Sustainability in restaurant design and operation

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The article shares the experiences in creating a Green Mark restaurant, highlighting how such a restaurant can be operated in the most environment-friendly and energy-efficient manner, to bring value to the stakeholders.

BACKGROUND

In 2009, McDonald's, the quick-service restaurant approached the Building and Construction Authority (BCA) to explore how it could participate as a stakeholder and partner in the BCA Green Mark programme, and green its restaurants. Whilst the idea of sustainable restaurants was being experimented in the US and Europe, it had yet to cascade down to Asia. McDonald's then engaged Metropolitan Green Design and Technology to design, develop and implement sustainable restaurant designs in Singapore.

In close partnership with McDonald's, and through the quick-service restaurant's pioneering involvement and support, BCA was able to develop the world's first set of green mark criteria for restaurants, which provides a completely new sustainable scheme to ensure that restaurants are designed to be more efficient and utilise less resources, while at the same time providing a safe and pleasant environment for diners.

OBJECTIVES OF BUILDING GREEN RESTAURANTS

The objectives of green restaurants can be encapsulated into three key areas, namely:

- Improving building performance - creating operational strategies to reduce energy and water consumption across all restaurants.
- Reducing the carbon footprint of buildings - identifying the current issues and considerations for achieving carbon neutrality.
- Strategies to optimise operational carbon - to increase productive gains; and ensure operational economies, reduction of operating cost, and effective correction of processes and energy management.

INTRODUCTION

McDonald's had already established a strong policy for sustainable operations in the form of a restaurant Standard Operating Procedure (SOP) that enabled every manager to learn how to manage utilities and optimise operating processes. The challenge in adopting a sustainable restaurant strategy was therefore not in the mind-set but rather in the unique configuration of restaurants which could be built either as a tenanted premise in a public commercial area, a tenanted premise under a landlord in a commercial building, or as a stand-alone restaurant. Given that McDonald's would continuously face such scenarios, it was decided that the design guidelines for the three categories of buildings be developed so that all future restaurants could incorporate these sustainable construction strategies.

McDonald's has long held sustainability and environmental responsibility as a key consideration when building new restaurants. However, this exercise provided invaluable insights as to how the restaurant design could be optimised. The construction team gained greater expertise in achieving energy efficiencies for lighting, air-conditioning and kitchen equipment. Although McDonald's was already using energy star rated kitchen equipment, it became even more conscious about how the energy efficiency Index (EEI) could be improved as it continuously built new restaurants that were more energy- and water- efficient than earlier ones.

McDonald's restaurant at Jurong Central Park (JCP), the first restaurant to be awarded the BCA Green Mark Platinum rating, was conceptualised as a green building at the planning stage. Various innovative strategies were incorporated into the design and construction to improve energy efficiency, and water and waste conservation, and creative air-conditioning design ideas were used to improve indoor air quality. The restaurant also features a green roof supported by its own rain water harvesting system, adding to its stylish ambience.

McDonald's restaurants at Bishan Park and Springleaf Tower clinched the BCA Green Mark Gold rating while its restaurant at City Square achieved a BCA Green Mark Certified rating.

BUSINESS CASE FOR GREEN BUILDINGS

According to statistics from BCA, green buildings usually have a higher upfront cost but offer several significant benefits. The average increased expenditure for a green building is estimated to be an additional 2% to 8%, depending on the desired green design score. The resulting benefit is an average lifecycle savings of 20%, for total savings amounting to 10 times the initial investment (Chia Yen Ling, 2010).

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

Business case for green buildings in Singapore (BCA, GMFM, May 2010).

McDonald's decided that the approach for the green restaurant should be practical, in terms of its implementation and maintenance. It was felt that the green restaurant design in Singapore should be an extension of its global strategy for energy efficiency, water conservation, sustainable packaging and waste management. The corporate policy of sustainable practice actually makes business sense as it embraces the fundamentals of Corporate Social Responsibility, customer satisfaction, assets sustainability and importantly it upholds stakeholder interest.

UNDERSTANDING SINGAPORE'S CLIMATE CHARACTERISTICS

According to Lovell (2010), the comfort level within the internal environment is related to the building envelope design which impacts temperature, humidity, light penetration, sound, view, ventilation and indoor air quality. For this design, the Green Mark standard from BCA was utilised as the minimum starting point, to create an acceptable comfort zone with an indoor temperature range of between 24° C and 26° C, and a relative humidity (RH) of between 30% and 70% (average RH is 84.2%).

