Innovative and sustainable solutions in the design of restaurants

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Conceptualised as a green restaurant, right from the design phase, the McDonald's 'drive thru' outlet at Yishun Safra Country Club (YSCC) received a Green Mark Platinum Award at BCA AWARDS 2014.

This article presents a case-study on the design and construction of the restaurant which, in turn, has benefitted from several earlier projects successfully completed by Metropolitan Green Design and Technology (MGDT), on behalf of McDonald's.

BACKGROUND

The concept of the 'green restaurant' in Singapore, originated in 2009, from a unique partnership between McDonald's, MGDT and the Building and Construction Authority (BCA), to voluntarily participate as a stakeholder in the first BCA Green Mark programme for the food and beverage sector. In 2011, through these pioneering efforts, BCA launched the Green Mark criteria for restaurants in Singapore.

Subsequently, the McDonald's restaurant at Jurong Central Park (JCP) received the Green Mark Platinum Award. McDonald's restaurant at Jurong East Mall (JEM) was awarded Gold^{Plus} and those at Bishan Park and Springleaf Tower clinched Gold, while the restaurant at City Square Mall was awarded the Green Mark Certified status.

OBJECTIVES OF BUILDING GREEN RESTAURANTS

The three key objectives for building green restaurants are primarily to:

- Improve building performance by reducing operational expenditure through strategic reduction in energy and water consumption.
- Reduce the carbon footprint of buildings by considering issues and improving areas where best practices in sustainable design could be implemented.
- Optimise operational carbon through effective productive gains, operational economies and reduction of operating cost by utilising effective processes and energy management.

McDonald's at YSCC is a single-storey stand-alone, quick-service, drive-thru outlet.

INTRODUCTION

For over 20 years, McDonald's has pioneered a variety of environmental initiatives that include reducing the amount and type of packaging it was using, moving a third of its fish purchases to more sustainable sources, and implementing a programme to buy recycled products. In the UK, some restaurants are converting used frying oil into biodiesel that is used to fuel the trucks delivering goods to the stores.

On a global scale, McDonald's has set goals and made tangible progress on priority products as identified in a Sustainable Land Management Commitment, by promoting socially responsible practices in its supply chain. These include efforts to reduce environmental impacts of direct suppliers through the use of the Supplier Environmental Scorecard which incorporates existing initiatives like animal welfare programmes and supplier social accountability programmes as well as new environmental guidelines and performance measures. Suppliers are expected to extend this vision of sustainability to their own suppliers (indirect suppliers to McDonald's), 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 PROCUREMENT

McDonald's has strived to ensure that every step of its supply chain contributes positively to the safety, quality, and availability of its final products. The ingredients and materials that go into the products have to be produced in ways that contribute positively to the development of sustainable agricultural and food manufacturing practices.

Leaders of the company's Worldwide Supply Chain department created a global governance structure via the Sustainable Supply Steering Committee (SSSC) in 2007 with representatives from the supply chain department and from each area of the world, who are responsible for corporate social responsibility, social accountability, and corporate communications. This group guides the company in its efforts to achieve sustainable supply, by identifying global priorities and ensuring progress in ways that complement local priorities and efforts.

SUSTAINABLE MATERIALS

McDonald's uses food wrappers, food containers, carry out bags, cups, plates, toilet rolls, napkins and serviettes that are made from environment-friendly materials such as recycled or recyclable materials.

F&B OPERATION AND MANAGEMENT

Embedded within the operating culture of McDonald's is the pursuit of sustainability and greater efficiency in business operations and reduced operating costs. Good maintenance and management practices ensure that all building systems function to the fullest designed efficiency whilst meeting specified levels of energy and indoor air quality performance. A comprehensive approach to maintenance and management helps to yield on-going energy and water savings for McDonald's while promoting occupant health and comfort.

McDonald's believes in full 'lifecycle management' of restaurant-generated waste. 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).

ENERGY EFFICIENCY

Beyond sustainable practices and operations, McDonald's also felt it prudent to review energy consumption across its restaurants and establish benchmarks to help operators manage energy efficiently. These sustainability and environmental responsibility and reduction efforts have enabled restaurant energy usage to remain stable despite increases in restaurant operation hours, equipment and menu items. Key performance indicators are tracked globally and shared across all countries. Measurements and best practices are also shared.

Restaurants implemented measures such as training managers to adopt best practices as well as installing LED lights, highly efficient HVAC systems and low-e windows to reduce heat gain.

