FRAMEWORK FOR A DECISION MATRIX IN GREEN
PROJECT MANAGEMENT PROCESSES

by

Mustafa Sahban Al-Tekreeti

A Thesis Presented to the Faculty of the
American University of Sharjah
College of Engineering
in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science in
Engineering Systems Management

Sharjah, United Arab Emirates
January 2015

Approval Signatures

We, the undersigned, approve the Master's Thesis of Mustafa Sahban Al-Tekreeti.

Thesis Title: Framework for a Decision Matrix in Green Project Management Processes.

Signature

Date of Signature

(dd/mm/yyyy)

Dr. Salwa Beheiry
Assistant Professor
Department of Civil Engineering
Thesis Advisor

Dr. Sameh El-Sayegh
Associate Professor
Department of Civil Engineering
Thesis Committee Member

Dr. Zied Bahroun
Associate Professor
Department of Industrial Engineering
Thesis Committee Member

Dr. Moncer Hariga
Director, Engineering Systems Management Graduate Program

Dr. Mohamed El-Tarhuni
Associate Dean
College of Engineering

Dr. Leland Blank
Dean
College of Engineering

Dr. Khaled Assaleh
Interim Vice Provost for Research and Graduate Studies

Acknowledgements

First of all, I thank Allah for giving me the willingness, strength and patience to carry out this research. This thesis is the result of a pleasant collaboration with my supervisor, Asst. Prof. Dr. Salwa Beheiry. I am grateful for her advice, support, and guidance throughout the study. I would like to express my regards and gratitude for the entire faculty in the Engineering Systems Management Master's Program at AUS. Special thanks to my committee members Dr. Zied Bahroun and Dr. Sameh El-Sayegh for their assistance and thorough review. I would also like to thank all expert panel members Eng. Muthana Helan, Eng. Khaleel Ibraheem, Eng. Zaid Isam, Dr. Issam Srour, and Dr. Oswald Chong. Finally, I would like to express my thanks and deep gratitude to my family (father, mother, and sister) for their unlimited support, encouragement, help, and patience throughout.

Dedication

To my family...

To my father and mother for their endless support.

Abstract

The purpose of this study is to develop a decision matrix for green project management processes (GPMPs) in commercial construction projects. A decision matrix for GPMPs can assist in decoding all the information required to make green conscious decisions at the various stages of the project. The study defines the process of integration of the environmental factors in the traditional project management processes of major construction projects. The integrated product is worked into a process index for the main green concepts affecting the PMP. Moreover, the analytical hierarchy processes method is used to prioritize the green project management processes according to pre-set criteria. The criteria are based on cost, risk and benefit to the project, whereas the processes include items such as environmental impact assessment studies, recycling plans, and green stakeholder interest. From the expert evaluation, it is clear that the cost criterion has the highest rank in all processes and all project phases. Nonetheless, the green project processes fluctuate in importance over the phases. In the initiation phase, green stakeholder interest ranked higher while environmental impact assessment deliverables and activities dominated the planning phase. In the detailed engineering design phase, experts highlight green design monitoring as the most significant process. Quality control assessment has superior ranking in the execution phase. The energy management systems process is the most preferable process in the commissioning phase and for managing hazardous materials in the decommissioning phase. Furthermore, a sensitivity analysis is applied to identify the experts' judgment stability. Both the planning and the commissioning phases show higher stability in this analysis. Ultimately, this research develops a fresh methodology to facilitate decision making in green project management processes, by the comprehensive integration of green indicators in the traditional project management process, the creation of a GPMP index and the linkage of a decision matrix to the index for major program and project evaluation. Additionally, the study assimilates the analytical hierarchy processes concept in the decision matrix for further tool validation.

Search Terms: Project Management Process, Green Project Management Processes, Decision Matrix, Green Concepts, Analytical Hierarchy Processes.

Table of Contents

Abstract.....	6
Chapter 1: Introduction.....	11
1.1 Background.....	11
1.1.1 Problem Definition.....	13
1.1.2 Objectives	13
1.1.3 Literature Review.....	13
1.1.4 Research Significance	14
1.1.5 Research Methodology	14
1.1.6 Thesis Organization	14
Chapter 2: Literature Review.....	15
2.1 Defining Project Management	15
2.2 Project Management Processes.....	16
2.2.1 Mapping Project Management Process.....	18
2.2.2 Detailed Description of PMPs.....	19
2.3 Green Project Management Concept	32
2.3.1 Green Management Techniques.....	35
2.3.2 Green Project Management Processes	37
2.4 Analytical Hierarchy Processes (AHP).....	38
2.4.1 How Analytic Hierarchy Processes Work	39
2.4.2 Priorities Process in AHP.....	39
2.4.3 Practical Application for AHP	41
2.5 What a Decision Matrix is	46
2.5.1 How a Decision Matrix Works in Practical Application.....	46
Chapter 3: Research Methodology.....	50
3.1 Integration of Green Project Management Processes	50
3.2 Process Index	56
3.3 AHP Analysis	62
3.3.1 AHP Model (Theoretical Run).....	64
3.4 Expert Validation	66
3.5 Green Decision Matrix and Process Index with Weighted Process	66
Chapter 4: Analysis.....	68
4.1 Expert Judgment	68

4.2 Expert Panel Analysis	71
4.3 Sensitivity Analysis	75
Chapter 5: Conclusion & Recommendations	79
5.1 Conclusion	79
5.2 Recommendations.....	80
References.....	82
Appendix A: Complete References for The Green Project Management Processes and Criteria	89
Appendix B: Experts Panel Members	92
Appendix C: Expert Panel Input	93
Appendix D: Complete Green Decision Matrix	108
Appendix E: Hypothetical Example of Decision Matrix for Green Project Management Processes (Project A)	109
Appendix F: Hypothetical Example of Decision Matrix for Green Project Management Processes (Project B)	110
Appendix G: Processes Index References	111
Vita.....	117

List of Figures

Figure 1: The structure of GPMAF model [19]	36
Figure 2: Initiation phase hierarchy tree	68
Figure 3: Planning phase hierarchy tree.....	69
Figure 4: Detail engineering design phase hierarchy tree	69
Figure 5: Execution phase hierarchy tree.....	69
Figure 6: Commissioning phase hierarchy tree.....	70
Figure 7: Decommissioning phase hierarchy tree.....	70
Figure 8: Overall criteria priority.....	71
Figure 9: Initiation processes priority	72
Figure 10: Planning processes priority.....	72
Figure 11: Detail engineering design processes priority	73
Figure 12: Execution processes priority.....	73
Figure 13: Commissioning processes priority	74
Figure 14: Decommissioning processes priority.....	74
Figure 15: Initiation processes priority before sensitivity analysis.....	75
Figure 16: Initiation sensitivity analysis	76
Figure 17: Detail engineering design processes priority before sensitivity analysis	76
Figure 18: Detail engineering design sensitivity analysis.....	76
Figure 19: Execution processes priority before sensitivity analysis	77
Figure 20: Execution sensitivity analysis.....	77
Figure 21: Decommissioning processes priority before sensitivity analysis	77
Figure 22: Decommissioning sensitivity analysis.....	78

List of Tables

Table 1: The managerial function [10]	17
Table 2: The average consistency with respect to matrix size	40
Table 3: Nine-scale rating system [23]	40
Table 4: Important criteria for selecting company suppliers [25].....	42
Table 5: Reference table of decision matrix usage	75

Chapter 1: Introduction

1.1 Background

Global warming is one of the major problems that faces humanity and the future of the next generations. Also, the carbon footprint is one of the main issues that requires mitigation in developing countries. The large number of consumers in these countries has led to an increase in the demand for resources and this makes the fulfillment of society needs a challenging problem for developers. Hence, a unique solution is required.

The planet Earth has limited resources that will deplete one day if we keep consuming the resources at the rapid rate we do now; therefore, we need to manage our resources and develop sustainable ways of living in order to survive in this world and save resources for future generations.

Ning and Shan, in their 2009 conference paper stated that one way to solve this problem is moving toward sustainable lifestyle, such as applying green project management concepts, which is one of the techniques used to enforce sustainability for any project and facilitate the challenges that face the green project. Meeting the needs of civilization today, without jeopardizing the future need of the next generation, is the main concept involved in adopting sustainable project management [1].

Yin, in his 2010 journal article highlighted that environmental impacts, societal factors, and the economy are the combination of green project management concepts in order to achieve sustainability and harmony in nature [2]. Each environmental adaptation has its own pros and cons that may affect the project in one way or another; therefore, to improve environmental management projects, several methods have been developed. However, increasing labor costs, material costs and other costs is a result of applying these methods, which puts restrictions on using some of them.

In addition, Yin indicated that, in recent times, project clients prioritize economic analysis in their decision to execute a project without analyzing the negative impacts of a project on the environment or society [2]. Furthermore, the selection of a project that has a shorter payback period will be the main factor in the pursuit of a project. In order for green project management to be implemented successfully, the support of the higher management in the organization is needed. In contrast, public awareness about the necessity of green and sustainable life is essential because they are

the end users for any product and the backbone for supporting green projects. During the last two decades, public awareness for environmental protection has increased and forced governments to impose more regulations on projects that conserve the environment and community.

Green management is a relatively new field and there are some areas that are still undiscovered which require more research and study. Investing in green projects is beneficial in the long term, but despite several risks and an additional budget required over a traditional project, this exerts tremendous pressure on the client to move to a green project.

A green project requires specific information from clients, such as knowing what the client wants from the start of the project along with the collaboration of all stakeholders, project teams, and regulatory institutions to have a successful project. On the other hand, streamlining the decision-making processes is one of the most important aspects to accomplish the project. Also, making fast and proper decisions, which is a complex task that many project managers fail to achieve during the project lifecycle, will help managers facilitate the proper flow of the project. Moreover, being responsive to the changing business environment or varying client specifications can also pose problems in the decision-making process. Applying green management to projects will increase the efficiency and productivity by decreasing the use of the organization's resources, implementing proper waste management systems, and reducing pollution.

Czuchry and Yasin, in their 2004 journal article, stated that when applying green project management processes, managers are required to change the culture of the organization by shifting toward open and horizontal communication systems and delegating responsibility to other team members [3]. Therefore, these changes are expected to face resistance, and managers should accept this resistance and try to change the employees' mind-set. Also, the manager is required to have a successful financial agenda for the organization in order to secure a profitable project that leaves an effective business impact on the organization's global environment. Furthermore, managers must have a full understanding of how to formulate, execute, and operate management processes during the project lifecycle to create a balance between formulating a process and implementing it. It is an obligation for the project manager

to solve any project problems by using the available information, resources, labor, and decent solutions that will result in cost savings and quality improvement for the project.

1.1.1 Problem Definition

Several projects have negative influences on the environment during their lifecycle. Construction projects have negative impact on the environment whether industrial or building construction, such as an increased percentage of CO₂ in the atmosphere and seepage of toxic materials into ground water. Those problems require proper decision making to mitigate these influences. For instance, a gap between formulating and implementing a decision which may lead to creating additional problems, which, if not properly solved may lead to continuous loss of the organization's resources. Moreover, managers do not have time to process all information in order to make proper decisions for the entire lifecycle of the project. In a nutshell, the drawbacks of green projects include an increased budget amount, tremendous effort to integrate all project aspects, and quick decision-making.

1.1.2 Objectives

- Integrate green aspects into traditional project management processes
- Develop a GPMP index based on the integrated processes
- Use the analytical hierarchy process to prioritize the integrated GPMPs
- Create a decision matrix based on prioritized GPMPs

Deliverable:

- A tool to help project managers utilize the green project management processes in specific projects.

1.1.3 Literature Review

The literature review provides broad narrative about the main topics in this study which are, traditional project management and project management processes, and green project management and its processes. On the other hand, analytical hierarchy processes and decision matrices will be used in this study. Therefore, the literature review provides a general explanation about those tools and how they work, as well as their practical application in the real world.

1.1.4 Research Significance

This research aims to propose a novel methodology to facilitate decision making in green project management processes (GPMPs) by:

- Comprehensive integration of green indicators in the traditional project management process (PMP)
- Creating a decision matrix for use by major project teams in GPMP implementation in commercial construction projects
- Integrating AHP analysis in the decision matrix
- Creating a GPMP index for future applications

1.1.5 Research Methodology

This study provides a framework for a decision matrix in green project management processes. The study integrates green factors into the traditional project management processes in order to specify green project management processes and uses the analytical hierarchy process (AHP) to discern green processes' priority according to feedback from an expert panel. A committee of five members is used in this panel. Two members are academic experts and three members are from industry. The experts prioritize green processes based on specific pre-set criteria by using pair-wise comparisons. The AHP-driven processes' prioritization will be used to specify the weights in the decision matrix. The matrix includes a process index that helps managers specify green processes. These indices must be rated by project teams according to the project information. Green matrices translate into project percentile achievement that assists top managers to identify the level of green concept integration in commercial building projects.

1.1.6 Thesis Organization

Chapter 2 will review all the literature related to the study. Chapter 3 specifies the research methodology followed in this study. The analysis and results will be included in Chapter 4. Chapter 5 will highlight the conclusion and the recommendations of the study.

Chapter 2: Literature Review

2.1 Defining Project Management

Project management is “the application of knowledge, tools, techniques, and skills to project activities to meet project requirements” (PMBOK Guide, 2004). Project management fulfills several duties for the community, such as problem solving and strategy development for future development. Larson and Gray, in their 2011 book, mentioned that there has been an increased interest in project management institutions (PMIs) over the past few years, as evidenced by the fast growth in PMI membership from 93,000 during 2002 to 270,000 in 2007, as well as the fact that some organizations are required to have project management professional (PMP) certification in order to hire in managerial positions [4].

In their 2013 journal article, Alsudiri and AL-Karaghoulis stated that project management executions have been a success for some projects and a failure in others. Any project must be aligned with the business strategy of the company because misalignment will lead to project failure [5]. On the other hand, facilitating the decision making process is one apparatus to identify misalignment between the project and the business impact on the company, especially in the early stages of the project.

Czuchry and Yasin [3] state that meeting stakeholder specifications is the ultimate result of the environmental and organizational modes with distinct phases for different projects. The three modes during the project life cycle are the main considerations of effective execution of the project, and they are decisional processes, critical skills, and execution procedures. Understanding the project comes from necessary information about the project in decision mode. Interpersonal skills such as leadership as well as performance capability are the main considerations for central information in the critical skills. Project implementation in diverse dimensions is the primary focus of the execution process. Also, incomplete information will create problems for decision makers; therefore, higher managers must deliver the right information at the right time in order to make the right decision, as well as to avoid any delay in the project or misunderstanding of these decisions by employees. Gathering information by using different tools as well as for initiating the process of gathering such information helps to facilitate decision making processes and solve problems.

2.2 Project Management Processes

In [6], Uppal states that project management processes are a series of actions or functions that need to be executed to meet project objectives. In order to attain project objectives, a sequence of systematic methods needs to be continuously carried out to execute and evaluate the project. Therefore, five phases were developed to structure the project processes: initiating, planning, execution, monitoring and controlling, and closing. The objective and deliverables need to be specified for each phase to mark the end of certain activities and passage to the next phase.

Hamilton indicates in his book in 1997 that innovational thinking, technology, and tools related to problem solving can be facilitated through project management processes [7]. In his book published in 2004, Cleland mentioned that the Project Management Body of Knowledge (PMBOK) guide links the project management processes involved in the project with the project life cycle [8]. PMBOK classifies a variety of processes into different groups based on the nature of the process done. Five process groups related to the life cycle of the project have been generated. Each process group will be related to specific project phases and define the actions necessary to complete as well as highlight the transaction zones between each phase. The information included in these project processes are significant and valuable to any project manager. Although processes are different from one project to another depending on project type, location, and size, PMBOK groups the most common ones to facilitate the managerial processes.

Furthermore Cleland [8] states that during the *initiation-process group*, senior managers start to identify what the project needs for the initiated phase. Furthermore, the project goals will be defined in terms of the scope that the client or the company requires for the project, time available to accomplish the work, and the budget or resources essential to finish the project. Defining the objective of the project and selecting the project manager will be established in this process group [8]. In the *planning-process group*, the project objective is defined in more detail by prioritizing the scope, time, budget of the project, and determining the suitable level of authority in the decision-making within the project. The project teams will establish an integration project plan to involve the work flow, time, cost, and the internal-relationship between them. Before the execution of the project starts, project managers must get the approval

from senior management for the project plan. In the *execution-process group*, the implementation of the approved project plan will be initiated according to the defined schedule and the specific budget. In the execution of the project activity, both time and resources will be consumed, which requires continuous monitoring to ensure that the work is moving according to the project plan. The *controlling-process group* will afford feedback for the project manager in order to revise the project plan. In addition, the project personnel will document the progress of the work in terms of the time consumed, the amount of money spent, and the actual work finished. Therefore, the main purpose of the controlling process is to monitor actual work with the project plan so that any corrective action can be taken if the progress of the project doesn't match the plan. The *closing-process group* marks the end of the project by satisfying project objectives. In this process, all the closeout contracts, paying contractors, resource allocation, reassigning team members, and lessons learned from the project will be completed. Furthermore, all documents related to the project must be archived for future projects if possible. In addition, in the book *Management by Project* written by Albert Hamilton also follows the same processes in the PMBOK because they are the most common processes among such projects.

Lientz and Rea in their 2002 book state that in order to integrate project management processes, the following project elements should be included: the company strategy, the establishment of the project, project review, getting approval from the client and the regulatory institution, managing organization resources, making decisions based on the progress of the project, integrating the project with other work, and measuring the success or failure of the organization's project [9].

The following table shows the managerial function in the project phase to develop an action plan necessary for the project teams during implementation. It is one of the work documents that could be included in the project [6].

Table 1: The managerial function [10]

Phase 1: conceptual	Phase 2: planning	Phase 3: execution	Phase 4: termination
Identify need	Implement schedule	Procure materials	Train functional personnel
Establish feasibility	Conduct studies and analyses	Build and test tooling	Transfer materials
Identify alternatives	Design system	Develop support requirements	Transfer responsibility
Prepare proposal	Build and test prototypes	Produce system	Release resources
Develop basic budget and schedule	Analyze results	Verify performance	Reassign project team members
Identify project team	Obtain approval for production	Modify as required	

2.2.1 Mapping Project Management Process

In 2008, the Project Management Body of Knowledge (PMBOK) guide divided nine knowledge areas for project management. The first area is integration project management, a process that integrates all activities and processes that will lead to the completion of the project [11]. Several activities will be done in the project integration such as creating a project charter, establishing a project management plan, monitoring and controlling project work, and closing the project or phase [11]. The second area, project scope management, is responsible for defining what is included in the project and providing detailed descriptions for it. The work included in the project, defining scope, creating a work breakdown structure, and controlling scope are examples of the processes involved in this knowledge area. The third area, project time management, deals with timely completion of the processes included in the project, defining activities, estimating activity resources, developing scheduling, and controlling schedules are processes in time management. The fourth area, project cost management, contains the processes that deal with cost estimation and budget control to ensure that the project will be finished within the accepted budget. These processes include estimating costs, determining budget, and controlling costs. Fifth is project quality management, all the processes responsible for tracking the quality of activities and establishing quality policies are involved in this area of knowledge. Planning quality, performing quality assurance, and performing quality control are project management processes contained in this knowledge area. Sixth, project human resource management includes all the processes that deal with project teams in order to manage, form, and lead them. These processes include developing a human resource plan, acquiring a project team, developing a project team, and managing a project team. Seventh, project communication management deals with activities that facilitate the information flow between the project teams and stakeholders to ensure that correct information will be received at the right time. The processes responsible for that job are identifying stakeholders, planning communications, distributing information, managing stakeholder expectations, and reporting performance. In the eighth area, project risk management, the main purpose for the processes included in this area is to plan and analyze the response plan for any risk that may face the project in the future. These processes include planning risk management, identifying risks, performing qualitative

risk analysis, planning risk responses, and monitoring and controlling risk. The ninth area, project procurement management, is typically defined as dealing with all processes related to purchasing necessary products or services from vendors. Planning procurement, conducting procurement, administering procurement, and closing procurement are processes included in this knowledge area.

2.2.2 Detailed Description of PMPs

1. The initiating processes include the following processes:

- **Project charter development:** This process is the formal acceptance to initiate the project. Information required includes the project statement of work, which provides a general description about the services or the products that need to be done by the project, a business case to provide justification to investing in the project and it contains a cost-benefit analysis about the project. PMBOK in 2008 also stated that such work requires a contract for customers from outside the company, enterprise environmental factors, such as governmental standards and limitation of the infrastructure in the organization, and organizational process assets that include the organization standard and the policies that may have an impact on the project charter [11]. The process is applied by expert judgment to assist the information needed for the project charter. The goal of this process is to complete the project charter.
- **Identifying stakeholders:** PMBOK [11] stated that this process specifies all the people or organizations that have influence on the project and documents their interest about the project. Information required includes a project charter to identify the internal and external parties involved and who have influence on the project, and the enterprise environmental factors that may affect the process of identifying stakeholders, such as company culture and governmental standards (e.g. regulations), and the organizational process assets, such as the previous registers of stakeholders from previous projects. The process is applied by analyzing stakeholders whose influence should be considered during the project, and practicing expert judgment to identify and list stakeholders. The goal of this process is stakeholder registration by defining the following information: general data (name, location, his/her role in the

project, and contact information), and stakeholder classification (internal or external, their influence on the project support or neutral or resistor).

