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GREEN POTENTIAL RATING TOOL: AN ASSESSMENT OF GREEN POTENTIAL FOR CONVENTIONAL BUILDINGS

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Abstract

Assessment of the green potentials in a conventional building is rarely discussed in past literature unlike other types of assessments, such as a building's current performance and qualities. 'Green potential' is the capacity of a conventional building to be refurbished into a green building. This paper presents the development of a rating tool to assess green potentials of existing conventional buildings. The development process involves reviewing relevant literature on the existing assessment tools. The review focuses on identifying methods and indicators that can be adopted for the assessment of green potentials. It is discovered that while literature on green potential assessment is limited, the frameworks of other types of assessments concerning green buildings are still suitable to be adopted. Additionally, with some modifications, commercial green building rating tools provide the most suitable indicators to assess green potentials. Apart from filling the knowledge gap, the tool developed may also assist building managers strategize towards achieving sustainability for large building stocks such as a small township or a university campus.

Key words: assessment indicators, energy performance, green building assessment, rating tool development, user perception

Introduction

The awareness on issues of sustainability which started nearly four decades ago has induced the birth of green buildings around the globe. With the increasing number of green buildings, studies in the recent decades have begun discussing and inventing new methods to assess green buildings' performances. In the early 1990s, Building Research Establishment (BRE), UK pioneered the development of Building Research Establishment Environmental Assessment Methodology (BREEAM) to assess and certify these green buildings (Larsson & Cole, 2001). BREEAM was developed and implemented successfully and has influenced other regions to formulate their own green building rating tools (GBRT) (Cole, 2005). It has been reported that more than 600 tools concerning the environment have been developed since BREEAM (Building Research Establishment, UK, as cited in Reed, Bilos, Wilkinson, & Schulte, 2009). Out of the 600 tools, more than twenty tools have been developed worldwide concerning green or sustainable buildings. Adjustments were made to the primary tools to suit the local environment and culture (Darus et al., 2009; Zuo & Zhao, 2014).

BREEAM, and many other GBRTs, are not mere conceptual tools. They are also adopted into practice and have been utilised either commercially or authoritatively in many countries (Baldwin, Yates & Howard, as cited in Banani, Vahdati, & Elmualim, 2013). Examples of these GBRTs include Leadership in Energy and Environmental Design (LEED) for the USA, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) for Japan, Green Globes for Canada, Green Star for Australia and Green Mark for Singapore.

Conveniently, Malaysia too, has developed a GBRT that does not vary much with tools from other countries. Concerned with the detrimental effect that follows rapid physical development, Malaysia embarked on devising its own GBRT, the Green Building Index (GBI) which was derived from Singapore's Green Mark and Australia's Green Star (Greenbuildingindex Sdn. Bhd., 2011). Prior to the launch of GBI in 2009 (Greenbuildingindex Sdn. Bhd., 2013), no rating was given on the buildings that were designed, constructed, or operated sustainably (Darus et al., 2009). The absence of an 'elite label' or gaining factor for moving towards green or sustainable buildings caused building developers to deter from the green building initiatives. To boost more sustainable developments, the government, together with professional bodies had devised GBI as an incentive to attract developers to integrate sustainability into the construction industry and real estate. Credits and special certifications are awarded to green buildings as recognitions of sustainable design, construction and lifestyle (Yusoff & Wen, 2014). In addition to ascertaining the level of sustainability of a particular building, the GBRT also act as an incentive for added value to property owners.

