# A STRUCTURED CRITICAL SUCCESS FACTORS MODEL FOR THE IMPLEMENTATION OF GREEN RETROFIT PROJECTS

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***Specially dedicated to my beloved father, mother and brothers***

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# ABSTRACT

Existing buildings contribute to half of all annual energy and greenhouse gas emissions. Green retrofit has been the latest value added service under the facility management field to mitigate climate change caused by greenhouse gas emission. Yet, green retrofit implementation is not widely practiced by existing building stakeholders due to lack of participation and cooperation among them. Among the issues of green retrofit are high upfront costs and uncertain return, lack of green building professionals, lack of financial incentives, knowledge gap in green development quantification, lack of green awareness, lack of communication among the stakeholders, lack of internal leadership and lack of green materials and technology. These factors contribute to the failure of green retrofit projects' implementation. Thus, the aim of this research is to identify the critical success factors (CSFs) of green retrofit projects' implementation. The specific objectives of this research are: to identify the CSFs of green retrofit; to evaluate the criticality and ranking of CSFs of green retrofit; and to develop structural model for the CSFs of green retrofit. The research methodology adopted to achieve the aim of this research is quantitative method using a survey based approach consisting of three steps namely literature review, experts' opinions and questionnaire survey. Based on literature review, eight CSFs with thirty three indicators of green retrofit implementation were identified. Experts' opinions were sought to validate the identified CSFs and to develop relationships among the CSFs using an Interpretive Structural Modelling (ISM). Questionnaire survey was conducted to empirically confirm the ISM-Based Model using Structural Equation Modelling (SEM). The final model consists of eight CSFs with twenty seven indicators with CSF 1 (green building professionals) and CSF 5 (internal leadership) being the major drivers for the success of the green retrofit projects implementation.

# ABSTRAK

Bangunan sedia ada menyumbang kepada separuh daripada jumlah pelepasan gas rumah hijau. Pengubahsuaian hijau merupakan nilai tambah terkini di bawah bidang pengurusan fasiliti untuk mengurangkan perubahan iklim yang disebabkan oleh pelepasan gas rumah hijau. Namun, pelaksanaan pengubahsuaian hijau tidak diamalkan secara meluas oleh pihak berkepentingan bangunan sedia ada disebabkan oleh kekurangan penyertaan dan kerjasama di kalangan mereka. Antara isu-isu utama pengubahsuaian hijau ialah kos yang tinggi dan pulangan yang tidak menentu, kekurangan profesional bangunan hijau, kekurangan insentif kewangan, kekurangan kesedaran hijau, kekurangan komunikasi di antara pihak-pihak berkepentingan, kekurangan kepimpinan dalaman dan kekurangan bahan-bahan dan teknologi hijau. Faktor-faktor ini menyumbang kepada kegagalan pelaksanaan projek pengubahsuaian hijau. Maka tujuan kajian ini adalah untuk mengenalpasti faktor-faktor kejayaan kritikal (FKK) bagi pelaksanaan projek pengubahsuaian hijau. Objektif-objektif khusus kajian ini adalah: mengenalpasti FKK untuk pengubahsuaian hijau; menilai tahap kritikal and kedudukan FKK untuk pengubahsuaian hijau; dan membangunkan struktur model bagi FKK untuk pengubahsuaian hijau. Kaedah penyelidikan yang digunapakai untuk mencapai tujuan kajian ini adalah berdasarkan kaedah kuantitatif menggunakan pendekatan kajian soalselidik yang terdiri daripada tiga peringkat iaitu kajian literatur, pendapat pakar dan kajian soal selidik. Berdasarkan kajian literatur, lapan FKK dengan tiga puluh tiga indikator pelaksanaan pengubahsuaian hijau telah dikenalpasti. Pandangan pakar telah dirujuk untuk mengesahkan FKK yang dikenalpasti dan membangunkan hubungan antara FKK dengan menggunakan kaedah permodelan tafsiran struktur (ISM). Kajian soal selidik dijalankan untuk mengesahkan secara empirikal Model Berasaskan ISM dengan menggunakan kaedah permodelan persamaan struktur (SEM). Model akhir terdiri daripada lapan FKK dengan dua puluh tujuh indikator dengan CSF 1 (profesional bangunan hijau) dan CSF 5 (kepimpinan dalaman) sebagai pendorong-pendorong utama kepada kejayaan pelaksanaan projek pengubahsuaian hijau.