From the psychrometric chart, it can be discerned that the thermal comfort level in the building can be physically modified through a combination of passive and active strategies that address the following:

- Geometry and building orientation (north-south orientation)
- Transient performance of envelope
- Thermal mass
- Cool surfaces and radiant barrier considerations
- Optimisation of roof and/or attic
- Size and location of glazing
- Solar gain control systems
- Shading features
- Foundation type and insulation
- Location of air ducts
- Potential air leakage and interface connections

SITE DESCRIPTION

The site for the McDonald's restaurant at JCP is located in the western side of Singapore, close to Boon Lay MRT station, on land leased from NParks. The building orientation is roughly north-south which reduces much of the sun's radiation along the building axis as well as the east and west facades. Located within a park, the restaurant was designed to be 'green' from the start and the key priority was to construct a low carbon building. Being both a 'drive-in' and 'dine-in' restaurant, it was essential for the restaurant to be designed aesthetically and functionally, and with a comfortable internal environment.

It was recognised that a multi-disciplinary approach for the integration of architectural components, structure, HVAC and communication systems, developed in tandem with effective sustainable facilities management and coupled with a strategic lifecycle approach, would help to optimise operational carbon to an acceptable baseline level.

BCA GREEN MARK CRITERIA FOR RESTAURANTS

The preliminary criteria for greening restaurants were established for five key areas, namely:

- Energy related requirements - 50 points
- Water efficiency - 20 points
- Sustainable management and operation - 30 points
- Indoor environmental quality - 19 points
- Implementation of various green features - 6 points

This was used as the starting point for sustainable restaurant design.

Singapore's geographical location; 1.4° latitude and 104° longtitude

Characteristics of Singapore weather

- There are no distinct seasons
- The average temperature range varies from 24ºC to 31ºC
- Position of sun towards southern hemisphere
- Humid throughout the year (50% to 90%) majority of time, varies throughout the seasons
- Wind direction rotates throughout the year from northeast to south west

