Energy Performance of Hotels in Singapore

Towards Performing Energy Smart Hotel
3rd August 2007
Singapore

Lee Siew Eang

Energy Sustainability Unit
Department of Building
School of Design and Environment
National University of Singapore

Background - Literature

One of the most energy intensive building categories

- **Mediterranean Greece – 273 kWh/m²** (Santamouris *et al.* 1996)
- **Hilton and Scandic hotels in Europe – 364 kWh/m2 and 285 kWh/m2 respectively** (Bohdanowicz *et al.* 2006)
- **US lodging buildings – 402 kWh/m2** (US Commercial Building Energy Consumption Survey Database, 1995)
- **Ottawa, Canada – 612 kWh/m2** (Zmeureanu *et al.* 1994)
- **Australia – 208 kWh/m2 and 292 kWh/m2, best practices for accommodation and business hotels** (Australian Government, 2002)
- **Hong Kong – 542 kWh/m2** (Deng, 2003)
- **Singapore – 468 kWh/m2** (APEC, 1999)

Background – Hotel Industry

- **227 registered hotels (Hotel Licensing Board), including 89 members of Singapore Hotel Association (SHA)**
- **Preponderance of many 4 and 5-star hotels on Singapore's skyline, as high land cost encourages hotel developers to shun budget options and instead build luxury hotels where cash flows are more substantial.** (Cornell Hotel and Restaurant Administration Quarterly, 1997)
- **Total room supply of 36,861 in 2005, with annual increase of about 1,000 new rooms**
- **2006 saw the historical heights of average occupancy rate (85%) as well as average room rate (S$164)**

Data Collection

- **Started from end of 2005, lasted until mid of 2006.**
- **A comprehensive survey form – historical energy data, building physical features & operating characteristics, building service systems, indoor environment, etc.**
- **Organizations like SHA helped in disseminating the survey form**
- **Post, e-mail, follow-up phone calls**
- **Site visit and face-to-face interview with hotel engineers**

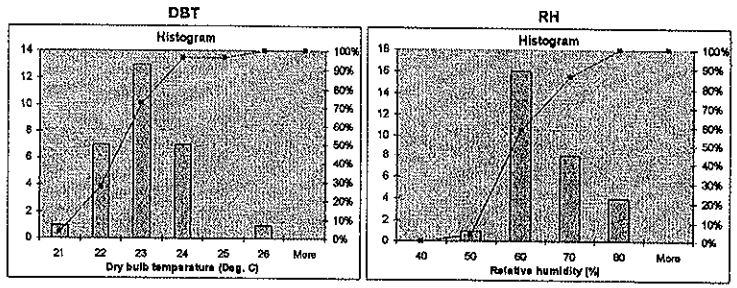
Data Collection - Result

Completed datasets collected from 30 hotels, 29% of gazetted hotels in Singapore

General characteristics of surveyed hotels

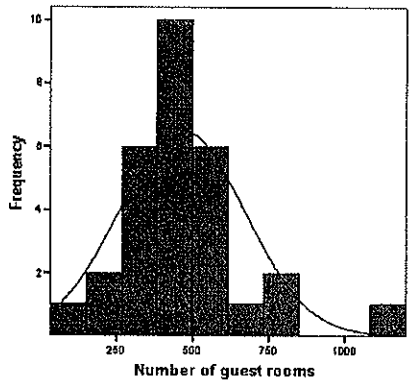
---	Minimum	Maximum	Mean	Std. deviation
Gross floor area (m^2)	1648	101998	33650	21207
Number of rooms	32	1200	464	208
Standard room area (m^2)	24	41	30	5
Age	1	75	20	14
Number of storeys	5	51	22	11

Data Analysis - Indoor Environment



DBT usually within the stipulated range, while RH in some hotels at the high end or even out of the acceptable range

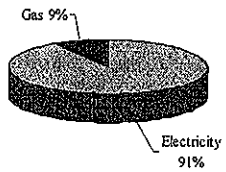
Data Analysis – Number of Guest Rooms



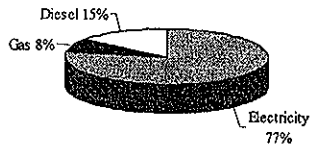
- The distribution is roughly normal
- Confirmed by test of normality (skewness/standard error = 0.04, kurtosis/standard error = 1.13, all approaching 0)

Data Analysis - Fuel Mix

Hotels with no diesel use



Hotels using diesel



Electricity is the main energy source, supplemented by gas and diesel, the latter being used for cooking or in boilers.

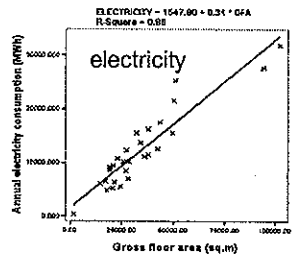
Data Analysis - Correlation

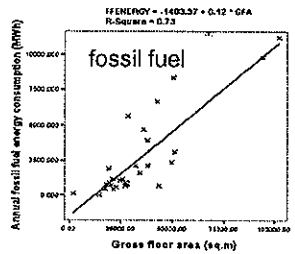
Correlations (R^2s) between energy use and hotel capacity indicators

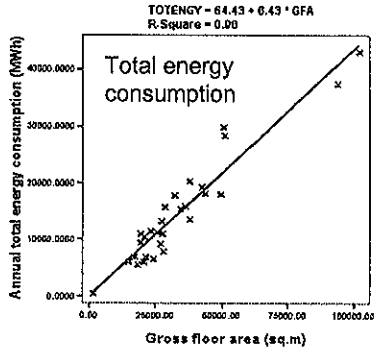
Capacity indicator	Electricity	Fossil fuel	Total
Gross floor area	0.86	0.73	0.90
Number of guest rooms	0.72	0.53	0.72
Number of occupied room-nights	0.71	0.48	0.70

Amongst all primary determinants, gross floor area has the best predicting power, i.e. best correlations with hotel energy use, which is indicated by higher R^2s.

Data Analysis - Regression







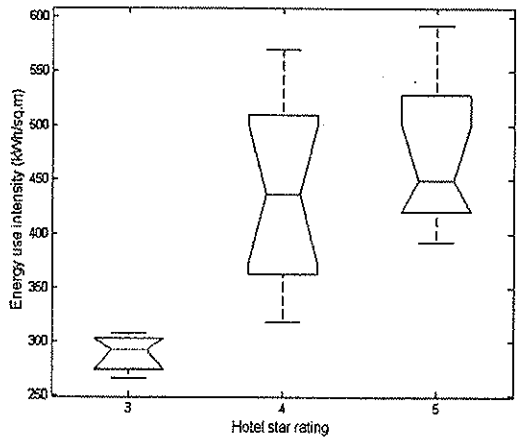
Data Analysis – Energy Use Intensity

Summary statistics of hotel total energy use intensity

Energy Use Intensity (EUI)	Minimum	Maximum	Mean	Std. Deviation
kWh/m²	264.71	592.33	426.96	95.89

Total energy consumption divided by gross floor area

Data Analysis – EUI and Hotel Star

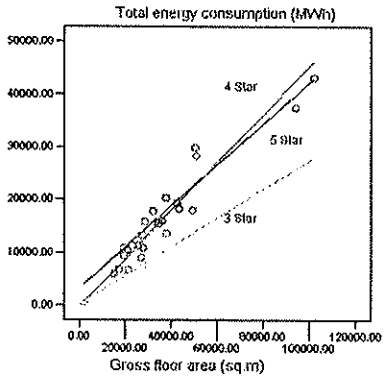


ANOVA analysis shows no significant difference between EUIs of four- and five-star hotels, but both differ significantly from that of three-star hotels.

In other words, three-star hotels generally use less energy per unit floor area than four- and five-star ones, a result of the different levels of amenities and services provided.

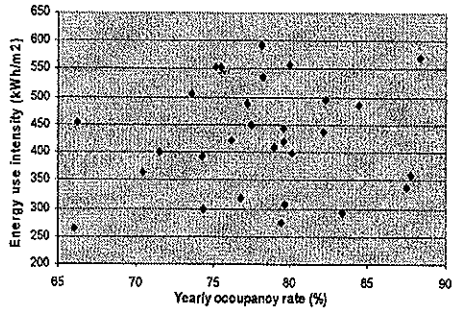
Data Analysis – EUI and Hotel Star

Total energy consumption vs. gross floor area



Regression lines confirm that three-star hotels are different from hotels of higher classes in terms of energy use patterns, but the difference between four and five-star hotels is not significant.

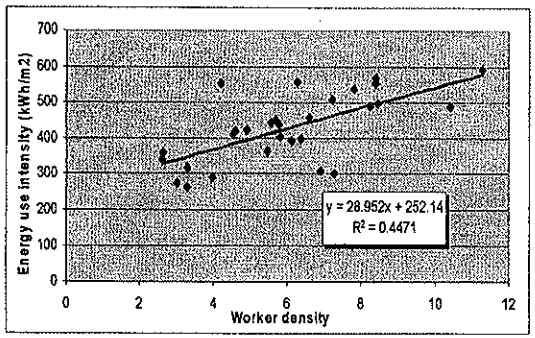
Data Analysis – Occupancy Rate



No visible pattern could be observed between hotel energy use and occupancy rate.

Good energy management rather than low occupancy rate is the reason why some hotels use less energy than their peers do.

Data Analysis – Worker Density



Worker density is an indicator of the activity level (functions held, meals served etc.) in hotels. The positive relationship clearly shows that energy use goes up when there are more activities.

Benchmarking Hotel Energy Use

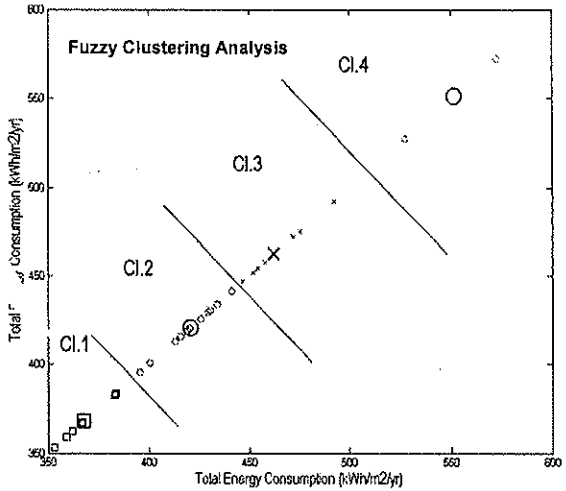
1. 21 physical and operational characteristics were examined in detail using stepwise regression procedure to identify statistically significant variables.
2. Normalization of floor area and star rating to make comparison of energy performance fairer and more meaningful
3. A benchmarking curve and an easy-to-use normalization procedure for hotels to do preliminary analysis of their energy performance and set achievable target for improvement

Hotel Energy Classification

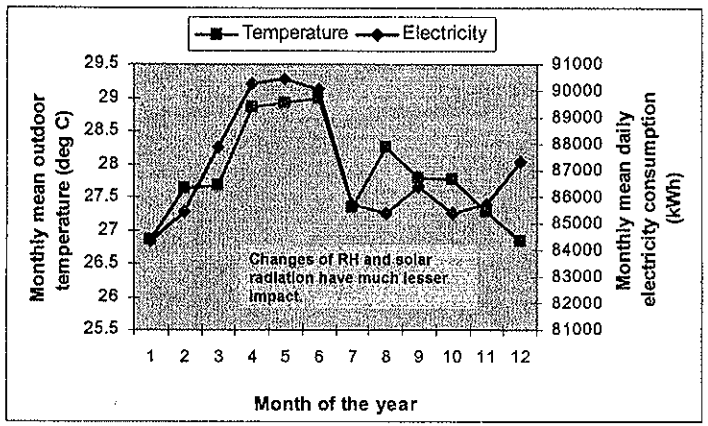
1. Purpose: to cross validate the results of equal frequency classification method
2. Method: intelligent fuzzy clustering analysis (fuzzy c-means)
3. Result: hotel classes determined on the basis of energy consumption and the natural 'clusters' existing in their distribution

Energy Classification

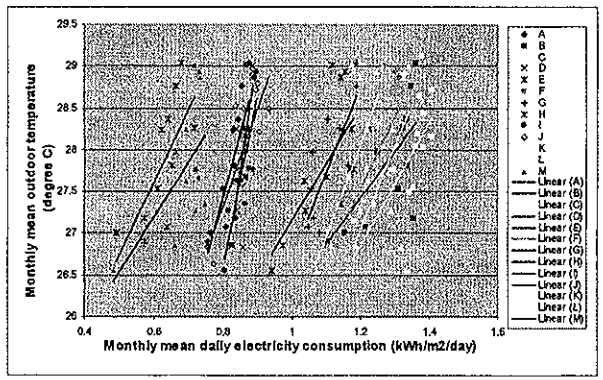
The first class corresponds to the top 25% in equal frequency method, showing consistency of results from two techniques



Energy Use and Weather Conditions



Energy Use and Weather Conditions



Though cooling is a non-linear process, the linear trend lines provide a very good understanding of how hotel buildings respond differently to changes of outdoor temperature, with the slopes indicating their respective thermal responsiveness.

Greenhouse Gas Emissions

Take into account the most recent efficiency advancement in Singapore's power generation sector when calculating CO_2 emissions factors

Calculate carbon footprint of hotels using greenhouse gas emissions accounting convention of the UN GHG Protocol Corporate Standard

Establish a direct link between the contributions made by individual businesses and the whole nation's carbon reduction target

Conclusion

Compared to the APEC database, average energy use intensity in Singapore hotels dropped from 468kWh/m2 to 427kWh/m2, evidence of improved energy efficiency in this sector.

Singapore hotels consume about 1,120GWh of energy, around 10% of energy use in buildings, and emits 644kilotons of carbon dioxide every year.

By going 'Energy Smart', a reduction of 15 to 25% in energy use is achievable in most hotels without the need of overall retrofit and replacement of major energy consuming equipment.

Acknowledgement

The ESU would like to acknowledge the following:

The Ministry for the Environment and Water Resources,

The National Environment Agency,

Industry members who support generously in the sharing of data and building information,

Staff and colleagues at ESU and NUS.

Thank you

For further information
And benchmarking, visit - www.esu.com.sg

Dr Lee Siew Eang

Head, Energy Sustainability Unit

School of Design and Environment
National University of Singapore

bdgleese@nus.edu.sg

An Introduction to Energy Smart Hotel

The Energy Smart Building Labelling Programme aims to grant recognition to best practices in building energy efficiency. The Label serves as a sign of excellence and hence creates values for the awarded buildings. In addition, it enables facility managers to set targets and work towards better energy efficiency by employing resources more effectively.

The first scheme of this Labelling Programme, Energy Smart Office, was launched in December 2005, and 8 office buildings were awarded the Label. These buildings are among the nation's top 25% in terms of energy performance, maintain a healthy and productive indoor environment, as well as uphold a minimum performance for different building systems.

As a popular tourist destination, Singapore attracts millions of visitors from overseas every year and the tourism sector has experienced constant growth over the past years. In 2006, it generated an estimated $ 12.4 billion in tourism receipts, and welcomed 9.7 million visitors. Both are historical heights in the tourism industry. Over the next two years, about 1,000 more hotel rooms will be put into use each year to meet the increasing demand. And another 4,300 new rooms will be added to the inventory when the two Integrated Resorts are completed by early 2010.

On the other hand, studies conducted in Singapore and other parts of the world all identified hotels as one of the most energy intensive building categories. Having more hotels in Singapore's skyline means the sector will impose extra pressure on the nation's energy supply, and its collective impact to the environment will inevitably become larger. Singapore acceded to the Kyoto Protocol in April 2006. No doubt, this commitment to combating climate change as part of the global effort requires contributions from all sectors, especially those energy and carbon intensive ones.

The second Energy Smart scheme, Energy Smart Hotel, was thus developed with the hope of bringing the prospering hospitality industry in line with the nation's "green" strategies. It is also an effort to broaden the scope of this energy efficiency initiative, which has already achieved some success.

Like the first scheme, Energy Smart Hotel was developed on the basis of a thorough and extensive survey, in which building physical features and operational characteristics as well as energy use data were collected from a representative sample of 30 quality hotels in Singapore. The data was then subject to rigorous analyses using techniques like multivariate regression and fuzzy clustering analysis. Among other findings, a hotel building energy benchmarking system was established, which provides an equitable platform for determining relative energy performance of hotel buildings and setting achievable targets for improvement.

By giving recognition to best performing hotels in energy efficiency, it is hoped that the scheme can create a "pulling effect" in the sector, which will motivate the less efficient to take actions in order to reap the benefits coming alone with energy efficiency. Amongst these benefits is reduction of energy related operating costs. The soaring oil price actually gives further justification to going "Energy Smart". Another important aspect of the scheme is it encourages hotels to target higher energy efficiency without compromising on the comfort and productivity of the occupants; hence strict requirements on indoor environment quality are set, which ascertains that a labeled building is not only energy efficient but also provides a healthy and productive environment. In addition, the Label serves to demonstrate an organization's commitment to environment protection and therefore projects a "green" image to the hotel guests as well as the general public.

The first step towards Energy Smart Hotel is to determine a building's current performance with an established and sound protocol. This can usually be done by engaging an accredited energy service company (ESCO), who will measure and verify the building's overall as well as system-level performance. If the building meets the criteria set for the Label, it qualifies for immediate award. If not, the building owner may engage the ESCO to do a more detailed study, which is expected to identify areas of inefficiency and set realistic benchmark targets. An action plan should then be created and implemented in order to meet these performance targets. After that, the measurement and verification process will be conducted again, and the award be presented if all requirements are met. The Energy Sustainability Unit at the National University of Singapore evaluates the applications submitted and also undertakes the responsibility of the award's management.

Building Name: The Regent Singapore
Address: 1 Cuscaden Road, Singapore 249715

The Regent Singapore consists of a 12-storey open atrium tower with a total of 439 guest rooms. Most areas are air conditioned, except staircases and the two floors for car parking. The gross floor area of the building is approximately 42,483 square meters.



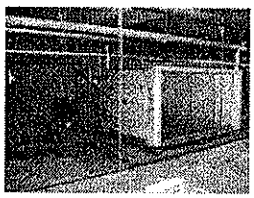
Measures have been taken to reduce lighting energy consumption, notably, shifting to electronic ballast and replacing conventional light fittings with energy efficient bulbs. Some of these measures are as follow.

- Car park lighting: from T8 36w batten with convectional ballast to T5 28w batten with high efficiency electronic ballast;
- Staircases from Level B1 to Level 12: convection light fittings 100w tungsten to energy saving PLC 20w;
- Guest room corridors: from T8 36w batten with convectional ballast to T5 14w and 18w batten with high efficiency electronic ballast;
- Chandeliers at guest room corridors: From light bulbs ping pong 25w to Energy saving 11w light bulbs.

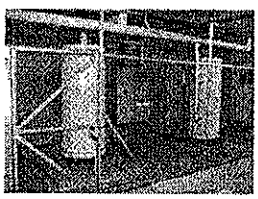
The air-conditioning system was optimized; chillers were properly sequenced to meet the varying loads throughout the day, and VSDs were installed for the chilled water system to control the speed pumps according to the water pressure to meet the required temperature.



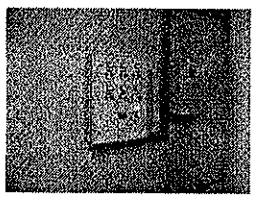
Hot water Storage Cylinders



Air-Cooled 60T Chiller



Heat exchangers



Backup Heater panel

In January 2006, the hotel replaced its boilers with a thermawater system. This heat recovery system completely eliminated the diesel consumption previously existed in boilers, and gas consumption was also reduced significantly. In addition to supplying hot water for the whole hotel, the system also produces chilled water, which is fed to the chilled water pipes and, hence reducing the load on the existing plant. A simple invest-to-return analysis shows that the project has a very favorable payback period of 1.8 years. Together with other energy saving measures implemented, the hotel realized an energy use reduction of about 26% in terms of kWh consumption in 2006 compared to the previous years.

Building Name: Shangri-La Hotel, Singapore
Address: 22 Orange Grove Road, Singapore 258350

Shangri-La Hotel, Singapore underwent a major renovation in year 1999. Three chiller plant rooms were incorporated into one centralised chiller plant room, resulting in savings of $1,000,000 in energy bills each year. This enabled the hotel to achieve the BCA EBBA Award in 2002 as well as the Asian Energy Efficient Award.

During the upgrading, Shangri-La Hotel also upgraded its BMS system with monitoring capability. The monitoring system assists the engineering department to keep a close watch on chiller plant room operations and performance, and help the department generate a maintenance and continuous improvement plan. Thanks to this maintenance plan, after seven years of operations, the upgraded chiller plant room still maintains a good system efficiency of 0.7kW/ton, a record that many buildings strive to achieve.

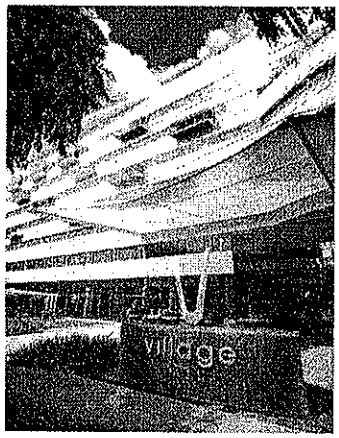
With plans for continuous improvements in energy savings, Shangri-La Hotel, Singapore reviewed all sensors and upgraded them to increase energy savings. The hotel also reviewed all kitchen exhaust operation hours and incorporated variable speed drives into the system. It also checks, calibrates and ensures proper settings of thermostats to reduce wastages.

One of the major initiatives the hotel undertook was to upgrade the lighting at the back-of-house areas. Shangri-La Hotel, Singapore upgraded the back-of-house lighting from the conventional Magnetic Ballast with T8 lighting to Electronic Ballast with T5 lighting. This change resulted in 25 per cent energy savings in terms of lighting and lighting in these areas was brighter by 10 per cent, thus improving working conditions for the staff.

Other improvements that Shangri-La Hotel, Singapore implemented are:
Installation of a heat recovery system to provide air conditioning system for the lift motor room and to provide hot water.
Replacement of the Service Residences' hot water electrical heater with a heat recovery system. This system harnesses heat from the existing air-conditioning system to produce hot water for guests.
Upgrading and replacement of the garden and landscape lightings. This has a huge impact on energy savings and beautifies the hotel's surrounds during sunset.
Replacement of existing diesel boilers to a newer and more efficient hot water system.

All properties under Shangri-La Hotels and Resorts have a commitment to save 12 per cent on the costs of total utilities. In order to achieve this goal, positive changes were made through cutting wastages, implementing best practices and carrying out a good preventive maintenance program.

Building Name: Changi Village Hotel
Address: 1 Netheravon Road, Singapore 508502



Far East Organization recognizes the needs and benefits in energy efficient investments. Back in 2004, a conscious decision was taken to employ the state-of-the-art chillers with variable speed drive pump sets. Accompanied with proper maintenance and optimized operations, the chiller plant efficiency achieves a level below 0.7kWh/RT.

Changi Village Hotel was also able to design energy efficient lighting system throughout the hotel lobby, corridor and guestrooms and achieving the highest standard of ambience.

Also, a reverse cycle heat recovery system was installed to produce hot water in place of the regular electric heater. Since hotels usually have high demand of hot water, systems like this can generate very favorable economical payback.



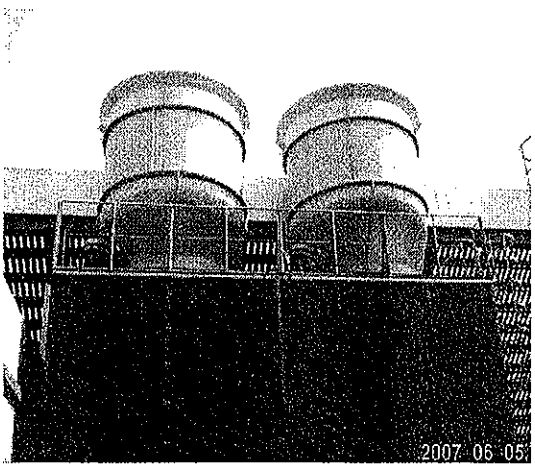
Building Name: Intercontinental, Singapore
Address: 80 Middle Road, Singapore 188966

The award winning Intercontinental Singapore showcases an unrivalled celebration of Singapore's rich heritage with its distinctive Peranakan architecture, elegant interiors and a contemporary tower for those who prefer to stay in colonial style rooms. On the other hand, this elegant architecture also features good energy efficiency, a fruit borne to the hotel management's determination and continuous efforts to bring about energy efficiency improvement and environmental impact reduction.

The Intercontinental, Singapore has good daylighting design in the lobby lounge area at 1st storey. Natural daylight goes through the skylight glass to reach the lobby lounge. In addition to lighting energy saving, it creates a natural and more comfortable environment for the guests. Besides, both dry bulb temperature and mean radiant temperature in the lounge area are within the acceptable ranges, ensuring that utilization of daylight has not comprised thermal comfort.



Cooling Towers are placed on the rooftop area which has quite a large space for heat rejection. Round ducts are installed above cooling tower which are connected to fan motor and heat can be rejected fully without occurrence of short air circle. Therefore, the cooling tower is operating quite efficiently, which also contributes to the overall efficiency of the chiller plant.



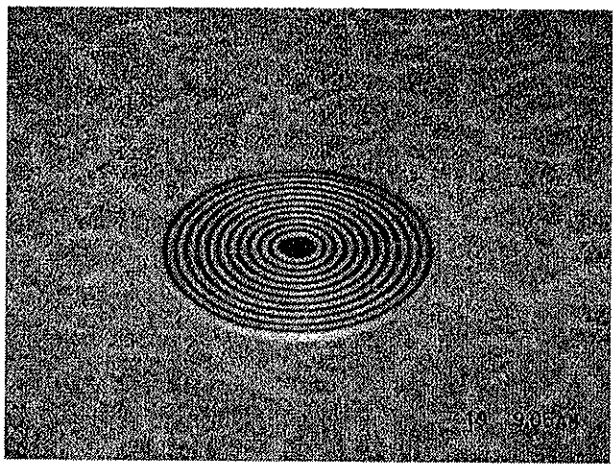
As in other air-con buildings, makeup air is induced into the building to maintain good indoor air quality for hotel occupants. The outdoor air provided in guest rooms ranges from 17 to 27 litres per second per room, which is well above the acceptable level of 15 liter per second per room in CP13. Besides, all thermal comfort parameters in the hotel satisfy the requirements as stipulated in the Energy Smart Hotel Technical Guide.

Building Name: MOE Building
Address: 1 North Buona Vista Drive, Singapore 138675

The MOE Building features innovative daylighting design. Light shelves that form part of the façade draw daylight and reflect it into the office area, and the ceiling near windows is slanted to ensure even gradation of the natural light. Thanks to good daylight utilization, provision of lux level by artificial lighting can be reduced to 300lux from the standard of 500lux. Lighting energy is further decreased by extensive use of energy efficient bulbs and adopting a general-task combination lighting strategy, which results in an impressively low lighting power density of 3.51W/m^2. To cut down heat gains from the facade, windows are all double-glazed, so that the benefit of lighting energy reduction will not be offset by extra heat gains from windows.



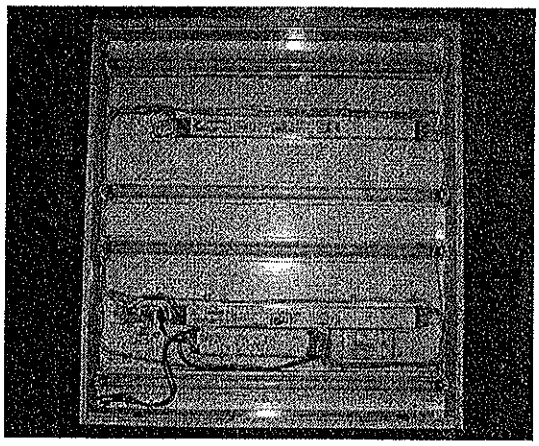
An under-floor air supply system is used in place of the conventional overhead system. It makes use of the displacement strategy and hence provides more effective cooling by allowing the air temperature to be set at a higher value as compared to the overhead system, while maintaining the same level of thermal comfort, thus saving energy consumption in air-conditioning the building.

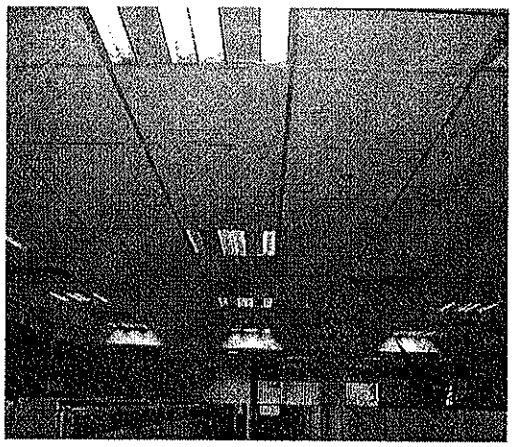


The chiller plant was optimized by making adjustments to the chilled water supply temperature and other parameters, and variable speed drives were installed for both condenser water pumps and on the air side to achieve better matching between supply and load. In addition, rooms with occasional use are installed with FCUs to provide the flexibility of turn-on-off according to whether there is any occupancy and demand.

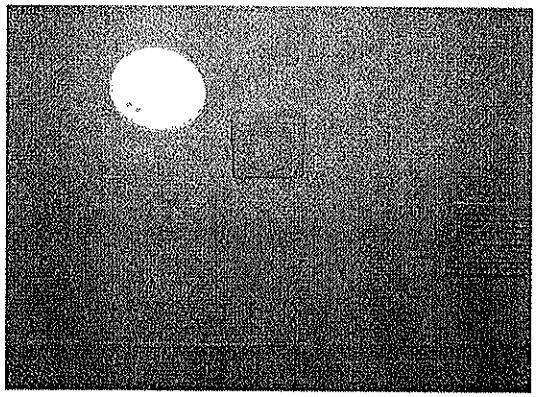
Building Name: Ministry of Foreign Affairs Building
Address: Tanglin, Singapore 248163

Ministry of Foreign Affairs is using energy efficient lightings (T5 lamps) for its offices and corridor areas. The use of T5 lamps combined with electronic high frequency ballast can save energy by up to 40% compare with equivalent standard TL-D systems.

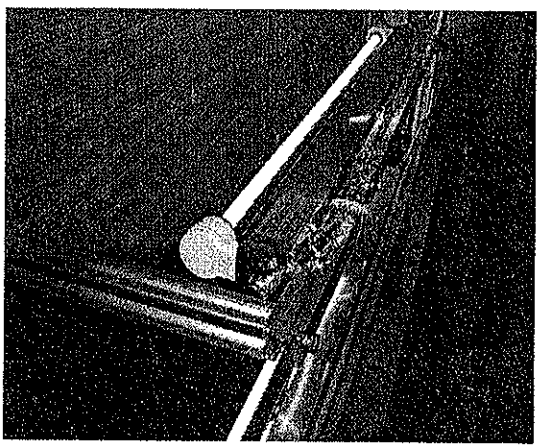


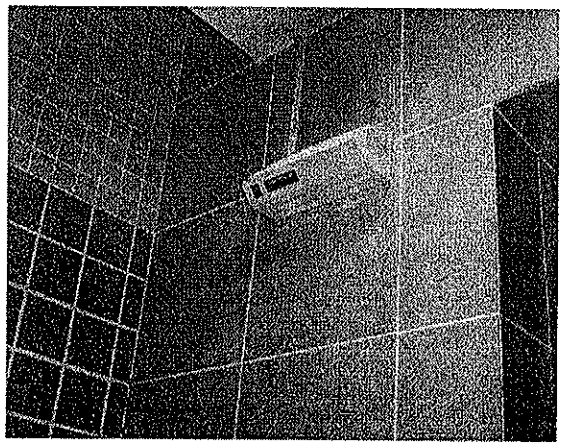


Motion sensors are installed in all toilets and pantries. Energy savings are realized since these areas have highly variable and unpredictable occupancy patterns.