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| | | |
|---|---|---|
| BEER | - | Building Energy Efficiency Retrofit |
| CB-SEM | - | Covariance Based Structural Equation Modeling |
| CSF | - | Critical Success Factors |
| DFD | - | Data Flow Diagram |
| FM | - | Facility Management |
| GBI | - | Green Building Index |
| IFMA | - | International Facility Management Association |
| ISM | - | Interpretive Structural Modeling |
| PLS-SEM | - | Partial Least Square Structural Equation Modeling |
| SEM | - | Structural Equation Modeling |
| SPSS | - | Statistical Package of Social Science |
| SSIM | - | Structural Self-Interaction Matrix |
| VIF | - | Variance Inflation Factor |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Facilities management (FM) is a term that covers a wide range of activities comprised in the effective management of built assets. Alexander (2003) acknowledged facilities management as a process by which an organization delivers and sustains support services in quality environment to meet strategic needs. Yet, the International Facility Management Association (IFMA) defines facilities management as a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, processes and technology. Generally, facility management is an umbrella term under which, a wide range of property and user related functions may be brought together for the benefit of the organization and its employees as a whole (Amaratunga, Baldry, & Sarshar, 2000). It involves the complete management of all services that support the fundamental business of the organization (Amaratunga, Baldry, & Sarshar, 2000). For instance, facilities management services cover real estate management, financial management, change management, human resources management, health and safety, contract management, in addition to, building and engineering services maintenance, domestic services and utility supplies (Kamaruzzaman and Zawawi, 2010). The latest value added service in the facility management field is sustainability (Pong, 2010)

Facility managers often become the promoter of sustainable and green building practices (Hodges, 2005). According to the World Commission on Environment and Development (1987) or the Brundtland Commission, sustainable development is

defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable or "green" building is a division under the umbrella of sustainable development and is in accordance with the three aspects of sustainable development; economic social and environmental benefits. Sustainable/ green building is defined as "an outcome of a design which focuses on increasing the efficiency of resource use energy, water and materials while reducing building impacts on the human health and the environment during the building's lifecycle, through better sitting, design, construction, operation, maintenance and removal (Frej & Browning, 2005). Furthermore, Kozlowski (2003) defines sustainable building as one that "uses a careful integrated design strategy that minimizes energy use, maximizes daylight, has a high degree of indoor air quality and thermal comfort, conserves water, reuses materials and uses materials with recycled content, minimizes site disruptions and generally provides a high degree of occupant comfort". Hence, there is no doubt that implementing sustainability and green building approaches to facilities will benefit an organization through greater financial returns, increased standing in the community, improved productivity and reduced detrimental effects on the environment (Hodges, 2005).

Besides, Pong (2010) added that majority of the facility teams do not practice sustainability services in the facilities management and are still in doubt with the actual meaning of sustainability itself. As a result, building sector by far has been one of the largest sources of greenhouse gas emissions around the world (Low et al., 2009). The American Institute of Architects (AIA) (2007) estimates that nearly 50% of all greenhouse gas emissions are generated by buildings and coming from energy used in producing and transporting materials from factories to construction site as well as energy used in running and operating buildings. In fact, according to USGBC (2009), existing buildings are accountable for 72% of electricity consumption, 40% of raw material usage, 39% of energy use, 35% carbon dioxide emissions, 30% waste output and 14% potable water consumption. To summarize, buildings are estimated to account for approximately half of all annual energy and greenhouse gas emissions (Brown et al., 2005). These numbers are enough to demonstrate that there is indeed a huge negative impact of buildings on the environment. Thus, one prospective solution is to make certain that the design, construction and maintenance of the built environment are sustainably developed (Brown et al., 2005; Commission for

Architecture and the Built Environment, 2007). Indeed, there is a strong business case for sustainable or "green" buildings (Davies, 2005). It is worth noting that green building has been used as a term interchangeably with sustainable building and high performance building (Zuo and Zhao, 2014). However, for the purpose of this study the term green building is preferred as it is widely used in the Malaysian government sector, for example, Ministry of Energy, Green Technology and Water, and Green Building Index Malaysia.

Apparently, there is a growing recognition that green buildings outperform conventional buildings in term of a variety of environmental, social and economic indicators (Miller and Buys, 2008), leading the former to represent the next phase of buildings. However, in reality, the vast stock of existing buildings which make up the bulk of the market are not sustainably built. The growing support for green building practices and the current development of new green building construction starts are not enough to reverse this cycle. Consequently, according to Miller and Buys (2008), if the challenge of climate change is to be successfully addressed; these vast stock of existing buildings needs to be retrofitted. Furthermore, according to Pedini and Ashuri (2010), the ratio of existing buildings to new green construction is overwhelming; retrofitting of existing buildings towards sustainability could be the logical solution to reduce the environmental effects sooner. Therefore, the enormous challenge in green building is not to construct a minority of highly new green buildings, so much as to raise the sustainability of the entire stock of buildings in active use through retrofitting.

Douglas (2005) defined retrofit as "any work to a building over and above maintenance to change its capacity, function or performance, in other words, any intervention to adjust, reuse or upgrade a building to suit new conditions or requirements". Retrofit events can be referred to as alterations and extensions, upgrade, change of use and renovations and multi-tenanted buildings can experience multiple events in one building (Wilkinson, 2012). United State Green Building Council (USGBC) defined green retrofit as "any type of upgrade at an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use, improve comfort and quality of space in terms of natural lighting, air quality and noise, all done in a way that it is financially beneficial to the owner". Additionally, green refurbishment does not only decrease energy consumption but also

improves whole condition of the building; its exploitation, noise insulation, exterior, and comfort; prolongs buildings lifecycle, increase value of the buildings, reduces negative impact to environment and guarantees healthy living and working condition (Mickaityte et al., 2008). Therefore, green retrofits will result in lower greenhouse gas emissions, less resource use and consumption and healthier workplaces for building users (Wilkinson, 2012). There is a surfeit of terms used to cover retrofit such as adaptation, refurbishment, upgrade, conversion, renovation and exist in a "state of happy confusion" (Mansfield, 2002). Furthermore, it is worth noting that the term retrofit has been used interchangeably with sustainable retrofit, sustainable refurbishment and green refurbishment. However, for the purpose of this study, the term green retrofit is preferred as it is more commonly used among researchers, despite the fact that some researchers used them interchangeably.