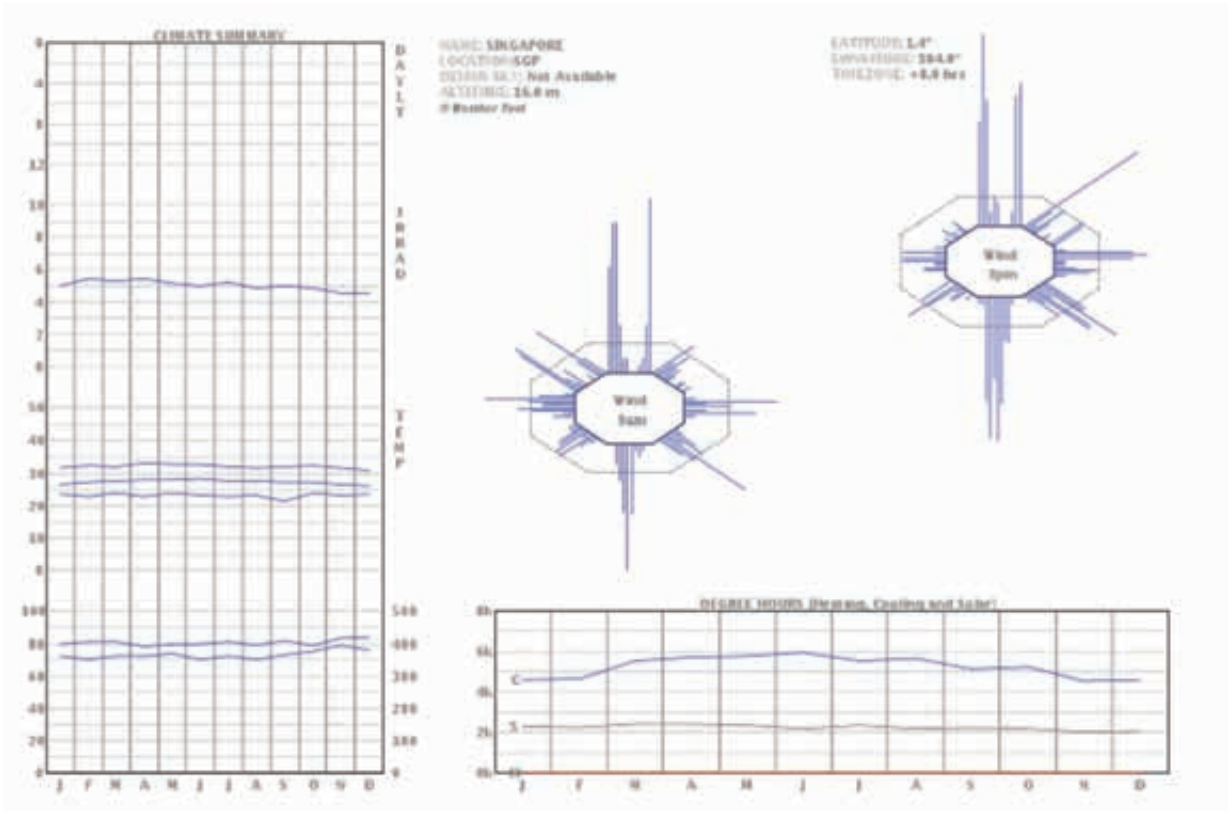
Picture ; Google Earth

Climate characteristics

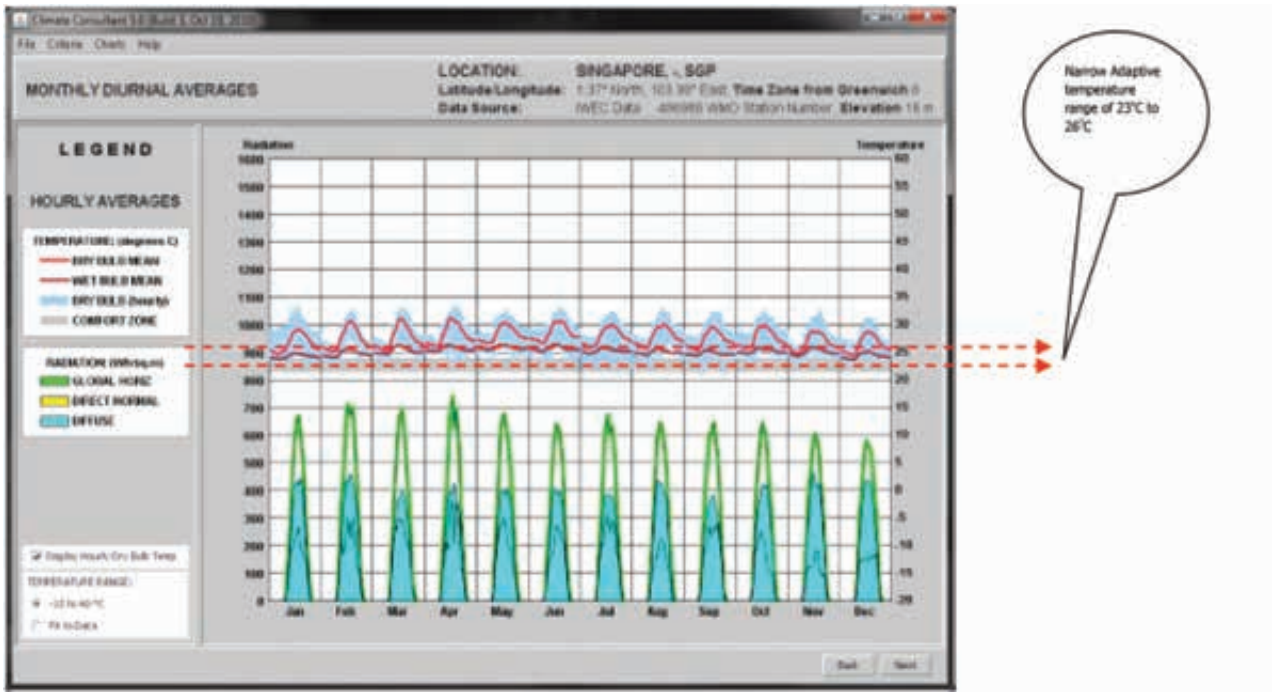
Koppen climate classification : tropical rainforest (Koppen classification Af)
Average temperature = 27.5ºC
Range of average monthly temperature = 24ºC to 31ºC
Warmest average max/high temperature = 31.7ºC (April)
Coolest average min/lowest temperature = 23.3ºC (January)
2,343.1 mm of precipitation per year with an average 195.3 mm per month
Driest month is July with 161.2 mm of rain
Wettest month is December with 288.2 mm of rainfall
Mean relative humidity for an average year is recorded as 84.2%
Average range of hours of sunshine is 168.5 hours per month with a total 2,022.4 sunshine hours per year and approximately 5.62 sunshine hours per day
Comfort band is set between 23ºC to 26ºC

Data from : National Environment Agency and Hong Kong Observatory

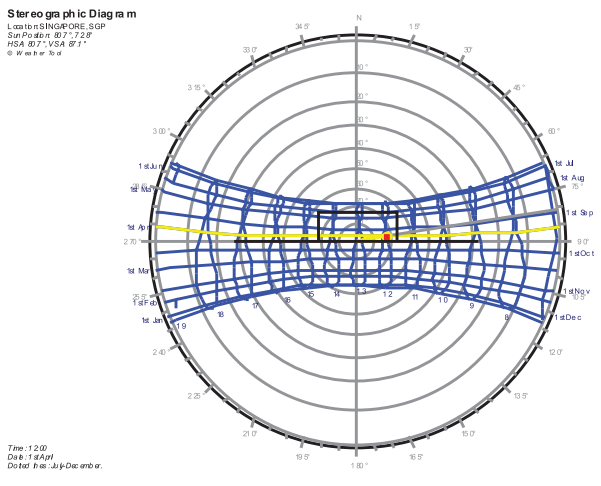
Summary of Singapore's climate characteristics.