MFA has installed ultra-violet lamps after the cooling coils of all its Air Handling Units, toilets and offices. UVC emitter produces high output of UVC photons to kill bacteria, viruses and mould, thus it improves indoor air quality. It also provides continuous disinfection and coil cleaning. Clean coils help to improve the heat transfer between air and coils. Hence saving of air conditioning energy is achieved.





Building Name: Defence Technology Tower A
Address: 1 Depot Road, Singapore 109679

Defence Technology Tower A (DTTA) is an 11 year-old building, which has some of the energy efficient systems being installed to ensure low energy usage. As DTTA is a typical office building, the main energy consumption comes from the air-conditioning system and lighting. As air-conditioning uses the main bulk of the energy, more effort has been focused on optimising the efficiency.

DTTA uses a centralised water-cooled chilled water system for the entire building's air conditioning requirement. The air-conditioning system serves the offices, lobby, data centre, canteen and library. A chilled water system has been used instead of less efficient stand alone direct expansion units.

Fresh air is being introduced into building via primary air handling units. The primary air handling units treat the fresh air through a charcoal filter before being pre-cooled and introduced into the building. This results in pressurising the building, hence preventing air leakage into building while maintains good indoor air quality.

To ensure efficient operation of the air-conditioning system, DTTA uses an intelligent BMS system to control the air-conditioning and ventilation systems.

The air handling units are being controlled using timer control to ensure unnecessary operation of air-conditioning after office hour.

The chillers are being controlled using load demand calculations by the BMS. During raining day when load is reduced due to lower ambient temperatures, the BMS will determine if it is necessary to operate the additional chiller.

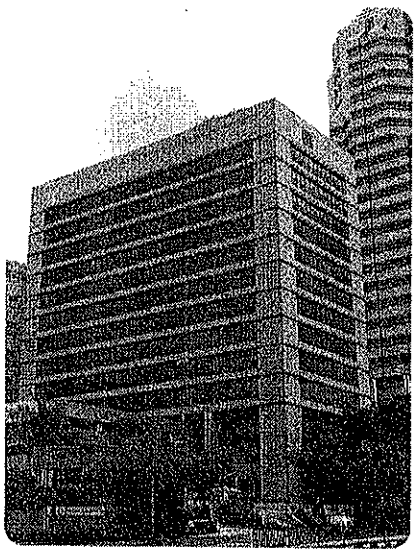
DTTA also uses auto tube-cleaning machines on the chillers. These auto tube-cleaning machines regularly clean the inner tubes of the chillers' condenser. With the regular cleaning, the chillers' efficiency is maintained over the years.

As for lighting, DTTA uses low-energy electronic ballast, which saves about 10 to 15% on the lighting. On top of lighting consumption, the heat load on the air-conditioning system is reduced.

Building Name: 450 Alexandra Road, HPAS
Address: 450 Alexandra Road

Since the millennia, with robust energy conservation program and full support of the management, HP Singapore has saved and avoided more that 16GWh of electric energy for its operations here. That is 11,000 metric tones of CO_2 equivalent and good for energy consumption of 6,000 households staying in 5-room flat for 5 years.

HPAS being one of many core sites of HP Singapore has got numerous features that directly contribute to this achievement. Some of these are:



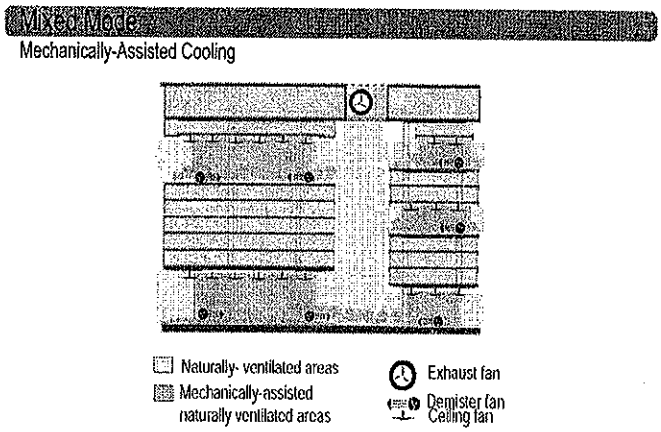
- 100% high efficiency electronic ballast – which is about 30% more efficient than conventional magnetic ballast.
- 100% windows with sun shade
- BAS control lighting (car park, compound and lamp posts)
- Office lighting switch-off – by operation technician and security officer.
- Chiller optimization – demand based morning start up by temperature control instead of timer control.
- BAS control air conditioning equipment start up and shut down.
- BAS energy trending – ensuring energy consumption is within the control and identifies any saving opportunities.
- Air con operation hour standardization – to minimize unnecessary wastage.
- VSD for AHU/exhaust – demand base part load operation

In addition to being prudent in energy usage, the EHS and IAQ programs also help to ensure air quality in office spaces is within the stipulated requirements. The Energy Smart Office label is a due recognition for the team that has been consistently contributing to the HP Singapore's operation. It marks the solid achievement despite the fact that it's an old building with the last major revamp of the critical equipment was back in 1995.

Building Name: National Library Building
Address: 100 Victoria Street, Singapore 188064

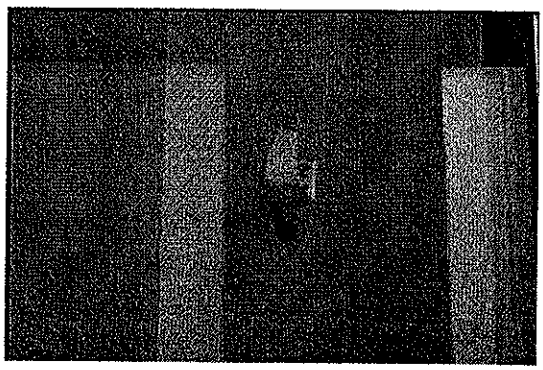
The National Library Building, which spans 16-storeys with a floor area of approximately 58,000 square metres, was designed as a state-of-the-art library design and an innovative library in the tropics that serves as an icon for the region and locality. The building is an innovative "green" (environmentally-responsive) tropical building designed using bioclimatic design techniques (e.g. passive low-energy systems, passive lighting concepts, climate-response building orientation and built form configuration, effective façade systems and bioclimatic use of landscaping). Some of these innovative energy efficient design features are briefed as follows.

Acknowledging that comfort is as much a question of lifestyle and perception as it is about cost and energy, a mixed mode ventilation strategy was adopted where natural ventilation is supplemented by mechanical means such as fans, in central transition spaces (internal street, public events plaza and courtyards).

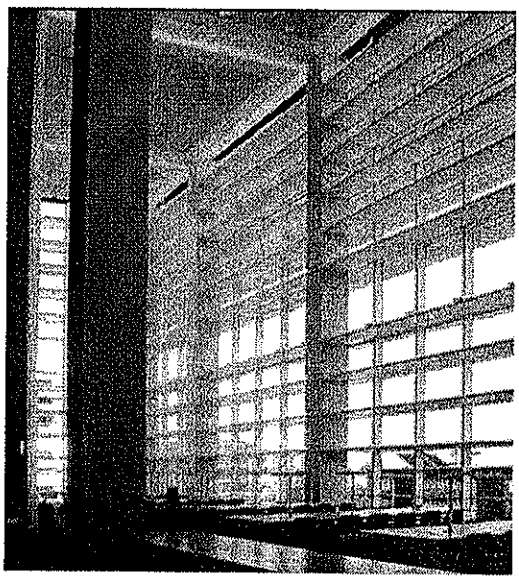


Mixed-Mode (mechanically-assisted systems) devices are located at transitional spaces to enhance user comfort.

Light sensors at the perimeter of the library areas allow the lighting control system to dim or switch off lighting when there is satisfactory natural light component to illuminate the building interior. Also, automatic blinds are located along the facades facing Victoria and North Bridge Road which will activate as necessary during the day to reduce solar gain and thus reduce air-conditioning load.



Light sensor



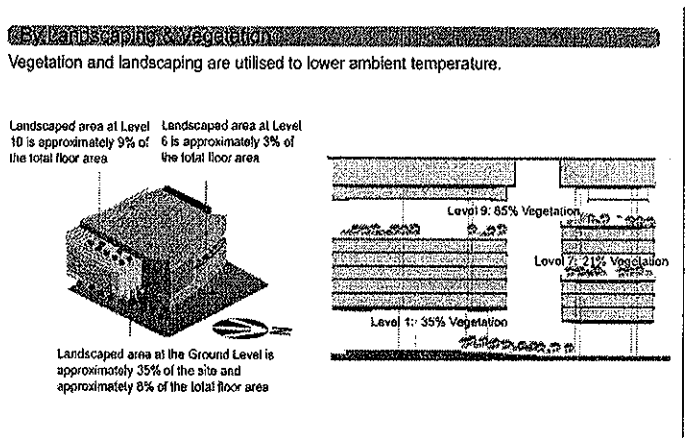
Adequate daylight - lights along perimeter switched off

About 2/3 of the building façade is double-glazed with high quality low-emissivity glass. The OTTV is 32.1 W/m2 and U-value for the glass is about 1.62W/m2K. In addition, the building is also heavily shaded to reduce solar heat gain through the façade.



High efficiency chiller of 0.61kW/RT has been provided for the project. The chiller plant is also configured with larger non-essential centrifugal chiller and smaller essential screw chillers which double up as the night-load chillers as well as a swing chiller in the day. The chilled water system employs a primary and secondary chilled water circuit with variable speed drive installed for the secondary chilled water pump. Better energy efficiency is thus achieved through a lower pump static for the constant speed primary chilled water pump and a reduced pump speed in the secondary circuit when the chilled water demand is low.

Approximately 6,000-8,000 m2 is designated 'green space' through out the library that creates urban "Sky courts" providing a positive psychological effect on building users and improving general working environments. The presence of these landscaped areas in the building reduces the surface temperature of the roofs due to the shading effect of vegetation and also reduces the heat transfer into rooms below, thus improving indoor thermal environment and thermal performance of the building.



Government Initiatives in Energy Efficiency and Clean Energy

National Environment Agency

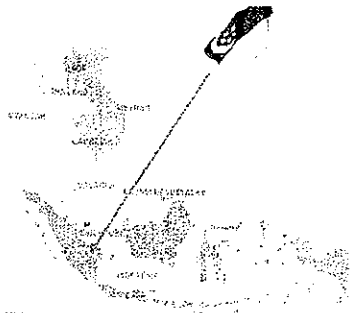
Ram Bhaskar

3 Aug 07



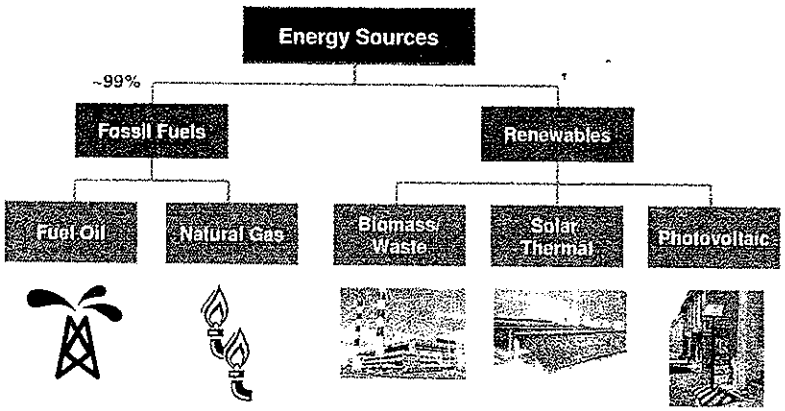
Introduction

- Small city-state
  - Total land area of 699 sq km
- High population density
  - Population of ~4.5 mil
- Highly industrialised economy
- Dependent on imported fossil fuels
- Lack of natural resources and renewable energy sources





- Singapore's Primary Energy Use

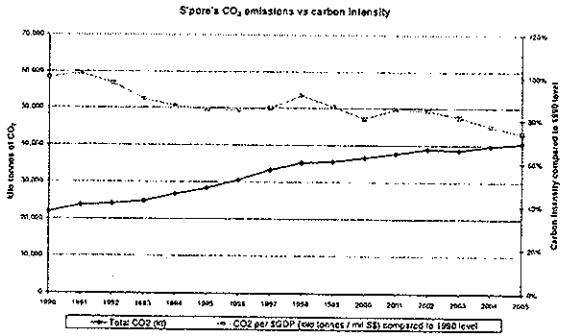


- Energy Consumption (2005)

	Electricity Generation	Industry	Transport	Buildings	Consumers/ Households	Others
Primary Consumption (combust fuel)	48%	33%	17%	1%	~1%	-
Secondary Consumption (use electricity)		21%	3%	14%	8%	2%
Overall		54%	20%	15%	9%	2%

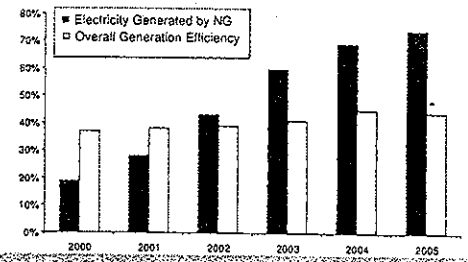
Singapore Green Plan 2012 Target

- To improve carbon intensity (CO_2 per $GDP) by 25% from 1990 to 2012
  - Carbon intensity in 2005 was 24% below 1990 levels



Electricity Generation

- Competitive electricity market
  - Introduced in Jan 03
  - Gencos have switched to NG fired combined cycle generation technologies over last 10 yrs in anticipation of market competition
  - Competition is expected to continue to drive improvements in generation efficiency



Electricity Generation

- Cogeneration
  - 800 MW natural gas-fired cogeneration plant by SembCorp Cogen
  - 500 MW natural gas-fired cogeneration plant by Keppel Merlimau Cogen
- Trigeneration
  - Demonstration projects
    - Pfizer Asia Pacific / TPGS Green Energy - 5MW facility
    - Schering Plough / TPGS Green Energy - 10MW facility

Industry

- Energy Efficiency Improvement Assistance Scheme (EASe)
  - $10 million incentive scheme introduced in Apr 05
  - NEA provides a grant of up to 50% of the cost of engaging accredited ESCOs
  - Open to manufacturing companies, building owners/operators etc
  - About 60 companies have signed up so far
  - $1 spent on an investment grade audit generates $5 - $10 in annual savings
  - Average payback period ~ 2.5 years

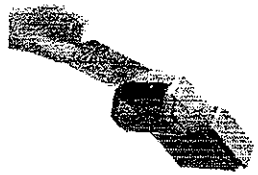
Transport

- Accelerated Depreciation Allowance Scheme
  - Introduced in Jan 96
  - Eligible companies can claim accelerated depreciation allowance on qualifying equipment

Energy Efficient Equipment	Energy-Saving Devices

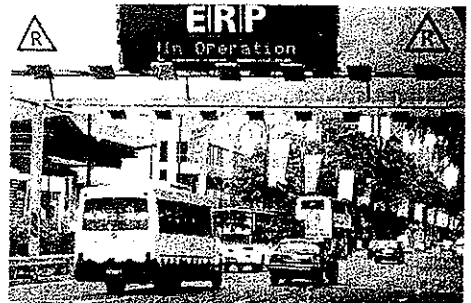
Transport

- Congestion/road usage taxes
- Vehicle population growth cap





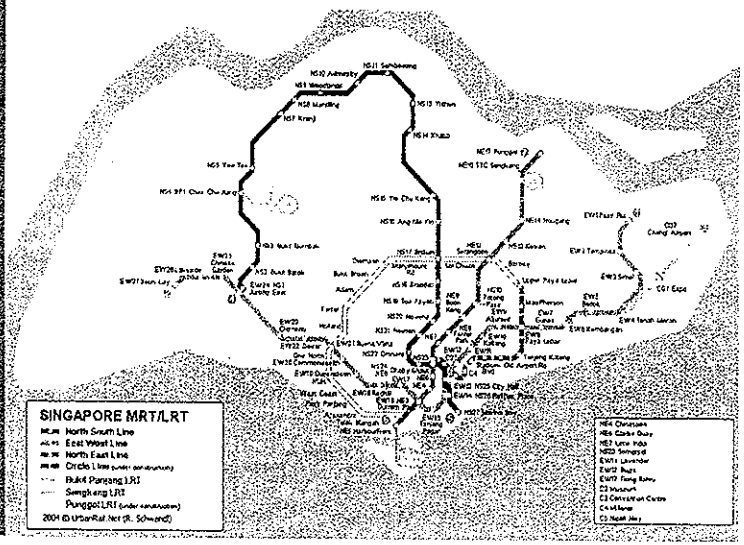
36 carparks included under Park & Ride Scheme



Vehicle Quota System & Electronic Road Pricing are effective measures to curb growth of vehicle population and excessive road usage

Transport

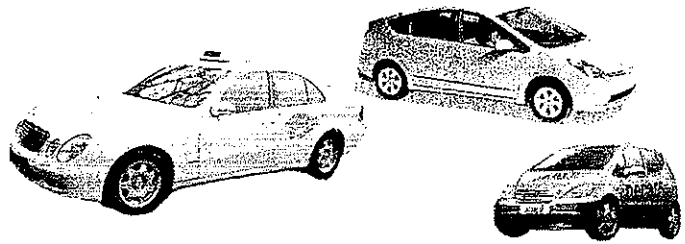
- Promotion of public transportation modes



Transport



- Promotion of green vehicles
  - Hybrid, fuel cell cars
  - Natural gas-powered taxis and buses
  - Green vehicle tax rebates
    - 40% of OMV for electric, hybrid, and CNG cars
    - 5% of OMV for CNG buses
    - Valid until 31 Dec 2009



Transport

Fuel Economy Labelling Scheme

- Voluntary scheme launched in Jun 03
- Provides information on fuel economy of passenger cars at the point-of-sale
- Jointly administered by Singapore Environment Council (SEC) and NEA
- Fuel Economy labels affixed on car models in showrooms
- To-date, 81 car models, representing 18% of available models, registered
- Mandatory labelling under review

SUZUKI Hyundai

TOYOTA HONDA

JAGUAR

Buildings

Regulations and standards

- Building and Construction Authority's Building Control Regulation for air-con buildings (revised in Jan 2004)
  - Maximum permissible Envelope Thermal Transfer Value (ETTV) and Roof TTV (RTTV) levels
  - Minimum efficiency requirements for air-con systems exceeding 30 kW referenced to SS530
  - Maximum lighting power budget

Buildings

Energy Efficiency Improvement Assistance Scheme (EASe)

FOUR SEASONS HOTEL Singapore

SingTel

HARILELA HOTELS

RAFFLES HOTEL SINGAPORE

Buildings

Energy conservation projects

- Energy audit of common area services in 40 blocks of Aljunied Town Council
- 14% - 18% potential energy savings uncovered
- Results and recommendations shared with Town Councils



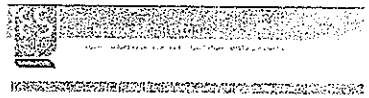
Buildings

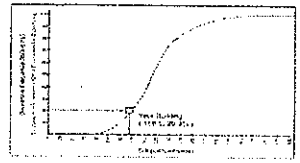
- Government taking the lead
  - All government buildings with more than 15,000 m² of air- conditioned space to be audited by 2010
  - All new government buildings to attain Green Mark status
- Energy efficiency improvement of public sector buildings under Economy Drive initiative
  - Pilot performance contracting for public sector buildings
  - Standard performance contracting documents developed
  - Two models: shared savings and guaranteed savings



Buildings

- Energy Smart Building Labelling Scheme
  - Accord recognition to buildings with good energy performance
  - Proviso – indoor environmental quality must be good

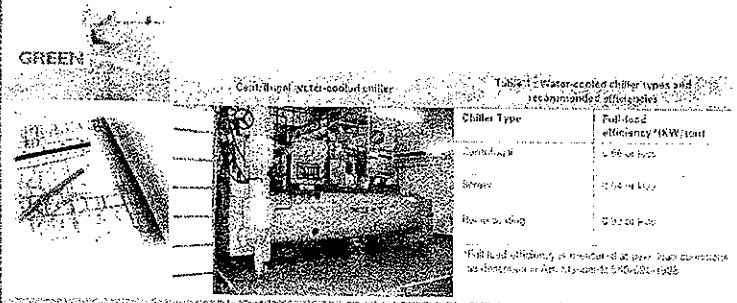




Buildings

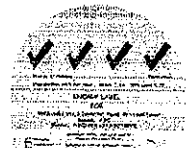
BCA GREEN MARK

- BCA Green Mark
  - To promote sustainability in the built environment
  - 35% of scoring devoted to energy efficiency
- BCA Green Mark Incentives



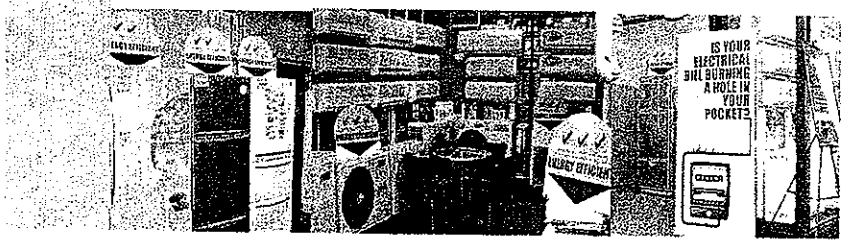
Buildings

- Energy labelling of household appliances
  - Launched in Apr 02
  - Jointly administered by Singapore Environment Council (SEC) and NEA
  - Covers refrigerators and air-conditioners, which typically account for 40-65% of household electricity consumption
  - Currently, about 25% of air-conditioner and refrigerator models are labeled
  - Mandatory labelling to be introduced from 1 Jan 08



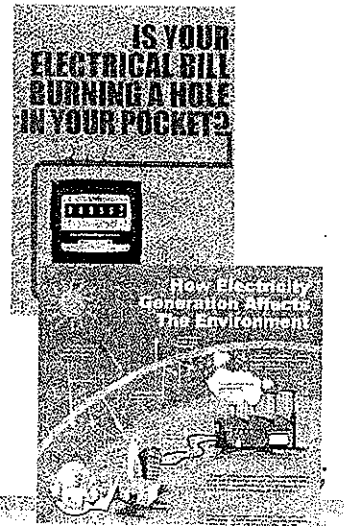
Green corners

- Launched in Mar 03
- Participating retail stores commit to:
  - Sell labelled products exclusively
  - Allocate space to feature labelled products
  - Ensure that at least 35% of displayed appliance models are labelled



Raising awareness for energy conservation



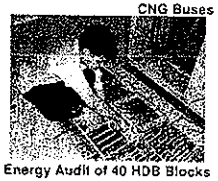


$20 mil fund to encourage and assist companies to undertake innovative projects for environmental sustainability


CNG Buses and Taxis


Conversion of Diesel Commercial Vehicles to Run on CNG


Conversion of LPG Taxis to Run on CNG


Energy Audit of 40 HDB Blocks

Energy Projects under IES Fund

Schering-Plough

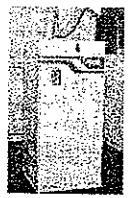
Pfizer

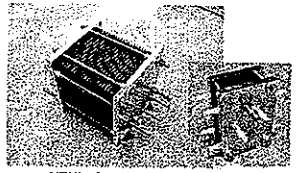
Trigeneration Facility


Intelligent Lighting Control and Monitoring System


Fuel Cell Backup Power Supply System

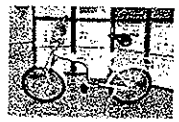

BIPV at Biopolis

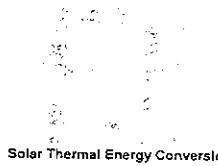

PEM Fuel Cell System


NTU's Compact Fuel Cell Stack

Joint research with tertiary institutions

- Projects of practical value to NEA and of academic interest to universities
- Costs and incomes shared
  - Compact polymer fuel cell stack for use as clean portable power source
  - Solar thermal energy conversion using nano-technology
  - Thermal performance of façade materials and design and impacts on indoor and outdoor environment
  - Designs for a low energy responsive façade
  - BIPV designs
  - Steam ejector heat pump cooling by automobile exhaust heat
  - Bicycle powered by fuel cell stack


Fuel Cell Bicycle


Solar Thermal Energy Conversion


NUS Study on Façade and Roof Materials and Design

Kyoto Protocol

Kyoto Protocol (KP)

- Entered into force on 16 Feb 05
- Set emission targets for 38 industrialised countries
  - reduce GHG emissions by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012
  - USA and Australia did not ratify KP
- Developing countries, including Singapore, have no emission targets
- Singapore acceded to the KP in Apr 06

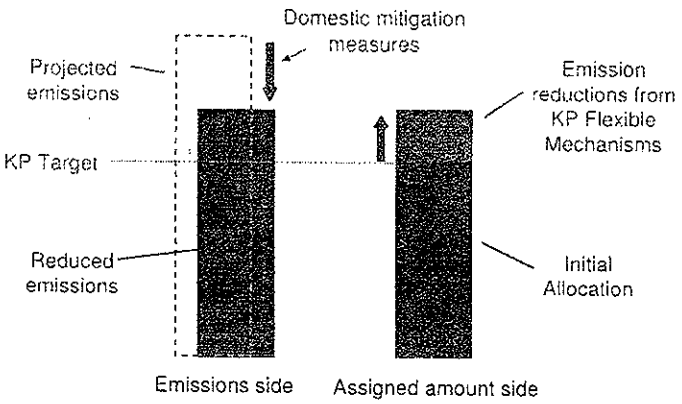
Clean Development Mechanism

Clean Development Mechanism

- Internal mitigation measures may be very costly to Parties
- Market based flexible mechanisms were introduced into the Kyoto process to help Parties reduce the cost of meeting their targets
- Clean Development Mechanism (CDM)
  - One of three market mechanisms allowed for under the Kyoto Protocol
  - Emission reduction projects in developing countries generate Certified Emission Reductions (1 CER per ton of reduction)
  - CERs can be used by Parties to meet their Kyoto targets
  - CERs are tradable

Clean Development Mechanism

How flexible mechanisms work



Clean Energy Programme Office

Clean Energy Programme Office (CEPO)

- Government committed S$350 million to develop Singapore as Clean Energy Hub
- CEPO started operation since 1 Apr 07
- CEPO will catalyse the development of clean energy technologies from idea conceptualization to the commercialization stage
- Clean energy blueprint targets to generate 7,000 new jobs by 2015

Clean Energy Programme Office

Clean Energy Programme Office (CEPO)

- CEPO's key initiatives include:
  - Competitive funding for R&D projects in identified areas of research required by industry (Clean Energy Research Programme)
  - Building world-class R&D centres and extending linkages with global centres
  - Making Singapore a global test-bed and site for early adoption of CE products and solutions
  - Incubating start-ups by creating a conducive environment
  - Grooming talent and manpower to fuel the growth of the industry here

Clean Energy Programme Office

Recent Clean Energy Projects in Singapore

- Solar Energy Power (Singapore)
  - Building Singapore's first solar cell manufacturing plant that will have an annual output of 30MW of solar panels by end 2007
  - It is also undertaking R&D to improve the efficiency of silicon solar cells
- Vestas Wind Systems (Denmark)
  - World's largest supplier of wind power systems
  - It chose Singapore as the base for its R&D centre and its Asia-Pacific headquarters, which will employ about 150 research scientists and engineers

Clean Energy Programme Office

Recent Clean Energy Projects in Singapore

- Conergy (Germany)
  - Largest solar company in Europe & leading international supplier in other fast growing-fields of renewable energies
  - Locating its Asia-Pacific regional headquarters in Singapore that will grow to 100 staff over 3 years
- Natural Fuels (Australia)
  - Building world largest bio-diesel production facility
  - The US$130 million facility will commence production by end 2007, with a full capacity of up to 1.8 million metric tons of bio-diesel per annum
- Rolls Royce (UK)
  - Investing US$100 million in solid-oxide fuel cell (SOFC) R&D in Singapore together with partners such as A*STAR & Temasek
  - Goal is to bring 1MW of distributed generation SOFCs to commercial uses by 2008

Thank You !

Introduction of Energy Smart Hotel Labelling

Launch of Energy Smart Hotel
3rd August 2007
Singapore

Lee Siew Eang

Energy Sustainability Unit
Department of Building
School of Design and Environment
National University of Singapore

IPCC Summary for Policymakers (2 Feb. 2007)

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.