Green retrofit projects in vast stock of conventional buildings offer significant opportunities for reducing global energy consumption and greenhouse gas emissions. This is because, although socio-economic growth generates a constant demand for new buildings, the number of buildings constructed annually in developed countries only corresponds to 1.5-2 percent of the existing building stock (Bullen, 2007). At this rate of construction output, it would take anything from 50 to 100 years to replace the current stock of existing buildings (Bullen, 2007). Therefore, the majority of these existing building stocks will remain with us for decades (Sustainable Construction Task group, 2004; Kohler & Hassler, 2002; Curwell & Cooper, 1998). Furthermore, existing buildings correspond to an energy investment that has already been expended in the procurement, manufacture and transportation of materials and in the construction process itself. Thus, to demolish an existing building and to build a new "green" building in its place is counter-productive to the idea of energy conservation. By some estimation, it would take more than 65 years to regain the energy savings of demolishing an existing building and replacing it with a new "green" building (Cheltenham Township's Boards of Historical and Architectural Review (BHAR), 2008).

Therefore, the negative impacts of existing buildings are twofold; on the one hand, if they are replaced, the demolition waste would fill and pollute landfills, on the other hand, if these buildings are allowed to stand without retrofitting, their negative impact on the environment would continue (Pedini and Ashuri, 2010). In these

circumstances, implementing green retrofit projects in existing buildings using any viable standard would bring the benefit of green building to existing structure and help mitigate the negative environmental impact caused by them. Green retrofit projects are considered as one of the major approaches to practically achieving reduced energy consumption and greenhouse gas emissions in the built environment at fairly low cost and high uptake rates (Ma et al., 2012). Since, when all building types are measured, the major single source of greenhouse gas emissions in buildings comes from commercial buildings, therefore the focus for making significant reductions of emissions lies within this group (Reed and Wilkinson, 2005). In fact, according to Menassa and Baer (2014), stakeholders are concerned with raising the sustainability of their existing buildings from social, environmental, economic and technical perspectives.

Despite of all these facts, the question is how much effort has been taken to make "green retrofits initiative" a common concern up to this present date? Unfortunately, even with the growing concerns of stakeholders over environmental, social and economic aspects, green retrofit project is not winning its place at the forefront as hoped for (Pedini and Ashuri, 2010). Existing buildings are continuing to be retrofitted at a very low rate (Olgyay and Seruto, 2010). For instance, according to Olgyay & Seruto (2010), existing commercial building stock is currently being retrofitted at a rate of approximately 2.2% per year only.

## 1.2 Problem Statement

This section is divided into two parts; the first part discusses the problems in implementing green retrofit projects from the stakeholders' perspectives and the second part of this section reveals the gap in current research on CSFs for green retrofit projects implementation.

### 1.2.1 Problems in Implementing Green Retrofit Projects

Green retrofit projects are still not widely practiced, although there is significant demand for green buildings (Menassa and Baer, 2014). The limited response of the commercial property markets to sustainability is well recorded (Pivo and McNamara, 2005; Cox and Cadman, 2000; Brownhill and Yates, 2001). For instance, in Malaysia, the situation is even worse, Table 1.1 below illustrates the GBI certified projects by category in Malaysia and Table 1.2 illustrates the GBI certified projects by rating categories in Malaysia. It is clear from the table that only 20 non-residential existing buildings have applied for the GBI status till 15 March 2015. Yet, 19 buildings are qualified for registration and only 7 buildings have obtained certification. Furthermore, out of 7 buildings, only 3 buildings received final certification after the completion and verification assessment and the remaining 4 buildings received provisional certification after design assessment. The term non-residential existing buildings will be used throughout this research, hereinafter, to denote existing commercial buildings in order to be in line with the term in Green Building Index Malaysia.

