DESIGN AND PROCURING A GREEN OFFICE IN UNIVERSITY CAMPUS

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ABSTRACT

In 2012, University of Malaya was selected to undertake the Low Carbon City Framework (LCCF), in collaboration with the Ministry of Energy, Green Technology and Water (KeTTHA). Several researches spurred from there on. This challenge was taken up at a micro level by UMCARES voluntary team to retrofit an existing office in a conventional building into a pilot green office campus. Research renovation and setting up an innovative and functional office will be carried out to transform the existing office into a living lab and show case for real environmental office solutions. This paper will discuss the process and challenges faced in the green office transformation at its preliminary stage of project; developing the spaces, acquiring partners and procuring such project in a public university. The design process has been an experiment staging from grappling with green procurement issues to finding the appropriate solutions and partners for this pilot project. This paper will also include results from the indoor environment inventory of the existing office space, which include the thermal condition, daylighting, acoustic level in different scenarios and indoor air quality level in various ventilation strategies. These parameters will continue to be monitored during post renovation and during occupancy period. The outcome of this research project would be possible recommendations for green retrofitting of office spaces or buildings for the entire campus to refer.

Keywords: green office, green procurement, daylighting, acoustic, thermal comfort, IAQ
INTRODUCTION

Starting the green

In 2012, University of Malaya was selected to undertake the Low Carbon City Framework (LCCF), collaboration with the Ministry of Energy, Green Technology and Water (KeTTHA). Several researches spurred from then to tackle various issues. Amongst the researches, UMcares had taken up the challenge at a micro scale by its voluntary team when it was given the opportunity to have its own base office to operate from in late 2012.

The office building has a large effect on the consumption of energy in use. With the increase of awareness on the energy consume and the environmental impact, the design of office building has been taken into another dimension. Nowadays, offices undergo refurbishment whether to upgrade the internal environment or to create modern interior design, provide an alternative to constructing a new building or demolishing. Refurbishment also provides an opportunity to improve the energy and environmental performance of an office. With the main objective as to minimise impact on health and performance of the occupants, the requirements for Indoor Environmental Quality (IEQ) has been emphasized in most green building rating systems, particularly to achieve an improved indoor environment. IEQ is defined in terms of indoor air quality, daylighting (glare) and views from windows, acoustics quality (noise), and thermal comfort (Burnett 2007; Burton 2001), but Burnett (2007) further explained that consideration on work place design and critical matters affecting occupants performance are also important in designing a green office.

University Malaya paid approximately RM30 million for its annual electricity bill in 2013; a very large figure just to run a campus. Being aware of this, the team decided to not just conduct a conventional renovation but to put forward a blueprint for a pilot green office. The main aim of this research project is for UMcares office to set the frontier and become the test bed for green office buildings through sensible renovations and purchasing considerations and methods in the University Malaya (UM) campus. This research project is indeed in tune with UMcares vision which is to transform University of Malaya into an environmentally sustainable campus.

The objectives of this paper is to share experience and discuss the process and challenges faced in the green office transformation at its preliminary stage of project; developing the spaces, acquiring sponsors and procuring such project in a public university. The design process has been a new experience particularly with regards to green procurement issues to finding the appropriate solutions and partners for this pilot project. This paper will also include results from the indoor environment inventory of the existing office space, which include the thermal condition,
daylighting, acoustic level in different scenarios and indoor air quality level in various ventilation strategies.

There are many definitions and interpretation of green building but somehow, it relates back to the same fundamental. American Society for Testing and Materials International (ASTM) characterises green building as, ‘a building that provides the specified building performance requirements while minimising disturbance to and improving the functioning of local, regional, and global ecosystems both during and after its construction and specified service life’ by focusing on the environmental aspect of sustainability, and clarifies that, ‘a green building optimises efficiencies in resource management and operational performance; and, minimises risks to human health and the environment’ (Burnett, 2007). As defined by (Robichaud and Anantatmula, 2011), there are four main criteria of green buildings, which are minimization and elimination of impacts on the environment, enhancing the health conditions and productivity of occupants, the return on investment to developers and local community, and the life cycle consideration during the planning and development process.

By understanding the theory and concept of green building, the objective may be concluded as to minimise, or completely avoid the impact of the built environment on health and the environment by using critical resources efficiently, protecting occupant health and improving productivity, and reducing waste, pollution and environmental degradation caused by facilities and infrastructure throughout the life cycle, and creating a built environments that are safe, comfort, healthy and liveable (WBDG, 2013).