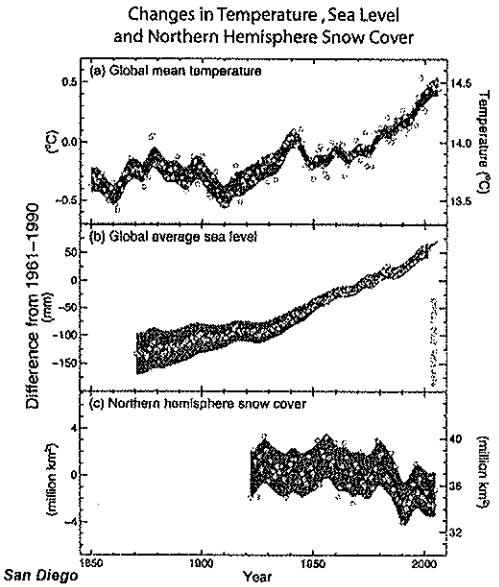
Source: Sommerville, AWI Workshop, 4 April 2007 San Diego

Direct Observations of Recent Climate Change

Gobal mean temperature

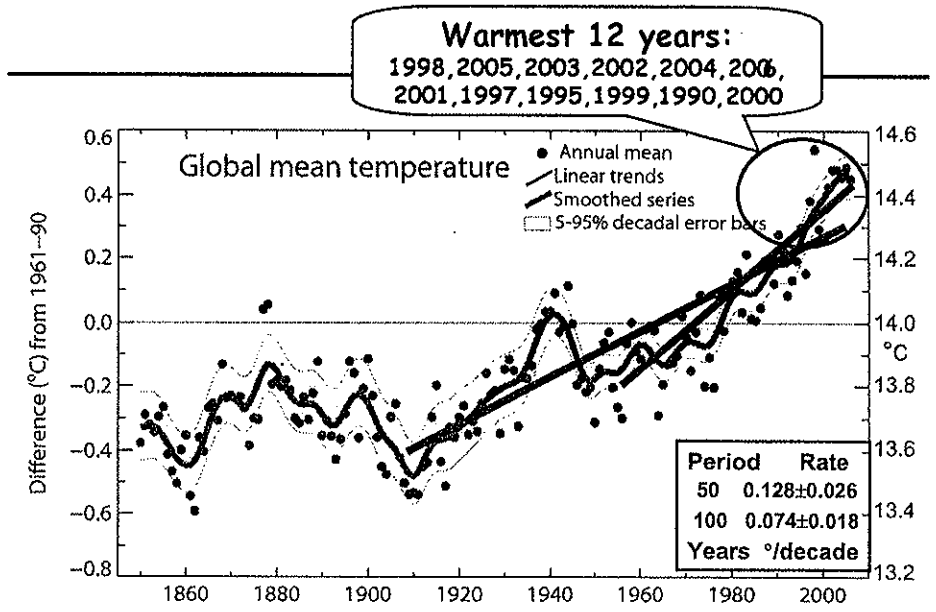
Global average sea level

Northern hemisphere Snow cover



Source: Sommerville, AWI Workshop, 4 April 2007 San Diego

Global mean temperatures are rising faster with time



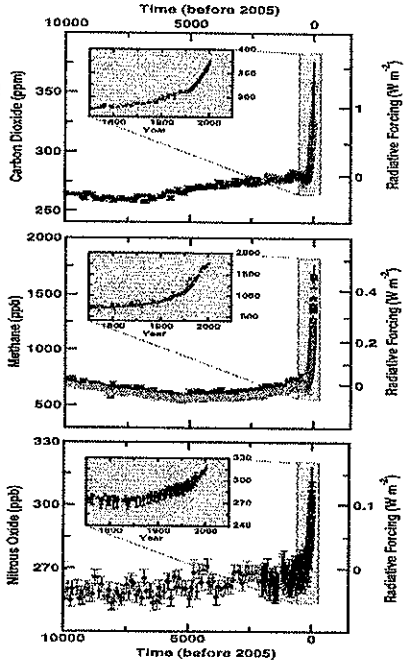
Source: Sommerville, AWI Workshop, 4 April 2007 San Diego

Human and Natural Drivers of Climate Change

CO_2, CH_4 and N_2O Concentrations

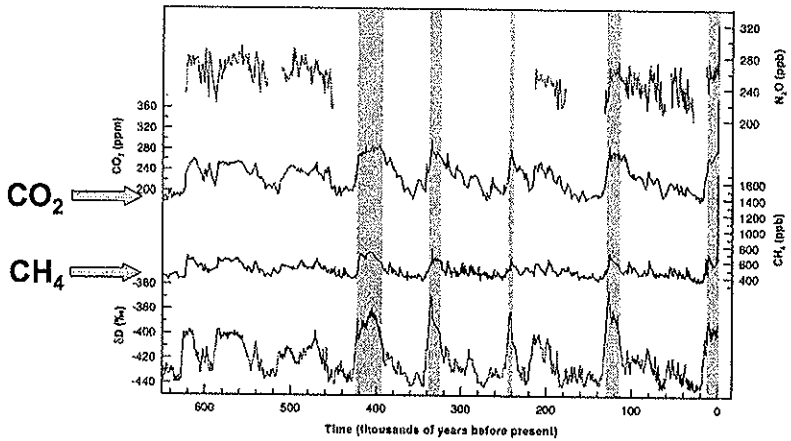
- far exceed pre-industrial values
- increased markedly since 1750 due to human activities

Relatively little variation before the industrial era



Source: Sommerville, AWI Workshop, 4 April 2007 San Diego

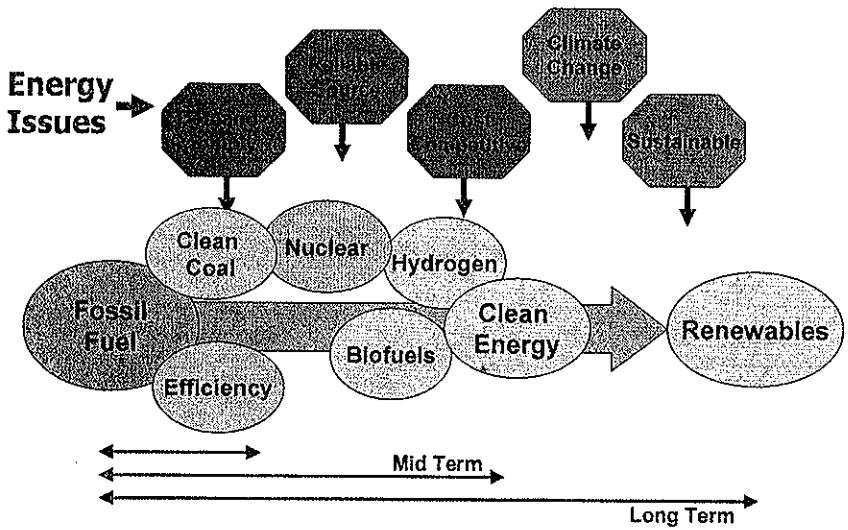
Glacial-Interglacial Ice Core Data



The atmospheric concentration of CO_2 and CH_4 in 2005 exceeds by far the natural range of the last 650,000 years

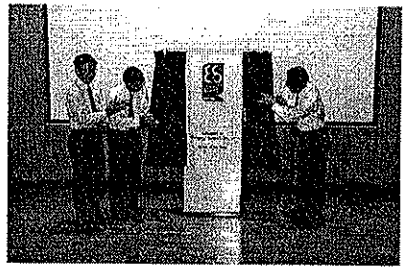
Source: Sommerville, AWI Workshop, 4 April 2007 San Diego

Background: The Real Issues



Introducing Energy Smart Hotel

ENERGY SMART HOTEL is the second product of the NUS-NEA joint project entitled "Development of Building Energy Efficiency Labelling System".



ENERGY SMART OFFICE was launched in December 2005 with 8 office buildings attained the Energy Smart Office Award.

Introducing Energy Smart Hotel

The hospitality industry plays a key role in Singapore's prosperous tourism, but is meanwhile an energy guzzler.

- 9.7 million visitor arrivals, and S$12.4 billion in tourism receipts in 2006
- 1,000 new hotel rooms per year over the next two years
- 4,300 rooms add to the inventory after the IR projects are completed in 2010
- Singapore hotels account for about 10% of the energy use in buildings
- Energy use intensity of hotels is amongst the highest in all building types

Introducing Energy Smart Hotel

An initiative to synergize such commitments from different interest groups (policy makers, building owners, ESCOs, etc.) and help achieve a win-win situation in energy conservation and environment protection.

It aims to promote an environmentally friendly hospitality industry by giving recognition to hotels with the best energy performance amongst peers and meanwhile maintaining a healthy indoor environment.

Benefits of Energy Smart Hotel

1. This label signifies lower operating energy costs, enhances competitiveness, and projects an environmentally responsible image for the hotel;
2. It provides a means for tracking the building's energy performance over time;
3. The label also emphasizes that the energy efficiency is achieved hand in hand with indoor environmental quality;
4. It helps to reduce CO2 emission and consumption of fossil fuels. This also results in lower pressure on infra-structural demand and cost.

Know the Energy Smart Hotel Logo

1. The continuous circular form represents the constant quest for a superior efficiency and management of energy.
2. The linked circles symbolises the cooperation and synergy among many parties in making the programme a success.
3. This logo is designed with maximum visual efficiency. The 'E' and 'S' stands out immediately - almost like a visually arresting icon.
4. An Auspicious Icon for Energy Efficiency and Healthy Environment, a hallmark for Management Excellence and User's satisfaction.

Development of Energy Smart Hotel

In-depth review of building labelling schemes developed in other countries, such as EnergyStar, EPLabel, GreenGlobe, to learn from their successful experiences;

Extensive survey in the hospitality industry to build a database with hotel energy data and other pertinent information;

Rigorous statistical analyses to correlate hotel physical and operational characteristics with energy use; and

Step-wise regression procedure to identify the most influential factors for energy normalization.

Development of Energy Smart Hotel

Completed dataset collected from 30 quality hotels, 29% of the gazetted hotels in Singapore;

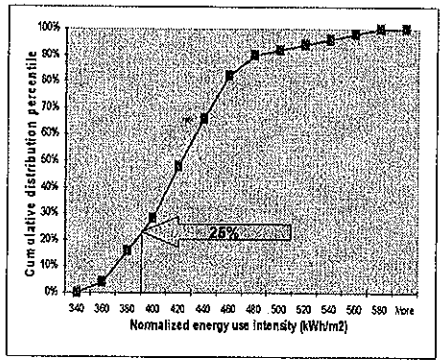
Building capacity indicators (GFA, number of rooms, etc.) found to be the primary determinant of energy use in hotels;

Factors like hotel star rating, number of workers, years after the last energy retrofit having statistically significant relationship with hotel energy use;

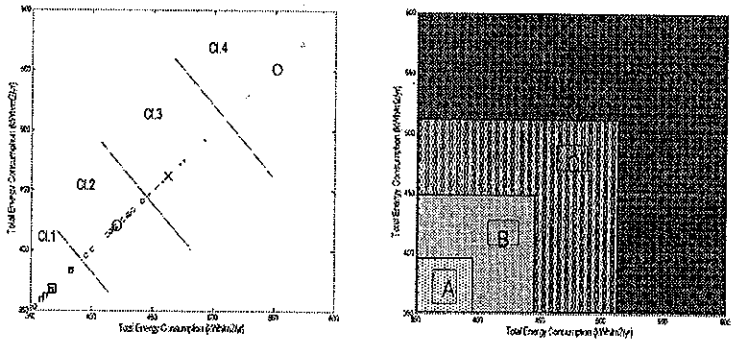
Energy normalization for uncontrollable factors using regression techniques to get hotel normalized energy use intensity.

Development of Energy Smart Hotel

Benchmarking curve of hotel Normalized Energy Use Intensity for preliminary assessment of a hotel's energy performance and helping hotel owners set reasonable targets for improvement



Development of Energy Smart Hotel



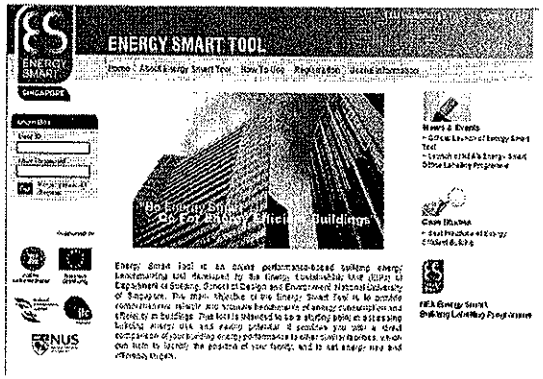
Verification by Fuzzy Clustering Analysis generated consistent result as that of the regression based benchmarking.

The Process towards Energy Smart Hotel -- 1

Preliminary benchmarking with Energy Smart Tool

Three simple steps

- Collect building physical and operating data.
- Register your facility in the portal.
- Benchmarking



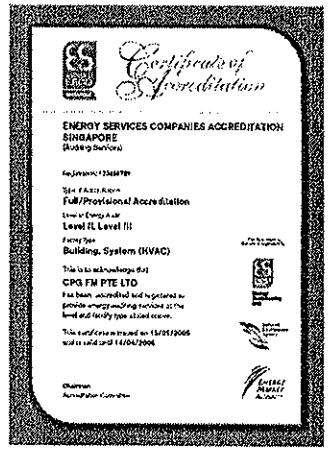
http://www.esu.com.sg/smarttool.php

The Process towards Energy Smart Hotel -- 2

Appoint an Accredited ESCO

The Accredited ESCO serves as independent assessor for the building's energy performance for the following:

1. **The energy performance of the building as a whole.**
2. **Key building systems' performance, including chiller plant, lighting and ventilation.**
3. **Indoor environment performance.**
4. **Users' satisfaction survey.**

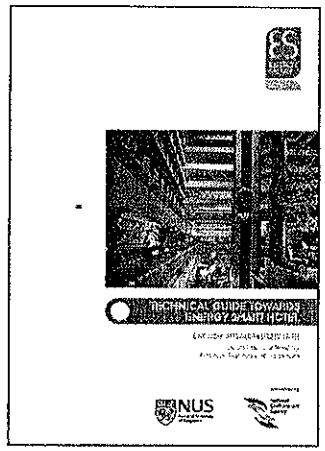


The Process towards Energy Smart Hotel -- 3

Review by ESU

ESU to check and verify the report submitted:

1. **Detailed data are correct and consistent.**
2. **Measurements are consistent and computed accurately.**
3. **Report and associated documents are complete.**
4. **All performance indicators meet stipulated requirements.**

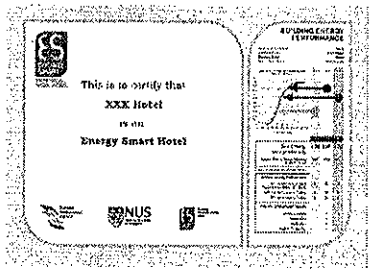


The Process towards Energy Smart Hotel -- 4

Administration and Records

ESU keeps records of report and certification:

1. **The Energy Smart Hotel label is valid for 3 years.**
2. **During this 3 years the building management should track and improve its performance records.**
3. **This provides ESU with a means to track progress of Singapore in energy performance and the accumulated benefits of the Energy Smart programme.**



The Achievements of an Energy Smart Hotel

1. It is energy efficient, and among the top 25% of cohort.
2. Its systems are fine.
3. Its indoor environment is healthy.
4. Its users are satisfied.
5. It is independently checked, measured and verified.

Conclusion

The Energy Smart Labelling system complement Singapore's Energy Policies towards energy efficiency.

The Energy Smart Hotel is the second product of this labelling system. It is a useful tool in ensuring energy efficiency without compromising on comfort, health and the quality services hotel guests seek.

We hope the industry will give this scheme its strongest support, and support us in the future products to come.

Acknowledgement

The ESU would like to acknowledge the following:

The Ministry for the Environment and Water Resources,

The National Environment Agency,

Industry members who support generously in the sharing of data and building information,

Staff and colleagues at ESU and NUS.

Thank you

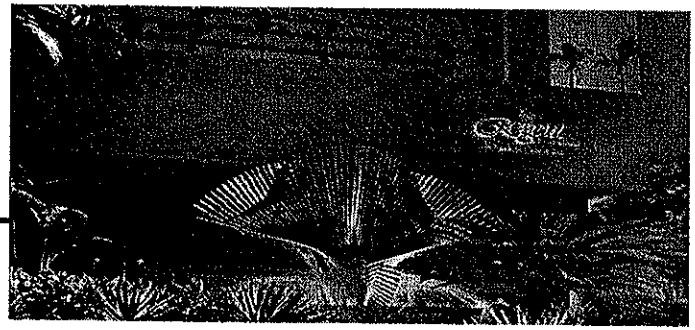
For further information
And benchmarking, visit - www.esu.com.sg

Lee Siew Eang

Head, Energy Sustainability Unit

School of Design and Environment
National University of Singapore

bdgleese@nus.edu.sg



The Regent Singapore
Energy Smart Hotel Experience
Presented By Lee Baharrudin
3rd August 2007

SUPERSOLUTIONS

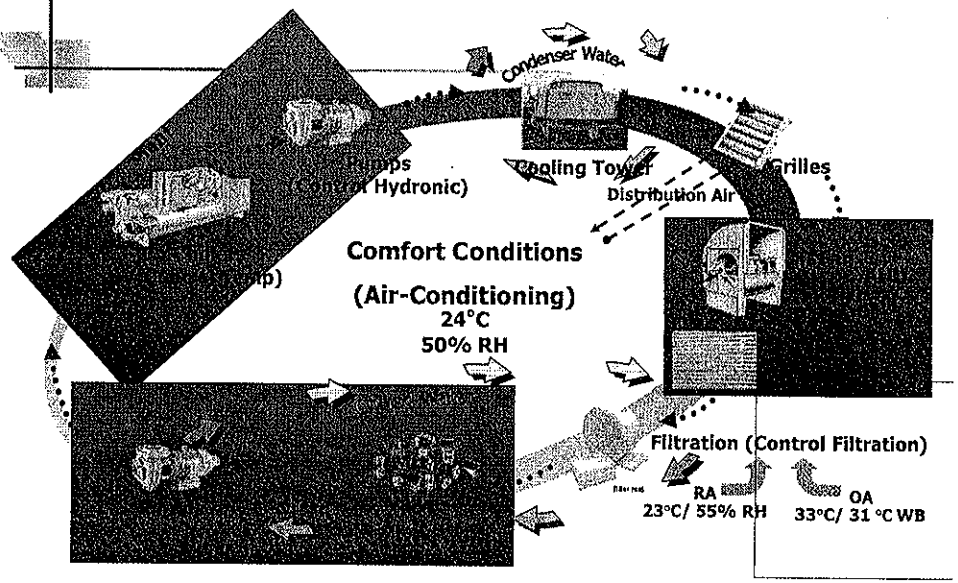
Agenda

1. Our Mission
2. Our Approach
3. Overview Of The Energy Consumption
4. Demand Side Audit
5. Supply Side Audit
6. Benchmarking
7. Discussion

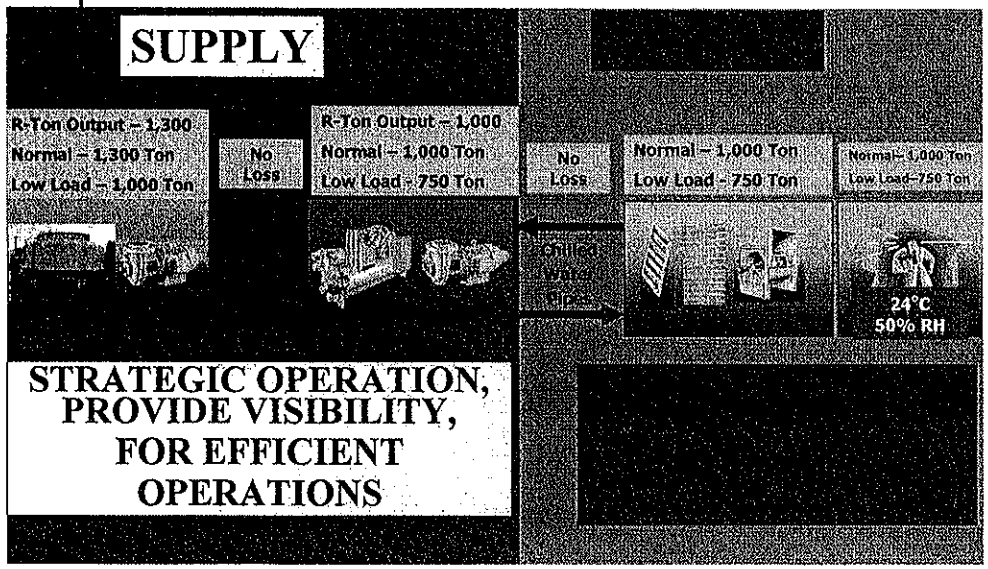
MISSION STATEMENTS

1. Committed to operate the world's leading luxury Hotel Company in an environmentally manner
2. Address our responsibility to the communities without impacting our Hotel Guests & Environment
3. Actively monitor potential recycling and waste management initiatives and improve energy conservation methods
4. Heighten employee's awareness of chemicals and potentially hazardous products through ongoing education.

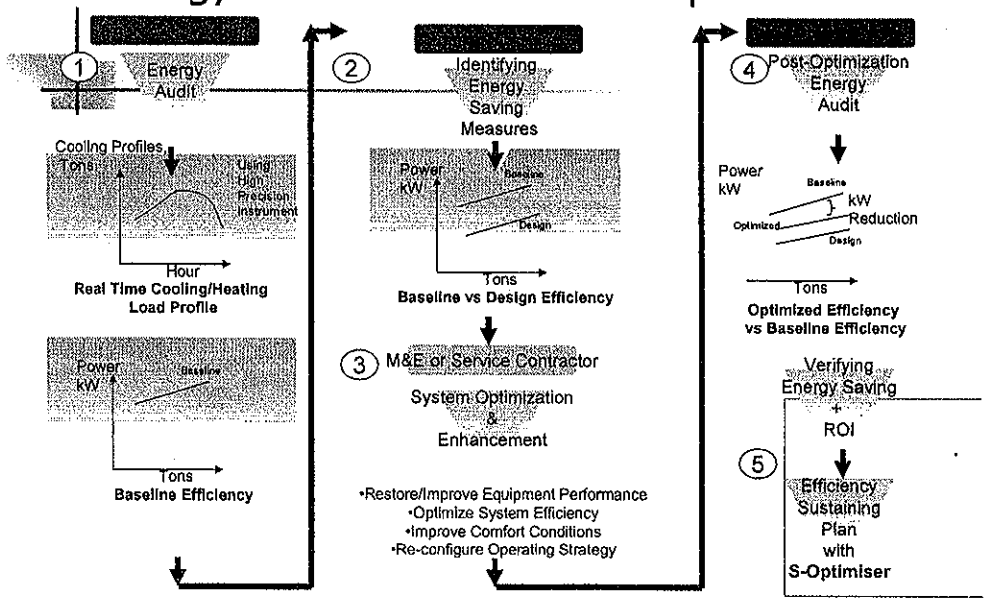
Our Approach



Monopolistic Opportunities

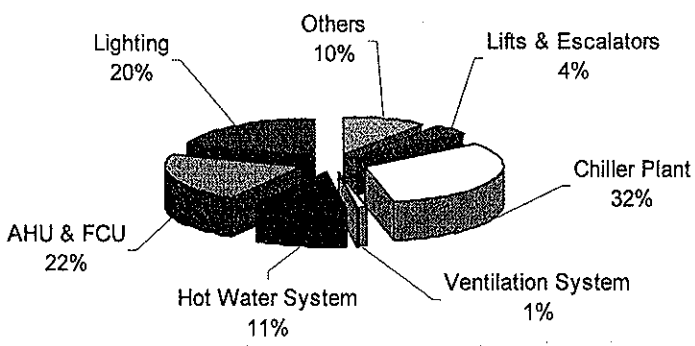


Energy Audit - First Crucial Step



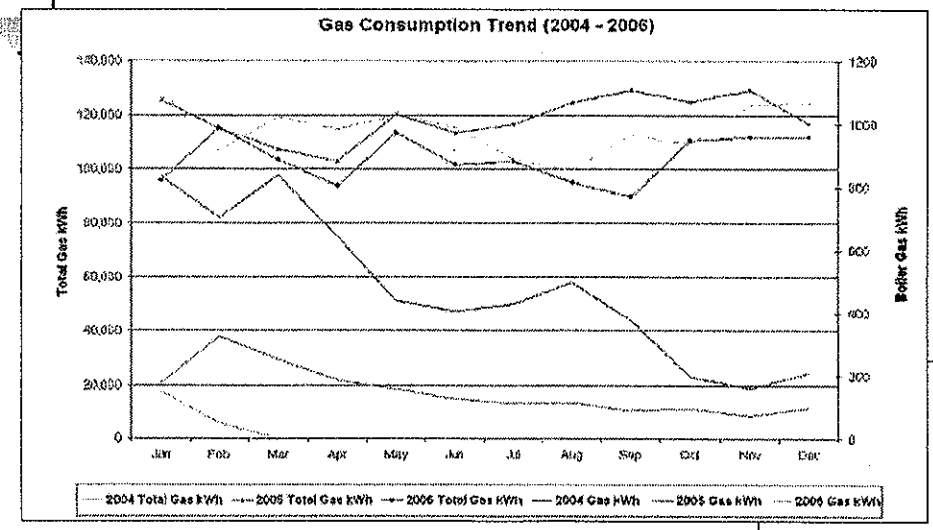
Baseline Electrical Consumption

Monthly Power Consumption Breakdown



Monthly kWh Consumption	**: 1,126,380 kWh**
Yearly kWh Consumption	**: 13,516,560 kWh**
Monthly Utilities Cost	**: $163,166**
Yearly Utilities Cost	**: $1,957,992**

Baseline Gas Consumption



Total Energy Consumption

Month	Elect. kWh Consumption	Gas kWh Consumption	Total kWh Energy Consumption
Jan-06	1,091,958	95,745	1,187,703
Feb-06	1,028,773	115,413	1,144,186
Mar-06	1,157,156	103,255	1,260,411
Apr-06	1,109,219	93,840	1,203,059
M			
Ju			
Ju			
Aug-06	1,161,303	95,078	1,256,381
Sep-06	1,109,710	89,700	1,199,410
Oct-06	1,153,491	110,541	1,264,032
Nov-06	1,151,130	111,762	1,262,892
Dec-06	1,148,342	111,763	1,260,105
Total in 2006	**13,561,605**	**1,244,928**	**14,806,533**

Carbon Print : 7.4 MTon per Year
2007 Objective:6.8 MTon per Year

Demand - Thermal Comfort

East Facade		Guest Rooms					
		# 12-44			# 11-44		
Measurement Point		Pt 7	Pt 8	Pt 9	Pt 10	Pt 11	Pt 12
Time taken		9:45 AM	10:10 AM	10:35 AM	11:00 AM	11:25 AM	11:50 AM
Parameters	CP 13 Requirement						
MRT (°C)		23.6	23.8	24.1	24.2	24.4	24
DBT (°C)	18 - 25.5	22.6	22.5	22.8	23.1	22.9	22.8
MRT-DBT (°C)	<= 2	1	1.3	1.3	1.1	1.5	1.2
RH (%)	< 70	61.1	60.5	59.7	54.8	54.5	53.8
Air Movement (m/s)	< 0.25	0	0	0	0	0	0

West Facade		Guest Rooms					
		# 10-01		# 09-01		# 09-02	
Measurement Points		Pt 7	Pt 8	Pt 9	Pt 10	Pt 11	Pt 12
Time taken		3:40 PM	4:05 PM	4:30 PM	4:55 PM	5:20 PM	5:45 PM
Parameters	CP 13 Requirement						
MRT (°C)		23.8	23.8	24.1	24.4	23.6	23.5
DBT (°C)	18 - 25.5	22.5	22.8	23.1	23.2	22.2	22.2
MRT-DBT (°C)	<= 2	1.3	1	1	1.2	1.4	1.3
RH (%)	< 70	51.3	51.7	60.1	60.3	53	54.8
Air Movement (m/s)	< 0.25	0	0	0	0	0	0

No Over Cooling Condition

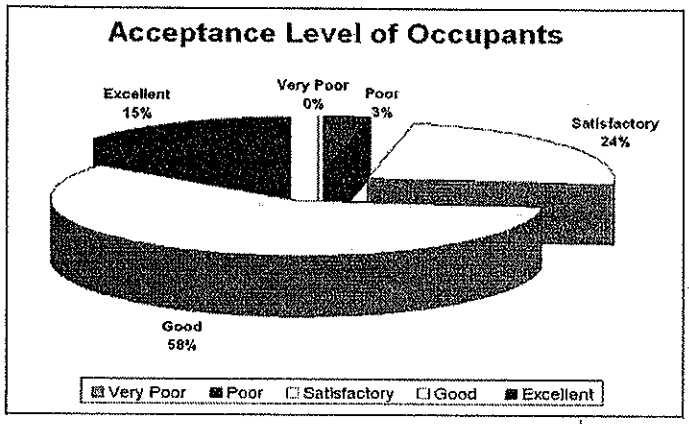
Demand - Lux Requirement

Description	Lux Reading
Entrance Hall	**CP 38 Requirement: 200 - 500**
Main Lobby	
Point 1	260
Point 2	390
Point 3	225
Point 4	275
Point 5	302
Lobby Lounge	
Point 6	235

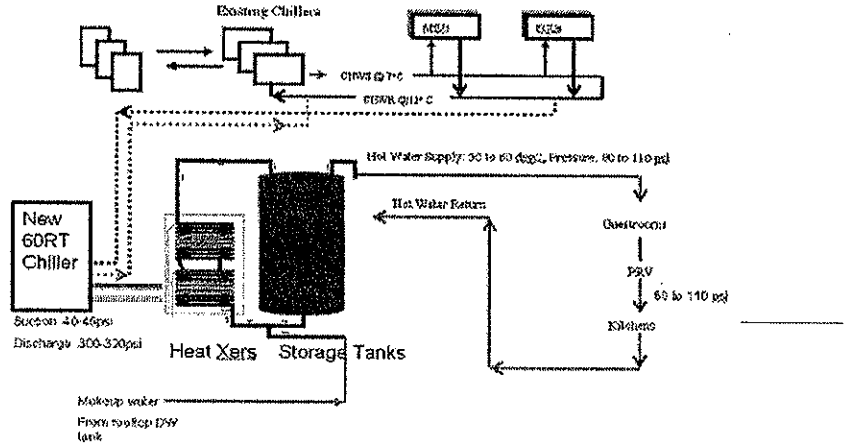
Demand - Ventilation

Area Served	Free Area (m^2)	Outdoor Air Flow Rate Ave Vel. (m/s)	m^3/s	Floor Area Served (m^2)	Actual Ventilation Rate	CP 13 Requirement
Hotel Guest Rooms					litres/sec/room	
# 12-44	0.018	0.60	0.011		10.60	15 l/sec/rm
# 11-44	0.018	0.70	0.012		12.37	15 l/sec/rm
# 10-01	0.018	0.77	0.014		13.61	15 l/sec/rm
# 09-01	0.018	0.73	0.013		12.90	15 l/sec/rm
# 09-02	0.018	0.63	0.011		11.13	15 l/sec/rm
		Had replaced YTD 138 sets of FCU to meet requirements				
Reception Areas					l/s/m^2 floor area	
Baggage Room	0.380	0.98	0.372	172.48	2.16	0.25 l/sec/m^2
Restaurants					l/s/m^2 floor area	
Summer Palace	2.000	0.02	0.040			2.8 l/sec/m^2
	2.000	1.55	3.100			2.8 l/sec/m^2
			3.140	457	6.87	2.8 l/sec/m^2
Retail Shops					l/s/m^2 floor area	1 l/sec/m^2
Gift Shop	0.025	0.36	0.009	57.8	0.16	1 l/sec/m^2