**Table 1.1: GBI Certified Projects in Malaysia**

| **Update on Green Building Index** | **TOTAL as of 15 MARCH 2015** | **NRNC** | **RNC** | **INC** | **NREB** | **IEB** | **T** |
|---|---|---|---|---|---|---|---|
| Applied | 649 | 333 | 259 | 19 | 20 | 4 | 14 |
| Registered | 608 | 306 | 248 | 18 | 19 | 3 | 14 |
| Total Certified | 288 (100%) | 139 (48%) | 128 (44%) | 6 (2%) | 7 (3%) | 2 (1%) | 6 (2%) |
| Received with Provisional Certification after DA | 248 | 120 | 116 | 2 | 4 | - | 6 |
| Received Final Certification after CVA | 39 | 18 | 12 | 4 | 3 | 2 | - |

**Table 1.2: GBI Certified Projects by Rating Categories**

| RATING | TOTAL as of 15 MARCH 2015 | NRNC | RNC | INC | NREB | IEB | T |
|---|---|---|---|---|---|---|---|
| PLATINUM 86 to 100 points | 13 (5%) | 7 | 4 | - | 1 | - | 1 |
| GOLD 74 to 85 points | 68 (24%) | 42 | 25 | 1 | - | - | - |
| SILVER 66 to 75 points | 35 (12%) | 19 | 12 | 1 | 1 | - | 2 |
| Certified 50 to 65 points | 172 (59%) | 74 | 84 | 4 | 5 | 2 | 3 |
| Total Certified | 288 | 142 | 125 | 6 | 7 | 2 | 6 |

Source: Green Building Index Malaysia

**LEGEND:**

| | | | |
|---|---|---|---|
| NRNC: | Non Residential New Construction | RNC: | Residential New Construction |
| NREB: | Non Residential Existing Building | IEB: | Industrial Existing Building |
| INC: | Industrial New Construction | T: | Township |
| CVA: | Completion & Verification Assessment | DA: | Design Assessment |

According to Menassa and Baer (2014), a decision on whether a building should undergo green retrofit needs to be agreed by the building stakeholders. Foley (2005) defines stakeholders as "… those entities and/or issues, which a business identifies from the universe of all who are interested in and/or affected by the activities or existence of that business, and are capable of causing the enterprise to fail, or could cause unacceptable levels of damage, if their needs are not met". Yu et al., (2011) stated that building stakeholders are encouraged to enable operations towards sustainability of non-residential existing buildings in order to reduce poor impacts on the environment as well as occupant health over the entire building life cycle. In particular, major initiatives from building stakeholders are necessary for implementing green retrofit projects. However, according to Wilkinson (2012), research has proven that particular building stakeholders are less likely to retrofit and authorities need to consider ways to initiate stakeholders towards green retrofit. Indeed, according to Cadman (2000), the major barrier that obstructs the development of sustainability in existing buildings is the circle of blame. Figure 1.1 displays the vicious circle in which the main stakeholders of sustainable real estate development have been trapped for

many years. All parties said that they are willing to contribute to green building, but they need cooperation of the other stakeholders (Vink, 2009). Admittedly, green retrofit requires cooperation and participation of a wide range of stakeholders (Miller and Buys, 2008). Therefore, lack of participation and cooperation among stakeholders has been the major reason behind the poor record of green retrofit projects implementation. Furthermore, Boecker et al., (2009) emphasized that engaging all stakeholders at the earliest stage which is the design process is the key to eliminate deeply held assumptions thus resulting in better solutions that are environmentally, functionally, esthetically and economically viable.