Pre Design Challenges

The given options of office spaces are all unoccupied in conventionally designed buildings owned by UM. There had been four choices of office space, of the first two which were located at Research and Development high-rise tower built in the mid-1980s at the periphery of UM campus which was later renovated in phases starting in 2008. Another two alternative office spaces was later offered in late-2012 is situated in a medium low rise newly completed Research Management and Innovation Complex building designed to house research clusters and units. All four sites were visited and the team made a checklist of the pros and cons of each space based on priority given to space dimension and shape, orientation, window to wall ratio, existing mechanical systems, existing passive building elements, connectivity, accessibility and surroundings.

Initially the team studied and designed proposals for one of the space on the 13th level at the Research and Development Tower Building. It was in August 2012 that
UMcares where offered two alternative office spaces by the Sustainable Science Research Cluster in campus. The team settled for an office space 146.45 m² located on the 6th floor of the Research Management and Innovation Complex. With the green pilot office in mind as the main goal, the objectives of the pilot office were to;

i. Provide example of green office renovation
ii. Increase value of the existing building
iii. Improve the indoor environment
iv. Decrease energy consumption

With the physical aspects at hand, the team studied the environmental performance of the office space. Daylighting performance, thermal performance, acoustic quality, indoor air quality was monitored for a period of two to four weeks. The importance of measuring these aspects prior to design stage are discussed in the following paragraphs. The results of each aspect are discussed in Preliminary Data Analysis section.

a. Thermal Comfort
   The comfort conditions may vary between people. For office spaces, the thermal comfort depends on the activity of the occupants, and the clothes they are wearing (Burton, 2001). Occupant comfort also influenced by the heat gain or lost through the glass of the windows design that may increase or reduce the temperature of the room. Beside air temperature, mean radiant temperature and the neighbourhood surfaces temperature are important consideration in planning a refurbishment of an office building. For tropical hot and humid climate such as Malaysia, to create an ideal indoor thermal comfort in the office spaces while reducing energy consumption is a challenging task to building designers.

b. Daylighting
   Occupants’ well-being in day lit office buildings reported increase in general. Specific benefits in these types of office environments include better health, reduced absenteeism, increased productivity, financial savings, and preference of workers. (Edwards & Torcellini 2002). One of green office characteristic is by optimising the natural daylight and at the same time by minimising the energy consumption used for electric light. Windows opening provide a dual purpose which are admitting natural light into the indoor environment and allowing people visual contact to the outdoor environment (Li & Tsang 2008). The strategy to bring the daylight into the building is to have a huge windows opening although the use of glass window will caused an acoustic problem while justifying for daylight maximisation (Rao et al. 2012).

In the Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (Department of Standards Malaysia 2007) suggested the design of good daylighting system must follow a certain building elements such as
orientation, space organisation; glazing shape and size; internal wall, partitions and ceiling surfaces; colour contrast; protection from solar gain and glare; and windows optical, solar and thermal properties. The recommended average illuminance levels in general office area is 300 – 400 lux. (Department of Standards Malaysia 2007).

c. Acoustic Quality
Acoustic quality is important in ensuring a healthy working environment. (Burton, 2001) suggested that there are two components to address acoustic quality which are noise level and room acoustic. In design planning, designer has to make sure the noise from the outside and from the building itself does not affect the occupant comfort level. Room acoustic in office building are affected from the reverberation time and should be not more than 1 second. By installing absorb sound material; it will help to reduce the reverberation time.

