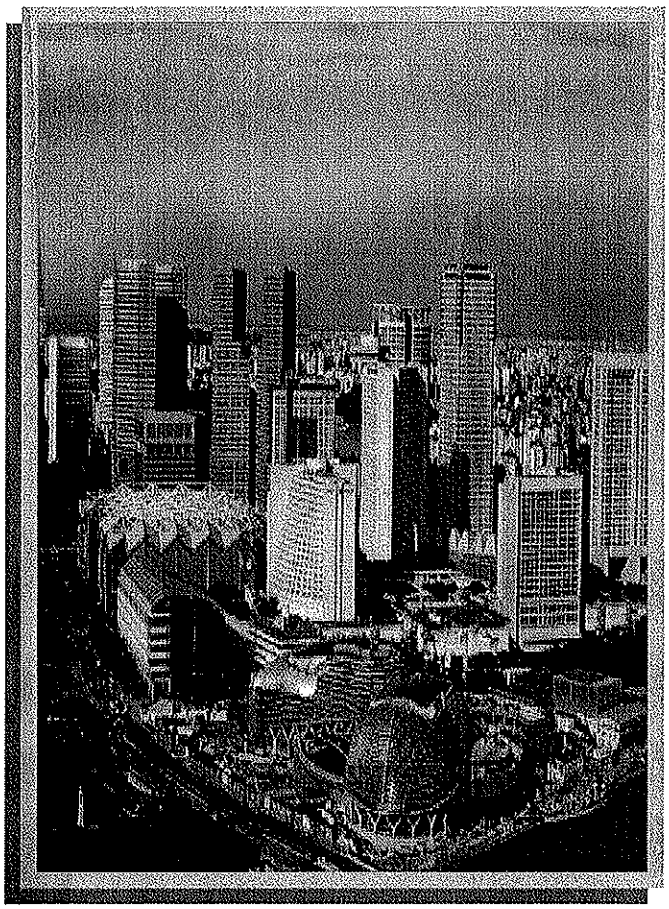
Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS



30th October 2001

9.00 am to 12.30 pm

Construction Industry Training Institute
CITI Function Hall
Level 2
200 Braddell Road
Singapore 579700

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Seminar Information

30th October 2001

Thank you for attending the seminar. Please take note of the following:

SEMINAR ASSISTANCE

If there is anything we can do to assist you, please let one of our BCA Seminar Executive know.

SEMINAR PROCEEDINGS

This file folder contains the proceedings for the presentations/papers delivered. Please write your name in your folder to avoid confusion or loss.

QUESTION & ANSWER SESSION

We encourage delegates to participate actively in the Q & A session. Please fill in the Q & A form contained in your folder and hand them to any BCA Seminar Executive before or during the Q & A session. Alternatively, you may field your question/s using the microphones provided.

EVALUATION FORM

We would appreciate it if you could complete the Evaluation Form contained in the folder and hand it to any of the BCA Seminar Executive stationed at the entrance of the reception area.

COFFEE BREAKS AND LUNCH

Coffee break and light lunch will be served at the reception area. There will be BCA Seminar Executives to guide delegates to the lunch area.

PAGERS AND HANDPHONES

Kindly switch off or put to silent mode your pagers and handphones before entering the Seminar Hall and throughout the seminar.

⌘⌘⌘ ***Thank you for your kind co-operation*** ⌘⌘⌘

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Programme

30th October 2001

08:15 am	Registration
08:45 am	Guests and participants to be seated
09:00 am	**Opening Address by Guest-Of-Honour** *Mr John Lim* *Chairman of Building And Construction Authority*
09:15 am	**Exemplary Energy Efficient Building - Revenue House** *by Mr Tham Khong Wing* *Inland Revenue Authority of Singapore (IRAS)*
09:40 am	**Exemplary Energy Efficient Building - URA Centre** *by Mr Koh Kian Chuan* *Urban Redevelopment Authority (URA)*
10:05 am	**Announcement on the Energy Efficient Building Awards**
10:20 am	Refreshments
10:45 am	**Innovative Approach to Energy Efficient Buildings** *by Mr Chua Hian Koon* *Defence Science & Technology Agency* *by Assoc. Prof Wong Yew Wah* *Nanyang Technological University (NTU)*
11:10 am	**Energy Management System in Changi General Hospital** *by Mr Kwan Fook Weng* *Changi General Hospital*
11:35 am	**Application of Photovoltaic Power Generation in Singapore** *by Mr Guido Haarpaintner* *Siemens Showa Solar Pte Ltd*
12:00 pm	**Q & A Session** *Panel of speakers*
12:30 pm	Light Lunch

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Exemplary Energy Efficient Building
Revenue House

Presented by

Mr Tham Khong Wing
Senior Admin Officer
Inland Revenue Authority of Singapore

BUILDING INFORMATION



- Building : Revenue House
- Owner : Inland Revenue Authority of Singapore
- Use : 80% Office 20% Retail
- Age : 5+ years
- Height : 24-storey & 4 Basements
- GFA : 108,000 m²
- Facilities : Recreation Club, Childcare, Cafeteria & Resource Library
- Operating Hrs for air-conditioning systems:
  - Office : 7.15am to 5.30pm (Mon – Fri)
    : 7.15am to 5.00pm (Sat)
  - Recreation Club
    : 8.00am to 10.00pm (daily)
  - Mainframe Computer & Microfilm Room
    : 24 hrs

OTTV ENVELOPE SYSTEM

Roof
- 50mm light wt concrete topping
- 50mm heavy wt concrete with dried aggregate
- 9.5mm built-up roofing
- 50mm expanded polystyrene insulation
- 150mm heavy wt concrete with undried aggregate
- 100mm or more air layer to roof
- 19mm acoustic tile

External Wall
- 6mm tinted curtain wall glass panel (2 layers)
- 19mm air layer between glass

Internal Wall
- 100mm light wt concrete block
- 20mm plaster cement with sand aggregate (on both side of concrete block)
- 13mm gypsum board (2 layers)
- 19-100mm air layer between gypsum board

Ceiling/Floor
Concrete floor construction with U-value of 0.233



Avg. Energy Consumption	12,285,000 kWh/yr
Energy Efficiency Index	147.5kWh/m² /yr
Temperature settings	22.5° C to 23.0° C
Relative Humidity	50% to 65%
Lighting Load	7.7W/m 2
Fresh Air Exchange	13m 3 /hr/person
Energy Efficiency of Aircon	0.61k/W/ton
Chiller Operational Hours	59hrs/week
Occupancy Rate	99%







EXCELLENT ENVIRONMENT FOR OCCUPANTS

The building design -

Glass curtain wall façade against the diagonal orientation of the solid frame. This innovative combination promotes the use of daylight to supplement in-door lighting.

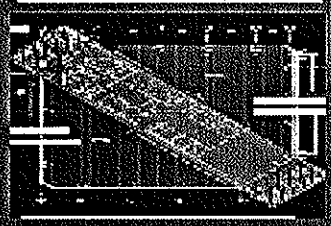
A water sculpture at the front plaza together with its lush greenery makes the environment a pleasing one. This open space provides a natural cooling transit before entering into the building.

The office environment is designed to be functionally efficient and at the same time sensitive to the differing needs of the occupants. The air-conditioning and the lighting of preset zones/rooms can be adjusted to suit preferred needs. The environment is thus dynamic and responsive.

It is also healthy through the use of the Air-conditioning Flushing System and the Electrostatic Air Cleaner System.



DESIGN CONCEPT (PASSIVE)

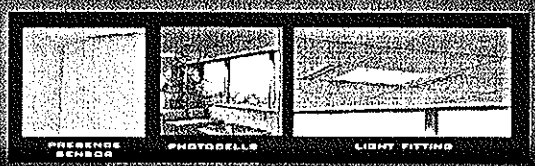


- DESIGN CONCEPT
- Building Orientation
- maximum daylight but not the heat load.
- The service cores are on building's East-West Orientation – it acts like a buffer zone to the internal workspaces.
- Locating the primary work-related areas on the outer zone to maximise daylight to supplement. This reduces wattage output from lamps.
- The lift lobby are lo-cated at the centre core.
- The 2 service-lift lobbies at the service core are most affected by the solar heat. As this is only a secondary work area, the lobby relies on the good airflow instead of air-conditioning. The louvers are placed at strategic angles of the building façade, which creates a scooping effect of airflow into the lobby.





- AIR-WELLS
- Large airwells puncture the 3 basement car parks as well as the podium office floors. The daylight supplements indoor lighting in large office zones.
- Lighting Zones are designed to economise usage to cater to zones requiring different level of intensity and.
- Lights for specific zones, however, can be extended after office hours via staff's desktop PC or by inserting the staff pass into the smart card readers.



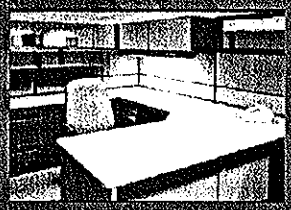
AMBIENCE & TASK LIGHTING (DUAL) LIGHTING

The office space has a dual lighting strategy to meet its needs for ambience as well as performance.

The ambience lights are through general ceiling lights — at 200 lux gives comfort & saves on lighting bills.

The overall lighting level is compensated by desktop task lights — to meet the efficient lumen level of 500 lux.

The Luminaire Housing for the general lighting has air return slots that allow airflow through the luminaire. This creates a self-cleaning action and enables fluorescent lamps to operate at near optimum temperatures to ensure maxi-mum output.





Airconditioning System

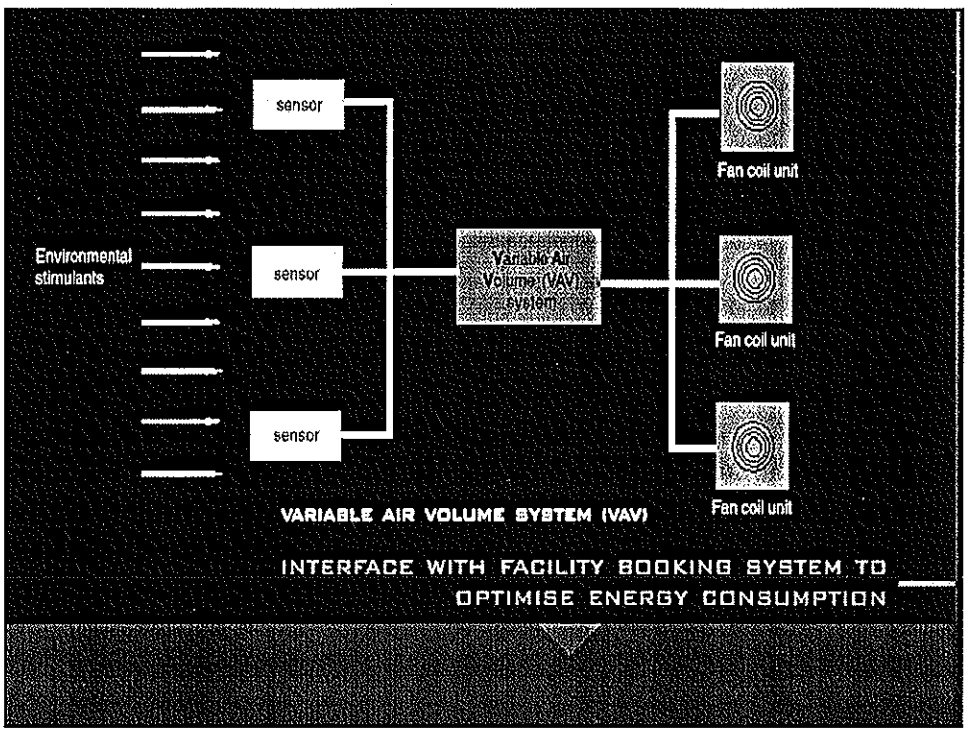
The Design of the system ensures flexibility and responsiveness to load fluctuation so as to maintain user comfort.

4 nos. 500tr water-cooled centrifugal chillers, which serve the entire building during the operational hours.