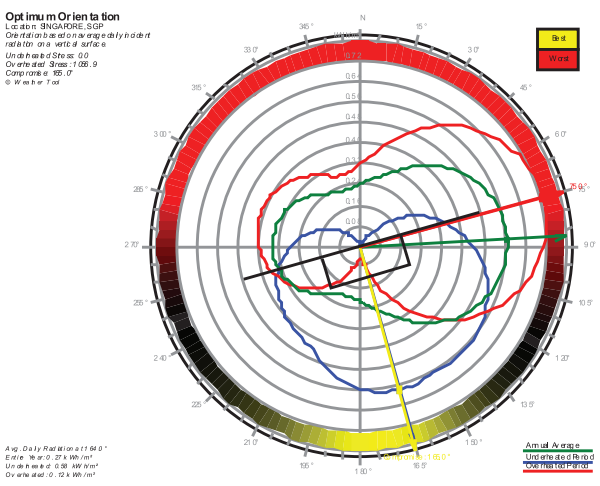
Summary of Singapore's weather (source: Ecotect loaded with EnergyPlus data).



Monthly diurnal averages for Singapore (source: Climate consultant 5, IWEC Data: 486980 WMO Station number at elevation 16 m).

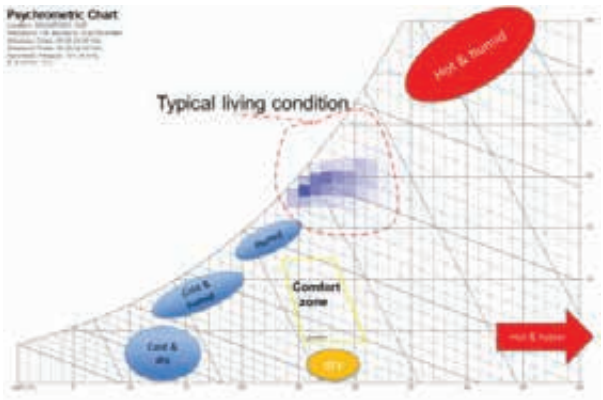


Stereographic sun path diagram for Singapore

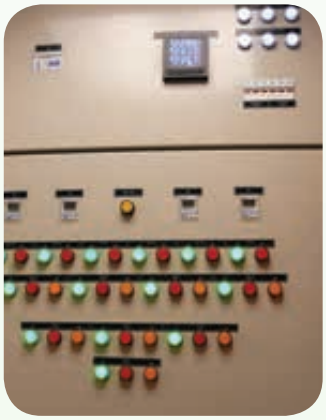


Ideal building orientation for Singapore is 165° azimuth

Stereographic sun path and best building orientation analysis (source: Ecotect, Martin Lim).



Psychrometric analysis of the Singapore climate.



Centralised air-conditioning monitoring panel.

Individual air-conditioning control panels for temperature and sensor monitoring.

CHALLENGES IN ACHIEVING ENERGY EFFICIENCY

Overall, McDonald's JCP restaurant obtained a Green Mark Platinum rating, largely due to its intense focus on energy reduction which formed the cornerstone for sustainable restaurant design. Although measurement of energy continues to be a challenge due to variations in business growth, expansion of store base, menu variety (resulting in equipment needs) and increases in customer counts, the technical team continues to improve on processes and methodologies for tracking energy consumption. McDonald's has taken great pains to monitor energy consumption through additional sub-meters for the kitchen, air-conditioning equipment, lighting points, irrigation pump and water features.

A total of five sub-meters (in addition to the main in-coming meter) were installed for better utility management at this store. Store managers are expected to track energy consumption as part of their responsibilities in managing the restaurant. To optimise energy usage, McDonald's implemented a colour coded light switching system which specifies the lighting zone to be switched on, at various times of the day.

Lennox TSA 090 and 072 air-conditioning system with an average COP of 3.35.

AIR-CONDITIONING EFFICIENCY

The store utilises five Lennox split units with a Coefficient Of Performance (COP) of above 3.0. The average COP of the compressors is around 3.35. A comfortable environment, based on scheduled settings, is maintained using the Honeywell T7350 thermostat. Zoning and controls have been designed into the

schematics, to provide some flexibility in serving areas with different usage patterns.

The various air-conditioning zones are monitored in a separate meter panel and separate controls have been installed for climate control, to allow some flexibility in managing zones that require additional cooling due to the different cooling loads imposed during hotter and cooler periods of the year, or when higher than usual human traffic causes an increase in the cooling load.

