	SS530 Ref (W/m2)	Ref Power Consumption	Savings
1	OFFICE AREA (4TH TO 21ST)	10260	2X28W T5 4 ft	56	5.6	1508	92892.8	9.05	15	153900	40%
2	TOILET AREA (4TH TO 21ST)	648	2 x 14 W (PLC Down Light)	28		108	3024	4.67	4.67	3024	0%
3	LIFT LOBBY (4TH TO 21ST)	459	2 x 5.5 W LED (LED Light)	11		78	858	1.87	10.00	4590	81%
4	CORRIDOR (4TH TO 21ST)	410	2 x 5.5 W LED (LED Light)	11		68	748	1.82	10.00	4100	82%
5	STAIRCASE	410	1x18 W (PLC Surface Mounted Light)	18	1.8	68	1346.4	3.28	6	2460	45%
6	PLANT ROOM	715	2X36W T8 4 ft (T 8)	72	7.2	74	5860.8	8.20	8.20	5860.8	0%
7	CAR PARK	715	28W T5 4ft	56	5.6	48	2956.8	4.14	6	4290	31%
8	1ST STOREY ENTRANCE LIGHT	350	2 x 5.5 W (LED Light)	11		38	418	1.19	10	3500	88%
			TOTAL				108,104.80			181,724.80	41%

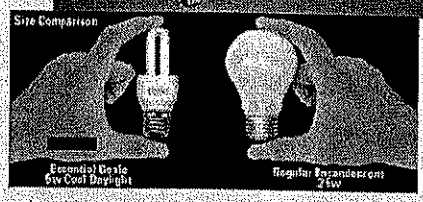
LCC in Artificial Lighting procurement



Use Electronic HF T5 Fittings



- energy improvement up to 25% compared to lighting budget of 15W/m²
- no additional cost for PF capacitor
- Air conditioning costs reduced because of less heat radiation (25% less)
- 50% longer lamp life, less maintenance costs
- lower lumen depreciation



GM Score = 0.3 x 25%
= 12.5 (Capped at 12)

Energy saved = 2000 fitting (@2x28W T5)x 20W x 3,650 h/year
= 146,000 kWh/year

Cost saved = 146,000 x $0.2237 (peak hour)
= $32,660

Investment = $50,000

Payback = 1.53 years

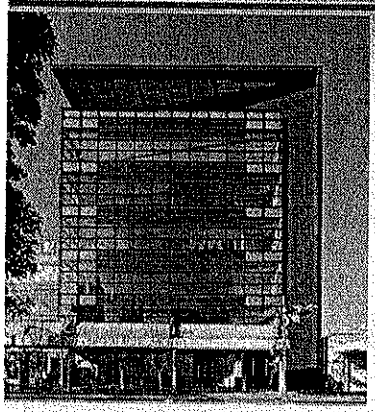
REVISION OF ELECTRICITY TARIFFS FROM 1ST JANUARY 2010

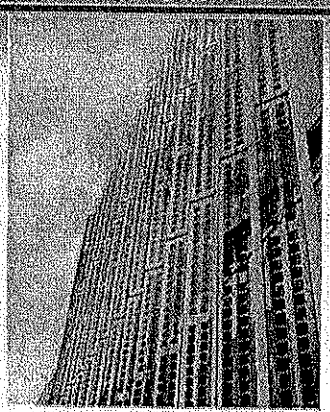
kWh charge, ¢/kWh	
Peak period (7am to 11pm)	22.37
Off-peak period (11pm to 7am)	13.32

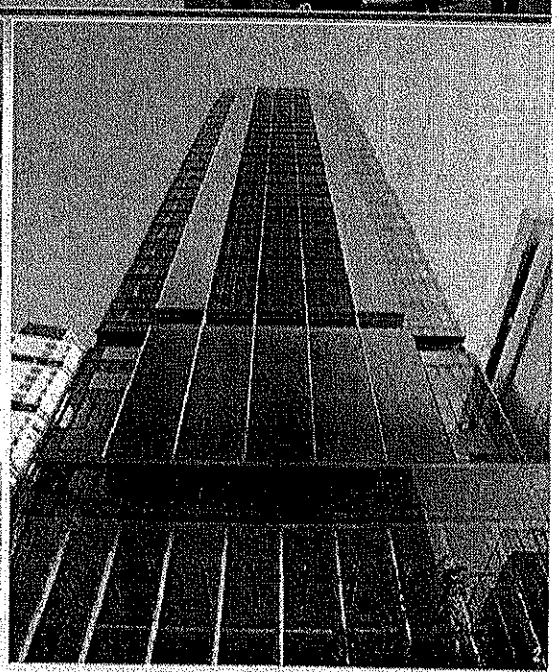
Assumptions:
a) 10 hours operation per day
b) Operational 365 days per year

Building Integratd Solar PV - Examples





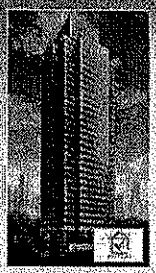




- Renewable energy + Shading feature
- Long pay-back
- Low maintenance
- Demonstrates CSR

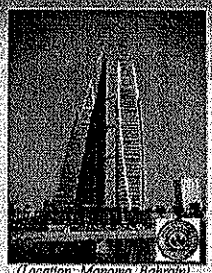
Lumiflon – Low life cycle cost Infrastructural Coatings for Enhanced Durability





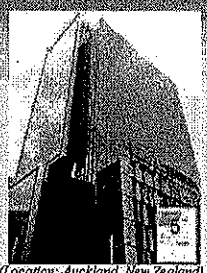
Green Mark "Gold"

Jotun Powder Coating "Corro-Coat Durasol"



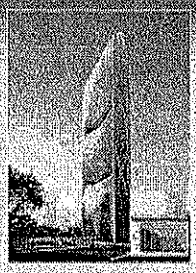
(Location: Manama, Bahrain) LEED "Platinum"

Mitsubishi Plastics "Alpolic"



(Location: Auckland, New Zealand) Green Star "5-Star"

Dulux Powder Coating "Fluoroset FP"



Low Energy Building

Akzo Powder Coatings "Interpon D-3000"



Mitsubishi Plastics "Alpolic"

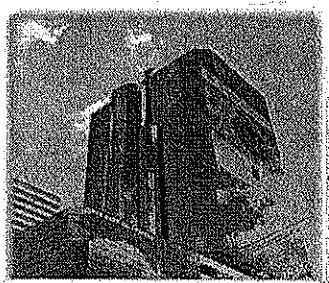


High Gloss
Wide range of colours
Lower Life Cycle Costs

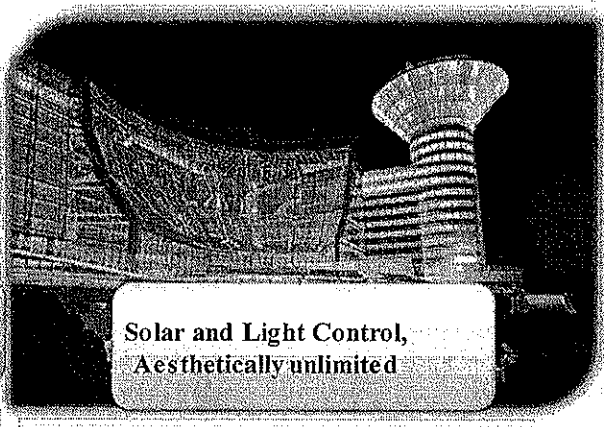
LUMIFLON

Options for Glass Facade – Comfort, Energy Savings, Unlimited choices

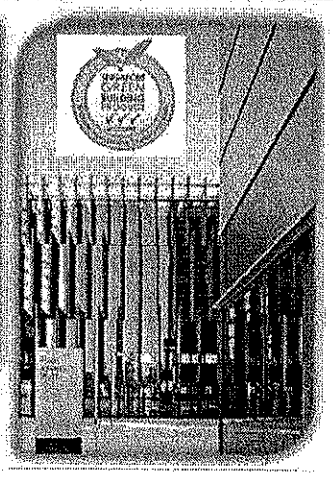




Comfort, Sustainable Energy Savings



Solar and Light Control, Aesthetically unlimited



T-Sunlux - soft coat reflective glass utilizing a wide variety of base glass to:
•Achieve a variety of aspects

STOPSOL® is a hard coat reflective glass with 3 different aspect;

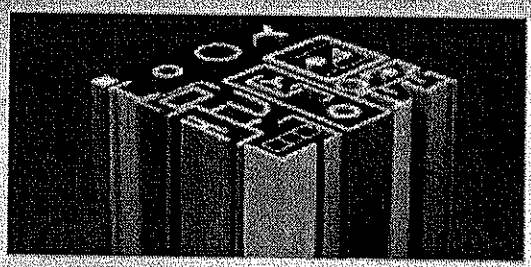
- CLASSIC : silver glass with a slightly amber reflection
- SUPERSILVER : glass with a silver, slightly bluish reflection
- SILVERLIGHT : glass with a lower degree of reflection with a bluish hue.

Stopray® is a high performance soft coat Low-E glass

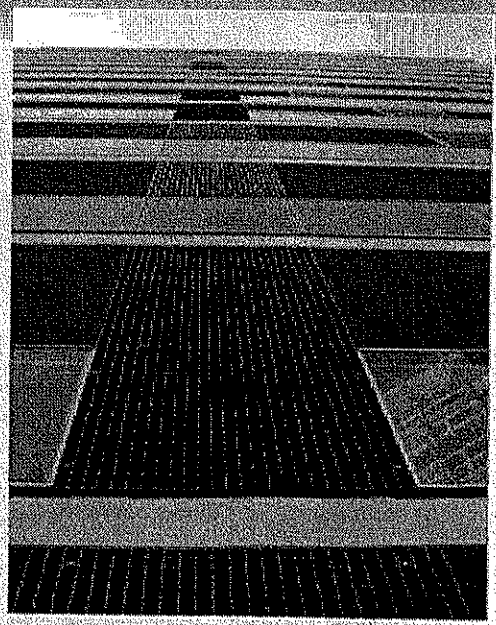
- Certified by SGBC as an excellent Green Building Product

Natural ventilation utilising Fibre Reinforced Plastics (FRP) construction materials





- Suitable material to hide compressors
- Application allows for natural ventilation
- Wide variety of available colours to match building design



Metropolitan Green Design and Technology

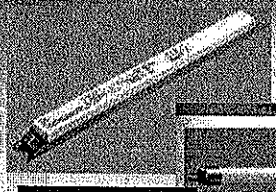
List of Commonly Approved Equipment



1. Variable Speed Drives (VSD)
2. Capacitor Banks
3. Motion Sensors
4. Energy Efficient Lighting e.g. T5/T8, PLC etc
5. Electronic Ballast
6. Building Automation System (BAS)
7. CO Carpark Ventilation Control System
8. Chiller Optimizer System
9. Hydro Carbon/Energy Efficient Refrigerant for Chillers, Air Con systems
10. Chiller Auto Condenser Tube Cleaning System
11. Photo Sensors
12. New Efficient Chiller replacement
13. Lighting Control System
14. CO2 Sensors for AHU System
15. Heat Pipe & Energy Recovery Wheel
16. Light Emitting Diodes (LED) Lightings
17. Energy Efficient lifts and escalators
18. Solar Energy or other renewable energy sources
19. Solar Film
20. Energy Saving Lighting Controllers
21. Voltage Regulators
22. Building façade/envelope that improves the ETTV value

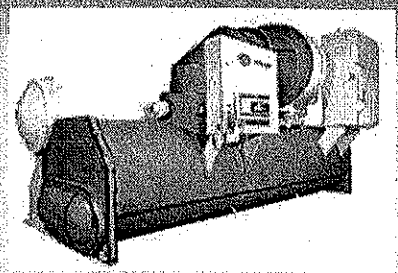
Note: Any other equipment not in the above common list will be subjected to review and approval from BCA.

