Green restaurant incorporating holistic design solutions

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Although architects, planners and engineers have attempted to adapt vernacular architecture to include sustainability, by integrating aspects of passive climate control such as shading, natural ventilation and increasing the thermal mass of walls, mechanical and electrical systems within facilities continue to consume energy. This article showcases the innovative sustainability solutions that were conceptualised and deployed in KFC Nilai in Malaysia.

KFC Nilai is a single-storey, stand-alone, drive-through, fast-food outlet with a seating capacity of 128 (indoors) and 46 (outdoors). Image by QSR Brands, Malaysia.

INTRODUCTION

The collaboration of the Building and Construction Authority (BCA) of Singapore and MGDT, Singapore, resulted in the launch, in 2011, of the Green Mark criteria for restaurants in tropical environments. The construction of Nilai KFC, located in Kuala Lumpur, is the result of efforts to design and develop the first fully integrated sustainable restaurant in Malaysia, by MGDT together with QSR Brands (M) Holdings Sdn Bhd which currently dominates Malaysia's rapidly expanding retail food industry as a fully integrated F&B operator.

Nilai KFC is a single storey, stand-alone, drive-through, fast-food outlet. It has a seating capacity of 128 (indoors) and 46 (outdoors) over a gross floor area of 582.55 m^2. The outlet was designed using the BCA restaurant criteria as a starting point, in order to incorporate all the energy efficiency and water efficiency ideas so as to achieve a Platinum rating.

Besides winning the BCA Green Mark Platinum Award for restaurants in 2014, Nilai KFC was certified Gold under Malaysia's Green Building Index (GBI) and the US Leadership in Energy & Environmental Design (LEED).

Restaurants are typically designed with active strategies leveraging mechanical & electrical (M&E) systems, but MGDT applied its experience in integrating passive solutions to the overall active M&E building blueprint.

Improving sustainability of buildings

BCA's Singapore Green Mark scheme was launched in January 2005 and over the past 10 years, BCA has steadily introduced a comprehensive suite of policy levers and initiatives to promote energy efficiency in buildings and encourage the adoption of green building practices. Through its first two Green Building Masterplans, BCA has successfully grown the number of green buildings in Singapore from just 17 in 2005 to more than 2,500 today. This is the equivalent of about 62 million m^2 or more than 25% of Singapore's total gross floor area (GFA).

Green Building Index Sdn Bhd was launched in Malaysia on 21 May 2009 to administer Green Building Index (GBI) accreditation whilst providing training for facilitators and certifiers. Jointly conceived and developed by the Institute of Architects (PAM) and the Association of Consulting Engineers (ACEM), it received over 655 applications for GBI certification, out of which 296 projects making up 12,948,560.12 m^2 of space have been certified (GBI data as at 15 April 2015).

According to statistics from BCA, green buildings demand additional capital expenditure (CAPEX) which, depending on the selected Green Mark score, can range from 0.3% to 8% of the overall construction cost. On the positive side, the resultant benefit comes from increased energy savings and an average lifecycle savings of 20% for a total savings of 10 times the initial investment.

Before any energy-efficient design commences, it is also practical to design the building envelope appropriately for thermal mass insulation, that results in less CO_2 emission from embedded carbon. Precast concrete uses materials efficiently, reducing construction waste, site disturbance, and noise.

Through studies conducted on thermal conductivity of building facades, MGDT proposed the use of precast aerated lightweight concrete, which is anticipated to contribute significantly towards the social, economic and environmental benefits of the building lifecycle.

ARCHITECTURAL DESIGN CHALLENGES

The built environment is directly influenced by the climate-adaptable approach which also considers internal conditions relating to comfort level, including temperature, humidity, light, sound, view, air flow and indoor air quality. Under Singapore Standards SS530, an internal temperature of 24 °C to 26 °C at 30% to 70% humidity is considered acceptable as the starting point for the Green Mark.

Lovell states that comfort is not something defined by a range of temperatures and humidity. The thermal comfort zone is also determined by the type of clothing worn, metabolic rates, activity levels, lighting and visual perception, and health conditions.

Integration of passive design

The mantra of designing an energy-efficient building is that it is able to do more with less, whilst providing the designed and required internal environment, with minimum energy consumption and wastage. It should also be easy to maintain and remain cost-effective to operate throughout its lifecycle, despite variations in loads and human activities. The premise for energy-efficient design therefore begins at the 'new construction phase' where owner and designer should consider green building design incorporating sustainable best practices to optimise total energy consumption and environmental lifecycle impact. The fundamental approach is to 'do it right the first time', as it is costly and highly unlikely that any building owner will try to undo the wrong done.