These GBRTs help ascertain a building's level of sustainability through green certification. The green certification is awarded to newly built buildings that comply with a predetermined set of criteria, which consist of indicators such as, energy efficiency, sustainable material and resources, and indoor environmental qualities (IEQ). GBRTs are easy to implement on new buildings, consequently there were concerns of the implementation on existing buildings. These concerns have brought scholars and stakeholders to explore the potentials for green refurbishment on existing buildings (Burton & Kesidou, 2005; Chileshe, Khatib, & Farah, 2013; Durmus-Pedini & Ashuri, 2010; Juan, Gao, & Wang, 2010; Ma, Cooper, Daly, & Ledo, 2012). Some of them even discussed specific strategies that respond to specific green certification criteria (Friedman, Becker, & Erell, 2014; Rysanek & Choudhary, 2013; Shika, Sapri, Jibril, Sipan, & Abdullah, 2012; Zakaria, Foo, Mohammad Zin, Yang, & Zolfagharian, 2012). These past researches only suggested strategies to convert conventional buildings into green buildings. For example, Rysanek and Choudhary (2013) listed strategies that can reduce energy consumption during building refurbishment. They also discussed decision-making methods on how to determine which strategy is best under certain conditions. While Rysanek and Choudhary (2013) focused only on energy reduction, Zakaria et al. (2012) offered and ranked strategies for green refurbishments by tackling not only energy reduction, they also addressed other indicators, namely; sustainable material selections and IEQ improvements. These strategies are proven effective in commissioning green refurbishment for individual buildings and treated in isolation (Konstantinou & Knaack, 2013). In spite of these past researches, studies on the implementation of these refurbishment strategies on large building stocks are still limited.

For parcels with large building stocks, such as a small township and a university campus, the assessment of green potentials, may provide solutions in the implementation of refurbishment strategies on large building stocks. Unlike other concepts of assessment, green potential assessment is rarely discussed in past literatures. Therefore, this paper presents the development of a conceptual framework for prioritising buildings that will be refurbished through assessing their green potentials. This study also discusses the concept of assessing green potentials in depth by reviewing relevant assessment tools.

Green Buildings

Prior to discussing about assessing a building's potentials on becoming a green building, it is important to define the scope of a 'green building'. The word 'green' has become popular to describe activities that have positive impact on the environment; including green buildings (Olanrewaju, 2011). Green buildings are defined as buildings that are designed to reduce impact on users and on the natural environment (Zigenfus, 2008). In general, a green building uses resources efficiently and at the same time creates healthy environment for its users. While Edwards (2011)concluded that the term 'green building' was not much used in its previous years,Berardi (2013) identified that the term was supplanted with 'sustainable buildings' or 'low-energy buildings' to better reflect the buildings' specific and long-term contribution to the environment. Based on the definitions postulated by Zigenfus (2008), Edwards (2011) and Berardi (2013), the term 'green building' will be used for this paper. 'Green building' is more appropriate as the discussion is limited to refurbishing conventional buildings into a building that only focuses on the impact to users and its immediate environment. This paper will not discuss long term impact and financial implications towards these types of buildings.

Assessing Green Potential in Existing Buildings for Green Refurbishment

Generally, green refurbishments are implemented on small and single projects such as office floors or residential homes (ACF, 2009; Wall & Shea, 2013). While these modest efforts are plausible, green refurbishments of large building stocks can provide more promising impacts on reducing carbon footprints. Green refurbishment is preferable over construction of new green buildings with the understanding that the benefits from the latter will be subdued and outnumbered by the large number of pre-existing conventional buildings (Durmus-Pedini & Ashuri, 2010). Green refurbishment is also favourable as it creates opportunities to incorporate sustainable strategies with other building improvements (Mickaityte, Zavadskas, Kaklauskas, & Tupenaite, 2008; Santamouris & Dascalaki, 2002). This way, the benefits from a green refurbishment is twofold.

Although the benefits are unquestionable, executing green refurbishment on a large scale building stock instantaneously is unrealistic and uneconomical (Olanrewaju, 2011). The volume of buildings to undertake, financial inadequacy and space constraints, are possible factors that may hamper the implementation of simultaneous green refurbishment. Refurbishment projects are best executed in phases and should be prioritised according to each building's potential on becoming a green building, also known as 'green potential' (Ben Avraham & Capeluto, 2011). This planning strategy is similar to planners' strategy of demarcating zones for deteriorated buildings in an urban context. The strategy to prioritise according to green potential is realistic and ensures successful implementation of green refurbishment throughout the entire building stock. Thus, it is necessary to develop a green potential rating tool to assess a scenario where one developer or building owner has a large building stock.

In order to carry out green refurbishment, green potential assessment is employed prior to any other stages, as illustrated in Figure 1. This is because assessing the green potential of each building in a building stock assists decision makers in prioritising buildings to be refurbished. The assessment ranks buildings from the highest to the lowest green potential. The building with the highest green potential signifies that less effort is needed to convert it into a green building compared with the building with the lowest green potential.

