GREEN BUILDING
PLATINUM SERIES

Building and Construction Authority

existing building retrofit

existing building retrofit

[Disclaimer]

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[Foreword]

Existing buildings form the main bulk of the building stock, and they are a significant consumer of energy. To meet the target set by the Inter-Ministerial Committee on Sustainable Development (IMCSD) of greening at least 80% of Singapore's buildings by 2030, special attention needs to be paid on retrofitting strategies for buildings.

It was also with the existing building stock in mind that BCA formulated the 2nd Green Building Masterplan. Many of the initiatives are targeted specially at existing building owners. To jumpstart the greening of existing buildings in the private sector, BCA has also introduced a bold new scheme – the S$ 100 million Green Mark Incentive Scheme for Existing Buildings.

Undertaking a green retrofit of a building brings about both tangible and intangible benefits to the owner and tenants. It can reduce the energy consumption, utilities and water consumption. It also improves the building's indoor environment quality and reduces the negative impacts of buildings on occupants, especially work-environment related illnesses or **'sick building' s**yndrome.

Together with our partner Arup Singapore, BCA has produced this 'Existing Building Retrofit' guide. This guidebook provides useful information on a green approach to retrofitting existing buildings using a simple six step program. It is a handy tool for building owners, facility managers and consultants, giving step by step guidance from building evaluation, target-setting, to selection of suitable retrofitting initiatives and finally, the implementation stage.

We have gone past the point where going 'green' is an option. It has now become an absolute necessity. We hope, through this Guidebook, to inspire all stakeholders in the industry to make a concerted effort to improve the performance of our buildings in every sense and ensure a better built environment for our future.

Dr John Keung

Chief Executive Officer
Building and Construction Authority

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INTRODUCTION

Buildings are an integral part of a city's heritage, skyline and distinct character. Although seen by many as a valuable asset, they also consume significant energy, resources and investment. Maintenance, new technologies and occupancy changes also need to be continually dealt with. Upgrading existing buildings not only helps to preserve the character of a place, it is an optimal solution for owners, tenants, the community and the environment.

In Singapore, the situation has been to demolish and rebuild buildings, in some cases after only 10 to 15 years. This pattern is simply not sustainable for the future as it requires huge amounts of resources that are becoming increasingly rare, thereby wasting a large amount of embodied energy. In the future, buildings are going to need to last 50 years and beyond.

Additionally, uncertain economic times and increasing environmental awareness and standards make maintaining and upgrading existing buildings a key priority for owners and occupiers. Inaction means that buildings will only fall further behind in efficiency, amenity, and resource use; their competitiveness will decline and tenants will most likely look elsewhere.

So…how can building owners improve the quality – and the performance – of their buildings so that they remain commercially viable into the future? First, of course, they must decide which is the more sustainable option for their specific cases: to refurbish, or to demolish and rebuild? If the answer is to refurbish, and it most often is, then the next decision is: what level of refurbishment would be appropriate? And, what do you need to know before you start?

This guide sets out a strategy to help buildings survive in a complex and demanding world: a strategy that turns a tired asset into a more competitive, more sustainable and more efficient one. Simply and clearly, this guide takes you through a six-step process that results in making your survival strategy happen: from raising the issues facing owners and occupiers, to helping define the goals and targets for a property and to assess a property's current condition, to evaluating a wide ranging list of initiatives to upgrade your property and to finally making it happen.

There is a solution that can work within your business and operational constraints, that can benefit all parties involved as well as the environment.

A selection of local and international case studies will demonstrate some of the outcomes from a range of strategies and interventions. The wealth of information and reference material are included to guide more in-depth study and assessment.

[The Right Time to Act is...]

BEFORE...

- A significant gap emerges between the rents being achieved in your property and those in the same class or location.
- Your building loses a major tenant or multiple tenants and there are prolonged periods of vacancy (in other words, when attracting new tenants becomes difficult).
- A major tenant's lease renewal is approaching – refurbishment could offer an incentive to stay.
- Major plant is due for refurbishment.

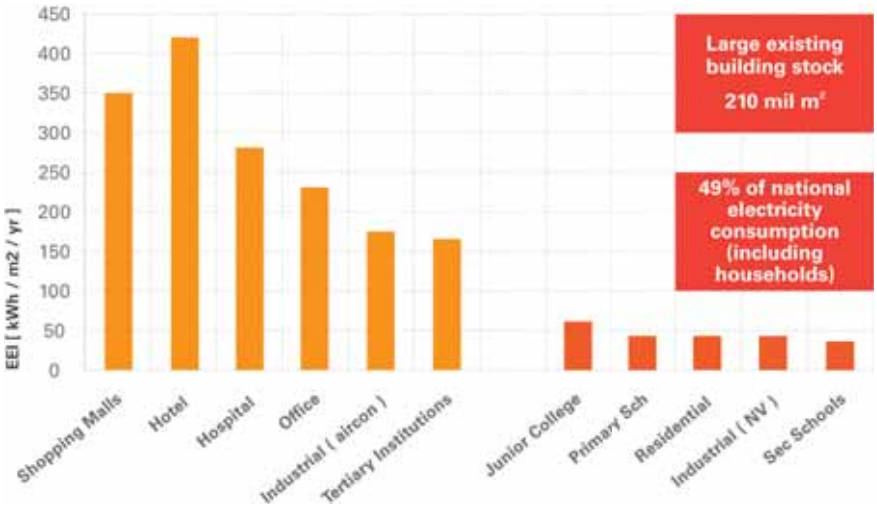
OR WHEN...

- You want to add value to your property portfolio.
- You want to attract international or local companies with strong corporate sustainability policies.
- You want to differentiate your building portfolio from the competition.
- You have just bought an undervalued building.
- You have to comply with recent or upcoming legislation.
- You want to reinforce and strengthen your brand and reputation.
- You want to improve your corporate and social responsibility.
- You want to adapt your building portfolio to the challenges that climate change will pose.

[Sustainability is Here to Stay]

The vast majority of the world's governments accept the need to reduce greenhouse gas (GHG) emissions and consumption of the world's non-renewable resources. Companies and organisations throughout Singapore are strengthening their commitment to sustainability and in turn, are starting to seek buildings and spaces that reflect their values. This trend is helped by a growing awareness that a well-designed and well-operated building can contribute towards staff comfort, health, and productivity while minimising GHG emissions and saving significant amounts of energy, water and other resources. As a result of this growing awareness, before signing a lease, companies are increasingly insisting that a building achieves a minimum environmental performance rating.

In Singapore, buildings consume about 31% of electricity and including households, that number jumps to 49% of all electricity. Furthermore, existing buildings are the overwhelming percentage of the building stock, and therefore, are the key to improving overall sustainability and efficiency. In any given year, the amount of new building construction as a percentage of all buildings in Singapore is very small, typically less than 5%: addressing only new construction simply won't do it.



Existing building stock, Singapore

Recognising this situation, the Building and Construction Authority (BCA) has developed Green Mark for Existing Buildings to encourage continued efficiency and savings over the life of a building. Similarly, the BCA's 2nd Green Building Masterplan for Singapore includes a strong focus on energy efficiency in existing buildings.

[Why Sustainability?]

Aside from energy efficiency, many other significant sustainability improvements can be made in existing buildings. In terms of resource use, significant reductions in potable water use and waste reduction via recycling programs are typically easily achieved. Also, sustainable purchasing policies, procurement, and ongoing operations & maintenance procedures can improve a property's performance.

Moreover, there are other 'intangible' benefits associated with green buildings that are hard to quantify but are just as important to address. Typically referred to as 'Indoor Environmental Quality (IEQ)', they encompass items like air quality, views, access to natural daylight, thermal and physical comfort, and the ability to control one's environment (i.e. temperature, air flow and lighting). All of which have positive psychological and physical benefits and contribute to happier, healthier occupants and/or employees. Good IEQ has been shown to increase productivity, decrease absenteeism due to sickness and improve morale, among other benefits. Simply put, good IEQ has economic benefits in the same manner as energy or water efficiency.

While the focus of sustainability has been primarily on green issues, changing economic climates remind us that sustainability also has an economic component: how businesses can survive and flourish. A well designed and well operated building will have enhanced value, demand and lower operating costs. The need to build, operate and maintain our buildings in a more sustainable way will only increase as energy costs rise, potable water and material resources become increasingly scarce and the impact of legislation increases. Increased sustainability is simply here to stay.

[Incentive Schemes for Existing Buildings]

In recognising the importance of upgrading existing buildings, several incentive schemes have been developed to aid property owners. A selection of incentive schemes are discussed below:

NEA – ENERGY EFFICIENCY

The Energy Efficiency Improvement Assistance Scheme (EASe) is a co-funding scheme administered by the National Environment Agency (NEA) to encourage companies in the manufacturing and building sectors to carry out detailed studies on their energy consumption, also known as energy audits, and identify potential areas for energy efficiency improvement. Eligible companies can receive funding for:

- Up to 50% of the qualifying cost of engaging an expert consultant or Energy Services Company (ESCO) to conduct an energy audit and recommend specific measures that can be implemented to improve energy efficiency. (Over a 5-year period, the maximum amount of funding to any single facility or building is capped at S$ 200,000.)

Refer to the website for more details: ***http://www.e2singapore.gov.sg/ease.html***

PUB – WATER EFFICIENCY

Through PUB's Water Efficiency Fund, companies can receive funding for a variety of water conserving efforts. Companies with water consumption greater than 1,000m³ per month can receive funding for:

- Feasibility Study: up to 50% of the study cost, subject to a cap of S$ 50,000.

- Conducting a Water Audit: up to 50% of the audit cost, subject to a cap of S$ 5,000.

- Recycling Efforts / Use of Alternative Source of Water:
  a. Fund the company at S$ 0.40 for every m³ of potable water / 0.10 for every m³ of NEWater or industrial water saved over the economic life of the facilities or 7 years, OR
  b. up to 50% of the capital cost of alternative water source facilities, whichever is lower and subject to a cap of S$ 1 million per project.