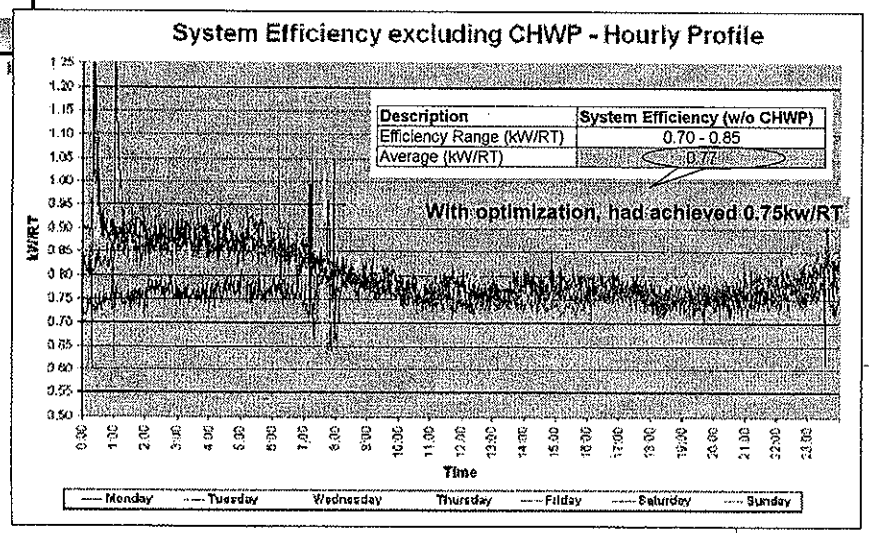
Demand - End User Perception



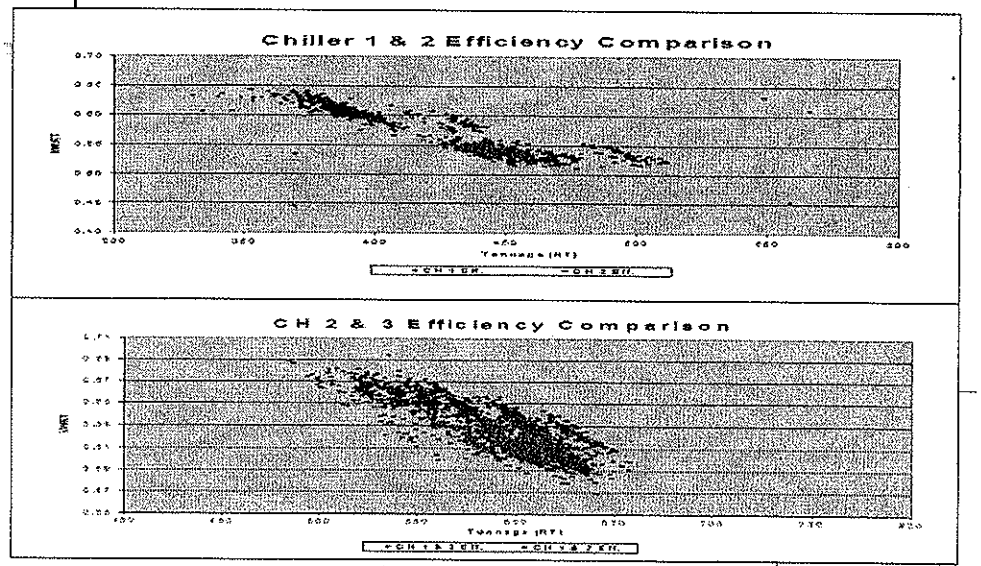
Supply - Hot Water Supplies



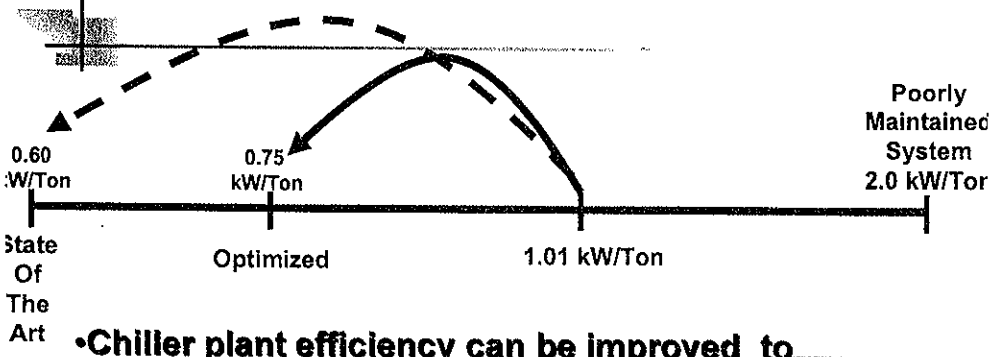
Supplies – Chilled Water System Ton



Supplies - Chiller Efficiency



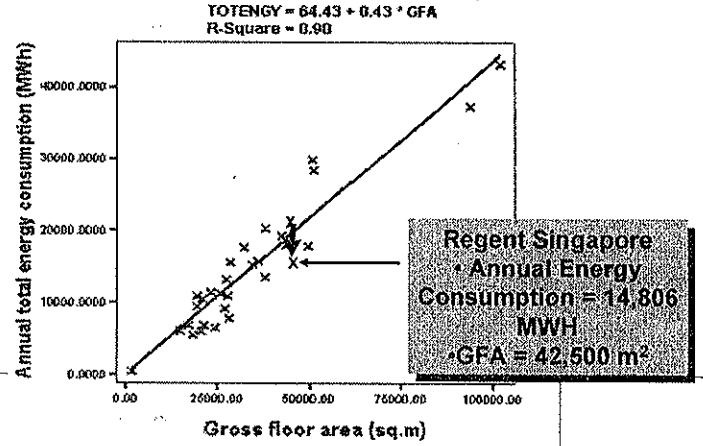
Chilled Water System Benchmarking



- **Chiller plant efficiency can be improved to**
  - **➢0.75 kW/Ton through chiller plant optimization**
  - **➢0.6 kW/Ton through re-engineered chiller plant retrofit**

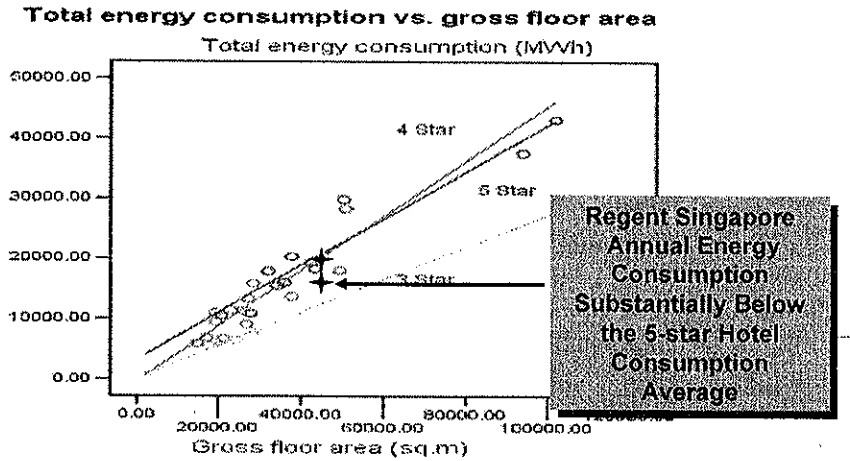
EUI Benchmarking

- *Energy Usage Index (EUI) = 349 kWh/m²/Year, 19% BELOW hotel industrial benchmark average at 431*

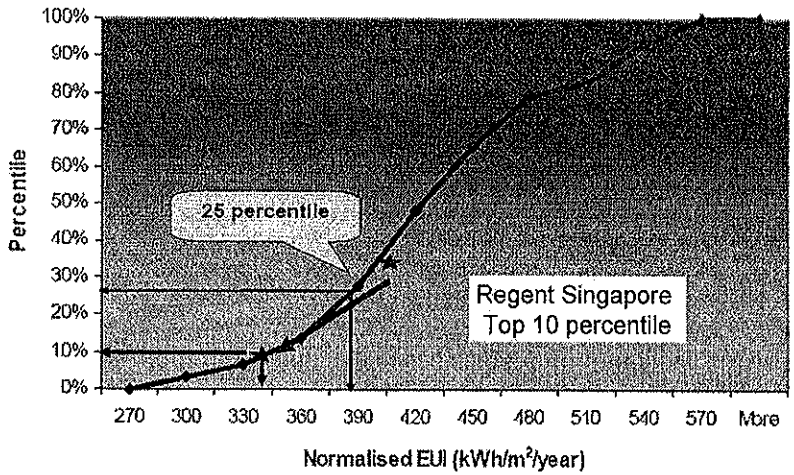


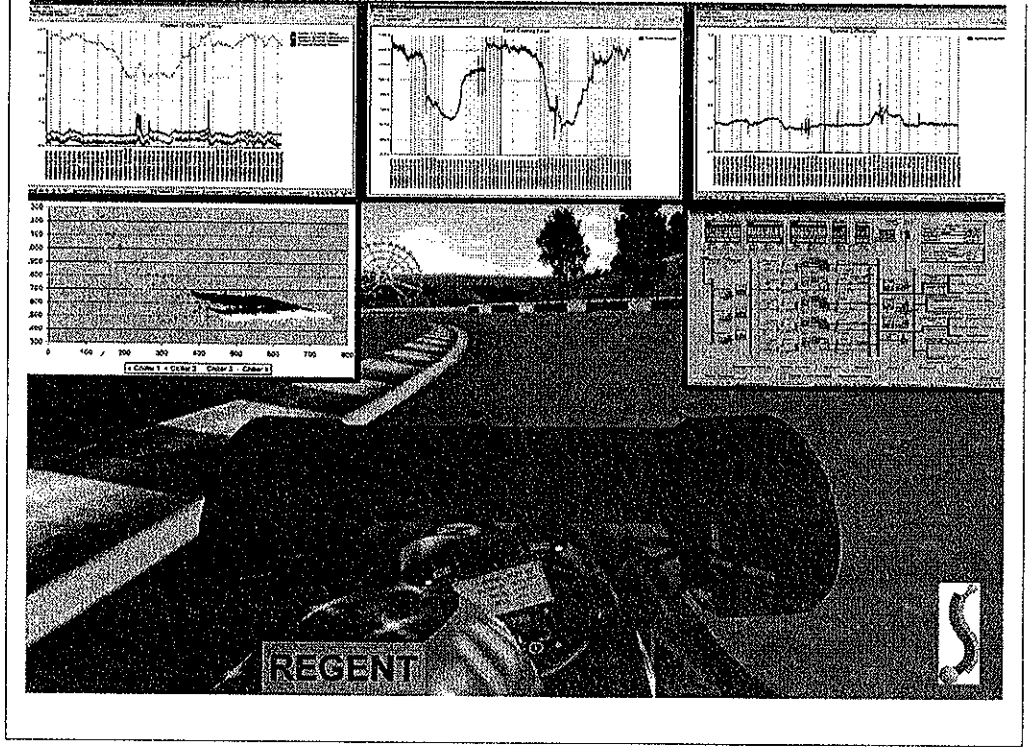
Source : ESU/NUS, Singapore

Benchmarking With Similar 5*Hotel



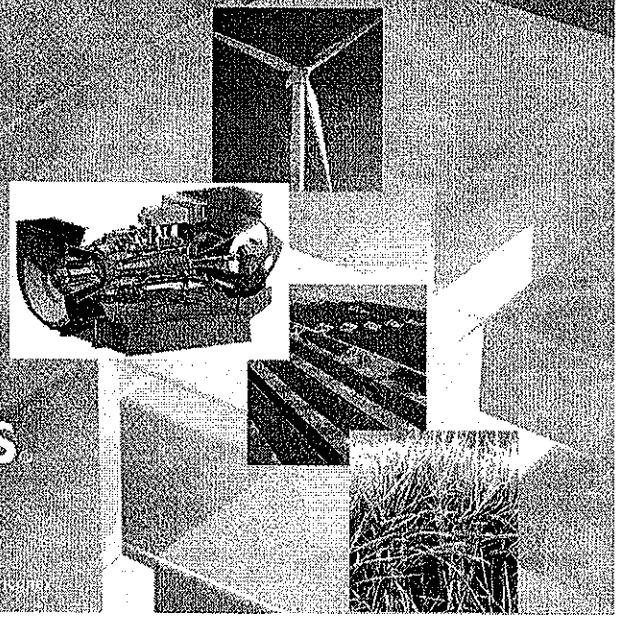
Benchmarking – Top 10 Percent




REGENT

Sustainable Enterprise for Environment and Financial Benefits

Singapore
3 August 2007



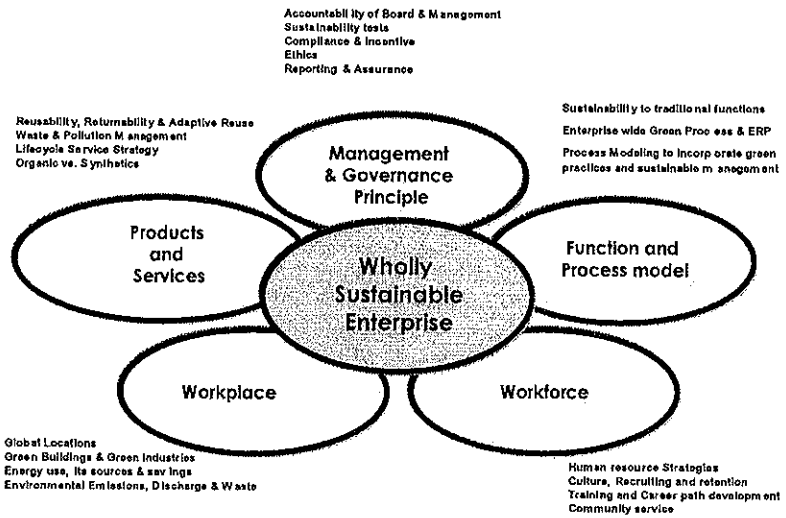
invensys
Process Systems

Get More from One
Avantis • Foxboro • SimSci-Esscor • Triconex

Agenda

1. What is the 'Wholly Sustainable Enterprise?'
2. Views of Past, Present and Future – Sustainable Design, Eco friendly…
3. Sustainable Enterprise as a Journey and business imperative
4. Painting a picture: Energy Efficient Facility a Roadmap for a Transformation
5. Why Sustainable Enterprise Transformation is so important now
6. Getting Started: Some Action is Better Than None

What is the 'Wholly Sustainable Enterprise?'



Views of Past, Present and Future

Past

- *1992 UN 'Earth Summit'*
- *1993 then President Bill Clinton established President's Council on Sustainable Development*
- *1995 World Trade Organization (WTO) linkages between Trade, development & Environment*
- *1996 The Global Community launches ISO 14001 standard*
- *1999 The Dow Jones Sustainability Group Index*

New Millennium

- *2000 UN Millennium Summit – Goals for 2015*
- *2002 1st World Summit on Sustainable Development*
- *2008 Singapore Acceded to KYOTO Protocol – Green House Gas Emission Reduction*

Score Card: environment reports

1996 → estimated 300-400

1999 → estimated 1100

Present

- *Over 2000++ Companies produces some Sustainability Report, corporations like GE, BP, DuPont, Wal-Mart, The Body Shop, ITC, Godrej, TATA Steel…*
- *Tools Used*
  - *Life Cycle Analysis*
  - *Industrial Ecology*
  - *Design for disassembly*
  - *The natural step framework*
  - *Carbon Neutralization*
  - *Global Energy Management*
  - *LEED Green Building Design*
  - *Social Responsible Investment*

Views of Past, Present and Future

Future

- What will exist...
  - Highly sophisticated infrastructure
  - Mix of housing
  - Industry, Offices and Recreational Facilities, Open Spaces and...
- What is the likely scenario...
  - Construction techniques will be different with energy efficiency and
  - Renewables pushed to the absolute maximum
  - Carbon and other polluting emissions to the absolute minimum
  - Oil trading over $ 100/Barrel
  - Roads with cars 4 to 5 times more efficient
  - People → Indeed be walking and cycling a lot more than they today!
  - Rapid Disappearance of Apple from New Zealand/US, S$ 9.99 flights to dozen destinations
  - Individual will have his/her own carbon allowance allocated on an annual basis!! Finding ways of living elegant, low carbon lives will be both *FASHIONABLE and PROFITABLE*

All these should Usher in the first moment in Modern history where cyclist have the edge over the owners of the next generation of gas guzzling SUVs!!

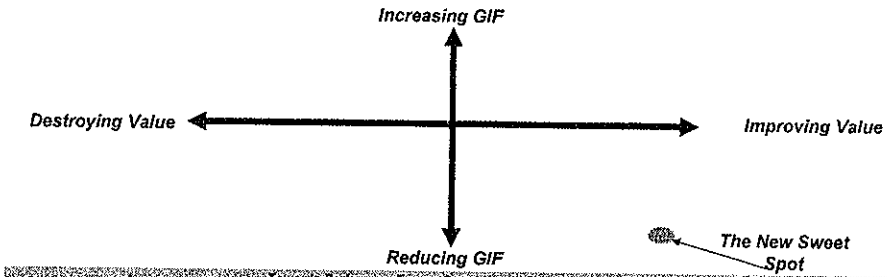
1. **People who are better off will almost certainly be paying higher taxes than they do today**
2. **Cornerstone of the sustainable economy – Increased Efficiency in terms of resources, energy, raw material, value for money, capital allocation and so on...**

Sustainable Enterprise as a Journey and business imperative

It's a WIN – WIN situation driving improved short term profitability and long term stake holder value, while continuing to permanent betterment of social and environmental issues...Thus sustaining indefinitely

Enterprise can frame all activities in 2 critical dimensions

1. The contribution to enterprise value
2. Impact on the Global Impact Foot Print (GIF)



Painting a picture: Energy Efficient Facility a Roadmap for a Transformation

The approach is grounded in the practical realities of

- Controllable
- Implementable
- Repeatable – Self Sufficient – Sustainable Cycle
- Valuable – Traditional Business Case Metrics → ROI, Payback etc.
  -- Application of full input accounting

Bold management teams will drive the changes advocated by politicians, environmentalist and alarmists – but the improvements will flow from positive elements of growth, profitability, and values – rather than from conflict, regulation, and premium costs.

Classification of the Clean Energy Business Opportunity

- Alternative Energy
  - Solar
  - Wind
  - Hydro, tidal and wave
  - Geothermal
- Distributed Energy
  - Microturbines
  - Fuel cells
  - Hydrogen generation
  - Flywheels
- Energy efficiency
  - Utilities – lighting, boilers, AC...
  - Process in the Industries
  - Buildings
- Energy Recycling
- Waste to energy
- Environmental technologies
  - Waste & wastewater treatment
  - Emission mitigation
- Information Technology
  - Net metering and real time pricing
  - Emission/Environment monitoring
  - Energy accounting & benchmark
  - Demand Response (energy efficiency)
  - Continuous energy audit & loss reduction management

Why Sustainable Enterprise Transformation is so important now

- Sustained high energy prices
- Accelerated technology shift
- Increased "rate of change"
- Wall Street - CSR

and

- Increased environment concern

Climate Change Impacts Business for the heavy industry on the triple concern of –
- cost reduction → Insurance
- secure revenue stream → Production
- The avoidance of bottlenecks → Intermediate goods/procurement

Clean Technology (Cleantech) Investment is Accelerating.....it is the fifth largest share of early stage venture capital in North America at 10% of market share and rising

Higher Global Demand in the BRIC (Brazil, Russia, India and China) economies with 800 million middle class consumers

Most have misjudged the scale of the cleantech revolution

Green is the new gold, and now is the time to watch it accelerate

The Opportunity: Buildings

Green Building Benefits

- **Tangible benefits**
  - **Energy savings up to 50%**
  - **Water savings up to 35%**
- **People spend 90% of their time inside building .**
  - **Productivity improvements up to 10% possible**
    - **Day-lighting**
    - **Views**
    - **CO2 monitoring**
- **Green corporate image**

Do Green Buildings Cost More?

- **First cost Vs Life cycle cost**
- **Depends on green features already considered & level of rating**
  - **Platinum-20 to 25 %**
  (Solar, High-end technologies)
  - **Gold – 8 to 10 %**
  - **Silver – 5 to 8 %.**

Operational savings offset initial costs



Getting Started: Some Action is Better Than None

THIS IS END OF THE BEGINNING – GREEN VALUE PROPOSITION

Tangible Returns ⟷ **Intangible Benefits**

1. Climate-friendly projects yield a positive return on investment
2. Increased income and/or market share from new or enhanced products or services
3. Creates new standard or benchmark
4. Reduction in emissions allows sale of CER credits
5. Enhanced energy-conservation practices and fuel switching stabilizes corporate energy use. ALSO, PROTECTS AGAINST ENERGY PRICE VOLATILITY.

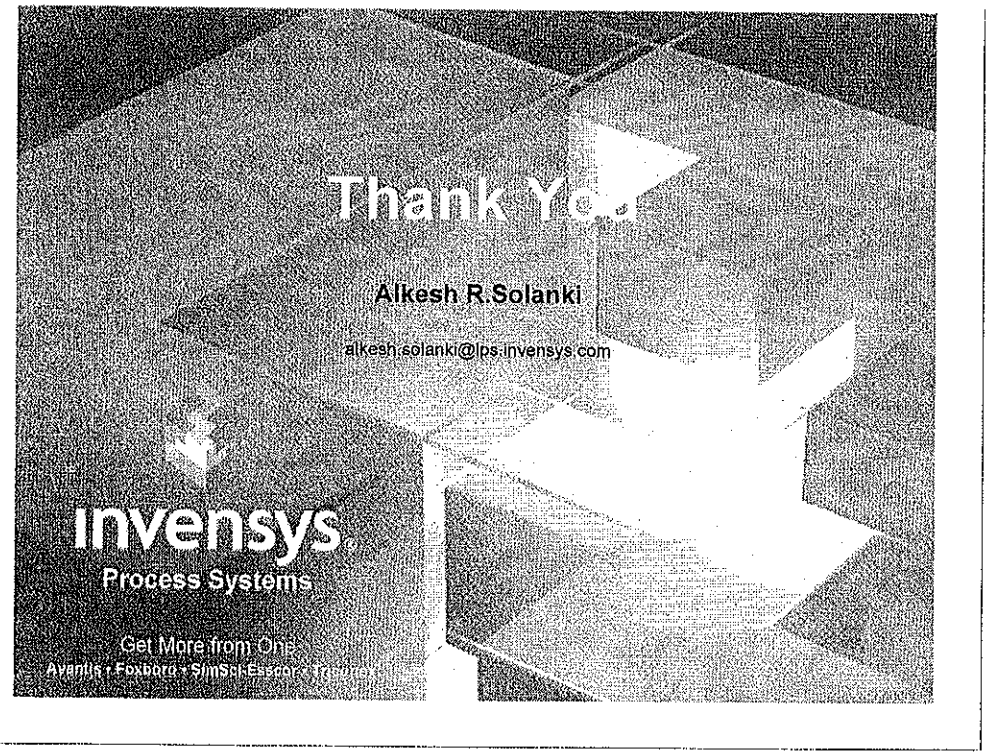
- **Competitive positioning**
  1. Low carbon product improve the company's position in the industry vis-à-vis competition
  2. The public perceives the corporate brand environmentally friendly, leading to improved public relations.
  3. Strong environmental performance results in higher employee recruitment, retention and productivity
- **Shareholder-related benefits**
  1. Investors perceives strong environmental performance as an indicator of superior business management, resulting in a premium on the stock price and lower cost for capital
  2. Include in specialized stock index like Dow Jones Sustainability Index
  3. Higher stock ratings from " socially responsible investment" (SRI) analysts, resulting in more stock purchases by SRI investors

THUS, IMPROVED BOTTOMLINE

Questions & Answers



invensys


Thank You
Alkesh R Solanki
alkesh.solanki@lps.invensys.com
invensys
Process Systems
Get More from One

Energy Smart Hotel Labeling Launch/Seminar

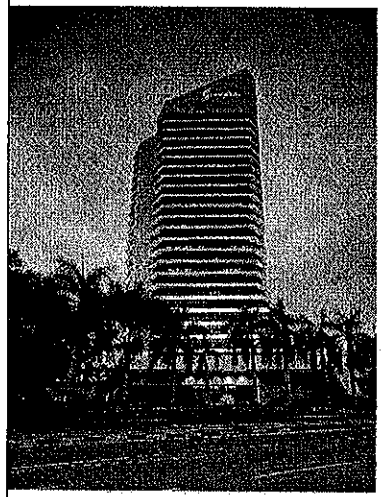
HITACHI
Inspire the Next



Hitachi Plant Technologies, Ltd. 3th August 2007

OUR COMPANY

HITACHI
Inspire the Next



Hitachi Plant Technologies, Ltd

456 Alexandra Road
#15-00 NOL Building
Singapore 119962

Tel: 65-6222 0665
Fax: 65-6224 8358

Email: hpcsgr@hitachiplant.com.sg

Website: URL:www.hitachi-pt.co.jp

1

CORPORATE DATA

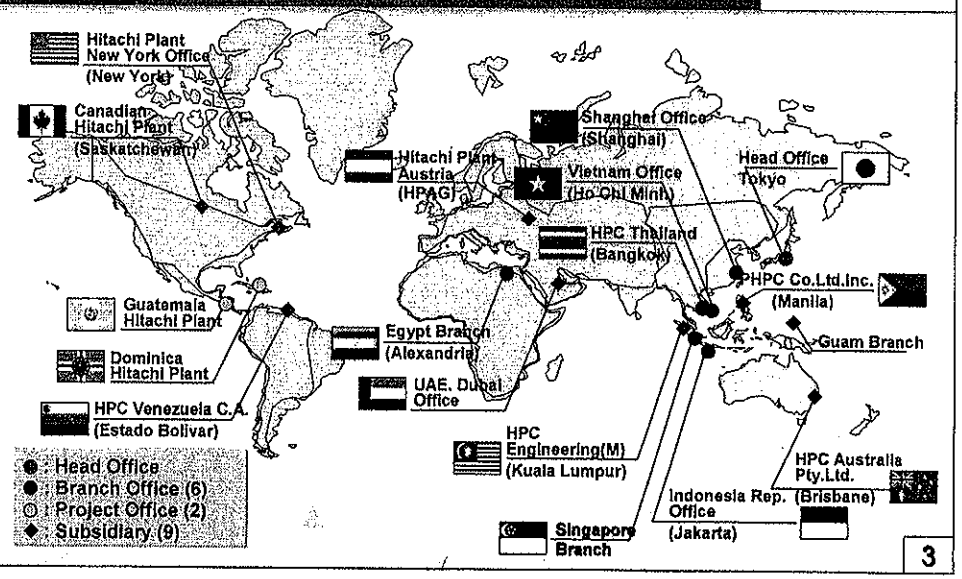
HITACHI
Inspire the Next

- ◆Company : Hitachi Plant Technologies, Ltd
- ◆Head Office incorporated in Japan since 1929
- ◆Paid Up Capital : S$ 150 Million
- ◆Turnover for 2006 : US$1.865 billion
- ◆Staff Strength: Over 7,300

2

Global Network Offices

HITACHI
Inspire the Next



3

Corporate Goals

HITACHI
Inspire the Next

Our Mission

Customer is part of our team, our customer enjoy the maximum benefit of our talent and our solution.

Our Core Activities

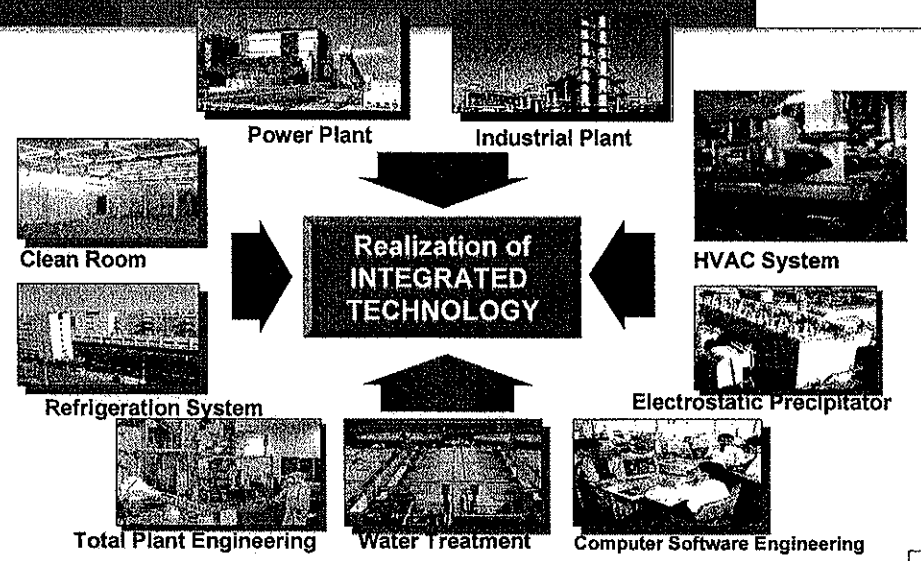
To help our customers to manage their energy effectively.

Our Objective

To help customer to minimise each facility's impact toward the environment to reduce energy cost and stay competitiveness.