Design strategy on controlling the acoustic is to reduce noise from the external and adjacent rooms; contain a specific area for internal noise; minimise the noise from mechanical system such as air-conditioning; and reduce the internal reverberation. Acoustics is one of major element in creating a workable office environment as it relates closely with human stress level, motivation and productivity (Danielsson, 2010, Veitch, 2012, Heerwagen, 2000). In office, the major acoustical concern is verbal communication. All activities in the office are dependent on speech audibility and intelligibility. The Malaysia’s first comprehensive green building rating system (GBI) is introduced for evaluating the environmental design and performance of Malaysia’s building. Indoor Environmental Quality (IEQ) is one of criteria with the purpose of “to achieve quality performance in indoor air quality, acoustics, visual and thermal comfort”. However, among the 21 score points allocated under this criteria (non-residential building category); only 1 score point is reserved for acoustic quality. It is under EQ13 – Internal Noise Level (PAM, 2009), refers Table 1.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>AREA OF ASSESSMENT</th>
<th>DETAIL POINTS</th>
<th>MAX POINTS</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQ13</td>
<td>INTERNAL NOISE LEVELS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintain internal noise levels at an appropriate level. Demonstrate that 90% of the NLA do not exceed the following ambient internal noise levels:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Within the entire baseline building general office, space noise from the building services does not exceed 40dBAeq. <strong>OR</strong></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Within the baseline building office space, the sound level does not exceed 45dBAeq for open plan and not exceed 40dBAeq for closed offices.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 1: Green building index assessment criteria of internal noise levels (PAM, 2009)*
In additional, the acoustical performance in green office buildings has become an issue. Some of literatures (Singh et al., 2010, Rao SP, 2012, Muehleisen, 2010, Jalil et al., 2013) addressed the green building design strategies might affect the acoustical performance of office spaces which have significant influence on the speech sound level, ambient background noise (BN), noise criteria (NC) and the reverberation time (RT) of the enclosure. However, in this pilot measurement, BN ($L_{Aeq}$) and NC were measured to characterize the acoustical conditions of selected rooms before design solutions (space planning and material chosen) are proposed.

\textit{d. Indoor Air Quality}

The realisation that people spend approximately 80-90\% of their lifetime indoors has raised growing concern over IAQ, which can contain pollutants at much higher concentrations than the outdoor air (Hui et al., 2006). Being aware of how much time people spend indoors has raised concerns about how IAQ can affect health in the long-term. The study of IAQ is complex due to the multiplicity of sources of contaminants. The perceived air quality cannot be determined objectively. It is defined as the immediate impression of the IAQ experienced by people entering a space. The method has been used extensively in a number of investigations (Fanger et al., 1988, Knudsen et al., 1998, Wargocki et al., 1999, Wargocki et al., 2000).

To obtain good IAQ some basic measures must be put in place, such as: ensuring adequate ventilation, proper insulation and the reduction of excess moisture production, amongst others (Essah, 2009). The effect of poor IAQ is experienced in all types of buildings that lack the basic control measures stated above. Some contaminants are not perceived by occupants and thereby do not cause complaints, but are still capable of causing various health effects that influence absenteeism, work performance, and some that include symptoms of allergies, asthma and respiratory illness (Fisk, 2000, Shendell et al., 2004, Coley and Greeves, 2004). Additionally the amount of air required to satisfy 80\% of the occupants in a space depends on the intended use of the space and the occupancy (BSI, 1991). According to Kosonen & Tan (2004) human perception of the indoor air quality can affect office task’s performance and that productivity loss is inversely proportional with air flow rate.

\section*{METHODOLOGY}

There are two main methods that were employed to run this stage of research before leading to the analysis and proposal. First is the site investigation and the second was brief development. The two are interrelated and feed information to design a green office.
Site investigation in architecture functions similarly to fieldwork in scientific research, whereby preliminary data are gathered through observation, measurements and interviews. The information collected will inform the designers the nature of the site.

Brief development stage is done after learning the site characteristics and project intentions. Interviews and discussions with the client takes place, the brief is formulated to become the roadmap for the design.

**a. Physical Field Measurements**

All data were collected and considered at the early stage, including: thermal comfort; indoor air quality and ventilation rates; daylighting; and acoustics.

**Sample rooms**

Table 2 presents data summarising the main physical characteristics of the chosen office. It includes information such as room’s length, width, height, volume and expected capacity.

<table>
<thead>
<tr>
<th>No.</th>
<th>Room ref.</th>
<th>On-site measurements</th>
<th>Calculated parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dimensions of room (m)</td>
<td>Volume (V) m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>1</td>
<td>Room A</td>
<td>11.8</td>
<td>6.954</td>
</tr>
<tr>
<td>2</td>
<td>Room B</td>
<td>9.26</td>
<td>6.954</td>
</tr>
</tbody>
</table>

**Table 2:** Summary on the physical characteristic of the rooms

To determine the effectiveness or the future planning and requirement of green office, three cases of measurements were conducted for acoustic and AIQ. Whereas two scenarios, case 1 and 3 only were used to measure thermal conditions. All measurements were done in the period of five to 15 days durations.