- Community-wide Water Conservation Campaign & Programmes: up to 50% of the cost of organising, subject to a cap of S$ 2,000 to S$ 5,000.

Refer to the website for more details: ***http://www.pub.gov.sg/wef/Pages/default.aspx***

BCA – GREEN MARK INCENTIVE SCHEME: EXISTING BUILDINGS (GMIS-EB)

CASH INCENTIVE SCHEME

The Green Mark Incentive Scheme for Existing Building was launched on 29 April 2009 by the Building and Construction Authority. It aims to encourage developers and building owners to carry out retrofitting works to improve the energy efficiency of their existing buildings. A cash incentive is provided to co-fund the costs of the energy efficient equipment installed in the course of such retrofitting works.

All private building owners are eligible for the GMIS-EB scheme if their buildings meet the following criteria:-

1 ›› It is an existing non-residential development with gross floor area of at least 2,000m^2;

2 ›› It is equipped with a central air-conditioning plant;

3 ›› It is planning to undergo retrofitting works related to energy efficiency;

4 ›› It achieves the Green Mark Certified rating or higher and also the targeted level of energy savings.

In addition, application for the GMIS-EB scheme must be lodged before the start of the energy-related retrofitting works.

The cash incentive is disbursed in two stages. The first disbursement, which is 50% of the approved grant, is paid out upon completion of the energy improvement retrofits. The final disbursement of the remaining grant is upon Green Mark certification and verification of energy savings achieved.

The approved list of energy efficient equipment includes chillers, variable speed drives, Building Automation System, energy efficient lightings, motion sensors, etc. For a complete updated list, please refer to BCA website at:
http://www.bca.gov.sg/GreenMark/others/GMISEB_AnnexB-ApprovedEquip.pdf

HEALTH CHECK SCHEME

In addition to the co-funding cash incentive, the GMIS-EB also includes a Health Check Scheme. The objective of this scheme is to help building owners to determine the efficiency of their existing air-conditioning plants, via an energy audit.

The audit will be carried out by BCA's appointed term contractor and GMIS-EB will co-fund 50% of this audit cost. Building owners can also engage their own Energy Services Company (ESCO) to carry out the audit and claim 50% subsidy from the Health Check Scheme. However, the subsidy rate will be based on BCA's term contractor's rate.

This scheme is a useful starting point for building owners to determine the performance of air-conditioning plants and also to identify effective energy efficiency solutions.

For more details and updates on the cash incentive and Health Check audit, please refer to BCA's website:
http://www.bca.gov.sg/GreenMark/gmiseb.html

STEP 1

Determine Your Baseline

People Who Can Help:

Facility Manager

Sustainability Consultant

Engineering Consultant

Architect

Energy Manager

Energy Service Company (ESCO)

Services, Structural & Façade Contractor

[Where Do I Start?]

Before jumping in to specific upgrades, the first step towards upgrading an existing property is to understand its current status, or baseline. In order to establish a building's baseline, the owner needs to assess two primary issues: current performance and operations of the building, and how the building is positioned against the current code and regulatory requirements.

[Building Performance and Operations]

ENERGY

Undertake an energy audit to find out which areas of the building are consuming large amounts of energy. Then target these areas for improvement. An energy audit should include electricity, gas use and any other energy source used. Also, be sure to review your energy bills so you can discover any abnormal variation in consumption. As mentioned on pages 10 and 11, there are incentive schemes available to help fund the cost of an energy audit.

WATER

A water audit should be performed to establish the areas of the building that are consuming large amounts of water and thus should be targeted for improvement. This should be done in conjunction with a review of water bills to determine any variation in consumption that may be abnormal. As mentioned on page 10, there are incentive schemes available to help fund the cost of a water audit.

Also, catalogue or review the type of water fittings (i.e. sinks, toilets, urinals and showers) that are installed in order to evaluate their individual water consumption (i.e. flow rates). Some or all of the water fittings may need to be replaced. As of 1 July 2009, all new premises and existing premises undergoing renovation are required to only be installed with water fittings and products (i.e. taps, dual flush Low Capacity Flushing Cisterns (LCFCs), urinals and urinal flush valves) that are labelled with at least one or more ticks under WELS (Water Efficiency Labelling Scheme). Are your water fittings compliant?

WASTE

Undertake a waste audit to find out the total amount of waste the building generates and also how much of this is being recycled and how much is sent to incineration and landfill. This knowledge will help you find opportunities to increase recycling efforts and reduce the amount of waste sent to incineration and landfill.

CONDITION AUDIT

A condition audit is intended to determine the current condition and expected remaining economic life of a building's components. It is a vehicle for producing a complete inventory of a building (including equipment) that identifies deficiencies. Typical areas to be examined will include the structure, external walls and roof, mechanical, electrical and IT systems, hazardous materials (asbestos, lead, etc), security and a review of safety issues.

INDOOR ENVIRONMENTAL QUALITY

Many existing buildings have a poor indoor environmental and/or air quality (IEQ/IAQ). IEQ encompasses thermal comfort, air quality, lighting levels and noise levels. Audit each of these to find out how they currently perform and where improvements can be made.

OCCUPANT SATISFACTION

Occupant surveys are highly effective as a way to judge the current performance

of a building. After all, the occupants are the people who spend the most time in the building. An occupant survey will highlight any day-to-day building performance that falls below tenants' expectations and can also highlight thermal comfort, noise, glare, transport and other operational issues.

To be effective, the audit has to be carried out in a highly structured manner so that the results can allow comparison with a well-established, benchmarked database of criteria.

FACILITIES MANAGEMENT

Facilities management (FM) providers contribute significantly to the success of an organisation. Ineffective providers can lead to occupant dissatisfaction and premature failure of major building systems. Conduct a review of the facilities management of the building including:

- Management process used in the property.
- Maintenance schedules and Operations & Maintenance manuals (O&M).
- Building Management System: Is it correctly calibrated? Is it being used correctly?

Did you know?

A building can actually make you sick. Poor IEQ is considered to be the main cause of Sick Building Syndrome.

[How Does My Building Compare?]

NEA / NUS ENERGY SMART BUILDING LABELLING PROGRAMME

You can find benchmarks for energy efficiency and indoor environmental quality (i.e. air quality, thermal comfort, ventilation and lighting level) on the NEA website ***(www.esu.com.sg/research2.html)***. These benchmarks will help you determine the current level of performance and can also help you set a target for reduction.

Refer to NEA Energy Smart Labelling Programme:

- *Technical Guide Towards Energy Smart Office*
- *Technical Guide Towards Energy Smart Hotel*
- *Technical Guide Towards Energy Smart Retail Mall*

[What's Changed?]

Depending on the age of the building, Singapore Codes of Practice and other regulations may have changed or new ones enacted since the building was first constructed. Another key to determining your baseline is therefore to establish what, if anything, may be non-compliant with current code or other statutory requirements.

FIRE SAFETY & EGRESS

In Singapore, fire code regulations and associated standards are reviewed and revised regularly (usually every 5 years) by the Fire Code Review Committee. Accordingly, existing buildings, especially older ones, often are no longer compliant with the latest requirements. Therefore, upgrading work may require additional works to address any non-compliance which can range from small (i.e. adding fire extinguishers) to large scale (i.e. adding stairs or sprinkler systems) interventions.

Depending on the extent of the upgrade, it may be that only the new works to an existing building need to comply with the current Fire Code, while if it is a major upgrade, the upgrading work may require the whole building to be brought up to current regulations. Understanding the level of undertaking needed to meet current fire and safety regulations is a key first step since it may involve extensive works and could define certain design constraints for the building.

Refer to:

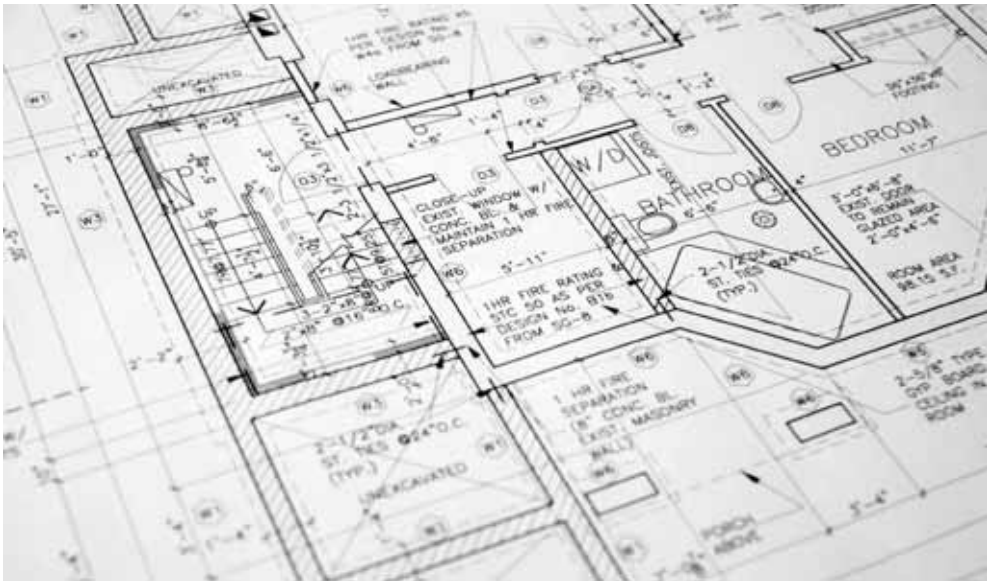
- *Fire Safety and Shelter Department (FSSD): Code of Practice for Fire Precautions in Buildings*

ACCESSIBILITY

Accessibility requirements for disabled persons have been in effect since 2002 in Singapore. Many buildings built prior to 2002 may not be compliant with the current accessibility requirements and may require additional ramps, lifts, guardrails, toilets or other changes to the current building. A building review should be conducted to assess what upgrades would be required for any retrofitting work since extensive works could potentially be required and could define certain design constraints for the building.