After office hours, 2 nos. 180tr reciprocating chillers serves the 24-hr operational Computer Center and Office automation cable rooms as well as the Clubhouse, which operates to 10 pm daily.

The Chiller Optimization System maintains the optimum number of the chillers and their cooling output to cool the sensible and latent heat loads measured in the building.

Variable Air Volume (VAV) system ensures optimum control of air conditioning to the building. The VAV together with the Variable Speed Drive motors installed in the Air Handling Units also reduce the motor load corresponding to the heat load.

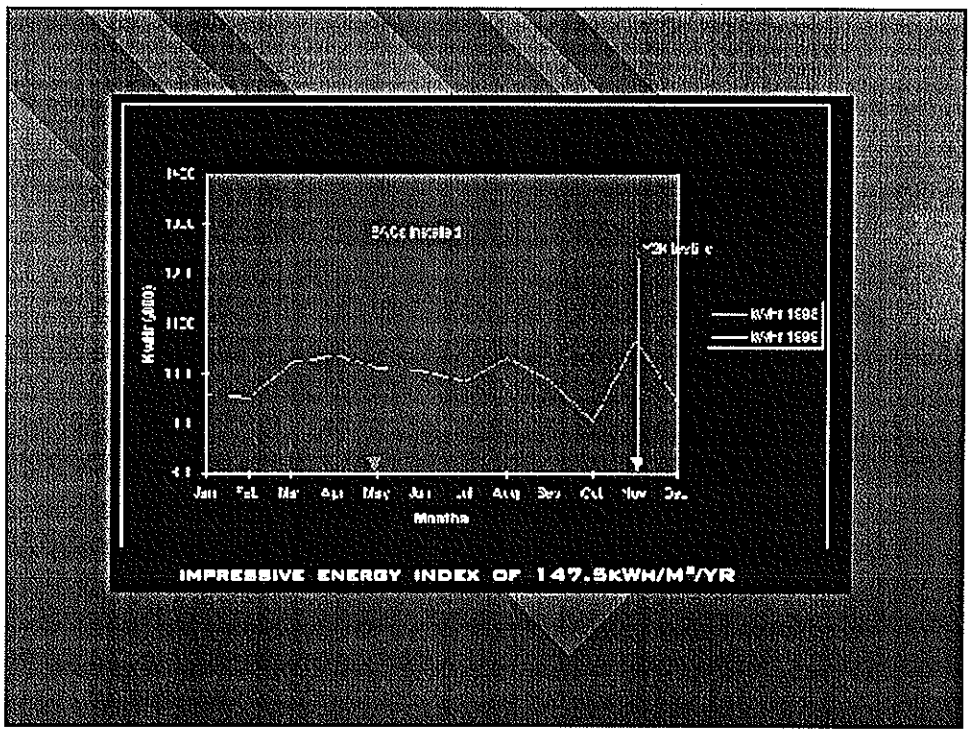


Flushing Fan System

reduces sick building syndrome and help saves energy. The flushing system operates during the coolest time in the early hours of the morning, bringing cool fresh air to replace the stagnant air in the building. This reduces the heat load when the chiller starts up.

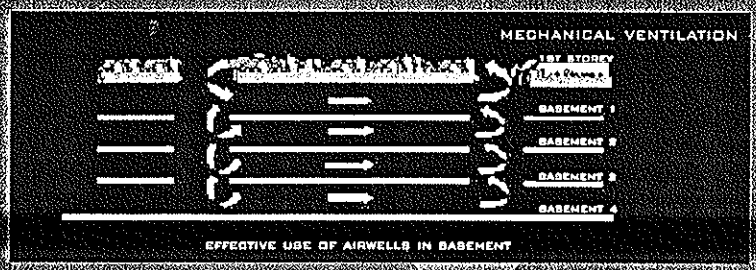
Electronic Air Cleaners

provide clean air to the air-conditioned environment and has great potential in reducing air-conditioning. The EACs are capable of 0.01 micron filtration of air. The cleaner air through the cooling coils eliminates poor heat transfer through coagulation of dust particles on the coil surface.



Mechanical Ventilation is used mainly for plant rooms, toilet exhaust system and car park exhaust.

The mechanical ventilation in the basement car parks is supplemented by Natural Ventilation through the use of large airwell. Thus reduces the need to provide large mechanical ventilators.



Replicability & Sustainability

MANAGEMENT INVOLVEMENT

Our Management is committed to *maintaining a pleasant, healthy and high performance environment with efficient and high energy conservation practice.*

External consultants are contracted to *conduct Annual Energy Audit to identify areas for improvements and highlight good practices.*

Staff awareness of energy conservation is promoted through *Quality Action Circles (QACs) and staff suggestion scheme.*

Continual Learning and Sharing with other organisations is also encouraged through inter-organisational visits.

A Building of Tropical Excellence.

Despite the challenges of having an up-to-date and intelligent building, Revenue House achieves a remarkable Energy Efficient Index of 147.5 kW/m2/yr.

This is considering that IRAS operates on a 6-full day week to serve members of the public and a computer mainframe, which runs 24 hours daily. This is possible through the Good Management & Maintenance Practice of staff and management, which are replicable & sustainable.



PROFESSIONAL & DEDICATED MAINTENANCE TEAM

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Exemplary Energy Efficient Building
URA Centre

Presented by

Mr Koh Kian Chuan
Head (Mechanical & Electrical)
Urban Redevelopment Authority

THE URA CENTRE



1.0 GENERAL

The URA Centre is the HQ of the Urban Redevelopment Authority (URA). The Centre is situated in a unique location between towering modern office complexes and charming low-rise conservation shophouses in the city area.

The building displays good urban design with its good massing, circulation and linkages with its surrounding. The Podium block is kept low at 5 storeys so that it blend with the adjacent low-rise conservation developments while the 16 storey slab block office is built to compliment the neighbouring high rise office buildings. The podium and tower is connected by a Five-storey high glass atrium, which functions as an amenity core.

Reflecting Our Tropical Climate

The atrium allows natural light to enter via the skylight to create a conducive public space for customer while they are waiting to be served. The location of the atrium is designed to block direct sunlight into the atrium while still allowing natural light to penetrate into the building interior most of the day. On the outside, the lush greenery continues to provide tropical landscaping to soften the grey exterior. All these efforts have improved the lighting level and reduce the amount of artificial lighting.

Tropical Roof-top garden and water pond

A pavilion on the rooftop of the Podium block is surrounded by water with floating lotus plants and Koi. This water garden is used as a design feature to reduce heat gain on the roof.

Conducive Working Environment

To achieve good performance for spatial and visual qualities, low partition furniture is used in relation to appropriate floor heights and clear glass panels to provide openness to the exterior environment. It allows daylight to penetrate into the inner space of the building.

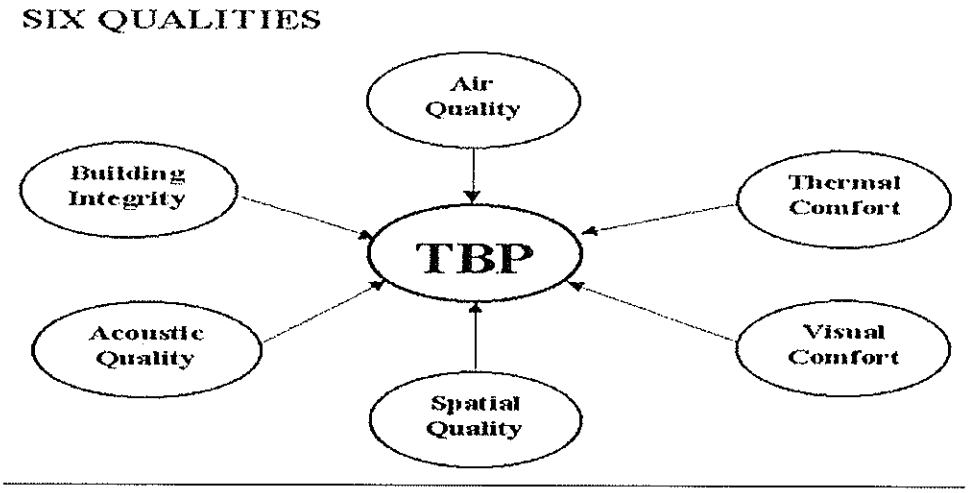
Good Indoor Air Quality

To provide a healthy building, we have made special efforts to take care of the indoor air quality. By monitoring and controlling the carbon dioxide (CO2) level in the air distributing system, we are able to achieve good indoor air quality. Outdoor air dampers are installed to allow more fresh air into the air distributing system when the carbon dioxide level reaches a predetermined level.

Air flushing system is installed to remove any foul and stale air that is trapped within the air-conditioned areas. We operate the fresh air fans and air handling units (AHUs) to supply fresh air via the air-conditioned ducting and air diffusion systems into the building during the air flushing operation. At the same time, we use exhaust fans to extract foul air via the air-conditioned return air stream to the exhaust ductwork system. The flushing system is programmed to commence and complete prior to the start-up of the main air-condition system daily.

2.0 DESIGN APPROACH (PASSIVE)

Integrated Building Design - Total Building Performance (TBP) Approach



To create an office environment that meets the physical and psychological needs of staff, we adopted the Total Building Performance (TBP) Approach. All uses of the building are well co-ordinated to ensure that it works as a whole. The result is a building that meets the high standards in acoustics, visual and thermal comfort, air and spatial quality and building integrity.

Excellent Building Envelop Design

Good thermal quality is achieved with low-e double glazed light green glass windows to reduce solar radiation and transmission without compromising visibility.

Granite cladding and special Sun Shading devices

The external granite cladding is carefully chosen with light grey colour. With the high thermal insulation properties of the stone, the influence of solar heat and outdoor temperature on the inner climate is reduced.

Angle profiled horizontal louvers and vertical fins are introduced at the window areas to achieve shading. The glass facade of the podium block and some parts of the Tower block are fitted with the aluminium sunshades to reduce glare and heat from the sun. These louvers function as reflectors to introduce natural light into the office. The allocation of these fins has been carefully studies for the best balance of effective solar control, exterior portion and outside view from the interior spaces.

Low Overall Thermal Transfer Value (OTTV) of 29.3 W/m^2

The application of low-e glasses and sun shadings have created an energy efficient building envelop that has an OTTV of **29.3 W/m^2** which is significantly below the $45W/m^2$ as stipulated by the construction authority. The low OTTV has resulted in the reduction of external heat gain and saving in energy.

3.0 DESIGN APPROACH (ACTIVE)

Energy Efficient Lighting System

To compliment the effective Daylight design, the office area is sub-divided into several zones. The lighting of each of these zones is set at the level that was suitable for its need.

The lighting system in the general office uses double parabolic recessed fluorescent fittings (2X36W) equipped with dimmable high frequency electronic ballasts to provide efficient lighting for the users. The lighting zones near the window are dimmed to 70% of the maximum achievable level, we are able to get 500 to 700 Lux average in the office area. PLC compact energy saving lamps are used in the lift lobbies, corridors and toilets. In the Basement car park levels, we installed dimmable lighting system to achieve optimal lighting level without compromise the driving safety and security.

Motion detectors are installed in areas such as toilets to cut down energy wastage

The overall lighting load of **10**watt/m^2 is achieved with the use of energy efficient fittings and better control through the Building Automation System (BAS).

Efficient Air-conditioning System

Primary and secondary chilled water circuits to save energy :The chillers in Primary circuit is optimised by the BAS to meet the day and night load demand. Whereas the secondary chilled water pumps could vary its' flow rates through the air handling unit (AHU) and fan coil units by means of Variable Speed Drive (VSD).
Automatic on-load brush tube cleaning system : on the condenser water side, brush tube is installed for each chiller's condenser tubes to remove deposits and maintain the fouling factor. Thus, better heat transfer and lower power input to the compressor are achieved.

Variable Air Volume (VAV) air distribution system: VAV is designed for the office block. Proper zoning of perimeter and interior areas is adopted. Variable Speed Drives are installed to modulate the supply air flow rate of the AHU in accordance with the load changes to save energy.