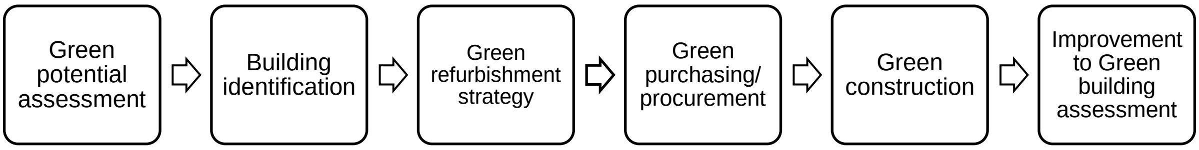

Figure 1: Green refurbishment milestone

Assessment of green potential is a fairly new concept in the building assessment industry. Ben Avraham and Capeluto (2011), who were, to the authors' knowledge, the pioneering users of the term 'green potential', took another step from just assessing the sustainability of an existing building to developing a tool to assess its green potential. The tool was developed based on Israel Green Buildings Standard SI 5281. The team tested the tool on buildings that were built in the 50's and 60's when air-conditioners were not used comprehensively and on buildings that were built more recently with glass facades. They analysed points scored by each building and tallied the scores comparatively.

The scores depicted the degree of flexibility of refurbishing the buildings using Israel Green Buildings Standard SI 5281 as the benchmark. Ben Avraham and Capeluto (2011) devised a visual coloured scorecard that is easy to interpret. Reds on the scorecard denotes lower potential while greens denote higher potential. While the tool developed was very useful and practical, the assessment was too subjective and was not evidence-based. Granted, they have intended that the tool can quickly evaluate the building's green potential without having to collect any data.

The team also saw the potential of this tool as, first, to identify a building's potentials so that it can be certified as a green building after refurbishment; and second, as a planning tool for sustainability zones for a building stock. For the latter, they envisioned that if the tool is used in an urban scale, it could be used to demarcate the zones of different levels of green potential in an urban area.

The idea proposed in the study by Ben Avraham and Capeluto (2011) formed the foundation of this paper that adopts their concept and applies it to the assessment of green potentials in an urban scale. The concept is very useful to large building stocks.

Overview of Assessment Tools

'Assessment' is defined as a diagnostic process that measures a subject's performance using a specific 'tool' in the form of instruments and procedures (John, 2011). For the purpose of this study, firstly, a very general search on assessment tools was done. The aim was to gather the types of tools available and to understand their developments in general. A broad range of tools were observed, including worker's productivity assessments and student's performance assessments alongside building performance assessments. As defined earlier in this section, all assessment tools are similar where they each measure performance, but, the subjects measured are different.

Through the first general review, it was also discovered that terms ‘assessment’ tool and ‘rating’ tool are used inter-changeably when describing tools to measure subject performance. The two terms are somewhat different as defined by Ding (2008). He describes ‘rating’ tool as a tool to ascertain the performance of a building through grades or stars, while ‘assessment’ tool provides detailed measurable indicators of the subject’s actual performance. For this study, a ‘rating’ tool is the proposed outcome. A grading system proves to be a simpler and quicker method of assessment to meet the objective of this study.

The authors also stumbled upon guidelines for the development of this form of tool. In a guideline by Davis and Morrow (2004), they suggested that a rating tool should be managed step by step. This is done to ensure that the objective of the tool is met without losing focus. Generally, four common steps are found in all the guidelines reviewed. They are, 1) determine, 2) design, 3) develop and 4) review (Davis & Morrow, 2004; Department of Education Employment and Workplace Relations, 2012; Education Research Centre of Victoria University, 2009; John, 2011). These steps are shown in Figure 2, which provided a methodical procedure towards the objective of the rating tool.