Refer to:

- *BCA: Code on Barrier-Free Accessibility in Buildings*
- *BCA: Code on Accessibility in the Built Environment*



AVAILABILITY OF GFA (GROSS FLOOR AREA)

Another key issue to assess is whether the allowable GFA on the particular site has increased since the building was first constructed. Zoning and density are often changed over time to allow for smart growth and to address socioeconomic trends. If more GFA is available, adding to an existing building could be explored in coordination with upgrading works. In some cases, if allowable GFA has increased significantly, there could even be a business case to tear down and rebuild.

Refer to:

- *Urban Redevelopment Authority (URA): Handbook on Gross Floor Area (GFA)*

CASE STUDY // Institutional

NATIONAL LIBRARY BUILDING
VICTORIA STREET, SINGAPORE

- Existing 58,800m² building
- Two (2), 16 storey blocks linked by 'sky bridges' at each level
- Green Mark-Existing Buildings Platinum certification

Key Initiatives:

- EEI of 151kWh/m²/year placing them in the top 10th percentile for office buildings in Singapore.
- Efficient Lighting via revised lighting layouts, switching to T5 fluorescent tubes and use of dimming, motion sensors and integrated lighting controls.
- Instituted Energy Management and Review Policy to monitor, set targets and optimise energy use.
- Conducted water audit and utiltised sub-metering to measure usage and meet performance targets.
- Ensured all water fittings meet WELS 'Excellent' rating.
- NEWater and Rainwater harvested to offset potable water use.
- Cooling tower concentration meets 10 cycles.

CASE STUDY // Commercial

Arup Fitzrovial Stage 1(copyright image) Hufton+Crow

ARUP FITROVIA STAGE 1

LONDON, UK

- Commercial office building constructed in the 1970s
- Phase 1 involved consolidating two existing buildings & the addition of a new three-storey block, which was linked to the existing buildings by an atrium.

Key Initiatives:

- A triple skin façade was implemented to improve the internal environmental quality (IEQ) of the office space.
- Due to the restricted floor to floor heights within the existing building (3.1m), it was not possible to conceal the mechanical air ducts within the ceiling void. The existing floor slab could also not be modified to accommodate the ducts due to its construction.
- To overcome this constraint, the air ducts were brought outside the building, and installed within the buffer zone of the triple skin façade. Supply ducts were run vertically down the building from the roof plant before being dispersed horizontally into a raised floor system.
- Data and air supply were coordinated into a new raised floor to minimise depth of floor and maximise amenity.

STEP 2

Review Your Maintenance, Purchasing* and Energy Procurement

People Who Can Help:

Facility Manager

Sustainability Consultant

Engineering Consultant

Energy Manager

ESCO

[Do You Know What's Going On?]

A maintenance and purchasing review doesn't cost much, but can lead to significant performance improvements. Published guides and technical manuals by the Chartered Institute of Building Services Engineers (CIBSE) and the Building Services Research and Information Association (BSRIA) from the United Kingdom can give you first hand information on how this can be achieved, including case studies of pre-refurbishment checks to show how others have successfully carried out these checks for a start. The outcomes include maintenance procedure changes and repairs to building fabric, controls, ventilation, refrigeration, lighting, hot water, and motors and drives.

Surprisingly significant improvements can be made with minimal cost through purchasing review, energy procurement, improved maintenance regimes and re-commissioning building services. Re-commissioning services are recommended when long time periods of well intentioned but un-informed tweaking has occurred.

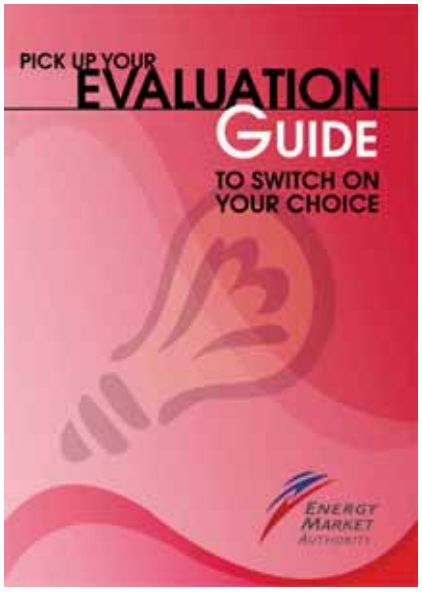
The relevant publications are listed below.

List for referenced CIBSE & BSRIA guides and technical manuals:

- *CIBSE Guide M: Maintenance engineering and management (2008)*
- *CIBSE TM39: Building energy metering (2006)*
- *CIBSE KS02: Managing your building services (2005)*
- *CIBSE KS05: Making buildings work (2005)*
- *CIBSE KS12: Refurbishment for improved energy efficiency (2007)*
- *BSRIA: Business-focused maintenance toolkit (2004)*
- *BSRIA: Operation and maintenance audits (1997)*

* Purchasing refers to all ongoing consumables, durable goods and goods related to facilities management or systems maintenance. Ongoing consumables refer to items like paper, toner, recyclable goods, cleaning products, paper products and food waste. Durable goods refer to items like office equipment, furniture, computers, monitors, printers, scanners, appliances, etc.

[Energy Procurement – Are You Getting Value for Money?]



With the transformation and liberalisation of the energy marketplace in Singapore, a majority of building / property owners now take the opportunity to switch suppliers to save money.

If you are an electricity consumer with a maximum power requirement (contracted capacity) of greater than 2 MW, the Energy Market Authority (EMA) classifies this as a 'contestable consumer'. This means that the consumer is able to choose to buy electricity from five electricity retailers apart from Power Supply Ltd. Please refer to EMA's "Pick up your Evaluation Guide to switch on your choice" for details. ***(http://www.ema.gov.sg/media/files/books/evaluation_guide/20071022184430_8128_contestable_consumers.pdf)***

A review of your electricity retailer could instantly save money. This has probably already been covered in most building strategies but have these strategies included an examination of potential technical modifications such as intelligent peak lopping or the reduction of reactive energy charges?

If you are undertaking a significant upgrade in the building's systems resulting in an increase in the required supply capacity you may have to negotiate a new connection contract with the incumbent utility or electricity retailer. Be sure to understand your demand requirements, and the impact in terms of the electricity tariffs.

[Purchasing & Facilities Management]

Typically, purchasing and FM activities are undertaken separately with little linkage or communication between the two activities. While this is a reasonable approach, in order to maximise cost savings, the two are most effective when they are coordinated. Smart meters and linking them to Building Monitoring System (BMS) systems make monitoring energy and utility costs much easier. Purchasing software can coordinate appropriate and responsive purchasing of required goods. Developing an integrated, coordinated approach to purchasing & FM can yield significant benefits and efficiency towards the building operations.

STEP 3

Establish Your Targets and Goals

People Who Can Help:

Facility Manager

Sustainability Consultant

Engineering Consultant

Architect

Quantity Surveyor

Project Management Consultant

[Where Do You Want to Go?]

After establishing a baseline and assessing the building's operations, the next step is to focus on where you want the building to go. A great deal of consideration should be given to this process before any building works are contemplated and cost plans prepared.

DEFINE YOUR ORGANISATIONS' GOALS

The first step towards setting your targets is in defining and prioritizing your own organisation's goals and motivation in refurbishing an existing property. Issues to consider include:

- Raising Brand Value
- Raising Building Value
- Lowering Carbon Footprint
- Enhancing Customer Experience
- Enhancing Image and Reputation
- Increasing Overall Sustainability
- Legislative Compliance
- Increasing Productivity
- Increasing Profitability
- Raising Rental Value
- Increasing Tenant Retention

Understanding the goals and aspirations will serve as a driver in developing a specific upgrade plan for a given property. It is important to also make sure these are in line with the target level of performance that is achievable for a particular building.

[How to Develop a Plan]

As soon as possible, involve all the relevant stakeholders. Once these stakeholders have offered their points of view and you have settled on your desired level of upgrade, design a set of key performance indicators and targets. These will help you create a clear framework for the building refurbishment.

THINK ABOUT ANY CONSTRAINT

It is important to think about the constraints imposed by the existing building when considering refurbishment. These constraints may be a result of the design methods used when the building was constructed: the frame (whether steel or concrete); the floor-to-floor height, the column spacing, loading capacities. Other constraints might be neighbouring buildings – or even the attitude of the occupants. Additionally, what code requirements or legislation has changed and what level of upgrade is required for compliance is another key constraint to take into consideration.

These constraints will make a difference to the level of refurbishment that can realistically be expected. But, it is important to think of these constraints as challenges that can be overcome, rather than barriers to improving the performance of your building.

THINK ABOUT YOUR EXPECTATIONS

When it comes to improving the performance of an existing building, your expectations will have to be realistic. For example, a office building currently consuming 250kWh/m^2 annually will likely require substantial refurbishment work in order to achieve Green Mark Platinum rating by cutting energy consumption down to 154kWh/m^2 annually. It is important to note though that behaviour changes in use and operations can also lead to substantial savings with little to no capital investment.

[Use the Rating Tools]

Rating tools can be used to assess the environmental performance of an existing building. There are a number of these on the market in Singapore. Set a target level of achievement against these tools, and use them to track progress along the way.

RATING TOOLS – GREEN MARK

Green Mark for Existing Buildings is a voluntary environmental rating scheme that evaluates the environmental attributes of existing buildings, including energy, water and resource management. It has been developed by the Building and Construction Authority (BCA), specially for non-residential existing buildings.

Green Mark for Existing Buildings rates the environmental attributes of existing non-residential buildings. The tool assesses 5 key areas i.e.:

- energy efficiency,
- water efficiency,
- sustainable operation and management,
- indoor environment quality,
- green innovation / features.