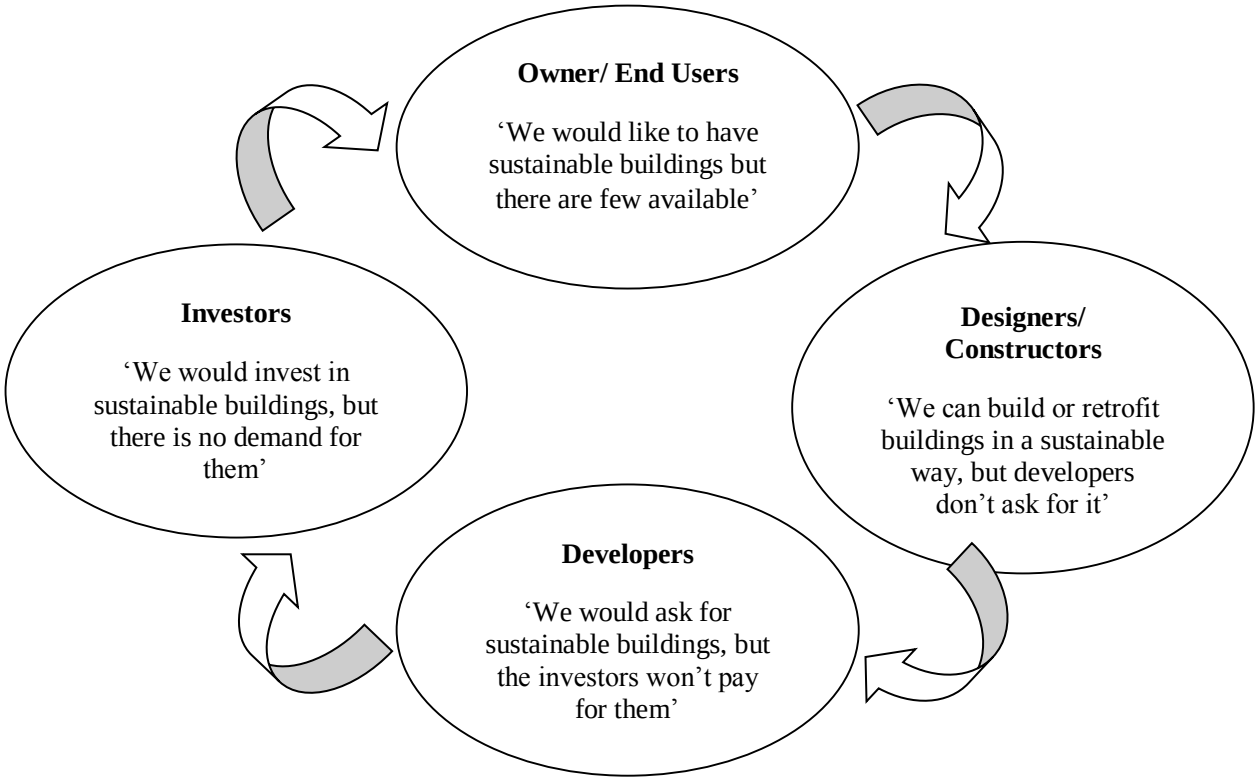


**Figure 1.1: The Circle of Blame**

(Source: Cadman, 2000)

Further review on the literature revealed the lack of participation and cooperation among stakeholders of existing buildings is due to the challenges, obstacles, barriers or problems faced by stakeholders which in turn affects the successful implementation of green retrofit projects (Ma et al., 2012). The challenges, obstacles, barriers or problems faced by stakeholders are tabulated in Table 1.3. These challenges, barriers, obstacles or problems stated below are the influential forces

which impede successful implementation of green retrofit projects. In a nutshell, they are the factors contributing to the failure of a retrofit project.

**Table 1.3: The Problems/Challenges/Obstacles/Barriers Faced by Building Stakeholders**

| No. | Problems/Challenges/Obstacles/ Barriers | References |
|---|---|---|
| 1 | Perceived high upfront costs and uncertain return | Urge-Vorsatz et al., 2007; Richardson and Lynes, 2007; Mcdonald et al., 2008; Choi, 2009; Pedini and Ashuri, 2010; Galuppo and Tu, 2010; Azizi et al., 2010; Reza et al., 2011; Benson et al., 2011; International Labour Office, 2011; Liu et al., 2012; Urban Land Institute, 2009; Bond, 2010, Yudelson, 2010; Bond and Perrett, 2012; Tam et al.,2012 |
| 2 | Lack of green building professionals | Pedini and Ashuri, 2010; Galuppo and Tu, 2010; Azizi et al., 2010; Reza et al., 2011; Benson et al., 2011; International Labour Office, 2011; Liu et al., 2012; Urban Land Institute, 2009; Bond, 2010; Yudelson, 2010; Tam et al., 2012; Urge-Vorsatz et al., 2007 |
| 3 | Lack of financial incentives | Richardson and Lynes, 2007; Pedini and Ashuri, 2010; Galuppo and Tu, 2010; Reza et al., 2011; Benson et al., 2011; Urban Land Institute, 2009; Bond, 2010; Yudelson, 2010; Bond and Perrett, 2012 |
| 4 | Knowledge gap in the quantification of green development | Kastenhofer and Rammel, 2005; Brown and Southworth, 2006; Mcdonald et al., 2008; Choi, 2009; Pedini and Ashuri, 2010; Benson et al., 2011; International Labour Office, 2011; Bond and Perrett, 2012; Tam et al., 2012 |
| 5 | Lack of green retrofit awareness | Richardson and Lynes, 2007; Pedini and Ashuri, 2010; Galuppo and Tu, 2010; Reza et al., 2011; International Labour Office, 2011; Bond and Perrett, 2012 |
| 6 | Lack of communication between stakeholders | Kastenhofer and Rammel, 2005; Richardson and Lynes, 2007; Mcdonald et al., 2008; Choi, 2009; |

| | | |
|---|---|---|
| | | Pedini and Ashuri, 2010; Liu et al., 2012 |
| 7 | Lack of internal leadership | Richardson and Lynes, 2007; Choi, 2009; Pedini and Ashuri, 2010 |
| 8 | Unavailability of green material and technology | Pedini and Ashuri, 2010; Azizi et al., 2010; Bond and Perrett, 2012 |

According to Toor and Ogunlana (2010), to make a project successful, it is imperative to start by determining the failure factors. In line with this, a variety of failure factors which inhibit the successful implementation of a green project have been determined. They are policies and regulations, client resources and expectations, retrofit technologies, building specific information, human factor and some other uncertainty factors (Ma et al., 2012). These varieties of failure factors, propel the study of this research onto the critical success factors. According to De wit (1988), a project is considered successful if there is a high level of satisfaction concerning the project outcome among key stakeholders from the parent organization, the project team and end users. However, there is no standard definition of a successful project. This is because every individuals in a team project find themselves in unique situations. As such, their definition of a successful project differs from the one coming from the other team individuals (Gudiene et al., 2013). In fact, according to Lapinski et al., (2007), successful implementation of green retrofit projects involves a significant amount of planning and communication with numerous stakeholders to obtain a commitment to shared goals and achieve a beneficial solution for all involved. According to Boecker et al., (2009), diversity of values, opinions, expectations and perspectives among stakeholders is expected but such diversity needs to be properly managed to turn it from a liability that can significantly impede project success into an asset. Therefore, to successfully implement green retrofit projects, the understanding and determination of stakeholder success factors are crucial considerations for facility manager/project manager or more commonly known as the change agent. The term change agent will be used throughout this research to represent the facility manager or the project manager. Once, the individuals in the change agent team are well aware of the success factors, they can easily identify and prioritize critical issues associated with implementing the project plan (Boynton and Zmud, 1984). In fact, understanding the structural relationship between different success factors is vital in developing strategies for effective implementation (Singh et al., 2007). The importance of the success factors cannot be ignored as they guide practitioners to focus on key areas