Retrofitting that improve Energy Efficiency

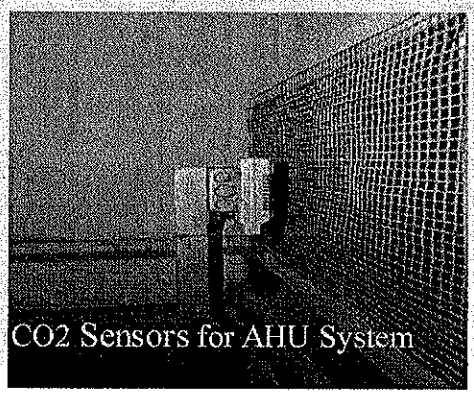




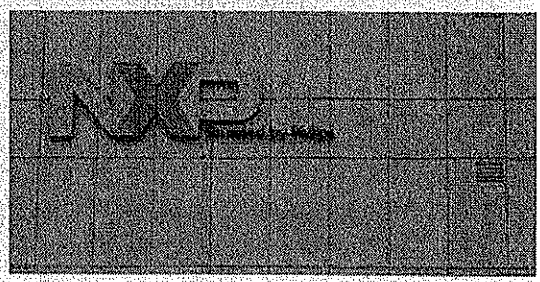
Energy Efficient Lighting



Highly Efficient Chilled Water System



CO2 Sensors for AHU System



Light Emitting Diodes (LED) Lighting Signs

What are Lifecycle priorities?

- **Building objectives**
  - short-term profit
  - long-term returns
  - safety compliant
- **Building timescales**
  - Length of ownership
  - length of project productivity
- **Capital sources**
  - Sources of funding (loans, retained profits, government funds/grants, REIT, IPO funds, etc)
- **Revenue sources**
  - Rental income
  - Production turnover
  - Government sources
- **Tax position**
  - Taxes which apply to organisation
  - Taxes claimed against

Key strategic actions for facilities manager



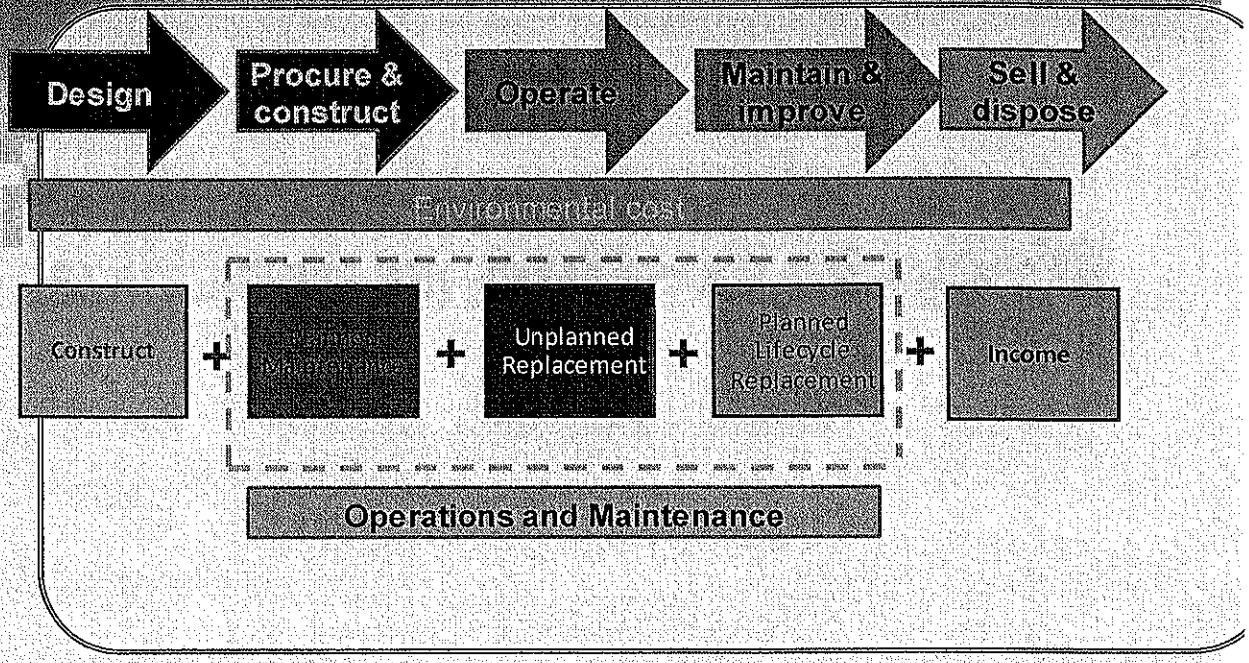
Strategic actions	Key results area (KRA)
Quality Repair & Maintenance - Introduce SLA/Measure Responsiveness	Tenant Retention
Reliable Temperature Control - Guaranteed a consistent level of comfort	Tenant Retention
Minimise Repair and Maintenance cost - No impact on quality	Maintenance Expense
Minimise energy cost - No capital upgrade	Energy expenses
Defer capital spending to a minimum - No increase in energy/repair cost	Capital expense



Integrating lifecycle in the procurement process

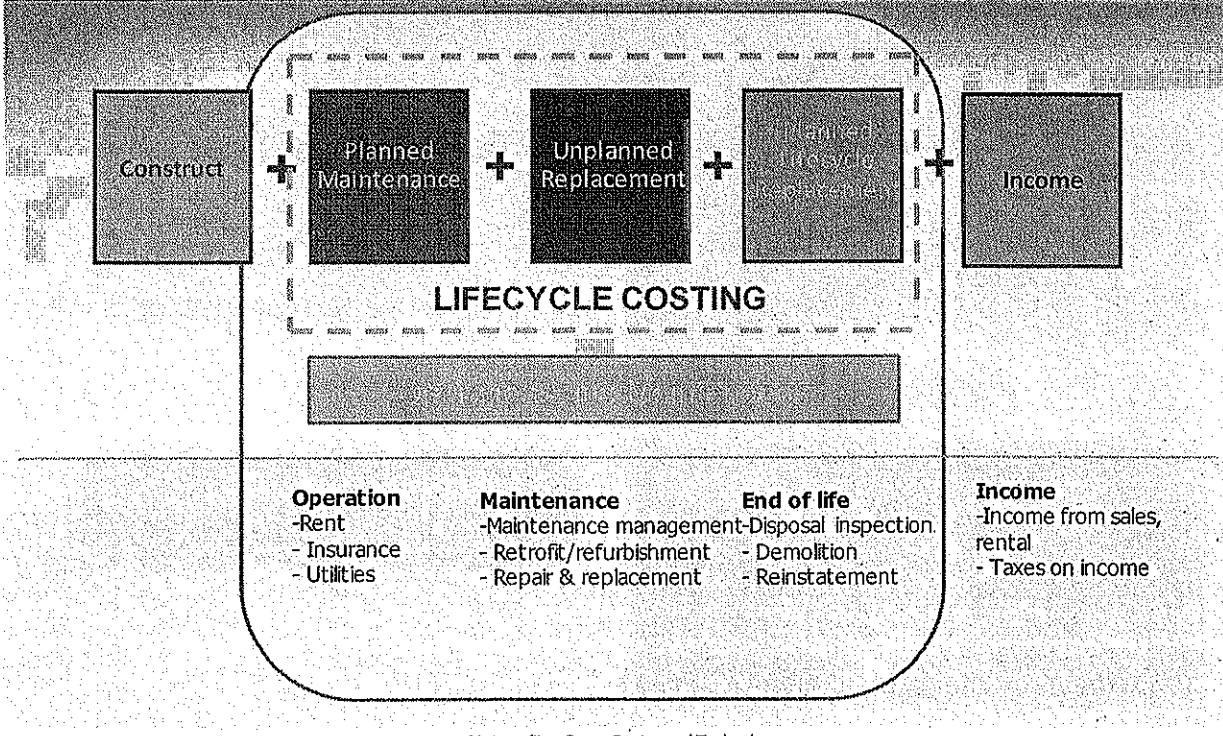
Holistic integration in whole life cycle





LCC integration to O&M



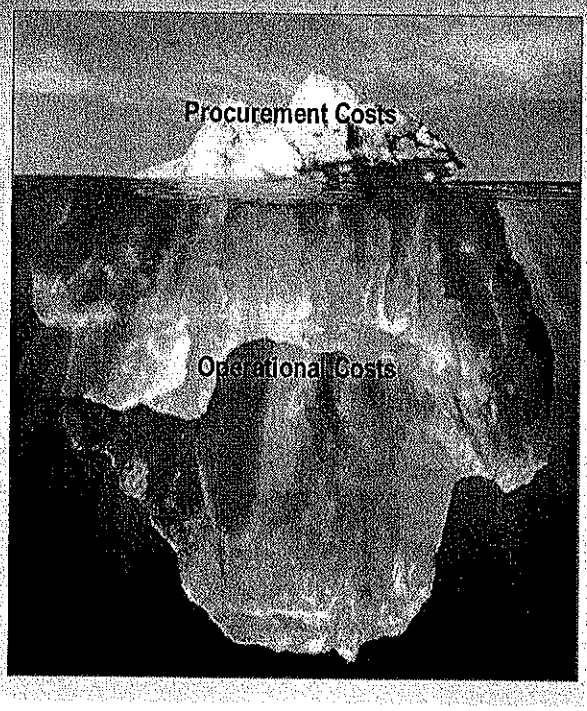




lifecycle costing in practice

The Iceberg Principle



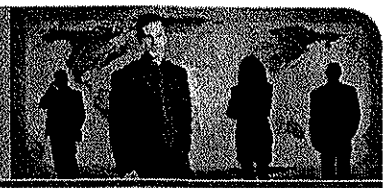


Total Lifecycle Cost

- 20% (Procurement)
- 80% (Operational)

Need to Balance First Cost with Total Cost

Lifecycle Costing



Need to look at each asset and determine:

1. Life expectancy
   - Building Sensors (>10 years)
   - Controllers /HVAC mechanical (10-15 years)
   - PC Hardware /Software (2-4 years)
2. Maintenance Strategy
   - Maintain /service/repair
   - Run to failure /replace
   - Software – upgrade or replace
3. Compare first cost with expected total cost

Key is to make informed decisions with each purchase

Building Systems have a Defined useful lifespan



Average useful life based on regular preventive maintenance properly performed at prescribed frequencies for systems used with typical duty cycles:

Air Handling Units	
Built Up	30
Packaged	25
Rooftop Air Conditioners	15
Hot Water Boilers	
Steel Water-Tube	24
Steel Fire-Tube	25
Cast Iron	35
Electric	15
Steam Boilers	
Steel Water-Tube	28
Steel Fire-Tube	25
Cast Iron	30

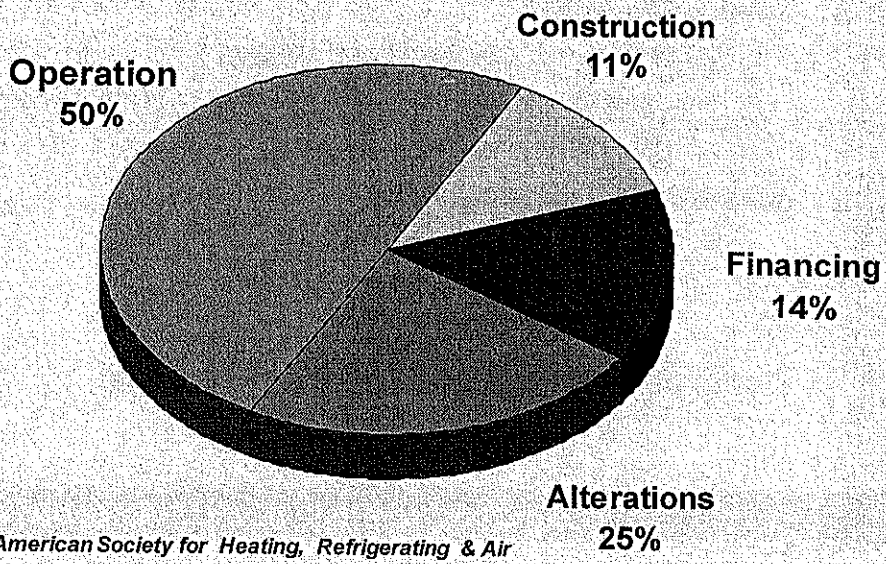
Source: Building Owners and Managers Association International 1996

Installation and specification quality can also impact equipment lifecycle

40 year life cycle cost of a building



"Untapped money"

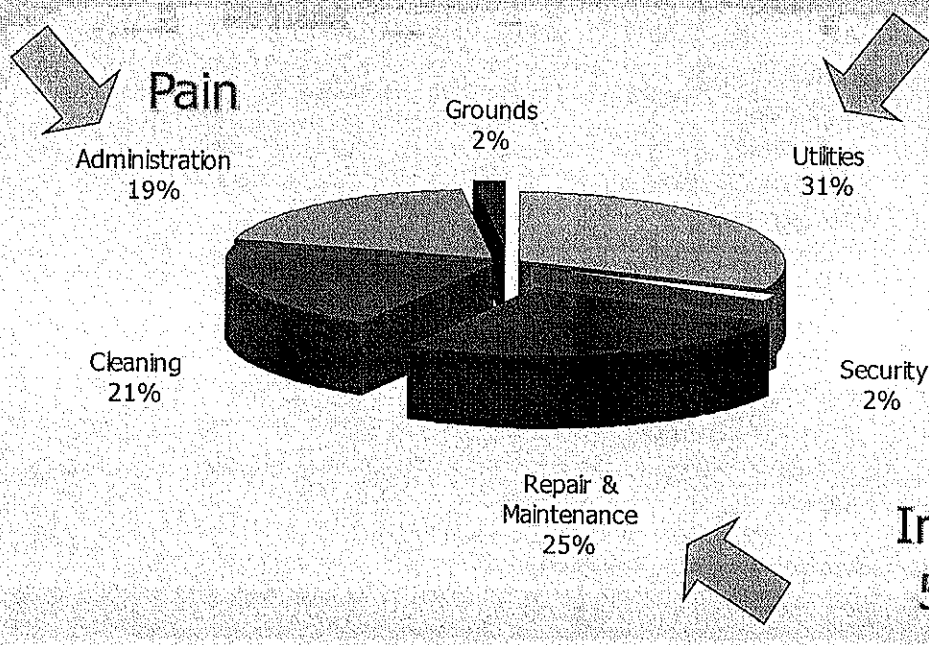


Source : ASHRAE– American Society for Heating, Refrigerating & Air Conditioning Engineers

Discovery of operating costs

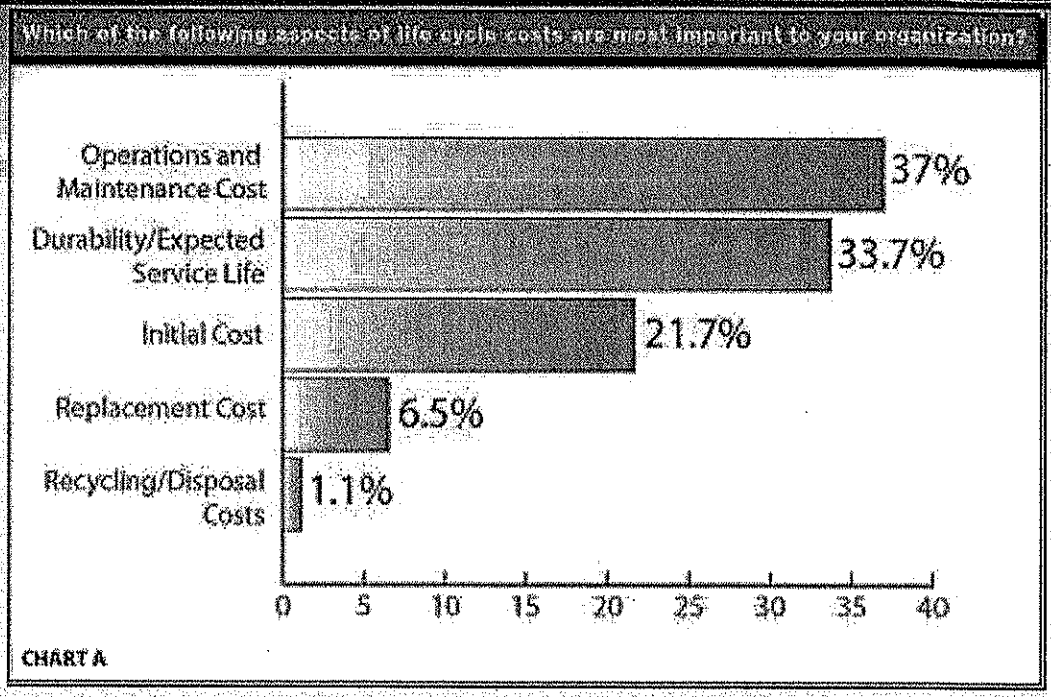


•Example Cost of Operations



What's your priority?

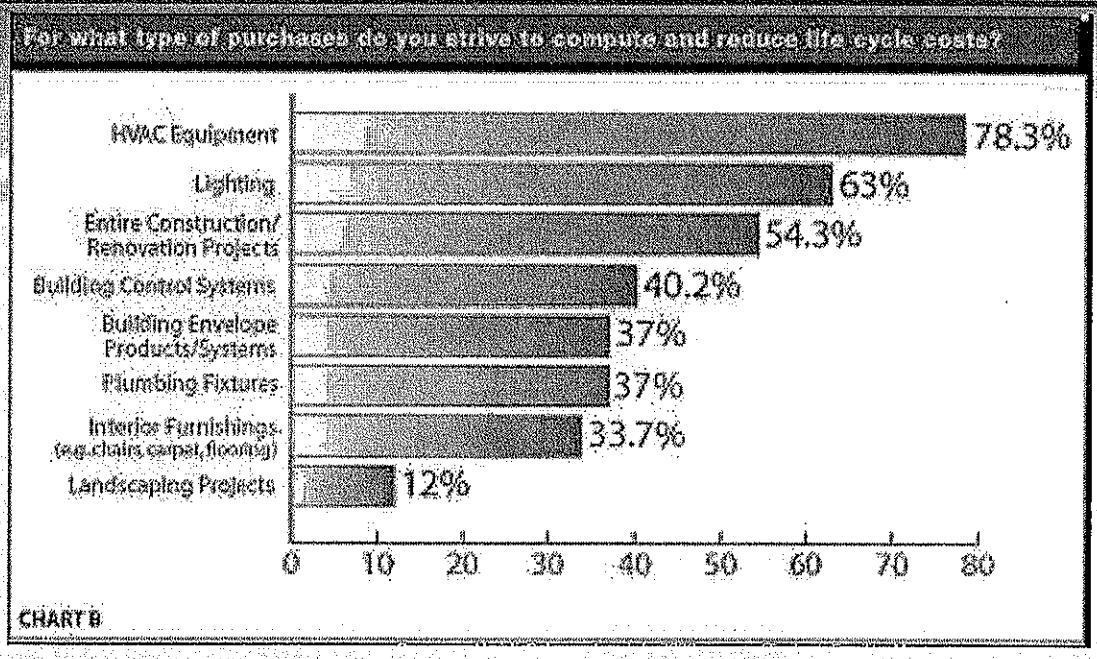




Metropolitan Green Design and Technology

Which one to start with?





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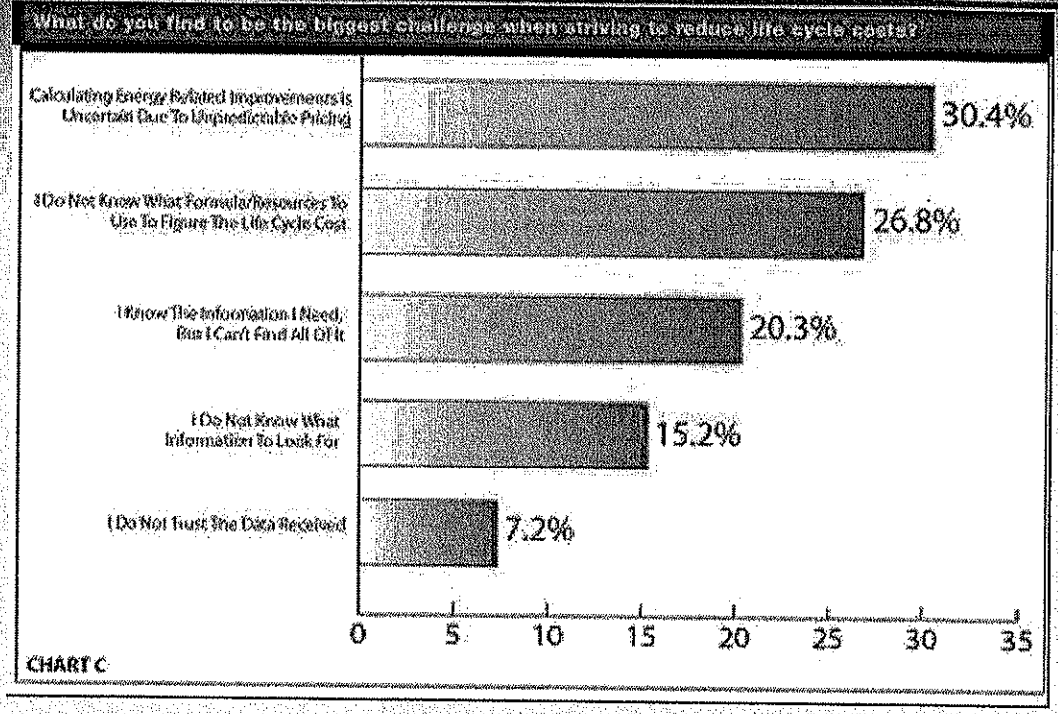
Biggest challenges