ENERGY LABELLING – ENERGY SMART

Energy Smart (ES) is a voluntary environmental rating system for existing office buildings, developed by the National Environment Agency (NEA). It rates a building by measuring its operational impacts on the environment. ES evaluation for offices includes Energy, Thermal Comfort, Indoor Environment and Illumination.

ES is a government scheme that sets energy and IEQ benchmarks against the average building performance. An ES label is awarded to buildings that fall within the top 25 percentile of buildings surveyed. This tool allows building owners to compare their building's performance with the rest of the existing building stock in the market.

[Information to Help Set Your Targets]

GREEN MARK FOR EXISTING BUILDINGS (GM – EB)

Although Green Mark – EB is voluntary, refurbished existing buildings should set energy efficiency as one of the key priorities and strive for higher Green Mark rating.

It is also important to note that 2 tracks exist for buildings seeking GM-EB:

1 ›› Projects not certified under Green Mark, i.e. buildings new to the Green Mark certification framework.

2 ›› Projects that have been certified under Green Mark and are seeking re-certification after the 3-year validity period.

ENERGY

The Inter-Ministerial Committee on Sustainable Development (IMCSD) has set energy targets to reduce Singapore's energy intensity per dollar GDP by 20% from 2005 levels by the year 2020, and a 35% reduction by 2030. This commitment is laid out in Singapore's Sustainable Development Blueprint.

Typical existing office buildings consume 180-240kWh/m^2 annually. To remain competitive with new buildings and in keeping with Singapore's energy targets, existing buildings should target to achieve the BCA Green Mark Gold^{PLUS} rating or the Energy Smart's top 25 percentile annual consumption of about 177kWh/m^2 for office buildings, 368kWh/m^2 for hotels, and 421kWh/m^2 for retail malls. These targets reflect the actual best practices in energy consumption of a typical building type in Singapore. While it might not be indicative of how efficiently the building is designed but rather how the energy is being consumed, it is nonetheless a useful benchmark that will allow you to know where your building energy performance stands in comparison with similar building types.

In general, a building designed to be more energy efficient will consume less energy. In a typical air-conditioned building, the air-conditioning load constitutes about 40% of the whole building energy consumption. Therefore, the use of energy efficient chiller plant system with an efficiency level below 0.7kW/ton is encouraged.

WATER

Most existing office buildings are fitted with old fixtures that have high flow rates (six litres per flush or three litres per minute for taps). Low-flow fixtures in the PUB Water Efficiency Labelling Scheme (WELS) can easily reduce these figures by half. New buildings are now required to have WELS rated fittings for taps, water closets and urinals.

A WELS water tap rated with 'one tick' saves three litres of water for every three minutes it is running. A 'two ticks' tap saves nine litres, and a 'three ticks' tap saves 12 litres for three minutes of use. Existing buildings need to implement similar water conservation measures or upgrade their fittings to remain competitive.

CASE STUDY // Institutional

NATIONAL INSTITUTE OF EDUCATION

NANYANG WALK, SINGAPORE

- Existing 106,900m^2 campus
- Six (6), 3 to 4 storey blocks
- Green Mark Gold^{PLUS} certification

Key Initiatives:

- Energy savings of 33% & EEI of 105.6kWh/m^2/yr.
- Improved the aircon plant efficiency from 0.8kW/RT to be in line with Energy Smart Label benchmark of 0.75kW/RT or lower. A new efficient small chiller will be installed to address the part load condition.
- Facilities booking via BMS (Building Management System) to control lighting and air-conditioning so they are 'on' only when a specific space is booked.
- Installed variable speed drives (VSD) to chilled and condenser water pumps and AHUs.
- Installed efficient lighting and motion sensors in all corridors and toilets.
- A PUB Water Efficient Building.
- Installed rainwater harvesting system to irrigate the hockey pitch to offset potable water use.

STEP 4

Crunch Time: Refurbish or Demolish?

People Who Can Help:

Building Performance Consultant

Facility Manager

Sustainability Consultant

Engineering Consultant

Architect

Quantity Surveyor

Project Management Consultant

Services, Structural and Façade Contractor

Once you know the condition and performance of your building and have decided on your targets, it is time to decide what degree of refurbishment is needed, or if it would be more practical and sustainable to redevelop the site.

Take a close look at the tables on the next few pages. They will help to assess the performance and condition of your existing building and determine what level of refurbishment you might need to make your building competitive with a new building.

LEVELS OF REFURBISHMENT DEFINED

There are various levels of refurbishment defined by the Building Services Research and Information Association (BSRIA, 1998) and the Building Research Establishment (BRE, 2000). Table 1 summarises these levels.

[Crunch Time]

Tables 2 to 4 will help you to determine the level of refurbishment that will probably be required in order to bring your building up to current new building standards. Remember: these tables are tools to help you make your decisions – they will not make the decision for you. You should compare the level of refurbishment determined here to your targets from Step 3. If it exceeds your targets, then consider a reduced level of refurbishment. Only if the building falls into the 'Very Poor' category in several areas, should you think about redeveloping the site.

A study by the Building Research Establishment (BRE, 2002) has looked at the relative sustainability of refurbishment versus redevelopment. It found that generally, refurbishment solutions are lower both in environmental impact and whole-life costs (over 60 years) than comparative redevelopments. The exception was when significant low-energy features, such as natural ventilation, could not be brought into the existing building - but could be built into a new development. In that case, the environmental impact of redevelopment can be lower than refurbishment, with the whole-life costs more-or-less equal.

HOW TO USE THE TABLES:

1 ›› Using **Table 3**, and the audit data from **Step 1**, rank the overall performance of the building.

2 ›› Using **Table 4**, and the audit data from **Step 1**, rank the overall condition of the building.

3 ›› Using **Table 2**, and the rankings of the overall performance and condition from above, see what level of refurbishment you are likely to need in order to make your building competitive with a new office building.

4 ›› Compare the level of refurbishment determined here to your targets from **Step 2**. Does this match your target? Revise the level if needed and move on to **Step 5**.

Table 1 – Levels of refurbishment

LEVEL OF REFURBISHMENT	EXAMPLES OF DEGREE OF INTERVENTION
Level 1 Tune up and minor refurbishment	Install modern blinds, revise layout to improve daylight and flexibility, repaint interior, low energy IT option on replacement, (i.e. replacing CRT monitors with flat screen monitors) and/or recommissioning of building services.
Level 2 Intermediate refurbishment	All level 1 works, as well as replace lighting and control systems.
Level 3 Major refurbishment	Replacement of major plant and services, floor finishes, raised floors and internal walls. Installation of external solar control.
Level 4 Complete refurbishment	Only substructure, superstructure and floor structure retained. Structural and façade alterations. Possible relocation of cores and risers.
Level 5 Demolition	Consider demolition and rebuild.

Table 2 – Matrix of refurbishment levels to consider for various building states, in order to make your building competitive with a new building

		BUILDING CONDITION			
		EXCELLENT	GOOD	POOR	VERY POOR
BUILDING PERFORMANCE	EXCELLENT	Maintain	Level 1	Level 2	Level 3
	GOOD	Level 1	Level 2	Level 3	Level 3
	POOR	Level 2	Level 3	Level 3	Level 4
	VERY POOR	Level 3	Level 3	Level 4	Level 5

Table 3 – Building performance - Simplified assessment table

PERFORMANCE GRADE	EXCELLENT	GOOD	POOR	VERY POOR
THERMAL COMFORT	± 0.5 PMV†	± 1 PMV	± 2 PMV	> 2 PMV or < - 2 PMV
ENERGY CONSUMPTION (NEA ENERGY SMART BENCHMARK)#	15 percentile	40 percentile	60 percentile	80 percentile
WATER CONSUMPTION (PUB RATING)*	WELS Excellent & Very Good Fittings	WELS Good Fittings	WELS Zero Tick Fittings	Not WELS rated fittings
MECHANICAL SYSTEMS	• 100% planned availability and meeting current functional demands. • No standing alarms, no losses or events. • Fully meets design functionality.	• 95-100% planned availability. • Fit for service for the next 3 years with routine maintenance applied. • Some minor defects.	• 50-95% planned availability. • Near misses. • Defect levels & significance increasing, will not remain fit for service for next three years with only routine maintenance.	• Must be replaced within the next 12 months. • Frequent system trips. • Significant losses and events. • Fails to meet design function. • Many defects affecting functionality.
ELECTRICAL / IT / COMMS SYSTEMS	• 100% availability. • No event reports due to equipment unreliability.	• > 95% availability. • 1 event report in last 6 months.	• > 50% availability. • 1 or 2 events reported in last 6 months.	• < 50% availability. • Causes trip loss of generation. • > 3 event reports in last 6 months.
STAFF SATISFACTION	• Few complaints. • Below average absenteeism.	• Some minor complaints, easily rectifiable. • Average absenteeism.	• Many complaints, difficult to rectify. • Above average absenteeism.	• Tenants leaving / untenanted. • Potential legal action due to poor building performance.
PERCENTAGE OF NET LETTABLE AREA (NLA) WITH 2.5% DAYLIGHT FACTOR	> 60%	30-60%	15-30%	< 15%
FLEXIBLE FLOOR PLATE	• Very flexible. • Multiple exits, no internal columns or obstructions, easily sub leased.	• Flexible. • Multiple exits, minimal internal obstructions.	• Less flexible. • Exit(s) from one end of the space, many internal obstructions, restrictive footprint.	• Inflexible. • Significant internal obstructions, restrictive building footprint.