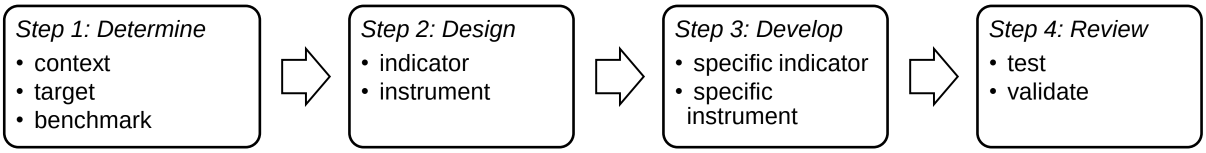

Figure 2: Four steps to develop an assessment tool

In the context of the built environment, a rating tool provides a systematic method to collect evidence to assess a building’s performance. The key objective of the proposed rating tool is to assess and rate the green potential of buildings in a large building stock and subsequently compare their scores against each other. Similar to other rating tools, information obtained from the assessment assists the decision making process (Bourdic & Salat, 2012). Ultimately, the proposed outcome, the Green Potential Rating Tool (GPRT) will rank buildings assessed according to their green potentials which, in turn, will provide suggestions to building owners for them to make informed decisions in prioritising which buildings are to be refurbished.

Development of the Green Potential Assessment Tool

Step 1: Determine context, target and benchmark

This study adopts the four steps mentioned in earlier section as the basis to develop the GPRT. Step 1 requires that the study determines the context, target and benchmark of the GPRT. In the context of a large building stock, conventional buildings are identified as targets to be assessed while green buildings are set to be the benchmark for the tool.

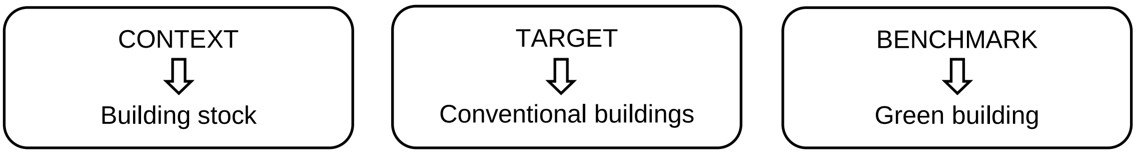

Figure 3: Subjects of Green Potential Rating Tool (GPRT)

Setting ‘green building’ as the benchmark had caused the proposed GPRT to have some similarities in terms of indicators and ultimate aim with GBRT. While both tools aim to assess green qualities in a building, GBRT is an entirely different tool from GPRT. Table 1 compares both tools. The most important comparison is that GBRT assessments are done *after* the green building is completed and, ready to be certified as a green building. Meanwhile, GPRT is an assessment that is done *prior* to the refurbishment of a conventional building into a green building. In addition, the objective of both tools is also dissimilar. The GBRT informs the assessor on the ‘greenness’ of a building, while; GPRT ascertains how far along is a building from being a green building.

Table 1: Comparison between green building rating tool and GPRT

GBRT	GPRT
• Assessed AFTER the building is completed	• Assessed BEFORE the refurbishment is done
• To assess how 'green' a building is	• To assess how 'green' a building could be
• To assess actual performance (Xu, 2012)	• To rank buildings according to green potential
• For green certification	• For selection of buildings to refurbish
• To assess individual buildings, often designed to be 'green'	• To compare between two or more buildings

Step 2: Design indicator and instrument

Next, Step 2 requires a more complex exercise where suitable indicators and instruments should be designed. A list of indicators and instruments were established via a more filtered review of the literature. While the first review of literature were very broad, the second review focused only on assessment and rating tools that are specific to: 1) building performance, 2) measure sustainability and 3) practiced in the building construction industry. Since the benchmark set for the GPRT is 'green building', the study was compelled to review and adopt the existing rating tools for green building that are practiced locally in Malaysia. The criteria had refined the wide range of literature into nearly twenty tools in total. However, only seven were taken into account for prevalent mention in literature and its close proximity to the study context. They are, BREEAM, LEED, CASBEE, Green Globes, Green Star, Green Mark, and GBI.

In the GBRTs reviewed, the level of sustainability of a completed building is ascertained through a scoring system provided by each GBRT. By allocating points from a list of indicators, a building's score will be referred to a predetermined band for rating. Each of the GBRT provided a different scoring structure and rating band. Interestingly, these scoring structures and rating bands do not vary much from each other. Perhaps, the small variation is due to the fact that all GBRTs were largely developed based on either BREEAM or LEED (Reed et al., 2009). Depending on the priority and focus of the country, each of the GBRT differs only from the indicators outlined and their scoring allocation.