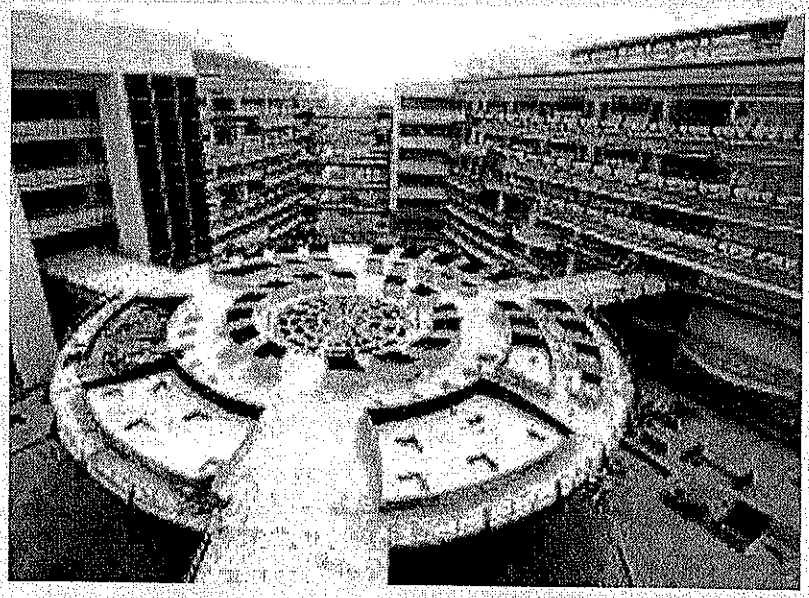




Real life case study



Institutional project



Project Outline

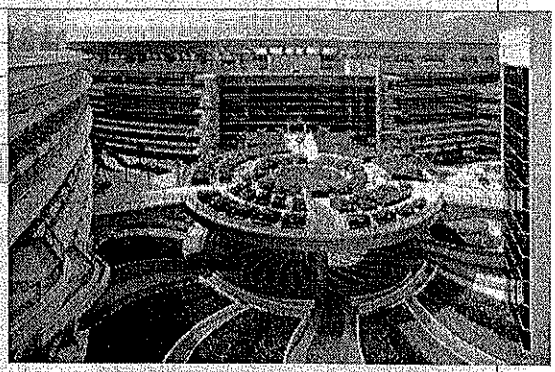


Project Name	**ITE College East**
Location	Simei Avenue / Upper Changi Road, Singapore
Consultants	
Client:	Institute of Technical Education
Architect:	RSP Architects Planners & Engineers (Pte) Ltd
C&S Engineer:	RSP Architects Planners & Engineers (Pte) Ltd
M&E Engineer:	Squire Mech Pte Ltd
QS:	Davis Langdon & Seah Singapore (Pte) Ltd
Interior Design:	RSP Architects Planners & Engineers (Pte) Ltd
Landscape:	Sitetectonix Pte Ltd

Building Outline

- RC/PCa Structure,
- LG+6 storey,
- CFA=**182,500m²**

- Admin Block (Admin Office, Auditorium, Cafeteria),
- Technology Block (Lab, Workshop)
- Business Block (Lecture Rooms, Sports Hall),
- External Facilities (Running Track, Swimming Pool)



Contract:	Lump Sum	**Contract Amount:**	S$191,380,000
Building Type:	Institution	**Contract Period:**	28/11/2002 – 28/7/2004

Case study of LCM design concept in an institutional project



The design philosophy for M & E services are to achieve the following:-

- Economical first capital cost
- Low operating cost
- Ease to operate
- Easy to maintenance
- Durable machine life span
- **Low life cycle cost**
- Control of energy usage so that equipment only operate only on need to use basis

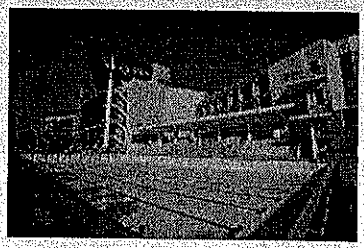
Lifecycle considerations

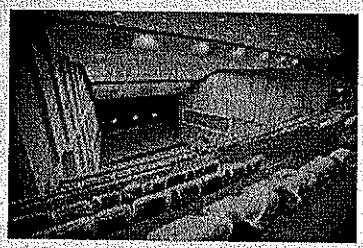


- **Selection of Materials (sustainable building)**Selection of materials of doors etc., Needs to be reviewed due to high levels of vandalism and abuse cases. Selection of glass door usage should be minimized to guard against vandalism

- **Buildability**
  Precast concrete components and prefabication to reduce construction cycle and improve maintenance

- **Acoustic Control in each room**
  Selection of green star rated electrical components that are energy saving. Future proofing the network and data infrastructure. To consider higher level of sound proofing required for each room





Lifecycle perspectives from active and passive strategies



Active strategies with energy efficiency and shorter payback considerations

- ❑ Primary variable flow system recommended for energy saving
- ❑ Sizing of Chiller Plant to meet future changes and operation of the College
- ❑ Use of primary / secondary air system (pre-cooled AHU to treat latent load and AHU to treat sensible load)
- ❑ Use of Variable Air Volume System for Multi-zone system
- ❑ Different control modes for AHU operation according to usage of the Multi-purpose Hall and Function Hall

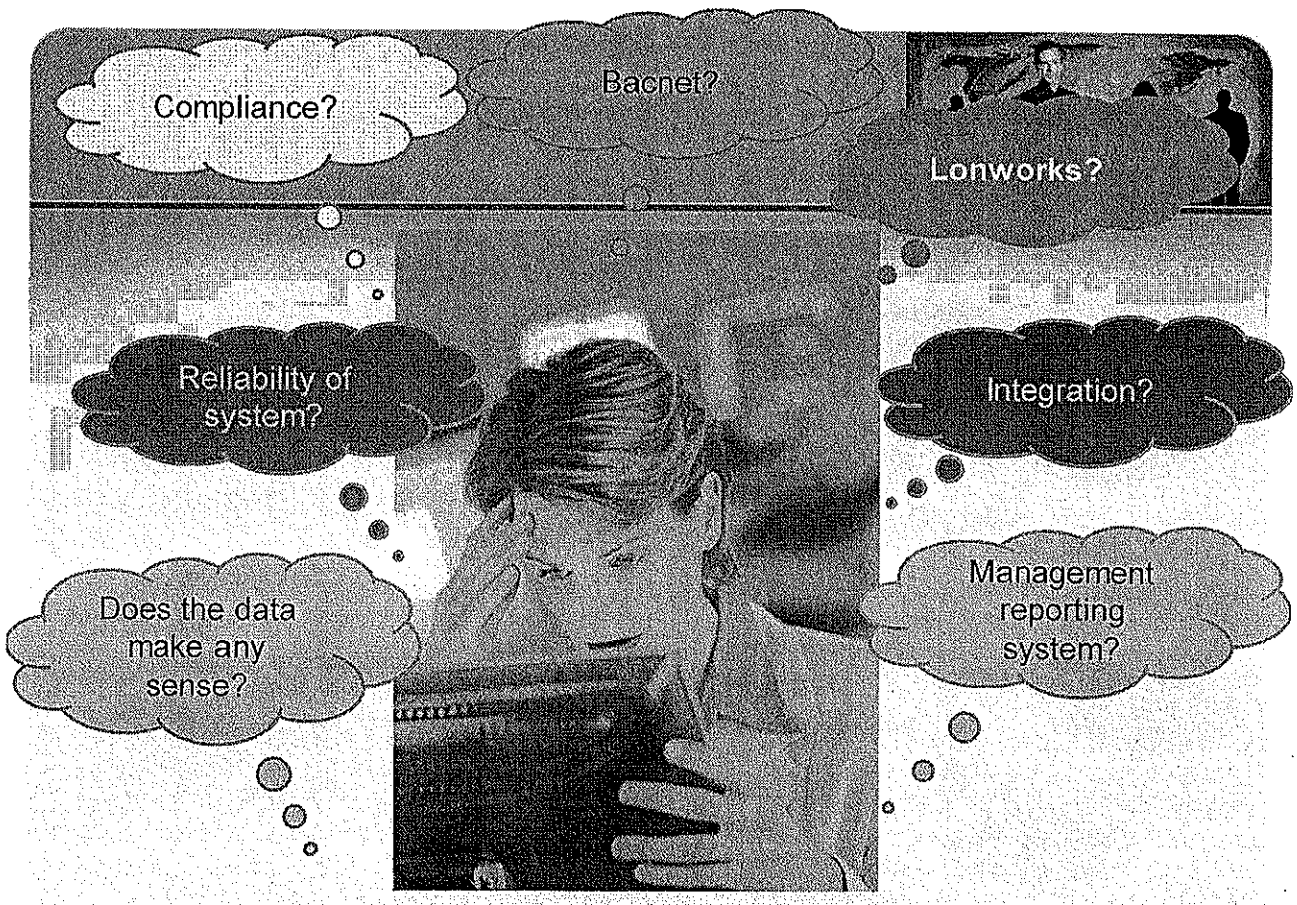
Passive strategies to reduce energy consumption

- ❑ Use of more double glazing and low E-glass for all facades instead of only East / West facades is recommended to reduce solar heat gain
- ❑ Use of open ventilation
- ❑ Shading features to reduce solar penetration
- ❑ Daylight harvesting to reduce dependence on artificial lighting

Considerations for Energy efficient and economical design provisions



- Sub-boards with adequate capacity are located in respective load centers for future ease of renovation
- Local switch control for lighting in offices
- Local consolidation panels for data points are provided in the labs and training rooms for ease of expansion
- Common areas lighting are controlled by BMS time signals
- Motion detectors are used to on/off the light fittings in toilets
- Energy efficient fluorescent lamps are used for functional areas

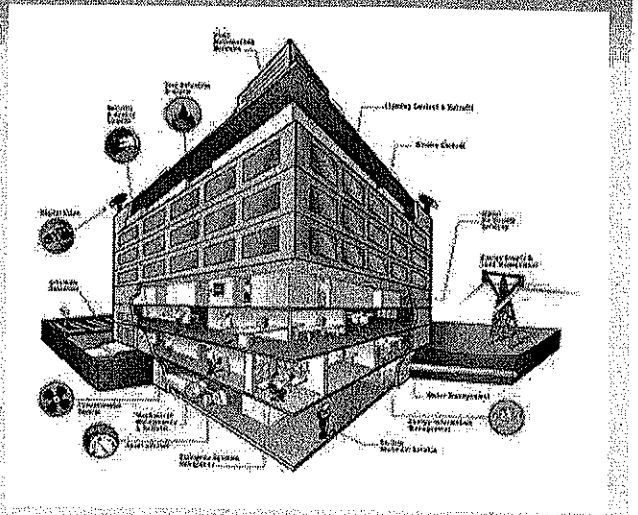


Technology - The Enabler for lifecycle management?