† Predicted mean vote. A predictive measure of human thermal comfort using the following scale:

+3 (Hot)	0 (Neutral)	-1 (Cool)
+2 (Very warm)		-2 (Cold)
+1 (Warm)		-3 (Very cold)

NEA Energy Smart Building Labelling Programme ***(http://www.esu.com.sg/research2.html)***

* PUB Water Efficiency Labelling Scheme ***(http://www.pub.gov.sg/wels/Pages/default.aspx)***

Table 4 – Building condition - Simplified assessment table

PERFORMANCE GRADE	EXCELLENT	GOOD	POOR	VERY POOR
MECHANICAL SYSTEMS	• High standard of material condition. • System defect free. • Condition monitoring parameters in specification.	• No investment requirements for material condition for at least 3 years.	• Investment required for material condition within 3 years. • Increased consumption of consumables. • Multiple modifications waiting implementation.	• Less than 10% of life remaining on specific equipment or life expired. • Investment required for material condition urgently. • Extremely high consumption of consumables.
ELECTRICAL / IT / COMMS SYSTEMS	• As new > 90% life. • Physically defect free.	• Minor physical defects.	• Requires attention. • Increasing maintenance burden. • Multiple modifications waiting implementation.	• Significant defects. • Potential safety hazard.
BUILDING AND CIVIL	• Sound structure, well maintained in as-new condition requiring only normal routine maintenance. • No deformation or settlement.	• Displays signs of minor wear and tear. • Requires some minor repairs in addition to normal routine maintenance. • No undue deformation or settlement. • No inappropriate modifications to non-critical elements. • Needs to be re-inspected in the medium term.	• Structure stable and functioning but needs careful nursing or investment to maintain in a safe condition. • Deformation of primary members or indications of undue settlement. • Significant design defects, inappropriate modifications to critical elements, serious misuse or impact damage to critical elements.	• Unsafe to use. Requires immediate action to make safe and replacement as soon as practical. • Major design defects, inappropriate modifications, serious misuse or impact damage likely to compromise the safety of the structure.

STEP 5

Select Your Optimal Upgrade Initiatives

People Who Can Help:

Facility Manager

Sustainability Consultant

Engineering Consultant

Architect

Quantity Surveyor

Project Management Consultant

[Top 10 'Quick Win' Initiatives]

These initiatives (listed in no particular order) are easy to achieve yet yield substantial benefits:

1 ›› Set energy and water consumption targets.

2 ›› Modify air-conditioning set points to provide a wider control band and ensure controls are working correctly, within acceptable comfort boundaries.

3 ›› Install vestibules at main entrances to the building(s) to reduce air-conditioning loss.

4 ›› Provide clear light switch labelling and ensure lights are turned off at night (manual or timer controlled) and on weekends.

5 ›› Replace existing lamps with T5 fluorescents.

6 ›› Use low-irritant or non-chemical cleaning products to improve IAQ. In addition, clean all ductwork and replace all air filters.

7 ›› Upgrade to water efficient fittings with the Water Efficiency Labelling and Standards (WELS) rating.

8 ›› Provide sub-metering of electricity and water, and link metering to Building Management System (BMS). Consider installing a BMS if one is not already installed.

9 ›› Rebalance and recommission all plant equipment.

10 ›› Review Operations and Maintenance (O&M) manuals and building user guides to make sure they are up-to-date, or create them if they do not exist. Also, make sure user guides have been distributed to all tenants.

After establishing a baseline, outlining your goals and targets and assessing the building's performance and operations, the next step is to start to identify specific upgrade initiatives.

[How to Use the Initiative Summary]

Over the following pages is a list of numerous initiatives and a qualitative assessment of their benefit in terms of sustainability, as well as to the building owner and occupants. The list also indicates the level of refurbishment required for each initiative and cost estimation ranging from minor works to a major renovation.

[Remember...]

This is not a 'shopping list', and the initiatives offered here need to be tailored and evaluated for your specific building. There is no one solution or approach for any building upgrade; each initiative needs to be assessed based on its merits and the building in question.

- Some initiatives can't be used for all building types.
- Use the resource hierarchy for energy: reduce demand first, maximise efficiency, and then harness free energy (energy recovery and/or renewables) and/or purchasing 'green power' or offsets.
- Use the resource hierarchy for water: reduce demand first and maximise efficiency before installing recycled water systems (i.e. rainwater, grey water or NEWater).
- Consider the system efficiency, not just that of the individual components.
- Some initiatives may not complement each other and an appropriate balance needs to be found, e.g. fresh air intake for IAQ have to be balanced with energy consumption.

KEY TO INITIATIVES CHART		DESCRIPTION OF INITIATIVES TOPICS
Level	Describes the degree of intervention typically required for the initiative.	1 • Tune up / minor refurbishment 2 • Intermediate refurbishment 3 • Major refurbishment 4 • Complete refurbishment
Capital Cost	Qualitative measure of capital cost requirement for the initiative.	Nil • No cost $ • Minor cost financed under maintenance budget $$ • Considerable cost financed under an annual project budget $$$ • Substantial cost financed over a number of years
Sustainability	Qualitative benefit of the initiative with respect to sustainability.	Nil • No benefit  • Minor benefit • Considerable benefit • Substantial benefit
Occupant	Qualitative benefit of the initiative to the occupant, i.e. related to tenancy elements and activities.	Nil • No benefit  • Minor benefit • Considerable benefit • Substantial benefit
Owner	Qualitative benefit of the initiative to the owner, i.e. related to base building elements and activities.	Nil • No benefit  • Minor benefit • Considerable benefit • Substantial benefit

[Initiative Summary]

Energy // ACMV	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Modify setpoints Modifying setpoints to the maximum levels permissible within acceptable thermal comfort boundaries (around 25°C).	1	Nil			
Ensure controls are working correctly Incorrectly set or non-functioning controls can significantly increase energy consumption, and reduce thermal comfort for occupants.	1	$			
Implement comprehensive preventive maintenance program A comprehensive maintenance program ensures that equipment is working as efficiently as possible, as well as extending the life of the product, ensuring cost savings for tenant and owner.	1	$			
Install vestibules at main entrances Installing a vestibule (i.e. set of double doors or revolving door) at main entrances can lead to energy savings by significantly reducing the amount of cold air loss to the outdoor environment.	1	$			
Rebalance and recommission all plant equipment Rebalancing and recommissioning all plant equipment ensures that these systems are running as efficiently as possible, reducing running costs. It is advisable to do this on a yearly basis.	1	$$			
Heat recovery ventilation A heat recovery ventilator transfers heat between the inbound and outgoing air flow in a ventilation system, reducing the cooling requirements of the inbound air.	2	$			
Occupancy sensor / switch controlled air conditioning Occupancy sensor or switch controls ensure that the air conditioning system does not operate unnecessarily, saving on energy cost and reducing greenhouse emissions.	2	$			

Energy // ACMV

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Chilled water temperature reset Reset CHW temperatures higher when conditions permit, thereby improving system efficiency.	2	$			
Check and repair any major ductwork leakage Ductwork leakage increases the amount of energy needed to meet indoor air conditions, as well as reducing indoor air quality.	2	$			
Provide digital control system to monitor and control all major plants Digital control systems can control and modify flow rates, compressors, pumps, fans, valves, etc. A digital system will ensure accurate and efficient use of these systems.	2	$$			
Introduce demand ventilation control Demand control ventilation involves monitoring the amount of carbon dioxide in the air, and varying the ventilation rates proportionally. This means the outside air rates are based on actual occupancy densities and levels rather than assumed occupancy patterns.	2	$$			
Zone existing air conditioning system Zoning existing air conditioning system can improve energy consumption by ensuring that only relevant parts of the office are cooled. This also increases thermal comfort for tenants.	2	$$			
Carpark CO monitoring and control Control air quality in carparks through the use of CO monitors; improve ventilation through ductless fans.	2	$$			
Introduce variable speed pumps and fans Variable speed works by decreasing power to pumps and fans to decrease flow rates to match decreased loads.	2	$$			

Energy // ACMV

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Add ductwork and pipework insulation Insulation reduces the amount of energy lost in transmitting heated or cooled fluids.	3	$$			
Condenser tube cleaning Self-cleaning condenser tube systems reduce the need for periodic maintenance, extend the life of your chiller and maintain chiller efficiency.	3	$$			
Replace existing air conditioning Antiquated systems can be replaced with modern more efficient types to significantly reduce energy consumption and improve thermal comfort.	3	$$$			
Mixed mode ventilation Mixed mode ventilation involves using natural ventilation when ambient conditions are suitable, with the air-conditioning operated only during peak conditions, thereby reducing energy consumption.	3	$$$			
Efficient chiller selection Modern chillers have increased efficiency (typical good whole chiller plant efficiency is ≤ 0.7kW/ton), which can reduce the energy demand of the building.	3	$$$			
Natural ventilation Significant energy savings can be realised if a fully naturally ventilated system is provided.	3	$$$			
Underfloor supply Underfloor supply systems can provide a more energy efficient mean of cooling space.	3	$$$			

Energy // Lighting

	LEVEL	CAPITAL COST	SUSTAINABILITY	OCCUPANT	OWNER
	1 TO 4	NIL TO $$$	NIL TO	NIL TO	NIL TO
Clear light switch labelling Clear light switch labelling is an effective way to reduce energy consumption by ensuring that employees are aware of the switches that control the various lighting zones. This is especially relevant for after-office hours and weekend office use and will reduce operating costs.	1	$			
Luminous glow exit lights Installing luminous glow exit signs provide an equivalent level of safety for occupants in the event of an emergency as standard exit lights, with lower energy usage.	1	$			
Individual light switches for individual enclosed spaces Enclosed spaces can be provided with individual lighting switches to ensure they are not unnecessarily lit, causing excess energy usage. This can be used in conjunction with occupancy sensors.	2	$			
Energy efficient lamps, luminaires, ballasts Significant cost reductions can be achieved by using energy efficient lighting systems, such as T5 fluorescents. This can significantly decrease operating costs, as well as decreasing the internal heat load from lights.	2	$$			
Provide programmable lighting control system Programmable lighting control systems can provide excellent control of lighting system energy consumption and light levels by automating their usage.	2	$$			
Provide layers of lighting Use general lighting for less visually demanding activities and supplement it with task lighting only when the need arises. It saves lighting energy by creating lighting layers specifically for tasks performed.	2	$$			
LED lighting LED lighting provides reduced energy consumption, better lighting properties (reduced flicker), and a longer lifespan, leading to reduced operating costs for occupants.	2	$$			