Stratum air conditioning system in the Atrium
At the lower part of atrium (at 1st and 2nd storey), well conditioned cool air is supplied to the atrium. Hot air rises and cooled air falls, the 1st storey level where people work and walk is well conditioned. At the upper part of atrium (3rd storey onward), the heated air is discharged to the outdoor through the ventilation system at the top of atrium.

Based on the field data recorded, the actual load of the air-conditioning system is about 28watt/m^2, which is 50% of the total electrical load.

State-of-the-art Lift System with revolution control system – Miconic 10
The main lift system, installed in the office block, which serves basement 2 to 16th storey, comprises six passenger lifts. Each lift has a capacity of 17 passengers and has a speed of 2.5m/sec.

The Miconic 10 lift control system is different from the conventional lift control system. With its powerful and unique control system, it allows the passengers to select the desired floor at the lift lobby before entering the lift car. A performance on waiting time/Round Trip time (RTT) comparison between the Miconic lift system and the conventional lift system is as shown in the following Table:

Mode	Conventional (Waiting/RTT)	Miconic 10 (Waiting/RTT)	Improvement
UP-Peak	30.8 sec/*107.7sec*	25.2 sec/*82.5sec*	**18.2%/*23.4%***
Lunch Peak	37.2 sec/*135.6sec*	32.0 sec/*103.1sec*	**14%/*24.02%***
Down-Peak	33.5 sec/*92.7sec*	32.4 sec/*71.6sec*	**3.3%/*22.8%***

This lift system provides more efficient services, i.e. fewer number of stoppages, shorter average waiting time (an improvement of 10%) and faster turn-around (an improvement of more than 20%). This translates into an overall reduction in the number of trips and thus lowers the energy consumption.

4.0 MANAGEMENT AND MAINTENANCE SECHEME

Good Energy management systems

All M&E systems such as ACMV and lighting are operating at their optimal settings with the use of Integrated Building Automation System (BAS). All energy usage is being monitored by the BAS and is trend logged. The in-house maintenance team reviews the energy bills and results on quarterly basis.

As part of the work improvement team (WITs) movement, the maintenance team has worked on energy saving projects that could lead to cost saving. For example, in last year, the team has completed 2 WITs projects: To reduce the amount of lighting needed at night for the basement car park & install timer for water feature pumps at the pavilion.

Effective Maintenance and Training programme

A comprehensive Computer Aided Facility Management (CAFM) system is used to pre-determined and tracked all the required maintenance work of the M&E plants or systems. The CAFM system will alert the maintenance team in advance which system is due for the routine servicing, etc. This is to ensure that all systems are maintained at their tip top condition.

100 hours per year of extensive training has been provided for all the maintenance staff to ensure that they are keeping pace with the latest facility management knowledge and skills.

5.0 Replicability and Sustainability of Energy Efficiency

The TBP Approach has achieved an excellent energy efficient building with a clean and healthy environment for the occupants. This design approach is systematic and effective in guiding the multidisciplinary team to predetermine and overcome the conflicts in design before construction. Thus, we are able to minimise errors made and save cost. The technology and expertise could be readily adopted by other developments.

With the daily air flushing and CO2 monitoring system, excellent Indoor Air Quality is achieved. Despite the 24-hour operation of the computer centre and the high ceiling height of 4.2m for every floor, the building is still able to achieve good energy efficiency of **191kwh/m^2/year**. The implementations of these design practices in our building have greatly contributed to the saving in energy.

------END--------

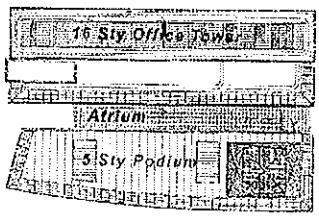
The URA Centre

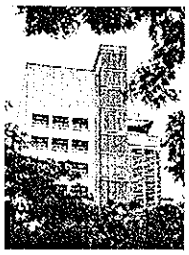


Energy Efficient Building

Layout

- 5 sty Podium
- 16 sty Office Tower
- 5 sty Atrium
- 2 Basements







Building Information

- Completed in Oct 1998
- Single Tenanted Office Building
- GFA : 38,187 sq m
- GPR : 6.44
- No. Of Occupants : 1000
- 10 Lifts & 2 Escalators

M&E Systems

- Approved Load : 4 MVA
- Installed A/C : 1500 RT

Key Design Considerations

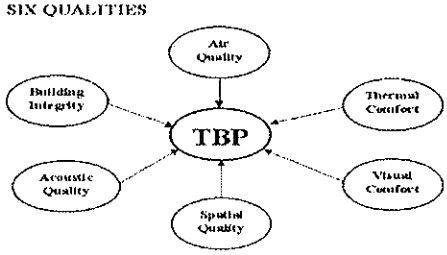
> contributed to energy saving

Key Considerations

- Passive Design - Orientation, facade, etc
- Active Design - M&E
- Maintenance & Mgt

Total Building Performance

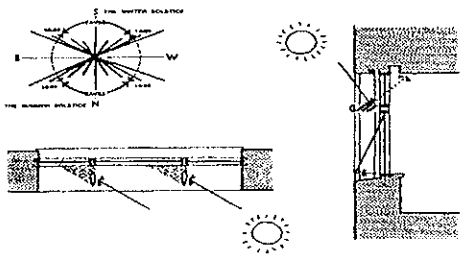
SIX QUALITIES



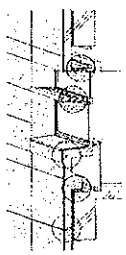
Building Envelop Design

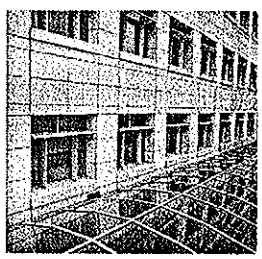
- Low-e double glazed light green glass windows
- Granite cladding
- Sun Shading devices

Sun Shading Devices

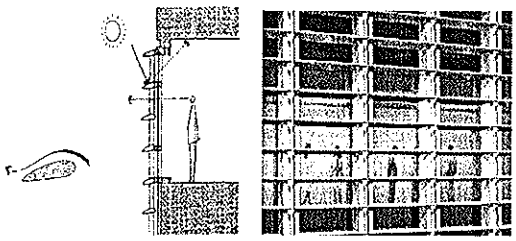


Sun Shading Device





Sun Shading Device



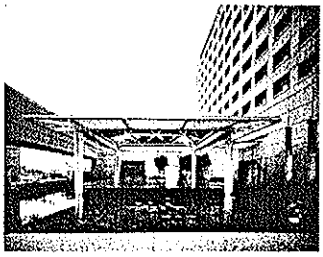
OTTV

29.3 W/ sq m

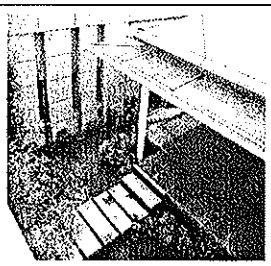
Roof Water Pond

- A Pavilion on Podium roof

>> Reduce heat



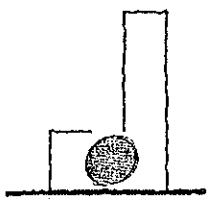
Pavilion





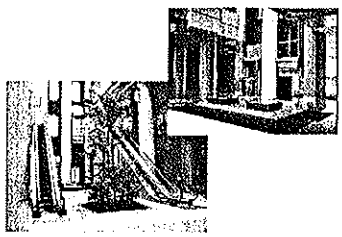
Atrium

- Reflecting Our Tropical Climate
- Natural lighting
- Sandwiched between Tower & Podium
- Greenery & water



ADOPTED APPROACH

Atrium





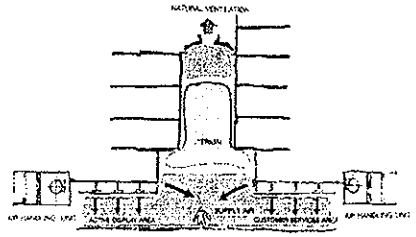
Lighting

- Zone Control
- Day light
- Motion Detector
- Energy Saving Lamp
- 10 W per sq m

Air Conditioning System

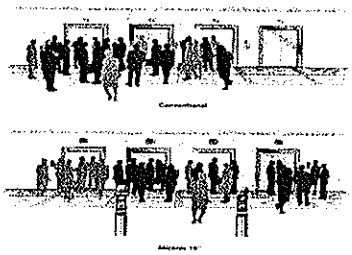
- Primary & Secondary chilled water circuits
- Automatic on-load brush tube cleaning system
- VAV

Atrium A/C Model

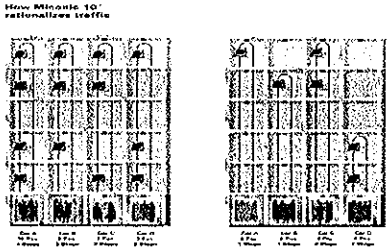


ATRIUM AIR CONDITIONING MODEL

Lift System



Lift System



Management & Maintenance

- Energy Mgt System
- Bldg Automation System
- Review of energy bills & results on regular basis
- Use Work Improvement Team (WITs) to look into area of improvement

Maintenance & Training

- Computer Aided Facility Mgt (CAFM) system is used
- 100 Hours per year of extensive training for the maintenance staffs

Sustainability

TBP Approach

- 6 key building qualities are taken care up front to reduce errors

- readily adopted by other developments

Thank You



Energy Efficient Building Award 2002

Building and Construction Authority

WELCOME. It is our pleasure inviting you to participate in the 1ST ENERGY EFFICIENT BUILDING AWARDS (EEBA). The purpose of the new award is to promote energy efficiency in buildings and to accord recognition to building owners, architects, engineers, energy consultants and energy service companies who have integrated energy efficiency into their building design, operation and maintenance. Winning entries will receive the awards at the BCA Awards Ceremony 2002 and represent Singapore at the ASEAN Building Energy Efficiency Best Practices Award (ASEAN Award) in 2002.

Award Categories

The award is open to all air-conditioned buildings. Building owners can participate in any one of the three categories, namely:

- NEW & EXISTING BUILDING CATEGORY
  Any air-conditioned buildings regardless of its age can participate under this category provided no major improvements have been made.

- RETROFITTED BUILDING CATEGORY
  This category is for air-conditioned buildings where major changes and improvements have already been introduced to improve energy efficiency.

- SPECIAL FEATURES CATEGORY
  The special features category is to recognise projects in building which studies and applies advanced technologies and/or implemented special measures to enhance energy efficiency.

Assessment Panel

All entries will be judged by an Assessment Panel comprising senior representatives from the following organizations:

- Association of Consulting Engineers Singapore
- Building and Construction Authority
- Energy Market Authority
- Institution of Engineers, Singapore
- Ministry of Environment
- National University of Singapore
- Real Estate Developers' Association of Singapore
- Singapore Environment Council
- Singapore Institute of Architects

Assessment Criteria

Entries will be assessed based on the following criteria:

For New & Existing Buildings Category

1.	On-Site Natural Environment Considerations (e.g. use of vegetation, landscape, hardscape, water body and wind)	(10%)
2.	Passive Design Concepts (e.g. building orientation and design, envelope design, daylighting and natural ventilation)	(25%)
3.	Active Design Concepts (e.g. air-conditioning, lighting, building automation and energy recovery)	(25%)
4.	Management and Maintenance Scheme (e.g. energy management system and maintenance programme)	(25%)
5.	Replicability and Sustainability (e.g. the ability to repeat the same energy efficient measure achieving the same result)	(10%)
6.	Environmental Impact Consideration (e.g. waste management and pollution management)	(5%)

For Retrofitted Buildings Category

1.	Actual / Measured Energy Savings	(20%)
2.	Passive Design Concepts	(20%)
3.	Active Design Concepts	(20%)
4.	Management and Maintenance Scheme	(25%)
5.	Replicability and Sustainability	(10%)
6.	Environmental Impact Consideration	(5%)

The decision of the Assessment Panel shall be final and the panel has absolute discretion to make or withhold an award. The Assessment Panel may also re-categorise any entry, which in their opinion, has been entered in the wrong category.