Why have building systems?

- Your customers needs
- Compliance issues
- A pro-active business need
- Protecting people/assets/intellectual property
- To manage your risk
- A business imperative - showing that the business is constantly improving

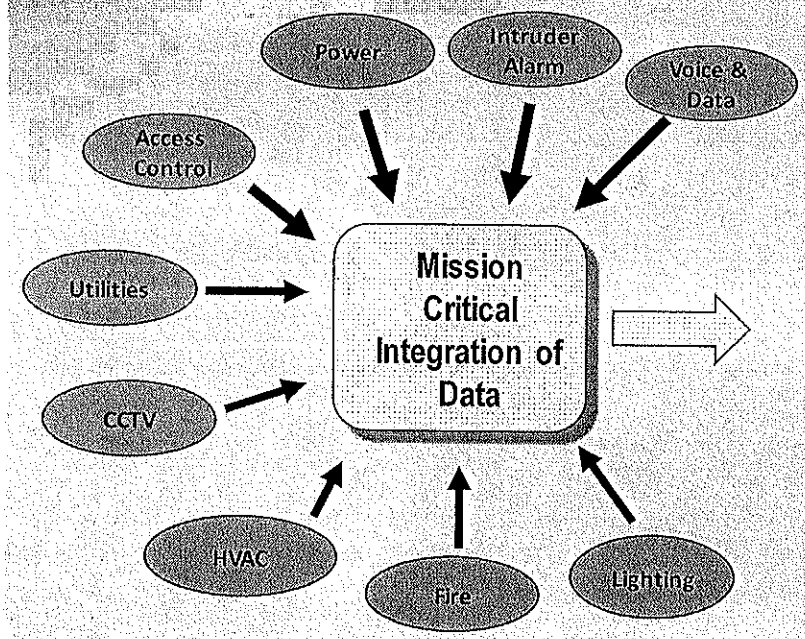


The Dividend Occurs When You Solve A Business Need

Effective Integration ; The Enabler



The more input you get from the performance of the various sub-system, the better your interpretation of lifecycle management



Event Management
- ➲ Alarm response
- ➲ Abnormal situations

Data Mining
- ➲ Predictive analysis
- ➲ Patterns /Trends

Link Human with System Performance
- ➲ Oversight
- ➲ Response times
- ➲ Audit Trail



Predictive lifecycle management of electrical systems using Power quality analysis

- Not just HVAC or Energy audit

Metropolitan Green Design and Technology

Extract from

PROCEEDINGS FROM THE INTERNATIONAL POWER QUALITY CONFERENCE

IPQC 2002

21-25 OCTOBER 2002
SUNTEC SINGAPORE INTERNATIONAL CONVENTION & EXHIBITION CENTRE



Metropolitan Green Design and Technology

An early warning predictive technology ....

On-Line Power Quality Monitoring Of A Commercial Building In Singapore



Prepared by :

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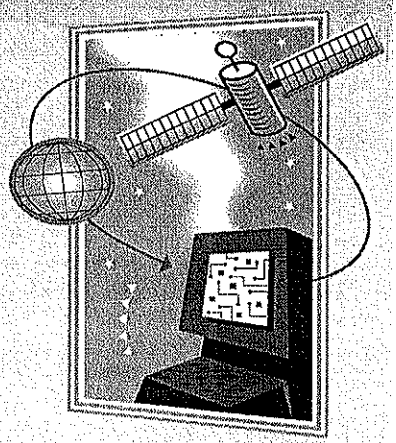
24 October 2002

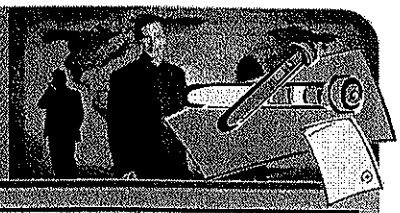
OBJECTIVES FOR PQ



- **Contractual fulfilment**
  - based on performance values as contractual defined
- **Corrective maintenance**
  - to mitigate against potential malfunctions
- **Optimising operational parameters**
  - to apply effective correction of processes
  - to identify energy management strategies



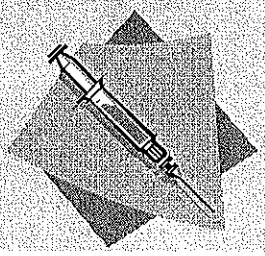
DIAGNOSTICS TOOL

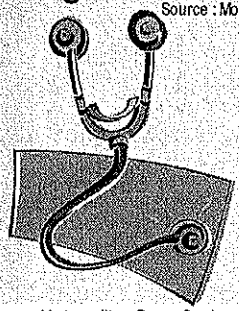


- **Performance benchmarking**
  - **"Blood test sample"**
  - **Detection of symptoms – harmonic distortion, voltage dips, interruptions, overvoltages, anomalies, etc**
- **Predictive maintenance**
  - **PQ critical and integral tool**
  - **Cost-effective PQ monitoring equipment and software**

RELIABILITY	EXPECTED DISRUPTIONS PER YEAR	SATISFACTORY FOR
99.9%	9 HOURS	HOMES
99.99%	59 MINUTES	FACTORIES
99.999%	5 MINUTES	HOSPITAL AIRPORTS
99.9999%	32 SECONDS	BANKS
99.99999%	30 MILLISECONDS	ON-LINE MARKETPLACES

Source : Monitoring power for the future, Afroz K. Khan, Power Engineering Journal April 2001





SITE CHARACTERISTICS OF CASE STUDY



- Class "A" high rise building with a built-in area of about 120,000m2
- Tenants type : high-profile financial institutions and multi-national companies
- Approved electrical load for the building : 7,000kW
- Power provision per floor is 200A and emergency supply per floor is 20kVA
- 3 X 1500kVA, 1 X 1,000kVA and 2 X 600kVA standby generators
- Electrical system : 200 Amperes 3 phase Alternating Current (A.C.)
- Average : 60 watts/m2 per floor (exceeds commercial provision of 40 watts/m2)
- Power supply reliability enhanced by the Intelligent Building Management System (IBMS) which can monitor critical power currents and generate alarm messages to appropriate personnel, both on and off site, for immediate attention
- An average 20kVA of power per floor has been set-aside for additional deployment to mission-critical situations

KEY PERFORMANCE INDICATORS (KPI)



1. How to effectively manage the contracted capacity (a unique power supply characteristic in Singapore);

2. Maximise the diagnostics observations derived from the load profile trending of the electrical equipment installed by the landlord and the tenants;

3. How to operate building efficiently and cost-effectively



MONITORING PARAMETERS



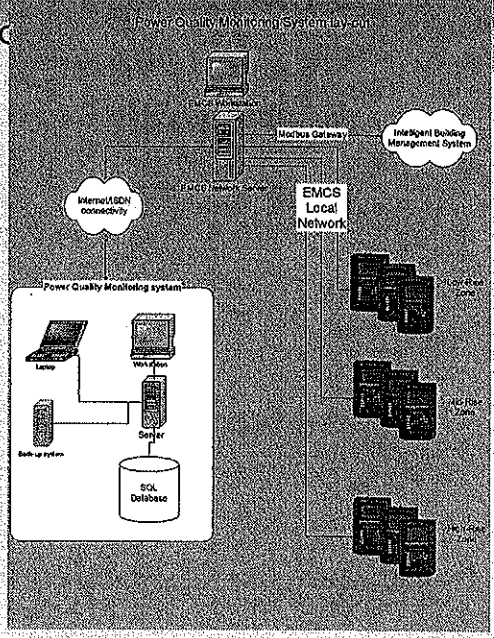
- **The following parameters were continuously monitored by the Electrical Monitoring and Control System (EMCS) :**
  - **Voltage sags and surges**
  - **Voltage and current distortion in percentage (%) Total Harmonic Distortion (THD) or Total Demand Distortion (TDD) of fundamental plus individual harmonic frequencies up to the 50th harmonic (IEEE 519 standard)**
  - **K Factor to indicate the harmonic load versus the non-harmonic loading and the percentage (%) the transformer should be devoted to avoid potential overheating of the transformers**
  - **Neutral current to indicate the level of triplen harmonics in the transformer**
  - **Profiling of power factor, KW and KVA Demand on the system**
  - **Demand load profile**
  - **Voltage and current demand**

MONITORING SYSTEM



- Data was extracted from the following sc

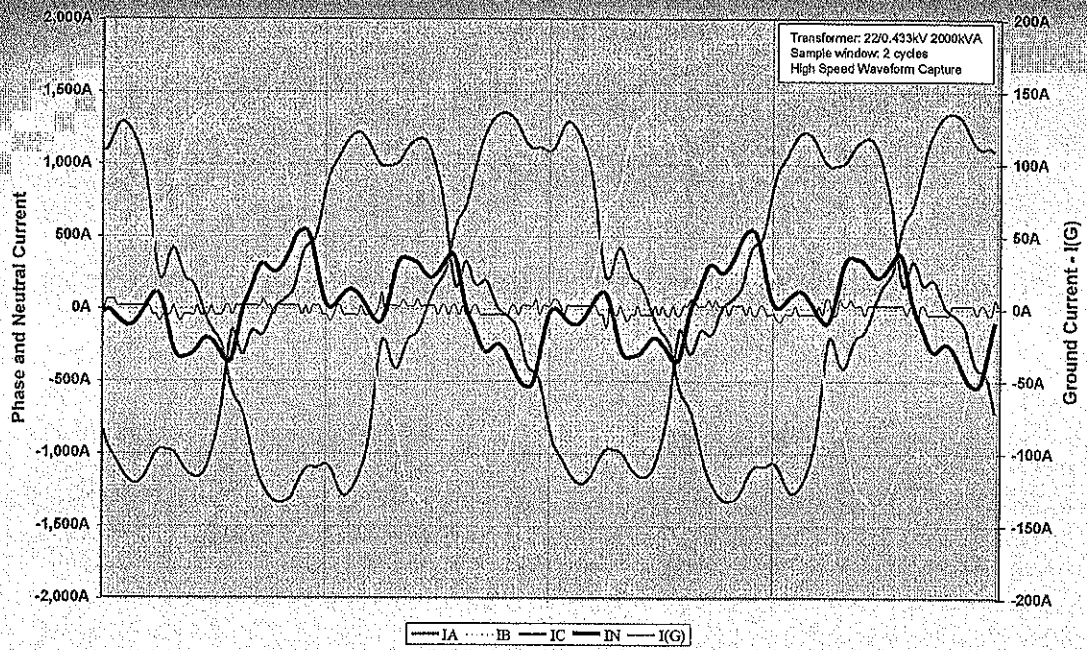
  - 2 numbers 22KV incoming feeders
  - 10 numbers 22KV/433 V transformers
  - All Low Tension (LT) switchboards
  - All sub-switchboards