during project implementation (Abdullah and Quaddus, 2012). In line with this, the basis of this research is thus the investigation on the CSFs of green retrofit projects implementation.

### 1.2.2 Current State of Research on CSFs for the Implementation of Green Retrofit Projects

CSF was first developed by Rockart (1979). CSFs are the limited number of areas which, when in satisfactory conditions, ensure successful competitive performance for the organization (Rockart, 1979). CSFs are also known as the few key areas where 'things must go right' for the business to flourish, areas of activity that should receive constant and careful attention from management, and also areas in which good performance is necessary to ensure attainment of goals (Rockart, 1979). Ranking and criticality among the CSFs are the important characteristic in considering CSFs and are acceptable in several construction management researches (Wang et al., 1999; Chan et al., 2004; Li et al., 2005). This characteristic is imperative in providing a structured way or commonly described in CSFs literature as "structural relationship" (Deshmukh, 2010; Singh, 2011).

Review on the literature on green retrofits revealed that at present, research on critical success factors (CSFs) for green retrofit projects implementation has been lacking (Refer Table 1.3). As a result, till to date there is no strong constructs of CSFs for green retrofit. In fact, in order to address the current issue of this study, specific review on CSFs has been conducted which highlights the current limitation.

#### 1.2.2.1 Lack of Comprehensive List of CSFs for the Implementation of Green Retrofit Projects

Critical review on previous researches on green retrofits has been tabulated in Table 1.4 below. Generally, most of the researchers on green retrofitting focused on green retrofit methods and framework. Nevertheless, few studies have explored the technical, economic and environmental implications of existing building green

retrofits (Chidiac et al., 2011; Entrop et al., 2010; Gaterell and McEvoy, 2005; Gluch and Baumann, 2004; Juan et al., 2010; Nemry et al., 2010; Papadopoulos et al., 2002; Poel et al., 2007). Additionally, a review on recent literature shows very few studies have conducted on what motivates public and private building owners to pursue green and green building design initiatives (Menassa and Baer, 2014). Fuerst and McAllister (2011) outlined the rational to pursue green building design. Where else, Yudelson (2010) identified multiple reasons why building owners and operators are interested in energy efficient and sustainably retrofitted buildings.

**Table 1.4: A Critical Review of Researches Related to the Implementation of Green Retrofits Projects**

| Issues | Literature | Frequency |
|---|---|---|
| Methods and Framework | Lam (2008); Hayter et al.,(2000); Asadi et al.,(2012); Ferrante et al.,(2011); Wolf (2011); Xing et al.,(2011); Mickaityte et al.,(2008); Boron & Murray (2004); Scichili & James(2010); Alanne (2004); Dascalaki & Balaras (2004); Ma et al.,(2012); Gohardani & Bjork (2012); Low & Goh (2010); Bullen (2007); Aroul & Hansz (2011); Kaklauskas et al.,(2005); Dong et al.,(2002); Phdungsilp & Martinac (2004); Dan (2004); Chidiac et al., (2011); Wilkinson (2012). | 22 |
| Technical, Economic and Environmental Implications | Chidiac et al., (2011); Entrop et al., (2010); Gaterell and McEvoy, (2005); Gluch and Baumann, (2004); Juan et al., (2010); Nemry et al., (2010); Papadopoulos et al., (2002); Poel et al., (2007). | 8 |
| Challenges | Pedini & Ashuri (2010); Brown & Southworth (2006); Mcdonald et al.,(2008); International Labour Organization (2011); Benson et al.,(2011). | 5 |
| Benefits/ Motivates | Kok et al.,(2012); Reed and Wilkinson (2008); Yudelson (2010); Fuerst and McAllister (2011); Miller & Buys (2008). | 5 |
| Sustainability Assessment | Juan et al., (2010); Rey (2004); Ellison and Sayce (2007). | 3 |
| Role of Stakeholders | Menassa and Baer (2014). | 1 |

### 1.2.2.2 Lack of CSFs in the Facilities Management Field

Various studies have been conducted since 1960, to explore the factors that are really important to be considered for achieving the success on projects (Cooke-Davies, 2002; Chan et al.,2001). Similarly, numerous studies related to CSFs have been conducted in various sectors until to date, such as information technology (IT), industrial systems, construction, process engineering, business development and operations management (Toor and Ogunlana, 2010). Nonetheless, no research has been conducted to investigate the CSFs in the facilities management sector. Table 1.5 below shows studies on CSFs over the years in various sectors.