Energy // Lighting	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Switching / dimming according to available daylight Daylight sensors can be used to dim, or even switch-off lights according to the amount of daylight the zone is receiving, reducing operating and energy costs.	2	$$			
Occupancy sensors for lighting Occupancy sensors can be installed as part of a lighting control system. These can control lighting based on the detection of an occupant, and should be installed as a minimum in intermittently occupied areas such as meeting rooms, toilets and print rooms.	2	$$			
Office lighting zones < 100m² Reducing office lighting zones below 100m² ensures that areas of the office that do not need the same level of lighting are not lit unnecessarily.	2	$$			
Daylight pipes A daylight pipe is a tube used for transmitting daylight to an internal space. These can be used as an alternative to electric lighting, and offer better heat insulation properties than skylights and windows, as well as reduced running costs.	3	$$			
Internal light shelves and tapered ceiling Daylight penetration can be enhanced through the use of internal light shelves and changing the ceiling profile to bounce light further into the space.	3	$$$			
Create an atrium within the building to improve daylight An atrium brings daylight into deep open spaces, reducing the requirement for electric lighting. Atria also provide social space and a different work setting. However, consideration must be given to potential heat gain.	4	$$$			

CASE STUDY // Commercial

500 COLLINS STREET
MELBOURNE, AUSTRALIA

- 30-year old commercial office with net lettable area: 23,870m^2
- 28 storey multi-tenanted office building
- Refurbishment was carried out with tenants in place. Three floors were upgraded at a time while the rest were occupied.

Key Initiatives:

- Active chilled beams were installed around the building perimeter zones, and passive chilled beams used in the interior space.
- Because the chilled beams reduce the need to circulate air around the building for cooling, the extra air handling capacity was used to supply fresh air onto the floors.
- 50% improvement in fresh air rates relative to Australian Standards.
- The system is expected to use 30% less energy than conventional air-con systems, courtesy of a reduced requirement for fan power and less heat rejection from the cooling plant (Carey, 2006).
- The refurbished office provided a 39% reduction in average sick leave days per employee per month (Fordred, 2007).
- No tenants moved out of the building during or after the refurbishment process.

Energy // Electrical

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Electrical sub-metering – lighting, small power, machinery, plant Electrical sub-metering ensures that all tenants are charged only for the energy they use. This will allow the building owner to pass on accurate costs to tenants, and highlight any areas operating inefficiently. It also provides the tenant with financial incentives to reduce energy use.	1	$$			
Time switches or similar on small equipment Time switches ensure that equipment is switched off automatically after a period of time when they are not used, reducing unnecessary energy usage.	2	$			
Occupant controlled master isolation switch An occupant controlled master isolation switch can be used to switch off appliances after hours automatically after all occupants have left.	2	$$			
Upgrade to high efficiency motors High efficiency motors improve the performance of equipment. They also tend to be quieter and cooler than regular motors.	2	$$			
Solar thermal hot water Solar thermal collectors can be installed in hotels, hospitals and other buildings that have high hot water demands to offset electric heater energy consumption.	2	$$$			
Power factor correction Power factor correction units can be installed to keep the power factor of the system as close to 1 as possible; this increases energy efficiency, and reduces operating costs.	2	$$$			
Building Management System (BMS) A computer-based control system that monitors, controls and optimises the mechanical and electrical equipment in the building.	3	$$			
Photovoltaics (PV) PV solar panels can be installed on the roof or incorporated into the façade or shading elements of a building to generate electricity.	3	$$$			

Energy // Building Envelope

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Paint roof with reflective paint Reflective paints or 'cool paints' can be used to reduce the amount of solar heat transmitted to the building.	1	$			
Add solar control film to existing glazing Solar control film can reduce heat gains and UV transmission. This results in cost savings by reducing cooling load and reduction of fading and other side effects due to UV exposure.	1	$			
Improve air tightness to reduce unwanted infiltration Unwanted infiltration can increase the amount of unconditioned air into a space; thereby increasing the cooling requirements. Infiltration can also decrease thermal comfort, and introduce unwanted particulates, such as dust, into the building.	1	$$			
Automatic blinds Automatic blinds can be programmed to close when the level of solar radiation reaches a threshold and to open when conditions become more favourable for daylighting and outside view.	2	$$			
Add jockey sash to existing single glazing to improve insulation value A jockey sash can be installed with an existing single glazed system to improve insulation, without the need to completely remove the framing.	2	$$			
Upgrade wall and roof insulation Upgrading wall and roof insulation can significantly reduce conduction through walls and roofs, with a corresponding decrease in the amount of heating and cooling required.	3	$$			
External light shelves Light shelves can be used to reflect the incoming sunlight upwards to illuminate the ceiling. The reflected light will have little solar heat content, and can reduce the need for indoor lighting. It is also useful for reducing glare.	3	$$			
External solar shading External solar shading can be used to reduce unwanted solar gains to a building.	3	$$			

Energy // Building Envelope	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Reduce window area Reducing the window area decreases the transmitted solar gains, reducing the cooling load on the space.	3	$$			
Upgrade to high performance glazing Upgrading the existing single glazing to high peformance low-e double glazing can reduce cooling load and improve visual and thermal comfort especially for occupants in the perimeter zones.	3	$$$			
Mid pane blinds Mid pane blinds can be installed in the air cavity of double glazed systems. They are particularly effective at reducing solar gain and controlling glare.	3	$$$			

Energy // Fitout

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Internal blinds Internal blinds can be used to reduce the solar gain to a building, decreasing the heat load with corresponding cost savings.	1	$			
Use LCD screens LCD screens use significantly less energy than CRT screens, as well as taking up less space, and emitting no harmful radiation.	1	$			
Use thin client technology Thin client technology is where the client computer is used for input and output to the user, while the actual processing is done on a central server. Thin client technology uses much less energy than traditional systems, as well as decreasing the cooling load within the office space. It can also produce a quieter working environment because the noise from computer fans is removed.	1	$			
Energy efficient appliance selection Selecting energy efficient (NEA's Energy Label or Singapore's Green Label) appliances can reduce energy consumption significantly.	1	$$			

Energy // Business Continuity

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Risers with security access Security access controls limit who can access risers.	2	$			
Gas rather than electricity for central hot water and boilers Gas has lower carbon emissions per MJ of energy used, and is therefore preferable to electric heating.	2	$$			
Dual cabling risers Dual cabling risers ensure redundancy in case of failure in one cable.	3	$			
Solar boosted domestic hot water Solar energy can be used to reduce fossil fuel energy consumption in domestic hot water generation.	3	$$			
Provide standby power to 100% of emergency services Identifies the minimum base building standby power provision required for all essential building systems.	3	$$			
Remove single points of failure with critical systems In critical systems, redundancy should be provided so that in case of a system failure, business operations can continue.	3	$$			
Provide backup cooling system A backup set of chiller, cooling tower or pump should be provided to supply cooling if the default set fails.	3	$$			

CASE STUDY // Commercial

SIX BATTERY ROAD
SINGAPORE

- 42 storey office tower
- Green Mark Gold certification

Key Initiatives:

- Instituted recycling programs to reduce waste generation.
- Installed 'green room' to educate occupants about recycling, Singapore green label products, water efficiency and energy efficiency.
- Installed variable speed drives (VSD) to chilled and condenser water pumps.
- Installed carbon monoxide sensor in car park to monitor and control the operation of the exhaust fans.
- Installed motion sensors and timers in all toilets to control the lights and exhaust fans.
- Extensive use of energy efficient T5 lightings for all common areas and car parks.

IEQ	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Low irritant or non chemical cleaning products Cleaning products have the potential to introduce harmful particulates and chemicals into the indoor environment; the use of low irritant or non chemical cleaning products minimises this risk & improves air quality.	1	nil to $			
Internal plants & greenery Internal plants & green walls or planters have been shown to increase the indoor air quality by reducing air-borne concentrations of volatile organic compounds (VOCs).	1	$			
Replace & upgrade air filters Ensure facilities managers replace air filters in AHUs & other equipment as required. Also, using higher rated filters improves air quality by reducing the number of particulates being circulated.	1	$			
Dedicated outdoor smoking areas Due to legislative requirements, smoking is generally prohibited from most buildings causing people to smoke outdoors. A dedicated smoking area ensures that second hand smoke will not infiltrate the building and smoking butts will be properly disposed of. Locate the area 8m (+/-) away from any entrances, air intakes and operable windows.	1	$			
Internal shading Internal solar shading, like blinds, can be used to reduce unwanted solar gains to a building and visual glare, increasing the thermal and visual comfort of occupants.	1	$			
Task lighting Providing task lighting to staff allows individual control of light levels and reduction of ambient lux levels, resulting in energy savings.	1	$$			
Low VOC products – interior finishes Volatile Organic Compounds (VOCs) arise from the use of solvents which can be found in paints, carpets & flooring, adhesives and composite wood products. VOCs can cause adverse health effects commonly associated with 'sick building syndrome'.	2	$			

IEQ	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Low VOC products – interior fit-out Low-VOC systems furniture, chairs & other office furniture are also available.	2	$			
Clean all existing ductwork Existing ductwork may contain dust and other particulates that can enter into the conditioned space through the air conditioning system. It should be cleaned on a yearly basis. Cleaning them not only improves air quality but can also improve performance.	2	$			
Add solar control film to existing glazing Solar control film can reduce heat gains to an office, as well as reduce UV transmission, which reduces fading. This results in decreased solar gains, improving thermal comfort for occupants.	2	$$			
High frequency ballasts High frequency ballasts control the flow of current through a lighting circuit with a high frequency. This reduces flicker, which can lead to eye strain and headaches for occupants.	2	$$			
Personal control of thermal conditions Personal control of thermal conditions allows the differing comfort needs of individuals to be met.	3	$$$			
Top level skylights Skylights can be used to introduce natural daylight into a building.	3	$$$			
Noise and vibration control Controlling noise and vibration from plant rooms creates a more pleasant and work-conducive indoor environment.	4	$$			
Underfloor supply Underfloor supply can improve air change effectiveness (the age of air in the occupied portion of the building to the age of air if perfect mixing of the ventilation air existed).	4	$$$			
Naturally ventilate some parts of the office, where appropriate The use of natural ventilation increases the amount of outside air supplied to the building, which improves the indoor air quality.	4	$$$			

CASE STUDY // Commercial

40 ALBERT ROAD,
THE SZENCORP BUILDING
MELBOURNE, AUSTRALIA

The Szencorp Building

- Szencorp purchased the 20 year old building to refurbish as their headquarters. It was an underperforming building with high energy consumption and was bought before the Green Star ratings system was introduced. The project involved a complete overhaul and integrated fit-out.