Table 2 presents a summary of indicators to illustrate the differences between the two GBRTs by Malaysia and Singapore and five other main global GBRTs. The table shows that energy efficiency, material and resources, indoor environment quality, site planning, water efficiency and, design and innovation are the most commonly used indicators for green building assessments.

Table 2: Summary of indicator listed in green building rating tools worldwide

	BREEAM	LEED	CASBEE	Green Globes	Green Star	Green Mark	GBI	Total
Country of origin	UK	USA	Japan	Canada	Australia	Singapore	Malaysia	
Energy efficiency	/	/	/	/	/	/	/	7
Material & resources	/	/	/	/	/	/	/	7
Indoor env. quality (IEQ)	/	/	/	/	/	/	/	7
Site planning	/	/	/		/	/	/	6
Water efficiency	/	/		/	/	/	/	6
Design & innovation	/	/			/	/	/	5
Emissions and effluents	/			/	/			3
Management	/			/			/	3
Transport	/				/			2
Awareness & education		/						1

To further relate to the objective of GPRT, which is developed in Malaysia, the indicators from GBI for non-residential existing building (NREB) are adopted. GBI for NREB is most suitable because the proposed GPRT seeks the local green certification, which is GBI; and the indicators are suitable for existing buildings. Table 3 lists the indicators according to six categories. The table reveals that point allocation is not equal for each indicator. This signifies that some indicators carry more weight than others.

Table 3: Indicator and sub-indicator of GBI non-residential existing building (NREB)

Indicator	Sub-indicator	Points	Total
Energy efficiency	Minimum EE Performance	2	38
	Lighting Zoning	3	
	Electrical Sub-metering	2	
	Renewable Energy	5	
	Advanced or Improved EE Performance - BEI	15	
	Enhanced or Re-commissioning	4	
	On-going Post Occupancy Commissioning	2	
	EE Monitoring & Improvement	2	
	Sustainable Maintenance	3	
Indoor environmental quality	Minimum IAQ Performance	1	21
	Environmental Tobacco Smoke (ETS) Control	1	
	Carbon Dioxide Monitoring and Control	1	
	Indoor Air Pollutants	2	
	Mould Prevention	1	
	Thermal Comfort: Design & Controllability of Systems	2	
	Air Change Effectiveness	1	
	Daylighting	2	
	Daylight Glare Control	1	
	Electric Lighting Levels	1	
	High Frequency Ballasts	1	
	External Views	2	
	Internal Noise Levels	1	
	IAQ Before & During Occupancy	2	
	Post Occupancy Comfort Survey: Verification	2	
Sustainable Site Planning & Management	GBI Rated Design & Construction	1	10
	Building Exterior Management	1	
	Integrated Pest Management, Erosion Control & Landscape Management	1	
	Green Vehicle Priority - Low Emitting & Fuel Efficient Vehicles	1	
	Parking Capacity	1	
	Greenery & Roof	4	
	Building User Manual	1	
Material & resources	Materials Reuse and Selection	1	9
	Recycled Content Materials	1	
	Sustainable Timber	1	
	Sustainable Purchasing Policy	1	
	Storage, Collection & Disposal of Recyclables	3	
	Refrigerants & Clean Agents	2	
Water efficiency	Rainwater harvesting	3	12
	Water recycling	2	
	Water efficient - irrigation/landscaping	2	
	Water efficient fittings	3	
	Metering & Leak Detection System	2	
Design & innovation	Innovation & Environmental Initiatives	9	10
	Green Building Index Facilitator	1	
	Total		100

Step 3: Develop specific indicator and specific instrument

Theoretically, this research improvises on Ben Avraham and Capeluto (2011)'s rating tool which only covers physical characteristics of the buildings assessed. This was mainly because it was developed based on the guidelines of GB certification authority in Israel, which gives little attention to the social values of a green building. Ben Avraham and Capeluto only assessed physical characteristics of their sample buildings. Although the buildings sampled are all existing conventional buildings that were completed and occupied since decades ago, the team did not take advantage of the building users' perceptions of the indoor environment qualities and several other important indicators. This study improved social factors by conducting an end-users' perceptions survey. Many GBRT incorporate users perceptions under the Indoor Environmental Quality (IEQ) indicator as measurement to rate sustainability in buildings. Therefore, the proposed GPRT intend to maintain users' perceptions of IEQ as one of its indicators.