Our Services

HITACHI
Inspire the Next



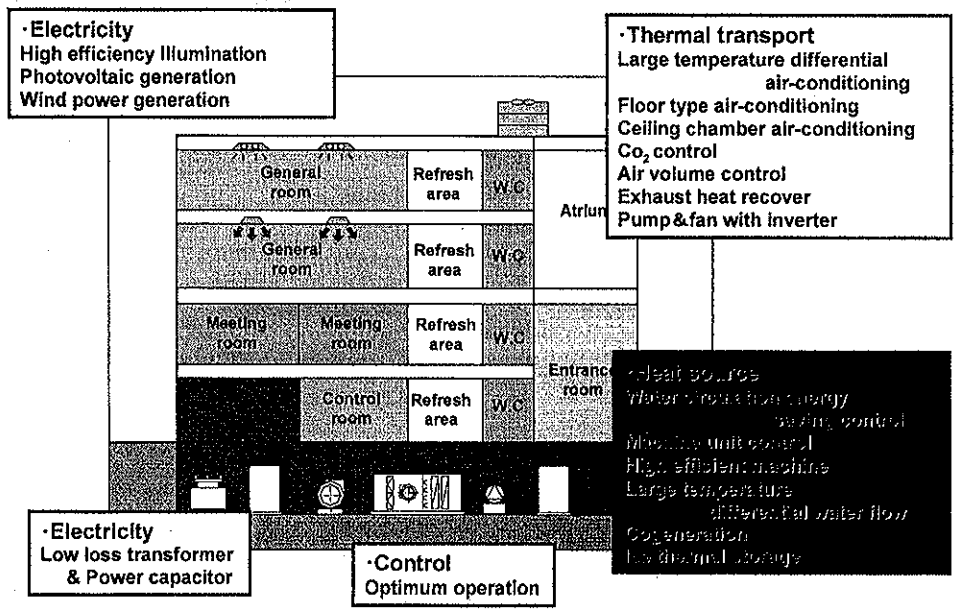
Hotel Track Record

HITACHI
Inspire the Next

•Harbour View Hotel Pte Ltd	(1983)	AC
•Raffles Hotel Pte Ltd	(1989)	AC
•Pontiac Hotel Pte Ltd	(1990)	AC
•Pontiac Marina P/L	(1995)	E
•City Development Ltd	(1996)	AC
•Ministry of Trade & Industry	(1997)	E
•Pontiac Hotel Pte Ltd	(1999)	AC
•Raffles City Hotel Ltd	(2000)	AC
•AquaMarina Hotel Pte Ltd	(2005)	M&E

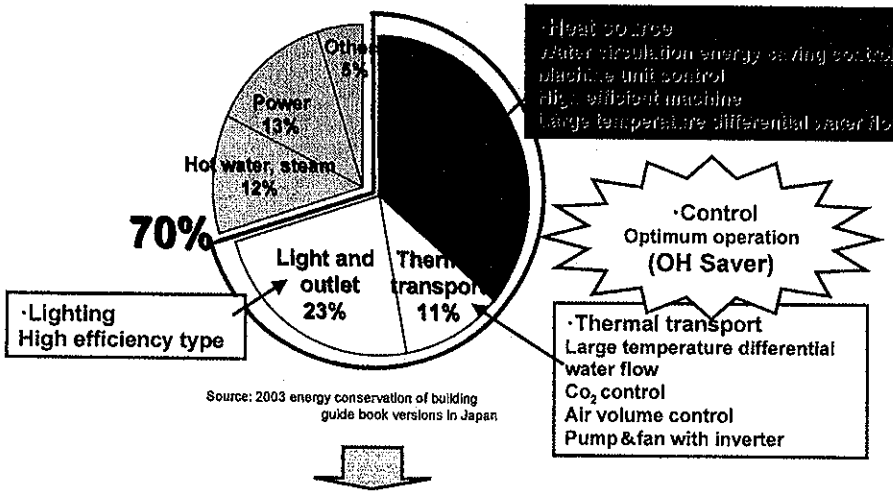
Energy-saving technology

HITACHI
Inspire the Next



Analysis Energy in Hotel

HITACHI Inspire the Next



Introduce Best practice with heat source, thermal transport, and lighting with a large energy consumption ratio

Best Practice in Energy Efficiency - The Japan way

HITACHI Inspire the Next



Structure	SRC
Total floor area	9,595 ㎡
Floor	B 1F, G9F
Usage	Office and shop
Complete date	1981
Upgrade date	2003

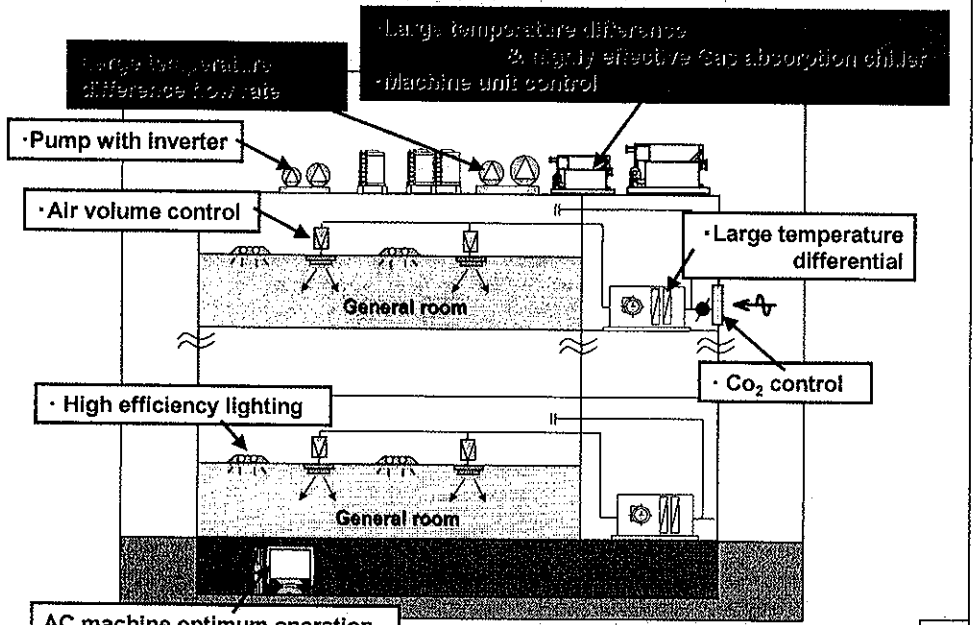
System Situation

- Operating at 7:00-23:00 though year
- Operating time is long
- Correspondence in each shop
- Partial load ratio is large

System Situation near hotel's Upgrade construction with Hitachi Plant Technologies

Upgrade outline

HITACHI Inspire the Next



① Equipment upgrade Detail

HITACHI Inspire the Next

Equipment	Before upgrade(1981)	Energy Consume	After upgrade (2004)	Energy Consume	Energy saving-effect
Absorption Chiller	Gas type (COP=1.0) Cooling capacity: 320RT Chilled water : 12→7℃ Cooling water : 32→37℃	474,395 kWh	Highly effective gas type (COP=1.35) Cooling capacity: 210, 120RT Cold water : 15→7℃ Cooling water : 32→37℃	294,741 kWh	179,654kWh (▲38%)
Cooling tower	Low noise type Cooling capacity : 2,037kW	9,533 kWh	Super-low noise type Cooling capacity: 1,360kW+839kW	6,482 kWh	3,052kWh (▲32%)
Cooling water pump	Water flow rate : 5,810 L/min	101,940 kWh	INV type : 3,500+2,000 L/min	66,131 kWh	35,809kWh (▲35%)
Chilled water pump	Water flow rate : 3,200 L/min	51,470 kWh	INV type : 1,323+757 L/min	33,362 kWh	18,108kWh (▲35%)
Air Handling Unit	Cooling capacity: 826kW	339,873 kWh	Cooling capacity: 814kW	255,641 kWh	84,232kWh (▲21%)
Fan coil Unit	Cooling capacity: 216kW		Cooling capacity: 251.5kW		
Lighting	Normal light type	344,911 kWh	High efficiency type	272,480 kWh	72,431kWh (▲25%)
Others		899,098 kWh		899,098 kWh	–
Total		2,221,221 kWh		1,827,935 kWh	393,286kWh (▲18%)

393,286kWh/year (▲17%) reduction by Equipment upgrade

Plant system COP

HITACHI Inspire the Next

Equipment	Before upgrade1981)	kW	After upgrade(2004)	kW
Absorption Chiller	Gas type (COP=1.0) Cooling capacity: 320RT Chilled water : 12→7℃ Cooling water : 32→37℃	E:12kW G:282kW (92㎥/h)	Highly effective type (COP=1.35) Cooling capacity: 210, 120RT Cold water : 15→7℃ Cooling water : 32→37℃	E:8kW G:130kW (42.8㎥/h) E:7.8kVA G:74.9kW (24.5㎥/h)
Cooling tower	Super-low noise type Cooling capacity : 2,037kW	7.5kW	Super-low noise type Cooling capacity: 1,360kW+839kW	3.7kW×2 5.5kW
Cooling water pump	Water flow rate : 5,810 L/min	45kW	INV type : 3,500+2,000 L/min	22kW 15kW
Chilled water pump	Water flow rate : 3,200 L/min	37kW	INV type : 1,323+757 L/min	11kW 7.5kW

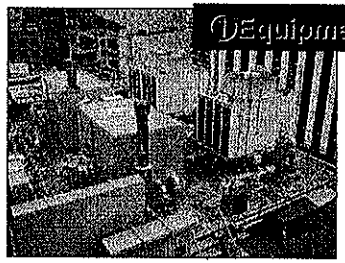
Plant room efficiency: Before 1.2kW/RT
After 0.86kW/RT

AC floor space: 0.0055RT/㎡

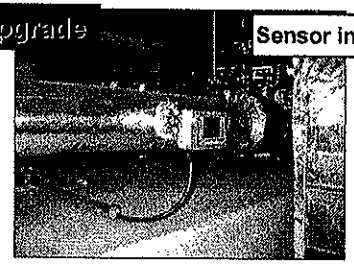
Upgrade photograph

HITACHI Inspire the Next

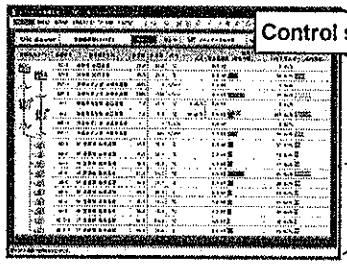
①Equipment upgrade



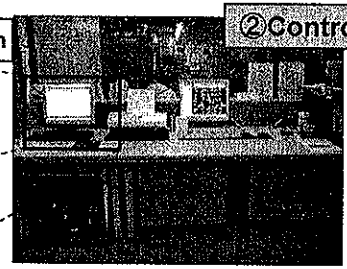
Sensor installation



Control screen

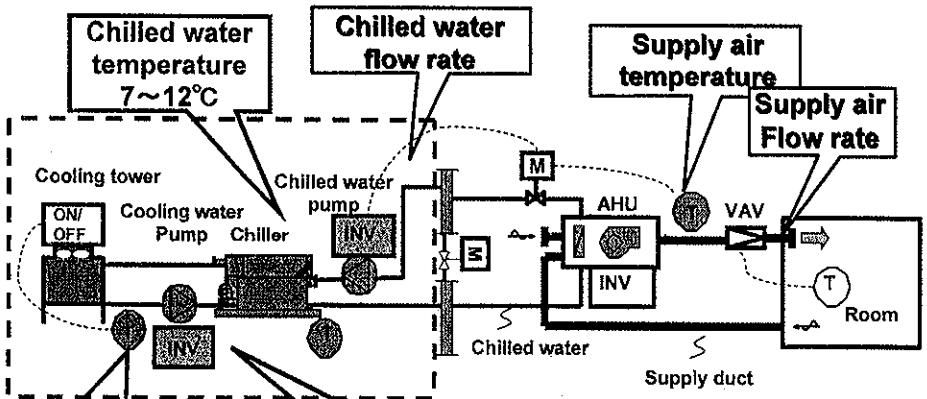


②Control upgrade



② Control upgrade Detail (OH Saver)

HITACHI Inspire the Next



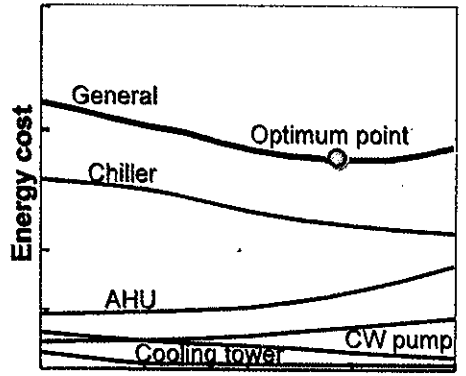
114,852kWh/year (▲5%) reduction by control upgrade

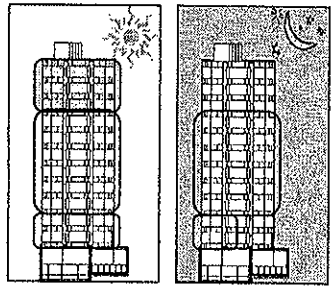
OH Saver Concept

HITACHI Inspire the Next

Optimization
Open Network
Object-method

Hitachi Plant energy Saver



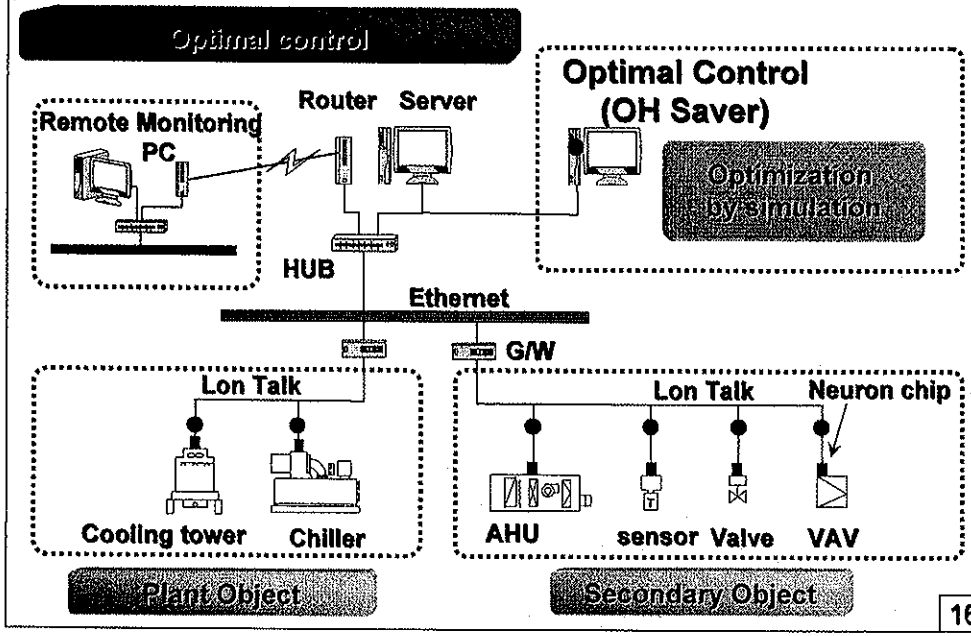


※Change Optimum point
・Heat load
・Outside Condition

Total system parameters are measured and controlled to obtain the highest energy saving operation point

OH Saver system Outline

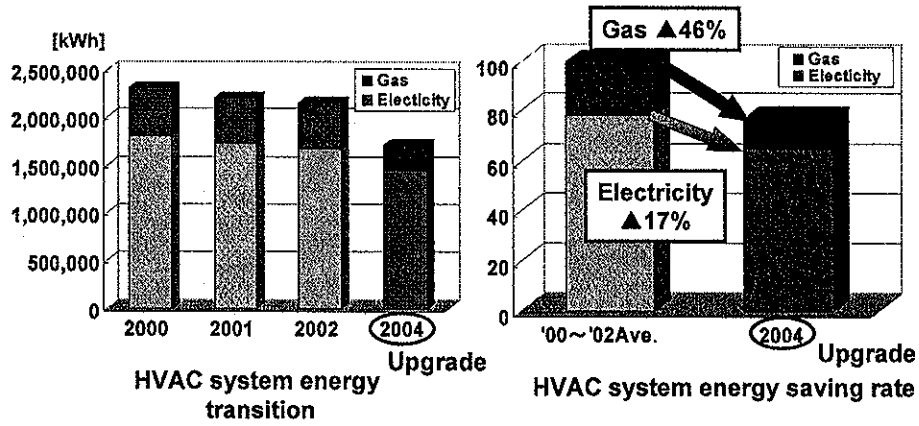
HITACHI Inspire the Next



16

Total energy saving effect by one year

HITACHI Inspire the Next



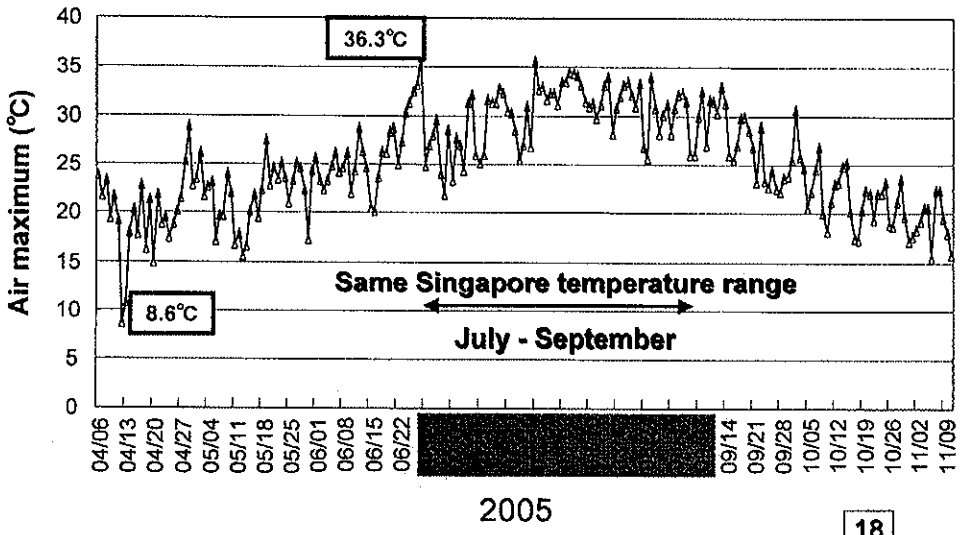
Energy saving effect →▲ 22%(2004)
(equipment upgrade 17% and control upgrade 5%)

17

Outside temperature degree transition

HITACHI Inspire the Next

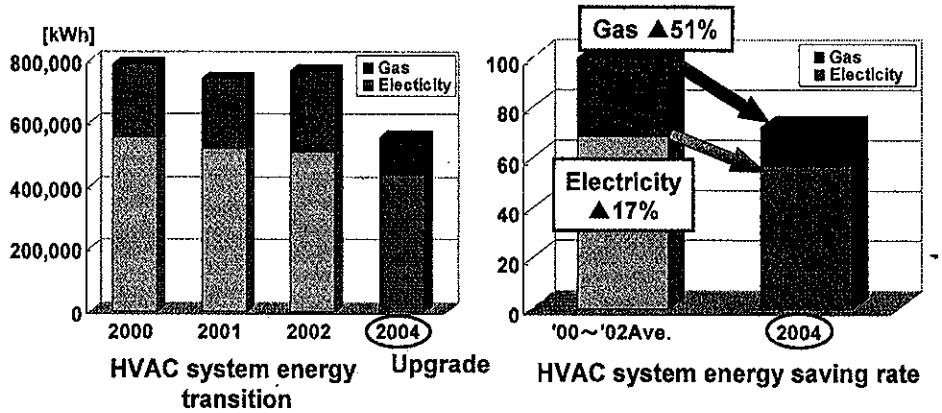
・Highest outside temperature degree transition



18

Total energy saving effect by three month

HITACHI Inspire the Next



Energy saving effect →▲28%(July～September)
(equipment upgrade 24% and control upgrade 4%)

19

Energy saving sample by only control upgrade

HITACHI Inspire the Next

・Relation condition

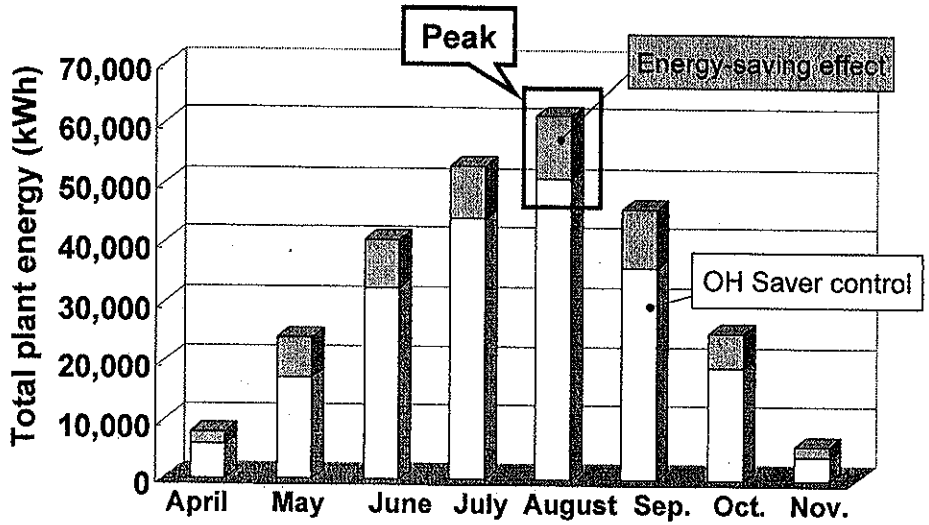
Control method	Conventional Control	Optimum control (OH Saver)
Energy consumption	Simulation value	Measurement value
Chilled supply water temperature	7℃	Measurement value (Optimum control)
Cooling supply water temperature	32℃	
Chilled supply water flow rate	100%	
Cooling supply water Flow rate	100%	

Simulation value based on measurement load

Energy saving sample by only control update

HITACHI Inspire the Next

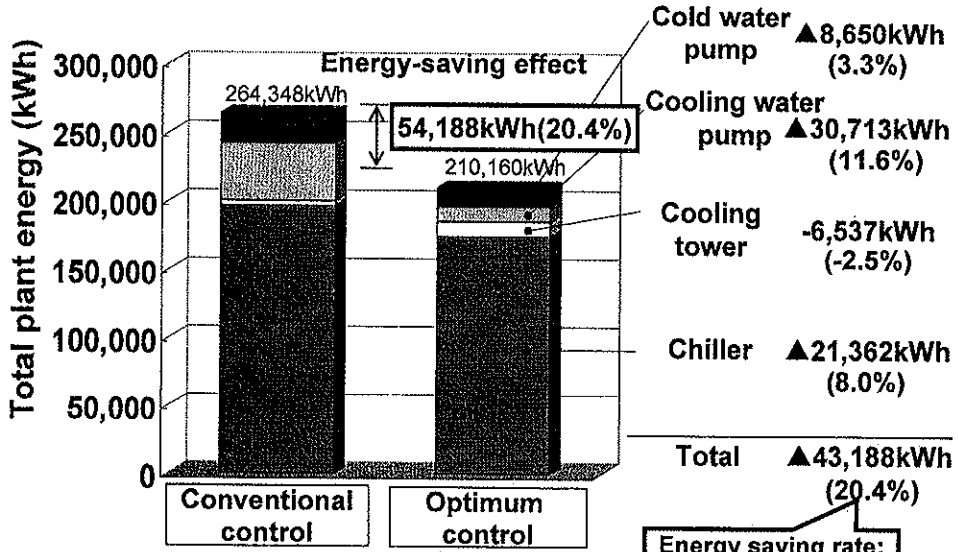
・Energy saving relation from April to November



Energy saving sample by only control update

HITACHI Inspire the Next

・Comparison result



Cold water pump	▲8,650kWh (3.3%)
Cooling water pump	▲30,713kWh (11.6%)
Cooling tower	-6,537kWh (-2.5%)
Chiller	▲21,362kWh (8.0%)
Total	▲43,188kWh (20.4%)

Energy saving rate: 20.4%

OH Saver tracking record in Japan

HITACHI Inspire the Next

OH Saver install Building

Place	Use	Scale
1.Tokyo	Own building	12,000㎡,B1F-7F
2.Kanagawa	Tenant building	9,600㎡,B1F-7F
3.B building	Own building	17,300㎡,B1F-7F
4.C building	Tenant building	11,200㎡,B1F-5F
5.D center	Physical education facilities	29,000㎡,B1F-4F

Floor Sensible Heat Storage Combined with Packaged Air-Conditioning

HITACHI Inspire the Next

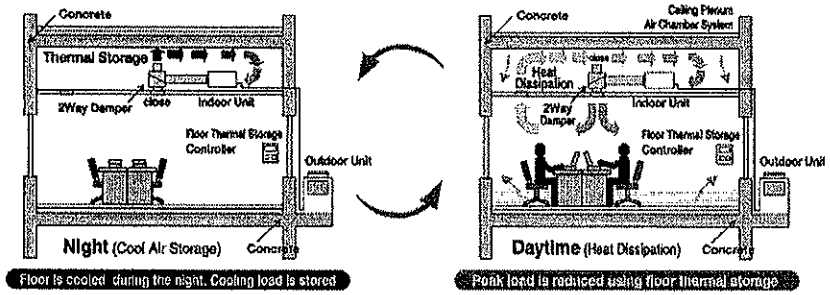
Energy Saving Using: Floor Sensible Heat Storage+ Packaged Air Conditioning

- 7% Energy saving. 10% Co_2 reduction.
- 15% Running cost reduction, Additional cost reduction through thermal storage discount contract signed with utility company 1).
- 20% Reduction in heat load peak using floor sensible heat storage 2).

(Based on Hitachi Plant Experiment)

1) Utility rate discounts ensured by shifting part of day-time cooling loads to night time.
2) Downsizing cooling equipments through Peak Cut (During Cooling Season).
Shifting day-time thermal loads to night time.

● Floor Sensible Thermal Storage Concept

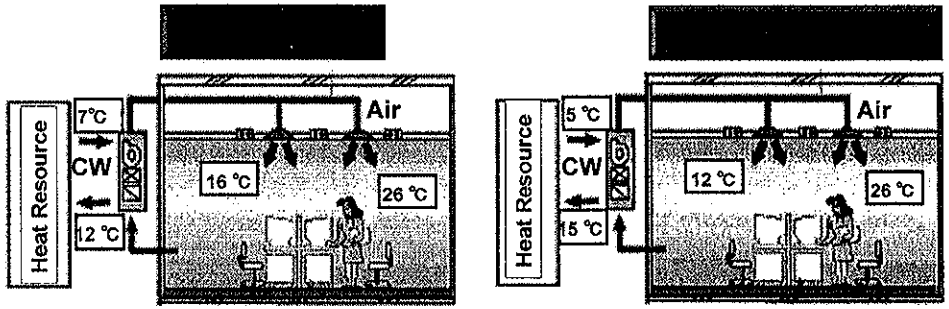


Large Temperature Differential Air Conditioning

HITACHI Inspire the Next

Reduced Chilled Water Flow and Air blast of HVAC System

High Cost and Energy Saving Achieved through Downsized pump, blower and duct sizing.



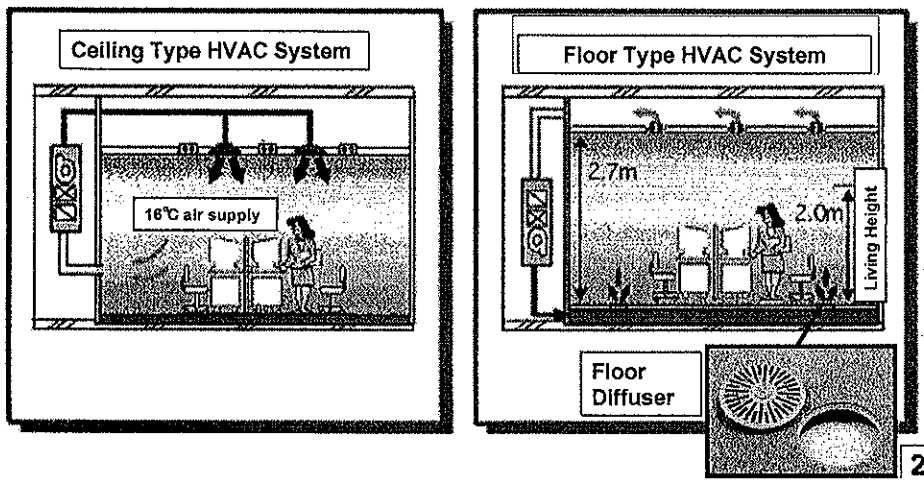
Water Temperature Differential	5 ℃
Air Temperature Differential	10 ℃

Water Temperature Differential	10 ℃
Air Temperature Differential	15 ℃

Floor Type Air Conditioning

HITACHI Inspire the Next

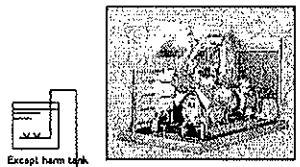
Floor Type HVAC With raised floor, with the cool air supplied from the floor and exhausted through the ceiling.
Personal A/C , High Energy Saving, Low Cost (Duct-less)

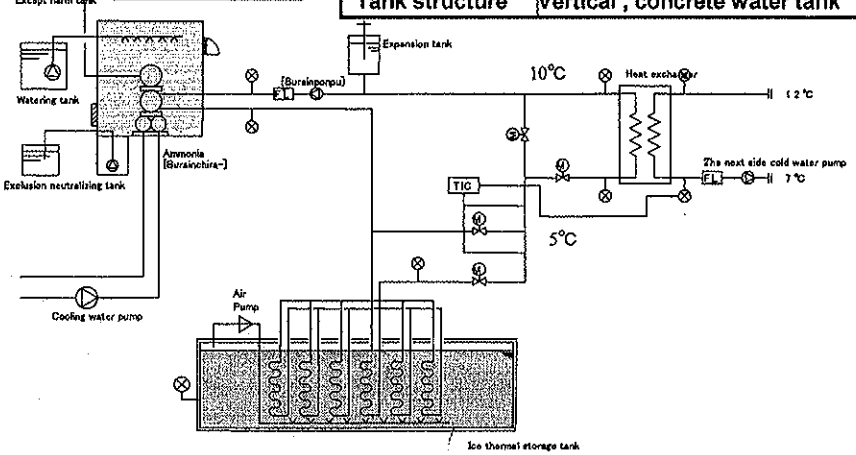


Ice thermal storage

HITACHI Inspire the Next

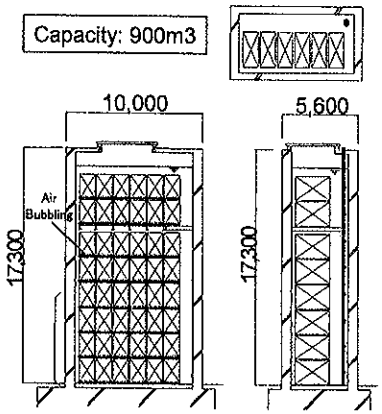
Chiller	Ammonia brine chiller(500 USRT) (non fluorocarbon type)
System	In tank 35 units coil for ice storage
Storage capacity	5,000 USRT·h
Brain flow rate	10,800 L/min (ethylene glycol 40%)
Tank structure	Vertical , concrete water tank





Feature of Ice thermal storage①

HITACHI Inspire the Next



Storage tank outline

Feature

- Adoption of Ammonia brine chiller (non fluorocarbon type)
- Adoption of Ice storage system at 500USRT Storage for 10 hours, Radiation in 7 hours including the peak
- Limit space and earthquake-proof required for ice thermal storage tank

Feature of Ice thermal storage②

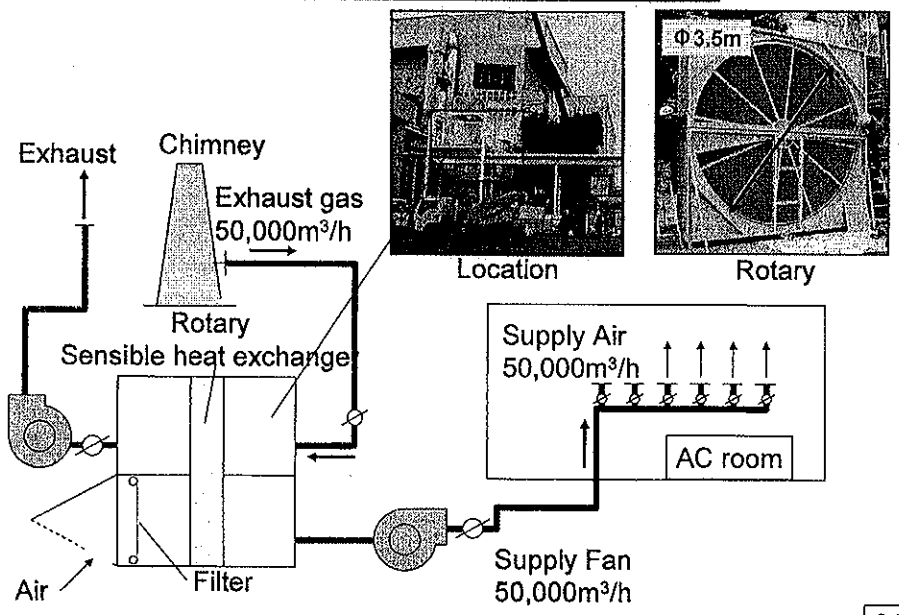
HITACHI Inspire the Next

Refrigerant	NH3	HCFC-123	HFC-134a
ODP	0	0.02	0
GWP ※1	0	93	1300
HGWP ※2	0	0.03	0.33
Toxicity	○ (high toxicity)	○ (high toxicity)	○ (low virulence)
ACGIH Exposure limit value TLV-TWA	25(ppm)	10～30(ppm)	1000(ppm)
Combustion	○ (flame resisting)	× (non-flammability)	× (non-flammability)
Price ※3	1.0	5.0	3.0
Remarks	except harm equipment necessary	Production prohibition after 2010 Effluent control	Effluent control

※1. CO2 gas standard ※2 CFC-11 standard ※3 Price for each weight

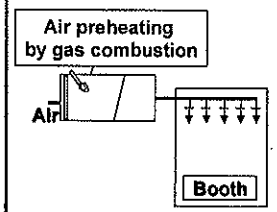
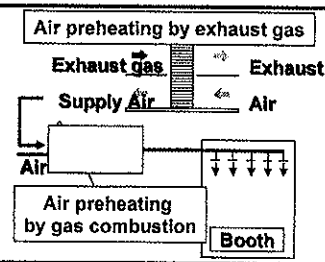
Exhaust heat recover system

HITACHI Inspire the Next



Exhaust heat recover system comparison

HITACHI Inspire the Next

	Existing system	Rotary sensible heat exchanger
System flow		
Outline	·System: in AHU gas combustion heating way ·Open air: 429,000m3/h ·Supply temperature degree: 22℃	·System: Rotary sensible heat exchanger exhaust gas preheating way ·Open Air: 429,000m3/h ·Supply temperature degree: 22℃ ·Exhaust gas: 50,000m3/h ·Heat exchange efficiency: 52%
Gas (13A) reduction	(consumption: 454,000Nm3/year)	▲12,200Nm3/year
Initial cost	-	60 million yen
Running cost	(cost: 19.5 million yen/year)	▲10.9 million yen/year
ROI	-	5.5 years

Membrane Type Sewage Treatment System

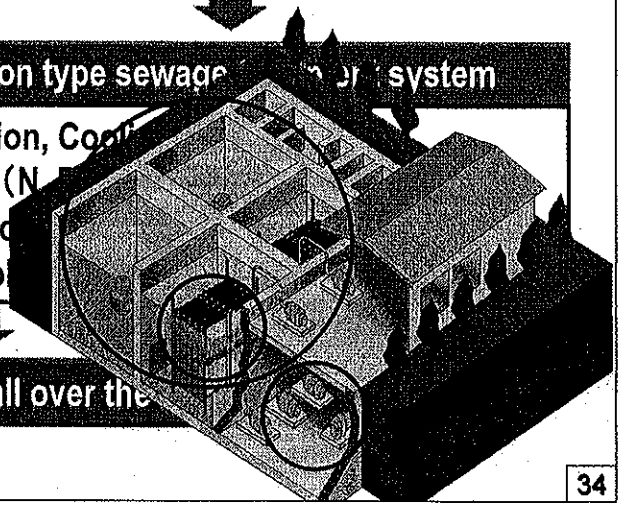
HITACHI Inspire the Next

Membrane Filtration Process + **Activated Sludge Process**

The next generation type sewage [illegible] system

- Water re-use (Irrigation, Coo
- Advanced treatment (N
- Space saving (Low fo
- Easy process contro

Installation area is all over the



Supply Records

HITACHI Inspire the Next

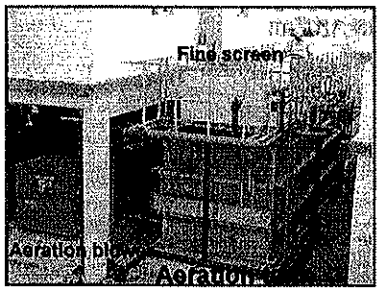
Mie	Industrial	(Optical material)	2004	100
Okayama	Industrial	(Food processing)	2003	225
Yamanashi	Industrial	(Semiconductor)	2002	2
Shizuoka	Industrial	(Animal)	2002	250
Chiba	Recycled	(Recycling water)	2001	300
Aichi	Industrial	(Power plant)	2001	480
Okayama	Industrial	(Food processing)	2000	50
Saitama	Recycled	(Recycling water)	2000	36
Ishikawa	Industrial	(Power plant)	1997	200
Chiba	Industrial	(Semiconductor)	1997	144
Kanagawa	Industrial	(Food processing)	1997	100
Tokyo	Industrial	(Semiconductor)	1997	2,400

Compact type MBR Unit

HITACHI Inspire the Next

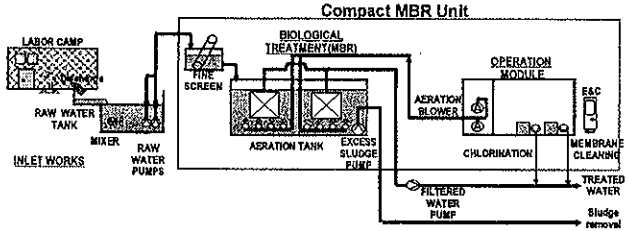
■ HPT Compact MBR for Temporary works

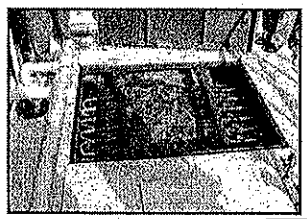
- **Capacity** : 200~500m³/day
- **Substance treated** : BOD, SS (Optional: N,P)
- **Application**
  - Treatment of waste water generated from Labor camp. (1,300 – 3,200 labors/unit)
  - Water treatment at construction site.
  - Temporary wastewater treatment for residential area.