PQ MONITORING OBSERVATIONS



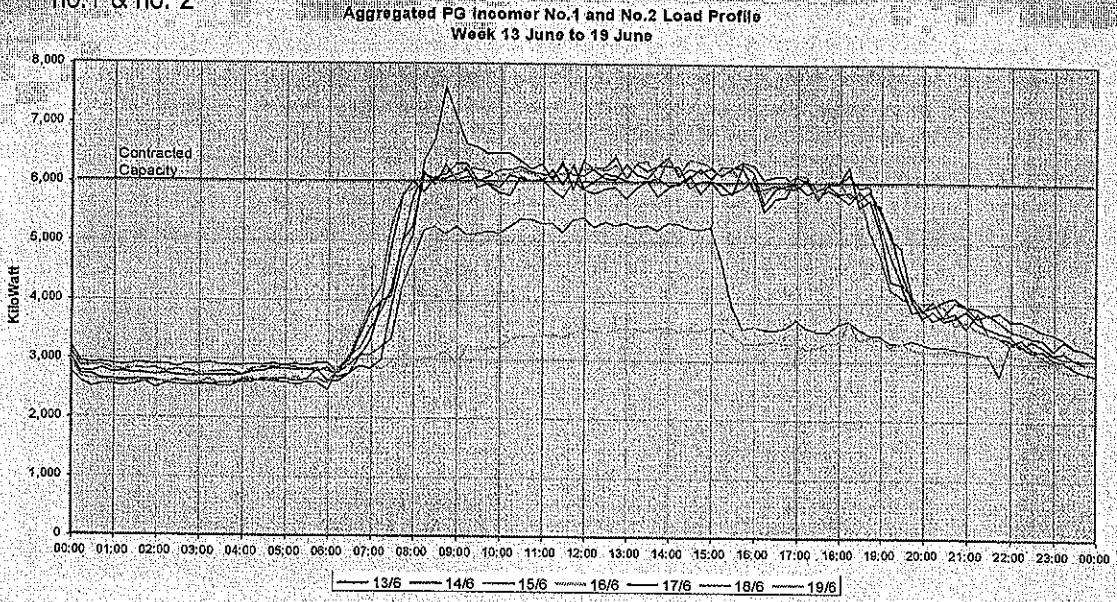
Current Waveform at Incomer no.1



PQ MONITORING OBSERVATIONS



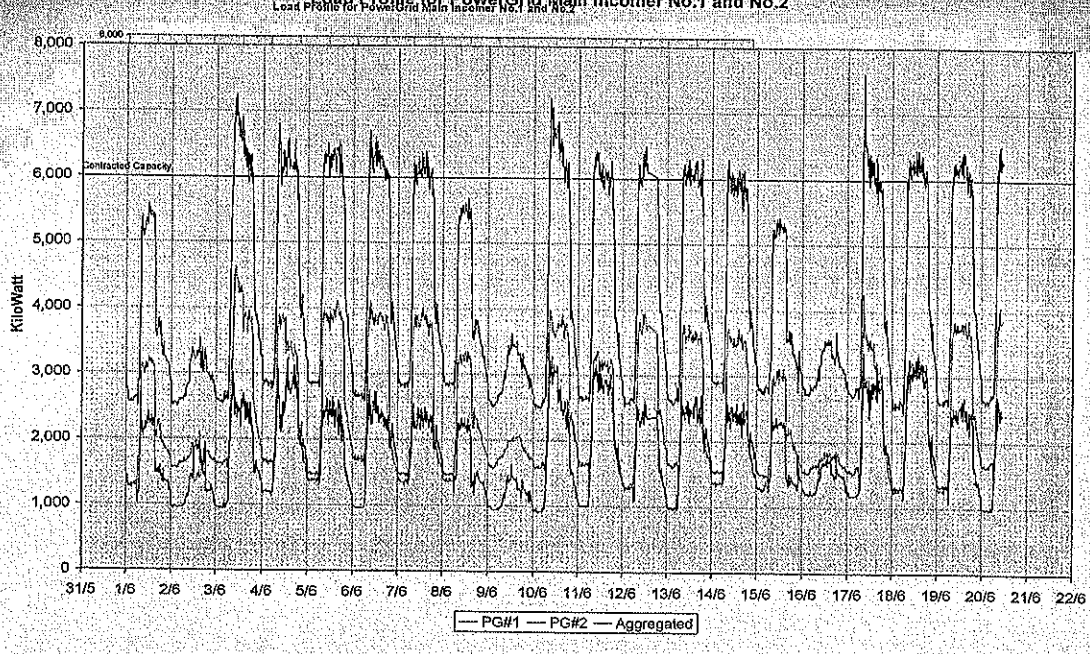
Superimposed daily aggregated load profiles (1 week period) for PowerGrid incomer no.1 & no. 2



PQ MONITORING OBSERVATIONS



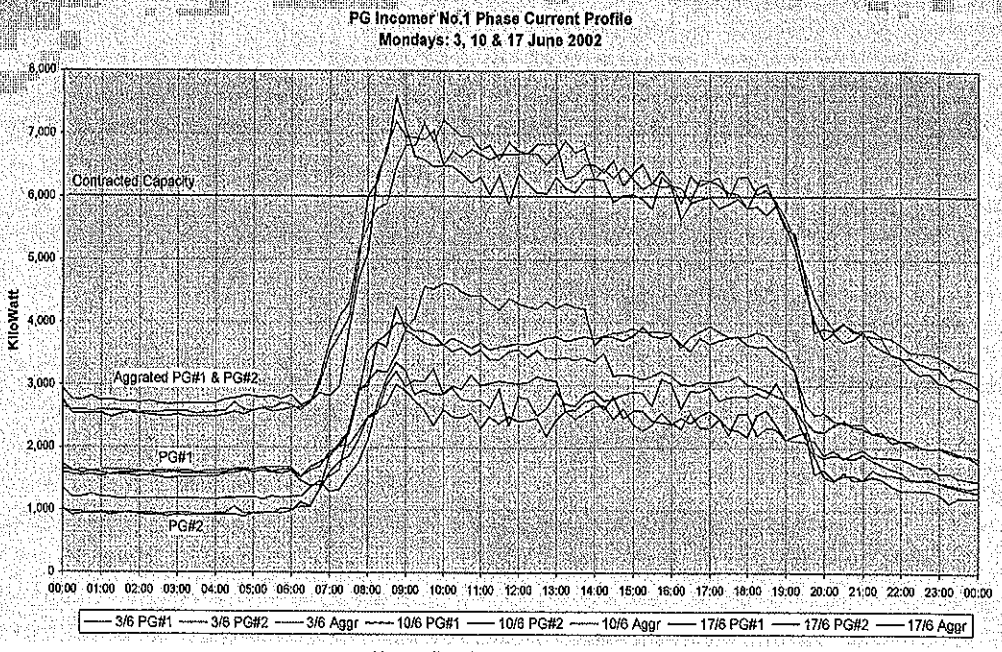
Load profile for PowerGrid main incomer no.1 & No. 2



PQ MONITORING OBSERVATIONS



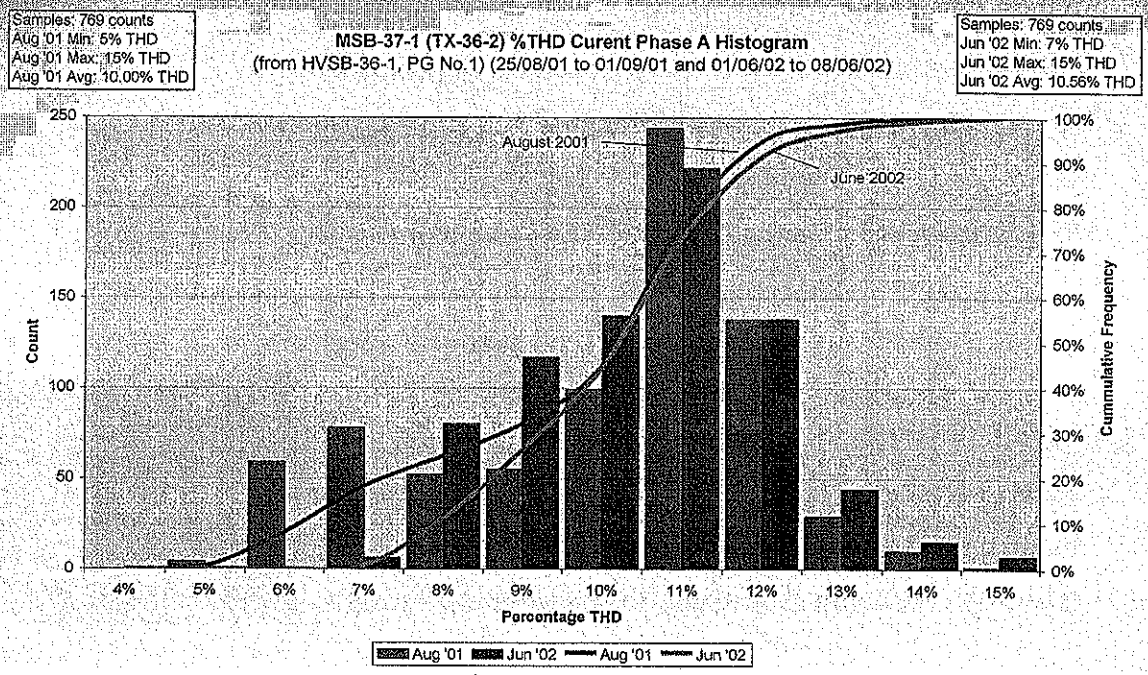
Superimposed load profile of PowerGrid incomer no.1 and no.2 for 3 Mondays



PQ MONITORING OBSERVATIONS



Red-Phase Current %THD Histogram for Tenants switchboard (August 2001 and Jun 2002)



Critical Benchmarking information



Harmonics and inter-harmonics
- Performance curve of each transformer
- Identify which transformers are under stress and at what level
- Predict (based on international standards) when the harmonics would reach a critical level
- Determine whether harmonics level generated into the electrical system (by tenant) is acceptable level or vice-versa

Contracted Capacity
- Characteristic in Singapore for customers with high tension (HT) intake
- Penalty charge if the customer exceeds the contracted demand
- Critical to determine his contracted capacity profile to avoid paying penalty or paying unutilized capacity

Building load balancing
- Potential phase current unbalancing as some distribution boards are higher than others
- Load movements within the building were not always coordinated with the building operator
- Load concentration may develop in specific operational areas of the building where not previously identified
- Loadings occur without regard to the harmonic loading requirements of the source transformer.