i. Case 1: Window Close and Air-Conditioning System OFF  
   ii. Case 2: Window Close and Air-Conditioning System ON  
   iii. Case 3: Window Open and Air-Conditioning System OFF

**Measurement procedures**

Thermal and daylighting performance of the room were evaluated by using the ONSET HOBO U12-012. The Autodesk Ecotect v5 was then used to analyse the daylighting levels. To evaluate the acoustical characteristics of the selected rooms,
the PC-based acoustic measuring system and analyser was utilised. The PC-based measuring system (dBAti) was integrated with sound level meter (01dB Solo Metravib) as analyser. To analyse the IAQ, YESair was integrated with YESdust were used to measuring the air quality of the room.

Based on shape and floor area of each the selected rooms, an adequate number of equipments and listener positions were chosen for measurement to achieve sufficient coverage of the room floor area (refer figure 1).

![Figure 1: Position of the measuring systems](image)

**b. Design Brief Development**

Considerations that were taken into account during the design stage;

i. The user’s demand are greatly importance – brief and interviewing the client

ii. The existing office building was audited to reveal problems, weaknesses and opportunities – observation

iii. Reuse or upcycling of existing materials

iv. Collaboration and sponsorships

v. Limited green material

vi. Limited Finance

vii. Time limitation

viii. Study / monitoring of office space

ix. Rating – benchmarking current space before the renovation
PRELIMINARY DATA ANALYSIS

Thermal Performances

Figure 2 shows the heat gains breakdown by hourly basis on several days on two different scenarios. Both reading indicates that temperature peaks between 5pm-7pm whereas, the lowest temperature indicates that the lowest temperatures are recorded in early morning between 3am to 7am.

Figure 2: Average day temperature levels on both scenarios – closed and open windows. Equipment used - ONSET HOBO U12-012
Summary

The average indoor temperature 29.66 Degree Celsius in open window scenario and 28.94 Degree Celsius in close window scenario in the duration of five days indicates that the office space can easily be reduced without high consumption of electricity for cooling purposes. The difference is about 4 Celsius to achieve Malaysian indoor comfort level of 25 degree Celsius. Opening the windows by automated mechanically or switching on extract fans during the early morning to induce fresh cooler air may assist in reducing the AC cooling load or end users can opt for no use of AC in between 8-9am. External shading devices can be installed to avoid heat gain through glass and retrofit double glazing.

Humidity Levels

Figure 3 depicts the measurements of RH in two scenarios obtained. Measurement of humidity is important to ensure working comfort and for the equipment life span. Recommended RH by ASHREA is between 30-60%. The space must retain RH level not to be over 70% as this may lead to development of condensation on surfaces in the interior and office equipment as well as building structure. If this is not treated, these areas may develop mould and fungi.
Figure 3: Average day humidity levels on both scenarios – closed and open windows  
Equipment used - ONSET HOBO U12-012

Summary

The average relative humidity indoor is 67.05% when windows are opened and 66.05% when windows are closed collected suggests that the RH in the room in both scenarios is slightly higher than the recommended level 40-60%. This condition can be easily reduced when air conditioning or dehumidifier are switched on.

Daylighting Performances

Figure 4: Site Orientation
**Figure 5:** Daylighting Levels on 21st June

**Figure 6:** Daylighting Levels on 21st September

**Figure 7:** Daylighting Levels on 21st December
Figure 5, 6 and 7 shows a three days daylighting analysis from 9 a.m. until 5 p.m. on 21st June, 21st September and 21st December – average daylighting levels in the office area is 300 to 600lux.

Summary

The simulation results for all three different key days shows that the room has sufficient amount of daylight throughout the working hours due to the large window to wall ratio along the external wall face South West. However, there may be glare occurring at certain time of the day that may cause discomfort for users. However, the glare is not too intense due to the filtration by the tall trees next to the building.

Acoustic Quality

It was necessary to measure the room’s BN and subsequently determine the NC rating. The 1/1 octave band setting of BN sound pressure level (dBA) was measured at five selected measurement points using sound level meter. The sound level meter was located 1.2 m above the floor. Time length every 5 sec is employed for ten minutes and a series of sound pressure levels are extracted using commercial software (dBBATI32).

For NC measurement, similar measurement was conducted with all HVAC and lighting operating. NC criteria will be referred to ANSI standard as ISO did not provide the criteria for this parameter.