2. The planning process includes the following processes:

- Project management plan: Norman [12] stated that this process includes specifying how the project will be executed, monitored, controlled and closed. Information required by Norman includes the project charter, which is similar to that previously mentioned, the planning processes result that includes all baselines and subsidiaries in the management plans, and the enterprise environmental factors, such as governmental standard, information system management (scheduling software, collection and distribution information system), existing facilities and equipment. The organizational process assets include the project management template, project files from the previous project, instructions for work, and evaluation for employees. The process is applied by using expert judgment to determine the technical and detailed management that will be involved in the project management plan, specifying the resources and skill needed for the project work, and determining the processes that will be used to meet the project objectives. The goal of this process is to complete the project management plan and determine how the project will be carried out to meet the project objectives.
- Collection requirements: This process includes identifying the stakeholder specifications for the project and documenting them in order to fulfill the project objectives. Norman in his 2001 book indicated that information required includes the project charter to give details about the project needs, product description as described earlier, and the stakeholder register similar to that previously mentioned [12]. The process is applied by interviewing the stakeholders to collect the necessary information about the project, convening a focus group to gather the stakeholders and experts to find out their expectations about the project, a facilitated workshop to identify the cross-function requirements and consolidate stakeholder variation, group creativity techniques where several groups collaborate to identify project requirements, group decision making techniques to evaluate several alternatives to select the most suitable one, questionnaires and surveys to collect as much information from wide respondents as possible, and observations of the employees in a work environment and how they perform. The goal in this process is to complete

the requirement documents, management plan, and traceability matrix to link the origin of the requirements with their traces in the project life cycle.

- **Defining the scope:** This process is accomplished by providing a detailed description about the project. Charvat in his 2003 book stated that information required includes a project charter and requirements document, same as stated above, organizational process assets to identify the scope of the previous project, and policies and templates for the scope statement of the project [13]. Additionally, the process is applied by expert judgment to evaluate the necessary information needed to establish project scope, and alternative identification to generate several approaches for the project execution and work performance. Finally, the goal for this process is updating the project scope statement and project document.
- **Work Breakdown Structure (WBS):** This is the process of dividing project work and project objectives into manageable components. Information required includes project scope statement and requirement documentation, similar to that previously mentioned, and organizational process assets to use previous WBS from previous projects and follow the guidelines of WBS templates. The process is applied by decomposition, which is dividing the project work into manageable work packages and this is the lowest level in the WBS. The goal is developing WBS.
- **Defining activities:** Charvat also stated this process is done to identify the actions that need to be performed to meet the project objectives [13]. Information required includes the scope baseline, similar to that mentioned earlier, organizational processes assets (this refers to applying previous activities lists that had been used in previous projects), and the two projects must share the same characteristics. Moreover, the process is applied by decomposition or dividing activities into smaller and more manageable parts, and the goal of each activity must be identified. Finally, the goal of this process is to generate an activity list and activity attributes by providing a detailed description for each activity, and a milestone list to identify special points or events in the project.
- **Sequencing activities:** In this process, Charvat (2003) define the relationship between the project activities and specify the chronological order for the activities using a logical relationship. [13]. Also, information required includes an activity list, activity attributes, milestone list, and project scope list, similar to that stated

earlier. The process is applied through the Precedence Diagramming Method (PDM) to identify the longest path for the project activities, which is called the Critical Path Method (CPM). CPM specifies the logical relationship among the activities, such as Finish-to-start and Start-to-start relationships. We must also identify the activities that may need lead or lag in order to either accelerate or delay the successor activity. Finally, the goal is the project schedule network diagrams.

- **Resource Loading:** This step requires defining what resources are needed to complete each activity. According to Dennis (2008), information required includes activity lists, and activity attributes. Resource calendars are used to identify the resource availability during the project execution, and enterprise environmental factors which define the available resources for the organization [14]. Furthermore, the process is applied by expert judgment to specify the resources needed for each activity, alternatives analysis to evaluate each alternative for accomplishment of the project and the required resources for each alternative, published estimating data, using what the companies publish to identify the production rate and the unit price of the resources for each company, and using the available project management software to manage the resources for the project activities. The goal is activity resource requirements, and resource breakdown structure.
- **Assessing activity durations:** this process estimates the duration to complete each activity according to estimated resources. Information required includes activity lists, activity attributes, activity resource requirements to specify the resources needed to complete each activity, resource calendars, project scope statement to specify the duration according to the project scope, enterprise environmental factors, using the company database for duration estimating, the published marketable information, and organizational process assets, such as historical information about the duration and the calendars for the project. This process is applied by expert judgment, analogous estimating in order to estimate the duration for the current project activities, where previous estimation for similar projects can be used. It also uses parametric estimating to calculate the time required for the project parameters by using statistical correlation between the historical data and the different parameters, and three-point estimates (using three estimates to enhance the accuracy for the estimated duration activities which are: most likely, optimistic,

pessimistic, reserve analysis). The contingency must be included in the project schedule to account for the uncertainty in the project execution. The goal is activity duration estimation.

- Developing schedules: Dennis in his 2008 book stated that to build a project schedule, the following processes should be considered: chronological sequences for the activities, time required for the activities, and the resources needed [14]. The information required includes a list of all activities with their duration, required resources for each activity with their scheduling time, and scope statement for the project. The process is applied by scheduling a network analysis, a technique used to calculate the early and late start also by using several analysis techniques such as the critical path method, which refers to defining the early 'start and finish' and late 'start and finish' by carrying out forward and backward pass analysis for all activities in the project and identifying the longest path to finishing the project. The critical chain method is a technique used to adjust the project schedule according to resource limitation. Resource leveling can be used if there are resources available for certain times with restricted quantity. Applying lead and lags, schedule compression reduces the project duration without changing project specification as an example for this technique. Fast tracking changes the sequence of the activities from series to parallel. The goal is project schedule, schedule baseline, and schedule data.
- Estimating costs: This process refers to defining the estimation for the budget required to finish the project activities. Information required includes scope baseline, project schedule, human resource plan (calculating the project cost related to labor and all personnel involved in the project), and enterprise environmental factors. This process is applied by expert judgment, employing the previous cost estimation for similar projects to be applied in the current project, and parametric estimation. Vendor bid analysis can be used to calculate the cost of the project based on the bids from qualified vendors. Finally, the goal from this process is to estimate the cost for the project activities.
- Determining budget: Meredith and Samuel in their 2003 book pointed out that this process refers to collecting the calculated cost for each activity to the initiated cost baseline [15]. The information required per Meredith and Samuel includes activity

cost estimates, project schedule, resource calendars, and contracts. In addition, all the contract information related to the purchasing processes should be included in the cost estimation of the project. This process is applied by expert judgment, cost aggregation (collecting the estimated cost for the work packages in the work breakdown structure for the entire project), reserve analysis (reserving the cost needed for the contingency in the project budget), and historical relationships by using the parametric estimation for the previous project to develop a model for calculate the project cost. Finally, the goal is cost performance baseline, which refers to identifying the relationship between the time and the project cost to track and monitor the cost performance of the project.

- **Planning quality:** This process means specifying the standard quality for the project. The information required includes scope baseline, stakeholder register, determining the stakeholders' specification, cost performance and schedule baseline, and enterprise environmental factors, for example the government standard for project quality [15]. This process is applied by cost-benefit analysis, a financial analysis to balance the cost of the project with estimated benefit to satisfy the stakeholders' quality. The goal is a quality management plan, quality metrics, measuring the project quality according to specific standards, and quality checklists.
- **Developing human resource plan:** This process refers to defining the human resources needed and required skills to complete the project. The information required includes activity resource requirements and enterprise environmental requirements (such as the current human resources of the organization and the structure and the culture of the organization). This process is applied by using several formats, developed to document project team members and their responsibility, such as hierarchical charts, matrices, and text-oriented formats. Networking identifies both formal and informal interaction between the project team members and evaluates the effectiveness for each of them. In conclusion, the goal is a human resources plan.
- **Planning communications:** this process refers to identifying the appropriate communication approach to carry the necessary information for the project stakeholders [15]. The information required includes stakeholder register and stakeholder management strategy. This process is applied by communication

requirements analysis (specifying and analyzing the needed information for the project stakeholders), communication technology (determining the method to transfer the information between project stakeholders), communication models (developing a model to identify how the information is sent and received among the project parties and ensure the secrecy of the transfer information), and a communication method, which refers to how the information will be shared between project stakeholders. The goal from this process is to construct the communications plan that governs information flow to the project stakeholders.

- Clements and Jack in their 2009 book identified the following elements: Planning risk management: specifying how the risk will be conducted for the project activities [16]. The information required includes project scope statement, cost management plan, schedule management plan, and a communications plan. This process is applied by planning meetings and analysis, and conducting meetings with project team members to build up a risk management plan. The goal is to develop a risk plan for the project.
- Identifying risk: This process refers to specifying the risks that may influence on the project and the characteristic of those risks must be documented. The information required includes a risk management plan, activity cost estimates, activity duration estimates, a stakeholder register, a cost management plan, and a quality management plan. This process is applied by documentation reviews (reviewing all the project documents to specify potential risk), information gathering techniques (suitable techniques that will be used to gather the information that will identify project risk), Strengths, Weaknesses, Opportunities, and Threat (SWOT) analysis, expert judgment, and an assumptions analysis (identifying the assumptions and scenarios that help to develop risk identification). The goal is risk register, listing all the risks that will affect the project processes.
- Risk analysis: this is the process of highlighting the most likely risk to be occurring and perform detailed analysis for those risks [16]. The information required includes risk register, risk management plan, and project scope statement. This process is applied by expert judgment, risk probability and impact assessment, identifying the probability of each risk occurring, developing a probability and impact matrix by developing a matrix that specifies both the probability and the impact of the risks in

order to identify risk rating and prioritize them, and risk categorization, such as sources of the risk, and area of the project affected by this risk. The goal is to update the list for the project risks.

- Performing quantitative risk analysis means performing numerical analysis to identify the effectiveness of risks on the project objectives. The information required includes a risk management plan and a schedule management plan. This process is applied by data gathering and representation techniques, using interviews to collect the necessary data to quantify the risk probability and their impact on the project, probability distributions used to model and simulate the uncertainty in the project values such as project cost, activity durations, expert judgment, and sensitivity analysis to identify the impact of each risk and determine which one has the most impact on the project. The goal is to update the list for the project risks.
- Planning risk responses: Prepare a plan in case risk occurs and reduce their impact on the project objectives. The information required includes a risk register and a risk management plan [16]. This process is applied by setting strategies for the negative risks or threats, avoiding and eliminating risks by changing the plan for the project management (or transferring the ownership of the negative impact for the risk to a third party), strategies for positive risks or opportunities (exploiting and identifying the risks that have positive impacts on the project and sharing the ownership of the positive impact with a third party), expert judgment, and contingent response strategies to include the risks that may occur in the project plan and identify the trigger and then track those risks. The goal is risk register updates.
- Planning procurements: This is the process of identifying the suitable vendor, documenting the decision for the project purchasing, and defining the appropriate approach for the procurement process. The Information required includes scope baseline, risk register, project schedule, activity cost estimates, a cost performance baseline, and enterprise environmental factors, which include marketplace condition, locale requirements, and suppliers' performance or reputation. This process is applied by make-or-buy analysis to identify which work can be done by the project teams of the company, or is best to be done by teams from outside the company, expert judgment, and contract type (to identify the risk shared between the company and the vendor by this contract). An example for contract types

includes fixed-price, cost-reimbursable, and time and material contracts. The goal is a procurement management plan, procurement documents, and make-or-buy decisions.

3. Executing includes the following processes:

- **Managing execution:** This process refers to implementing the project works that had been defined in the management plan in order to meet the project objectives. The information required includes a project management plan, approved change requests to identify which changes on the process or the objective in the project are approved and which changes are not, and enterprise environmental factors, such as organization structure or culture, organization infrastructure, and stakeholders' tolerances about the risk. This process is applied by expert judgment, using automated tools such as a project management information system to monitor and direct project execution. The goal is to specify the processes that must be performed in order to meet project objectives, work performance information by collecting the information regarding the project activities to monitor project progresses, and project management plan updates.
- **Quality assurance:** This process refers to identifying the quality requirements needed to ensure the quality standards of the project. The information required includes a project management plan, quality matrices, work performance information, collecting the information regarding the project activities to monitor project progress, and quality control measurements, which refer to the process of evaluating project quality. This process is applied by planning quality and performing quality control, quality audits to specify whether project activities finished according to the organization and project policies, and process analysis to identify which processes need to be improved in the project improvement plan. The goal is project management plan updates, and change requests to take corrective action for any problem in the project.
- **Assigning project team:** This is the process of forming project teams to perform project activities. The information required by PMBOK in 2008 includes a project management plan and enterprise environmental factors, such as checking the availability for the human resource of the organization [11]. This process is applied by pre-assignment to assign the teams for the project process in advance, and

starting the negotiation process to select project teams. In case the project lacks teams to complete the project tasks, the company may use the in-house staff to finish the job. The goal is assigning project staffs.

- **Developing project team:** This is the process of improving the team's environment to reinforce their performance [15]. The information required includes project staff assignments, a project management plan, and resource calendars. This process is applied by interpersonal skills, such as creativity and influence, which help project team members to understand each other, providing training for the project teams to improve their competencies, team-building activities, helping team members to work effectively together, and recognition and rewards for preferable behavior. The goal is team performance assessments.
- **Organizing project team:** This is the process of tracking the performance of the project team members and providing feedback for their work in order to solve team issues. The information required includes project staff assignments, a project management plan, and team performance assessments. This process is applied by observation and conversation. Managers can stay in touch with project teams and see their attitudes on site. It can also be applied by conflict management, which is the process of solving any conflict among the project teams in the work environment in order to improve the team's productivity and interpersonal skills. Managers use their skills to deal with project teams, such as leadership, influencing, and effective decision making. The goal is an updated project management plan.
- **Distributing information:** This is the process of providing the necessary information about the project to the stakeholders. First, the information required includes a project management plan, organizational process assets (such as the organization policies about the information distribution and the company's historical information). Moreover, this process is applied by setting proper communication methods, such as group meetings, conferences, and computer chats. Finally, the goal is specifying the suitable method to distribute the information.
- **Managing stakeholder expectations:** Norman in his 2001 book indicates that the process of contacting and working with stakeholders involves meeting their requirements of the project and solving any issues that may occur [12]. The information required includes a stakeholder register, a project management plan,

and a stakeholder management strategy. This process is applied by communication methods to specify the suitable method for each stakeholder, and interpersonal skills. Managers need to apply suitable interpersonal skills to meet the stakeholders' specifications, such as resolving conflict and building trust. The goal is to update the project management plan and project document.

- Conducting procurements: This is the process of receiving vendors' proposals and selecting the most suitable one to award the contract. The information required includes a project management plan, procurement documents, source selection criteria which include all the information about the vendors, such as his capabilities, technical expertise, and capacity. The qualifying seller list contains the entire pre-qualified vendors who can possibly be awarded the contract, vendor proposals, and project documents. This process is applied by a bidder conference for the company and the vendors to submit their proposal, expert judgment, advertising about the required procurement items in the newspapers as an example, and an internet search for materials on the internet to buy. The goal is selecting the vendor, awarding the contract, and project management plan updates.
- 4. Monitoring & controlling includes the following processes:
 - Monitoring and controlling project execution: This is the process of evaluating, monitoring, and reviewing work progress to meet the project objectives. The information required includes a project management plan, performance reports prepared by project teams and includes the following information: current status, schedule for the activities, milestone, and forecasts. This process is applied by expert judgment. The goal is project management plan updates, and change requests that include any changes.
 - Performing change control: PMBOK in 2008 stated that this process refers to all the changes in the project scope, organizational process assets, and project documents that must be reviewed [11]. The information required includes a project management plan, and change requests to evaluate and monitor the changes in the process execution. This process is applied by expert judgment and change control meetings with project stakeholders to identify and review the requested changes, and the goal is updates change request, and project management plan updates.

- **Verifying scope:** This is the process of getting the formal acceptance from project stakeholders regarding project deliverables. The information required includes a project management plan, requirements documentation that includes all the project requirements that need to be satisfied along with stakeholders' acceptance, and validated deliverables. This process is applied by inspection to evaluate and investigate the project specification and whether they meet the acceptance criteria or not. Finally, the goal is accepted change requests.
- **Controlling scope:** This is the process of monitoring project specifications and managing changes in the baseline scope. The information required includes a project management plan and organizational process assets, such as the existing control policies and the methods to be used for the reporting and monitoring. This process is applied by variance analysis to compare the project scopes on the plan with the scopes that exist on the site and take corrective actions if variations are not within the tolerance zone. The goal is project management plan updates, and change requests.
- **Controlling schedule:** This is the process of supervising the project progress and managing the changes in the schedule baseline. The information required includes a project schedule. This process is applied by performance reviews to evaluate and review the schedule performance for work progress, variance analysis to measure the schedule performance and identify the variations between the original schedule and the existing schedule, project management software, and adjusting leads and lags to align the activities that delay the project plan. The goal is project management plan updates, and change requests.
- **Controlling costs:** This is the process of supervising the project budget and managing the changes in the cost baseline. The information required includes a project management plan, project funding requirements, and organizational process assets, such as the existing cost control policies and the methods to be used for reporting and monitoring. This process is applied by the earned value management, a project management technique used to integrate the scope, cost, and schedule baseline to help project teams measure project progress. In forecasting, project teams can forecast and estimate the budget at the completion of the project based on project performance. In variance analysis we identify the variations between the

original cost estimation and the existing cost by using project management software, and the goal is budget forecasting, change requests, and project management plan updates.

- Quality control: this is the process of evaluating and monitoring the quality of executing activities to measure the project performance and suggest any necessary adjustments. The information required includes a project management plan, quality metrics, and deliverables. This process is applied using several diagrams and charts to measure the quality of the project activities, such as cause and effect diagrams, flowcharting, histograms, Pareto charts, and scatter diagrams in addition to using inspection to evaluate and investigate the quality of the project activities and whether they meet the acceptance standards or not. Finally, the goal is quality control measurements, change requests, an updated project management plan, and validated changes to inspect any changes in the project and get the acceptance or rejection of the stakeholders before applying those changes.
- Reporting performance: This is the process of how the information about the project performance will be collected and distributed [11]. The information required includes a project management plan, work performance information, such as progress of the schedule, status of the deliverables, and incurred costs, and budget forecasts to provide information about the necessary additional funds for the remaining work in the project. This process is applied by variance analysis to evaluate the variances among the actual performance and the baseline, and forecasting method to anticipate the future performance of the project according to actual performance. The goal is reports about the performance, and change requests.
- Monitoring risks: Smith [17] stated that this is the process of monitoring and evaluating the risks that face the project or may face it in the future. Information required includes a risk register, a project management plan, and performance reports. This process is applied through risk reassessment to reassess the current risks, future risks, and close risks on a regularly scheduled basis. The goal is risk register updates, change requests, and project management plan updates.
- Administering procurements: This is the process of monitoring and managing the procurement relationships between the vendor the company. The information required includes procurement documents, a project management plan, a contract,

and approved change requests that include all the adjustment for the contract terms and conditions along with the approval about those changes. This process is applied through a contract change control system to identify how to modify the procurement process, procurement performance reviews to compare vendors' progress with terms of the contract, inspections and audits to check that the vendor meets the contract terms, performance reporting to document the performance of the vendor (that they fulfill the contract objectives), and a records management system to manage the contract and document the procurement process during the project execution. The goal is procurement documentation and project management plan updates.

5. The closing process includes the following processes:

- Closing the project: This is the last stage in the project life cycle which finalizes all the activities of the project and reviews all the documents related to the project processes before closing the project. The information required includes a project management plan, and accepted deliverables and the specifications accepted by the stakeholder during the execution of the project process. This process is applied by expert judgment. The goal is the final product or service.
- Closing the procurement systems: Every project procurement should be closed in this process. Information required by PMBOK in 2008 includes a project management plan, and procurement documentation [11]. This process is applied by procurement audits to review the procurement process that has been generated from the plan procurement, and negotiated settlements to settle all the issues and disputes in the procurement relationship between the vendor and company by negotiation. The goal is closed procurements.