WATER EFFICIENCY

Ever mindful that water usage in restaurants is high, 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. Basin taps and mixers, flushing cisterns, sink/bib taps and mixers, certified to be water-efficient, are installed.

ICE PRODUCTION

Energy star air-cooled ice makers ensure further water conservation in the restaurants. The Manitowoc energy star-rated Indigo Series air-cooled ice making equipment has a space-saving design, and its preventative diagnostics continually monitors itself for reliable ice production, is programmed for cleanability, and is less expensive to operate.

CONSTRUCTION MATERIALS

McDonald's also advocates the use of sustainable construction materials such as green ceilings, manufactured under a stringent German process which is designed to produce environment-friendly products that are recyclable; road pavements made of recycled concrete granules; and environment-friendly green paint with low Volatile Organic Compounds (VOC). McDonald's recycles all of its used oil which is used to make soap.

PROJECT OVERVIEW

The already well-known and iconic Platinum-rated McDonald's restaurant then was at Jurong Central Park (JCP), constructed in 2012 with a green roof and a rainwater harvesting system. However, for the McDonald's restaurant at YSCC, the development team was challenged and thereby compelled to think of innovative ways to design a sustainable restaurant without a green roof and without a rainwater harvesting system.

Many of the best practices on energy efficiency, water conservation and waste recycling as well as creative air-conditioning design ideas were incorporated into the design. Innovative technologies were considered but the installation of solar panels was ruled out due to shading issues created by surrounding residential flats and the low amount of electricity that would be generated.

PASSIVE AND ACTIVE STRATEGIES

The 495 m^2 McDonald's at YSCC is a single-storey, stand-alone, quick-service outlet with a seating capacity of 158 (indoors) and 45 (outdoors).

Its unique architecture meant that the building is not 100% enclosed as in a typical built-up structure. Instead, some areas are open for outdoor dining, which meant that the passive and active strategies had to be adapted to the building usage. The restaurant was built to be energy- and water-efficient.

The building envelope design impacts the comfort level within - defined by the temperature, humidity, light penetration, sound, view, ventilation and indoor air quality. For the design of this restaurant, 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 relative humidity (RH) of between 30% and 70% (average external RH is 84.2%).

The thermal comfort of the building can be physically modified through a combination of passive and active strategies, based on 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

PASSIVE STRATEGIES

Passive architectural design features include optimised building orientation; a large expanse of high performance, low-e glass with good visible solar transmittance and non-visible reflectance, to reduce artificial lighting requirements and internal heat gain; shading features; and natural ventilation.

Daylight harvesting

Lighting was designed to meet the illumination parameters as stipulated under CP 38 which serves to ensure a good balance between comfort and energy efficiency.

A high window-to-wall ratio (WWR) enables a high degree of daylight harvesting - as much as possible of quality sunlight is drawn in to illuminate the interior spaces of the building. The low-e glass windows installed all around the building reduces glare and solar heat transmission into the interior spaces, thereby reducing the cooling load for the air-conditioning system.

At the same time, the large expanse of glass is aesthetically pleasant, inviting prospective diners to enter the restaurant, whilst allowing people seated inside to have a good view of the outside.

Natural ventilation

The outdoor dining area, with a seating capacity of 45, was designed with a single large opening at one end. Using empirical principles, it was established that while such openings are sufficient for ventilation, there is no guarantee of 100% air movement. Therefore, the design incorporated a 'Big S' fan to generate air movement throughout the dining area, thereby creating a pleasant, cooling effect to counter the outdoor tropical heat.

The incorporation of natural ventilation, a form of passive strategy into the overall design concept proved that balancing the natural environment with mechanical systems can enhance the air quality and comfort of the environment.

Landscaping

With its larger footprint, McDonald's at YSCC has been designed with extensive landscaping that is aesthetically pleasing and blending well with the surrounding Yishun Park

ACTIVE STRATEGIES

Active strategies include the use of energy-efficient systems for air-conditioning and lighting as well as energy-efficient heat recovery system, kitchen equipment etc.

Air-conditioning

McDonald's at YSCC utilises an air-conditioning system that includes five Lennox split units, with an average Coefficient of Performance (COP) of 3.34 for the compressors which are controlled via a Honeywell T7350 thermostat. The various air-conditioning zones

Daylight is drawn into the restaurant through the use of a large window-to-wall ratio designed to reduce the dependency on artificial lighting.

Aesthetically pleasant landscaping

The 'Big S' fan generates air-movement throughout the outdoor dining area.

Recycled concrete has been used for pavement construction.

are monitored via a separate panel of meters. Separate controls have been installed for climate control, providing flexibility in the control of air-conditioner usage.