BENEFITS OF PQ ANALYSIS



PQ analysis allows early detection by:

- **Listing and explaining the main causes of PQ problems**
- **Detect the sensitivity of electronic equipment to PQ events**
- **Monitor PQ at the source**
- **Predict the performance of electronic equipment**
- **Use circuit analysis techniques to predict PQ levels for specific circuits**
- **Apply a holistic approach to solving power quality problems**

Through PQ analysis, consultants are able to improve:

- **Sags in voltage**
- **Interruptions in supplied voltage**
- **Distortion of supplied voltage due to harmonic currents**





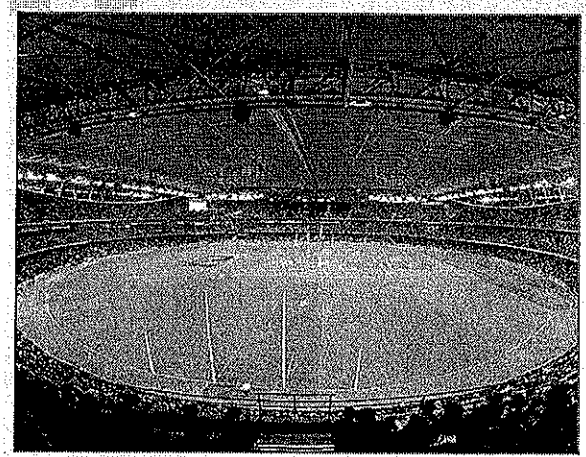
Examples of applied real lifecycle

PPP Example –Telstra Dome



Melbourne, Australia

- ✓ **Major sports stadium**
- ✓ **Movable roof for full enclosure**



Scope - Construction

- **Core technology packages**
  - Air-conditioning controls
  - Building Management
  - Security, Access & CCTV

Scope - Operation

- **Total Asset Management – 25 years**
  - Essential services, building certification & compliance
  - Engineering management
  - Repair & Maintenance of nominated building systems
  - Fault / service response
  - Asset Replacement program
  - Event fault coverage (staff member on event facilities team)
  - Fully comprehensive agreement, "one stop shop"

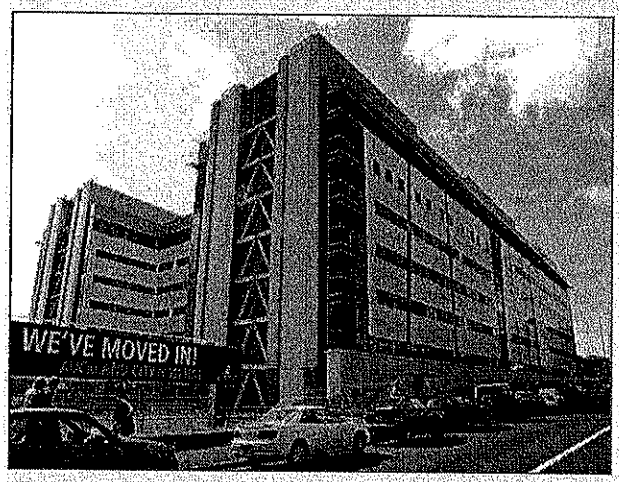
Source : Honeywell Building Solutions

Example –Auckland Hospital



Auckland, NZ

- ✓ 2 major campuses
- ✓ 12 separate buildings
- ✓ New Acute Facility NZ's largest building



Hospital Requirements

- Single system solution
- Manage multiple stakeholders
- Teaming approach
- Manage multiple simultaneous projects
- Hospital Experience

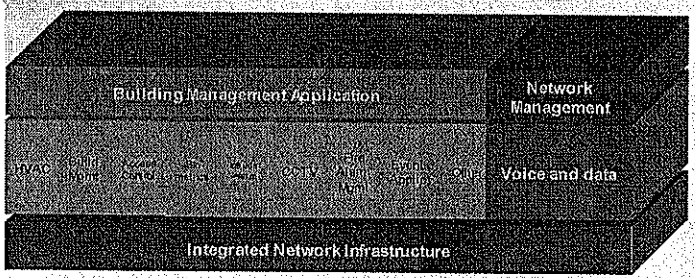
Honeywell Scope

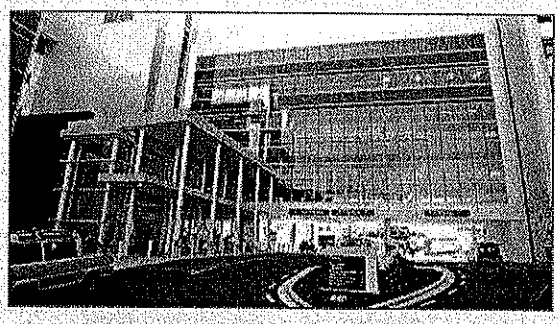
- Integrated building management (EBI)
- HVAC
- CCTV Integration
- Intercoms
- Nurse call
- Access Control
- Emergency Power Integration
- Medical Gas Integration
- Patient wandering /Baby tracking

Source : Honeywell Building Solutions

Example –Auckland Hospital







Effective Integration

- Single system solution across two major sites
- Use of Hospital IT backbone
- IT services /support (eg backups)
- Reduced wiring costs
- Multiple systems integrated into one building management application
  - HVAC, Access, Emerg Power
  - CCTV, Nurse call, Med Gas etc
- Energy reporting and cost centre re-charge
- Standardised training (126 users)
- Single card for both sites
  - buildings
  - carparks



LCC process simplified

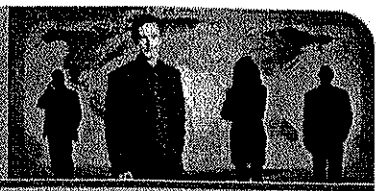
- *Planning*
- *FM strategies*
- *Developing a cost plan*



Lifecycle planning considerations

- Review building requirements and schedule of bill of quantities
- Identifying which assets should be classified as lifecycle assets
- Identify which life cycle assets has material effect on operations
- Preparing the Annual Life Cycle Programme and Five Years Life Cycle Programme on the life cycle assets identifies (with regards to Good Industry practice and any manufacturers instructions and recommendations)
- Identify usual life expectancy and optimise life expectancy and the level of routine maintenance and repair that would be required
- Identify the replacement cost at the end of each of the assets life expectancies

Develop output specifications ; Facilities Management strategies



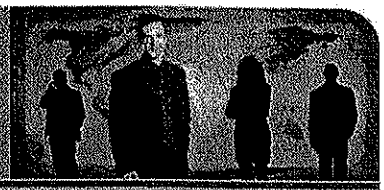
- Develop the operations and management parameters
- Determine service levels and KPIs
- Ensure technical compliance including health, safety & environmental parameters
- Quality control procedures
- Monitoring and inspection process including sustainability, operations and maintenance

Development of cost plan



- Prepare an estimated (budget) operations cost model and casflow for the facilities including
- Development of a detailed and flexible cast database
- Establishment of an operations cash flow model and budgets to be integrated within the project financial models
- Assume major cost items
- Optimise life cycle programme
- Develop the financial model for the building(s)

WHAT GOES INTO LCC?



Planning process involves the following considerations;

- Define the problem requiring LCC
- Prepare cost breakdown structure/tree
- Choose analytical cost model
- Gather cost estimates and cost models
- Make cost profiles for each year of study
- Make break-even charts for alternatives
- Pareto charts of vital few cost contributors
- Sensitivity analysis of high costs and reasons
- Study risks of high cost items and occurences
- Select preferred course of action using LCC
- Alternatives and acquisition/sustaining costs

Setting up your LCM tool



LCM includes every cost that is appropriate and appropriateness changes with each specific case which is tailored to fit the situation. LCC steps;

- **Step 1-Identify what has to be analyzed and the time** period for the project life study along with the appropriate financial criteria.

- **Step 2-Focus on the technical features by way of the** economic consequences to look for alternative solutions.

- **Step 3-Develop the cost details by year considering** memory joggers for cost structures

- **Step 4-Select the appropriate cost model, simple** discrete, simple with some variability for repairs and replacements, complex with random variations, etc. required by project complexity

WHAT GOES INTO LCM?



- **Step 5-Acquire the cost details**
- **Step 6-Assemble the yearly cost profiles**
- **Step 7-For key issues prepare breakeven charts to** simplify the details into time and money.
- **Step 8-Sort the big cost items into a Pareto distribution** to reconsider further study
- **Step 9-Test alternatives for high cost items such as what** happens if maintenance cost is ±10% than planned, etc.



Financial models for lifecycle cost analysis

Financial models for lifecycle cost analysis



- **Net present value (NPV)** is the Sum of initial investment less salvage value, replacements, operations, maintenance and repair over the lifecycle expressed in present value

- **Internal Rate of Return (IRR)** is the Compound rate of interest which when used to discount the lifecycle cost and benefits

- **Return on investment (ROI)**, rate of profit or sometimes just return, is the ratio of money gained or lost (whether realized or unrealized) on an investment relative to the amount of money invested. on investment

Net present value (NPV)



Cost	S$3,000	S$7,000
Net annual cash flow	1,000	2,000
Payback period	3 years	3.5 years
Preferred investment	A!	

NPV = Present value of future cash flows – Net investment

	Advantages	Disadvantages
1	Gives consideration to time value of money	Makes assumptions as to the cost of capital
2	Considers all relevant cash flows	More difficult to calculate needs
3	Commonly used & understood	More difficult to calculate & needs table of discount factors

Internal rate of return (IRR)



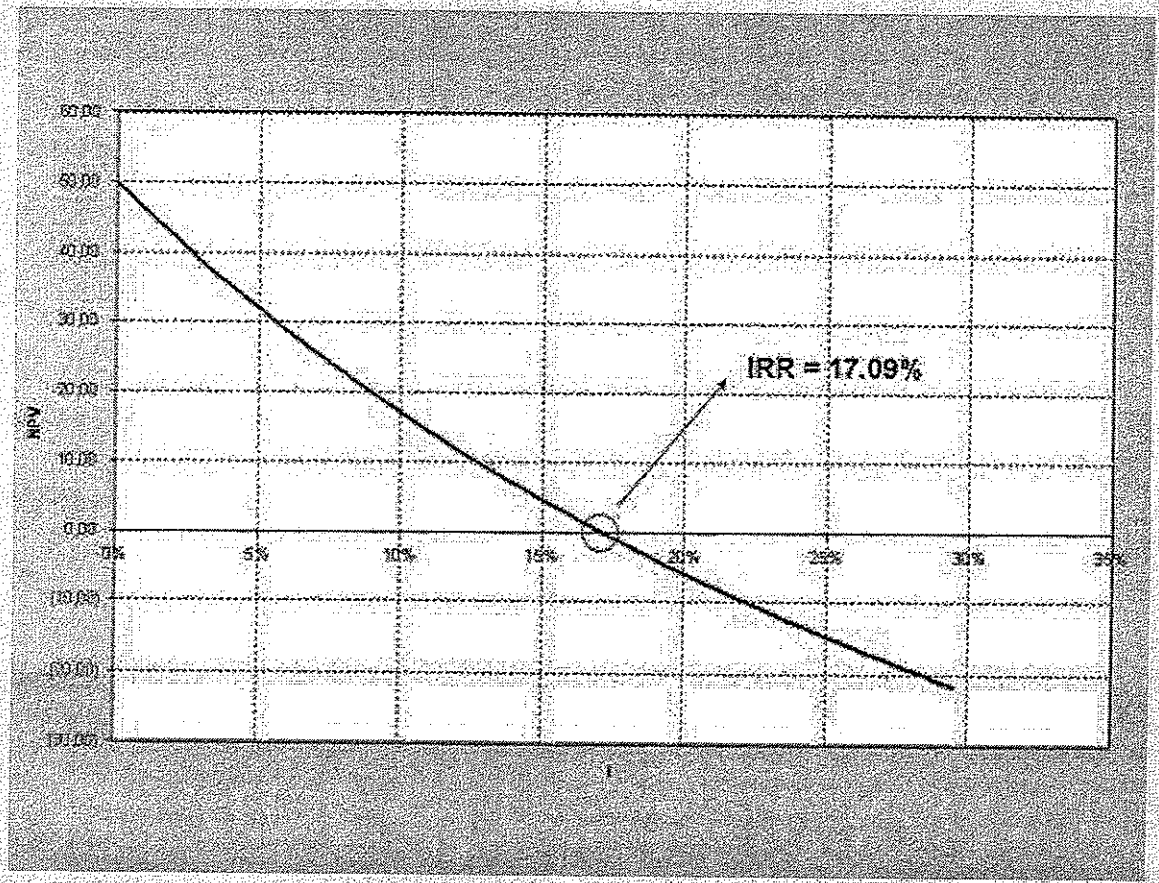
The **internal rate of return** (**IRR**) is a rate of return used in capital budgeting to measure and compare the profitability of investments. It is also called the discounted cash flow rate of return (DCFROR) or simply the rate of return (ROR).[1] In the context of savings and loans the IRR is also called the effective interest rate. The term *internal* refers to the fact that its calculation does not incorporate environmental factors (e.g., the interest rate or inflation).