Energy-efficient design begins with the strategy for selecting the building fabric which forms the critical interphase between the internal environment and the external environment. In the first place, a building has to be designed to be as air-tight as possible, to guard against heat gain and cooling load losses. The strategic façade design for KFC Nilai focused on the selection of low embedded carbon building fabric materials coupled with passive design strategies to reduce energy consumption over the building's lifecycle.

ENERGY CONSERVATION

The focus on energy consumption was identified as a key component of green building design, as restaurants have very high levels of energy intensity due to their relatively small footprint and the significant amount of cooking, ventilation and refrigeration needed to prepare and serve food.

In designing the Nilai drive-through restaurant, QSR took great pains to ensure that lighting designs were energy-efficient. At the conceptual stage, MGDT advised that all lighting be converted to LEDs, to maximise energy savings, and additional energy savings strategies included the implementation of perimeter lighting, skylights, photosensors and other daylight harvesting systems, for the dining and kitchen areas.

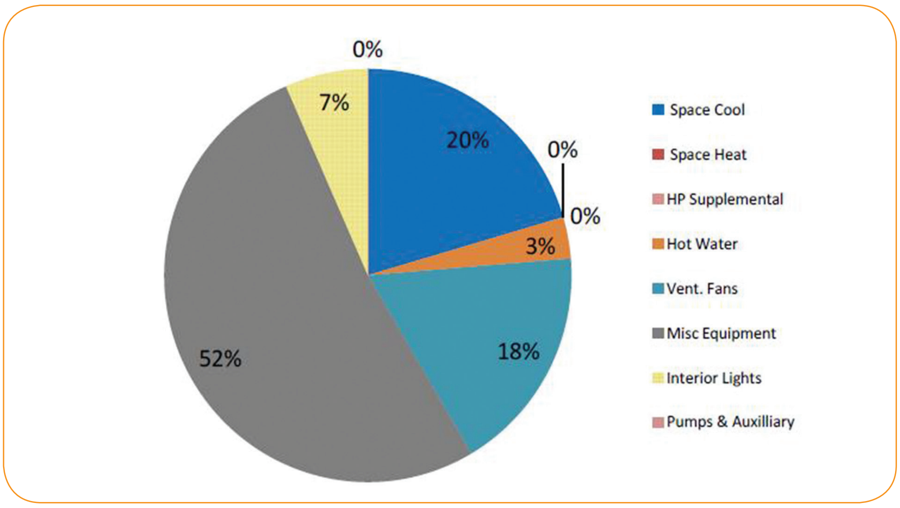
Going one step further, QSR conducted a preliminary analysis of the end-use energy consumption, based on the ASHRAE 90.1-2007-compliant model, for KFC Malaysia. The focus was to analyse the impact of envelope upgrades on overall energy usage.

The preliminary energy modelling, performed by a US-based energy consultancy, Green Building Services, in compliance with LEED requirements, indicated that kitchen equipment consumption constituted 52% of the total energy consumption, followed by space cooling (20%) and ventilation fans (18%). The energy modelling also confirmed that lighting loads can be reduced further through more energy-efficient LED lighting.

The basis for evaluating energy efficiency is the benchmarking of the annual energy consumption per square metre (kWh/m^2/year), or the Energy Efficiency Index (EEI), of typical restaurants across a sample size of over 100 KFC restaurants located in West Malaysia, in various configurations, ranging from 2,000 ft^2 and below to 5,000 ft^2 and above.

Using 2013 data as a baseline, it was determined that the EEI ranged from 280 kWh/m^2/year to 2,933 kWh/m^2/year, which is extremely high, because it includes the consumption from kitchen equipment. The energy consumption of kitchen equipment, in relation to the total consumption, ranges from 44% to 57%, with an aggregate average value of 50%.

EEI mapping for KFC restaurants across Malaysia indicates that from 2014 onwards, there has been a drop in EEI, ranging from 137 kWh/m^2/year to 1,381 kWh/m^2/year, which is approximately a 10% improvement overall, as compared to 2013 baselines. This is due largely to the aggressive implementation of an energy management project in 2014, initiated by MGDT in partnership with QSR, to reduce energy consumption.



Consumption components as analysed using energy modelling software. Image by Green Building Services, USA.

Outdoor dining and playground areas are naturally ventilated. At the same time, mechanical fans have been installed to improve the air-flow quality and air circulation. Image by Martin Lim.