Lighting efficiency

This is the first McDonald's restaurant to utilise 100% LED lighting, achieving a lighting budget of 8.2 W/m^2, which represents an improvement of 45.4% over the 15 W/m^2, as stipulated in SS530. Energy is saved through the zoning of lighting for different usage / locations, the installation of controls to switch on or switch off the lighting, and colour-coding of the lighting switches to enable the staff to manage the lighting zones.

An efficient, split air-conditioning system achieves a COP of 3.34, with separate zoning to serve areas with different usage / occupancy needs. The system is scheduled for 7-day, 24-hr operation, with control of the air-conditioning achieved with time-based set-points.

Heat recovery system

Other strategies to reduce the mechanical and electrical energy required include making use of heat exchangers to produce 100% of the hot water needed for the kitchen. In this instance, the Lennox HWL21/65 water heater module is a typical heat recovery system that produces hot water from the waste heat generated by the air-conditoning units, saving on three water heaters that would otherwise have been required to produce the same amount of hot water.

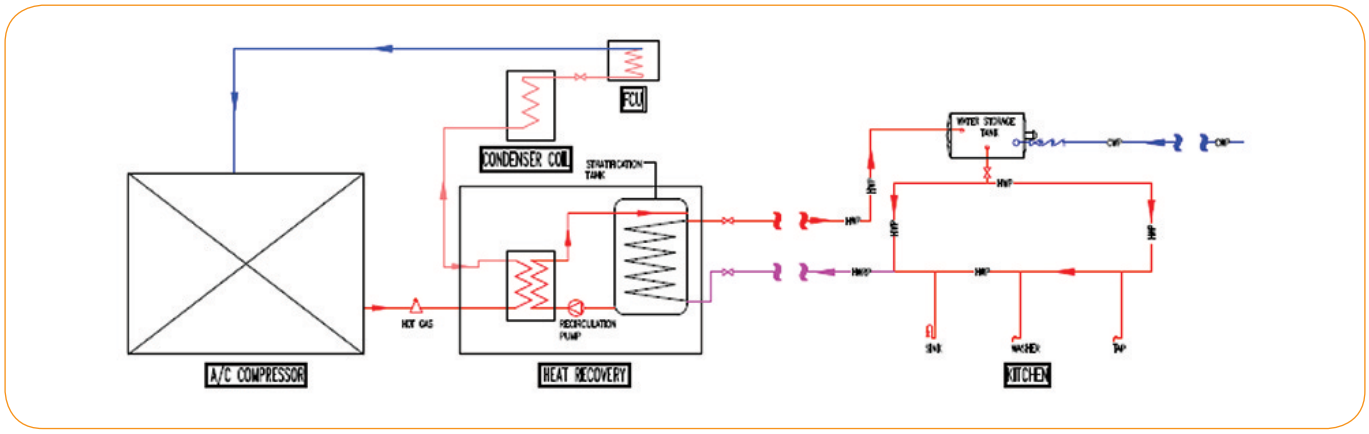
Energy-efficient kitchen equipment

Recognising that varying restaurant sizes would pose a challenge in establishing an average value for the energy consumption by kitchen equipment, McDonald's conducted an internal study on restaurants in various configurations, ranging from 2,000 ft^2 and below to 5,000 ft^2 and above. The study concluded that energy consumption of kitchen equipment ranged from 44% to 57%, with an aggregate average value of 53%. This value is critical in the computation of the Energy Efficiency Index (EEI) where the kitchen equipment is to be excluded, as it would not realistically reflect the consumption profile due to its high load (kW).

McDonald's actively collaborates with its equipment suppliers to redesign kitchen equipment so that

The restaurant uses energy-efficient LED lighting.

The Lennox HWL21/65 water heater module produces hot water from the waste heat generated by the air-conditoning units.



Heat recovery schematics

it consumes less energy and produces better-tasting food, whilst improving crew productivity and reducing energy consumption.

For instance, the Low Oil Volume (LOV) fryer improves cooking efficiency, simplifies filtering and cleaning, and provides enhanced environmental benefits while using approximately 4% less energy and 40% less oil than standard fryers.

Halton hood with capture jet technology

McDonald's introduced the Halton hood technology to various restaurants around 2011 on a trial basis, to validate energy savings. Capture jets work on the principle of an air curtain which keeps the cooking heat from 'spilling' into the kitchen environment. This heat is then forced back into the inlets by pressure and a suction fan then exhausts the heat to the external environment.