2.3 Green Project Management Concept

Before adopting green practices into the organization, managers need to execute new activities beside their traditional activities in the organization in order to ensure effective execution of the project. Nancy Kurland and Deone Zell interviewed 30 sustainability management staff in 20 different industries, and they highlighted the most important activities in green management [18]. Ten activities have been suggested along with the managers' traditional activities. The first activity of the company would

be to establish the green value. Managers need to recruit employees who believe in green values as well as company values. The second activity would be for the company to plan and implement the green goal by preparing company facilities. The company services and products would need to be green oriented. The third activity would require managers to set up a sustainable metric system to measure the green goal development in the company through measuring and addressing sustainable metrics in the organization and motivating employees. All necessary information will be gathered either by an in-house department or outsourcing to a consultant company. Different municipalities, countries, and governments require specific requirements from the company to apply green management. The fourth activity would need a business case to be established for the green value implementation; for example, return on investment must be analyzed to ensure that the company's facilities will enhance operational efficiencies. The fifth activity would include overcoming expected resistance towards changes in the organization; therefore, employees should be educated about the green management as it is a new field in the business environment, and leadership positions should be offered to the right people. Managers should motivate employees toward green processes by providing incentives, either by recognition or money. The sixth activity states that inside the organization, managers need to support sustainable practices and green values by creating a new job title for sustainability, which will be located in higher levels of the organization. Managers should also provide training for employees on sustainability to improve their experience. The seventh activity requires managers to seek the support of their suppliers for green practices of the organization by using the company's position in the business environment to encourage suppliers to adapt to the new sustainability criteria. The eighth activity would be for managers to ensure proper communication and collaboration in order to achieve integration with suppliers by providing necessary data to support the product life cycle and customer awareness about eco-friendly products in order to increase demand. On the other hand, collaboration with competitors who have more experience with environmental practices may help the company to achieve a successful business environment. The ninth activity is for managers to work with nongovernmental organizations that try to resolve environmental issues. This will enable the company to be familiar with the standards required from the regulators to ensure that the company is meeting them. The tenth

activity is in the field of sustainability in an organization that requires managers to promote these green concepts to maintain the company's reputation in this field.

Green project management highlights specific bases in the process of planning, coordination, and controlling to satisfy clients' requirements. Those bases meet the project objectives within approval time, and the cost of the project should not exceed the agreed budget, but without compromising the quality standards or the environmental aspect. The main goals for green project management related to the organization will be to improve the efficiency of the organizational economy and the organization can achieve its sustainability developments.

On the other hand, in their 2011 conference paper Dai and Xu said that the impact of green project management goals on the society is that human living standards will be improved, and they will preserve the environment while maintaining an improved quality of life [19]. In other words, humans and nature will be in harmony and achieve the saying "being one with the environment." To reach those goals of green project management, companies must use the latest green technologies, energy preservation, and pollution control techniques. Finally, companies must adapt scientific methods to construct a waste disposal plan. There are four parts in the green project management concept. First, the guidelines for the project will be the ecological objectives to achieve sustainable goals and create green values. In order to formulate these objectives, companies must understand the law of ecological movement and how to minimize the negative impact that the project can pose on the environment. Second, companies must consider the economic, social, and environmental objectives. Both natural and social attributes are related to green project management which increases the complexity on managers when they establish project objectives. Third, consider implementing green project management on the full life-cycle of the management, which includes project conception, project approval, project execution, and project closing to balance the organization's resources with the environmental processes. Fourth, deep understanding for quality, economy, scheduling, and safety control when companies implement green project management will give new perspectives on the cost, time, quality, and safety. It also introduces new requirements, such as resource conservation, environmental protection, and decreasing pollution.

2.3.1 Green Management Techniques

In [20], Vivian Tam and Tsui stated that green construction assessment provides the assessment tools to help continuously improve the construction process as well as quantify environmental fulfillment. The green construction assessment will be based on what the client wants to measure, not what the assessment tools measure; therefore, a pilot study will be conducted to identify the assessment criteria that concern green developers. To develop suitable weighting indicators for such complex and uncorrelated green assessment criteria, a scientific method should be used to identify the weighting criteria for Green Construction Assessment (GCA). A “Non-Structural Fuzzy Decision Supporting System” (NSFDSS), decomposition, comparative judgment, and synthesis of priorities are principles that this system depends on. The framework for the decomposition principle starts from the goal of the criteria followed by the sub-criteria which involves working from the top level toward the lower level. On the other hand, the comparative judgmental principle depends on pair-wise between the criteria in one level and the property of the preceding level, after which it will be used in the corresponding matrix. On the contrary, the synthesis of priorities principle will be the multiplication of level two criteria with the criteria in the above level and weighing each component depending on the effects of these criteria which give the general priority of each element. There are similarities between the Analytical Hierarchy Process and NSFDSS which are both methods which use the three principles discussed above. In essence, these processes simplify the problem into several levels and compare between the elements individually and consistently. Checking has been provided for both techniques to provide the justification for the final decision matrix. NSFDSS has three options for measuring the internal relationship between the criteria which are different from the techniques that Saaty uses. Tam and Tsui established the following criteria relationship measurement: “C1” is better than “C2”, “C1” is equally as important as “C2”, “C1” is worse than “C2”, where C1 and C2 refer to any criteria that will be used in the process [20]. Therefore, Saaty’s technique is much more complicated than the NSFDSS technique because Saaty’s technique is based on nine levels, whereas NSFDSS comprises three levels to determine the internal relationship between the criteria. The consistency index for AHP is 0.1; if it is exceeded, the entire matrix should be re-constructed manually. To verify the efficiency and the consistency

of green construction assessment for the effectiveness in the environmental performance, three projects that had similar characteristics were located in the urban area, under the control of managers with similar levels of understanding in the field of environmental projects in order to avoid the inconsistency and the deviation of results caused by assessment standard deviation.

In the Study of Green Project Management journal, the authors talked about the concept of green project management. Also the authors establish a Green Project Management Assessment Framework (GPMAF) in the construction field [19]. Figure 1 highlights the structure of the GPMAF model

Figure 1: The structure of GPMAF model [19]

The most essential properties of the GPMAF are: *Guiding* for the green indicator variable; in order to reflect the impact of the environment on the project processes in each phase, those green indicators must be flexible enough to cope with changes in the environmental criteria. *Dynamic* is another property. Because there are multi-disciplinary concerns in the GPMAF model and the complex process involved in it, an evolving model needs to be developed to monitor and evaluate the project management organization processes in order to cope with the dynamic environment. *Comparison* is one of the properties used to provide reasonable explanations for the model implementation due to lack of its own assessment by comparing with other green projects. *Systematic* is required for the model to provide integrated thinking for the total framework construction. *Limitations* in applying the GPMAF are considered a drawback in this model because the implementation of the model depends on the type

of project, and this model deals with only construction projects and cannot be implemented on other project types. [19].

2.3.2 Green Project Management Processes

As mentioned earlier in this study, green project management is a relatively new field in the business. Therefore, few research papers have been conducted on green project management processes. On the other hand, the increasing demand for green projects will boost the research effort in this area to facilitate green projects.

Introducing the green thinking concept in project management processes is the first step to move toward green projects through making decisions that consider the impact on the environment [21]. The main purpose for green project management is not to convert every decision related to the project to be environment friendly, but to put the environmental aspect into account when making decisions without ignoring it. The nine areas of project management defined by PMBOK will be considered in the process of implementing green thinking to project management processes. In *integration management*, the environmental aspect will be included in the evaluation process for each change in the project activities as factored in the decision-making process. Usually, project charters include a section for environmental concerns, but most project managers will not take it into consideration when defining the project. Considering the environmental impact to the *scope management process* besides the business value and project impact will be one way to introduce green thinking into the project. In addition, project management can add new work packages to the WBS to emphasize the alignment of the company strategy with environmental policy. As an example, applying Leadership in Energy and Environmental Design (LEED) criteria to construction projects will reduce the environmental impact of the project. In *time management*, new activities that support the environmental policy of the company will be added into the project schedule when a company adopts green project management, such as activities related to fixing solar panels on the roof of residential buildings. On the other hand, *cost management* will include the additional cost related to environmental activities and processes. The role of *quality management* is to specify quality criteria that suit the specific project and reinforce the company's environmental policy. Moreover, if the company focuses on green project practices, managers need to expand the quality

discussion that deals with satisfying the shareholders' expectations to include the environmental considerations of the project. The main function of *human resource management* is to educate project team members on green practices because project teams will be responsible for evaluating the green processes and providing alternatives as well as recommendations for the project. With respect to *communications management*, managers should include in their communication plan any activities that help to increase the awareness of stakeholders about green processes. All actions in the project related to the environment must be included in the status reports. In *risk management*, project teams must evaluate the risk of adapting green processes and their impact on the company. Green project management is a new approach in the business; therefore, it poses high risk. Moreover, they must prepare a contingency plan in case the probability of the risk is high. Regarding *procurement management*, companies must provide proper education for the vendors working with the company on specific projects about green processes the company adopts. The main idea here is not to address new processes but to adopt green project management into existing processes.

2.4 Analytical Hierarchy Processes (AHP)

The Analytical Hierarchy Process (AHP) a method for decision-making developed by Saaty. The main purpose of this analysis is to quantify a set of alternatives by using a ratio scale approach according to the decision-maker criteria. A decision-maker is judged on the alternatives depending on his knowledge and experience. One of the strong points of the AHP analysis is its capability to quantify and classify both tangible and intangible factors which simplify the problem solving process in decision-making. It also breaks down a large difficult problem into several smaller problems that can be solved easily. On the other hand, Al-Hardi and Al-Subhi in their 2000 article stated that the Multiple Criteria Decision-Making (MCDM) approach is one of the assistant methods of decision-makers to provide full understanding for the project problems. Also, this method helps identify suitable courses of action to solve the problem. MCDM will evaluate the different courses of action with several dimensions that cannot be evaluated by a single dimension measurement [22].

Saaty stated that AHP analysis develops a framework for decision-making in order to reach effective decisions for complex problems. The Analytic Hierarchy Process method has the capability to convert decision-making processes into a

systematic structure, and synthesize them to mutually interacting parts by quantifying their impact on the ranking of these parts [23].

2.4.1 How Analytic Hierarchy Processes Work

Before starting to use this method, managers need to collect all relative information that concerns the project in as much detail as possible. Then, this information needs to be constructed into a hierarchy. For example, the objective for the project should be at the highest level of the hierarchy. The following level is a set of criteria in order to evaluate the objective of the project. The subsequent level is a series of alternatives that have either negative or positive impacts on the project's objective. After the hierarchy is constructed, the managers' judgment is used to quantify the criteria by assigning a number from 1 to 9 to each criterion to highlight the important elements in the hierarchy. These judgments must be made by experts in the project field who have proper knowledge to help them in the ranking the process. Although experts will carry on the process of prioritizing the judgment, mistakes may occur. Therefore, a consistency test will be run in order to measure the uniformity of the judgments. If the consistency test fails, the prioritizing process of judgments should be redone, or the hierarchy should be re-constructed. The hierarchy of the project and the consistency test are considered powerful tools to ensure expert judgment homogeneity and is one of advantages in AHP analysis.

2.4.2 Priorities Process in AHP

In order to solve the problems that may arise by applying the AHP analysis, a specific outline needs to be constructed. First, the problem and its desired solution must be identified. Second, a hierarchy must be constructed to solve any complicated problems; the brain usually tends to decompose it into clusters and these will be divided into small parts that share the same characteristics in the hierarchy. Third, priorities should be established by developing a pair-wise comparison matrix to compare two similar parts with specific criteria. In order to have excellent judgment while setting the priorities, a clear understanding of the project is required for all members involved in this process so as to reach the most effective decision during the project life cycle. The result of each weighted element should be collected and the highest one should be

selected. Then, the consistency of the judgment for each element should be tested; either the criteria are grouped in one coherent part that shares the same objective or they are grouped as inconsistent parts that do not have any relationship between them. To estimate the consistency test for the entire hierarchy, each criterion is multiplied with a consistency index. Then the products are added. To find the consistency index, first Eigenvector $\lambda_{\max}$ must be identified for each weighted criteria; then the consistency index is calculated by using the following equation:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \text{ where } n \text{ represents the number of alternatives in the pair-wise}$$

comparison matrix.

Furthermore, Saaty stated that to define the consistency ratio, the next equation $CR=CI/RI$ will be applied, where RI represents a Random Index that can be obtained by knowing the number of alternatives and matching it with the corresponding random index [23]. Table 2 shows the RI for the consistency ratio.

Table 2: The average consistency with respect to matrix size

Matrix size	1	2	3	4	5	6	7	8	9
consistency	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45

According to Saaty, if the consistency ratio is superior to 0.1, the test fails to find a consistency between the weighted criteria; otherwise, the ratio will be in the accepted zone [23]. The next table shows the nine-scale rating system.

Table 3: Nine-scale rating system [23]

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An evidence is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometime one needs to interpolate a compromise judgment numerically because there is no good word to describe it
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with j , then j has the reciprocal value when compared with i	A comparison mandated by choosing the smaller element as the unit to estimate the larger one as a multiple of that unit

2.4.3 Practical Application for AHP

In their 2008 article, Wong and Li stated that one of the applications for AHP analysis is the selection of intelligent systems for a sustainable building, which will improve the performance of the building and reduce the energy and water waste in the building. There are two factors that make the justification of other modules for the selection of intelligent building technology not practical and inefficient. Some models focus on cost performance without considering other factors, such as environmental protection and the flexibility of the building [24]. Therefore, the decision will be misleading and biased. Other modules fail to quantify some criteria. As a result, these factors get neglected, which causes severe consequences in the long-term. In order to define the criteria that will provide guidelines for planning the improvement for the upcoming design, experts and professionals in the field of intelligent building technology were asked to fill out a questionnaire to identify the suitable and most effective criteria. Then an AHP matrix was constructed and the weight assigning process was developed through the feedback of the survey. The criteria that the survey highlighted were as follows: The main criteria for Intelligent Building (IB) are the work efficiency, such as fire detection and alarm system, security monitoring and access control system, and hydraulic and drainage system. On the other hand, the HVAC system and lighting system tend to prioritize user comfort rather than work efficiency. The sub-criteria that were placed under the main criteria of cost effectiveness were the operation and maintenance costs. One of the findings that the survey showed was that none of the sub-criteria had dominance over the other. Therefore, all sub-criteria set below work efficiency were equally important. All the criteria had been identified and organized by using Saaty's consistency test to reach a suitable decision. In summary, each IB system had been developed using a set of selective criteria that had a special weight. Work efficiency is considered the most important criteria among all the others such as user comfort, safety, and cost effectiveness which are less significant. Reliability and operating and maintenance cost are two sub-criteria that have high significance according to the responses of the survey. These indicate that the owner and decision-maker consider the long term expenses as the main priority. In this study, AHP analysis was used to consider the different criteria in the IB and facilitate the decision-

making process to choose the most suitable and effective intelligent techniques to use in modern buildings.

AHP analysis can be a powerful tool to integrate environmental factors for purchasing decisions and as an assisting tool for managers to recognize the trade-offs among the environmental dimensions as well as to evaluate the performance of suppliers with differences in environmental traits. Both quantitative and qualitative elements are involved in the decision-making, which makes it a complicated process. Constructing an AHP model can help deal with different industrial applications which are the main challenges to overcome. In order to establish a framework for the various types of environmental criteria, a Delphi group study was conducted for a group of supply chain managers. The purpose of this method is to evaluate the individual criterion ranking and develop a single collective framework to emphasize the result. Table 4 shows the most important criteria in selecting company suppliers.

Table 4: Important criteria for selecting company suppliers [25]

Top 10 criteria for supplier environmental performance	
Top 10 – most important	Top 10 – most easily assessed
1. Public disclosure of environmental record	1. ISO 14000 certified
2. Second tier supplier environmental evaluation	2. Ozone depleting substances
3. Hazardous waste management	3. Recyclable content
4. Toxic waste pollution management	4. VOC content
5. On EPA 17 hazardous material list	5. On EPA 17 hazardous material list
6. ISO 14000 certified	6. Remanufacturing/reuse activity
7. Reverse logistics program	7. Returnable or reduced packaging
8. Environmentally friendly product packaging	8. Take back or reverse logistics
9. Ozone depleting substances	9. Participation in voluntary EPA programs
10. Hazardous air emissions management environmental record	10. Public disclosure

Each of these attributes has identical importance in the supplier's assessment development for the environmental performance. Moreover, this model has the flexibility to fit into any supplier's assessment [26]. Each criterion had a pair-wise comparison with the other criteria and they ranked them from (1) to (9) in order to evaluate the importance of each. To determine the effectiveness of the AHP models for the environmental assessment performance, three pilot studies had been developed to ensure the usefulness of the model produced in the Delphi group, as well as to investigate the weaknesses and the strengths of the various environmental purchase

tools. Each pilot study was conducted with a specific manager in different industrial areas to verify the effectiveness of the AHP model that had been developed, and the company tried to apply the constructed AHP model to their suppliers list. The first pilot study shows that the AHP model is a helpful tool to achieve a better understanding of the suppliers' evaluation in the environmental criteria. The second and the third studies show similar results to what has been seen in the first one. AHP analysis is considered a helpful tool to close the gap between the assessment of the supplier to the environmental responsibility and their products. In their 2002 journal article Handfield et al. stated that the framework that AHP provided does not only solve the problems due to the difference in the environmental criteria, but also integrates the environmental criteria with the decision-making process and addresses the environmental issues in this process [26].

In their 2012 article, Bentes et al. point out that the organizational performance measurement can be a complex task due to several factors involved in this process including the priorities of these elements that vary from the managerial perspective. The inconsistency between these factors is the main issue faced in the organization assessment. In order to overcome these problems, two methods were integrated which are the Balanced Scorecard (BSC) to develop the framework for the assessment performance and the Analytic Hierarchy Process (AHP) that establishes performance prioritization and develops a unified metric for the alternative ranking [27]. AHP analysis is considered an effective tool in addressing multiple criteria problems, such as performance analysis comparison. In addition, AHP takes into account all the performance dimensions relevant to the organization and is a helpful method in the BSC analysis. The main focus in the organizational performance is the financial department, particularly the three financial functional units in a specific company. After the final result is found, it can be applicable to the other departments in the company. In order to construct an AHP diagram, sixteen members had been chosen; nine performance indicators had been set to evaluate weighting performance indicators, which were built based on the group agreement approach to balance the relative indicators as well as provide the reasons behind the chosen specific weight for the given indicator. For each indicator, a local normalized weight was calculated and the consistency test was checked for each indicator in the comparison matrix to ensure that they were in the

accepted zone and to minimize inconsistency. The next step was to evaluate the alternatives for each sub-criteria of the performance indicator. Once the evaluation was complete, the higher performance weight was chosen.

In their 2012 article, Bruno et al. stated that the process of evaluating suppliers is an essential step in any large company to determine the competitiveness between them. AHP analysis is one of the methods that has been used in the supplier evaluation process [28]. In order to implement the AHP method, first, a hierarchy of the problem must be developed by using a committee to identify the relative information; each committee member chooses the most significant features in the supplier evaluation from 30 attributes. The committee holds a meeting at the end and selects four attributes which are process and product quality, service level, management and innovation, and financial position. Next, the same committee chooses three sets of measurable alternatives for each attribute. Moreover, the committee asks to weigh each attribute by using pair comparison for two attributes simultaneously. This minimizes the inconsistency in this process and simplifies the consistency test. To calculate priority vectors, first the eigenvector must be identified from the maximum eigenvalue for each attribute as well as for the corresponding alternatives. After the calculation of each attribute is completed, the global score is assigned for each of the suppliers. To find this score, an indicator must be recognized for each alternative; to establish these indicators tremendous effort is required for the sake of the comparability of various measurements. The final step is to analyze the results and rank the selected suppliers according to their score from highest to lowest. One of the shortcomings in this method is that any change in the indicator's score will change the final ranking of the suppliers; therefore, expert judgment is required in the processes of weighting the attributes. On the other hand, the main advantage of AHP analysis is the ability to collect information by breaking down the problem in a hierarchical order; therefore, it is the most suitable method to use in the supplier selection. Also, it considers different criteria, a variety of indicators and the contribution of the data that is collected by experts to calculate the final score of the supplier. In addition, intangible and qualitative measurement is recognized in the AHP method for the evaluation performance. Due to the dynamic nature of the supplier selection methodology, continuous improvement and monitoring is required. To achieve that, the result of implementing the methodology is considered

the initial point for the next suppliers' selection evaluation. The AHP method will help the customers and suppliers to enhance the understanding of how the supplier system works and define the weaknesses as well as the strengths of the suppliers. Moreover, AHP methodology will enhance decision-making for the purchasing process which will help the decision maker in this process.

Wu et al. [29] used AHP to establish the ranking process for the accessibility criteria in developing a molding for building accessibility assessment. To determine the accessibility indicator for the AHP methodology, the following steps are needed. First, accessibility indicators are established as an objective of the study, and the hierarchy for the accessibility indicator is structured depending on British standards (BS 8300:2001) used for the detailed criteria for the building design. Four levels are structured for the design accessibility criteria. The first level involves ensuring the accessibility of the building and overall accessibility indicator; the accessibility assessment capacity will represent the second stage which has two areas, physical features and access management issues. Decomposing the second level into detailed elements for each distinct area is the third level. The component that will affect the accessibility assessment will lie in the fourth level. After the hierarchy is completely constructed, a pair-wise comparison is established for each element by using a 9 point scale to quantify the accessibility criteria. In order to weight these elements, a direct questionnaire with experts in building accessibility is conducted as a contrast to other studies that depend on a group of experts gathered to emphasize the weighting criteria. After the pair-wise comparison is completed, a matrix for the individual level in the hierarchy is produced. In addition, the matrix eigenvalue as well as the global weight will be calculated according to Saaty's equation. A consistency test will be established by using the calculated Eigenvalue for each matrix. Furthermore, Wu and Tah stated that in order to calculate the overall accessibility indicator for the entire building, a five-rating method is used. The five-rating score to evaluate building components separately will be as follows: outstanding (O=1), good (G=2), average (A=3), fair (F=4), and poor (P=5). Finally, the highest global weight of the accessibility criteria is selected [29].