Natural ventilation

One of the key considerations was to ensure that the outdoor dining area, with a seating capacity of 46, and the playground area, which were designed with a single large opening at one end, should be adequately ventilated, to guarantee quality air-circulation throughout the year.

Openings could serve the dual purpose of cooling as well as improving indoor air quality (IAQ), through constant air circulation as fresh air is brought into the areas through convection currents created by wind. The incorporation of natural ventilation, with shading features such as louvres located on the ceiling, provides respite from the afternoon sun and confirmed that balancing the natural environmental conditions with mechanical systems, such as fans, can improve air quality and comfort in the dining environment.

Air-conditioning

The restaurant has an air-conditioning system incorporating intelligent thermostats, to maintain a comfortable environment based on scheduled settings. The system uses four Daikin energy-saving VRV II split units with an average Coefficient of Performance (COP) of 4.03 for the compressors.

Based on SS530, for the unitary air-conditioners and condensing units, electrically operated, the COP calculations are as follows:

a) For air-cons >19 kW < 40 kW, minimum COP requirement = 3.02

COP at Nilai KFC = 4.27

Percentage improvement =

$$\frac{4.27 - 3.02 \times 100}{3.02} = 41.4\%$$

b) For air-cons >70 kW < 223 kW, minimum COP requirement = 2.70

COP at Nilai KFC = 3.88

Percentage improvement =

$$\frac{3.88 - 2.70 \times 100}{2.70} = 43.7\%$$

Lighting design

The following lighting strategies, which were incorporated into the fenestration design for windows, contributed much to improvement in the envelope design:

- Larger size north-light windows increased the window wall ratio (WWR) to improve lighting penetration and diffusion within the interior spaces.
- The use of light shelves, prismatic glass, light tubes and anidolic ceilings draws more sunlight into the interior spaces.

The key passive ingredient is harvesting of natural daylight, drawing as much of the quality light as possible, into the interior spaces of the building, through skylights and side slits located around the ceiling zone.

Where lighting is insufficient, energy-efficient LED lights are used in place of the conventional lighting system. Energy consumption by lighting accounts for some 15% of the building's total annual energy consumption. LED lighting is the 'low hanging fruit' which can easily be 'plucked' to achieve energy savings.

Low-e glass windows are used all around, to reduce glare and solar radiation, whilst allowing natural daylight to penetrate into the dining areas. An analysis of the room depth showed that a depth of 8 m is sufficient to meet the lighting requirements although the room would be dark at the back. This was improved with increased window openings and artificial lighting. The glazed windows reduce solar heat gain, thereby contributing to a lower cooling load despite the fact that the restaurant is located in a hot tropical environment. The low-e glass has a U value of 3.90 W/m^2K which allows the transmittance of 52% visible light whilst absorbing 71% of solar radiation.

Lighting designed to meet the illumination parameters as stipulated under CP 38 (or equivalent) helps to achieve a good balance between comfort and energy efficiency. The restaurant is also designed with large floor-to-ceiling glazed windows and skylights, with low-e value, allowing natural daylight harvesting throughout the day. Images by Martin Lim.

A central light well was initially proposed to provide quality lighting to interior spaces more than 3 m from the windows and slits were created above the kitchen area to draw in natural lighting during the day.

Solar PV

Malaysia enjoys an average of 2,228 hours of sunlight per year (out of a possible 4,383 hours). On average, sunlight availability is for 6.06 hours per day. Generally, the weather is sunny for 50.8% of the daylight hours and the remaining 49.2% of daylight hours is likely to be punctuated with cloudy skies, shade, hazy weather or low sun intensity.

At midday, the sun is, on average, 75° above the horizon at Kuala Lumpur. Nilai KFC has installed a solar PV system that utilises the abundant sunlight to power nine units of LED lighting, each with a consumption of 11 W, at the 'Funland' area.

Solar thermal system

The client was open to testing green technologies at restaurant and market levels and then adopting the best practices in new markets. A solar thermal system is used to generate 100% of the hot water required for the kitchen, which amounts to a saving of 78,840 kWh per year, or a reduction of 10.5% of the annual energy consumption.

WATER EFFICIENCY

Ever mindful that water usage in restaurants is high, KFC restaurant managers are required to monitor water consumption on a monthly basis. This information is sent to headquarters to be consolidated for further analysis. Basin taps and mixers, flushing cisterns, sink/bib taps and mixers, with three ticks ratings, under the Water Efficiency Labelling Scheme (WELS) of PUB, Singapore's national water agency, have been installed. Energy star air-cooled ice makers are one of KFC's strategic acquisitions in ensuring water conservation in its restaurants, regionally.