Design Intent:

- High end corporate look with green credentials fully integrated into the design
- Demonstrate that it is possible to be mainstream & green
- Substantial reduction in energy and water consumption
- Minimise greenhouse gas emissions
- Zero waste to landfill
- Create a pleasant and highly sustainable work environment

Key Initiatives:

- Occupier integrated controls – system of sensors so that services such as air-conditioning and lighting are only provided if the area is occupied.
- On-site power generation from different sources, including multiple solar arrays and ceramic fuel cell.
- Lift controls and lift car were completely modernised for smoother, safer operation and reduced energy consumption
- Major reduction in water usage using rainwater capture and grey water recycling for flushing, waterless urinals, dual flush toilets, low flow taps and cut-off sensors on basin faucets.
- Natural ventilation throughout automated opening windows, automated louvers and open air meeting spaces.
- Lighting utilises new generation triphosphor and T5 lamps, dimmable DSI ballasts controlled via an intelligent occupancy based system achieving 1.4 watts per 100 lux.

Outcomes:

- Energy savings of 61% in the first year & 71% in the second year
- Potable water usage reduction is 94% lower than an average building
- 5 Star NABERS water and energy rating
- Reduced waste to landfill by 81%
- Productivity of workforce up 13% on previous site.

More information about the Szencorp Building, including the design team, performance results and features can be found at www.theszencorpbuilding.com

Operation & Management	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Dedicated parking for hybrid and/or ultra low-emission vehicles Preferred parking spaces can encourage hybrid or ultra-low emission vehicles.	1	Nil			
Energy consumption targets and monitoring Setting consumption targets allows the performance of the building to be objectively measured.	1	$			
Water consumption targets and monitoring Setting consumption targets allows the performance of the building to be objectively measured.	1	$			
Green waste compost Compost can be collected for use in landscaping or sold to local nursery.	1	$			
Reuse fitout and building materials as much as possible Reusing materials reduces wastage and saves money.	1	$			
Appropriate planting Native plants, once established, require less maintenance, are more tolerant to the local environmental conditions and improve biodiversity.	1	$			
Density of planting Increase the amount of dense plants with large leaf areas like shrubs, palms & trees to further mitigate solar gains & heat island effects.	1	$			
Up to date, comprehensive, accessible O&M manuals Effective operations & maintenance manuals will help ensure that equipment is maintained at optimal working conditions.	1	$			
Building user guides The building user guide is expected to provide details regarding the everyday operations of the base building to tenants. This includes information on sustainable features and strategies in relation to the building.	1	$			

Operation & Management

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Develop a building user training program A training program can be used to facilitate energy, waste and water management.	1	$			
Sustainable brief for tenants A sustainable brief for tenants give tenants guidance on sustainable features, both in general, and those specific to the building they occupy.	1	$			
Preference for environmentally friendly suppliers & procurement methods Overall environmental impact can be reduced by selecting environmentally conscious suppliers for all manner of services & supplies.	1	$			
Comprehensive cooling tower maintenance program A comprehensive cooling tower maintenance program can prevent the growth of legionella in cooling towers.	1	$			
Waste generation targets and monitoring Setting waste reduction targets allows the performance of the building to be objectively measured.	1	$			
Supply chain management Suppliers can be selected on the basis of environmental performance.	1	$			
Low maintenance, durable materials Low maintenance, durable materials last longer, use less consumable materials and take less time to maintain.	1	$			
Formal tenant feedback mechanisms Tenant feedback can identify any under-performing areas of the building, as well as any indoor environmental quality issues.	1	$			
Operational waste management plans A waste management plan details the expected levels of waste, and plans strategies to minimise the waste sent for disposal.	1	$$			

Operation & Management

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Environmental management system An environmental management system can be used to track the consumption of energy, water, materials as well as waste generation.	1	$$			
Ongoing training of building management staff Staff that undergo ongoing training will be able to work efficiently and respond quicker to any problems. They will also stay up to date with the latest technological advances, ensuring the building systems do not become outdated. Ongoing training will assist staff to stay abreast of current technology, OH&S and code requirements. This will ensure high quality maintenance and up to date building management processes.	1	$$			
Electric, water and gas sub-metering Sub-metering ensures that all tenants are charged only for what they use. This will allow the building owner to pass on accurate costs to tenants.	2	$			
Waste separation for organic waste F&B establishments can also recycle their organic food & cooking oil waste.	2	$			
Refrigerant leak detection Refrigerant leak detection as part of the BMS ensures that dangerous refrigerant leaks are detected quickly. This reduces a safety and environmental hazard, as well as saving money.	2	$			
Automatic refrigerant pump down Provision of automatic refrigerant pump down means that refrigeration is captured and stored during maintenance of refrigeration systems.	2	$			
Provide a concierge desk (instead of just visitor logging) The security and visitor logging desk can be converted into a concierge facility that provides assistance and other further amenities.	2	$			
Waste separation and recycling facilities Waste separation and recycling ensure that waste is diverted from landfill. Recycling of paper, metals, glass, plastics & cardboards should be standard.	2	$$			
Real time display of indoor environmental performance Provide real time display on energy, water usage, benchmark etc to raise public and users awareness.	2	$$			

Operation & Management

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Centralised waste Centralised waste handling & recycling collection facilities can improve the effectiveness of collecting waste and can help to increase the lettable area of the building.	2	$$			
Bike storage, accessible showers, changing facilities, lockers Providing facilities encourages staff to ride to work which helps to reduce transport emissions.	2	$$			
Electric charging stations Providing charging facilities for electric cars to encourage staff to use low-emission private vehicles.	2	$$			
Permeable landscape Permeable landscaping allows water to seep into the landscaping, providing plants and vegetation with water, and reducing runoff to the sewer system.	2	$$			
Improved accessibility Provision of appropriate foot paths, lifts, floor layouts and access ways to cater for all levels of physical ability.	2	$$			
Circulation and social spaces Circulation and social spaces foster informal and spontaneous interactions.	2	$$			
Acoustic attenuation for neighbours Acoustic attenuation from building equipment and activities minimises noise pollution into the surrounding areas.	2	$$$			
Recycled concrete Recycled concrete can be used as an environmentally friendly substitute for new concrete i.e. Green Concrete. The reclaimed concrete is crushed and used as a substitute for crushed virgin rock.	3	Nil			

Operation & Management

	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Sustainable timber Sustainable timber refers to timber that is either reused, post-consumer recycled timber or Forest Stewardship Council (FSC) certified timber.	3	$$			
Minimise PVC in pipes, conduits, cables PVC production can produce harmful chemicals such as dioxins. They also are difficult to dispose of, and much PVC is either left in situ or sent to waste landfill at its end-life.	3	$$			
High albedo roof materials Upgrade roof materials with high albedo materials to reduce heat gains. White or light colored materials, green roof and 'cool paints' all can considerably reduce heat gains into the building and mitigate heat island effects.	3	$$$			

Water	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Water efficient fittings Products should be chosen with reference to their Water Efficiency Labelling and Standards (WELS) scheme rating.	1	$			
Water audits Regular water audits can determine potential areas to reduce the use of water.	1	$			
Fire hydrant and sprinkler test water recycling Fire hydrant and sprinkler test water can be collected and recycled for non-potable uses such as irrigation.	1	$			
Water sub-meters for all major end uses Water sub-metering ensures that all tenants are charged only for the water they use. This will allow the building owner to pass on accurate costs to tenants, and identify any leaks.	2	$			
Water leak detection A leak detection system as part of a BMS can pick up leaks quickly, meaning they can be repaired without significant quantities of water been wasted.	2	$			
Silt and oil separators in stormwater system Silt and oil separators ensure harmful particulates are removed from stormwater.	2	$			
Flow / pressure responsive flow regulators Flow regulators throttle the amount of flow through pipes to ensure water is not used unnecessarily.	2	$			
Urinal flush controls Urinal flush controls can be used to ensure that urinals flush only when used, rather than continuously.	2	$			
Dual flush toilets Dual flush toilets provide the option of a full or half flush, reducing water consumption.	2	$$			
Waterless urinals Waterless urinals operate without the use of water, thereby greatly reducing water consumption.	2	$$			

Water	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Drought resistant landscape design Drought resistant landscaping design ensures the landscape does not require supplemental irrigation.	2	$$			
Condensate recovery Air conditioning condensate can be recovered treated and reused.	2	$$			
Underground storage tanks Underground storage tanks can be used for rainwater collection storage. This is especially useful for buildings where space is a major constraint.	2	$$$			
Cooling towers with minimum 6 cycles Cooling towers which have a lower number of concentration cycles use more water and chemicals to operate.	3	$			
Rainwater capture, treatment and reuse Rainwater capture treatment and reuse systems can be used to reduce reliance on potable water.	3	$$			
Non potable water in cooling towers Non potable water such as NEWater, recycled water, rain-water, treated grey water, may be used in cooling towers instead of potable water.	3	$$			
Remove cooling towers Cooling towers can be removed through the use of air cooled systems or the use of natural ventilation.	3	$$			
Stormwater detention Stormwater detention refers to capturing stormwater on site, and then releasing it slowly to reduce impact on the stormwater system at discharge.	3	$$			
Grey water capture treatment and reuse Grey water can be captured from showers, basins and dishwashing, then treated and reused for non-potable uses.	3	$$$			

CASE STUDY // Commercial

FUJI XEROX TOWERS
ANSON ROAD, SINGAPORE

- 38 storey office tower
- Green Mark Gold certification

Key Initiatives:

- Optimised chiller plant efficiency by 49% from 1.316kW/ton to 0.67kW/ton.
- Heat pipes installed to reduce interior humidity levels without energy consumption.
- Provided condensate water collection system to reduce potable water use and increase chiller plant efficiency.
- Instituted recycling programme to reduce waste.
- Installed energy efficient T5 lightings for car park, corridors and lobbies.
- Installed ultrasonic sensors and motion sensors to control lightings at toilets and staircases.