2.5 What a Decision Matrix is

A decision matrix is another tool used to facilitate the process of decision-making. It has been applied broadly in different industrial areas. The main purpose of this method is to ensure the contribution of all relative aspects related to the decision process and arrange them into a matrix. A decision matrix will provide a clear understanding of all factors related to the decision in order to help the decision maker reach a suitable decision.

2.5.1 How a Decision Matrix Works in Practical Application

In their 2000 journal article, Colwell et al. stated that a decision matrix can be used as an assistance tool in the process of selecting a vendor in a company. The main idea of this matrix is to quantify a criteria weighting and identify potential vendors by measuring successful key criteria for each of them [30]. Six steps were developed to design the vendor selection matrix. The first step is to identify the key criteria in the vendor selection. In fact, a common definition has been established for these criteria in order to eliminate any confusion in the process of selecting vendor and searching for these criteria during vendor presentation. The second step is to separate the individual criteria and identify the weighting scale. To define a suitable weighting criterion, first, the weighting criteria are grouped into three categories according to the level of importance (high, medium, or low). Next, the weight of each criterion is distributed among these categories and the sum of all criteria must be equal to 1. In the fourth step, each criterion has a rating scale to measure the success of the vendor. There are no specific rules in the process of defining a rating scale. The critical criteria in the fourth step must satisfy the minimum score; each vendor must meet the minimum critical criteria set for the project to consider that vendor qualified. In the fifth step, the differences in the knowledge between the voting practitioners must be considered in evaluating the vendor. If any member in the voting committee does not have the necessary experience or knowledge for a specific criterion, he/she rates zero for this criterion and is eliminated from the total vendor score in order to avoid any unfair rating for the vendor. Both selected vendors and voting members must set a definition for the criteria to ensure they have a similar understanding for each criterion. The final step is to get the approval of the senior manager for the buy-in process for the selected vendor,

as well as the support of the senior manager for the decision that comes from team members. Each team member will complete their own rating matrix and consolidate them after finishing the entire matrix for each member. This method will ensure that the opinion of each voting member will not affect the judgment of the other. The consolidation process will be as follows: all the information is obtained from individual voting members for every criterion for each vendor. Then it will enter the consolidation matrix and the mean rating and mean value will be calculated through this matrix. After the consolidation process is complete, Berens (1971) mentioned that the members will receive the score value of each criterion to compare with the mean score criteria for the individual vendor [31].

Nicholls in his 1995 journal article stated that a decision matrix is used to determine the strategic decision for the company and how to arrange an organization portfolio for the selected project, in order to manage the scarce resources of the company. A mission and core competences (MCC) decision matrix is developed to support the core competences of the organization, re-allocate the resources to the organization's activities, and fulfill the mission of the company [33]. An MCC matrix consists of two axes, the core competences are located on the X-axis and the mission is placed on the Y-axis. Each axis is separated into two halves: good and poor fit. In order to place the resources claim either for the project or product in the MCC matrix, two questions must be answered: "What will help achieve the company's mission?" and "How will the core competences of the organization be developed?" Strategic assessment in any level in the organization considers the main advantages of using an MCC matrix. Also, any sub-unit in the organization that has a clear understanding about the mission and core competences can use this matrix which makes it a powerful tool in leadership transformation. MCC has three advantages in the allocation of resources among the selected projects. First, it combines both mission and core competences in the process of strategic decision making for the sake of the organization's fundamental health. Second, it is used to challenge and improve any assumption for the core competences and mission definition. Finally, it can be employed by any sub-unit in the organization. In the MCC matrix there are four quadrants. Drive, located in the upper right quadrant, contains both mission and core competences, and these are higher in this

quadrant. Therefore, any products or projects located in this quadrant should be cherished because they derive the synergy of the organization's strategies.

On the other side, any projects or products sited in the Drain, which is located in the lower left quadrant, have low mission and core competences and should be a nominee for elimination because they are wasting the organization's resources. The other two quadrants which are considered sub-options because they can satisfy only one criterion are called Dilution and Distraction. Distraction is located in the bottom right quadrant; therefore, any projects or products that fall in this quadrant will only meet the core competences of the organization. On the other hand, any products or projects that fall in the Dilution quadrant which is located at the top left quadrant can satisfy the mission criterion only. The MCC matrix helps the organization to answer the basic question of how the scarce resources will be allocated.

In his 2003 journal article, Ball stated that some public sector services for the local government need to outsourcing, especially in libraries, by forming a partnership with the private sector. Therefore, a matrix needs to be developed in order to identify whether the service is suitable for outsourcing or not. In this matrix, the X-axis is for the relationships and the Y-axis is for the process continuum. In the vertical axis, there are four continuum processes. The folklore or traditional process that have no real justification, therefore, must be "rooted out". Both Mandated and Background processes are possible nominees for outsourcing [34]. On the other hand, Priority, which deals with effectiveness as well as major operations, and identity which represents organizational characteristics, must be kept in the house because outsourcing these processes may impact negatively on the organization and compromise the organization strategies. The horizontal axis represents the relationship between the organization's suppliers or partners or stakeholders as well as determines the intensity of this relationship; the relationship that is located at the right side is more suitable for outsourcing and the relationship that is placed at the left side should be handled in the house. There are nine factors to be considered in the process of assigning suitable services for outsourcing procedures, which are located in three categories: cultural, economic, and functional. These factors will be weighted by the experts in the organization and multiplied with the rating scales in order to get the total score.

In order to develop a decision-making matrix, Zanchettin in his journal article in 1992 stated that the following steps must be followed. First, the important parameters must be established to formulate the decision. After that, each parameter should be weighted according to the level of importance. Weighting them from 1 to 10, the highest parameter will be the most important. This will be done by professionals either individually or in groups. The next step is to assign ratings for the parameters such as the 1 to 4 rating scale, where four is considered the most favorable parameter and one is the least favorable parameter. The final step is the mathematical procedure of multiplying each weighted parameter with its respective rating and calculating the sum of them to find the total score; the highest total score represents the most preferable choice to be selected over the other. This decision matrix is suitable for any decision process that may face the company or a person in the business world or even in life [35].

Chapter 3: Research Methodology

This study provides a framework for a decision matrix in green project management processes. A combination between the analytical hierarchy process and decision matrix method has been used in this study. Green project management involves several criteria such as cost, time, quality, social factors, and environmental impact. Therefore, these methods were chosen because they are considered powerful tools in the multi-criteria decision-making process. In order to formulate the framework for the research methodology, two stages will be followed. Stage one will discuss the integration of the environmental impact in the project management process to identify the green project management process. In stage two, both the AHP and the decision matrix will be constructed.

3.1 Integration of Green Project Management Processes

Khalfan in his 2006 journal article indicated that adopting green processes in the construction industry is considered the most critical factor. The impact of the construction industry on the environment will vary according to its size, activities, people involved, and waste generated; therefore, it will be considered in this study due to its major impact on the environment. In addition, the process related to the construction industry will be considered as well [36].

In his 2010 article, Kubba stated that including sustainable activities into traditional activities requires redefining and redesigning the construction processes to ensure the effective adaptation of those practices into project objectives [37]. For the purposes of this study, the integration of green aspects into the traditional project management processes was carried out and the result is shown below.

1. The Initiation Phase

- **Environmental Impact Assessment Study:** Ravi et al., in their 2012 book indicated that this process helps manager to determine the environmental consequences for the entire project [38]. Those impacts may have a positive or negative impact on the environment. Carroll and Turpin in their book in 2002 stated that an environmental study for the project must be prepared to specify environmental assessment [39].

Similarly in the project charters, all those impact assessments can be included in the environmental concerns section [40].

- **Green Stakeholder Interest:** Knowledge of stakeholders about green practices and the environmental impact must be identified, along with their tolerance about the risks in green projects must be specified. Luyet et al. in their 2012 article stated that stakeholders should provide clear definitions about their green specifications for the project to avoid any misunderstanding later in the project phases. Identifying the interest of the stakeholder will be done through regular meetings with project management [41].
- **Green Organizational Thinking:** This is done so the organization can cope with dynamic requirements for the green project and prepare the organization to handle multi-dimensional criteria for the environmental factors. Training must be provided for the organization employees about green practices to change the mindset of the employees. Incentives must be offered to encourage the employees to accept green thinking in the organization. Eccleston in his 2000 book pointed out that an example of green thinking is recycling the old equipment of the organization [42].

2. The Planning Phase

- **Environmental Impact Assessment Deliverables and Activities:** In defining the project scope and activities that have significant impact on the environment as well as the environmental risks about the project, activities should be specified. To start environmental impact assessment for the project, first managers must provide clear definitions for the project deliverables and activities such as what changes in the environment that project deliverables and activities may cause, quantifying those impacts if it is possible, and reporting the result to the project stakeholders to be used in the decision-making process [43]. Glasson et al. in their 1999 book state that the environmental consequences for the project activities must be identified, the interests between the development action and the environment must be balanced, and the trade-offs associated with a proposed action for the project must be clarified [44].
- **Green Integration Across Engineering Sectors:** Cross-functioning between all the engineering sectors such as architecture, electrical, mechanical, and civil engineers should be present in the project plan to have a clear understanding about the project

green factors and provide guidelines for them. Comprehensive estimation for the project activities and their duration, as well as the budget required must be provided to finish those activities, such as forming multi-disciplinary teams which involves a variety of engineering specialists that can help identify possible environmental impacts for the project at the early stages of planning.

- **Green Project Definition:** All the specifications of the project must be defined at this stage in the project. In addition, all the parties involved in the project must be identified, and the main guidelines for those specifications will be evaluated based on green factors, such as low energy consumption, resource conservation, and waste reduction that must be satisfied during the project execution. In this stage, Best et al. argue that all the environmental policy and regulations from the government must be identified to find out if the project will satisfy them or not [45].

3. The Detail Engineering Design Phase

- **Green Design Strategies:** There are several strategies that help reduce the environmental and resource impact of building projects, such as *using less to achieve more*. By addressing effective design solutions to solve a number of needs using few elements, one *incorporates design flexibility and durability*. Project design should be flexible to adapt to any changes in the project functions during the useful life of the project and reduce the resource consumption. On the other hand, using durable materials in the project will help to reduce the maintenance and energy costs as well, and *combinations of design strategies must be carefully considered to be truly effective*. In the integrating design, the impact of each element on each other and on the entire building must be considered and these combinations will help reduce the resource usage which will lead to money saving during project construction as well as building operation [37].
- **Green Design Code:** In the design process, the code that has been used must be specified, whether those codes are following green certifications such as Leadership in Energy and Environmental Design (LEED) or the traditional one. Some governments specify their own codes that the designer must follow [27]. There are several codes that specialize in particular work, such as electrical codes.
- **Green Design Monitoring:** Both the stakeholder and designer need to schedule design review meetings. The main purpose for those meetings is to ensure that the

project design meets the stakeholder's specifications and expectations. Also, the designer needs to understand the stakeholder scope for the project to avoid any misunderstanding because correcting this misunderstanding later in the project will consume extra time and cost.

4. The Execution Phase

- **Quality Control Assessment:** This is conducted to establish green standards for the execution of the project activities as well as for the procurements [42]. The main concept for quality control is to ensure that the work meets the quality standards through work inspection. Any defect in the work quality can cause the project to be delayed and it will increase the cost of the project. Therefore, Schexnayder in his 2004 book stated that the manager must regularly check the feedback from inspection of the work quality in the project to avoid any problems in the future [46].
- **Green Construction Management and Coordination:** The main idea of green construction management is to minimize the negative impact of the project activities on the environment, such as noise pollution, water pollution, and waste pollution. Gould and Joyce in their 2002 book explained that this can be achieved by choosing and applying the most effective green construction management techniques, such as using new technology building equipment, as well as directing the production process for the project activities [48]. In order to develop green construction management, first, managers need to establish green construction systems and the targets for this system. After that, a dynamic management must be carried out over the entire construction process. Finally supervision on the activities must be conducted on-site to enhance the green construction management, and monitor the environmental impact on-site. On the other hand, coordinating with the project teams is considered a critical part during construction to ensure that all teams are moving according to the project plan, and this can be done by providing the necessary information for all parties participating in the project through appropriate communication channels. Effective communication can help stakeholders deal with the project problems quickly and provide suitable solutions so the project can remain on schedule [49] [50].
- **Resource Management on Green Basis:** This is done to track the consumption of the organization resources during the project execution in terms of environmental

consideration, such as waste management and demographic management, including urban environmental and public health and safety [44]. The materials efficiency strategy must be used to reduce the amount of materials needed for the project, which will lead to reducing the cost of the project. On the other hand, procurement of the materials from the vendor must be managed to ensure that the specific amount of the materials needed for the project activities will be delivered on time and according to the project schedule to reduce the waste in the materials, and this can be achieved by proper communication with vendors [11]. Since green projects require an additional budget, managing the cost of the project is one of the key factors for success in the project and this needs the manager's attention to control project cost.

5. The Commissioning Phase: This phase includes all the processes responsible for ensuring that the performance of the building facility is handled according to the design documentation.
 - Energy Management Systems: These include all the commissioning processes that control the usage and cost of the building energy; improvement opportunities for the project facilities must be identified, and applying effective upgrades must be done. In addition, a commissioning method for the energy systems must be used to ensure that the project facilities reach full technical potential and maximize the efficiency for the energy consumption in the building. Djuric and Novakovic in their 2009 journal article stated that the main idea for energy system commissioning is to obtain energy savings through optimal control and detect the defaults in the project systems at an early stage in the project operation, which makes the project more sustainable and environmentally friendly [51].
 - System Synergy: The building facilities are functionally interrelated and integrated in operation. All the systems in the project must test at full capacity, and maximum overloading of the system is used to identify any default in the building systems which will lead to system failure and project shutdown because the project systems are interrelated. Tsengin [52] mentioned that fixing such problems will lead to productivity improvement, cost and energy savings, system reliability, improving the indoor environmental quality, improving the project operation and maintenance, and ultimately enhancing the market value for the project.

- Guidelines for Green Commissioning: These guidelines aim at evaluating commissioning for the building facilities on environmental bases by creating a checklist for this process. Wallace et al. in their 2005 journal article stated that this list will contain all the green aspects that must be checked for the project facility, such as energy and water saving, facility optimization, and indoor air quality [53]. There are several factors that have an impact on the guidelines for the commissioning, such as the complexity of the systems, number of systems to be commissioned, the size for the project, and commissioning process protocol. The entire commissioning checklist for the project must be approved and reviewed by the commissioning authority, which is the project stakeholder. Sometimes commissioning can be done by a third-party organization that has its own checklist forms and can be reviewed from the project stakeholder [37].
6. Decommissioning phase: this process includes all the processes that can be done during project shut down.
- Recycling Plan: This plan pertains to how to reuse the materials from the project after the shutting down process is completed. The company needs to prepare an effective recycling plan to get the maximum benefit from the resources that can be obtained from the project. Developing a recycling plan can be started in the project planning phase, in order to know all the recyclable materials in the project and their quantity. Bryan and Craig in their 2008 article stated that recycling materials will help preserve the natural resources and can be used for other projects in the future. Some governments encourage companies to recycle by providing incentives, such as reducing taxes for them [54]. In addition, companies must specify how the waste materials of the project will be managed and how to create a closed loop for the project life cycle [43]. Some companies provide incentives for the customers who return their products after the end of the useful life of the product such as Apple.
 - Environmental Remedy: There are two negative impacts of the project on the environment; one is temporary and the other is permanent. Temporary negative environmental impacts of the project such as reducing ground water pollution, air pollution, and land use must be reversed. On the other hand, treating the permanent impacts will be a difficult task because it requires more time and an additional budget to complete those tasks. Examples are the crises of the Chernobyl reactor

which caused severe damage to the environment; the company is still spending money to reduce the damage [37].

- **Managing Hazardous Materials:** Some projects such as nuclear reactors will have hazardous materials and cannot be used again or recycled and need to be disposed of in a proper way because if they are kept, they will damage the environment and contaminate the air and the water. Therefore, companies must plan for those materials and specify the necessary budget to dispose of them. Engovatov et al. in their 1998 journal article stated that there are several companies which specialize in decommissioning such materials that may help the company for this process. Also, some governments require companies to dispose of their hazardous materials in a suitable way, and have fined companies that disposed of them in places such as sea water or bury them in the ground [55].

Appendix A shows the references of the integrated project management process with environmental factors.

3.2 Process Index

As mentioned earlier, the purpose of a process index is to help the managers have better understanding about green project management processes in each project phase. The manager will rate those indexes according to the project information which he/she manages. Those indexes are treated separately in each project phase. The following paragraphs will explain those indexes.

Initiation Phase:

Environmental Impact Assessment Study (EIA-S): This process is used to recognize the environmental consequences of the proposed project. Morgan in his 1998 book pointed out that those consequences are the result of human activities during the project life cycle [56]. It is essential to identify the necessity of the environmental impact assessment on the proposed project to find whether it is worth spending the time and money on this process or not [56]. Assessing and predicting the level of air, water, and noise pollution for the project will help the manager to implement this process effectively and save time and money for the project [38]. A preliminary investigation about process impact on the environment is essential in this stage. This investigation will help to select which method for predicting process impact can be applied on the

project. Finally, Canter in his book in 1996 mentioned that all the results from this investigation must be organized and presented to the owner in order to make the proper decisions for the project [57].

Green Stakeholder Interest (GSI): This process aids the manager in defining stakeholder concern about green practices which may be used in the project, and whether stakeholders are familiar with those practices or not [41]. This process will help to recognize stakeholder tolerance about risks in green practices, since the risk level in some of those practices is high. Specifying the green specifications as well as green practices for the stakeholders is a way for the manager to define those risks for the project stakeholder, and help the stakeholder make proper decisions about selecting project green practices [21]. For example, if renewable energy will be used in the project such as added solar panels, the owner must know all the costs for implementing this technology as well as maintenance cost, because the cost for the maintenance is very high and the efficiency is lower than the traditional power sources. However, the cost savings in the long run will be huge; therefore, the owner must know all those aspect before proceeding [36].

Green Organizational Thinking (GOT): A green project has multidimensional tasks includes in the project, and therefore it is essential to recognize the green orientation of the construction company, and how much the company is committed to green practices such as using less paper for daily activities, being concerned about the environment, and understanding green process requirements. A construction company with broad experience with green projects and green technologies will have a competitive advantage in the selection process to choose which company will carry out the project execution. It is vital to measure the organization's ability to cope with multi-dimensional tasks for the green project to know if the company will execute the project as specified or not. In order to change the employees' mindset to be green oriented, an incentive must be provided to adopt green practices, as well as training employees on green practices so they have all the required knowledge for the green process and can identify all aspects that deal with those processes.

Planning Phase:

Environmental Impact Assessment Deliverables and Activities (EIA-D): Recognizing direct and indirect environmental consequences for particular activities

before they start is the core knowledge of this process, so in the project execution the team will be prepared for any environmental consequences. Also, predicting the future change in the environment will prepare the team to deal with unexpected environmental impacts in the future [43]. It is essential to evaluate the risks caused by environmental change due to the proposed activities to have a clear picture for the project execution [37]. Recommending a set of changes for the proposed activities to mitigate the environmental impact is essential for green project execution and is the key point that the project manager must pay attention to [44].

Green Integration Across Engineering Sectors (GI): Recognizing the collaboration level between cross-functional engineering sectors is vital to coping with green projects because it includes an enormous number of variables that need to be analyzed [44]. A manager is required to assess and train engineers for a solid level of understanding about green project factors in order to all engineers to have the same level of knowledge with respect to green practices. Since the construction industry is characterized as a fragmented industry [37], it is useful to set multidisciplinary teams to identify and analyze all project variables. Also, this team will be responsible for interpreting the green specifications for the project and how to execute those on the ground in an effective way. Graham in his 2006 book argues that integrating engineers from different sectors is useful for analyzing the project from different points of view and selecting the best way to complete the project [58].

Green Project Definition (GPD): In order to identify a detailed definition for green project specifications, the main guidelines for the project specification on green factors must be evaluated to see if those specifications are applicable on the project with the set budget or not [45]. Yudelson in his 2009 book stated that this process can be implemented by correlating the environmental policies and governmental regulations to the project plan. Accomplish that will help to complete the project without any delay. Furthermore, this will provide a clear idea about the project and avoid any misunderstanding [59].

Detailed Engineering Design Phase:

Green Design Strategies (GDS): this process utilizes the best practices to maximize results in the building design, which ultimately will reduce both the environmental and recourse impact on the environment, as well as enhancing the

occupants' health and satisfaction [37]. Wilkinson et al. in their 2014 book explained that the tradeoff here is to evaluate green design strategy cost with respect to environmental benefit, because some time managers spend a lot of money on one green design strategy and the final result will not be as expected [60]. Some of those strategies that are used include: controlled solar load, utilizing the daylight, ventilation and natural cooling. At this stage in the project, using simulation will be beneficial for the project to see how those strategies will work together and identify the right combinations. Project location will play a crucial part in selecting the green project strategy.