However, not all indicators found in GBRTs are suitable to rate green potentials. GBRTs are used to rate buildings that are already designed and built according to green building certification criteria (Xu, Chan, & Qian, 2012). As a result, most data used to rate the buildings are prepared during construction and are readily available during assessment for certification. In contrast, the GPRT aims at assessing the potential of a building prior from being refurbished into a green building. Many of the indicators from GBI as listed in Table 3 are unquantifiable because they have not been implemented in the existing building (i.e. lighting zoning, renewable energy etc.). Conventional buildings are often designed without considerations for sustainable qualities.

Furthermore, the GPRT is intended to be a simple tool for building managers to determine which building needs to be refurbished first. An extensive checklist of indicators may defeat the original purpose of the tool. Some of the indicators may also be challenging to measure due to limitations to obtain information (i.e. recycled content materials, sustainable purchasing policy etc.).Therefore, it is crucial to scrutinize each indicator for adoption and modification so that the collection of evidence is kept feasible and measurable.

Based on the review of GBRTs shown in Table 2, the research scrutinises each indicators with focus to achieve the objective of the study. This study has selected mainly indicators from GBRT that can be measured quantitatively to be used for GPRT. The same strategy was used by El shenawy and Zmeureanu (2013) who developed an assessment method using only one indicator, which is the energy consumption. By only adopting one measureable indicator, El shenawy and Zmeureanu (2013) ensured that the assessment became a quantitative tool rather than qualitative. Compared to quantitative qualities, qualitative indicators are rather difficult and subjective to assess. For this research, the GBI sub-indicators are simplified to be more feasible and measurable as shown in Table 4. Except for the pre-existing passive design elements, which will still require subjective evaluations, all proposed sub-indicators listed in Table 4 are now quantifiable and measurable using specific instruments.

Table 4: Proposed modified GPRT sub-indicator (by author)

Indicator	GBI Sub-indicator	GPRT Sub-indicator (Modified)	Instrument
Energy efficiency	Advanced or Improved EE Performance - BEI	calculation of BEI	power logger
	EE Monitoring & Improvement	electricity consumption monitoring	power logger
Indoor environmental quality	Thermal Comfort: Design & Controllability of Systems	Thermal comfort: user satisfaction	occupant survey
	Thermal Comfort: Design & Controllability of Systems	Thermal comfort: user controllability	occupant survey
	Daylighting	Visual comfort: user satisfaction (natural)	occupant survey
	Daylight Glare Control	Visual comfort: user controllability (natural)	occupant survey
	Electric Lighting Levels	Visual comfort: user satisfaction (artificial)	occupant survey
	Electric Lighting Levels	Visual comfort: user controllability (artificial)	occupant survey
	External Views	Visual comfort: user satisfaction (external view)	occupant survey
	Internal Noise Levels	Acoustic comfort: user satisfaction	occupant survey
	Internal Noise Levels	Acoustic comfort: user controllability	occupant survey
	IAQ Before & During Occupancy	Indoor Air Quality: user satisfaction	occupant survey
	Post Occupancy Comfort Survey: Verification	Overall comfort: user satisfaction	occupant survey
Sustainable Site Planning & Management	Parking Capacity	parking provision per occupancy	observation

Water efficiency	Metering & Leak Detection System	water consumption monitoring	water meter
	Metering & Leak Detection System	calculation of water consumption per occupancy	water meter
Design & innovation	Innovation & Environmental Initiatives	Pre-existing passive design elements	observation