Rainwater harvesting system

KBM Konsult, the Civil & Structural Engineering firm, designed an above-ground and below-ground rainwater harvesting and storage solution. The above-ground storage utilises a tank measuring 2 m (length) by 1 m (width) by 1 m (height), which stores approximately 2,000 litres of rainwater collected from the main trapezoidal roof. From this tank, water is distributed via gravity flow around the building.

For below-ground storage, a reinforced concrete tank was constructed. Measuring 5 m (length) by 2 m (width) by 1 m (height), it stores 4,250 litres, and this is linked with the 750 mm by 750 mm by 131 m long box culvert located below side parking lots and road to store an additional 17,370 litres, making a total of 21,620 litres. Excessive overflow water from the above-ground storage as well as from areas, other than the main trapezoidal roof, are channelled through the rainwater downpipes and diverted to the box culvert. The stored water is then pumped to the irrigation taps provided around the site boundary.

MONITORING ENERGY AND WATER USAGE

To meet energy efficiency goals, sensors are attached to the Building Management System (BMS) via a data infrastructure, allowing real-time information to pass seamlessly through the integrated system. Electrical sub-meters have been provided, with integration to the BMS, for the following sub-systems where energy consumption is in excess of 100 kVA:

- All lighting (internal & external)
- Kitchen equipment
- ACMV system
- Plug loads
- Fire protection
- Air-conditioning system

Integrated Building Management System

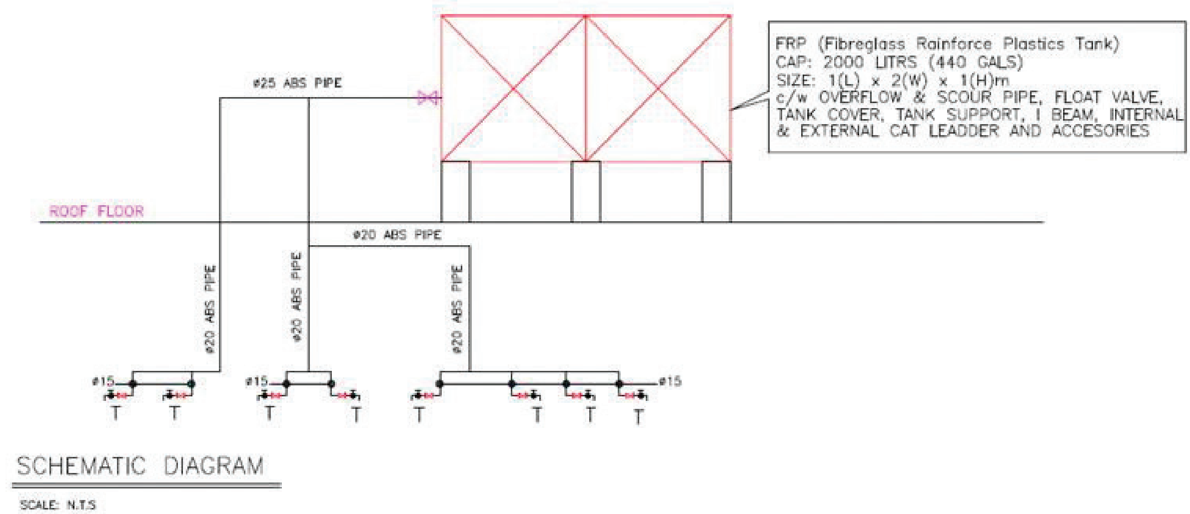
The Building Management System (BMS) provides the essential instrumentation and control to co-ordinate, regulate and manage the different building systems including air-conditioning, lighting, water consumption and power. Nilai KFC uses the BMS to automate control over the building sub-systems. With the seamless integration of the BMS, the Operations Manager is able to achieve the following:

- Reduce operational and energy costs by connecting the building sub-systems, with the HVAC equipment, lighting, security management and fire protection working together as a cohesive unit.
- Increase productivity by the seamless integration of equipment from virtually any manufacturer.
- Make fast, accurate decisions on energy strategy, with data collected from sensors.
- Ensure wide connectivity, using the latest wireless technologies linking more devices into every hard-to-reach corner of the building.