Green Design Code (GDC): in the construction industry there are several codes that can be used to enhance building design by using a variety of design concepts, which will reduce the negative impact on the environment [27]. It is necessary to revise and follow the code requirements which will be used in the project to guarantee maximum benefit from those codes [41]. Following those codes will improve energy efficiency, indoor air quality, and site sustainability for the project. Therefore it is recommended to know which design code is the best for the project benefit. Design codes such as LEED and Green Globes are widely used in commercial building, and each one has its requirements that need to be followed, those codes have advantages and disadvantages and the project team must specify them before applying any code.

Green Design Monitoring (GDM): Monitoring the design will help to assess design progress for the project and overcome any delay in the project schedule or solve any possible design problems as quickly as possible [61]. This process will aid the manager to identify congruence between project design, stakeholder specifications and designer understanding, and recognize any misunderstanding about project specifications which have been established by the stakeholder. In order to do so, the manager must specify the accuracy of the cost estimates and recognize meeting frequency between stakeholders and the project designer [46]. During this meeting, the project team will present what had been done in the project design and perceive the client satisfaction level and any changes that the clients want to be implemented in the project. This is the last stage before the project execution. Therefore, any changes will be easy to include in the project design without compromising the project budget and time [60].

Execution Phase:

Quality Control Assessment (QC): This process is used to evaluate the project's execution quality. If the quality of the activities is not as stated in the project specifications, then the manager can take immediate action to solve this problem and overcome any delays in the project [42]. Because quality is an essential part of project execution, the project manager must identify and implement systematic activities in order to fulfill quality requirements. Inspecting project activities' execution is essential to insure the quality level [46].

Green Construction Management and Coordination (GCMC): The manager is required to assess planning, coordination, and control project activities which are the basic managerial tasks that can be used to achieve project goals [47]. Those tasks will help to specify that the project is within budget, moving according to schedule, and that all project green goals have been satisfied [48]. Several methods have been developed to aid the manager in completing those tasks which are: lean construction, Monte Carlo, and just in time methods. Since there are several parties involved in project execution, the project manager must enhance communication between project parties by specifying proper communication methods to be used. The manager must also make sure that the important information about the project will reach to all parties as soon as possible. This information will be vital in the decision-making process, because incorrect information will result in wrong decisions which cause the project to be delayed [49].

Resource Management on Green Basis (RM): Utilize the company's resources efficiently is one of the key factors for saving money during activities execution [50]. The manager must measure the company's resource consumption during project execution which can be done by provide enough physical resources during project execution and assign people to tasks. Also, the manager must ensure that all the required material will be delivered according to the schedule and with proper quantity by assessing the commitment of material vendors to the project delivery plan [37] [44].

Commissioning Phase:

Usually commissioning is done by a third party which has superior knowledge and technology than the project contractor. Assigning those tasks to them will save the essential time and money to the project. Commissioning is important to ensure that the complex systems in the project are installed and operate as intended. By extension,

energy will be saved and the building environment will be improved. Commissioning is essential if special features in the building have been installed such as solar panels, gray water processing, and air filtering to reduce the environmental impact [37]. The following paragraphs will highlight the main commissioning process indexes:

Energy Management Systems (EMS): All building systems must be evaluated during commissioning phase. Panke in his book in 2002 stated that identifying sets of computer systems which can be used for energy monitoring and controlling building systems is an essential step in managing building energy [62]. Therefore, checking, assessing, and testing building equipment as well as building systems to identify their reliability, efficiency, and performance level is mandatory. For this reason, developing a tailored energy management system software to control building operation sequences is a main step to managing building energy. Moreover, providing the owner's staff with proper training to operate building systems will help them to have full knowledge about any defects in the software and how to overcome them [60] [51].

Systems Synergy (SS): the efficiency of the building system will be improved if two or more systems have been integrated [52]. Krarti in his 2011 book stated that this process is important to measure the efficiency of system recovery during a power failure simulation and identify the tolerance energy load for the building systems when those systems are fully loaded [63]. Therefore, evaluating and testing the functioning and operation of hardware, software, and subsystems of the building and assessing end-to-end spot checks' system integrity is essential to identify any problems in the building systems [62].

Guidelines for Green Commissioning (GGC): Defining the processes which can be used to enhance building systems and, by extension, improve the building value for the owner is the core knowledge for this process [53]. The process is important to specify overall system efficiency and fulfillment of the project's environmental goals [37]. Identifying a number of systems which require commissioning and specifying the detailed requirements for the commissioning test is the main step to effectively implement a commissioning checklist [60].

Decommissioning Phase:

Recycling Plan (RP): After the useful life of the project ends, it is important to evaluate the process of reducing project waste by applying a suitable recycling plan,

which can save the natural resources of the company that can be used for other projects [64]. The project manager must specify the efficiency of the recycling plan and measure the preservation level for the project materials. Developing a recycling plan can be started as early as possible during the project life cycle [42]. The project manager should identify a coordinator for recycling, waste auditing, and deciding which materials will be recycled in the project in order to have an effective recycling plan [59].

Environmental Remedy (ER): Any construction project has an impact on the environment. Therefore, assessing the remedy for the negative environmental impact caused by the project is an essential step in the environmental remedy [37]. Vallero in his 2004 book stated that this process will help to mitigate the permanent and temporary environmental impact and specify the proper technology to be used for this purpose [65]. Several remedy technologies have been developed over the past few years, and will help to reduce the negative project effect on the environment. Those technologies include thermal disruption, drilling and dumping, pump and treat, and bioremediation.

Managing Hazardous Materials (MHM): Projects may include some hazardous materials which will affect the public health. For this reason, managers must identify the process of collecting and treating a project's hazardous materials [55]. Effectively managing hazardous materials will help to provide protection for public health and company employees [64]. A manager must specify the legal requirements for storing, treating, transporting, and disposing of those materials [65].

Two theoretical case studies are used to identify how the matrix works. Case 1 (the ideal case) represents Project A which fulfills all the requirements for process integration with respect to green concepts. On the other hand, Case 2 presents Project B which has a 61% integration level that requires further assimilation of green concepts. Appendices E and F show a hypothetical case study of the process index workings. Appendix G shows a complete processes index reference list.

3.3 AHP Analysis

The main objective for the AHP analysis is to prioritize and weight the green processes in the project management according to pre-set criteria. There are four levels in the AHP hierarchy. Level one (decision goal) involves prioritizing Green Project Management Processes. Level two involves viewing the project phases according to the

project life cycle which are initiation, planning, details engineering design, execution, commissioning, and decommissioning. Best and Valence in their 1999 book explained that managers must identify the criteria that will govern the prioritization process for green project management processes by searching the most common criteria which are required by a green project [45]. Appendix A shows complete references for the green project management processes and criteria. On the other hand, the project manager identifies the processes that have a major impact on the project budget and try to mitigate this impact to control process execution cost. Furthermore, the manager specifies the processes that have a positive impact on the project and facilitates project completion. In addition, project stakeholders prefer safety and try to minimize any risk in the project. Therefore, level three will have the following criteria: *benefit for the project* (adapting those process will have a significant impact on the project and facilitate or not), *the degree of risk in these processes* (since the green process is a relatively new field in the construction industry, it has risks which must be considered if the manager wants to adapt those processes, and *cost of applying green processes* (estimating the additional cost for applying green process which will be added to the project budget is one of the criteria that the manager must identify before making the decision to apply green processes to the project. Level four will be for the green processes of each phase. A panel of experts in construction projects will weigh the project criteria and green project management processes by utilizing pair-wise comparisons.

After the results from the panel of experts are available, developing the AHP analysis will commence. There are three steps that will be followed in order to do so:

- 1) Pair-wise comparisons for selected criteria will be developed in order to prioritize those criteria based on feedback from experts.
- 2) Pair-wise comparisons for the green processes will be developed to prioritize and weight those processes according to experts' feedback.

Saaty's nine scale rating criteria will be used to evaluate the criteria and the green processes in both matrices. A vector of priorities will be calculated for each pair-wise matrix and the sum of those vectors must be equal to one. The vectors' rating will be from 0 to 1, where one represents the desirable alternative according to Saaty's rating system.

- 3) A consistency test will be conducted to ensure that the process consistency falls within the accepted zone which is less than 0.1.

3.3.1 AHP Model (Theoretical Run)

In order to find the proper weighting for the project management processes, AHP analysis will be conducted in this study. The first step in this analysis is to compare criteria with respect to each other to identify the criteria ranking. Then the processes are compared with each other according to pre-set criteria by using a pair-wise comparison. The comparison will be based on the importance of the process for the construction industry. The project will be divided into six phases which represent the life cycle of the project: Initiation, Planning, Detail Engineering Design, Execution, Commissioning, and Decommissioning. Each phase is divided into three green project management processes. These processes will be compared according to specific criteria which are the cost of each process (which process has the highest cost), the risk of each process (the process that has high risk will require extra attention from the project manager), and finally the benefit from the process to the project. In the second step, the processes will be weighted according to a 1-9 rating scale (the rating scale corresponds to Saaty's scale). The 1-9 rating scale is as follows: 1 (Equally significant), 2 (Equally to moderately significant), 3 (Moderately significant), 4 (Moderately to strongly significant), 5 (Strongly significant), 6 (Strongly to very strongly significant), 7 (Very strongly significant), 8 (Very strongly to extremely significant), and 9 (Extremely significant). In this comparison, if the process is compared to itself the rating will be 1, and the reciprocal comparison will be as follows: if process (1) compared with process (2) has weight of (5), then the reciprocal comparison (process (2) against process (1)) will be weighted as (1/5).

Both criteria and project management processes weighting will be identified through a pair-wise comparison. After this process is finished, the subsequent mathematical operation will be carried out to identify the criteria ranking and the processes evaluation. First, the summation for each column of each process in the inconsistent matrix will be carried out ($\text{Column Sum} = W_1 + W_2 + W_3$, Environmental impact assessment (EIA) = $1 + 1/8 + 1/4 = 1.375$) W = the weighting for each process. Next, to find the normalized matrix, each column entry in each column will be divided to the

corresponding column sum (Environmental impact assessment (EIA))= $1/1.375=0.727$, $(1/8)/1.375=0.1$, $(1/4)/1.375=0.18$, the sum for this column must be =1). Finally, the average of the normalized matrix row is found by finding the sum of each row and dividing it by the number of the row entries (Environmental impact assessment (EIA) average row= $(5/7 + 4/7 + 3/4)/3=0.69$). This will represent the overall priority for the process.

To ensure the consistency of the decision, the following calculation will be carried out. The consistency vector is calculated by multiplying overall average priorities with each entry in the inconsistent matrix (Environmental impact assessment (EIA)) = $1*0.69+8* 0.067+ 4*0.244 = 2.199$). Next, we apply this process to all rows in the inconsistent matrix, and divide them by the overall priority vector (consistency vector= $2.199/ 0.68=3.19$, $0.2/0.066=3.015$, $0.75/0.24=3.07$). After that, lambda max will be defined by the average of the consistency vector ($\lambda_{max} = 3.19+3.015+3.07/3=3.09$). The Consistency Index (CI) can be specified by the following formula:

$$CI = \lambda_{max} - n / (n - 1)$$

$$CI = 3.09 - 3 / 2 = 0.0478$$

N = numbers of the matrix entry

In order to specify the consistency ratio, the average consistency for the matrix must be specified. This average is been determined according to the matrix size as shown in Table 3.

The Consistency Ratio (CR) can be determined by the using the below formula:

$$CR = CI / \text{random consistency}$$

$$CR = 0.0478 / 0.52 = 0.082 \text{ (if CR is } < 0.1 \text{ then it is ok)}$$

The final step in AHP analysis is to identify the final processes ranking. In order to do so, we multiply the overall criteria priority with the overall processes priority and sum them to identify the overall priorities vector (Environmental impact assessment (EIA) final rank= $0.27*0.689 + 0.068*0.735 + 0.657*0.124 = 0.317$). This step will be carried for all the project management processes. The same calculation will be done for the criteria as well.

3.4 Expert Validation

In this study the expert panel will consist of five members. Three members will be field experts and two of them will be academic experts. Appendix B shows the names and functions for all expert panel members. Experts will use the pair-wise comparison that has been stated above to input their opinions. Appendix C shows the expert panel input filled by experts. Field and academic experts will validate the green project management processes based on their input for those processes and identify whether those processes are applicable or not in the construction of commercial buildings. Moreover, a sensitivity analysis will be carried out to define the experts' judgment stability as well as opinion reliability.

3.5 Green Decision Matrix and Process Index with Weighted Process

The decision matrix will be developed after the result for AHP analysis has been obtained. This matrix will represent the green project management processes, and helps the project manager to evaluate the level of project integration with respect to green concepts. A process index will be provided to facilitate the decision making process.

The AHP driven processes prioritization will be used to specify the weights in the decision matrix. The main reason for using a green project management process matrix is to aggregate all the information about the weighted processes from the AHP in this matrix along with their criteria.

The index in the matrix will guide the manager through the green management processes and help him/her to identify the suitable processes for the project. The matrix index will raise the following questions which need to be answered. Those questions are: what are those processes, why the manager needs those processes, and how to implement those processes. The rating process index by the project manager will be as follows: (0) if the process is not applicable to the project, (1) if the manager has initial idea about the process, (2) if the manager possesses some knowledge about the green process requirement, (3) if the manager has reasonable knowledge about required process, (4) if the manager has a deep understanding about green processes and the required actions that need to be implemented on the project, and (5) if the manager starts to document actual steps that have been taken to address any concerns about the process and how to complete them. After that, we take the sum of the global total

weight, which is the product of each weighted process with its corresponding rated index. The final step in the decision matrix will decide whether to use green management processes in the project, and identify how much the project is following those processes. Appendix D shows a complete decision matrix for the green project management processes.

Chapter 4: Analysis

4.1 Expert Judgment

Experts in project management provide a judgment on the green project management processes using AHP analysis to identify the process priorities based on expert judgment. One round was carried out in this analysis to specify process rankings. The final result will be used in the green matrix, which will help the project manager to have clear ideas about those processes. In order to identify the result for the expert judgment, Expert Choice software will be used. It's a powerful tool that can be used to evaluate a set of alternatives based on specific criteria. By structuring the criteria and the alternatives into a hierarchy, a series of pair-wise comparisons will be used to prioritize the green project management processes. Expert Choice will calculate the Inconsistency Ratio (IR) for each comparison. If the IR is lower than 0.1, the expert computation is acceptable; otherwise, expert judgment must be revised. Five experts will input their opinion about the green processes as well as preset criteria. The experts will compare the green project management processes with each other and with respect to the three criteria in a pair-wise comparison. After that, an overall priority vector will be calculated for each project phase. Each expert will complete his pair-wise comparison for both criteria and project processes. The comparison will be combined by Expert Choice. Each phase is analyzed separately in Expert Choice in order to identify the processes priority by project phase. Figures 2 to 7 show the hierarchy tree in each project phase:

Figure 2: Initiation phase hierarchy tree

Figure 3: Planning phase hierarchy tree

Figure 4: Detail engineering design phase hierarchy tree

Figure 5: Execution phase hierarchy tree

Figure 6: Commissioning phase hierarchy tree

Figure 7: Decommissioning phase hierarchy tree

Pirdashti et al. in their 2011 article stated that to combine expert opinion and synthesize results for criteria weighting and alternative priorities, a geometric mean is used [66]. The geometric mean is the n th root for the product of (n) input. The geometric mean is calculated by the following equation [67]:

$$(\prod_{i=1}^n a_i)^{1/n} = \sqrt[n]{a_1 a_2 \dots a_n}$$

a : the value of expert input

n : number of input

4.2 Expert Panel Analysis

The expert panel consisted of five members, three members from industry and two from academia. Appendix B shows the names and functions for all experts in the panel. The experts' pair-wise comparison has been analyzed to specify criteria weighting and green project management processes priority and the results are as shown below.

Criteria ranking for overall project: Based on the expert opinion, 80% of experts prioritized the cost of applying green process criterion over the other criteria. The degree of risk in these processes was next in the priority ranking. This criteria ranking will be applied for all green process comparisons in all project phases. Figure 8 shows the overall criteria ranking:

Figure 8: Overall criteria priority

Project phase 1- Initiation: In this phase, processes will be ranked as follows: 67% of field experts prefer Green Organizational Thinking (GOT) process above other processes. On the other hand, all academic experts selected the Environmental Impact Assessment Study (EIA-S) to be the highest process. 80% of experts chose the Green Stakeholder Interest (GSI) process to be second in the priority ranking, but Green Stakeholder Interest GSI has the highest ranking when experts' judgment is combined, and Environmental Impact Assessment Study EIA-S is then second in priority ranking. Figure 9 shows the priority ranking for the initiation processes.

Combined instance -- Synthesis with respect to: Goal: Prioritize Green Project Management Processes (GPMPs)

Figure 9: Initiation processes priority

Project Phase 2 – Planning: 80% of experts ranked the Environmental Impact Assessment Deliverables and Activities (EIA-D) higher in this phase, and Green Integration across Engineering Sectors GI is second in line of processes priority. Figure 10 highlights the process rankings for the planning phase:

Combined instance -- Synthesis with respect to: Goal: Prioritize Green Project Management Processes (GPMPs)

Figure 10: Planning processes priority

Project Phase 3 - Detailed engineering design: 67% of field experts ranked Green Design Monitoring (GDM) as the highest priority, and Green Design Code (GDC) process as the second priority. On the other hand, all academic experts put a higher priority to Green Design Strategies (GDS) processes than the others. When combined, experts' judgment places Green Design Monitoring (GDM) as the highest process, and Green Design Strategies (GDS) is next in processes priority. Figure 11 shows complete process priorities.

Figure 11: Detail engineering design processes priority

Project Phase 4 – Execution: In project execution, 67% of field experts consider Resources Management on Green Basis (RM) to be the first priority in execution processes and Quality Control Assessment (QC) to be second. On the other hand, there has been a major debate between academic experts in prioritizing execution processes. Since 50% of experts put higher priority on Green Construction Management and Coordination (GCMC), and 50% prefer Resources Management on Green Basis (RM) to be the highest priority, combining experts' input shows that Quality Control Assessment (QC) is to some extent higher than Resources Management on Green Basis (RM). Figure 12 shows the process priorities.

Figure 12: Execution processes priority

Project Phase 5 – Commissioning: In the commissioning phase, all experts agree that Energy Management Systems (EMS) processes have the highest priority in this phase and Systems Synergy (SS) is second priority among commissioning processes. Figure 13 highlights the commissioning process priorities.

Combined instance -- Synthesis with respect to: Goal: Prioritize Green Project Management Processes (GPMPs)

Figure 13: Commissioning processes priority

Project Phase 6 – Decommissioning: 80% of experts prioritize Managing Hazardous Materials (MHM) among other decommissioning processes. When experts' opinion is combined, Managing Hazardous Materials (MHM) has the highest priority in this project phase and Recycling Plan (RP) is second in the process ranking. Figure 14 identifies the decommissioning processes priorities.

Figure 14: Decommissioning processes priority

After project manager finishes evaluating the processes index, he/she can assess the level of project integration with respect to green concepts by specifying total Project Percentile. Table 5 shows a reference table for matrix usage.

Table 5: Reference table of decision matrix usage

Project Percentage	Level	Remark
Below 50%	Unsatisfactory	Inadequate integration (raise a red flag)
50%-70%	Developing	Requires further assimilation of green concepts
70%-90%	Reasonable	Minor gaps in green integration
Above 90%	Exemplary	Substantial incorporation of the important green concepts in the project management processes

4.3 Sensitivity Analysis

A sensitivity analysis was used to investigate the stability of experts' judgment about green processes' priorities. The approach that was followed in this analysis is to change criteria ranking until the process priorities for the first and second processes change. Additionally, Expert Choice has been used to facilitate the sensitivity analysis process since Expert Choice provides a dynamic sensitivity analysis, which allows a change to the criteria ranking directly and recognizes variation in the process priorities [68]. The sensitivity analysis results are shown below:

Project Phase 1- Initiation: Increasing the cost of applying green process by 10% led to a change in process priorities. Furthermore, the Environmental Impact Assessment Study (EIA-S) has the highest priority and Green Stakeholder Interest (GSI) has the second highest priority.

Figure 15 below shows the process priorities before the sensitivity analysis. Figure 16 shows the sensitivity analysis for the initiation phase:

Figure 15: Initiation processes priority before sensitivity analysis

Figure 16: Initiation sensitivity analysis

Project Phase 2 – Planning: In this phase, any change in the criteria rankings has no effect on process priorities, which indicates a high stability for expert’s judgment in this phase.

Project Phase 3 - Detailed engineering design: Originally, Green Design Monitoring (GDM) had superior priority over other processes, but increasing the benefit criterion by 40% causes Green Design Monitoring to shift to a second in priority ranking while Green Design Strategies (GDS) shifts to the highest priority in this project phase.

Figure 17 below highlights the process priorities before the analysis. Figure 18 identifies the sensitivity analysis for the detailed engineering design.