Eligibility

The EEBA is opened to all air-conditioned buildings completed in Singapore and meet the following pre-qualification criteria:

1. Energy Efficiency Index
   - Air conditioned area: <250 kWh/m^2/year

2. Temperature and Other Settings
   - Between 23°C and 25°C
   - Relative humidity between 55% to 65%

3. Lighting Load
   - Maximum 15 W/m^2 (gross floor area) for offices
   - Maximum 25 W/m^2 (gross floor area) for commercial buildings

4. Occupancy Rate (average over the last 12 months)
   - Minimum 60% of total units for hotels
   - Minimum 80% of total area for offices/commercial buildings

5. Additional Criteria for Retrofitted Buildings
   - Total energy savings of at least 20% after retrofitting

Trophies & Certificates

Building owner of the top entry in each category will receive a trophy. The first and second runners-up will receive certificates of merit. Project consultants will be presented certificates of recognition. Trophies and certificates will be presented at the BCA Awards Ceremony 2002.

ASEAN Awards

EEBA winners will also have the honour of participating at the ASEAN Awards as Singapore nominated entries.

Entry Form and Write-Up

Entries for the awards shall be submitted using the attached prescribed form which are also available from BCA-NUS energy website at www.bdg.nus.edu.sg/buildingenergy. A six-page write-up (A4 size) of the energy efficient features is also required for participating in the New & Existing Building and Retrofitted Building categories. For the Special Feature category, the six-page write up should highlight the advanced technologies and/or special measures implemented to enhance energy efficiency. The entry form and write-up must reach BCA **not later than 5pm on 28th Dec 2001**.

Presentation to Assessment Panel

Shortlisted projects will be required to make a presentation to the Assessment Panel tentatively in the **first week of February 2002**. The presentation of not longer than 20 minutes should focus on the project's energy efficient features and their effectiveness.

Site Visit by Assessment Panel

Shortlisted projects will also be required to grant access for site visits by the Assessment Panel tentatively in the **last week of February 2002.** The site visits will enable the Assessment Panel to verify and clarify the information presented.

Participation in ASEAN Awards

All winning entries will be required to participate in the ASEAN Awards. Details of the ASEAN Awards will be available in March 2002.

Publication of Materials

All materials submitted in connection with the entry are non-returnable and shall become the property of the Building and Construction Authority. The Authority reserves the right, without the payment of fees, royalties or otherwise to make whatever use it may consider desirable of all materials submitted in connection with the entries, including the publication of photographs and names and exhibition & publication of materials.

Entries for the BCA Energy Efficient Building Awards or any enquiry should be addressed to:

The Secretariat
BCA Energy Efficient Building Awards
Building and Construction Authority
5 Maxwell Road #07-00
Tower Block MND Complex
Singapore 069110

Attention:
Miss Alice Goh
Email: alice_goh@bca.gov.sg
Tel: 3258660
or
Thomas Goh
Email: thomas_goh@bca.gov.sg
Tel: 3258652

Entry Form for Energy Efficient Building Award

Name of Building:
Name of Owner/Management Company:
Address:

Contact Person:
Email:
Tel. No.: Fax No.:

Instructions:

i. Please answer ALL the questions given in this questionnaire. If relevant information is not available, please indicate NA.

ii. ***Please indicate one category you wish to participate in:***

- ☐ ***New & existing building***
- ☐ ***Retrofitted building***
- ☐ ***Special feature***

---

1 **Physical Building Background**:

1.1 Usage of the building:

☐ a) Single use development

☐ b) Mixed use development

If your answer is (a) please proceed to (1.1a), otherwise proceed to (1.1b)

(1.1a) For single use development

☐ Office ☐ Hotel ☐ Others (please specify) _____

(1.1b) For mixed use development (please indicate types)

☐ Office ☐ Hotel ☐ Retail ☐ Warehouse

☐ Light industry ☐ Shopping centre

☐ Others (please specify) _____

[1.1b (continue)] Please indicate the percentage space allocation for mixed use development

Types	Percentage of Designated Space (%)
Example: Office Retail	 80% 20%
Office	
Retail	

1.2 Age of building: _____(years)

1.3 Date of the last retrofit, if applicable: _____ (month/year)

If retrofitted:

(a) Complete retrofit ☐ Partial retrofit ☐

(b) Please tick if the following have been retrofitted:

Facades system ☐

Air-conditioning system ☐

M & E systems ☐

Transportation system ☐

Lighting system ☐

Others (please specify)_____

1.4 Total number of storeys (including above ground car park): _____

1.5 Total number of basement floors (including basement car park): _____

1.6 Number of above ground car park levels: _____

1.7 Number of below ground car park levels: _____

1.8 Total gross floor area (m^2): _____

1.9 Car park area (m^2): _____

1.10 Lettable area (m^2): _____

1.11 Air conditioned area (m^2): _____

1.12 Non air-conditioned area excluding car park (m^2):_____

1.13 Total building height (m): _____

1.14 Floor to floor height (m): _____

1.15 Building operation hours (hrs/week): _____

1.16 Air-conditioning system operation hours (hrs/week): _____

1.17 Total number of occupants (estimated): _____

1.18 Current occupancy rate (%): _____

2 **Building Energy Consumption**:

2.1 Energy consumption for:

☐ Owner occupied

☐ Landlord and tenants

2.2 Please provide the total monthly energy consumption of the last 12 to 24 months in column A. Details of the monthly energy consumption of landlord and tenants may also be provided in columns B and C.

Month & year	Building energy consumption **(Total)** (kwh/month)	Building energy consumption **(Landlord)** (kwh/month)	Building energy consumption **(Tenants)** (kwh/month)
	Column A	**Column B**	**Column C**

Month & year	Building energy consumption **(Total)** (kwh/month)	Building energy consumption **(Landlord)** (kwh/month)	Building energy consumption **(Tenants)** (kwh/month)
	Column A	**Column B**	**Column C**

2.3 Does your building use other energy source?

☐ Yes ☐ No

If yes, please specify fuel and purpose.

☐ Gas, please specify purpose:_____

☐ Solar, please specify purpose:_____

☐ Wind, please specify purpose:_____

☐ Others, please specify purpose:_____

3 What are the on-site natural environment considerations?

_____

_____

_____

_____

_____

4 **Passive Design Information:**

4.1 Envelope OTTV (W/m^2): _____

4.2 Roof OTTV (W/m^2): _____

4.3 Type of façade

☐ Stone cladding ☐ Aluminum curtain wall

☐ Tiles ☐ Glazed curtain wall

☐ Plastered wall ☐ Others (please specify)_____

4.4 Colour of façade:

☐ Light ☐ Dark ☐ White

☐ Metallic ☐ Others (please specify)_____

4.5 Use of shading devices

☐ Blinds/curtains

☐ External sun shade

☐ Others (please specify)_____

4.6 Building orientation

☐ East facing

☐ West facing

☐ Others (please specify)_____

4.7 Location of service core:

☐ Central

☐ Perimeter

☐ Others (Please specify)_____

4.8 What are the other passive design features adopted (e.g. daylighting and natural ventilation)?

_____

_____

_____

_____

5 Active Design Information

5.1 Office area building systems operating schedule:

Schedule	Weekdays	Saturday	Sunday	Public holiday
Start time				
End time				

Percentage of total area served:_____

5.2 Retail area building systems operating schedule:

Schedule	Weekdays	Saturday	Sunday	Public holiday
Start time				
End time				

Percentage of total area served:_____

5.3 Other areas: Please specify: _____

Schedule	Weekdays	Saturday	Sunday	Public holiday
Start time				
End time				

Percentage of total area served: _____

5.4 Building indoor environment

Indoor air setting : Temperature (°C) _____

: Relative Humidity (%) _____

5.5 Building air-conditioning system and equipment:

Fresh air exchange rate (m^3/h per m^2 floor area)_____

Efficiency of air-conditioning chiller (kW/ton) _____

5.6 Building lighting load (W/m^2)_____

5.7 What are the other active design features adopted (e.g. energy recovery system, energy saving lighting fixtures and control and building automation system)?

_____

_____

_____

_____

_____

6 Management and Maintenance Scheme

6.1 Is there an energy committee to monitor and conserve energy consumption?

☐ Yes ☐ No

6.2 Does the Building Management have a clearly spelt out energy policy? If yes, please provide details of the policy and methods of implementation.

_____

_____

_____

_____

6.3 Is energy efficiency featured in the maintenance programme? If yes, please give details.

_____

_____

_____

_____

_____

7. **What are the environmental impact consideration adopted (e.g. waste and pollution management)?**

_____

_____

_____

_____

_____

8 **Project Team**

Architect:_____

M & E Engineer:_____

Others (please specify):_____

9 **Affirmation**

We certify that the information given above is true and accurate and that the Assessment Panel may seek to verify them independently, if required.

a) Signature of Building Owner/Manager _____

Name: _____

Designation:_____

Date: _____ Company Stamp: _____

b) Signature of Architect:_____

Name: _____

Designation:_____

Date: _____ Company Stamp: _____

c) Signature of Engineer:_____

Name: _____

Designation:_____

Date: _____ Company Stamp: _____

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Innovative Approach to Energy Efficient Buildings

Presented by

Mr Chua Hian Koon
Defence Science & Technology Agency
Programme Manager

&

A/Prof. Wong Yew Wah
School of Mechanical & Production Engineering
Nanyang Technological University

Innovative Approach to Energy Efficient Buildings

Chua Hian Koon, Ng Yew Soon, Tay Leng Chua
Defence Science & Technology Agency (DSTA)

Assoc Prof Wong Yew Wah
School of Mechancial and Production Engineering
Nanyang Technological University

ABSTRACT

This paper describes the approach applied by Defence Science & Technology Agency's Building & Infrastructure (BI) to achieve higher standards of energy efficiency for its building and infrastructure development projects. The Energy Management and Economisation Committee (EMEC), a sub-Committee under the Ministry of Defence Economic Drive committee (EDC), was formed in 1994 to implement the Utility Management Policy. This has resulted in the integration of energy efficiency and utility conservation measures into the organisation's routine decision making process making way for the facilitation and implementation of energy efficient designs in several of their projects including the Changi Naval Base (CNB).

The process includes a set of requirements and incentives for designers to strive for higher energy efficiency standards. The use of inhouse expertise as well as outside partners are called upon to evaluate and fine tune designs throughout the process. The results are substantial economic and environmental benefits.

INTRODUCTION

The Defence Science & Technology Agency (DSTA) is the first statutory board set up under the Ministry of Defence (MINDEF) on 15 March 2000. As the national authority for defence science and technology, we provide leading-edge solutions for the defence and security of Singapore.

DSTA manages programmes in defence acquisition and systems engineering, in areas such as aeronautical, guided, land, armament, naval and sensor systems. DSTA also manages programmes in infocomm technology, research and development and defence construction. The latter task is undertaken by DSTA's Building & Infrastructure (BI), which specialises in large-scale defence infrastructure development projects.

UTILITY EFFICIENCY FRAMEWORK

MINDEF has a major commitment to sustainable development. This is expressed through the framework of the Utility Management Policy formulated by the Energy Management and Economisation Committee (EMEC), a sub-committee of MINDEF's Economic Drive Committee (EDC). The framework allows ideas to be examined systematically on the prospects of technical viability, economic payback, benefits, ecological impact and conservation of utilities.

The Utility Management Policy has shaped the workings of DSTA's BI in several significant ways, viz:

1. Integration of energy efficiency and utility conservation measures into its organisational routine, becoming part of the decision making process thereby ensuring its long term commitment to the development and implementation of energy and environmental policies and programs.

2. Constant reference to its internal targets, efficiency standards and benchmarks for conservation and efficiency measures, yet at the same time is aware that these standards and targets by themselves are not static and has placed them under continuous review and improvements.

3. Continuously seeking innovative technological solutions for energy efficiency, and water conservation. This has led to broad explorations of utility conservation and energy efficiency concepts, and the promotion of technological R&D through demonstration projects. The project findings are then incorporated into the defence infrastructure long-term work plans.