	Advantages	Disadvantages
1	Gives consideration to time value of money	Difficult to calculate without a good financial calculator
2	Considers all relevant cash flows	Less understood by non-financial managers
3		Assumes that all intermediate cash flows are re-invested at company's IRR

Internal Rate of Return



The internal rate of return on an investment or potential investment is the *annualized effective compounded return rate* that can be earned on the invested capital. In more familiar terms, the IRR of an investment is the interest rate at which the costs of the investment lead to the benefits of the investment.



Return on investment (ROI)



In finance, **rate of return** (**ROR**), also known as **return on investment** (**ROI**), **rate of profit** or sometimes just **return**, is the ratio of money gained or lost (whether realized or unrealized) on an investment relative to the amount of money invested. The amount of money gained or lost may be referred to as interest, profit/loss, gain/loss, or net income/loss. The money invested may be referred to as the asset, capital, principal, or the cost basis of the investment. ROI is usually expressed as a percentage rather than a fraction

E.g
Equipment A costs S$10,000 and will save S$2,500 per year in operating costs. Equipment B costs S$12,000 and saves S$2,000 per year. Which equipment gives the best payback?

Equipment A ROI = S$10,000/S$2,500 = 4.0 years √√
Equipment B ROI = S$12,000/S$2,000 = 6.0 years

Benefit Cost analysis



BCR = Benefit Cost Ratio

$$= \frac{\text{Value of benefits of project}}{\text{Cost of project}}$$

Projects with BCR <1.0 reject

Evaluation criteria
e.g Taking bus versus owning a car
No. of trips made with bus
No. of trips via car
Walking time quantified into time and S$$
Time saved quantified into S$$$
Loads carried via bus and car quantified into S$$$

Data sources for lifecycle costing



A system
- set of rules and procedures for the LCC technique
- Based on assumptions/presuppositions

Hard Data
- info from specialist manufacturers, suppliers, contractors
- Data from model building
- Historical data – software system

Professional skill and judgment

Forecasting strategies



Need to review ;

- Personnel
- Utilities
- Breakdown maintenance
- Preventive maintenance
- Repair projects
- Alteration projects
- Furniture

Costs & values



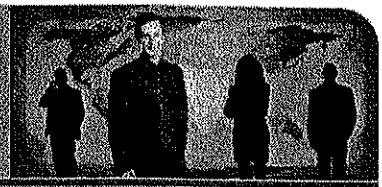
- Capital expenditure (CAPEX)
- Financing costs
- Operating expenditure (OPEX)
- Annual & intermittent maintenance costs
- Replacement and alteration costs
- Residual values & disposal costs

Typical data required



S/N	PROGRAMME	FORECASTING METHOD
1	Personnel	Extrapolate the addition/increment of manpower in each category. Multiply by average salary plus benefits
2	Utilities	Extrapolate historical usage based on square footage. Get metered readings for accurate estimates from retailers
3	Breakdown maintenance	Can be extrapolated in straight line manner plus incremental/decremental value if asset is to be acquired or released
4	Preventive maintenance	Driven mainly by labour cost. Determine crew size and multiply by annual rate per craft and add material costs
5	Repair projects	Obtain estimate and keep 15 – 25% contingency for emergencies
6	Alteration project	Estimate budget based on number of staff to be moved or square footage to be altered. Add 25 to 33% for contingency
7	Furniture (non-capital)	Get vendors to help forecast. Extrapolate from historical data

Typical data required



S/N	PROGRAMME COST	DATA TO ACQUIRE
1	Personnel cost	Cost by category Benefits cost Personnel positions
2	Utilities	Utility rates by type Days Usage data by type
3	Maintenance cost	Cost per square foot or by staff - preventive maintenance - custodial Shop costs Unit cost per product - annual cost Annual cost of repair projects
4	Space	Amount by location/facility - owned - leased Leasing rate
5	Alteration projects	Number of projects Unit cost by location/facility - per square feet - per linear foot - per employee

Typical data required



S/N	PROGRAMME COST	DATA TO ACQUIRE
6	Furniture	Items purchased by type Prices
7	Grounds	Unit rate per square foot
8	Roads	Amount by category Unit cost by category - Repair - Maintenance
9	Building works	Amount by category - Unit rate per category - Repair - Maintenance

Example



- Lifecycle costing from a hospital project in the Middle East

Example – Capital Replacement



Capital Replacement Schedule			
Item	Cost (To be quoted separately)	Supplier projected life	Supplier replacement %
Heading			
Item 1: Building Management Systems	NA	3 years	100%
Item 2 : Building Management Systems - Software	NA	3 years	100%
Item 3 : Building Management Systems - PCs	NA	3 years	100%
Item 4 : Security systems - card readers	NA	10 years	100%
Item 5 : Security systems - cameras	NA	10 years	100%
Item 6 : Security systems - Monitors	NA	10 years	100%
Item 7 : Security systems - Controllers	NA	10 years	100%

Hospital case study

Fabric replacement

Hospital lifecycle

Lifecycle components



S/N	DESCRIPTION	PERIODIC MAINT ANNUAL COST				LIFE CYCLE MANAGEMENT			
		QTY	FREQ PER YR	RATES	COST	QTY	FREQ PER 25YR	RATES	COST
	GENERAL WARD								
1	Building Fabrics	26							
	Wall touch up painting	26	3	$ 500.00	$ 39,000.00	26	5	$ 25,000.00	$ 3,250,000.00
	Wall panel repair	26	3	$ 500.00	$ 39,000.00	26			$ -
	Cubicle Screen	680	0.1	$ 400.00	$ 27,200.00	680			$ -
	Curtain Track	680	0	$ 1,800.00	$ -	680	3	$ 1,800.00	$ 3,672,000.00
	Sanitary fittings	208	0	$ 3,000.00	$ -	208	3	$ 3,000.00	$ 1,872,000.00
	Sewerage main stack	52	0.05	$ 3,500.00	$ 9,100.00	52	2.5	$ 6,800.00	$ 884,000.00
	Vertical Blinds	1352	0.2	$ 1,500.00	$ 405,600.00	1352	6	$ 1,500.00	$ 12,168,000.00
	Kitchen & Treatment Cabinets	26	0		$ -	26	2.5	$ 5,000.00	$ 325,000.00
	Wall & Floor Tiles include waterproofing	26	0		$ -	26	2	$ 120,000.00	$ 6,240,000.00
2	Laboratory	4							
	Wall touch up painting	4	1	$ 350.00	$ 1,400.00	4	4.5	$ 50,000.00	$ 900,000.00
	Wall panel repair	4	0.2	$ 200.00	$ 160.00	12	1	$ 200.00	$ 2,400.00
	Sanitary fittings	2	0	$ 3,000.00	$ -	2	3	$ 3,000.00	$ 18,000.00
	Sewerage main stack	0	0	$ 1,800.00	$ -	0	0	$ 1,800.00	$ -
	Sewer line to IC	26	0		$ -	26	0		$ -
	Vertical Blinds	40	0.05	$ 1,500.00	$ 3,000.00	40	5	$ 1,500.00	$ 300,000.00
	Kitchen & Treatment Cabinets	30	0	$ 25,000.00	$ -	30	2	$ 25,000.00	$ 1,500,000.00
3	CSSD								
	Wall touch up painting	1	1	$ 800.00	$ 800.00	4	4.5	$ 100,000.00	$ 1,800,000.00
	Wall panel repair	1	0.2	$ 200.00	$ 40.00	12	1	$ 200.00	$ 2,400.00
	Sanitary fittings	2	0	$ 3,000.00	$ -	2	3	$ 3,000.00	$ 18,000.00
	Sewerage main stack	0	0	$ 1,800.00	$ -	0	0	$ 1,800.00	$ -
	Sewer line to IC	26	0		$ -	26	0		$ -
	Vertical Blinds	50	0.05	$ 2,000.00	$ 5,000.00	50	5	$ 2,000.00	$ 500,000.00
	Stainless steel Cabinets	15	0	$ 15,000.00	$ -	30	2	$ 15,000.00	$ 900,000.00
	Kitchen & Treatment Cabinets	5	0	$ 3,000.00	$ -	5	2	$ 3,000.00	$ 30,000.00



HOSPITAL EQUIPMENT COSTING

S/N	DESCRIPTION	PERIODIC MAINT REPLACEMENT				LIFE CYCLE MANAGEMENT			
		QTY	FREQ PER YR	RATES	COST	QTY	FREQ PER 25YR	RATES	COST
	GENERAL WARDS								
1	Bedpan sanitizer / washer	26				26	2	$ 8,000.00	$ 416,000.00
	- rubber gasket for cover	26	1	600	15600				
	- solenoid valve for discharge	26	1	350	9100				
	- 'O' - rings	26	4	35	3640				
	- thermistor	26	1	150	3900				
	- thermostat control	26	0.5	250	3250				
	- mimic panel	26	0.5	600	7800				
	- penumatic press	26	0.2	250	1300				
	- penumatic valves	26	0.2	250	1300				
	- heating element	26	0.5	1500	19500				
2	Treatment room sterilizer	26				26	5	$ 3,500.00	$ 455,000.00
	- rubber gasket for cover	26	1	350	9100				
	- heating element	26	0.5	400	5200				
	- timer	26	0.2	150	780				
	- thermistor	26	0.2	150	780				
	- thermostat control	26	0.2	150	780				
3	Defiberator	52				52	5	$ 4,500.00	$ 1,170,000.00
	- rubber gasket for cover	52	1	350	18200				
	- timer	52	0.3	400	6240				
	- penumatic valves	52	0.5	150	3900				
	- 'O' - rings	52	2	150	15600				
	- weighing m/c calibration								
4	SECA weighing machine digital	26				26	6	$ 1,800.00	$ 280,800.00
	- weighing m/c calibration	26	1	100	2600				
	- power unit	26	0.5	280	3640				
	- digital display unit	26	0.5	400	5200				
	- CPU	26	0.5	600	7800				