(Membrane units are installed)

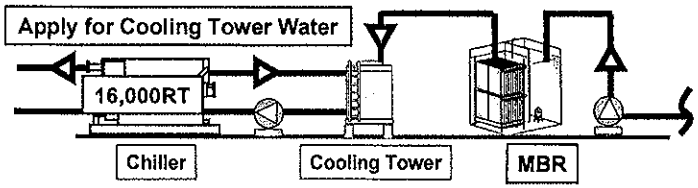
Compact MBR Unit





Estimate MBR's ROI by cost reduction

HITACHI Inspire the Next



Current Situation		→ Proposed Recycle	
(1) Recirculation Rate	15,500 m³/h	(3) Target Recovery	2,652 m³/D [50% of (2)]
(2) Water Usage	5,304 m³/D [1.43% of (1)]	(4) Water Bill @ (3)	S$1,963,700/y [S$2.03/m³]
		(5) MBR System Cost	S$4,500,000
		(6) O&M Cost	S$54,750/y

ROI = 2.35 Years ← $\frac{\text{S\$4,500,000}}{\text{S\$(1,963,700 – 54,750)}}$

Conclusion

HITACHI
Inspire the Next

Achieve Energy saving effect of 23% in Japan Practice

In Singapore We can supply energy saving in various field based on Japanese performance

Hitachi Plant Technologies, Ltd is the FIRST Japanese Company accredited as an Energy Services Company (ESCO) in Singapore


Certificate of Accreditation

ENERGY SERVICES COMPANIES ACCREDITATION
SINGAPORE

Provisional Accreditation

Level 1,2

General, Building & Industrial

Hitachi Plant Technologies,Ltd

Energy Smart Hotels Seminar 3 Aug,
Regent Hotel Singapore

HITACHI
Inspire the Next

Energy Conservation Efforts in Japan

3 August 2007

Hitachi Ltd.
Urban Development Solutions Division
Dr. Masaaki BANNAI P.E
E-mail : masaaki.bannai.xu@hitachi.com

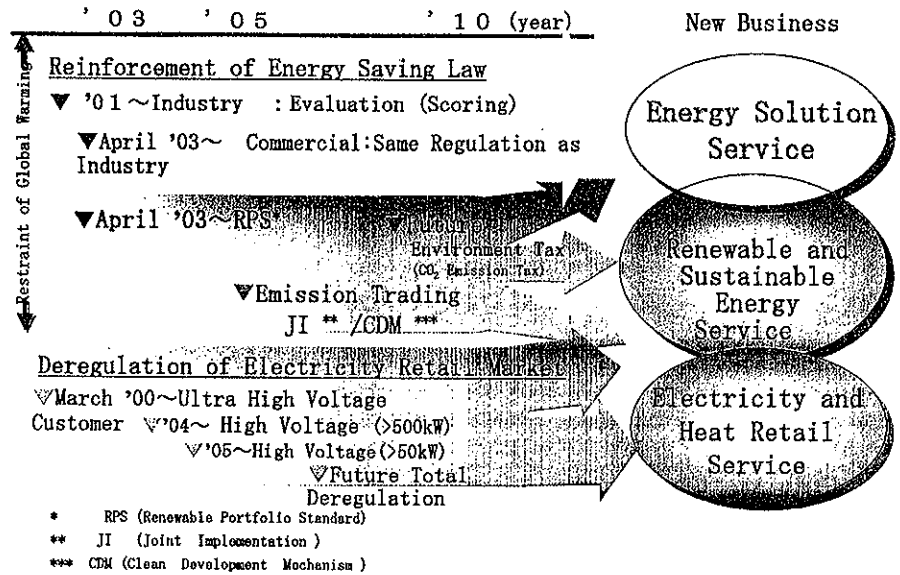
© Hitachi, Ltd. 2007. All rights reserved.

Contents

1. Trend Energy Saving Law
2. Introduction of Energy Solution Business
3. Energy Solution Business Expansion
4. Future Trend

© Hitachi, Ltd. 2007. All rights reserved.

Trend of New Business



* RPS (Renewable Portfolio Standard)
** JI (Joint Implementation)
*** CDM (Clean Development Mechanism)

© Hitachi, Ltd. 2007. All rights reserved.

Revised Energy Conservation Law ; started at 1 April '06

Main revised points

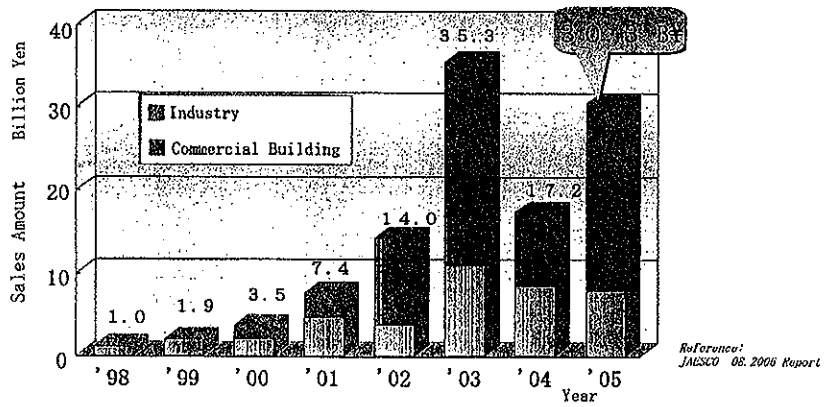
- Heat and electricity are managed unified as energy
- No of applied works/offices (10,000 to 13,000)

Designated works/offices	Primary Energy Management Factory	Secondary Energy Management Factory
Applied to	All	All
Energy Consumption (Heat & Power)	more than 3,000 kl/annual	more than 1,500 kl/annual
Duty	Assign Energy management staff with specified knowledge of heat and electricity qualified by Government	Assign Energy management personnel with taken a energy lecture
	Submit middle/long-term plan	
	Periodic Report	Periodic Report
Inadequate Correspondence	Instructed, announced and commanded by Minister	Counseled by Minister

© Hitachi, Ltd. 2007. All rights reserved.

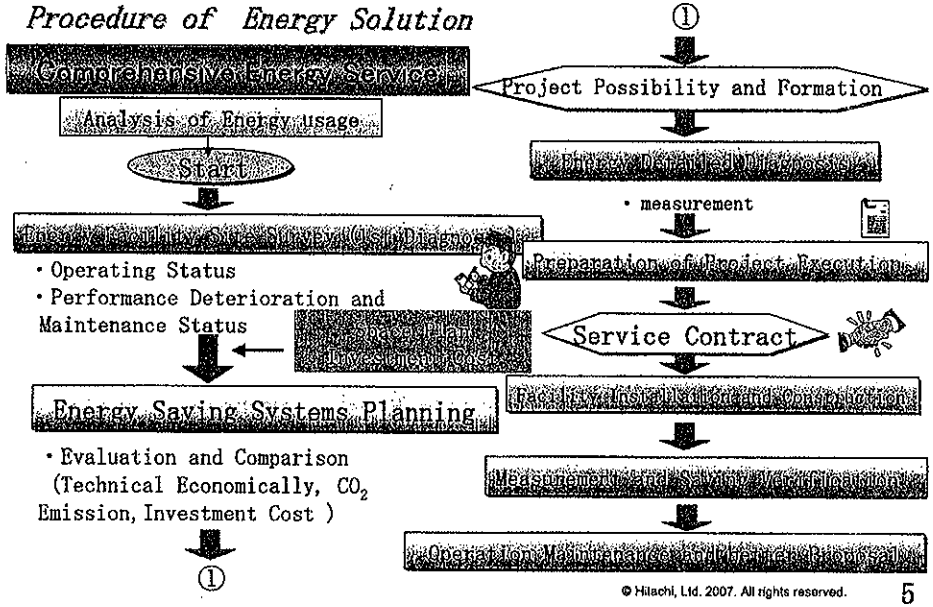
Historical Market Trend in Japan

'97 「ESCO Introduction Committee」 Founded
'Oct. '99 「ESCO Promotion Council (JAESCO) 」 Started



© Hitachi, Ltd. 2007. All rights reserved.

Procedure of Energy Solution



© Hitachi, Ltd. 2007. All rights reserved.

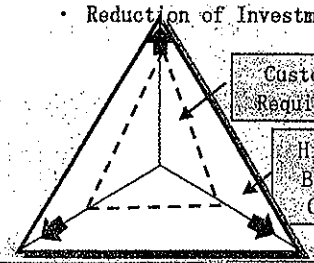
Customer's Status and Requirement

- Energy Saving and Reduction of CO_2 Emission (Duty : annual Energy Saving more than1%)
- Production Cost Increase
- Improve ROA/ROE



Triple Bottom Line of Energy
(Investment×Energy Saving×CO_2Reduction)

Improve Profitability
- Improve ROE
- Reduction of Investment



Corporative Social Responsibility

Provision for Environment

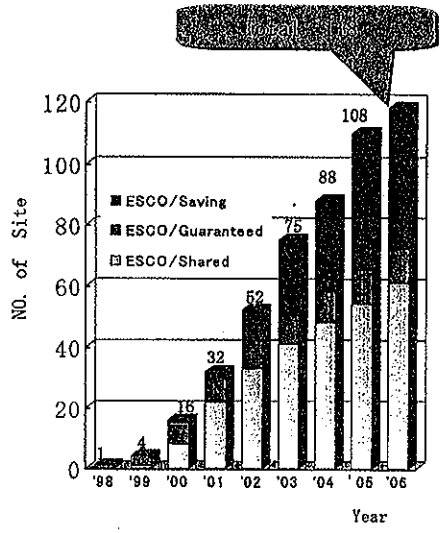
Information Disclosure of an Action to the Energy Saving Improvement of Company Brand

CO_2 Emission Reduction

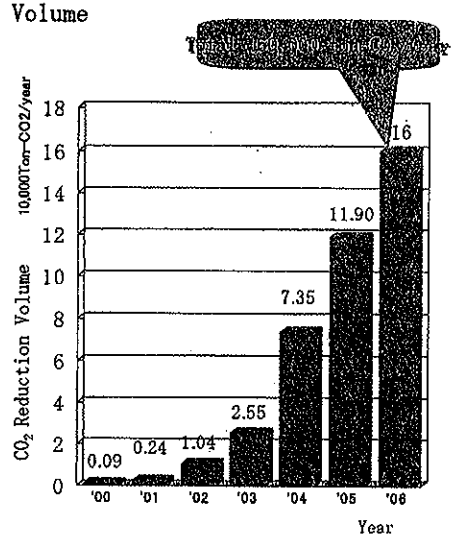
© Hitachi, Ltd. 2007. All rights reserved.

Accumulated experiences

(As of Sept. '06 Including planned.)

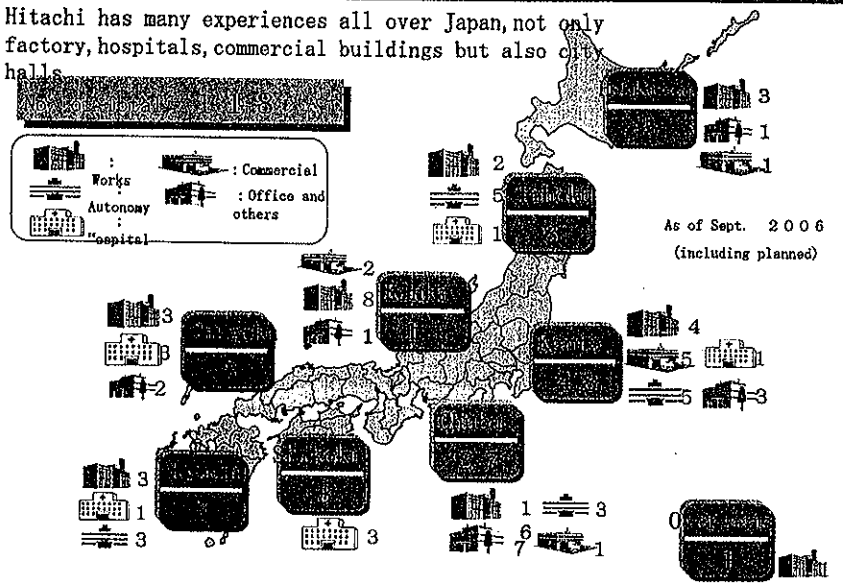


Accumulated CO2 Reduction Volume

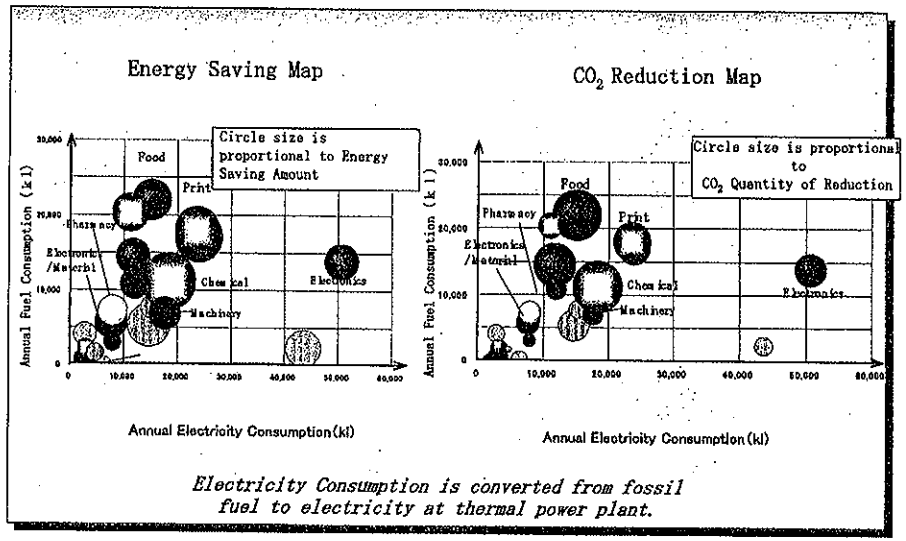


© Hitachi, Ltd. 2007. All rights reserved.

Hitachi has many experiences all over Japan, not only factory, hospitals, commercial buildings but also city halls



© Hitachi, Ltd. 2007. All rights reserved.



Electricity Consumption is converted from fossil fuel to electricity at thermal power plant.

© Hitachi, Ltd. 2007. All rights reserved.

Outline of Works

・Produce Construction Machines ・Rated Maximum Electricity : 22,000kW

Air-Conditioning Improvement: Displacement Air Conditioning* → Fan Power is reduced to 1/10

Co-Generation: Much Energy Conservation by Flexible Co-Gen

- No Investment Cost (Owned by ESCO Company)
- Guarantee Energy Saving Ratio for 10 years

■ Annual Energy Saving Amount ; 2,280 kl (9 %)

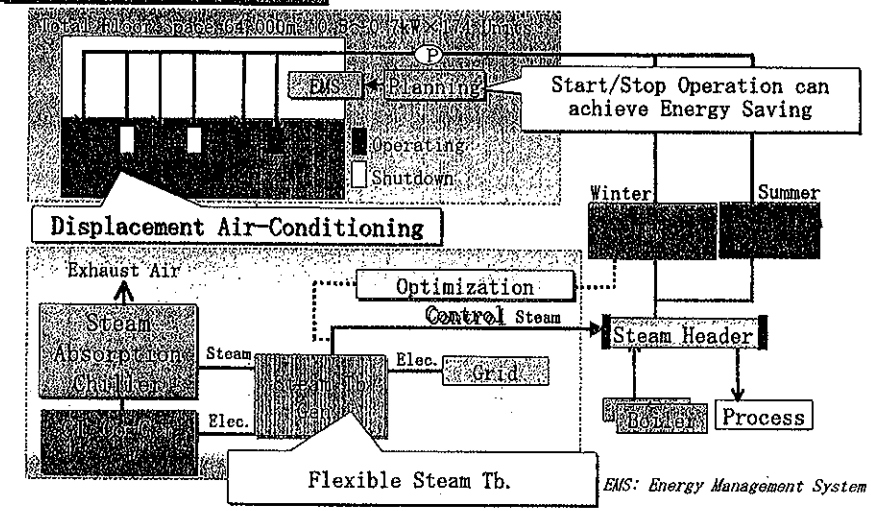
■ Annual CO_2 Reduction Rate ; 4,650 ton-CO_2 (6 %)

*Displacement Air-Conditioning
Ultra low air velocity 0.3~0.6m/s

© Hitachi, Ltd. 2007. All rights reserved.

System Configuration

Energy Saving Eq.

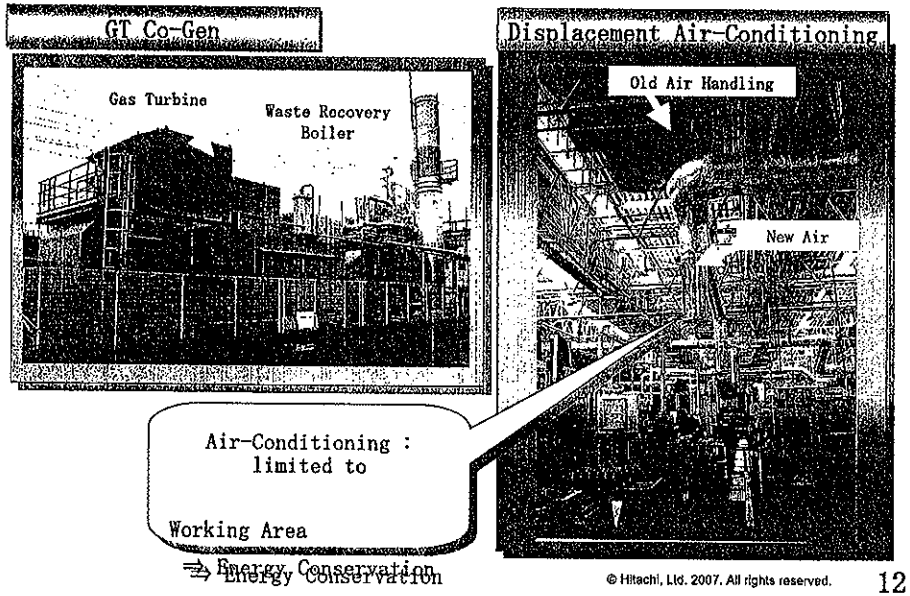


EMS: Energy Management System

© Hitachi, Ltd. 2007. All rights reserved.

(Construction Machinery Factory)

HITACHI Inspire the Next


GT Co-Gen

Displacement Air-Conditioning

Air-Conditioning : limited to
Working Area
⇒ Energy Conservation

© Hitachi, Ltd. 2007. All rights reserved.

(A Factory of Semi-Conductor Product)

HITACHI Inspire the Next

Outline of Work

- Semi-Conductor Manufacturing
- Contract Electricity : 25000kW

Introduction

- Much Energy Usage Especially Chilled Water

Supply System

Promote Energy Saving and Environmental Preservation

Introduction Facility

Low Cooling Water Temp. according to Ambient Condition

◆Make Cooling Water Low
→ Chiller Performance Improvement

Reduction of Pumping Power

◆Reduction of Chilled Water Friction by a surfactant

Integrate Chiller System

Total Effect

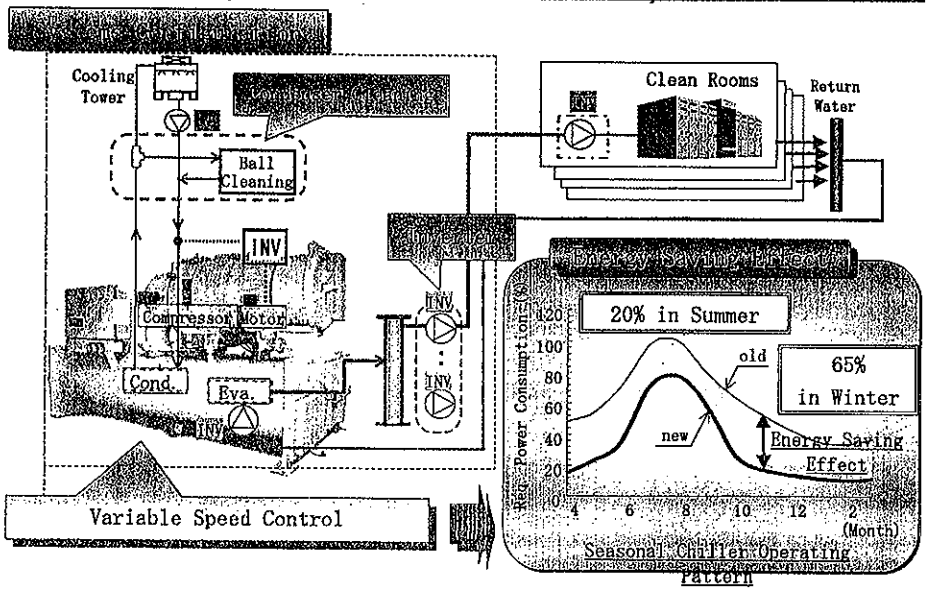
- Annual Energy Saving Amount ; 2,800 kl (6 %)
- Annual CO_2 Reduction Rate ; 3,800 ton-CO_2 (6%)

© Hitachi, Ltd. 2007. All rights reserved.

(A Factory of Semi-Conductor Product)

HITACHI Inspire the Next

Cooling Tower

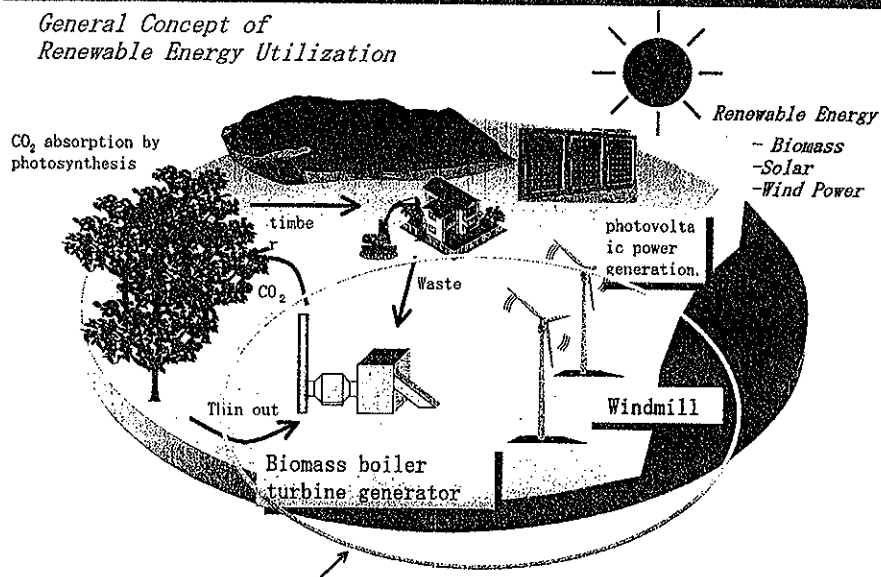


© Hitachi, Ltd. 2007. All rights reserved.

Business Experience

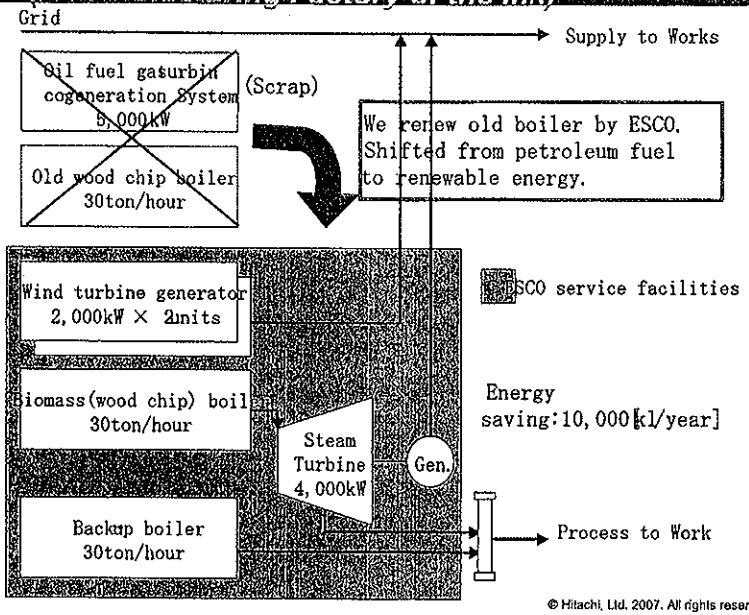
HITACHI Inspire the Next

General Concept of Renewable Energy Utilization



© Hitachi, Ltd. 2007. All rights reserved.

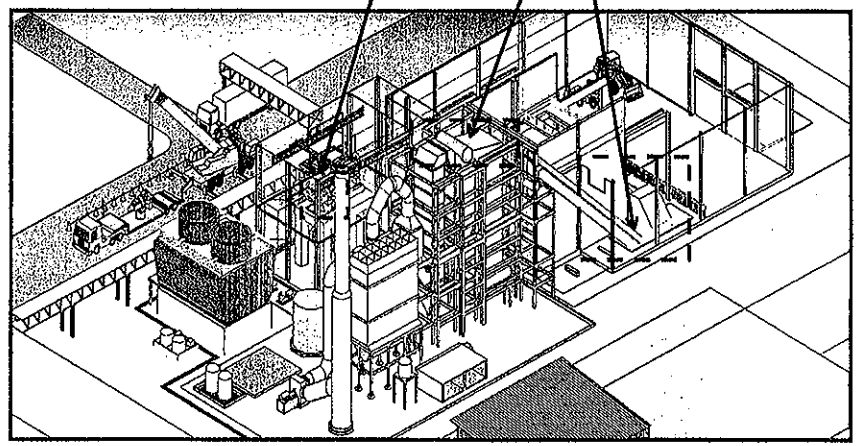
(A Manufacturing Factory of the Ink)



© Hitachi, Ltd. 2007. All rights reserved.

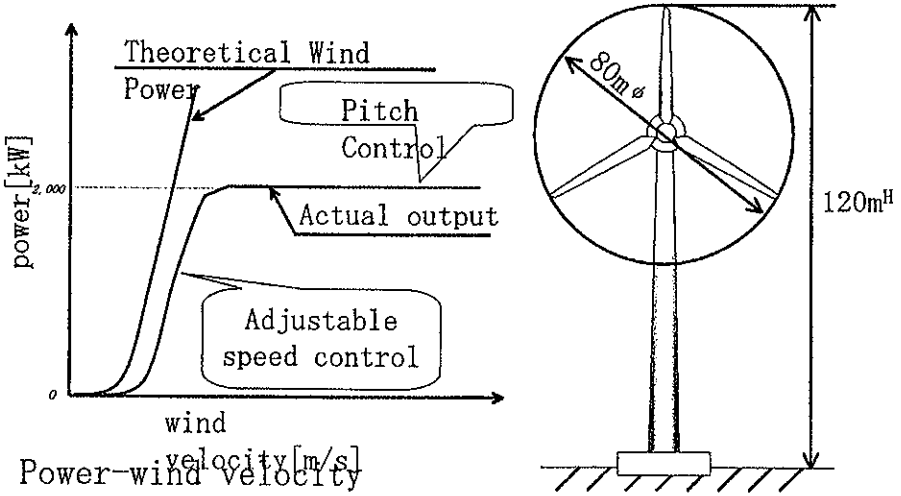
Biomass (wood chip) Boiler & Steam Turbine Generator Plant

Biomass Fuel emits none of CO_2



© Hitachi, Ltd. 2007. All rights reserved.