STRATEGIC THRUSTS

The main strategic thrusts identified for utility conservation and energy efficiency for defence infrastructures developments are as follows: -

1. Energy efficiency in M&E systems and energy efficient building design
2. Adoption of alternative or new energy sources
3. Strategic water conservation

These strategic thrusts are being embodied in the planning, design and construction of all defence infrastructure projects. During the planning stage, the project team brainstormed on possible ideas to conserve energy and water. This is followed by studies on their technical and economical feasibility. Approved ideas or schemes are finally translated into design requirements for subsequent implementation.

Some of the energy and water conservation schemes implemented in the recent Changi Naval Base (CNB) development are used to highlight the outcomes of this strategy.

1. Energy efficiency in M&E systems and energy efficient building design

Air-conditioning and lighting are the major end-use components in electricity consumption, the lighting system by itself forming a large component of the cooling load. The main strategy for energy conservation will be via a three pronged approach of :

a. System innovation
b. Optimise sizing of equipment
c. Selective use of energy efficient equipment

One of the notable system innovations in energy saving in CNB is the Indirect Seawater Cooling and Thermal Storage Systems [1]. This involves the unique integration of Indirect Seawater Cooling, Thermal Storage and an On-Demand District Cooling System (condenser water distribution network). The objective is to provide air-conditioning to the entire base in an energy efficient manner using water-cooled equipment without consuming a large amount of potable water - a much valued resource in land scarce Singapore. Thermal storage favours the demand side energy management and is therefore ready to exploit the increasing differentiation of electricity tariff between peak and off-peak rates brought about by the deregulation of the power supply industry thus saving energy cost. The unique combination of thermal storage with seawater cooling has generated significant payoffs in terms of savings in infrastructure costs amounting to $1,000,000. The savings come from reduced power supply infrastructure, smaller size piping for the district cooling network and reduced capacity for the seawater cooling system.

Furthermore, computer simulation techniques were used to model and aid optimization of the hydronic performance of the district cooling network and seawater circuit. This simulation study has aided the optimisation of the hydronic system and the expected overall system efficiency improvement is about 15%. It also established the control strategy for optimal performance, sized the pumps and determined the pumping configuration for optimal energy performance during part load and full load operations. This system innovation has also enabled the optimisation of life cycle cost (capital and operation costs) for providing air-conditioning to the base. An economic analysis has shown that a total cost saving of $6,000,000 is achievable.

High efficiency motors are used extensively in the air-conditioning systems and plants. High efficiency motors' 90%-95% efficiency are superior to the 85% efficiency of the normal ones. Furthermore most of the pumps are equipped with variable speed drive (VSD) for optimal capacity regulation. A fully variable flow system or otherwise known as the decoupler concept was adopted to supply condenser and chilled water according to demand. Chillers are equipped with automatic cleaning devices in the condenser tubes for optimal heat transfer performance.

High performance glazing systems and reflective roof finishes are used to reduce building envelope load. The glazing system consists of spectrally selective glazing units with high visible transmittance for daylighting and a very low shading coefficient. Within the building, demand-based ventilation using space CO_2 sensors to modulate fresh air supply saves energy needed to treat outside air. Office equipment such as personal computers, printers and copiers are required to be Energy Star rated thereby reducing direct and indirect energy consumption. Energy saving lighting systems integrated with natural daylighting further reduce energy use. Daylight sensor adjust artificial lighting output in response to available daylight maintains a constant illumination level. Intelligent energy management system optimises the operation of the building systems using smart or intelligent sensors and controllers for improved efficiency.

For the power system, the base is equipped with a fleet of high tension frequency converters to support ship hotel loads at 60Hz. As ship loads have lagging power factor, synchronous alternators are used in these frequency converters to effectively correct the power factor to near unity. In addition, a fleet of emergency high tension power generators have been uniquely engineered using control technologies to provide dual frequency power synchronised at 50Hz for emergency power and at 60Hz to supplement the ship supply. This creative innovation allowing the dual usage of the same generators for both power needs has led to a significant reduction in the number of frequency converters installed and enables the base to meet surges in ship load demand. Also, the base is able to implement a demand side energy management strategy where it can be operationally cheaper to run the generators during the peak hours than to use the grid's supply. An advanced SCADA system is used to monitor and manage energy consumption and collect trend data for realising conservation and efficiency.

2. Adoption of alternative or new energy sources

Selected buildings in CNB are being designed with grid connected building integrated photovoltaics (BIPV) systems. This uses solar panels to replace architectural elements in a building and the solar power is directly injected into the electrical grid without the use of storage batteries [2]. The first pilot experimentation was done in an offshore island and led to a live implementation in Tuas Naval Base. The pay back of BIPV without storage batteries ranges between 5 to 10 years. Grid connected wind power generators are being installed along the breakwaters which extend about 1.2 km from the wharves. Through the use of wind power, savings in electrical cables for the supply of 50 street lightings are achieved on top of the 'free' wind energy.

3. Strategic water conservation

The main strategy for water conservation is by reducing potable water demand through optimal use, using alternative sources and water recycling. Alternative sources identified are use of seawater, rainwater and condensate from air-conditioning plants. By using seawater for heat rejection in the air-conditioning plant and process cooling system a saving of approximately 350,000 m^3 per year of potable water is realised.

Rainwater run-off from the roof and condensate water from air handling units (AHU) are collected and stored at high level tanks and is gravity fed to serve non-potable applications, such as toilet WCs, urinals and garden taps, whenever possible. This implementation in CNB has enabled a saving of approximately 30,000m^3 per year of potable water.

COLLABORATIONS, SIMULATIONS AND STUDIES

With the established R&D culture in DSTA, the project teams are able to exploit the ample opportunities to collaborate with and learn from customers, external experts, researchers and technology providers who share common interests in the projects. Computerised engineering and other simulation tools can assist the engineers to evaluate the various design options before deciding on the optimum implementation.

In developing the seawater cooling and thermal storage systems for CNB, experts from Nanyang Technological University (NTU), National University of Singapore (NUS) and DSO National Laboratories, an affiliate of DSTA, are involved to undertake specific studies. These include computer simulation study on the performance of the proposed on-demand district cooling system (condenser water network) [3], performance study on thermal storage [4] and research in corrosion and marine growth controls for the seawater circuit [5]. Computer simulations on daylight and shadow effects were conducted for BIPV implementation [6]. The Artificial Sky chamber available in the Lighting Laboratory, NUS School of Architecture, was used for special daylight studies in buildings. A load optimisation and forecasting software has been jointly developed with NUS for optimising the contracted capacities of our HT electricity accounts. We have also embarked on a pilot project using SCADA to monitor the energy performance of our buildings.

CNB INDIRECT SEAWATER COOLING SYSTEM

One of the highlights in this paper is the collaboration works with researchers from NTU, which covered the optimisation of energy performance for the Indirect Seawater Cooling System in CNB. Complexes loading pattern from multiple users and phased implementation for the development require comprehensive studies and optimisation effort.

The indirect seawater cooling system consists of a condenser water circulation system rejecting heat to a seawater circuit through a heat exchanger. The condensing water system consists of two circuits of constant 500 mm diameter cement-lined ductile iron piping reticulating fresh water throughout the base from a plant housing the circulation pumps and plate heat exchangers. The fresh water loops are 2.91 km, and 1.97 km in length, respectively. Along the circuits are located the various demand nodes such as air-conditioning equipment and electricity generators, which it serves. The plants are located near to the seawater intakes resulting in short seawater piping length. The estimated ultimate capacity of the system is approximately 915 l/s of condensing water with a supply temperature of 32.2 °C and leaving at 37.7 °C (21 MW).

The cooling demand is such that day loads are usually much higher than the night loads upon which may be added the intermittent demands from the electricity generators. Moreover the demand will increase progressively as the capacity of some air-conditioning equipment are increased or more equipment are connected to the system. The system uses staged pumping with variable speed drives for flexibility and economy. The numbers of heat exchangers as well as the corresponding sets of fresh- and sea- water circulating pumps will be installed in phases.

The focus of the design study was to analyse the system operations to achieve optimum energy efficiency over several stages in its phased operation. The flow in the network was solved using the Newton-Raphson method. Flow to various demand nodes was estimated for phased-operation of the system in year 2000, 2002, 2003 and beyond. Figure 1 shows all the estimated operating points plotted against the fresh-water pump curves for the most suitable combination of staged pumps and pump operating speeds.

The system curves of the fresh-water circuits for the entire range of flow and routing through the heat exchangers are next analysed. The resultant head against flow and pump shaft power against flow performance suggest minimising the pumping head requirements by distributing the flow through as many heat exchangers as possible commensurate to its heat exchange performance.

The four plate heat exchangers have a total heat transfer area of 574.72 m^2 each. The fresh water and seawater are in alternate channels and flows through the exchanger in a single pass under counter flow arrangement. Rated design conditions at sea water (cold side) inlet temperature of 29°C and fresh water (hot side) inlet temperature of 42.6°C is 10560 kW exchanged at flow rates of 240 l/s on both sides.

The performance of the condensing- and sea-water heat exchangers were modelled at full- and part load operating conditions (Figure 2). Power savings due to operation of the heat exchanger and seawater pumps depend upon the balance between the two major load components of chillers and generators. At part load operations, which is the more significant operating mode of the system, the study recommended that there is substantial benefits to reduce seawater flow rates and condenser water return temperatures concurrently when the generators and the low temperature chillers are operating. The reason being that significant reduction can be obtained from power savings from the chiller to offset the slightly increased pump power. However when the generators are not operating, it would be advantageous to equalise the flow of the fresh and seawater flow in the heat exchangers. When the normal chillers are used the fresh water flow should reduce with the load and the seawater flow to follow accordingly for the best results.

The system has been in operations since July 2000 and its performance is being tracked.

THE CHALLENGE

Singapore lacks manpower, land and natural resources. To counter these limitations, our defence facilities must be exceptionally effective. In the drive for utility conservation and efficiency, DSTA is propelled by its vision to develop and employ superior technology to provide the critical edge and achieve a force multiplier effect in its services to the SAF and the nation.

The paper has shown how the Utility Management Policy has guided DSTA's BI in its quest to develop resource and energy efficient defence infrastructures. It has integrated energy efficiency and utility conservation measures into its routine decision making process, constantly checking its designs against benchmarks and standards, and seeking innovative technological solutions to energy efficiency and resource conservation.

The experiences of DSTA's BI can provide a model of how others can develop new methods and technologies in the building and construction industry. For us, it is a direct response to the collective challenges faced by the industry on the need for further energy efficiency, professionalism and innovation.