Figure 17: Detail engineering design processes priority before sensitivity analysis

Figure 18: Detail engineering design sensitivity analysis

Project Phase 4 – Execution: Increasing cost criterion by 10% in the dynamic sensitivity analysis results in changing the Quality Control Assessment (QC) priority from first to second, while making Resources Management on Green Basis (RM) have the highest ranking.

Figure 19 shows the execution processes before the analysis. Figure 20 shows the execution sensitivity analysis.

Figure 19: Execution processes priority before sensitivity analysis

Figure 20: Execution sensitivity analysis

Project Phase 5 – Commissioning: Due to the highest ranking for the Energy Management Systems (EMS) process, any change in criteria ranking has no effect on process priority in this sensitivity analysis.

Project Phase 6 – Decommissioning: Environmental Remedy (ER) has superior process priority if the benefit criterion is increased by 60%. This enormous increase in criterion indicates a relatively high stability for the experts' judgment.

Figure 21 below shows the process priorities for the decommissioning phase before the sensitivity analysis. Figure 22 shows the sensitivity analysis for the commissioning phase.

Figure 21: Decommissioning processes priority before sensitivity analysis

Figure 22: Decommissioning sensitivity analysis

Chapter 5: Conclusion & Recommendations

5.1 Conclusion

A matrix for green project management processes is important to facilitate the decision making process for the project manager. A green matrix can aggregate all necessary information for the manager to make a suitable decision. Two techniques were used which are AHP analysis and construction of a decision matrix. We utilized a panel of experts in the AHP analysis to specify the priority vector for the green processes. We used pair-wise comparisons to prioritize green project management processes, and experts weighted the processes based on the relative importance of each process in the construction industry.

The cost of applying the process, risks in this process, and benefit of this process to the project are the criteria that have been used in the AHP analysis to compare the green processes. Experts' judgment indicates that the cost of applying green process criteria is the highest among all criteria. In the initiation phase, the Green Stakeholder Interest (GSI) process was prioritized over the other processes, while Environmental Impact Assessment Deliverables and Activities (EIA-D) has the highest ranking in planning phase. In the detailed engineering design phase, experts highlight Green Design Monitoring (GDM) as the highest process in this phase, and Quality Control Assessment (QC) has a superior ranking in the execution phase. In the commissioning phase, the Energy Management Systems (EMS) process is the most preferable process. Managing Hazardous Materials (MHM) in the decommissioning phase has the highest ranking above the other decommissioning processes.

A sensitivity analysis was carried to specify expert judgment stability and change criteria ranking to measure process priority stability. Both the planning and commissioning phases show higher stability in this analysis. Furthermore, increasing the cost criterion by 10% in the initiation phase causes a shift in the Environmental Impact Assessment Study (EIA-S) process from second to first in priority ranking. Once the benefit criterion in the detailed engineering design phase was increased by 40%, it led to a change in the Green Design Monitoring (GDM) process priority from first to second in the ranking. Furthermore, the Resources Management on Green Basis (RM) process has highest priority after the cost criterion was increased by 10% in the

execution phase. In the decommissioning phase, an increase in benefit criterion by 60% results in a change in priority of the process of Managing Hazardous Materials (MHM) from first to second in ranking order.

The decision matrix includes the process index to highlight essential information for each process. Three indexes have been developed for each process to help the manager to decide which processes should be used in the project. The process index will represent specific questions which are: what is the process, why this process is important, and how to implement the process. Eighteen green processes have been used in this research by integrating traditional project management with green factors. Those processes have been divided into six phases which represent the project life cycles. Green processes aid the manager to bring sustainability into the project. The construction industry is considered the largest contributor in environmental pollution, as well as the biggest consumer of the natural resources. Therefore, implementing green practices to those projects will help to reduce both environment pollution and depletion of natural resources. Creating a green matrix is the first step for introducing green factors to the project, which may ultimately lead to a decrease in global warming. Awareness about green projects has increased in the last decade and additional green project have been established. Global warming and resource consumption are the main problems facing the generations in the future and green projects are the best way to solve those problems.

5.2 Recommendations

This research represents the framework for a decision matrix in green project management processes since sustainability is relatively new in the construction industry and each year new techniques and technologies are being developed. New movements for green project are rising and more project owners are likely to use green practices in their project. As a result, further research dealing with sustainable development is mandatory. Several recommendations have been proposed for this research:

- Including additional construction types such as industrial, heavy civil, and transportation construction
- Additional processes can be added to the matrix
- Additional criteria can be used in weighing the green processes

- Extra experts can be used for the panel of experts to have more accurate results for the process ranking
- Additional process indexes can be added to the green matrix

References

- [1] C. Ning, Z. Shan-Jie and L. LEI, "Sustainable Project Management: A Balance Analysis Model of Effect," in *International Conference on Management and Service Science*, China, 2009, pp. 1-4.
- [2] Y. He, "Environmental management within projects," *International Journal of Business and Management*, vol. 5, no. 1, pp. 205-210, 2010.
- [3] A. J. Czuchry and M. M. Yasin, "Managing the project management process," *Industrial Management & Data Systems*, vol. 103 , no. 1, pp. 39-46, 2003.
- [4] E. W. Larson and C. F. Gray, *Project Management :the managerial process*, New York: McGraw-Hill, 2011, pp. 105-130.
- [5] T. Alsudiri, W. AL-Karaghoul and T. Eldabi, "Alignment of large project management process to business strategy: A reviw and conceptual framework," *Journal of Enterprise Information Management*, vol. 26, no. 5,pp. 569-615, 2013.
- [6] Uppal and K. B, "project management process and action plans," *AACE International Transactions*, vol. 2, no. 15,pp. 31-38, 2004.
- [7] A. Hamilton, *Management by Projects: Achieving Success in a Changing World*, London: Thomas Telford House, 1997, pp. 155-200.
- [8] D. I. Cleland, *Field Guide To Project Management*, Canada: John Wiley & Sone INC., 2004, pp. 95-300.
- [9] B. P. Lientz and K. P. Rea, *Project Management for the 21 Century*, San Diego: Academic Press, 2002, pp. 200-230.
- [10] J. R. Adams and S. E. Barndt, "Behavioral implications of the project life cycle," *International Journal of Project Management*, vol. 2, p. 227, 1983.
- [11] Project Management Institute, *a Guide to The Project Management Body of Knowledge*, Pennsylvania: Project Management Institute, Inc., 2008, pp. 50-100.
- [12] H. N. R, *Modern Project Management : Successfully Integrating Project Management knowledge Areas and Processes*, New York: AMACOM, 2001, pp. 58-123.
- [13] C. Jason, *Project Management Methodologies : Selecting,Implementing, and Supporting Methodologies, and Processes for Projects*, New York: Wiley, 2003, pp. 42-99.

- [14] L. Dennis, *Project Management*, Burlington: Gower, 2008, pp. 52-80.
- [15] J. R. Meredith and S. J. M. Jr, *Project Management : a Managerial Approach*, New Jersey: J Wiley, 2003, pp. 200-311.
- [16] C. J. P and G. Jack, *Effective Project Management*, Ohio: South-Western Cengage Learning, 2009, pp. 99-239.
- [17] N. J. Smith, *Engineering Project Management*, Oxford: Blackwell, 2008, pp. 66-158.
- [18] N. B. Kurland and D. Zell, "Green management :principles and examples," *Organizational dynamics*, vol. 40, pp. 49-56, 2011.
- [19] A.-n. DAI and D. XU, "The study of Green project Management," in *2011 IEEE 18Th International Conference Industrial Engineering and Engineering Management (IE&EM)*, Changchun, 2011, pp. 267-271.
- [20] C. Tam, V. Y. Tam and W. Tsui, "Green construction assessment for environmental management in the construction industry of Hong Kong," *International Journal of Project Management*, vol. 22, no. 7, pp. 563-571, 2004.
- [21] A. Krasnoff, "the Green Economy post" Internet: www.greeneconomypost.com/green-project-management-greenpm-iso-14000-11040.htm, May 12, 2010 [Nov. 25, 2013].
- [22] Al-Hardi and K. M. Al-Subhi, "Application of the AHP in project management," *International Journal of Project Management*, vol. 19, no. 1, pp. 19-27, 2000.
- [23] T. L. Saaty, *Decision Making for Leaders; The Analytic Hierarchy Process for Decision in a Complex World*, Pittsburgh: RWS publications, 2008, pp. 155-235.
- [24] J. K. W. Wong and H. Li, "Application of the analytic hierarchy process (AHP) in the multi-criteria analysis of the selection of intelligent building systems," *Building and Environment*, vol. 43, no. 1, pp. 108-125, 2008.
- [25] H. Robert, W. S. V, S. Robert and M. S. A, "Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process," *European Journal of Operational Research*, vol. 141, p. 78, 2002.
- [26] R. Handfield, S. V. Walton, R. Sroufe and s. a. Melnyk, "Applying environmental criteria to supplier assessment : A study in the application of the Analytical Hierarchy Process," *European Journal of Operational Research*, vol. 141, no. 1, pp. 70-87, 2002.

- [27] A. V. Bentes, J. Carneiro, J. F. D. Silva and H. Kimura, "Multidimensional assessment of organizational performance: integrating BSC and AHP," *Journal of business research*, vol. 65, no. 12, pp. 1790-1799, 2012.
- [28] G. Bruno, E. esposito, A. Genovese and R. Passaro, "AHP-based approaches for supplier evaluation: problems and perspectives," *Journal of purchasing and supply management*, vol. 18, no. 3, pp. 159-172, 2012.
- [29] S. Wu, Lee and J. Tah, "The use of a multi-attribute tool for the evaluating accessibility in building : the AHP approach," *Facilities*, vol. 25, no. 9, pp. 375-389, 2007.
- [30] S. Colwell, M. Friedmann and D. Carmichael, "The research vendor selection process: A quantitative decision matrix for increasing value for both buyers and sellers," *Journal of Financial Services Marketing*, vol. 5, no. 2, pp. 181-196, 2000.
- [31] J. S. Berens, "A decision matrix approach to supplier selection ," *Journal of Retailing*, vol. 47, no. 4, pp. 7-47, 1971.
- [32] B. J. S, "A Decision matrix approach to supplier selection," *Journal of Retailing*, vol. 47, no. 4, p. 52, 1971.
- [33] J. Nicholls, "The MCC decision matrix: a tool for applying strategic logic to everyday activity," *Management Decision*, vol. 33, no. 6, pp. 4-10, 1995.
- [34] D. Ball, "A weighted decision matrix for outsourcing library services," *The Bottom Line: Managing Library Finances*, vol. 16, pp. 25-30, 2003.
- [35] L. R. Zanchettin, "Decision-making using matrix analysis," *American Association of Cost Engineers. Transactions of the American Association of Cost Engineers*, vol. 2, no. 2, pp. 1-4, 1992.
- [36] M. M. A. Khalfan, "Managing sustainability within construction projects," *Journal of Environmental Assessment Policy and Management*, vol. 8, pp. 41-60, 2006.
- [37] S. Kubba, *Green Construction Project Management and Cost Oversight*, London: Architectural Press, 2010, pp. 99-300.
- [38] R. Ain, L. Urban, H. Balbch and M. Webb, *Handbook of The Environmental Engineering Assessment; Strategy, Planning, and Management*, Boston: Butterworth-Heinemann, 2012, pp. 211-299.
- [39] B. Carroll and T. Turpin, *Environmental Impact Assessment Handbook; A Practical Guide for Planning, Developers, and Communities*, London: Thomas Telford, 2002, pp. 55-90.

- [40] M. EL-Halwagi, E. Lovelady, A. Abdel-Wahab and H. Alfadala, "Apply Process Integration to Environmental Impact Assessment," *Chemical engineering progress*, vol. 105, no. 4, pp. 2-105, 2009.
- [41] V. Luyet, R. Schaepfer, M. Parlange and A. Buttler, "A framework to implement Stakeholder participation in environmental projects," *Journal of environmental management*, vol. 111, no. 3, pp. 213-219, 2012.
- [42] C. H. Eccleston, *Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning*, Canada: John Wiley & Sons Inc., 2000, pp. 66-133.
- [43] A. Gillpin, *Environmental Impact Assessment; Cutting Edge for The Twenty-First Century*, Cambridge ,UK: Cambridge University Press, 1995, pp. 23-66.
- [44] J. Glasson, R. Therivel and A. Chadwick, *Introduction to Environmental Impact Assessment; Principle and Procedures, Process, Practice and Prospects*, London: UCL Press Limited, 1999, pp. 202-266.
- [45] R. Best and G. d. Valence, *Building in Value: Pre-Design Issues*, London: Arnold, 1999, pp. 133-189.
- [46] C. J. Schexnayder and R. E. Mayo, *Construction Management Fundamentals*, New York: McGraw Hill, 2004, pp. 199-300.
- [47] X. Liu, "Green construction management system for construction project," in *International Conference on E -Business and E -Government (ICEE)*, Shanghai, 2011, pp. 1-4.
- [48] F. E. Gould and N. E. Joyce, *Construction Project Management*, Ohio: Prentice Hall, 2002, pp. 55-268.
- [49] J. Heagney, *Fundamentals of Project Management*, London: American management Association, 2012, pp. 1-22.
- [50] S. M. Levy, *Project Management in Construction*, New York: McGraw-Hill, 2000, pp. 232-333.
- [51] N. Djuric and V. Novakovic, "Review of possibilities and necessities for building lifetime commissioning," *Renewable and Sustainable Energy Reviews*, vol. 13, no. 2, pp. 486-492, 2009.
- [52] Tseng and P. C, "Commissioning sustainable Buildings," *Ashrae Journal*, vol. 47, no. 9, pp. 20-24, 2005.

- [53] B. Wallace, M. Cash and S. Engineers, "Commissioning takes hold in the construction Industry," *EC & M*, vol. 104, no. 6, pp. 18-21, 5 Dec 2005.
- [54] B. Bryan and G. Craig, "Facility Decommissioning," *Professional Safety [H.W. Wilson - AST]*, vol. 53, pp. 18-24, 2008.
- [55] I. Engovatov, V. Mashkovich, V. Orlov, B. Pologikh, S. Khlopin, and S. Tsypin, "Decommissioning of civil and military reactors," *Atomic Energy*, vol. 85, no. 4, pp. 706-709, 1998.
- [56] R. K. Morgan, *Environmental Impact Assessment A Methodological Perspective*, Norwell: Kluwer Academic, 1998, pp. 102-133.
- [57] L. Canter, *Environmental impact assessment*, Boston: McGrawHill, 1996, pp. 255-300.
- [58] D. Graham, *Managing Residential Construction Projects: Strategies and Solutions*, New York: McGraw-Hill, 2006, pp. 105-200.
- [59] J. Yudelson, *Green Building Through Integrated Design*, New York: McGrawHill, 2009, pp. 69-135.
- [60] S. Wilkinson, H. Remoy and C. Langston, *Sustainable Building Adaptation Innovations in Decision-Making*, London: Wiley Blackwell, 2014, pp. 56-145.
- [61] R. S. Means, *Green Building: Project Planning & Cost Estimating / by R.S. Means*, New Jersey: RSMMeans, 2011, pp. 200-245.
- [62] R. Panke, *Energy Management Systems and Direct Digital Control*, New York: The Fairmont Press, 2002, pp. 45-99.
- [63] M. Krarti, *Energy Audit Of Building Systems An Engineering Approach*, London: CRC Press, 2011, pp. 66-103.
- [64] D. o. E. Services, "opala.org," Internet: www.opala.org/solid_waste/How_to_Set_up_a_recycling_program.html, Apr. 5 ,2005. [Oct.14 ,2014].
- [65] D. Vallero, *Environmental Contaminants assessment and Control*, Boston: Elsevier Academic Press, 2004, pp. 39-99.
- [66] M. Pirdashti, M. Omid, H. Pirdashti and M. Hassim, "An AHP-Delphi multi-criteria decision making model with application to environmental decision-making," *Iranian Journal of Chemical Engineering*, vol. 8, no. 6, pp. 1-17, 2011.

- [67] T. Ando, L. Chi-Kwong, and M. Roy "Geometric means," *Linear Algebra and Its Applications*, vol. 385, no. 2, pp. 305-334, 2004.
- [68] E. Triantaphyllou and A. Sánchez, "A sensitivity analysis approach for some deterministic multi-criteria decision making methods," *Decision Sciences*, vol. 28, no. 1, pp. 151-194, 1997.

Appendices

Appendix A: Complete References for The Green Project Management Processes and Criteria

Green project management criteria			References
Cost of applying green process			C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133. J. R. Meredith and S. J. M. Jr, Project management : a managerial approach, New Jersey: J Wiley, 2003, pp. 200-311.
Degree of risk in these processes			A. Krasnoff, "the Green Economy post" Internet: www.greeneconomypost.com/green-project-management-greenpm-iso-14000-11040.htm , May 12, 2010 [Nov. 25, 2013]. C. J. P and G. Jack, Effective project management, Ohio: South-Western Cengage Learning, 2009, pp. 99-239.
Benefit for the project			C. J. Schexnayder and R. E. Mayo, Construction Management Fundamentals, New York: McGraw Hill, 2004, pp. 199-300. p. m. institute, A GUIDE TO THE PROJECT MANAGEMENT BODY OF KNOWLEDGE, Pennsylvania: Project Management Institute, Inc., 2008, pp. 50-100.
Project management processes	Environmental factors	References	
	Initiation phase		
	Environmental Impact Assessment Study	R. J. ain, L. Urban, H. Balbch and M. D. Webb, Handbook of the environmental engineering assessment; strategy, planning, and management, Boston: Butterworth-Heinemann, 2012, pp. 211-299.	
	Green Stakeholder Interest	V. Luyet, R. Schaefer, M. B. Parlange and A. Buttler, "A framework to implement Stakeholder participation in environmental projects," Journal of environmental management, vol. 111, pp. 213-219, 2012. A. Krasnoff, "the Green Economy post" Internet: www.greeneconomypost.com/green-project-management-greenpm-iso-14000-11040.htm , May 12, 2010 [Nov. 25, 2013].	
	Green Organizational Thinking	C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133. A. Krasnoff, "the Green Economy post" Internet: www.greeneconomypost.com/green-project-management-greenpm-iso-14000-11040.htm , May 12, 2010 [Nov. 25, 2013].	

Project management processes	Planning phase	
	Environmental Impact Assessment Deliverables and Activities	<p>A. Gillpin, Environmental Impact Assessment; Cutting edge for the twenty-first century, Cambridge ,UK: Cambridge University Press, 1995, pp. 23-66.S. Kubba, Green Construction Project Management and Cost Oversight, London: Elsevier Inc., 2010.</p> <p>J. Glasson, R. Therivel and A. Chadwick, Introduction to Environmental Impact Assessment; Principle and Procedures, Process, Practice and Prospects, London: UCL Press Limited, 1999, pp. 202-266.</p>
	Green Integration Across Engineering Sectors	A. Gillpin, Environmental Impact Assessment; Cutting edge for the twenty-first century, Cambridge ,UK: Cambridge University Press, 1995, pp. 23-66.
	Green Project Definition	R. Best and G. d. Valence, Building in value: pre-design issues, London: Arnold, 1999, pp. 133-189.
	Detail engineering design phase	
	Green Design Strategies	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Green Design Code	<p>A. V. Bentes, J. Carneiro, J. F. D. Silva and H. Kimura, "Multidimensional assessment of organizational performance: integrating BSC and AHP," Journal of business research, vol. 65, pp. 1790-1799, 2012.</p> <p>V. Luyet, R. Schaeffer, M. B. Parlange and A. Buttler, "A framework to implement Stakeholder participation in environmental projects," Journal of environmental management, vol. 111, pp. 213-219, 2012.</p>
	Green Design Monitoring	C. J. Schexnayder and R. E. Mayo, Construction Management Fundamentals, New York: McGraw Hill, 2004, pp. 199-300.

Project management processes	Execution phase	
	Quality Control Assessment	C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133. C. J. Schexnayder and R. E. Mayo, Construction Management Fundamentals, New York: McGraw Hill, 2004, pp. 199-300.
	Green Construction Management and Coordination	X. Liu, "Green Construction Management System for Construction project," in International Conference on E - Business and E -Government (ICEE), Shanghai, 2011, pp. 1-4.. F. E. Gould and N. E. Joyce, Construction Project Management, Ohio: Prentice Hall, 2002, pp. 55-268.
	Resources Management on Green Basis	J. Glasson, R. Therivel and A. Chadwick, Introduction to Environmental Impact Assessment; Principle and Procedures, Process, Practice and Prospects, London: UCL Press Limited, 1999, pp. 202-266. S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300. p. m. institute, A GUIDE TO THE PROJECT MANAGEMENT BODY OF KNOWLEDGE, Pennsylvania: Project Management Institute, Inc., 2008, pp. 50-100.
	Commissioning phase	
	Energy Management Systems	N. Djuric and V. Novakovic, "Review of Possibilities and Necessities for Building Lifetime Commissioning," Renewable and Sustainable Energy Reviews, vol. 13, pp. 486-492, 2009.
	Systems Synergy	Tseng and P. C, "Commissioning sustainable Buildings," ASHRAE JOURNAL, vol. 47, pp. 20-24, 2005.
	Guidelines for Green Commissioning	B. D. Wallace, M. J. Cash and S. w. Engineers, "Commissioning Takes Hold in the Construction Industry," EC & M, vol. 104, pp. 18-21, 5 Dec 2005. S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Decommissioning phase	
	Recycling Plan	C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133. B. D. Wallace, M. J. Cash and S. w. Engineers, "Commissioning Takes Hold in the Construction Industry," EC & M, vol. 104, pp. 18-21, 5 Dec 2005.
	Environmental Remedy	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Managing Hazardous Materials	E. I. A, M. V. P, O. V, P. B. G, K. N. S and T. S. G, "Decommissioning of civil and military reactors," Atomic Energy, vol. 85, pp. 706-709, 1998.