Figure 8: Background noise (BN) level in Room A and B.
BN and NC results

Figure 8 depicts the BN values of Room A are mostly more than 40 dB. The results of measured BN for Case 1 are good performances which are satisfied within the recommended value. However, Case 2 and Case 3 show the maximum value of sound pressure level over than recommended but there are no significant differences in the dispersion based on the maximum dispersion being below than 1.7 dBA.

The similar basic tendencies can be observed for the Room B in Figure 8 but there are noticeable differences if the recommended value is set as equivalent to the conference room following the existing condition.

Figure 9 present the combined results measured in Room A and Room B. The NC ratings of measured BN indicate a moderately noise to noisy environment for Room A (NC-41) and Room B (NC-37). However, the preferences of NC rating are ranging between NC-30 to NC-35 based on condition in spaces such as private offices. It is should not be exceeded from NC-35 to determine the acceptable indoor environment for hearing preservation and speech communication.

Figure 9: Noise criteria (NC) for both Room A and Room B.
Summary

In this study, pilot measurements in two rooms have been performed. A series of measurement offer plausible characteristics to confirm the tendency of fair acoustical performance of Case 2 and Case 3 whereby the resulting in maximum difference with 1.7 dBA. However, some improvement and refinement in designing process need to take into consideration following the recommended values of equivalent level. Then, the investigation also revealed that the operating facilities in rooms resulting higher rating NC-41 which is reducing the performance of speech intelligibility. This phenomenon indicates the used of absorptive materials can be an effective way to improve the intelligibility of speech. Further investigations are now being pursued intensively.

Indoor Air Quality

Research has shown that, productivity will be affected if health and well-being are jeopardised by poor indoor environment. This may lead to high absenteeism, more sick leaves being taken, and lower worker efficiency (quality of work). Based on Table 4, elevated Total Volatile Organic Compound (TVOC) levels were observed in cases 1 and 2, no ventilation and using mechanical ventilation respectively. In case 3 where room is naturally ventilated, TVOC level (average of 0.28) was within acceptable guidelines established by DOSH (2010) with the threshold limit value of 0.3mg/m³. However, based on the ECA (1992) general exposure guidelines for TVOC, concentration that ranges between 0.2 – 0.3 mg/m³ gives multifactorial exposure range of irritation or discomfort possible if other exposures interact.

<table>
<thead>
<tr>
<th>Case</th>
<th>Indoor Temperature (°C)</th>
<th>RH (%)</th>
<th>CO₂ (ppm)</th>
<th>TVOC (mg/m³)</th>
<th>Particulates (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min-Max</td>
<td>Average</td>
<td>Min-Max</td>
<td>Average</td>
<td>Min-Max</td>
</tr>
<tr>
<td>Case 1</td>
<td>27.3-31.6</td>
<td>28.6</td>
<td>37-55</td>
<td>49</td>
<td>373-443</td>
</tr>
<tr>
<td>Case 2</td>
<td>18.3-20.6</td>
<td>19.20</td>
<td>58-80</td>
<td>66</td>
<td>369-455</td>
</tr>
<tr>
<td>Case 3</td>
<td>27.3-33.8</td>
<td>29.1</td>
<td>40-53</td>
<td>46</td>
<td>373-529</td>
</tr>
</tbody>
</table>

Table 4: IAQ results

Summary

In addition, in cases 1 and 2 with higher level of TVOC, a discomfort range with probable headache would occur. With regards to the thermal condition, it is also
observed that when the room is naturally ventilated, the indoor temperature swing ranges remarkably ($\approx 6^\circ$C). The level of CO$_2$ in all cases indicates that the room were unoccupied and that the source of contaminants in the office room would have come from the room paints and other materials. Since there is a high level of TVOC in the room when the air conditioning is switched on, there is also a probability that source of these contaminants were delivered from the air supply through the ducting of the AC supply cassette to the indoor environment.

**Green Design Challenges**

As proposed by (Burnett, 2007) and explained by (Burton, 2001), both agreed that spatial organisation may has an impact on occupant comfort in office building. Open plan office design is a not only a strategy to maximising the natural ventilation but it can also optimising the daylight (Rao et al. 2012).

From the results drawn from the above calculations, three green design approaches were drawn up, the first and most ideal would be a renovation that consists 80% or more recycled or green products, the second was 60% and the third was 40% recycled or green products. This strategy was devised to be open and practical for the costing and sponsorship drive purposes.