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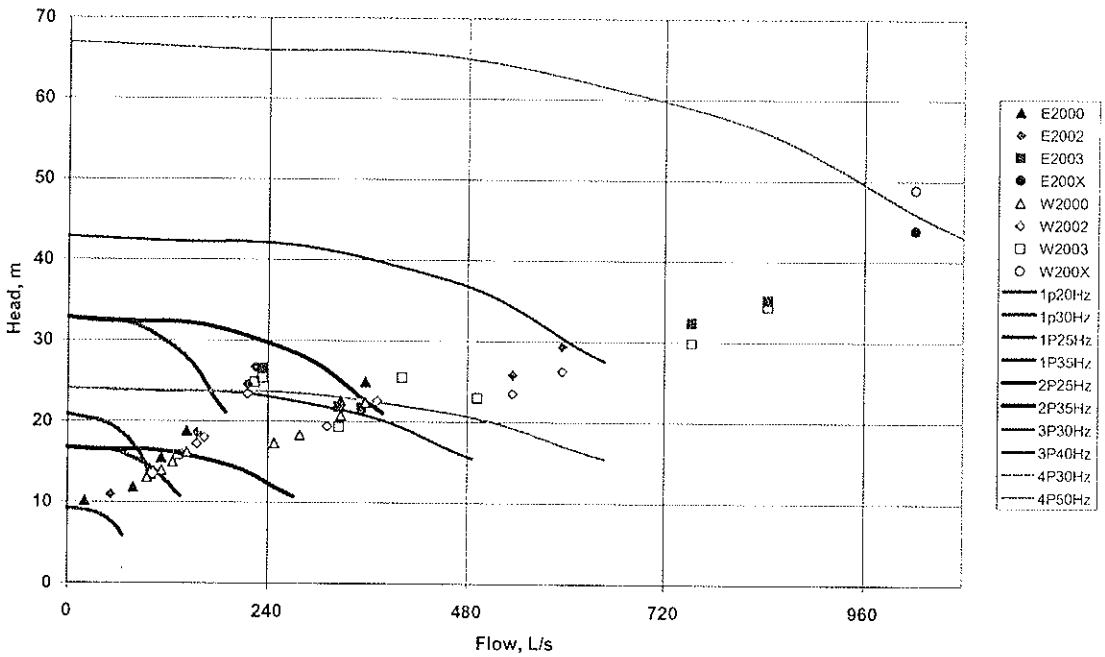


Figure 1 : Staged Fresh-Water Pump Operation Matching Phased-Operation Scenario

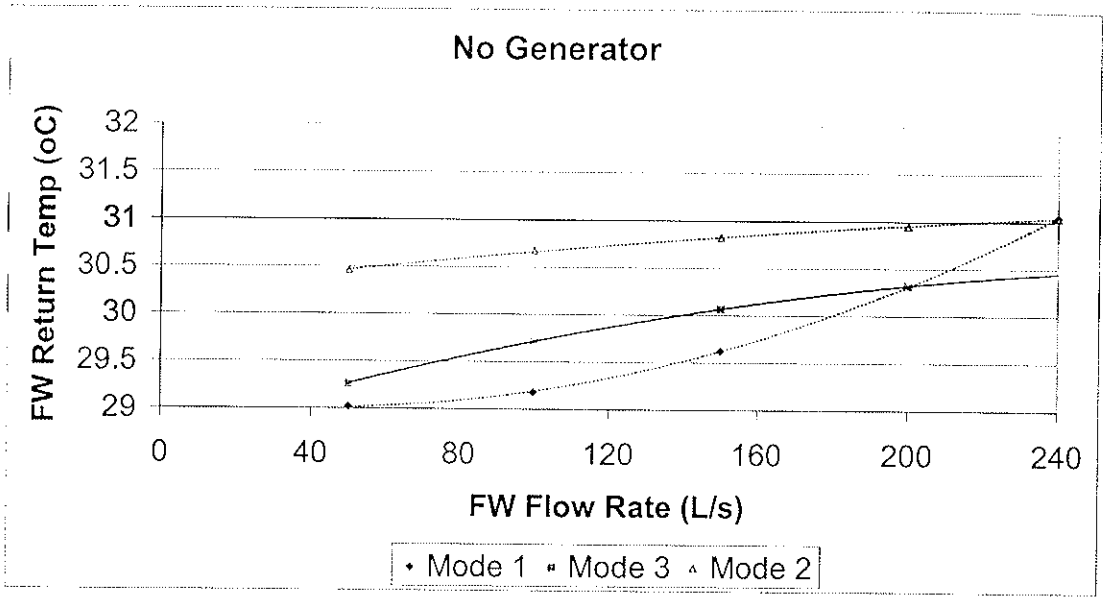


Figure 2(a) : Changes In Condenser Water Return Temperature Without Generator Operation And Under Different Modes

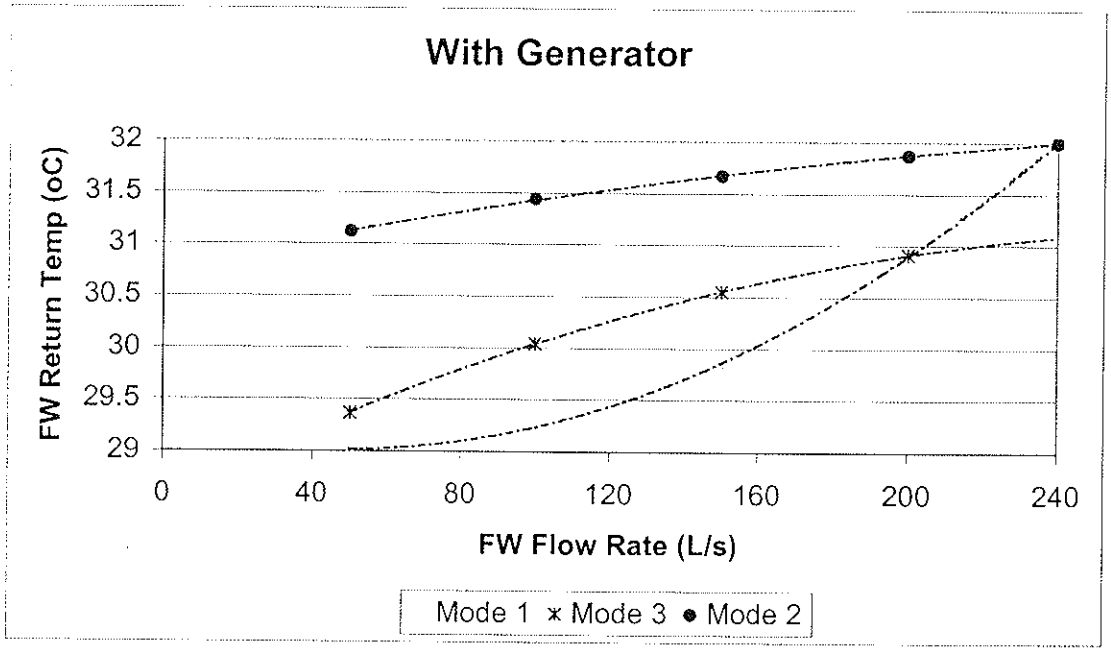


Figure 2(b) : Changes In Condenser Water Return Temperature With Generator Operation And Under Different Modes

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Energy Management System in Changi General Hospital

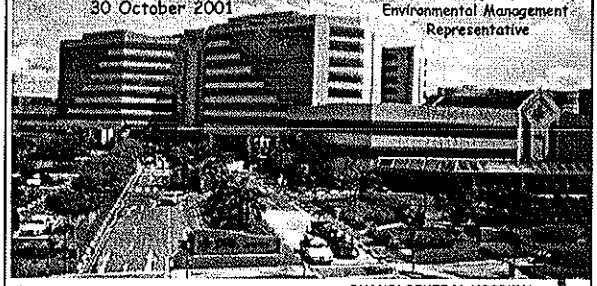
Presented by

Mr Kwan Fook Weng
Manager
Changi General Hospital

Doorways To Energy Efficient Buildings

30 October 2001

Mr Kwan Eook Weng
Manager, Emergency Planning
Environmental Management Representative



Environmental Management System

ISO14001



Staff Suggestion Scheme



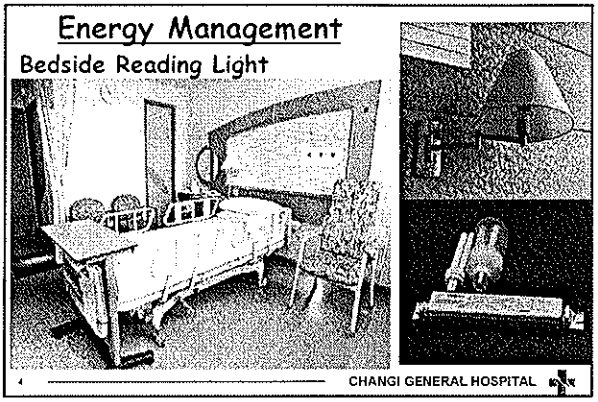
Energy, Water and Waste Management

- Project Teams (multi-discipline)
- EMPs - Objectives and Targets
- Continual Improvement in our EMS

Energy Management in CGH

Energy Management

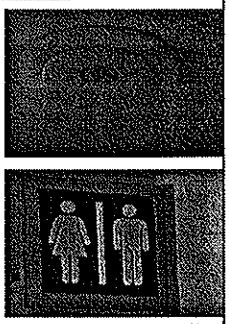
Bedside Reading Light



Energy Management

Lighting Control Sensors

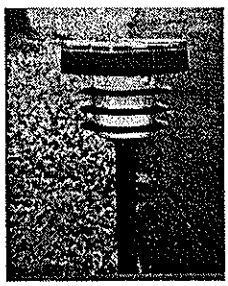




Energy Management

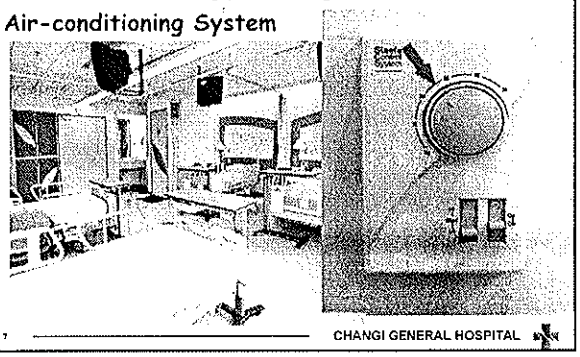
Solar Energy Light (4 units)





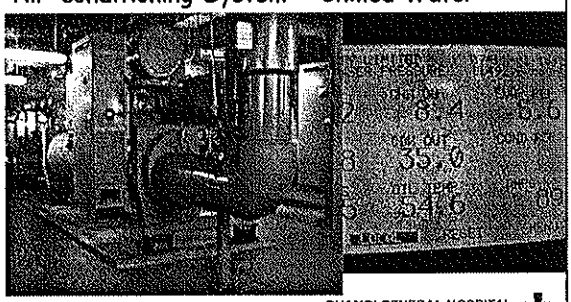
Energy Management

Air-conditioning System



Energy Management

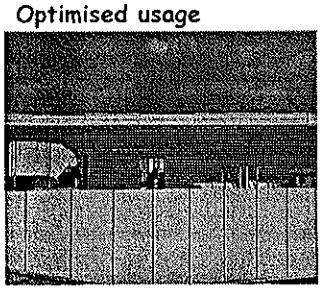
Air-conditioning System - Chilled Water

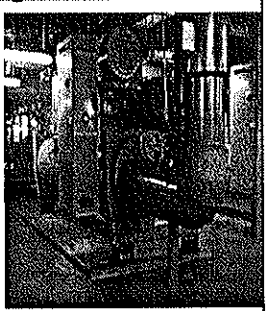


Energy Management

Chillers & Cooling Towers

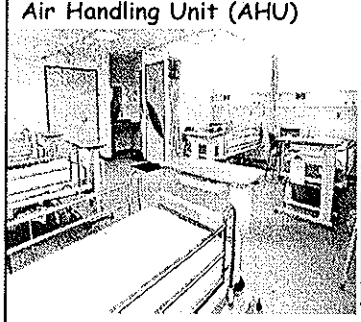
Optimised usage

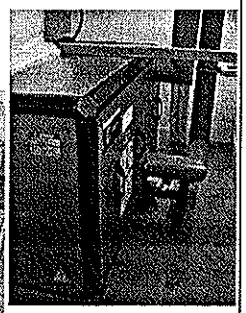




Energy Management

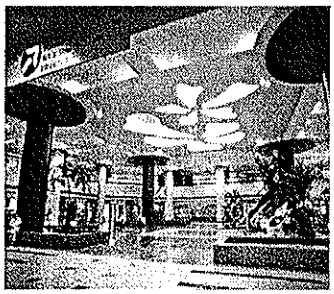
Air Handling Unit (AHU)