The proposed instruments to be utilised for the assessment are power and energy data loggers and occupant surveys. The two methods have been presented in numerous studies as the best instruments to measure the respective indicators (Alajmi, 2012; Building Use Studies, 2011; Frontczak, Andersen, & Wargocki, 2012; Oladiran, 2013). The power and energy data loggers will measure the real-time electricity consumption of the building against time. The data obtained from the loggers will also allow the estimation of the building's energy performance. A building's energy performance are commonly used to determine the buildings energy consumption against its building size for the purpose of comparison (Abdul-Rahman, Wang, & Kho, 2011; Altan, Douglas, & Kim, 2014). Evaluating energy consumption alone is unable to determine whether the building over-consumes or under-consumes energy. Energy consumption has to be analysed relative to its building size. Calculating the energy consumption over building size is known as building energy index (BEI) or sometimes as energy utilisation index (EUI) (Bishop, 2012; GreenTech Malaysia & SEDA, 2013; Moghimi, Lim, Mat, Zaharim, & Sopian, 2011). BEI is calculated simply by dividing the total annual energy consumption of the building (kWh/year) with its total occupied floor area (m2) as follows:

$$BEI(kWh/m^2/year) = \frac{\sum annualenergyconsumption(kWh/year)}{\sum netfloorarea(m^2)}$$

The occupant survey will be used to measure the second part of the indicators (indoor environmental quality) that involves user's comfort and satisfaction of the building they are currently occupying. Although there are countless equipment available to measure these set of indicators (i.e. temperature, lighting, humidity etc.) based on literature (Baird & Penwell, 2012; Zuo & Zhao, 2014), the authors are determined that seeking users' perception of these indicators are more meaningful. This notion is supported by a study by Baird and Penwell (2012) where the study discovered that involving the users in the early stage of design produces a better building for the users.

Part three of the indicators only requires a simple observation of the parking capacity. In an existing development, the number of parking lots observed should not be more than required by the local authorities (Greenbuildingindex Sdn. Bhd., 2011).

Next, water consumption can be obtained simply by attaching data logging equipment to the water meter. Similar to the power and energy logger, the equipment allows monitoring of real-time consumption against time. Depending on the type of building assessed, water consumption may differ substantially from one building to the other. For example, for an academic building such as most found in the university campus, water consumption is not as crucial as compared to student accommodation buildings, which consume water almost as high as the electricity consumption.

The final indicator is the only indicator that is not measurable quantitatively. Design features that have been recognised by literature to be 'green' or sustainable will be compared. This part of the assessment requires subjective evaluation. However, to ensure that the evaluation is done methodically, lists of identifiable features were developed as shown in Table 5.

Table 5: Example of design feature notes of building assessed (by author)

Name of Building	X
Building facade	Recessed openings/curtain walling/small openings/grilled opening
Building Form	Square/oblong/slim
Building Orientation	North-south facing/East-west facing
Roof Properties	Flat/pitched/concrete/clay-tiled
Glazing Properties	Tinted/double-glazed/laminated/E-glass
External Wall Properties	Metal-cladded/Plaster & paint/brick wall/timber wall
Internal Wall Properties	Plaster & paint/gypsum partitions/brick wall
Ventilation Type	Mechanical cooling/split-unit/air-cooled/chill water-cooled/natural

Internal spaces	Along perimeter/centre of building/open plan
Lobby	Open/enclosed/along external wall/centre of building
Walkway/ corridor	Open/enclosed/along external wall/centre of building
Staircase	Open/enclosed/along external wall/centre of building
Toilet	Open/enclosed/along external wall/centre of building
Observations and comments	Renovation on-going/occupant behaviour

It is important to note, that when comparing a group of buildings, the assessor must ensure that the buildings are similar in functions (Altan et al., 2014). The functions of the building will determine its electricity and water consumptions. For example, the electricity consumptions of a laboratory building will definitely be higher than a building full of lecture rooms that only operate ten hours daily. Comparing the BEI for a lab building and lecture building will beinaccurate and misleading. Therefore, determining the type of building function is crucial for this assessment.

Upon selecting the buildings to compare, a simple tally system is adopted. First, indicators for each building are measured and collected independently. Then, the measurements for each building are tabulated side by side according to the indicators. For each indicator, the buildings are ranked from first to n^{th} depending of the total of number of buildings compared. The buildings are ranked based on the benchmark set for each indicator. Finally, the rank is tallied at the bottom of the table according to building. The building with the least tally has the highest green potential, while the building with the most tally has the lowest green potential. An example is demonstrated inTable 6. As demonstrated, building A possesses highest green potential compared to building B and C with the total point of 24 against 40 and 35 respectively. This means, Building A should be refurbished first, then Building C, while Building B will be last since it needs a lot of work to refurbish into a green building. Similar tallying system applies to any number of buildings assessed.