**Table 1.5: Previous Studies on CSFs across Various Sectors**

| | **Sector** | **Literature** |
|---|---|---|
| CSFs | Project Management | Pinto and Slevin (1987) |
| | Educational Management | Volery and Lord (2000) |
| | Information Management System | Magal, Carr and Watson (1988) |
| | Product Management | Edgett and Kleinschmidt (2003) |
| | Enterprise Resource Planning | Nah and Delgado (2006) |
| | Construction Project | Chua, Kog and Loh (1999) |
| | Business Management | Yusuf (1995) |
| | Software Projects | Reel (1999) |
| | Financial Services | Cooper and Edgett (1996) |
| | Information Technology | Gottschalk and Solli-Saether (2005) |
| | Industrial | Rothwell (1992) |
| | Banking | Chen (1999) |
| | Marketing | Baker and Cameron (2008) |
| | Tourism | Thomas and Long (1999) |
| | **Facilities Management** | **No reference available. Existence of Research Gap.** |

Based on the above studies on the problems in implementing green retrofit projects and critical review of literature on CSFs for green retrofit projects implementation and facilities management, it is clear a substantial gap in research exists in the area of CSFs of green retrofit projects implementation. Since, every project has a specific set of success factors which may not be transferable to another project (Liu et al., 1999), this research aims to fill in the substantial gap in the current research area. Therefore, this thesis proposes to develop a structured critical success factors (CSFs) model for green retrofit projects implementation. The identification of CSFs model for green retrofit projects implementation is an important starting point as this will enable limited resources such as time, manpower and money to be allocated appropriately (Chua et al., 1999). This research is designed to be the first step in developing the knowledge base, focusing on the CSFs for implementing green retrofit projects in non-residential existing buildings.

## 1.3 Research Questions

This research focuses on answering the following research questions:

a) What are the CSFs and indicators for the implementation of green retrofit projects?
b) What are the most significant CSFs for the implementation of green retrofit projects?
c) How are the structural relationships between the identified CSFs for the implementation of green retrofit projects?

## 1.4 Objectives of the Research

Based on the problems mentioned above, the gap in the CSFs literature on retrofitting implementation and the research questions derived, the following objectives are formulated:-

a) To identify the CSFs for successful implementation of green retrofit projects.
b) To evaluate the criticality and ranking of the CSFs for successful implementation of green retrofit projects.
c) To develop the structural relationship between the CSFs for successful implementation of green retrofit projects.

## 1.5 Scope of the Research

Like in other studies, this particular study has its own limitations, both in scope and methodology. To achieve the objectives of this research within a limited time, this study focuses on only the following features discussed below.

First of all, this study focuses on implementing green retrofit projects in non-residential existing buildings. This is because, according to Reed and Wilkinson (2005), the major source for high level of greenhouse gas emissions in buildings is mainly generated from non-residential existing buildings. Therefore, it is pertinent to focus on non-residential existing buildings in order to achieve significant reductions of global energy consumption and greenhouse gas emissions.

Next, a critical review on previous literature regarding success factors for green retrofit projects implementation has revealed that information on establishing a structural relationship between identified factors has so far lacking. Thus, this research aims to seek experts' opinion to validate the identified CSFs and to establish the structural relationship between the identified factors.

Finally, this research mainly focusses on identifying stakeholders' success factors due to lack of participation and cooperation among stakeholders which in reality has been the major reason that prevents the implementation of green retrofit projects. The focused groups of stakeholders were narrowed to those involved in the development of circle of blame, namely, owners/end users, designers/constructors and developers. However, the change agent or the group of stakeholders responsible to undertake the management of identified CSFs in favor of achieving satisfaction among stakeholders for healthier participation and cooperation among stakeholders lies within the facility managers. This is because, sustainability is a service under the facilities management field, and thus, facility managers are more likely to embark on the sustainability idea in the building facility. In particular, participation and cooperation of building stakeholders are necessary for facility managers to implement green retrofit projects successfully.

## 1.6 Research Methodology

The research methodology adopted was quantitative using survey based approach. To achieve the objectives of this research, the research methodology consists of the following steps were employed:-

a) Literature review
b) Experts' opinion
c) Questionnaire survey

### 1.6.1 Literature Review

The purpose of reviewing related literature on CSFs was to identify success factors for green retrofit projects implementation in non-residential existing buildings. A vast number of articles related to success factors regardless of the types of industry and level of implementation were carefully reviewed. The analyses of all the articles which results in the identification of the significant gap and the methods used by the

researchers in identifying the CSFs were listed. The gap was the absence of the CSFs study for green retrofit projects implementation in non-residential existing buildings. Since, articles that were directly related to CSF for green retrofit were lacking, literature on the ingredients and strategies that make green projects implementation successful and what make the project fails were analyzed. The final lists of CSFs at this phase were based on the success ingredients/strategies and particularly the failure factors which inhibit building stakeholders from participating and cooperating in the implementation of green retrofit projects in non-residential existing buildings. As according to Toor and Ogunlana (2009), to be able to complete a project successfully, one must start by determining the factors that affect project success and failure.