LIGHTING STRATEGIES

In targeting a Green Mark Platinum rating, the team ensured that lighting designs are energy-efficient. Preliminary findings in the US indicated that installing high-efficiency LED lights could actually save up to 50% in energy consumption, in comparison with conventional lighting systems utilising PLCs, halogen lights and fluorescent tubes.

ANALYSIS OF ENERGY CONSUMPTION BY KITCHEN EQUIPMENT

With varying restaurant sizes, it was a challenge to establish the average energy consumption from kitchen equipment and with no benchmark, the team had to collect data on a monthly basis from restaurant meter readings and energy bills.

The kilowatt-hour (kWh) data was then extrapolated to cover all restaurants in various configurations ranging from 2,000 ft^2 (186 m^2) and below, to 5,000 ft^2 (465 m^2) and above. From a comprehensive analysis of all restaurants surveyed, it was determined that energy consumption of the kitchen equipment ranged from 44% to 57% with an aggregate average value of 53%. In the computation of the Energy Efficiency Index (EEI), the high energy consumption of the kitchen equipment has been excluded, in order to realistically represent the energy consumption as a Green Mark criterion.

Category			Point Allocations
(I)	Energy Related Requirements		
	Minimum 20 points	**Part 1 : Energy Efficiency**	
		1-1 Energy Efficiency	5
		1-2 Electricity Usage	2
		1-3 Air-conditioning	10
		1-4 Lighting	16
		1-5 Kitchen Equipment	10
		1-6 Energy Efficient Features	7
		Category Score for Part 1 – Energy Efficiency	**50**
(II)	Other Green Requirements		
		Part 2 : Water Efficiency	
		2-1 Water Efficient Fittings	11
		2-2 Water Usage	2
		2-3 Water Efficient Practices	4
		2-3 Water Efficiency Improvement Plans	3
		Category Score for Part 2 – Water Efficiency	**20**
		Part 3 : Sustainable Management & Operation	
		3-1 Sustainable Consumable Materials	6
		3-2 Sustainable Material Selection	5
		3-3 F&B Operation & Maintenance	6
		3-4 Post Occupancy Evaluation	4
		3-5 Waste Management	5
		3-6 Greenery	2
		3-7 Public Transport Accessibility	2
		Category Score for Part 3 – Sustainable Management & Operation	**30**
		Part 4 : Indoor Environmental Quality	
		4-1 IAQ Performance	6
		4-2 Indoor Air Pollutants	5
		4-3 Lighting Quality	4
		4-4 Thermal Comfort	4
		Category Score for Part 4 – Indoor Environmental Quality	**19**
		Part 5 : Other Green Features	
		5-1 Green Features & Innovations	6
		Category Score for Part 5 – Other Green Features	**6**
		Total Points Allocated :	**125**

BCA Green Mark criteria for restaurants (BCA, August 2012).

DATA COLLECTION FROM 3 STORES SHOWING THE KITCHEN CONSUMPTION (%)

WCP			
	MAIN	86311	
	KITCHEN	48823	57%
	AIRCON	22397	
	LIGHTING	8759	
	OTHERS	6332	
AMKP			
	MAIN	70086	
	KITCHEN	40882	58%
	AIRCON	17926	
	LIGHTING	6949	
	OTHERS	4329	
SLT			
	MAIN	881522	
	KITCHEN	388897	44%
	AIRCON	336287	
	LIGHTING	8890	
	OTHERS	147448	
AVERAGE			53%

Energy consumption statistics compiled from three McDonald's stores.

Computation of the Energy Efficiency Index or EEI

EEI = (TBEC – DEC – CPEC) ÷ (GFA – CPA – DCA)

TBEC = Total Building Energy Consumption/yr in kWh (excluding kitchen consumption of 44%)
= 42,321 X12 kWh X 56%
= 284,397.12

DEC = Calculated Data Centre Energy Consumption/yr in kWh = 0 kWh

CPEC is Car Park Energy Consumption (per annum) in kWh = 0 kWh

GFA is Gross Floor Area in m^2 = 673.13 m^2

CPA is Car Park Area in m^2 = 0 m^2

DCA is Data Centre Area in m^2 = 0 m^2

EEI = (284,397.12)/(673.13)
= 422.51 kWh/ m^2

EEI (normalised) = EEI X (NF/ OH)
= 422.51X 55/168
= 138.32 kWh/ m^2 /year

where NF is assumed to be 55 hrs/week and weighted weekly operating hours (OH) is 24 hrs X 7 days = 168 hrs/week

JCP's EEI is 138.32 kW/m^2/year (after normalisation) as compared to an average of 200 kW/m^2/year to 884 kW/m^2/year for other McDonald's restaurants in Singapore.