Along the exit passage, the exhaust air is treated with air ionisers which break up the cooking fumes into smaller particles whilst removing odours.

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

Energy consumption statistics compiled from three McDonald's restaurants, showing the percentage consumption by the kitchen.

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

The Halton hood technology is extensively deployed in the kitchen. The canopy hood system is able to save approximately 21,120 kWh in terms of cooling load by preventing excess cooking heat from dominating the kitchen environment.

Electronic air cleaners

McDonald's green practices extend to the treatment of dry and wet air in the kitchen, contaminated by particulates from oil. This contaminated air is drawn by a motor/blower through Rydair electrostatic air cleaners which have a system of filters that trap large dust particles.

The Rydair air cleaner incorporates two cleaning sections - a UVC section and an electrostatic section. UVC lamps break down oxygen in the contaminated air to form two unstable O atoms that fuse with oxygen (O_2) to form O_3 (ozone) which is a powerful oxidant and an extremely effective germicidal agent that destroys micro-organisms in the air and removes grease and oil from kitchen exhausts. However, ozone tends to have a short lifespan lasting just 20 to 30 minutes before reverting to normal O_2.

The rest of the smaller particles, which are less than 0.01 microns, are then drawn into an electrostatic section where ionising takes place. In this chamber, the particles are charged up electrically and pass into a collector plate made up of a series of equally spaced parallel plates each charged with the same polarity as the particles. This repels the contaminants into plates that are grounded. The contaminants remain in the plates until they are washed away.

High-efficiency intelligent hand dryer

The SmartDri hand dryer

In recognition of the fact that conventional hand dryers have high energy consumption, McDonald's selected the SMARTdri hand dryer which is designed to optimise drying time, energy consumption and sound quality. The intelligent, flexible controls allow customising of air flow, sound quality and heating options to fit any application environments. Following successful trials, SMARYdri was installed at McDonald's at YSCC and JEM.

Indoor air quality

The positive pressurisation design ensures that the air pressure within the dining zone is higher than that in the kitchen and in the external environment, thereby helping to keep out odours and even dust penetration. This ensures a clean and hygienic environment.

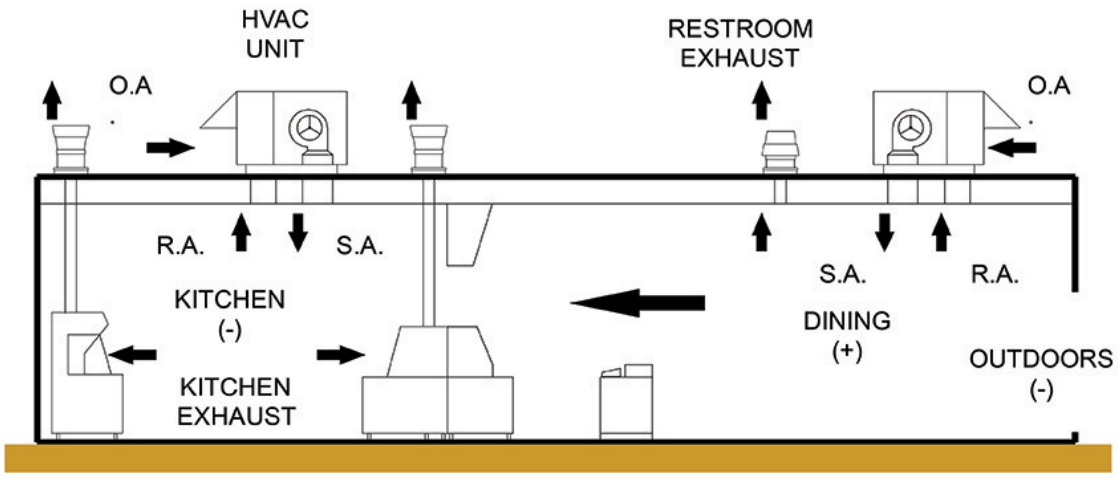
Negative pressurisation is induced by the kitchen exhaust with an input fan capacity of +3,000 cmH and an output fan capacity of +4,000 cmH. This high-speed exhaust fans are designed to draw out heat, odours and other pollutants from the dining areas and out of the kitchen at a rate of 4,000 cmH.

Sensors in the carbonated drinks room detect the presence of carbon dioxide (CO_2) gas. Should the CO_2 level in the kitchen reach an undesirable level due to any accidental leakage from the CO_2 cylinders for the carbonated drinks, an alarm will sound. The store manager will then take immediate action to bring the CO_2 concentration to the desired level.