### 1.6.2 Experts' Opinion

Critical literature review suggests that up to date information to establish the structural relationship between factors is lacking. As such, experts' opinions is used to replace the gap and there are two reasons for this. First, to validate the construction of the CSFs for successful implementation of green retrofit projects in non-residential existing buildings. Second, to establish the structural relationships between the CSFs which is done by determining which "factors" lead to the others and also those that are not related to one another.The structural model developed using ISM has been empirically confirmed using PLS-SEM.

### 1.6.3 Questionnaire Survey

Data collection for this thesis was based on a quantitative, survey-based methodology. This approach was pertinent to establish the contextual structural relationships between the CSFs, in which, the causal relationship among the underlying theoretical constructs was determined. Hence, self-administered questionnaires are considered to be the most suitable tool. Furthermore, this method is

quick, economical, and proficient and can be administered to a large sample (McCelland, 1994; Churchill, 1995; Sekaran, 2000; Zikmund, 2003).

The purpose of questionnaire survey was to get the industry to verify the green retrofit CSFs and to empirically confirm the relationship model developed earlier from experts' interview. This confirmation was done by analyzing the structural relationship of green retrofit CSFs using Partial Least Square Structural Equation Modeling (PLS-SEM). SEM is a multivariate statistical technique which is often used to determine the causal relationships among latent variables. For the purpose of this thesis, SEM was conducted using the two-stage approach as recommended by Anderson and Gerbing (1988). The first stage (measurement model) was carried out to specify the causal relationships between the observed variables (items) and the underlying theoretical constructs and provides reliable and valid constructs, while the second stage was to test the relationships between these theoretical constructs.

## 1.7 Significance of the Research

The significance of the research is very much related to the importance of the research and its relevance to the theory, practice and future research. The proposed model developed from this research has the following impacts.

a) The compilation of CSFs for green retrofit projects implementation in non-residential existing buildings contributes knowledge to the academic world. The knowledge gained should introduce new area in understanding the relationships among the factors as well as between the factors.
b) The result of this research on the CSF for green retrofit project implementation in non-residential existing buildings should become useful to facility managers who wish to implement green retrofit projects in successful manner.
c) The structural relationship model of the CSF for green retrofit projects implementation presents a comprehensive structural cause and effect relationship between various success factors which in turn helps to ease facility

manager in deciding the priority, direction and implementation strategy for green retrofit projects implementation.

## 1.8 Organisation of the Thesis

This section provides a brief review of the thesis structure.

Chapter 1 introduces the issues related to the topic under investigation, with a brief discussion about the methodology used.

Chapter 2 portrays the proposed CSFs which are recognized from the success ingredients/strategies and inhibiting factors for green project implementation. This chapter begins with an overview of facilities management, the wide range of disciplines and services related to facilities management, performance measurement of facilities management and relation to sustainability. This is followed by an introduction to sustainability, green retrofits and benefits of green retrofits. Then, it continues with a brief discussion on building stakeholder and the change agent. A critical review on the relevant literature related to the problems inhibiting building stakeholders from participating and cooperating in the implementation of green retrofit projects is also presented. Followed by, a brief introduction on the definition of project success and success criteria. Then, continues with an introduction to CSFs and in depth discussion on the CSFs definition, CSFs identification methods and the hierarchical nature of CSFs. The following section discusses project CSFs and the success ingredients/strategies for the implementation of green retrofit projects. Finally, an Onion Model which summarizes the chain link of study from facilities management to sustainability to green retrofit CSFs was developed with a list of proposed CSFs illustrated in a conceptual framework.

Chapter 3 describes the research methods employed for the study. The methodology comprises an overview of the design and justifies the use of the methods, discusses the scale items selected to measure the underlying constructs, the instruments used to collect the data, justifies the techniques used to analyze the collected data,

discusses the reliability and validity of the constructs. The modeling techniques used to develop the structural relationship model such as ISM and SEM are also discussed.

Chapter 4 reports the outcome of the statistical analysis of the data collected from the questionnaire survey and experts' opinion. This includes the preliminary analysis of the questionnaire survey; respondents' demographic study and respondents' agreement on the CSFs which were conducted using Statistical Package of Social Science (SPSS). The development of the proposed structural relationship model through Interpretive Structural Modeling (ISM) based on experts' opinion is also presented. Finally, the Structural Equation Modeling (SEM) techniques empirically confirms the structural relationship model are shown in detail. In relation to the objectives of the research, the conclusion part displays the empirically confirmed structural relationship model.

Chapter 5 highlights the discussion on the findings from the analysis of the questionnaires and expert opinions in answering the objectives of the research. The three objectives are, to identify the CSFs of green retrofit projects implementation, to evaluate the criticality and ranking of the CSFs of green retrofit projects implementation, and to develop the structural relationship model of successful implementation of CSFs for green retrofit projects.

Chapter 6 highlights the main conclusions and several limitations of the research. Several points for further investigations are highlighted as well.

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