Apart of the project challenge was to also engage and collaborate with the industry that also promotes green products and technology. UMcares invited several industry players and shared their project’s aims. After three attempts, the team managed to secure a main partner – Panasonic Malaysia who will provide expert advice on electrical appliances, sponsorship of energy efficient electrical appliances and photovoltaic to the building. As UM is a public university and had its intellectual rights regulations, we had to obtain clearance and made agreement with Panasonic that all research outcomes from this project will be co-owned. The team also managed to secure two products at lower than commercial price.

After various proposals were draughted and brainstormed amongst the team members and client, the third option was selected due to the availability of funds and decision on not to discard items and finishing in the existing newly completed office to avoid wastage and maintain a lower carbon footprint for the renovation.

**Contract Documentation Challenges**

From the start, the team and UMcares knew that proposing a green procurement to UM would be a great test. This had no precedent in any projects or purchase. During the preparation of the Bill of Quantities, we are faced with the difficulties of specifying the green products and materials without mentioning the specific brands.
Furthermore, there are limited green products and suppliers available in local markets. To make it more difficult, the team had to educate and convince Department of Developments and Assets Maintenance of UM and its Quantity Surveyor to render the closest specifications to the desired products and materials. As a result, drafting the Bill of Quantities took longer than usual.

Another challenge was during the calling of tender. As the estimated project price was relatively small, the difficulties became more apparent to award the skilled and experienced contractor to renovate a green project as specified in the class of contractor to project cost by the Ministry of Finance. Having to abide to this regulation and procedure, the tender was void twice for not being able to find a suitable contractor to undertake the renovation work. Our team tried getting assistance from CIDB however; there is no specific list available for ‘green’ contractors.

Conclusions

The selected office space had not fit hundred percent of the criteria for an ideal green office space but had been the best out of the four choices. The aspect that was most attractive and provided merits was 1). The function and role of the building as a research institute, was found as an advantage to provide room for experimental renovation designs to be carried out, 2). The building had minimal car parks and most car parks are shared between three neighbouring buildings which directly contributed to low carbon footprint for the office, 3). In a low rise building, 4). In main campus grounds rather than off campus alike the two earlier choices; is seen as a plus point for greater connectivity on foot, bicycle, university shuttle buses or shorter drive to get to for the office potential users, 5). Pleasant green view towards the campus reserved greens areas. The physical disadvantages or rather challenges with the selected space were 1). Long elevation / external wall faces South West orientation (refer figure 4) 2). Narrow and empty corridor and triangular courtyard; a negative space, 3). Not visible to public at lobby or entrance level, 4). Faces rows of air conditioning compressor units from neighbouring building, 5). Low headroom, 6). Had already been tiled, painted and fixed with suspended ceiling from non-green materials.

A good office design is a building operating with natural ventilation and maximising the usage of daylight. Since office operating during the day, the main factor caused the increase of internal heat is climate. Besides that, human and machines also play a role that makes the interior temperature is not comfortable.
Since the project is a refurbishment of conventional office towards green office design, the key elements to be considered in designing the interior are lighting system, interior layout, space zoning; materials use and reuse; and windows glazing.

Referring to figure 10, the key design features in the office space are by introducing natural daylight into the interior space and minimising the electricity consumption. Most office buildings in Malaysia have major glazed facades. Therefore, the workplace shall be located along the building perimeter to encourage the full use of daylight and good views. The secondary function spaces shall be located at the core or less daylighted areas.

![Diagram of the proposed interior design layout](image)

**Figure 10:** The proposed interior design layout

The designs opened up walls internal wall and change the plywood glass doors to create visual link to the inactive narrow corridor and this will borrow daylight available at from the triangle atrium courtyard. To improve the office social space quality, the wall facing the lift is hacked to also create connectivity with the corridor and a green wall is proposed to create a fresh look to a dull wall whilst providing educational information of indoor plants.

The wall will be sealed and repainted with low VOC paint. Plants were also used to improve the air quality levels of the room. Where possible the furniture and finishing
specified are from forest stewardship programme or recycled wood and other green materials.

**Future challenges**

This design project will continue to be developed and improvements are made in phases. The immediate challenges that need to be tackled are;

i. Retrofit the existing window with Low-E character

ii. Design and install effective solar shading

iii. Seal leaky windows

iv. To find the appropriate rating tool rating to suit refurbishment projects

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