SELECTING ENERGY-EFFICIENT KITCHEN EQUIPMENT

Recognising the need to build better next generation equipment in view of business sustainability, McDonald's worked with its equipment suppliers to redesign kitchen equipment that consumed less energy, created better tasting food whilst improving crew productivity. The Low Oil Volume Fryer (LOV), the next generation fryer, improves cooking efficiency, simplifies filtering and cleaning, and provides enhanced environmental benefits while using approximately 4% less energy than standard fryers.

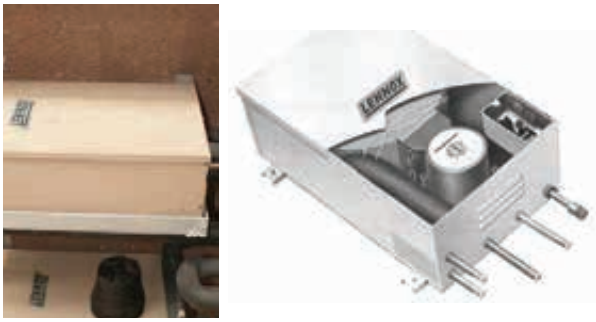
The Low Oil Volume (LOV) fryer uses less oil and is more energy-efficient.

HEAT RECOVERY SYSTEM

The Lennox HWL21/65 water heater module is a sophisticated heat recovery system that utilises the heat generated by air-conditioning to heat water for domestic use. In the restaurant, the HW2-21 /65 provides a free source of heat for generating 100% of the hot water required for the kitchen, eliminating the need to install three water heaters and thereby also reducing operating costs.

WATER EFFICIENCY

In order to conserve water, McDonald's restaurant managers are required to monitor water consumption on a monthly basis. This information is sent to the headquarters to be consolidated for further analysis. The monitoring of water consumption is taken seriously as part of the pre-requisites for running a restaurant profitably. The store has to know how water is used, identify leaks (if any) quickly and monitor the monthly consumption for better management strategies. Basin taps and mixers, flushing cisterns, sink/bib taps and mixers, with PUB three ticks water-efficient labels, have been installed.



Lennox HWL21/65 heat recovery system.

IMPLEMENTATION OF ENVIRONMENTAL SCORE CARDS FOR SUPPLIERS

McDonald's adopts a comprehensive approach to promoting socially responsible practices in its supply chain. It incorporates existing initiatives like animal welfare programmes and supplier social accountability programmes and also new environmental guidelines and performance measures. Suppliers are expected to extend this vision of sustainability to their own suppliers (indirect suppliers), as well.

VOLUNTARY SUSTAINABILITY REPORTING

McDonald's takes its environmental, economic and social activities seriously and makes it a point to update its stakeholders and the public on a regular basis, on the various initiatives that have been undertaken.

SUSTAINABLE MATERIALS

McDonald's encourages the selection of materials that are environment-friendly and sustainable. These include recyclable/ recycled / non-disposable products such as food wrappers, food containers, carry out bags, cups, plates, serving utensils, toilet rolls, and napkins/serviettes.

F&B OPERATION AND MANAGEMENT

Ingrained within the McDonald's operating culture is the pursuit of sustainability, greater efficiency in business operations and reduced operating costs. Good maintenance and management practices ensure that all building systems function to the maximum designed efficiency and meet specified levels of energy and indoor air quality performance. A comprehensive approach to maintenance and management will help to generate energy and water savings for McDonald's while promoting occupant health and comfort.

McDonald's is striving towards full 'lifecycle management' of restaurant-generated waste. The objective is to reduce the restaurants' used resources in a smarter way, by organising proper waste monitoring and ensuring that raw materials involved in the restaurants are optimised so that waste production is minimised.

The restaurant monitors food products, materials in the kitchens such as delivery trays, used cooking oil and cardboard boxes, as well as segregated trash bins in the lobby areas. Restaurants have been provided with waste collecting bins especially for food wastes and also buckets for collection of shortening (used cooking oil).

INDOOR ENVIRONMENTAL QUALITY

In considering ways to improve the indoor environment, McDonald's reviewed the benefits of daylight harvesting, the ways to prevent food and kitchen odours from migrating into the dining areas, and ways to enhance thermal comfort for diners.