Additional Features & Amenities	1 TO 4 LEVEL	NIL TO $$$ CAPITAL COST	NIL TO SUSTAINABILITY	NIL TO OCCUPANT	NIL TO OWNER
Allow tenant service zone of > 150mm Identifies the minimum contiguous above ceiling or sub-floor service zone for reticulation throughout 80% of the nett lettable area of every office level.	2	$	nil		
Provide CCTV of main public areas, carparks and goods lifts Identifies the minimum level of CCTV coverage provided by the base building.	3	$	nil		
Provide tenant supplementary cooling loop Identifies the minimum cooling W/m² required to be provided to every office level by a dedicated supplementary base building mechanical system(s).	3	$$	nil		
Locally strengthen structure to allow for heavy loads Identifies the minimum high loading capacity for every office level of the building.	3	$$	nil		
Base building electrical supply to tenancies to allow for sufficient electrical load Identifies the minimum base building power requirements to be provided to 100% of the nett lettable area of every office level.	3	$$	nil		
Provide / upgrade tenant data risers Identifies the minimum number of dedicated data risers provided in the base building for use by tenants for their communications reticulation.	3	$$	nil		
Provide appropriate access control system Identifies the type of access system incorporated into the base building, including entry / exit, lift cars, tenant floors, etc.	3	$$	nil		
Provide good lift service Minimises waiting time, maximises handling capacity.	4	$$$	nil		
Provide goods lift with high capacity Identifies the minimum capacity of each goods lift. Consideration should always be given to the size and shape of fitout materials.	4	$$$	nil		

CASE STUDY // Commercial

UNILEVER HOUSE

LONDON, UK

- Refurbishment of Unilever's commercial HQ with a net lettable area of 43,000m² and Grade II English heritage rating
- Excellent BREEAM rating
- Office Refurbishment of the Year award at the MIPIM 2008 awards
- Structural Steel Design Award, Excellence in Modern Office Restoration (Jul 08)
- BCO, Refurbished Building Award, London (Oct 08)

Key Initiatives:

- The redevelopment retained the building's original facade and a 10m² strip of the floor slab whilst the core was rebuilt. In total, around 50% of the existing floor plate was retained.
- A detailed schedule listing of all elements of the building was produced, identifying those that could be re-used or recycled and those which could be given away for re-use. Doors, marble, parquet flooring, fireplaces, light fittings & grilles, the historic gill lift panels and timber panels were all re-used.
- In order to remove part of the building and continue working on the remaining section, Arup developed caisson foundations with demolition contractor McGee as an alternative to using bored piles. These were excavated under the structure whereas piles would need to be driven down into the ground, limiting work that can take place around them.

STEP 6

Make It Happen

People Who Can Help:

Appointed Consultants

[Let's Get Started...]

Newly constructed office buildings already deliver the benefits of reduced energy consumption, water use and other efficiencies in addition to the features & amenities that meet their tenants' needs.

Will your building be able to continue to compete with these newer buildings?

Can you meet the challenge of future-proofing your property portfolio?

DEMONSTRATE THE BUSINESS CASE

Key to the success of any initiative is being able to demonstrate the returns for the business from the investment. Some will be financial, and some may be non-financial but no less important, such as reputation, security, increased amenities, more meeting or breakout spaces, or on-site support facilities.

ESTABLISH COSTS

Now that you've done the assessments and are looking at a range of options, find out more accurately what the cost of a proposed intervention will be. Likely cost ranges of many interventions can be established relatively easily, typically by consulting a Quantity Surveyor (QS).

These figures must then be "tuned" to fit the particular circumstances of your building. For example, must tenants be re-housed to allow work to proceed? What are the incentives of achieving a Green Mark certification? Larger scale or more intrusive interventions will need the involvement of a design team containing building services engineers, structural engineers, architects, sustainability consultants, cost consultants, and possibly specialists such as fire or façade engineers.

DETERMINE THE SEQUENCE OF INTERVENTIONS

Will the upgrades be phased progressively or will they all be carried out at once? Depending on the works to be implemented, tenants or occupants may need to be relocated temporarily. Review leases and contracts to see when certain areas may be available for upgrading work or if major renovations are to be implemented, relocation of tenants or occupants will need to be planned.

Each intervention can be assessed on its own merits, with a payback or other parameter calculated in the way best suited to the owner's business. However, potentially more beneficial is to regard the interventions as part of a programme that may be carried out over time, perhaps over more than a single financial year. Interventions can then be planned to begin with low-cost, speedy-payback actions such as those that form part of a well-designed re-commissioning exercise.

As savings accrue, other more expensive initiatives can be undertaken. The right course will be determined by the needs of the business, measured by the indicators it prefers, such as NPV (net present value) or IRR (internal rate of return). As returns occur over time, predictions of inflation, not just in retail price index but also in energy and other essential consumables, will be required. These should be the same that the business uses when making its financial plans, and can be varied to test the sensitivity of the outcome to the assumptions made.

WORKING WITH CONSTRAINTS: PERFORMANCE-BASED FIRE ENGINEERING

Many initiatives to improve an existing building present difficulties with fire safety including:

- Adding an open atria or interconnections through stairs and voids
- Natural ventilation, lighting or mixed mode ventilation
- Large open floor plates
- Increased occupancy densities to maximise efficiency of rental space

Fire safety engineering approaches can clear the way for environmental, aesthetic and functional improvements to a building that would not be permitted under prescriptive fire code. The adoption of performance-based fire engineering design enables the fire strategy to first, identify the current condition (compliant or non-compliant), then develop different options to address non-compliance and finally, prove the practical and pragmatic solution(s).

Often, a customised fire safety solution, rather than a generic and prescriptive one, will provide both the optimal solution to fire safety requirements and flexibility in achieving the required level of safety. This approach is accepted by the Fire Safety & Shelter Department (FSSD) of Singapore Civil Defence Force (SCDF) since its inception in year 2004. More information about this approach can be found via SCDF website:

http://www.scdf.gov.sg/building_professionals/fire_safety_plan_approval/performance/introduction.html

[Making It Happen...]

This book has laid out a process towards upgrading an existing building rather than a prescriptive one-size-fits-all formula. It is this process then that can also work from one property to the larger scale of an entire building portfolio as it is an adaptable framework. The most important thing is to understand that the PROCESS is integral for enabling informed decisions as to how to proceed; first understanding the current baseline, the goals and constraints and then developing the optimal solutions for the specific situation.

[Acknowledgements]

This guide is based on a series of publications:

- "Existing buildings // survival strategies a toolbox for re-energising tired assets", prepared by Arup for the Property Council of Australia and published by the Property Council of Australia in July 2008 www.propertyoz.com.au

- "Existing buildings survival strategies, a guide for re-energising tired assets and reducing operating costs", prepared and published by Arup in the UK, January 2009.

- "Existing buildings // survival strategies, making it happen – putting the tools to work", prepared by Arup for the Property Council of Australia, June 2009.

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Association of Consulting Engineers Singapore

Institution of Engineers Singapore

Singapore Institute of Architects

[About CSBC and ARUP]

CSBC

The Centre for Sustainable Buildings and Construction (CSBC) is BCA's dedicated research unit that drives R&D efforts in support of BCA's strategic policies and directions on green buildings and sustainable construction. The Centre undertakes, commissions and manages research to develop solutions for the future, serving as a bridge to accelerate the transfer of technology and know-how from research institutions and innovation hubs to Singapore's building and construction industry. Through test-bedding via its flagship project, the Zero Energy Building (ZEB@BCA Academy) and sharing Singapore's unique experience in promoting green buildings in the tropics, the Centre also serves as BCA's gateway for international collaboration on sustainable buildings and construction, to advance the knowledge and awareness on the role of buildings in mitigating climate change, as well as to enhance technical capabilities in dealing with the new challenges that climate change brings to the built environment.

ARUP

Founded in 1946, Arup is the creative force behind many of the world's most innovative and sustainable buildings. Our capacity to provide both multi-disciplinary engineering design and project management services is instrumental in our pursuit of smaller environmental footprints for buildings, large and small, new and refurbished.

A pioneer in green buildings, the firm's approach addresses pressing needs of energy and resource conservation, as well as the social value and environmental consequences of urban development. Globally, Arup is working closely with governments and legislators on policies, metrics and objectives that are influencing the construction industry worldwide. Arup's track record in completed green buildings include the BedZED development in London, UK, the Druk White Lotus School in Ladakh, India and the California Academy of Sciences in San Francisco, USA.

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