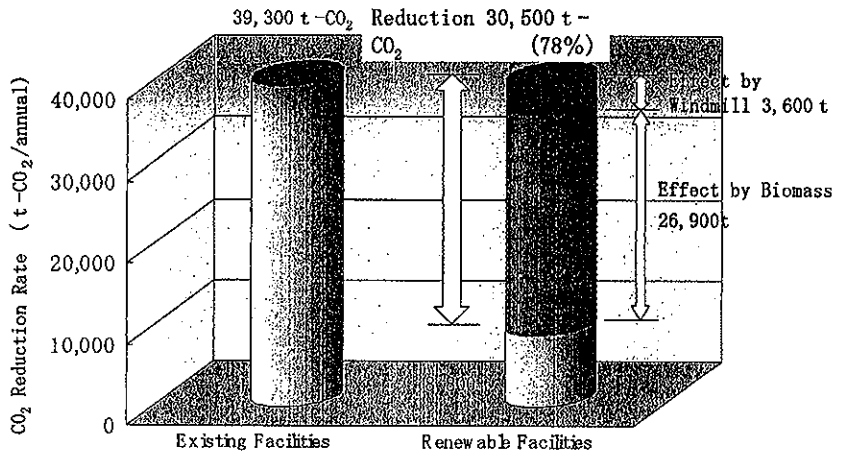
2 MW Windmill



Power-wind velocity characteristics

© Hitachi, Ltd. 2007. All rights reserved.

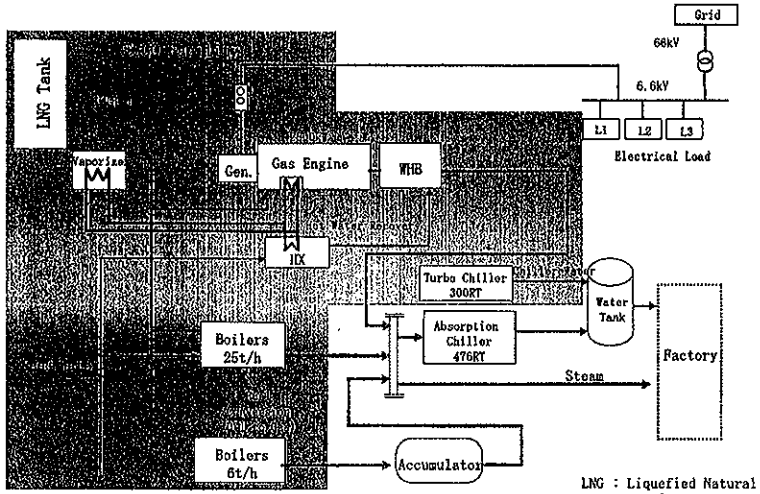
CO_2 Reduction Effect by Renewable Facilities



© Hitachi, Ltd. 2007. All rights reserved.

(Bottling Factory of Beverages)

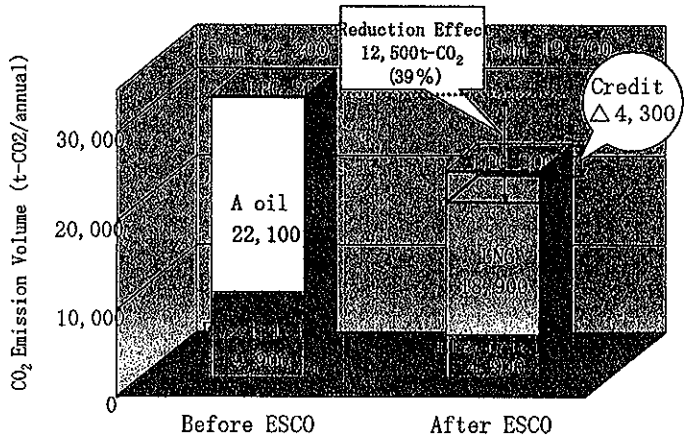
General Systems Configuration



© Hitachi, Ltd. 2007. All rights reserved.

(Cooling Factory of Beverages)

CO_2 Emission Reduction by Gas Engine CoGen

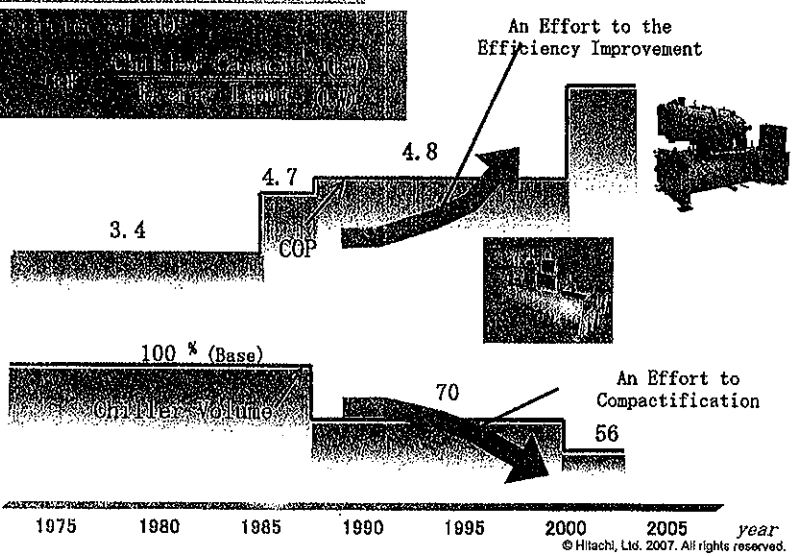


LPG (Liquefied Petroleum Gas)
LNG (Liquefied Natural Gas)

© Hitachi, Ltd. 2007. All rights reserved.

(COP and Volume)

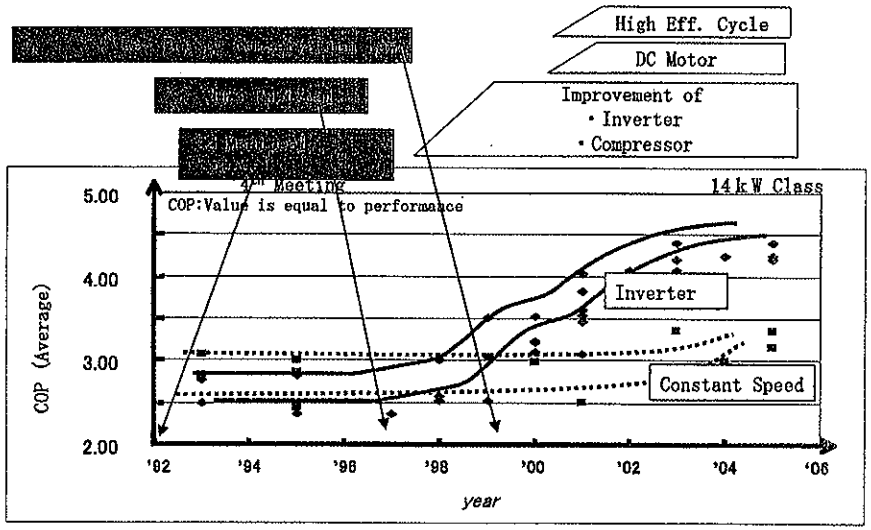
COP : Coefficient of Performance



© Hitachi, Ltd. 2007. All rights reserved.

Measures

Ingenuity



© Hitachi, Ltd. 2007. All rights reserved.

1. Continuous Effort to Energy Conservation
   - Ingenuity and Creative Energy Saving by ESCO
   - Development of High-Efficient Equipment

2. Information Exchange Globally, Especially Asian Countries and Region

© Hitachi, Ltd. 2007. All rights reserved.

END

3 August 2007

Hitachi Ltd.
Dr. Masaaki BANNI P.E

© Hitachi, Ltd. 2007. All rights reserved.

Towards Performing Energy Smart Hotels

SingPost
Case Study
3 August 2007
by
Trane Singapore
Lee Eng Lock
GM Energy Division



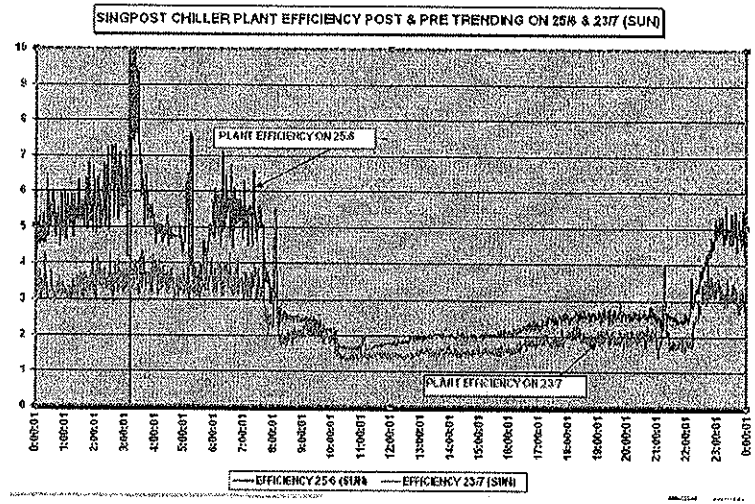
Chiller System Baseline Data as provided by CPG

2 X 900 Tr and 1 X 450 Tr

Time	Tonnage %	Operating Hrs Per Day	Days Per Year	Efficiency kW/ton	Chiller Energy Cost %
Mon-Friday	100%	10	260	1.25	0.20%
	45%	4	260	1.25	0.04%
	25%	10	260	1.25	0.05%
Sat	100%	5	52	1.25	0.10%
	75%	5	52	1.25	0.07%
	45%	4	52	1.25	0.04%
	25%	10	52	1.25	0.05%
Sun	75%	10	52	1.25	0.15%
	45%	4	52	1.25	0.04%
	25%	10	52	1.25	0.05%
Per Week					2%
Per Month					8%
Per Year					100%

Baseline Energy Cost Per Year = **100%**

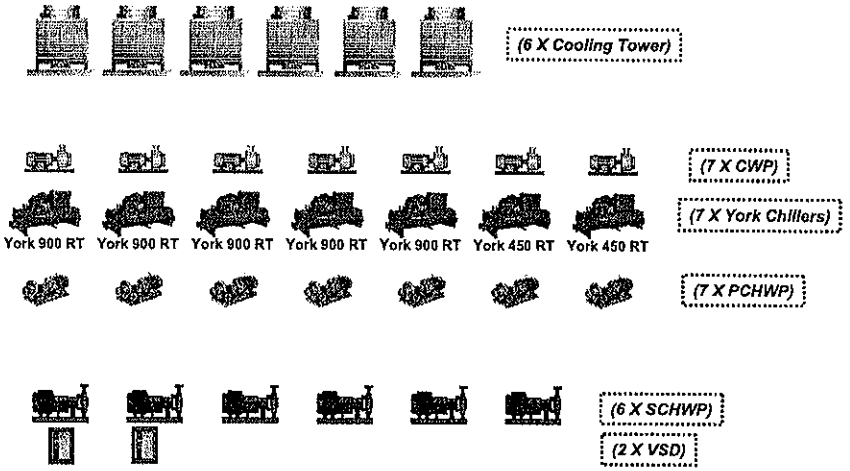
Chiller System Baseline Data as provided by CPG



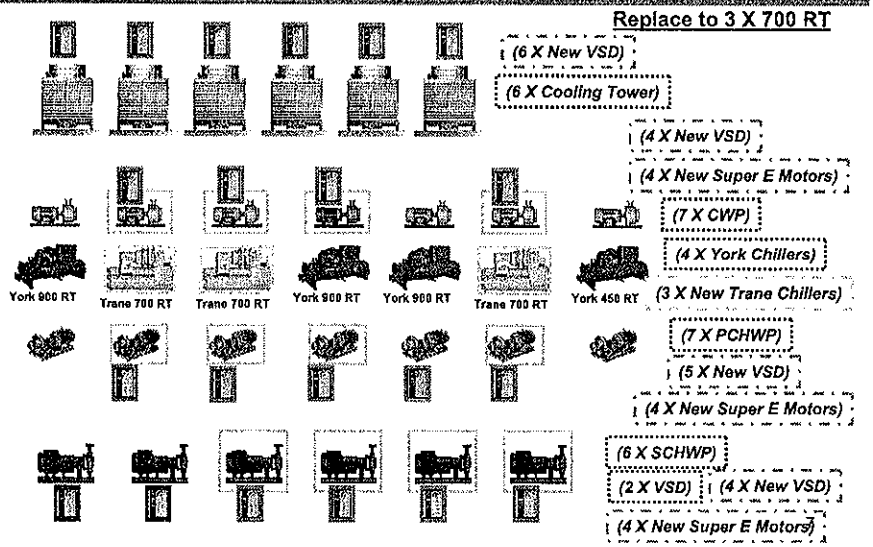
Chiller System	Weekly Consumption (kWh/week)	Plant kW/RT	Chiller kW/RT
North Spine	193,600	1.42	1.04
South Spine	110,200	0.85	0.64
NTE	152,100	1.27	0.65
N2	25,800	0.86	0.63
SCI	14,000	1.34	0.95

Table 1 Chiller and Chiller Plant Efficiencies

Existing System at SingPost Chiller Plant



Alternate 1 Offer by Trane Singapore



Alternate 1 Offer by Trane Singapore

Targeted Component kW/Ton

Component	kW/Ton
Chillers	0.498
PCHWP	0.02
SCHWP	0.03
CWP	0.03
CT	0.025
Total System	0.603

Time	Tonnage %	Operating Hrs Per Day	Days Per Year	Efficiency kW/ton	Chiller Energy Cost (%)
Mon-Friday	99.15%	10	260	0.603	0.10%
	44.62%	4	260	0.603	0.02%
	24.79%	10	260	0.603	0.02%
Sat	99.15%	5	52	0.603	0.05%
	74.36%	5	52	0.603	0.04%
	44.62%	4	52	0.603	0.02%
	24.79%	10	52	0.603	0.02%
Sun	74.36%	10	52	0.603	0.07%
	44.62%	4	52	0.603	0.02%
	24.79%	10	52	0.603	0.02%
Per Week					0.92%
Per Month					3.68%
Per Year					47.83%

Projected Energy Cost Per Year on Trane's Alternate 1 offer = **47.83%**

Projected Energy Saving Per Year :
100% - 47.83% = 52.17%

Investment = **SGD X,XXX,XXX.XX**

Projected Payback ~ **2 Years**

Statement of Guarantee

Alternative Proposal 1 (3 X 700 RT)

The tender specification baseline for System Efficiency (combination of Chillers, Cooling Towers, Condenser Water Pumps, Primary Chilled Water Pumps and Secondary Chilled water Pumps) is verbally stated at ***1.05 kW/Ton*** (may be subject to change during our baseline audit stage). The projected System Efficiency for the above is ***0.603 kW/Ton***; a saving of ***0.45 kW/Ton*** (equivalent to ***42.8%*** in saving). In the event of a shortfall in saving from ***0.383 kW/Ton*** (equivalent to System Efficiency of ***0.67 kW/Ton*** or ***36.2%*** in saving), Trane Singapore shall reimburse ***100%*** of the shortfall every quarterly. The savings verification will be computed quarterly.

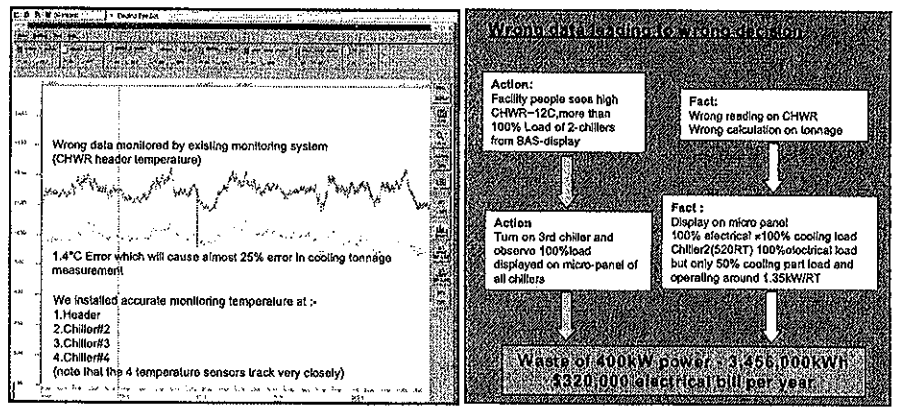
Note: Trane Singapore shall install a very accurate Web Monitoring System

Garbage in, garbage out

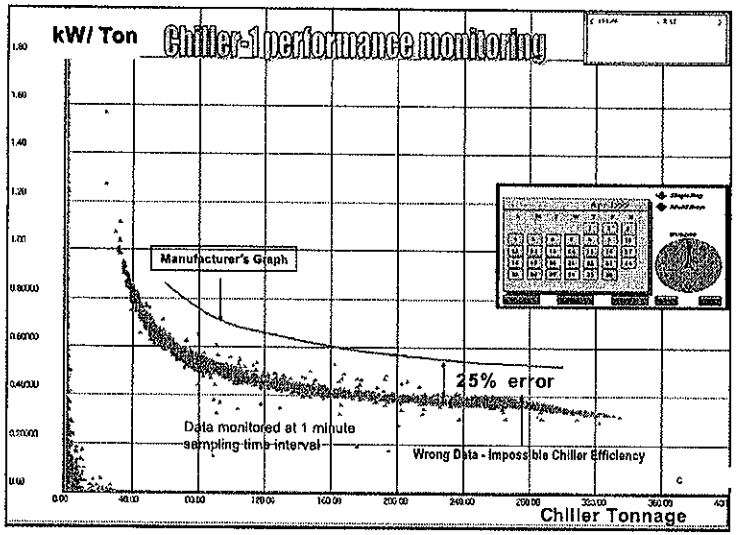


Inaccurate sensors (±1 deg F) = 20 % error in Energy Efficiency = Wrong decision = US$ xx million lost

Example of in-accurate sensor reading in a Semiconductor Factory



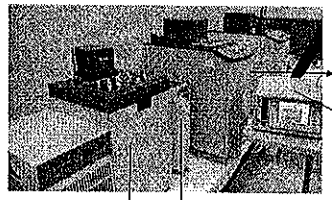
In-accurate Sensors and Monitoring System



Trane Singapore Calibration Lab

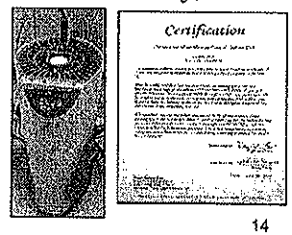
Trane Singapore has invested heavily on sensors, instrument, calibration equipment and computers. We are the only Total Performance Energy Service Company in the world to have such sensors and equipment to do energy jobs.

Calibration Lab



We hand calibrate our temperature sensor to an uncertainty of ± 0.01 °C

Gallium Cell Bath 29.7646 Deg C



Agilent 3458 (81/2 digit)

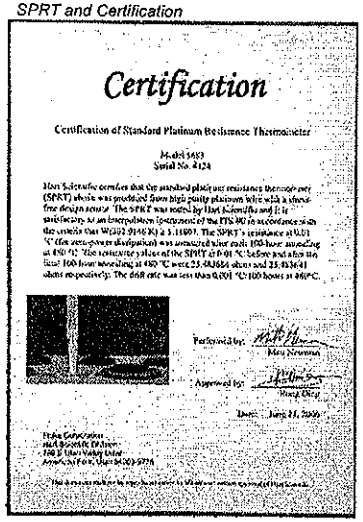


Triple Point Cell (0.01°C)

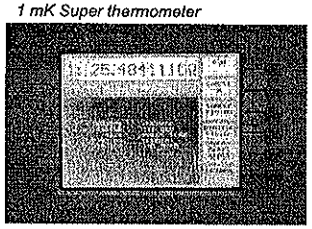


Trane Singapore Calibration Lab

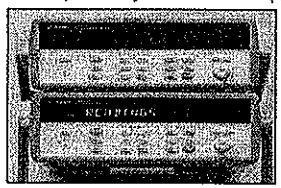
SPRT and Certification



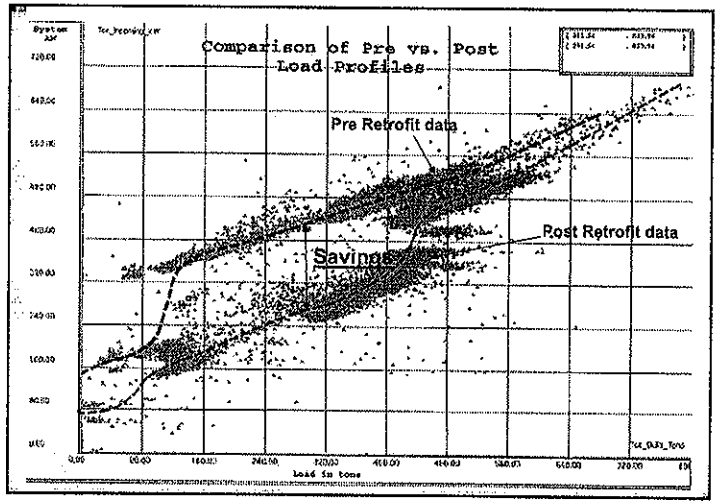
1 mK Super thermometer



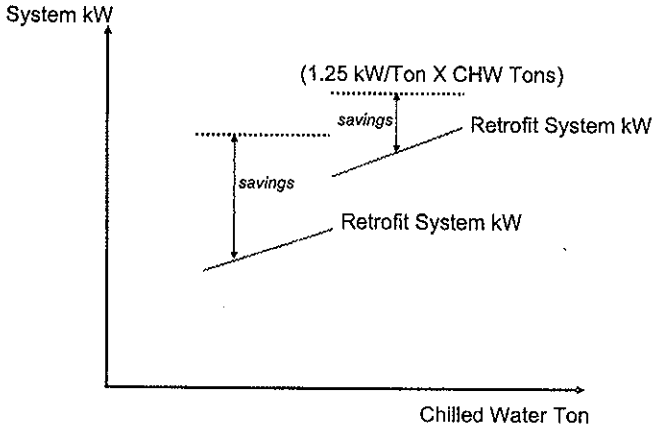
Data Acquisition system used at site (20~24 bit A/D)



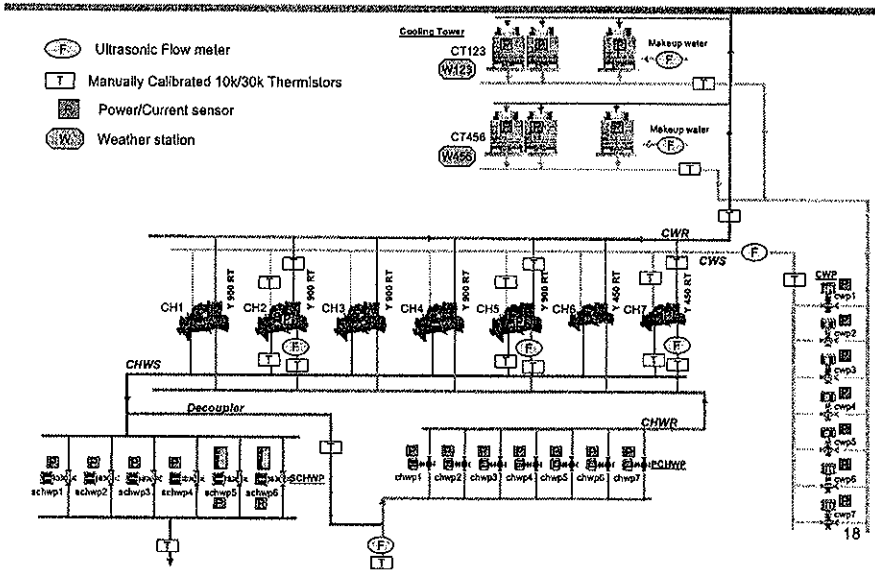
Example of Pre and Post Data on Savings



SingPost Savings Methodology

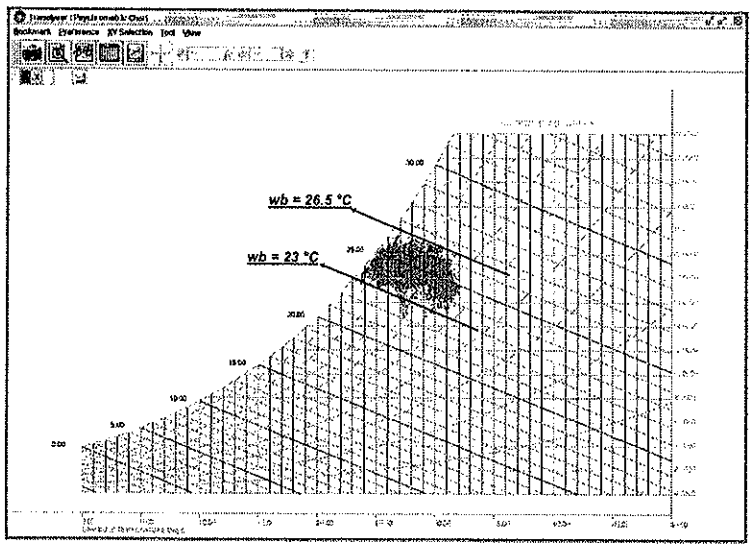


Baseline Monitoring Points

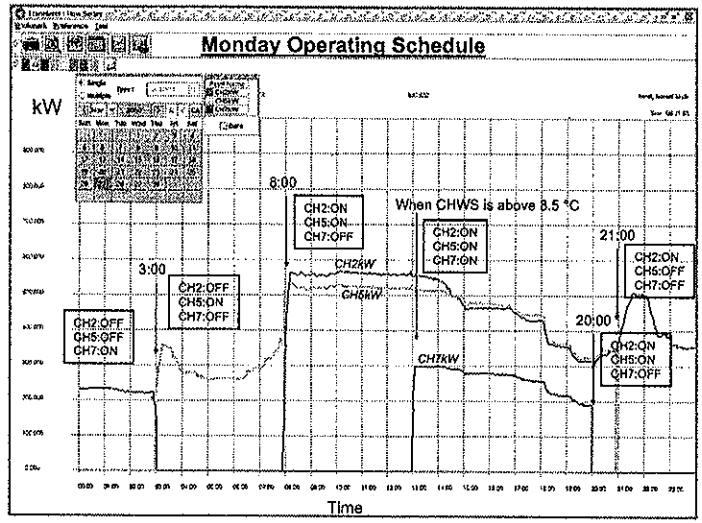


Weather Data for CT-123

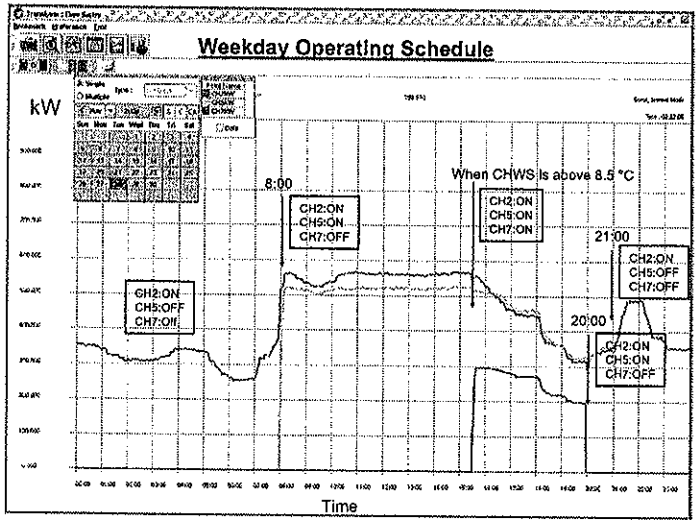
Data from 20th Nov, 2006 to 19th Dec, 2006