Daylighting (passive strategy)

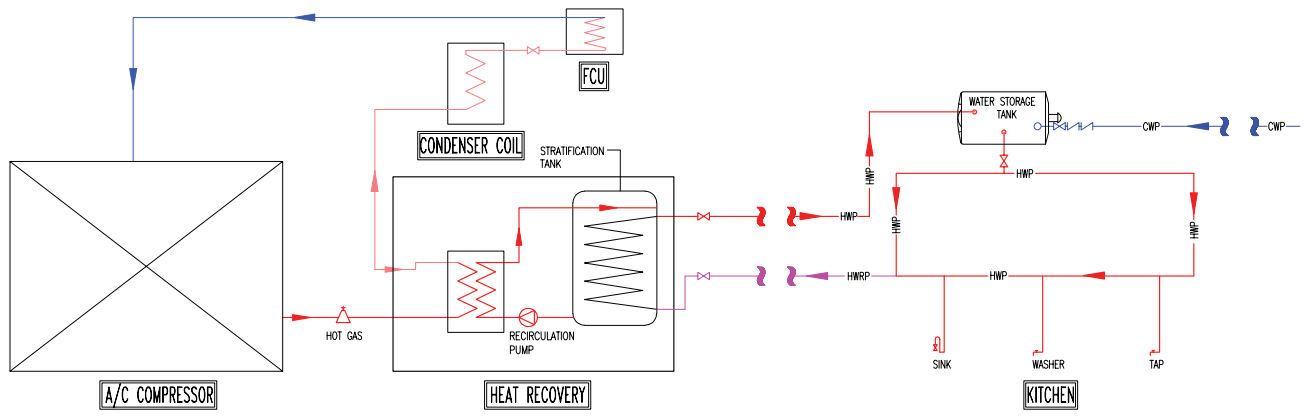
The restaurant is designed with a large expanse of windows that allow daylight to penetrate into the dining areas. Low-e glass windows are used all around, to reduce glare and solar radiation into the dining space, thereby reducing the cooling load on the air-conditioning system. Lighting has been designed to meet the illumination parameters stipulated under CP 38, achieving a good balance between comfort and energy efficiency.

Preventing the migration of odours and pollutants

The migration of odours and other pollutants from the kitchen to the dining areas is prevented by using an effective kitchen exhaust. The positive pressurisation of the restaurant ensures that the air pressure within the dining zone is higher than the kitchen and the external environment and this ensures that odours, smells and even dust are effectively kept out of the dining area.

Thermal comfort level

Thermal comfort is designed to meet the CP 13 standard, with a



HEAT RECOVERY SYSTEM CONCEPT

Heat recovery schematics.

A wide expanse of low-e glass is used throughout the restaurant to emphasise the ambience.

Interior view of McDonald's restaurant at JCP.

temperature between 23° C and 24° C. The sizing and selection of the AHU / FCU equipment (cooling coil and fan) ensures that the RH is kept below 70%, against the average external RH of 84.2%.

GREEN FEATURES AND INNOVATIONS

The restaurant at JCP represents a new generation of eco-friendly restaurants built by McDonald's to integrate environmentally responsive elements of energy and water efficiency with green technologies like LED lighting, green roof and rainwater harvesting, and the use of sustainable construction materials.

LED lighting

The LED lighting system installed in the restaurant is highly efficient and emits very little heat compared with conventional fluorescent lights, thus lowering the cooling load on the air-conditioning system. As a result, the lighting power budget is around 20% lower than the 15 W/m^2 stipulated in Singapore Standard SS530.

Sustainable construction materials

The restaurant has green ceilings, manufactured under a stringent German process for making products that are recyclable. The road pavements were constructed using recycled concrete granules which are environment-friendly. Environment-friendly green paint with low Volatile Organic Compounds (VOC) has been used on the walls in the restaurant.

CO_2 sensor

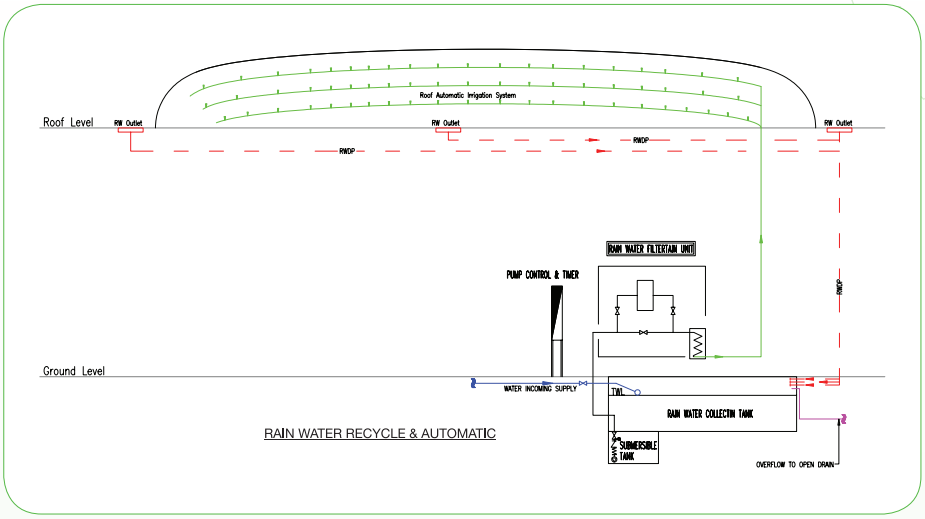
Should the carbon dioxide (CO_2) levels in the kitchen reach undesirably high values, due to accidental leakage of gas from the CO_2 cylinders required for the carbonated drinks, an alarm will sound. The store manager will then take immediate action to reduce the CO_2 level to the desired value.