Energy Management

Escalators





Energy Management

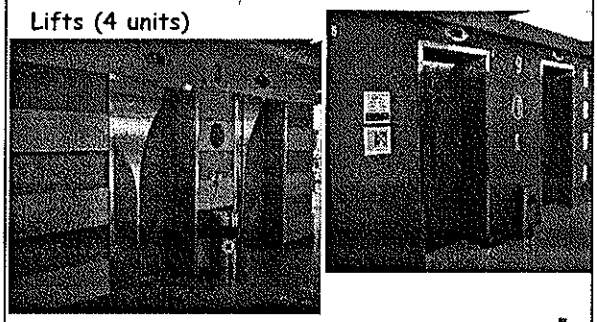
Escalators - 6 units





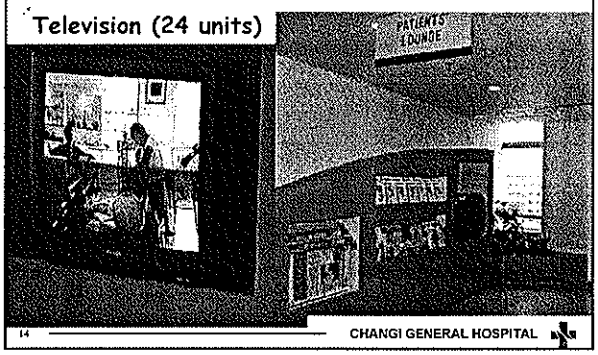
Energy Management

Lifts (4 units)



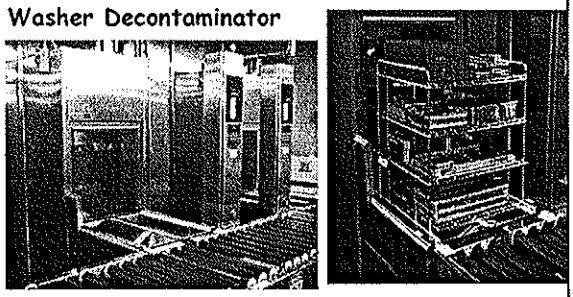
Energy Management

Television (24 units)



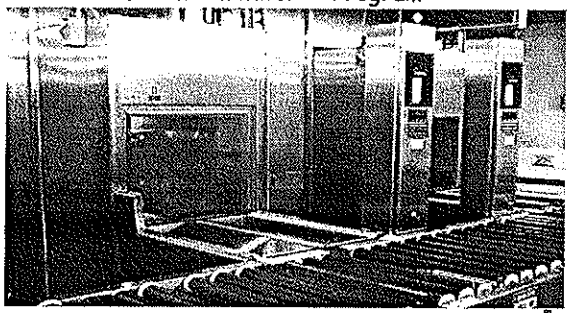
Energy Management

Washer Decontaminator



Energy Management

Washer Decontaminator - Program



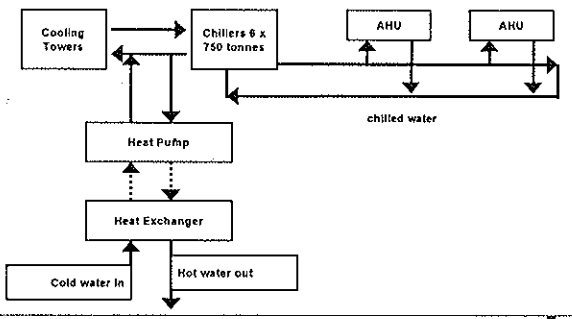
Variable Speed Device

- Modulate the speed of cooling tower fan based on the demand of condensate water temperature
- Advantage
  - Reduce current
  - Reduce cost
  - Reduce fan noise level
  - Reduce wear and tear





Heat Recovery System



SQC Best Practice Network Forum
Temasek Polytechnic - 31 July 2001

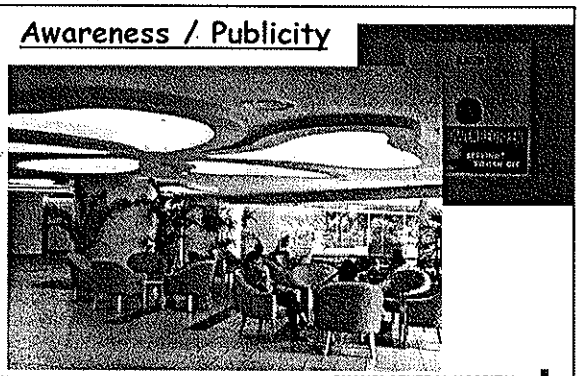
CHANGI GENERAL HOSPITAL ncs making IT happen

Energy Management Critical Success Factors

- Management Commitment and Staff Involvement (Awareness & Training, Publicity & Promotion, Incentives & Recognition)
- Equipment Maintenance
- Energy Conservation Initiatives
- Optimal use of Building Automation System

CGH Awareness Programme

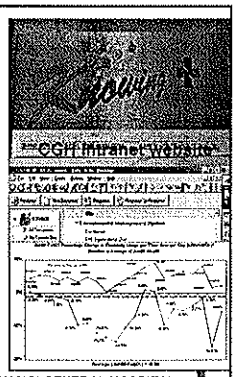
Awareness / Publicity



Awareness / Publicity

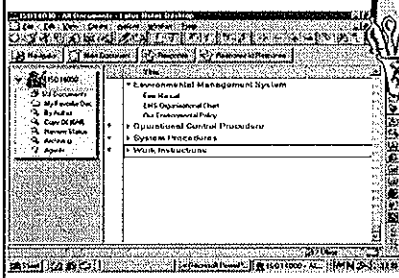
- Create awareness and promote conservation of resources and waste recycling (Newsletter, Exhibition, Intranet, Email, Talks, etc.)

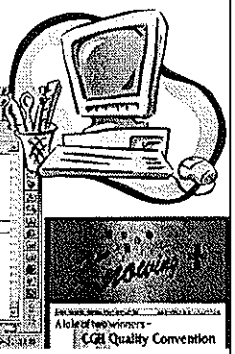




Awareness / Publicity

Computer rating ~ 0.3kW

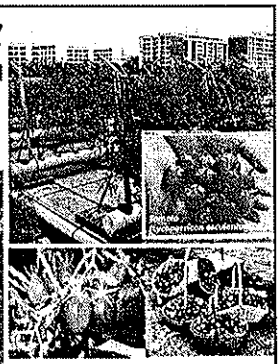




Awareness / Publicity

- Hydroponics plants on Level 4 roof - Pilot project and green effort to promote awareness

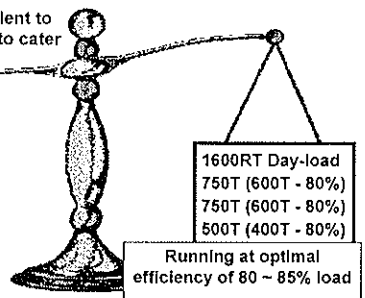




Bloopers

Design and Sizing of Chillers

- More flexible and efficient to have a smaller chiller to cater for part load.



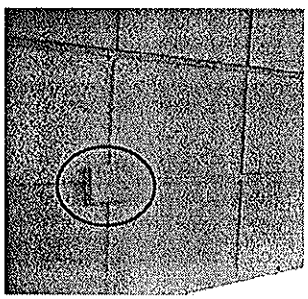
1600RT Day-load
750T (533T - 71%)
750T (533T - 71%)
750T (533T - 71%)

1600RT Day-load
750T (600T - 80%)
750T (600T - 80%)
500T (400T - 80%)

Running at optimal efficiency of 80 ~ 85% load

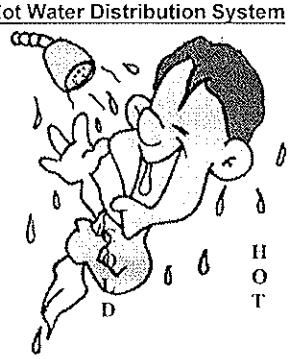
More energy efficient

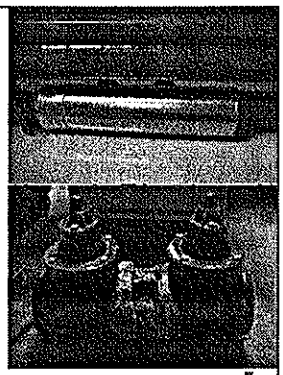
Air-con Temperature Control



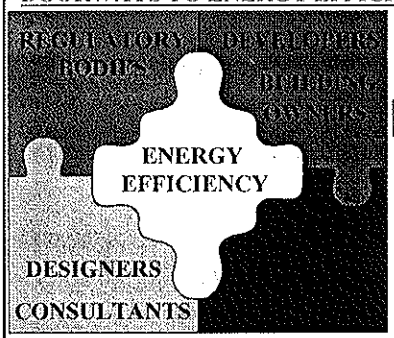


Hot Water Distribution System

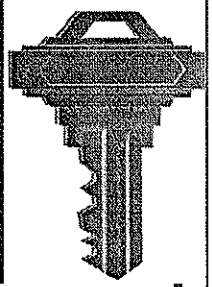




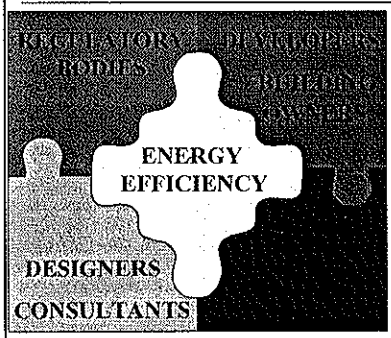
DOORWAYS TO ENERGY EFFICIENT BUILDINGS

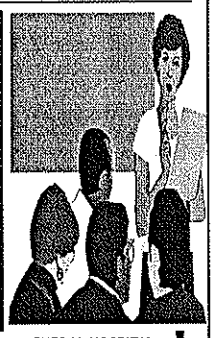


The KEY



DOORWAYS TO ENERGY EFFICIENT BUILDINGS





THANK YOU



Nursing is caring

... caring for our patients
... caring for our community
... caring for our environment

Building and Construction Authority

DOORWAYS TO ENERGY EFFICIENT BUILDINGS

Application of Photovoltaic Power Generation in Singapore

Presented by

Mr Guido Haarpaintner
Marketing Manager
Siemens Showa Solar Pte Ltd

Siemens & Shell Solar

Application of Photovoltaic Power Generation in Singapore

Guido Haarpaintner
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Abstract

Solar photovoltaic (PV) cells convert sunlight directly into electricity – with no moving parts or chemical reactions. This is not to be confused with hot water systems, where the sun's heat energy is used to heat water or another fluid.

The technology has been around for over a century, but PV markets are only recently taking off. The growth comes primarily from grid-connected systems, which feed PV electricity directly into mains power grids.

A common misconception is to propose meeting our future electricity demands by covering vast tracts of land with PV power plants.

A far more realistic and effective approach is to install countless small-scale rooftop PV systems, integrated seamlessly into the public grid.

Incentive schemes in Japan, United States, Europe and Australia encourage private households and commercial enterprises to generate electricity from sunlight and feed it into the public grid. These schemes are driving average annual growth rates that have ranged from 25%-40% in recent years. As production capacity increases, costs will fall further and the market will grow even faster.

PV currently supplies an insignificant portion of the electricity consumed world-wide. But at current growth rates, PV looks set to play a visible role within the next 10-20 years.

Singapore is an ideal location for implementing PV grid technologies with its dense building concentration and fast growing construction industry. The next steps in growing this market require the utility companies to approve grid-connected systems, and the government to set up an effective incentive scheme.

Before long, we can expect all new buildings to include built-in PV generating equipment to make them far less dependent on conventional power supplies.

While a grid tied PV system on the roof supplies power for local use it reduces not only the electricity bill and grid transmission losses but also the need for expensive grid upgrading. At the same time the PV modules can act as an extra external skin of the building, prolonging the lifetime of the roof cladding and adding insulation against thermal losses from air-conditioned rooms underneath.

The Singapore electricity pool already trades energy in half-hourly time slices with price variations exceeding a factor of 2 between the midday peak, when air-cons and fridges are all running full throttle, and at night time, when conventional power stations run below optimum capacity. Solar electricity can supply power just at the time when it is dearest. Thus shaving off the grid peak load, future investments into central power station can be postponed.