The BMS utilises the ASIC/2-8540, a configurable unitary controller that has the ability to switch power supply for AC operation, and flash and NVRAM memory for program and data storage. The ASIC/2-8540 is designed for energy management and control of a wide range of building systems including air handlers, chillers, cooling towers, rooftop air-conditioning, pumps, lighting etc, in a networked system. It is a good stand-alone solution for small buildings, such as bank branches, drive-through restaurants, retail stores and utility company sites.

GREEN KITCHEN EXHAUST SYSTEM

KFC's green practices extend to the treatment of dry and wet contaminated air in the kitchen. The contamination is caused by particulates



Schematic diagram for above-ground rainwater storage. Image by KBM Konsult.

from oil. At the Nilai KFC restaurant, innovative technologies have been installed in the kitchen exhaust system to effectively reduce all odour from the fumes discharged into the environment.

Contaminated air is drawn by motor/blower through the cyclonic air cleaners which has a system of filters to trap particles from 10 microns and large dust particles. KVL canopies, incorporating advanced Halton Capture Jet technology, have been installed, to remove contaminated air and excess heat emitted by cooking equipment, thereby helping to provide a comfortable and hygienic environment.

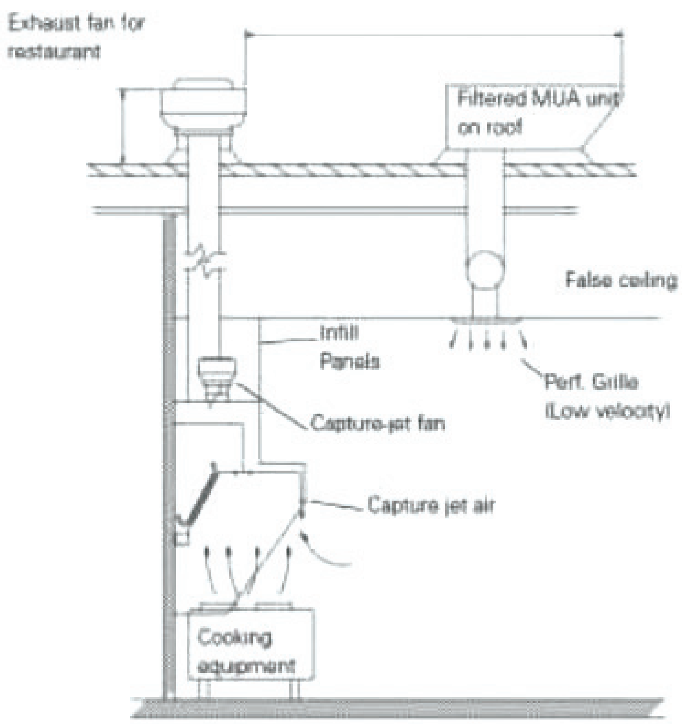
CONCLUSION

This case study has helped to validate the fact that cost-effective solutions are attainable in the construction of sustainable restaurants. With this green restaurant, KFC has proven that lessons learnt from experimentation with materials, technologies and construction methodologies can all lead up to the successful development of a green building DNA that can be replicated in future expansion programmes. Another important lesson was that drive-through restaurants can achieve the highest green rating as they benefit directly from the architectural design, sustainable construction and green technologies, unlike tenanted premises where the landlord or developer determines the entire construction process.

The experience of constructing green restaurants has served to expand the skills and knowledge of KFC's development team and each improvement leads to a reduction in the carbon footprint.

In retrospect, sustainable design could be expanded to include making further improvements in passive design, especially of the building envelope, through the selection of a more thermally insulated façade that reduces heat gain as compared with the typical brick and mortar construction.

More research could be undertaken on the use of double-glazed glass windows with high transmission of light, instead of the low-e glass currently utilised.



Schematic of the Halton Hood system.

PROJECT DATA

Gross Floor Area
582.55 m^2

Seating Capacity
Internal - 128 seats
Outdoor - 46 seats

EEI
212.16 kWh/m^2/yr

Lighting Power Budget
6.92 W/m^2

PROJECT CREDITS

Client
KFC (Peninsular Malaysia) Sdn Bhd

Architects
Azhar Design Consult
Aziz Darmawi Architect

Civil & Structural Engineer
KBM Konsult

Mechanical & Electrical Engineer
KBM Konsult

ESD Consultant
Metropolitan Green Design and Technology

Landscape Consultant
Aminuddin Badawi Landscape Consulltant

Quantity Surveyor
CIC-QS Services

Main Contractor
Ngai Thong Plumber & Construction Sdn Bhd