Appendix B: Experts Panel Members

Name	Function	Organization
Muthana Helan	Project management	ACTECO
Zaid Isam	Sr. Technical Engineer	Ghantoot
Khaleel Dahash	Project management	Desert Knight
Issam Srour	Assistant Professor	The American University of Beirut
Oswald Chong	Associate Professor	Arizona State University

Appendix C: Expert Panel Input

A DECISION MATRIX FOR GREEN PROJECT MANAGEMENT PROCESSES

EXPERT PANEL INPUT

Name: Muthana Helan

Function: Project management

Organization: ACTECO

Ranking key

1	2	3	4	5	6	7	8	9
Equally significant	Equally significant to moderately more significant	Moderately more significant	Moderately to strongly more significant	Strongly more significant	Strongly to very strongly more significant	Very strongly more significant	Very strongly to extremely more significant	Extremely more significant

Ranking example

<i>Pairwise Comparison of Criteria for Overall Project</i>	Cost of applying green process	Degree of risk in these processes	Benefit for the project
Cost of applying green process	1	5	8
Degree of risk in these processes		1	
Benefit for the project			1

- In the construction of commercial buildings, the *cost of applying green process* is **strongly more significant** than the *degree of risk in those processes*.
- In the construction of commercial buildings, the *cost of applying green process* is **very strongly to extremely more significant** than the *benefit for the project*.

In your expert opinion, please rank the processes below:

Overall Project Life Cycle									
Pairwise Comparison of Criteria for Overall Project	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	Cost of applying green process			1			1/5		
	Degree of risk in these processes			9			4		
	Benefit for the project			5			1		
Project Phase 1- Initiation									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)
Environmental impact assessment (EIA-S) Study	1	4	8	1	1/7	1/8	1	1/8	2
Green stakeholder interest (GSI)	1/4	1	5	7	1	2	8	1	7
Green organizational thinking (GOT)	1/8	1/5	1	8	1/2	1	1/2	1/7	1
Project Phase 2 -Planning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)
Environmental impact assessment deliverables and activities (EIA-D)	1	1/9	2	1	9	1/2	1	8	3
Green integration across engineering sectors (GI)	9	1	8	1/9	1	1/7	1/8	1	1/6
Green project definition (GPD)	1/2	1/8	1	2	7	1	1/3	6	1
Project Phase 3 - Detail engineering design									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)
Green design strategies (GDS)	1	1/3	1/6	1	3	1/4	1	8	3
Green design code (GDC)	3	1	1/4	1/3	1	1/6	1/8	1	1/5
Green Design Monitoring (GDM)	6	4	1	4	6	1	1/3	5	1

Project Phase 4 - Execution									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)
Quality control assessment (QC)	1	6	9	1	9	7	1	9	3
Green construction management and coordination (GCMC)	1/6	1	3	1/9	1	1/3	1/9	1	1/7
Resources management on green basis (RM)	1/9	1/3	1	1/7	3	1	1/3	7	1
Project Phase 5 - Commissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)
Energy management systems (EMS)	1	1/8	1/4	1	5	7	1	1/6	2
Systems synergy (SS)	8	1	5	1/5	1	3	6	1	6
Guidelines for green commissioning (GGC)	4	1/5	1	1/7	1/3	1	1/2	1/6	1
Project Phase 6 - Decommissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)
Recycling plan (RP)	1	5	1/3	1	1/6	1/8	1	1/5	2
Environmental remedy (ER)	1/5	1	1/8	6	1	1/3	5	1	5
Managing hazardous materials (MHM)	3	8	1	8	3	1	1/2	1/5	1

Definitions

- **Green Design Monitoring (GDM)**
 - Tracking green design progress and verifying design specifications.
- **System Synergy (SS)**
 - Checking the systems integration to measure building efficiency for better resource use.
- **Environmental Remedy (ER)**
 - Mitigating the negative environmental impact due to asset disposal at the end of the economic life of the project.

A DECISION MATRIX FOR GREEN PROJECT MANAGEMENT PROCESSES

EXPERT PANEL INPUT

Name: Khaleel Dahash

Function: Project management

Organization: Desert Knight

Ranking key

1	2	3	4	5	6	7	8	9
Equally significa nt	Equally significan t to moderatel y more significan t	Moderatel y more significan t	Moderatel y to strongly more significan t	Strongly more significa nt	Strongly to very strongly more significa nt	Very strongly more significa nt	Very strongly to extremel y more significa nt	Extremel y more significa nt

Ranking example

<i>Pairwise Comparison of Criteria for Overall Project</i>	Cost of applying green process	Degree of risk in these processes	Benefit for the project
Cost of applying green process	1	5	8
Degree of risk in these processes		1	
Benefit for the project			1

- In the construction of commercial buildings, the *cost of applying green process* is **strongly more significant** than the *degree of risk in those processes*.
- In the construction of commercial buildings, the *cost of applying green process* is **very strongly to extremely more significant** than the *benefit for the project*.

In your expert opinion, please rank the processes below:

Overall Project Life Cycle										
Pairwise Comparison of Criteria for Overall Project		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Cost of applying green process		1			5			4		
Degree of risk in these processes		1/5			1			2		
Benefit for the project		1/4			1/2			1		
Project Phase 1- Initiation										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)
Environmental impact assessment (EIA-S) Study		1	1/4	1/5	1	1/5	1/6	1	1/5	1/6
Green stakeholder interest (GSI)		4	1	1/2	5	1	1/2	5	1	1/3
Green organizational thinking (GOT)		5	2	1	6	2	1	6	3	1
Project Phase 2 -Planning										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)
Environmental impact assessment deliverables and activities (EIA-D)		1	5	6	1	1/7	1/8	1	1/7	1/5
Green integration across engineering sectors (GI)		1/5	1	3	7	1	1/2	7	1	2
Green project definition (GPD)		1/6	1/3	1	8	2	1	5	1/2	1
Project Phase 3 - Detail engineering design										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)
Green design strategies (GDS)		1	1/8	1/7	1	1/2	1/9	1	4	1/3
Green design code (GDC)		8	1	2	2	1	1/3	1/4	1	1/5
Green Design Monitoring (GDM)		7	1/2	1	9	3	1	3	5	1

Project Phase 4 - Execution									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)
Quality control assessment (QC)	1	6	1/3	1	7	5	1	9	5
Green construction management and coordination (GCMC)	1/6	1	1/7	1/7	1	1/3	1/9	1	1/4
Resources management on green basis (RM)	3	7	1	1/5	3	1	1/5	4	1
Project Phase 5 - Commissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)
Energy management systems (EMS)	1	7	7	1	3	8	1	7	6
Systems synergy (SS)	1/7	1	2	1/3	1	6	1/7	1	2
Guidelines for green commissioning (GGC)	1/7	1/2	1	1/8	1/6	1	1/6	1/2	1
Project Phase 6 - Decommissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)
Recycling plan (RP)	1	7	7	1	1/2	1/8	1	8	7
Environmental remedy (ER)	1/7	1	1/2	2	1	1/7	1/8	1	2
Managing hazardous materials (MHM)	1/7	2	1	8	7	1	1/7	1/2	1

Definitions

- **Green Design Monitoring (GDM)**
 - Tracking green design progress and verifying design specifications.
- **System Synergy (SS)**
 - Checking the systems integration to measure building efficiency for better resource use.
- **Environmental Remedy (ER)**
 - Mitigating the negative environmental impact due to asset disposal at the end of the economic life of the project.

A DECISION MATRIX FOR GREEN PROJECT MANAGEMENT PROCESSES

EXPERT PANEL INPUT

Name: Zaid Isam

Function: Sr.Technical Engineer

Organization: Ghantoot

Ranking key

1	2	3	4	5	6	7	8	9
Equally significa nt	Equally significan t to moderatel y more significan t	Moderatel y more significan t	Moderatel y to strongly more significan t	Strongly more significa nt	Strongly to very strongly more significa nt	Very strongly more significa nt	Very strongly to extremel y more significa nt	Extremel y more significa nt

Ranking example

<i>Pairwise Comparison of Criteria for Overall Project</i>	Cost of applying green process	Degree of risk in these processes	Benefit for the project
Cost of applying green process	1	5	8
Degree of risk in these processes		1	
Benefit for the project			1

- In the construction of commercial buildings, the *cost of applying green process* is **strongly more significant** than the *degree of risk in those processes*.
- In the construction of commercial buildings, the *cost of applying green process* is **very strongly to extremely more significant** than the *benefit for the project*.

In your expert opinion, please rank the processes below:

Overall Project Life Cycle										
Pairwise Comparison of Criteria for Overall Project		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Cost of applying green process		1			6			5		
Degree of risk in these processes		1/6			1			2		
Benefit for the project		1/5			1/2			1		
Project Phase 1- Initiation										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)
Environmental impact assessment (EIA-S) Study		1	1/5	1/6	1	1/6	1/5	1	1/2	1/8
Green stakeholder interest (GSI)		5	1	1/3	6	1	1/2	2	1	1/9
Green organizational thinking (GOT)		6	3	1	5	2	1	8	9	1
Project Phase 2 -Planning										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)
Environmental impact assessment deliverables and activities (EIA-D)		1	3	6	1	2	6	1	1/5	1/6
Green integration across engineering sectors (GI)		1/3	1	4	1/2	1	7	5	1	1/3
Green project definition (GPD)		1/6	1/4	1	1/6	1/7	1	6	3	1
Project Phase 3 - Detail engineering design										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)
Green design strategies (GDS)		1	1/4	1/5	1	2	1/4	1	1	1/5
Green design code (GDC)		4	1	1/3	1/2	1	1/4	1	1	1/2
Green Design Monitoring (GDM)		5	3	1	4	4	1	5	2	1

Project Phase 4 - Execution									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)
Quality control assessment (QC)	1	3	1/4	1	8	6	1	7	2
Green construction management and coordination (GCMC)	1/3	1	1/5	1/8	1	1/3	1/7	1	1/9
Resources management on green basis (RM)	4	5	1	1/6	3	1	1/2	9	1
Project Phase 5 - Commissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)
Energy management systems (EMS)	1	4	7	1	3	6	1	1/8	2
Systems synergy (SS)	1/4	1	2	1/3	1	4	8	1	7
Guidelines for green commissioning (GGC)	1/7	1/2	1	1/6	1/4	1	1/2	1/7	1
Project Phase 6 - Decommissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)
Recycling plan (RP)	1	5	1/3	1	1/7	1/7	1	3	5
Environmental remedy (ER)	1/5	1	1/8	7	1	1/2	1/3	1	4
Managing hazardous materials (MHM)	3	8	1	7	2	1	1/5	1/4	1

Definitions

- **Green Design Monitoring (GDM)**
 - Tracking green design progress and verifying design specifications.
- **System Synergy (SS)**
 - Checking the systems integration to measure building efficiency for better resource use.
- **Environmental Remedy (ER)**
 - Mitigating the negative environmental impact due to asset disposal at the end of the economic life of the project.

A DECISION MATRIX FOR GREEN PROJECT MANAGEMENT PROCESSES

EXPERT PANEL INPUT

Name: Issam Srou

Function: Assistant Professor

Organization: The American University of Beirut

Ranking key

1	2	3	4	5	6	7	8	9
Equally significa nt	Equally significan t to moderatel y more significan t	Moderatel y more significan t	Moderatel y to strongly more significan t	Strongly more significa nt	Strongly to very strongly more significa nt	Very strongly more significa nt	Very strongly to extremel y more significa nt	Extremel y more significa nt

Ranking example

<i>Pairwise Comparison of Criteria for Overall Project</i>	Cost of applying green process	Degree of risk in these processes	Benefit for the project
Cost of applying green process	1	5	8
Degree of risk in these processes		1	
Benefit for the project			1

- In the construction of commercial buildings, the *cost of applying green process* is **strongly more significant** than the *degree of risk in those processes*.
- In the construction of commercial buildings, the *cost of applying green process* is **very strongly to extremely more significant** than the *benefit for the project*.

In your expert opinion, please rank the processes below:

Overall Project Life Cycle										
Pairwise Comparison of Criteria for Overall Project		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Cost of applying green process		1			3			3		
Degree of risk in these processes		1/3			1			2		
Benefit for the project		1/3			1/2			1		
Project Phase 1- Initiation										
Processes	Criteria	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
		(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)
Environmental impact assessment (EIA-S) Study		1	5	6	1	6	5	1	6	5
Green stakeholder interest (GSI)		1/5	1	3	1/6	1	2	1/6	1	2
Green organizational thinking (GOT)		1/6	1/3	1	1/5	1/2	1	1/5	1/2	1
Project Phase 2 -Planning										
Processes	Criteria	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
		(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)
Environmental impact assessment deliverables and activities (EIA-D)		1	4	4	1	6	5	1	5	4
Green integration across engineering sectors (GI)		1/4	1	2	1/6	1	2	1/5	1	2
Green project definition (GPD)		1/4	1/2	1	1/5	1/2	1	1/4	1/2	1
Project Phase 3 - Detail engineering design										
Processes	Criteria	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
		(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)
Green design strategies (GDS)		1	3	2	1	5	3	1	3	4
Green design code (GDC)		1/3	1	1	1/5	1	1	1/3	1	1
Green Design Monitoring (GDM)		1/2	1	1	1/3	1	1	1/4	1	1

Project Phase 4 - Execution									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)
Quality control assessment (QC)	1	1/3	1/3	1	1	2	1	1/5	1/3
Green construction management and coordination (GCMC)	3	1	1/2	1	1	3	5	1	3
Resources management on green basis (RM)	3	2	1	1/2	1/3	1	3	1/3	1
Project Phase 5 - Commissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)
Energy management systems (EMS)	1	3	5	1	2	4	1	3	5
Systems synergy (SS)	1/3	1	3	1/2	1	3	1/3	1	3
Guidelines for green commissioning (GGC)	1/5	1/3	1	1/4	1/3	1	1/5	1/3	1
Project Phase 6 - Decommissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)
Recycling plan (RP)	1	1/3	1/6	1	1/3	1/7	1	1/4	1/6
Environmental remedy (ER)	3	1	1/3	3	1	1/5	4	1	1/3
Managing hazardous materials (MHM)	6	3	1	7	5	1	6	3	1

Definitions

- **Green Design Monitoring (GDM)**
 - Tracking green design progress and verifying design specifications.
- **System Synergy (SS)**
 - Checking the systems integration to measure building efficiency for better resource use.
- **Environmental Remedy (ER)**
 - Mitigating the negative environmental impact due to asset disposal at the end of the economic life of the project.

A DECISION MATRIX FOR GREEN PROJECT MANAGEMENT PROCESSES

EXPERT PANEL INPUT

Name: Oswald Chong

Function: Associate professor

Organization: Arizona State University

Ranking key

1	2	3	4	5	6	7	8	9
Equally significant	Equally significant to moderately more significant	Moderately more significant	Moderately to strongly more significant	Strongly more significant	Strongly to very strongly more significant	Very strongly more significant	Very strongly to extremely more significant	Extremely more significant

Ranking example

<i>Pairwise Comparison of Criteria for Overall Project</i>	Cost of applying green process	Degree of risk in these processes	Benefit for the project
Cost of applying green process	1	5	8
Degree of risk in these processes		1	
Benefit for the project			1

- In the construction of commercial buildings, the *cost of applying green process* is **strongly more significant** than the *degree of risk in those processes*.
- In the construction of commercial buildings, the *cost of applying green process* is **very strongly to extremely more significant** than the *benefit for the project*.

In your expert opinion, please rank the processes below:

Overall Project Life Cycle										
Pairwise Comparison of Criteria for Overall Project		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Cost of applying green process		1			5			8		
Degree of risk in these processes		1/5			1			4		
Benefit for the project		1/8			1/4			1		
Project Phase 1- Initiation										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)	(EIA-S)	(GSI)	(GOT)
Environmental impact assessment (EIA-S) Study		1	6	8	1	6	7	1	2	7
Green stakeholder interest (GSI)		1/6	1	3	1/6	1	3	1/2	1	7
Green organizational thinking (GOT)		1/8	1/3	1	1/7	1/3	1	1/7	1/7	1
Project Phase 2 -Planning										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)	(EIA-D)	(GI)	(GPD)
Environmental impact assessment deliverables and activities (EIA-D)		1	5	5	1	6	6	1	2	4
Green integration across engineering sectors (GI)		1/5	1	3	1/6	1	2	1/2	1	4
Green project definition (GPD)		1/5	1/3	1	1/6	1/2	1	1/4	1/4	1
Project Phase 3 - Detail engineering design										
Criteria		Cost of applying green process			Degree of risk in these processes			Benefit for the project		
Processes		(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)	(GDS)	(GDC)	(GDM)
Green design strategies (GDS)		1	5	6	1	4	3	1	3	6
Green design code (GDC)		1/5	1	3	1/4	1	2	1/3	1	5
Green Design Monitoring (GDM)		1/6	1/3	1	1/3	1/2	1	1/6	1/5	1

Project Phase 4 - Execution									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)	(QC)	(GCMC)	(RM)
Quality control assessment (QC)	1	1/4	1/4	1	1/6	1/6	1	1/4	1/2
Green construction management and coordination (GCMC)	4	1	1/2	6	1	2	4	1	5
Resources management on green basis (RM)	4	2	1	6	1/2	1	2	1/5	1
Project Phase 5 - Commissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)	(EMS)	(SS)	(GGC)
Energy management systems (EMS)	1	2	5	1	2	8	1	6	6
Systems synergy (SS)	1/2	1	5	1/2	1	8	1/6	1	2
Guidelines for green commissioning (GGC)	1/5	1/5	1	1/8	1/8	1	1/6	1/2	1
Project Phase 6 - Decommissioning									
Criteria Processes	Cost of applying green process			Degree of risk in these processes			Benefit for the project		
	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)	(RP)	(ER)	(MHM)
Recycling plan (RP)	1	1/2	1/3	1	1/2	1/3	1	1/4	1/5
Environmental remedy (ER)	2	1	1/3	2	1	1/4	4	1	1/2
Managing hazardous materials (MHM)	3	3	1	3	4	1	5	2	1

Definitions

- **Green Design Monitoring (GDM)**
 - Tracking green design progress and verifying design specifications.
- **System Synergy (SS)**
 - Checking the systems integration to measure building efficiency for better resource use.
- **Environmental Remedy (ER)**
 - Mitigating the negative environmental impact due to asset disposal at the end of the economic life of the project.