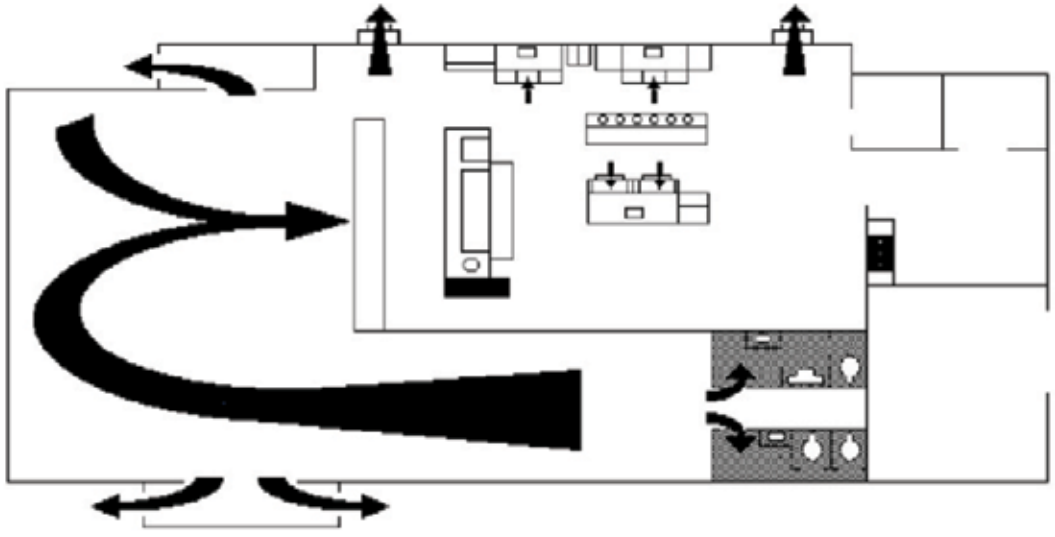
CONCLUSION

Building upon its success of six green restaurants in Asia, McDonald's has proven that lessons learnt from experimentation with materials, technologies and construction methodologies can all lead to the successful development of a green building DNA that can be replicated in future expansion programmes. Another important lesson was that it is highly feasible for drive-through restaurants to achieve Green Mark Platinum certification through architectural design, sustainable construction and green technology.

The experience of constructing green restaurants has expanded the skills and knowledge of the McDonald's development team. With each improvement, there is a reduction in the carbon footprint.



The mechanical system ensures a positive pressurisation that increases fresh air intake into the dining areas and prevents the ingress of hot humid air from outside.



Negative kitchen pressurisation is achieved with high speed exhaust fans which draw out the heat generated by the kitchen equipment.

Sustainability can be improved in the passive design, especially of the building envelope, through the selection of a more thermally insulated façade to reduce heat gain. Another worthwhile consideration is the use of double glazed glass windows with high transmissivity of light and a reduction in heat flux through the selection of the glass pane.

It was observed that the interior of the restaurant tended to be darker due to lower light penetration. This situation could be rectified through the incorporation of skylights at various locations on the roof-top and on the side of the building façade. Unfortunately, this concept was not pursued in the McDonald's at YSCC, due to the limited footprint available on the roof-top as considerable space was taken up by M&E equipment.

Air-conditioning performance is another area worth improving. The current average COP is around 3.35 to 3.4 and this could be improved to above 4.0, if more energy-efficient and cost-effective systems are installed.

Low VOC paint is used on the walls of the restaurant.

Recycled ceiling boards are used throughout the restaurant. This is a sustainable solution for improving acoustics.

Recycled containers are used for storing shortening (used cooking oil), before it is sent for conversion into soap.

The adoption of many Singapore Green Label-certified green products and solutions, such as cool paint, laminated finishes, low VOC paints, recycled toilet paper, cleaning detergents etc, has helped McDonald's to meet the sustainability criteria. The introduction of capture jet technology and other innovative solutions has also contributed to improving the green features score.

Overall, it is felt that sustainable restaurant design has benefitted tremendously from the lessons learnt in the early green pilot programme. The invaluable learning will provide the basic building template for McDonald's to construct cost-effective green restaurants that are innovative as well as water- and energy-efficient. The integration of passive and active design strategies played a pivotal role in the design of the McDonald's restaurant at YSCC and helped to validate energy savings opportunities during the design and construction phases. In the near future, the focus should be on reducing the embedded carbon and operational carbon so that the new generation of restaurants are not only built to be environment-friendly but also possess a smaller carbon footprint which will translate to lower operating costs.

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.

PROJECT CREDITS

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