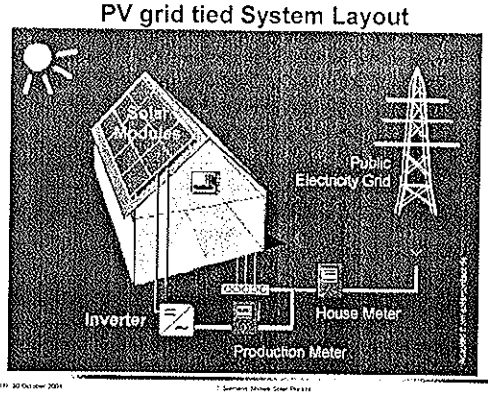
Siemens & Shell Solar

Application of Photovoltaic Power Generation in Singapore

Guido Haarpaintner
Siemens Showa Solar

Siemens & Shell Solar

PV grid tied System Layout



PV cell technologies

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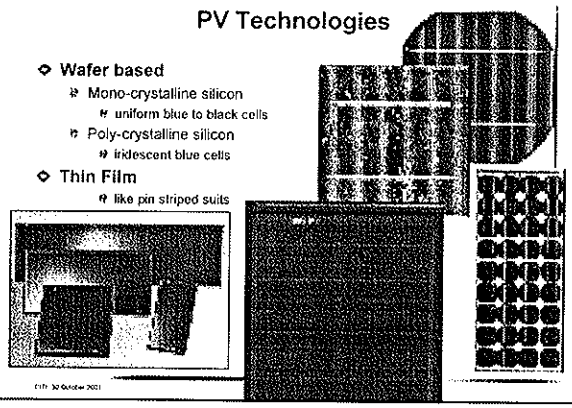
PV Technologies

- Wafer based
  - Mono-crystalline silicon
    - uniform blue to black cells
  - Poly-crystalline silicon
    - iridescent blue cells
- Thin Film
  - like pin striped suits



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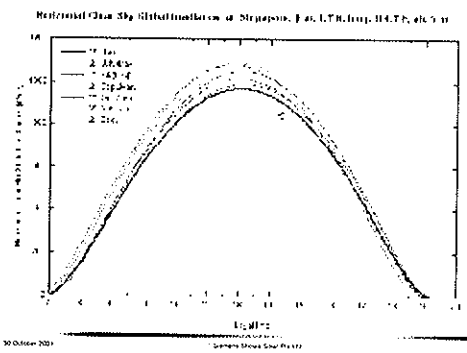
Horizontal Solar Energy distribution in Singapore



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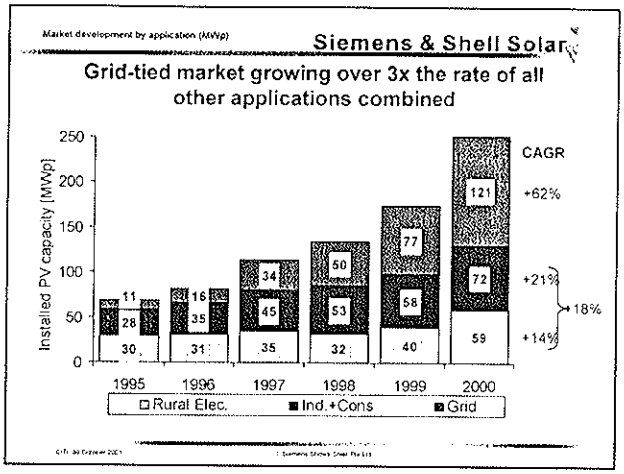

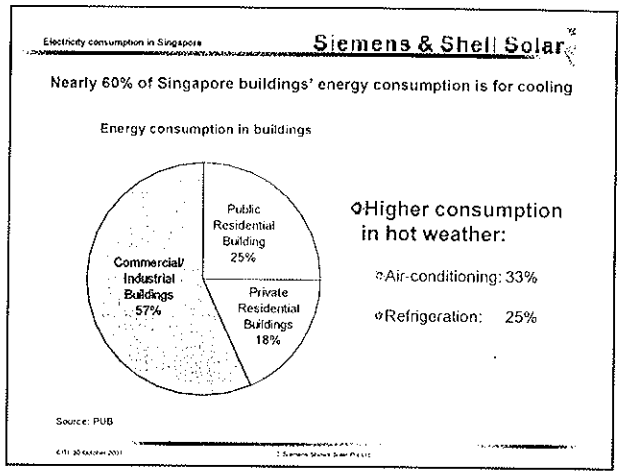

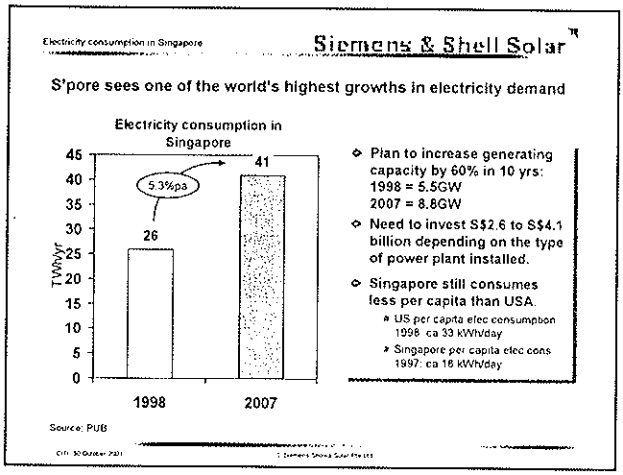

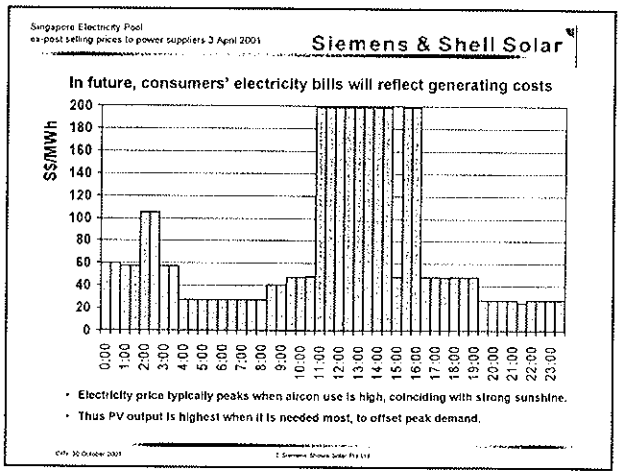

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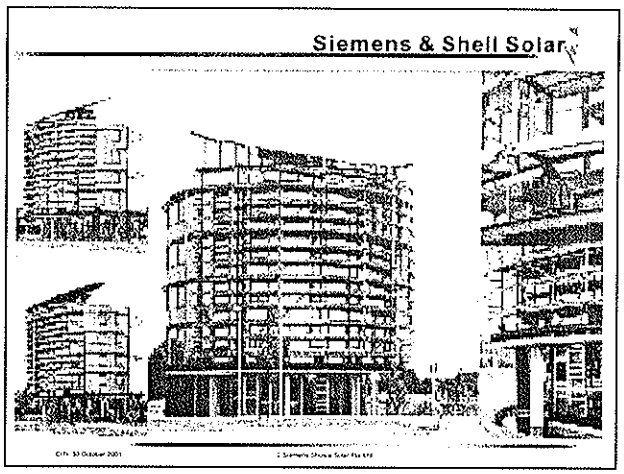

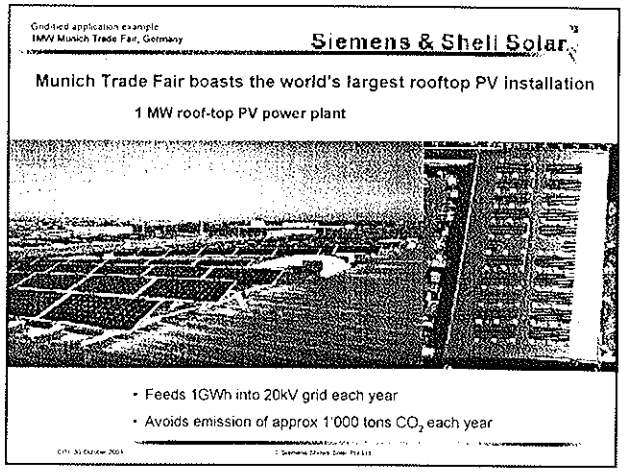

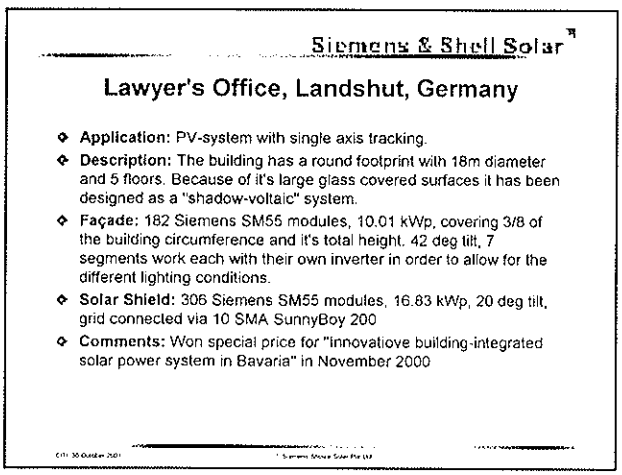

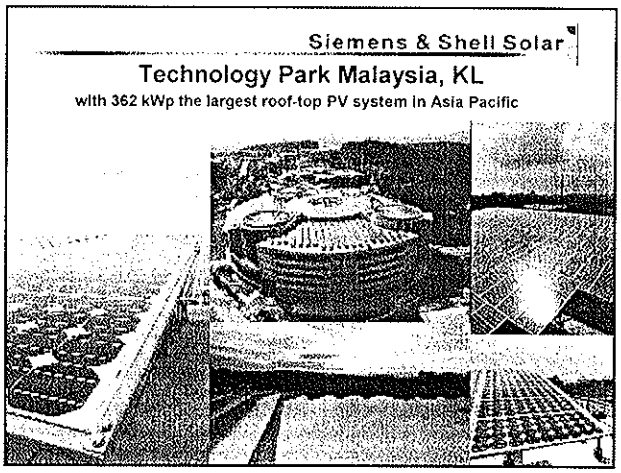

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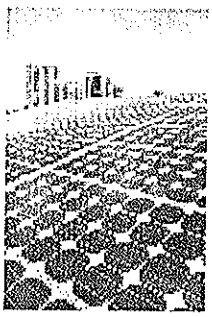
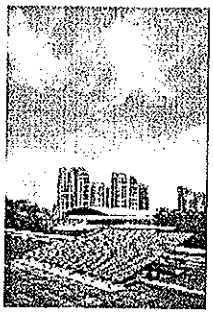
Singapore CITI, 2.5 kWp





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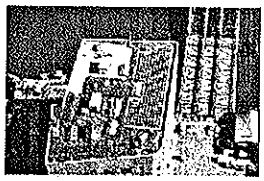
US coastguard Boston - 35 kWp

- Flat Roof mount
- includes insulation
- almost like the Singapore skyline!





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Flat Roof mount

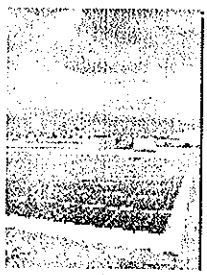
Mauna Lani Resort

- 120 kWp
- neat roof finish with side flashing
- environmental resort
- popular with European tourists



Anaheim Convention Centre

- 100 kWp



Non-economic benefits of a PV system

Siemens & Shell Solar

Why invest in a grid-tied PV system on your roof?

- Comparing the cost per kWh is only partly relevant today ...
  - People do not buy a PV system just to lower their electricity bills
  - People do not buy a luxury car just to travel from A to B
  - People do not buy a fancy watch just to tell the time
- Image is important; stand out from the crowd:
  - Project a green corporate image:
    - TPM, Van Melle Candy Factories, Hawaii Resort, ST Microelectronics, ...
  - Contribute to a cleaner environment
  - Free press saves a lot in advertising costs
- Extra security against power cuts
- Take advantage of government subsidies - recover your own taxes!
- One day, fossil fuels WILL run out...

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