The scoring method demonstrated above is the best method and simplest for assessment between small number of buildings. For large number of buildings, the GPRT scoring bands can be applied, where the total points obtained by each building is classified into the degree of its potential. Similar to GBI, where it classifies points 86 and above into Platinum label, 76 to 85 points into Gold, 66 to 75 into Silver and 50 to 65 into Certified. For the GPRT, score band is labelled as “Very high potential”, “High potential”, “Low potential”, “Very low potential” and “No potential”. This scoring method is useful to assess larger number of buildings, say more than ten. However, the scoring band changes according to the number of buildings assessed. Where the total number of building assessed is N, the formula used to determine the band is:

$$Veryhighpotential = N$$

$$Highpotential = (N\ x\ 17)/4$$

$$Lowpotential = (N\ x\ 17)/3$$

$$Verylowpotential = (N\ x\ 17)/2$$

$$Nopotential = Nx\ 17$$

Table 6: Demonstration of tallying the score for green potential assessment

Indicator	Sub-indicator (GPRT)	Unit	Benchmark	Building A	Rank A	Building B	Rank B	Building C	Rank C
Energy efficiency	Calculation of BEI	kWh/year/m^2	lower is better	39.83	1	78.59	3	76.71	2
	Electricity consumption monitoring	Max peak kWh	lower is better	18.72	1	52.88	3	46.87	2
Indoor environmental quality	Thermal comfort : user satisfaction	Mean score	higher is better	5.43	2	4.98	3	5.99	1
	Thermal comfort : user controllability		higher is better	5.78	1	3.99	3	5.23	2
	Visual comfort: user satisfaction (natural)		higher is better	5.55	1	5.17	2	5.17	2
	Visual comfort: user controllability (natural)		higher is better	4.98	2	5.33	1	5.33	1
	Visual comfort: user satisfaction (artificial)		higher is better	3.99	3	5.78	2	5.89	1
	Visual comfort: user controllability (artificial)		higher is better	5.17	3	5.55	2	5.99	1
	Visual comfort: user satisfaction (view)		higher is better	5.33	1	4.98	3	5.23	2
	Acoustic comfort: user satisfaction		higher is better	5.89	1	3.99	3	5.78	2
	Acoustic comfort: user controllability		higher is better	5.99	1	5.33	2	4.98	3
	Indoor Air Quality : user satisfaction		higher is better	5.23	2	5.78	1	3.99	3
	Overall comfort : user satisfaction		higher is better	5.67	1	5.23	2	5.17	3
Sustainable Site Planning & Management	Parking provision per occupancy	nos	lower is better	0.45	1	1.01	3	0.99	2
Water efficiency	Water consumption monitoring	m^3/month	lower is better	1134	1	2356	3	1979	2
	Calculation of water consumption per occupancy	m^3/pax/day	lower is better	0.37	1	1.45	2	1.89	3
Design & innovation	Pre-existing passive design elements	NA	higher is better	-	1	-	2	-	3
				TOTAL	24		40		35

Step 4: Review, test and validate

Like any other assessment tools, the validation process is important to confirm that the tool has assessed the targets appropriately and the instruments used have addressed all the evidences accurately. The validation process also tests the applicability of the tool for the intended context. However, this paper will not discuss the final stage of the GPRT development as it involves testing the GPRT that has been developed on case studies through collections of evidences.

Conclusion

To summarize, this review of the existing assessment tools namely, GBRTs and the narratives of the development of the GPRT have shown how green potential assessment can contribute towards ensuring sustainability in large building stocks. The green potential rating tool ensures that it is achievable not only in theory but also in practical. The green potential rating tool is developed by modifying the indicators of the existing green building rating tools due to lack of existing tools for green potentials. The next step of the research is to test the GPRT on selected conventional buildings in a large building stock such as a small township or a university campus. The test is conducted to evaluate the workability of the tool for assessing green potential. The tool is sufficient as a simple method to assess green potential. However, it can be improved by validating the proposed indicators and scoring system through expert opinions and insights. It would be an evolution from the current and previous research. Apart from filling the gap in knowledge, these findings will also assist policy makers, building owners, developers, planners and other stakeholders to strategize their efforts efficiently towards achieving sustainability.

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