The CO_2 detector to monitor the CO_2 levels in the area where carbonated drinks are stored.

Green roof

Planted with lawn grass on a soil substrate, the restaurant's green roof has a unique identity and aesthetic appeal, whilst blending in seamlessly with the surrounding park.

The roof also improves the building's thermal insulation. Studies conducted by National Environmental Agency (NEA) and the National University of Singapore (NUS) have established that the thermal effect of a green roof can translate into a drop of 2° C to 3° C internally all year round, resulting in energy savings in air-conditioning operations.



Schematics for automatic rainwater harvesting.

Rainwater harvesting

Water conservation initiatives including the use of water-efficient water fittings, waterless urinals and a rain water harvesting system with a water storage capacity of three days, reduce the restaurant's reliance on PUB water supply.

CONCLUSION

Building its first four green restaurants in Asia has encouraged McDonald's to continue to work towards the enhancement of guidelines for future restaurants in Singapore.

Sustainability is undeniably an important goal for the McDonald's system. As such, the company has continued to evaluate and measure emerging environmental best practices.

Metropolitan Green Design and Technology has been an integral part of the building management team at McDonald's, providing regular advisory and consultancy support in the area of green building design as well as in operations and maintenance.

Although the full range and nature of green elements vary by location, generally, the focus is on innovation and efficiency in the design and construction of the restaurant; reduction of energy and water use in equipment and operations; incorporation of green décor options in the restaurant; and incorporation of features that enhance indoor air quality and promote natural lighting and ventilation, where possible. As a result, the operating costs for the restaurants will be reduced.

McDonald's believes that thinking and acting green is good not just because it is the right thing to do, but also because it is the right thing to do for its business. It believes in continuous improvement and also in improving its environmental performance, as this makes it a stronger brand and a more sustainable company.

McDonald's has shared many of the project findings with BCA, and continues to work with various stakeholders to promote the development of sustainable restaurants and workplaces in Singapore.

REFERENCES

Building and Construction Authority (BCA): 'Guidelines on envelope thermal transfer value for buildings', February 2004.

Chia Yen Ling: 'Shaping a Sustainable Built Environment in Singapore', Green Mark for Facilities Managers course, BCA Academy, Building and Construction Authority, May 2010.

Colomban M, Zobec M, Kragh M: 'An integrated design approach to the environmental performance of buildings', Building Services Systems, pp 583-601, Spon Press, Taylor & Francis Group, 2001.

Council on Tall Buildings and Urban Habitat: 'Tall buildings in numbers', Issue 11, 2009.

Energy Market Authority (EMA): 'Singapore's electricity and gas sector: The Competitive Market Moves Forward', 7 June 2004.

Jenny Lovell: 'Building envelopes: An integrated approach', Princeton Architectural Press, 2010.

John Straube and Eric Burnett: 'Building science for building enclosures', Building Science Press, 2005.

Koo Tsai Kee, Assoc Prof, Senior Parliamentary Secretary, Ministry of the Environment and Water Resources, and Chairman of the National Energy Efficiency Committee: 'Seminar on Energy Management Best Practices and Technologies', Keynote Address, 7 April 2005.

Mahadev Raman: 'Limits on energy efficiency in office buildings', 6th World Congress of the Council on Tall buildings and Urban Habitat, pp 575-582, 2001.

Michael Wong: 'Environmental benefits of green roofs', Singapore Environmental Institute, 25 August 2006.

National Environmental Agency (NEA) website, viewed, October 2011.

Nik Vigener and Mark A Brown: 'Building envelope design guide - curtainwalls', American Architectural Manufacturers Association, 06.07.2010.

Steven Szokolay: 'Introduction to architectural science: the basis of sustainable design', 2nd revision, Elsevier Science and Technology, June 2008.

Vladimir Mikler: 'Secrets to climate adapted building design', World Sustainable Building Conference, 2005.

Wong N H, Cheong D K W, Yan H, Soh J, Ong C L and Sia A: 'The effects of rooftop garden on energy consumption of a commercial building in Singapore', Energy and Buildings, Elsevier, 12 July 2002.