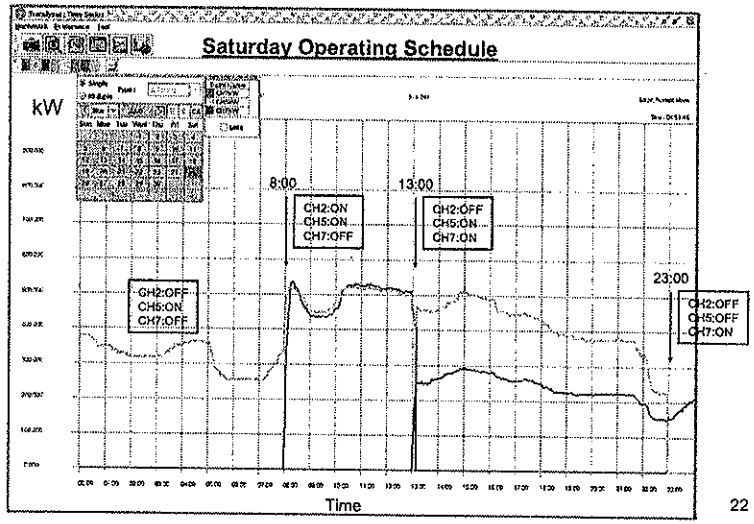
Typical Operating Schedule



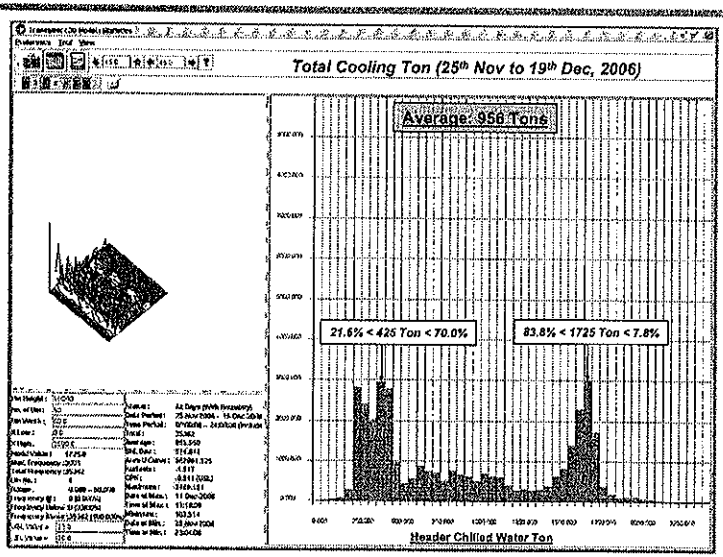
Typical Operating Schedule



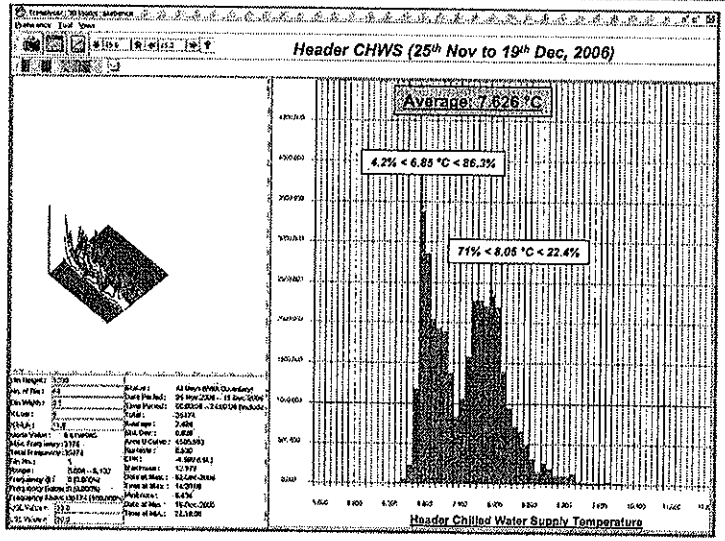
Typical Operating Schedule



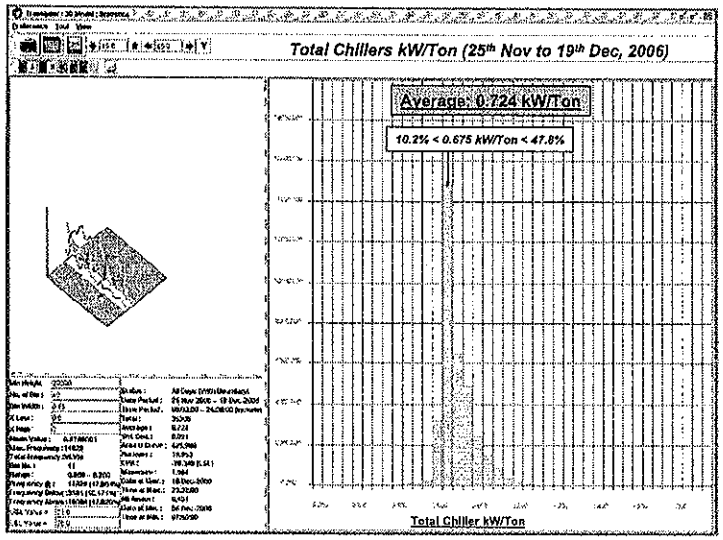
Component's Average



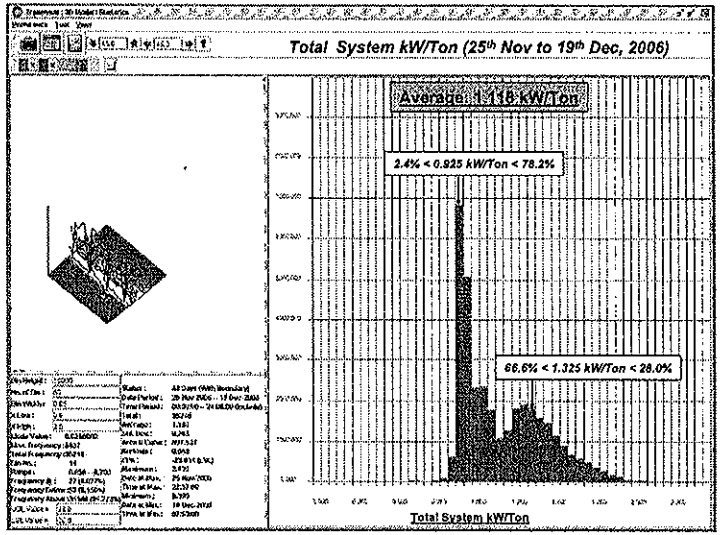
Component's Average



Component's Average



Component's Average

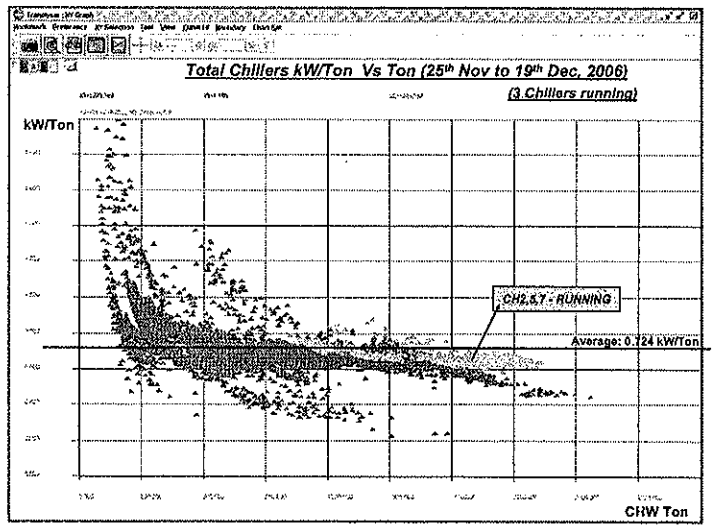


Summary of Averages

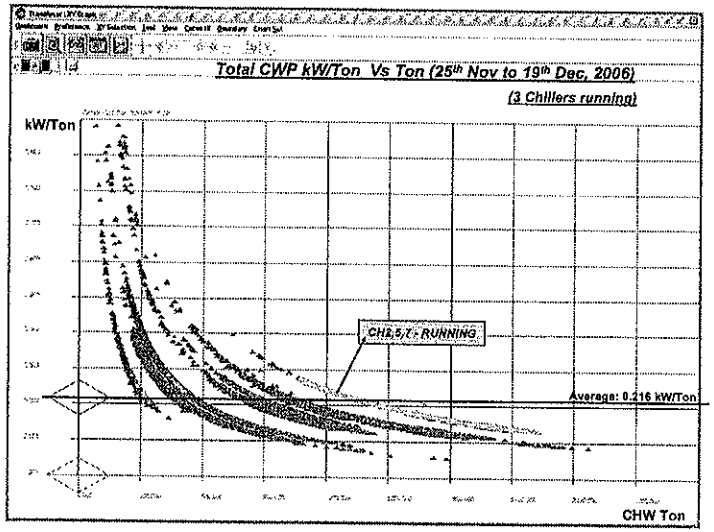
#	Component	Average
1	Chillers	0.724 kW/Ton
2	Condenser Water Pumps	0.216 kW/Ton
3	Primary Chilled Water Pumps	0.059 kW/Ton
4	Secondary Chilled Water Pumps	0.115 kW/Ton
5	Cooling Towers	0.075 kW/Ton
6	**System**	**1.188 kW/Ton**
7	Cooling Ton	956 Tons
8	Header Chilled Water Temperature Supply	7.626 Deg C

note: monitored data from 25th Nov to 19th Dec, 2006

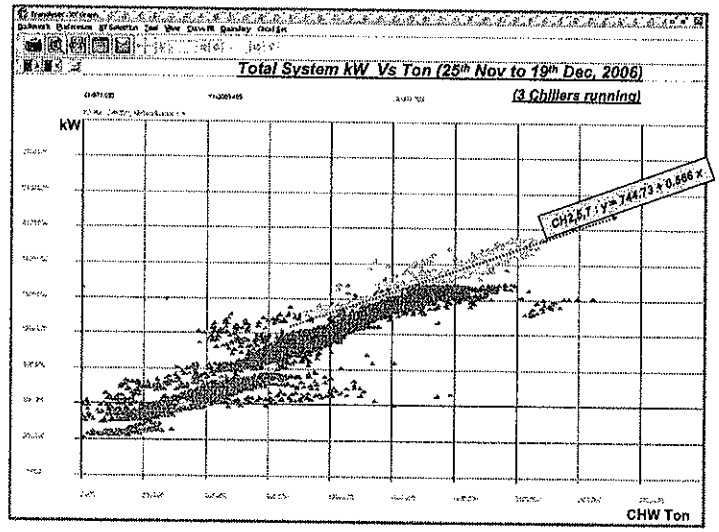
Component's Performance Chart.



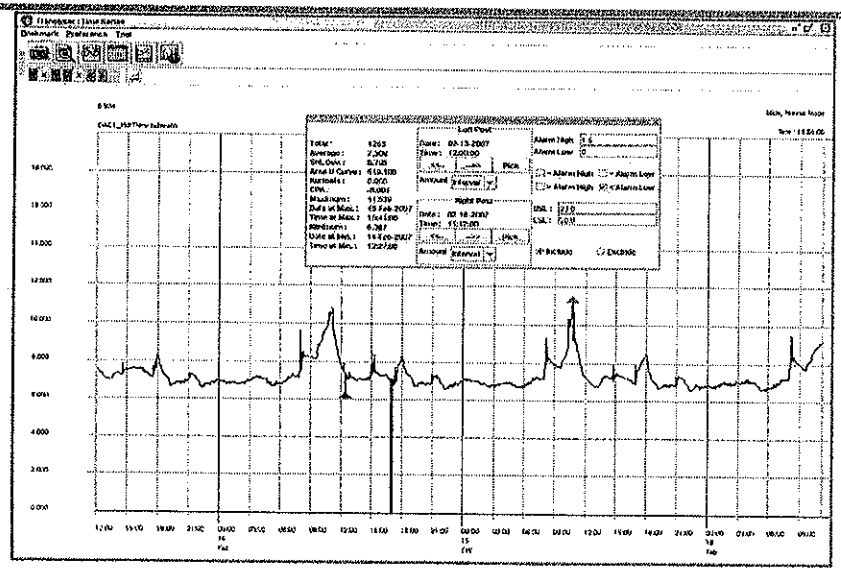
Component's Performance Chart.



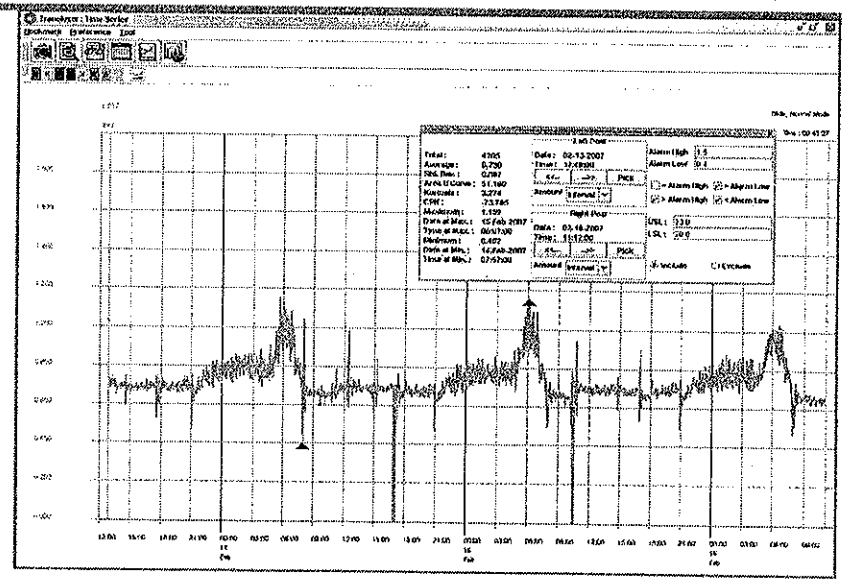
Chiller Plant System Performance Chart.

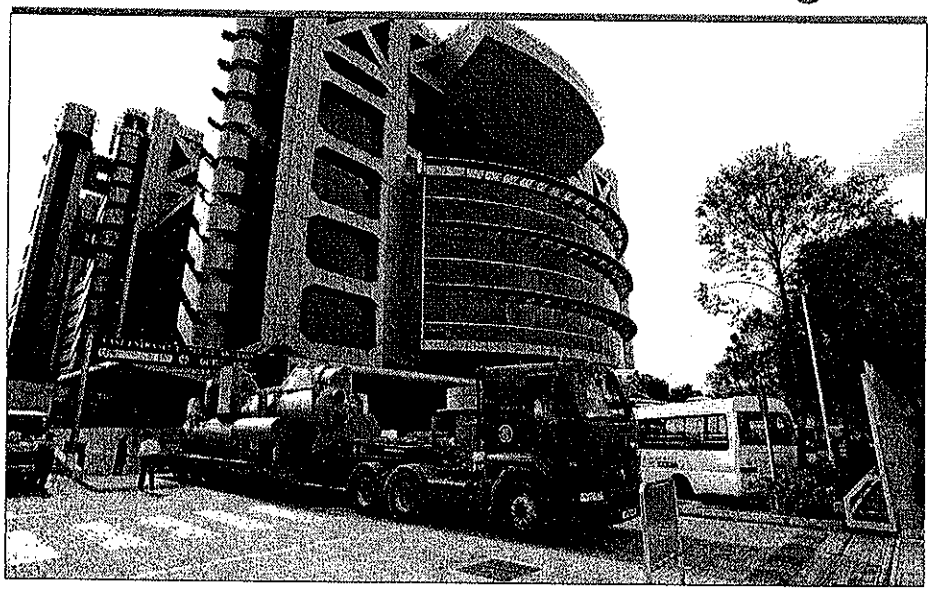


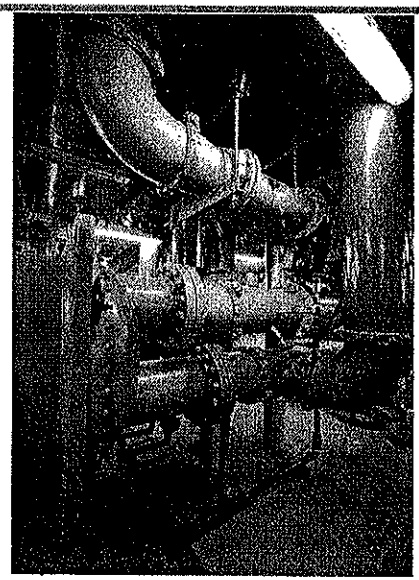
HEADER CHWS TEMPERATURE 13-16-FEB-2007

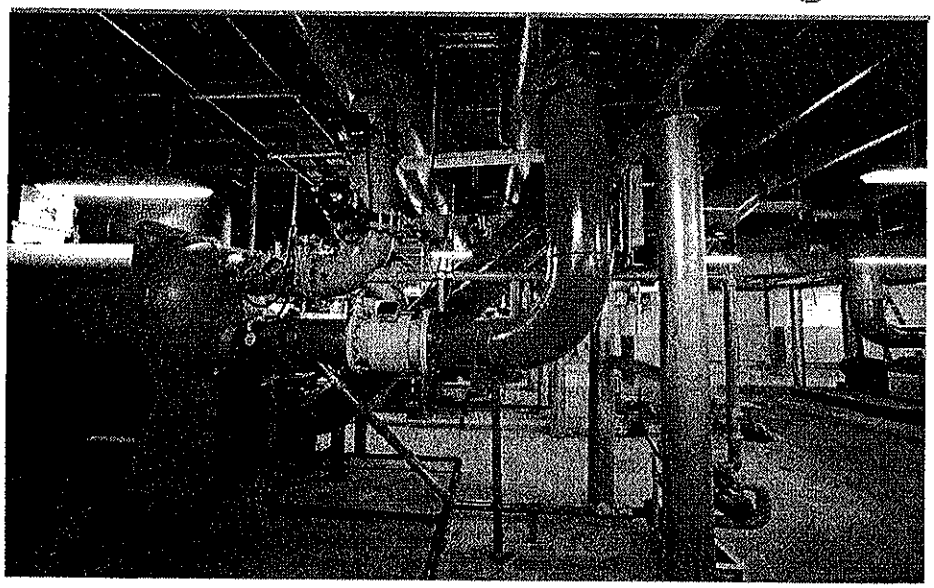


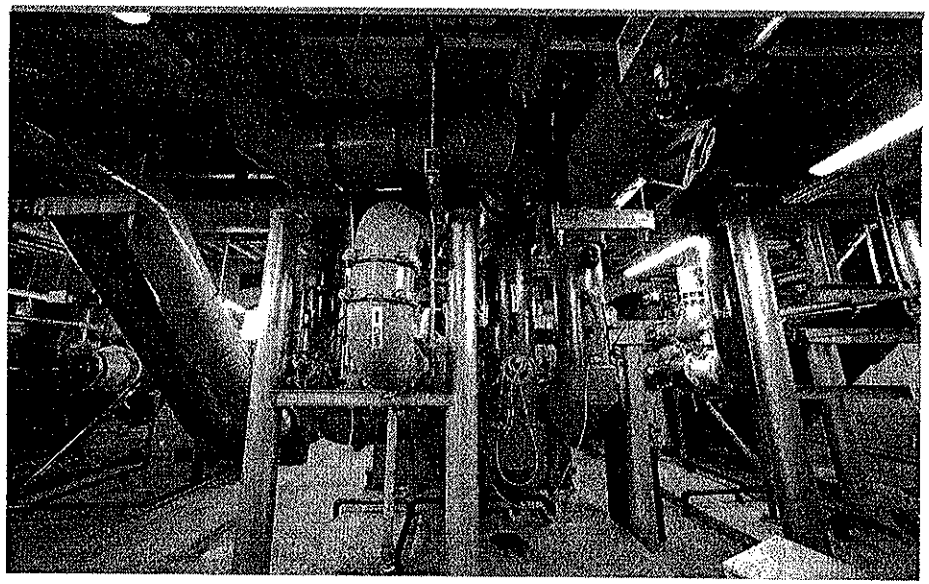
SYSTEM KW/RT 13-16-FEB-2007

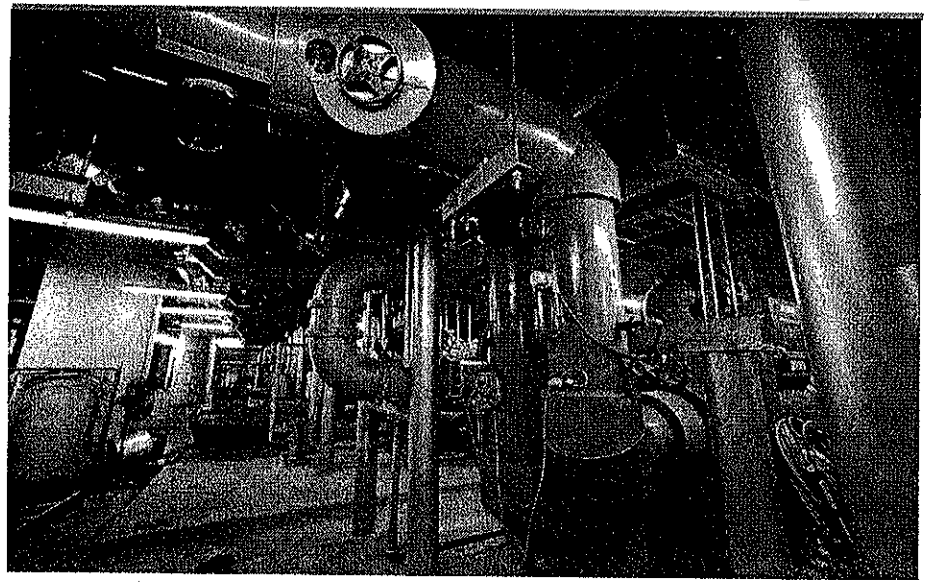


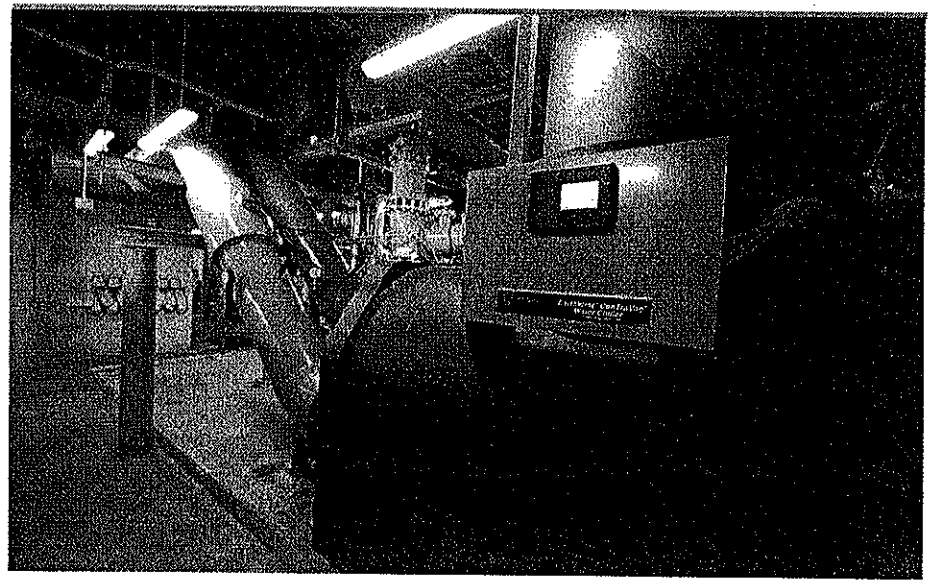


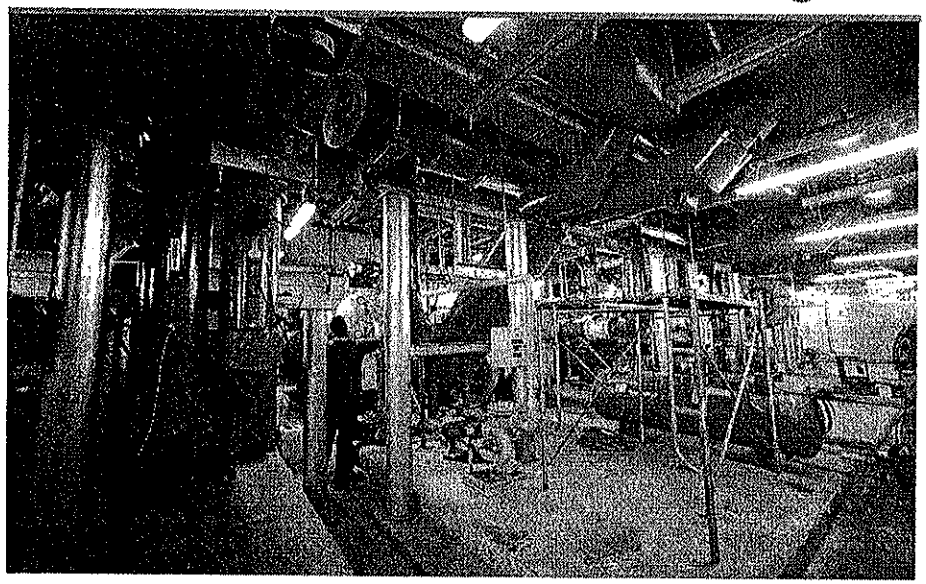


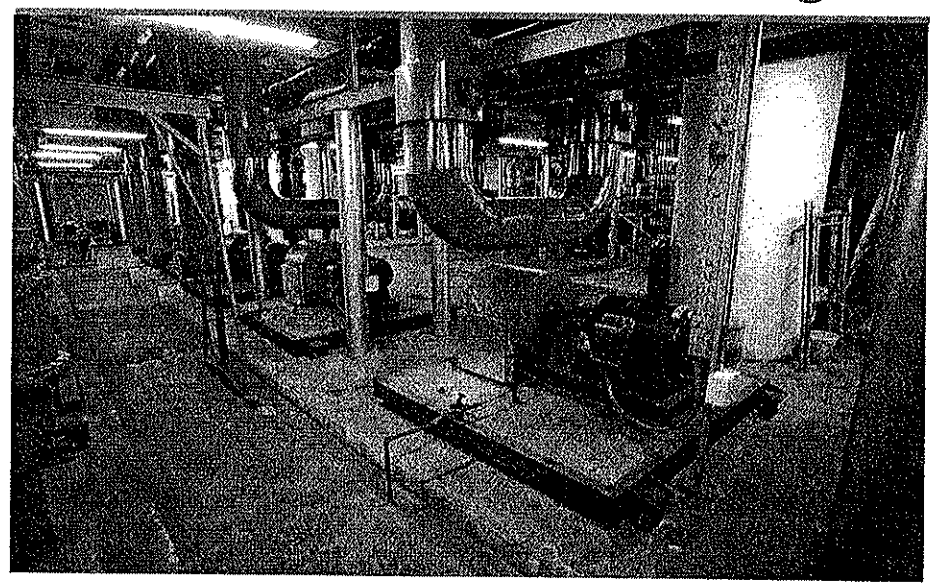


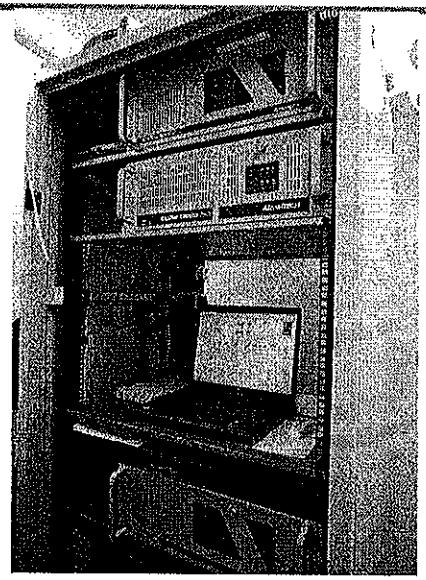






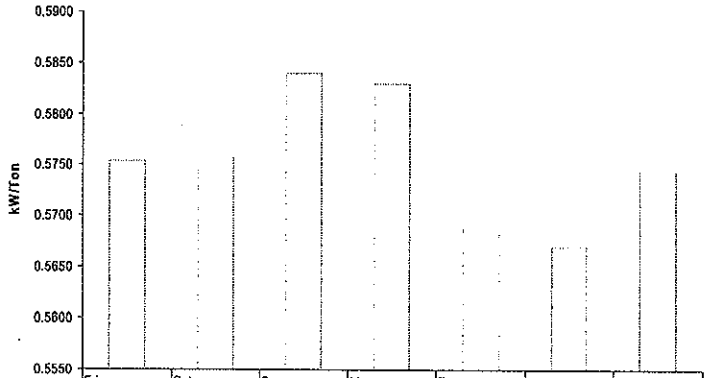






Singapore Post Centre
System Efficiency (kW/Ton) – Daily/Weekly Analysis

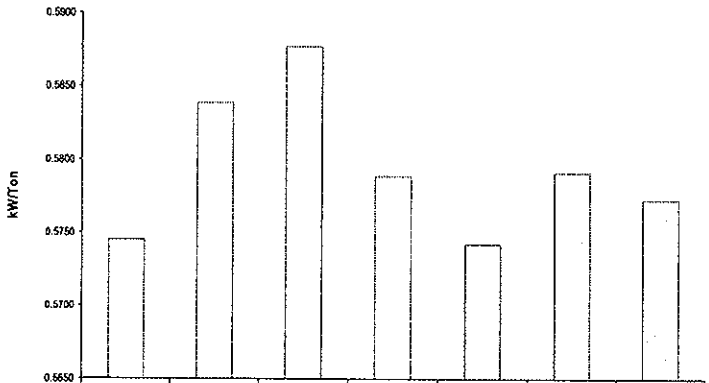
For the week: 15-June-2007 to 21-June 2007



	Fri	Sat	Sun	Mon	Tue	Wed	Thu	
	15-Jun-07	16-Jun-07	17-Jun-07	18-Jun-07	19-Jun-07	20-Jun-07	21-Jun-07	Average
kW/ton	0.5753	0.5758	0.5840	0.5830	0.5688	0.5670	0.5745	0.5755

Singapore Post Centre
System Efficiency (kW/Ton) – Daily/Weekly Analysis

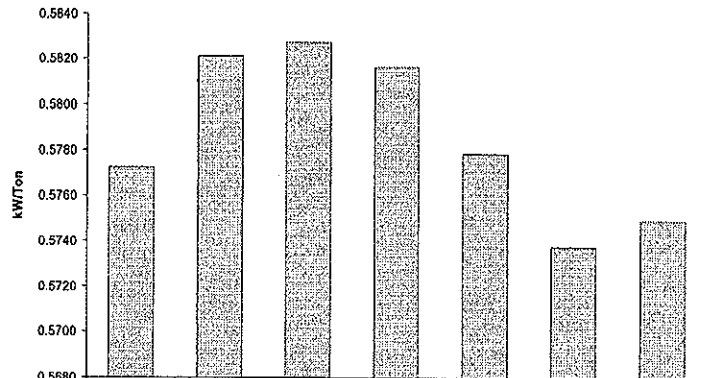
For the week: 8-June-2007 to 14-June 2007



	Fri	Sat	Sun	Mon	Tue	Wed	Thu	
	8-Jun-07	9-Jun-07	10-Jun-07	11-Jun-07	12-Jun-07	13-Jun-07	14-Jun-07	Average
kW/ton	0.5745	0.5839	0.5878	0.5789	0.5743	0.5791	0.5773	0.5794

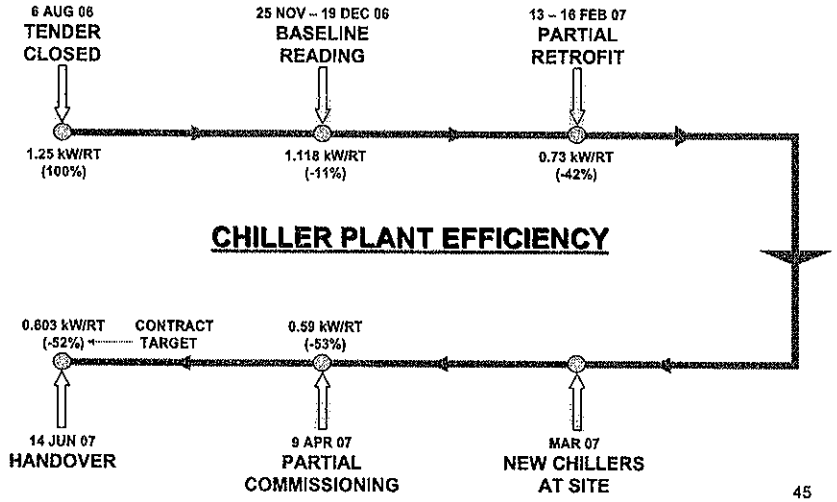
Singapore Post Centre
System Efficiency (kW/Ton) – Daily/Weekly Analysis

For the week: 1-June-2007 to 7-June 2007



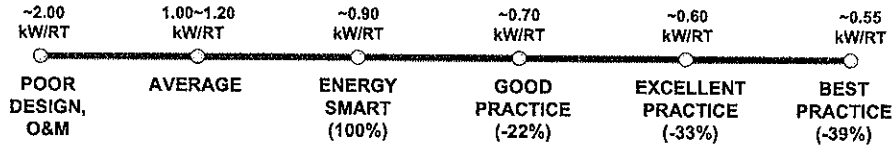
	Fri	Sat	Sun	Mon	Tue	Wed	Thu	
	1-Jun-07	2-Jun-07	3-Jun-07	4-Jun-07	5-Jun-07	6-Jun-07	7-Jun-07	Average
kW/ton	0.5773	0.5821	0.5828	0.5817	0.5779	0.5738	0.5749	0.5786

SingPost Project Schedule



Chiller Plant System Performance (kW/RT)

PUMPS, TOWERS, CHILLERS
SINGAPORE WEATHER CONDITIONS



NOTES:

1. Chiller plant lifetime 15 ~ 20 years
2. Fossil fuel prices increasing
3. IPCC report says Global Warming serious problem
4. Once you commit $$$ to retrofits, you are unlikely to upgrade for many years

Thank You !