Appendix D: Complete Green Decision Matrix

project phases					
Project Management Processes	Initiation Phase	Process rank	Process index	Rating index	Final rating
	Environmental Impact Assessment Study (EIA-S)	0.352	Recognize environmental consequences of the proposed project		
			Identify the necessity of the environmental impact assessment on the proposed project		
			Assess and predict the level of air, water, and noise pollution for the project		N/A
	Green stakeholder interest (GSI)	0.364	Define stakeholder concern about green practices which may be used in the project		Initial idea about issues at hand
			Recognize stakeholder tolerance about risks in the green practices		Some knowledge about required processes
			Specify the green specifications as well as green practices for the stakeholders		Reasonable knowledge about required processes
	Green Organizational Thinking (GOT)	0.284	Recognize green orientation of the company		Deep understanding of required processes and needed action
			Measure organization capability to cope with multi-dimensional tasks for the green project		Documented actual steps taken to address concerns and complete tasks
			Provide employees incentive to adopt green practices as well as training on green practices		
			Total		
	Planning Phase				
	Environmental Impact Assessment Deliverables and Activities (EIA-D)	0.498	Recognize direct and indirect environmental consequences for particular activities before they start		
			Evaluate the risks caused by environmental change due to the proposed activities		
			Recommend a set of changes for the proposed activities to mitigate the environmental impact		
	Green Integration Across Engineering Sectors (GI)	0.299	Recognize the collaboration level between cross-functional engineering sectors		
			Assess and train engineers for a solid level of understanding about green project factors		
			Set multidisciplinary teams to identify all project variables		
	Green Project Definition (GPD)	0.203	Identify detail definition for green project specifications		
			Evaluate the main guidelines for the project specification on green factors		
			Correlate the environmental policies and governmental regulations to the project plan		
			Total		
	Detail Engineering Design Phase				
	Green Design Strategies (GDS)	0.304	Utilize the best practices to maximize results in the building design		
			Evaluate green design strategy cost with respect to environmental benefit		
			Specify design strategies combinations, (controlled solar load, utilizing the daylight, ventilation and natural cooling)		
	Green Design Code (GDC)	0.278	Enhance building design by using a variety of design concepts in order to reduce the negative impact on the environment		
			Improve energy efficiency , indoor air quality, and site sustainability for the project		
			Revise and follow the code requirements which will be used in the project		
	Green Design Monitoring (GDM)	0.418	Assess design progress for the project		
			Identify congruence between project design, stakeholder specifications and designer understanding		
			Specify the accuracy of cost estimate and meeting frequency between stakeholders and the project designer		
			Total		
	Execution Phase				
	Quality Control Assessment (QC)	0.397	Evaluate project's execution quality		
			Identify and implement systematic activities to fulfill quality requirement		
			Inspect project activities' execution		
	Green Construction Management and Coordination (GCMC)	0.209	Assess manager planning, coordination, and control which will be used to achieve project goal		
			Specify that project is within budget, moving according to schedule, and that all project green goals have been satisfied		
			Implement green management techniques such as lean construction, Monte Carlo, and just in time methods as well as enhance communication between project parties		
	Resources Management on Green Basis (RM)	0.395	Utilize the company resources efficiently		
			Measure company resource consumption during project execution		
			Provide enough physical resources and assign people to tasks for project execution, and ensure commitment of materials' vendors to the project delivery plan		
			Total		
	Commissioning Phase				
	Energy Management Systems (EMS)	0.543	Identify sets of computer systems which can be used for energy monitoring and controlling building systems		
			Check, assess, and test building equipments as well as building systems to identify their reliability, efficiency, and performance level		
			Develop a tailored energy management system softwares to control building operation sequences, and provide owner's staff with proper training to operate building systems		
	Systems Synergy (SS)	0.34	Integrate two or more systems to improve efficiency		
			Measure the efficiency of system recovery during power failure simulation and identify the tolerance energy load for the building systems		
			Evaluate and test function and operation of hardware, software, and subsystems of the building, and assess end-to-end spot checks system integrity to identify any problems		
	Guidelines for Green Commissioning (GGC)	0.118	Define the processes which can be used to enhance building systems and, by extension, the building value for the owner will be improved		
			Specify overall system efficiency and fulfillment of the project's environmental goals		
			Identify number of systems which require commissioning and specify the detailed requirements for commissioning test		
			Total		
	Decommissioning Phase				
	Recycling Plan (RP)	0.244	Evaluate the process of reducing project waste		
			Specify the efficiency of the recycle plan and measure preservation level for the project materials		
			Identify a coordinator for recycling, waste auditing, and which materials will be recycled in the project		
	Environmental Remedy (ER)	0.223	Assess the remedy for the negative environmental impact caused by the project		
			Mitigate the permanent and temporary environmental impact		
			Utilize remediation technologies such as: thermal disruption, drilling ,pump and treat, and bioremediation		
	Managing Hazardous Materials (MHM)	0.532	Identify the process of collecting and treating project's hazardous materials		
			Provide protection for public health and company employees by effectively managing hazardous materials		
			Specify the legal requirements for storing, treating, transporting, and disposing of those materials		
			Total		
				Total Project Percentage	

Appendix E: Hypothetical Example of Decision Matrix for Green Project Management Processes (Project A)

Project phases		Process rank	Process index	Rating index	Final rating			
Initiation Phase								
Project Management Processes	Environmental Impact Assessment Study (EIA-S)	0.352	Recognize environmental consequences of the proposed project	5	1.76	N/A	0	
			Identify the necessity of the environmental impact assessment on the proposed project	5	1.76			
			Assess and predict the level of air, water, and noise pollution for the project	5	1.76			
	Green stakeholder interest (GSI)	0.364	Define stakeholder concern about green practices which may be used in the project	5	1.82	Initial idea about issues at hand	1	
			Recognize stakeholder tolerance about risks in the green practices	5	1.82			
			Specify the green specifications as well as green practices for the stakeholders	5	1.82			
	Green Organizational Thinking (GOT)	0.284	Recognize green orientation of the company	5	1.42	Deep understanding of required processes and needed action	4	
			Measure organization capability to cope with multi-dimensional tasks for the green project	5	1.42			
			Provide employees incentive to adopt green practices as well as training on green practices	5	1.42			
				Total		15		
	Planning Phase							
	Environmental Impact Assessment Deliverables and Activities (EIA-D)	0.498	Recognize direct and indirect environmental consequences for particular activities before they start	5	2.49			
			Evaluate the risks caused by environmental change due to the proposed activities	5	2.49			
			Recommend a set of changes for the proposed activities to mitigate the environmental impact	5	2.49			
	Green Integration Across Engineering Sectors (GI)	0.299	Recognize the collaboration level between cross-functional engineering sectors	5	1.50			
			Assess and train engineers for a solid level of understanding about green project factors	5	1.50			
			Set multidisciplinary teams to identify all project variables	5	1.50			
	Green Project Definition (GPD)	0.203	Identify detail definition for green project specifications	5	1.02			
			Evaluate the main guidelines for the project specification on green factors	5	1.02			
			Correlate the environmental policies and governmental regulations to the project plan	5	1.02			
				Total		15.00		
	Detail Engineering Design Phase							
	Green Design Strategies (GDS)	0.304	Utilize the best practices to maximize results in the building design	5	1.52			
			Evaluate green design strategy cost with respect to environmental benefit	5	1.52			
			Specify design strategies combinations, (controlled solar load, utilizing the daylight, ventilation and natural cooling)	5	1.52			
	Green Design Code (GDC)	0.278	Enhance building design by using a variety of design concepts in order to reduce the negative impact on the environment	5	1.39			
			Improve energy efficiency , indoor air quality, and site sustainability for the project	5	1.39			
			Revise and follow the code requirements which will be used in the project	5	1.39			
	Green Design Monitoring (GDM)	0.418	Assess design progress for the project	5	2.09			
			Identify congruence between project design, stakeholder specifications and designer understanding	5	2.09			
			Specify the accuracy of cost estimate and meeting frequency between stakeholders and the project designer	5	2.09			
				Total		15		
	Execution Phase							
	Quality Control Assessment (QC)	0.397	Evaluate project's execution quality	5	1.985			
			Identify and implement systematic activities to fulfill quality requirement	5	1.985			
			Inspect project activities' execution	5	1.985			
	Green Construction Management and Coordination (GCMC)	0.209	Assess manager planning, coordination, and control which will be used to achieve project goal	5	1.045			
			Specify that project is within budget, moving according to schedule, and that all project green goals have been satisfied	5	1.045			
			Implement green management techniques such as lean construction, Monte Carlo, and just in time methods as well as enhance communication between project parties	5	1.045			
	Resources Management on Green Basis (RM)	0.395	Utilize the company resources efficiently	5	1.975			
			Measure company resource consumption during project execution	5	1.975			
			Provide enough physical resources and assign people to tasks for project execution, and ensure commitment of materials' vendors to the project delivery plan	5	1.975			
				Total		15		
	Commissioning Phase							
	Energy Management Systems (EMS)	0.543	Identify sets of computer systems which can be used for energy monitoring and controlling building systems	5	2.715			
			Check, assess, and test building equipments as well as building systems to identify their reliability, efficiency, and performance level	5	2.715			
			Develop a tailored energy management system softwares to control building operation sequences, and provide owner's staff with proper training to operate building systems	5	2.715			
	Systems Synergy (SS)	0.34	Integrate two or more systems to improve efficiency	5	1.7			
			Measure the efficiency of system recovery during power failure simulation and identify the tolerance energy load for the building systems	5	1.7			
			Evaluate and test function and operation of hardware, software, and subsystems of the building, and assess end-to-end spot checks system integrity to identify any problems	5	1.7			
	Guidelines for Green Commissioning (GGC)	0.118	Define the processes which can be used to enhance building systems and, by extension, the building value for the owner will be improved	5	0.59			
			Specify overall system efficiency and fulfillment of the project's environmental goals	5	0.59			
			Identify number of systems which require commissioning and specify the detailed requirements for commissioning test	5	0.59			
				Total		15		
	Decommissioning Phase							
	Recycling Plan (RP)	0.244	Evaluate the process of reducing project waste	5	1.220			
			Specify the efficiency of the recycle plan and measure preservation level for the project materials	5	1.220			
			Identify a coordinator for recycling, waste auditing, and which materials will be recycled in the project	5	1.220			
	Environmental Remedy (ER)	0.223	Assess the remedy for the negative environmental impact caused by the project	5	1.115			
			Mitigate the permanent and temporary environmental impact	5	1.115			
			Utilize remediation technologies such as: thermal disruption, drilling ,pump and treat, and bioremediation	5	1.115			
	Managing Hazardous Materials (MHM)	0.532	Identify the process of collecting and treating project's hazardous materials	5	2.660			
			Provide protection for public health and company employees by effectively managing hazardous materials	5	2.660			
			Specify the legal requirements for storing, treating, transporting, and disposing of those materials	5	2.660			
				Total		15		
				Total Project Percentage	100%	Level: Exemplary (Substantial incorporation of the important green concepts in the project management processes)		

Appendix F: Hypothetical Example of Decision Matrix for Green Project Management Processes (Project B)

project phases		Process rank	Process index	Rating index	Final rating						
Initiation Phase											
Project Management Processes	Environmental Impact Assessment Study (EIA-S)	0.352	Recognize environmental consequences of the proposed project	2	0.704	N/A	0				
			Identify the necessity of the environmental impact assessment on the proposed project	3	1.056						
			Assess and predict the level of air, water, and noise pollution for the project	5	1.76						
	Green stakeholder interest (GSI)	0.364	Define stakeholder concern about green practices which may be used in the project	2	0.728			Initial idea about issues at hand	1		
			Recognize stakeholder tolerance about risks in the green practices	3	1.092					Some knowledge about required processes	2
			Specify the green specifications as well as green practices for the stakeholders	5	1.82						
	Green Organizational Thinking (GOT)	0.284	Recognize green orientation of the company	3	0.852	Deep understanding of required processes and needed action	4				
			Measure organization capability to cope with multi-dimensional tasks for the green project	2	0.568			Documented actual steps taken to address concerns and complete tasks	5		
			Provide employees incentive to adopt green practices as well as training on green practices	5	1.42						
				Total		10					
	Planning Phase										
	Environmental Impact Assessment Deliverables and Activities (EIA-D)	0.498	Recognize direct and indirect environmental consequences for particular activities before they start	4	1.99	Some knowledge about required processes	2				
			Evaluate the risks caused by environmental change due to the proposed activities	4	1.99						
			Recommend a set of changes for the proposed activities to mitigate the environmental impact	5	2.49						
	Green Integration Across Engineering Sectors (GI)	0.299	Recognize the collaboration level between cross-functional engineering sectors	5	1.50			Documented actual steps taken to address concerns and complete tasks	5		
			Assess and train engineers for a solid level of understanding about green project factors	2	0.60						
			Set multidisciplinary teams to identify all project variables	4	1.20						
	Green Project Definition (GPD)	0.203	Identify detail definition for green project specifications	4	0.81						
			Evaluate the main guidelines for the project specification on green factors	3	0.61						
			Correlate the environmental policies and governmental regulations to the project plan	5	1.02						
				Total		12.20					
	Detail Engineering Design Phase										
	Green Design Strategies (GDS)	0.304	Utilize the best practices to maximize results in the building design	0	0	N/A					
			Evaluate green design strategy cost with respect to environmental benefit	0	0						
			Specify design strategies combinations, (controlled solar load, utilizing the daylight, ventilation and natural cooling)	0	N/A						
	Green Design Code (GDC)	0.278	Enhance building design by using a variety of design concepts in order to reduce the negative impact on the environment	2	0.556						
			Improve energy efficiency , indoor air quality, and site sustainability for the project	2	0.556						
			Revise and follow the code requirements which will be used in the project	3	0.834						
	Green Design Monitoring (GDM)	0.418	Assess design progress for the project	4	1.672						
			Identify congruence between project design, stakeholder specifications and designer understanding	4	1.672						
			Specify the accuracy of cost estimate and meeting frequency between stakeholders and the project designer	5	2.09						
				Total		7.38					
	Execution Phase										
	Quality Control Assessment (QC)	0.397	Evaluate project's execution quality	1	0.397						
			Identify and implement systematic activities to fulfill quality requirement	2	0.794						
			Inspect project activities' execution	4	1.588						
	Green Construction Management and Coordination (GCMC)	0.209	Assess manager planning, coordination, and control which will be used to achieve project goal	2	0.418						
			Specify that project is within budget, moving according to schedule, and that all project green goals have been satisfied	2	0.418						
			Implement green management techniques such as lean construction, Monte Carlo, and just in time methods as well as enhance communication between project parties	3	0.627						
	Resources Management on Green Basis (RM)	0.395	Utilize the company resources efficiently	0	0	N/A					
			Measure company resource consumption during project execution	0	0						
			Provide enough physical resources and assign people to tasks for project execution, and ensure commitment of materials' vendors to the project delivery plan	0	N/A						
				Total		4					
	Commissioning Phase										
	Energy Management Systems (EMS)	0.543	Identify sets of computer systems which can be used for energy monitoring and controlling building systems	2	1.086						
			Check, assess, and test building equipments as well as building systems to identify their reliability, efficiency, and performance level	4	2.172						
			Develop a tailored energy management system softwares to control building operation sequences, and provide owner's staff with proper training to operate building systems	4	2.172						
	Systems Synergy (SS)	0.34	Integrate two or more systems to improve efficiency	5	1.7						
			Measure the efficiency of system recovery during power failure simulation and identify the tolerance energy load for the building systems	3	1.02						
			Evaluate and test function and operation of hardware, software, and subsystems of the building, and assess end-to-end spot checks system integrity to identify any problems	4	1.36						
	Guidelines for Green Commissioning (GGC)	0.118	Define the processes which can be used to enhance building systems and, by extension, the building value for the owner will be improved	3	0.354						
			Specify overall system efficiency and fulfillment of the project's environmental goals	5	0.59						
			Identify number of systems which require commissioning and specify the detailed requirements for commissioning test	5	0.59						
				Total		11					
	Decommissioning Phase										
	Recycling Plan (RP)	0.244	Evaluate the process of reducing project waste	3	0.732						
			Specify the efficiency of the recycle plan and measure preservation level for the project materials	3	0.732						
			Identify a coordinator for recycling, waste auditing, and which materials will be recycled in the project	5	1.220						
	Environmental Remedy (ER)	0.223	Assess the remedy for the negative environmental impact caused by the project	2	0.446						
			Mitigate the permanent and temporary environmental impact	2	0.446						
			Utilize remediation technologies such as: thermal disruption, drilling ,pump and treat, and bioremediation	2	0.446						
	Managing Hazardous Materials (MHM)	0.532	Identify the process of collecting and treating project's hazardous materials	3	1.596						
			Provide protection for public health and company employees by effectively managing hazardous materials	4	2.128						
			Specify the legal requirements for storing, treating, transporting, and disposing of those materials	5	2.660						
				Total		10					
				Total Project Percentage	61%	Level: Developing (Requires further assimilation of green concepts)					

Appendix G: Processes Index References

Initiation Phase	Index	References
Environmental Impact Assessment Study (EIA-S)	Recognize environmental consequences of the proposed project	R. J. ain, L. Urban, H. Balbch and M. D. Webb, Handbook of the environmental engineering assessment; strategy, planning, and management, Boston: Butterworth-Heinemann, 2012, pp. 211-299.
	Identify the necessity of the environmental impact assessment on the proposed project	R. K. Morgan, Environmental Impact Assessment A Methodological Perspective, Norwell: Kluwer Academic, 1998, pp. 102-133.
	Assess and predict the level of air, water, and noise pollution for the project	Canter and L. W., Environmental impact assessment, Boston: McGrawHill, 1996, pp. 255-300.
Green Stakeholder Interest (GSI)	Define stakeholder concern about green practices which may be used in the project	V. Luyet, R. Schaeffer, M. B. Parlange and A. Buttler, "A framework to implement Stakeholder participation in environmental projects," Journal of environmental management, vol. 111, pp. 213-219, 2012.
	Recognize stakeholder tolerance about risks in the green practices	A. Krasnoff, "the Green Economy post "Internet: www.greeneconomypost.com/green-project-management-greenpm-iso-14000-11040.htm , May 12, 2010 [Nov. 25, 2013].
	Specify the green specifications as well as green practices for the stakeholders	M. M. A. Khalfan, "MANAGING SUSTAINABILITY WITHIN CONSTRUCTION PROJECTS," Journal of Environmental Assessment Policy and Management, vol. 8, pp. 41-60, 2006.
Green Organizational Thinking (GOT)	Recognize green orientation of the company	C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133.
	Measure organization capability to cope with multi-dimensional tasks for the green project	A. Krasnoff, "the Green Economy post "Internet: www.greeneconomypost.com/green-project-management-greenpm-iso-14000-11040.htm , May 12, 2010 [Nov. 25, 2013].
	Provide employees incentive to adopt green practices as well as training on green practices	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.

Planning Phase		
Environmental Impact Assessment Deliverables and Activities (EIA-D)	Recognize direct and indirect environmental consequences for particular activities before they start	A. Gillpin, Environmental Impact Assessment; Cutting edge for the twenty-first century, Cambridge, UK: Cambridge University Press, 1995, pp. 23-66.
	Evaluate the risks caused by environmental change due to the proposed activities	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Recommend a set of changes for the proposed activities to mitigate the environmental impact	J. Glasson, R. Therivel and A. Chadwick, Introduction to Environmental Impact Assessment; Principle and Procedures, Process, Practice and Prospects, London: UCL Press Limited, 1999, pp. 202-266.
Green Integration Across Engineering Sectors (GI)	Recognize the collaboration level between cross-functional engineering sectors	A. Gillpin, Environmental Impact Assessment; Cutting edge for the twenty-first century, Cambridge, UK: Cambridge University Press, 1995, pp. 23-66.
	Assess and train engineers for a solid level of understanding about green project factors	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Set multidisciplinary teams to identify all project variables	D. Graham, Managing Residential Construction Projects: Strategies and Solutions, New York: McGraw-Hill, 2006, pp. 105-200.
Green Project Definition (GPD)	Identify detail definition for green project specifications	R. Best and G. d. Valence, Building in value: pre-design issues, London: Arnold, 1999, pp. 133-189.
	Evaluate the main guidelines for the project specification on green factors	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Correlate the environmental policies and governmental regulations to the project plan	J. Yudelson, Green Building Through Integrated Design, New York: McGrawHill, 2009, pp. 69-135.

Detail Engineering Design Phase		
Green Design Strategies (GDS)	Utilize the best practices to maximize results in the building design	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Evaluate green design strategy cost with respect to environmental benefit	S. J. Wilkinson, H. Remoy and C. Langston, Sustainable Building Adaptation Innovations in Decision-Making, London: Wiley Blackwell, 2014, pp. 56-145.
	Specify design strategies combinations, (controlled solar load, utilizing the daylight, ventilation and natural cooling)	D. Graham, Managing Residential Construction Projects: Strategies and Solutions, New York: McGraw-Hill, 2006, pp. 105-200.
Green Design Code (GDC)	Enhance building design by using a variety of design concepts in order to reduce the negative impact on the environment	A. V. Bentes, J. Carneiro, J. F. D. Silva and H. Kimura, "Multidimensional assessment of organizational performance: integrating BSC and AHP," Journal of business research, vol. 65, pp. 1790-1799, 2012.
	Revise and follow the code requirements which will be used in the project	V. Luyet, R. Schaeffer, M. B. Parlangue and A. Buttler, "A framework to implement Stakeholder participation in environmental projects," Journal of environmental management, vol. 111, pp. 213-219, 2012.
	Improve energy efficiency, indoor air quality, and site sustainability for the project	S. J. Wilkinson, H. Remoy and C. Langston, Sustainable Building Adaptation Innovations in Decision-Making, London: Wiley Blackwell, 2014, pp. 56-145.
Green Design Monitoring (GDM)	Assess design progress for the project	RSMeans, Green Building: Project Planning & Cost Estimating, New Jersey: RSMeans, 2011, pp. 200-245.
	Identify congruence between project design, stakeholder specifications and designer understanding	C. J. Schexnayder and R. E. Mayo, Construction Management Fundamentals, New York: McGraw Hill, 2004.
	Specify the accuracy of cost estimate and meeting frequency between stakeholders and the project designer	S. J. Wilkinson, H. Remoy and C. Langston, Sustainable Building Adaptation Innovations in Decision-Making, London: Wiley Blackwell, 2014, pp. 56-145.

Execution Phase		
Quality Control Assessment (QC)	Evaluate project's execution quality	C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133.
	Identify and implement systematic activities to fulfill quality requirement	C. J. Schexnayder and R. E. Mayo, Construction Management Fundamentals, New York: McGraw Hill, 2004, pp. 199-300.
	Inspect project activities' execution	S. J. Wilkinson, H. Remoy and C. Langston, Sustainable Building Adaptation Innovations in Decision-Making, London: Wiley Blackwell, 2014, pp. 56-145.
Green Construction Management and Coordination (GCMC)	Assess manager planning, coordination, and control which will be used to achieve project goal	X. Liu, "Green Construction Management System for Construction project," in International Conference on E -Business and E -Government (ICEE), Shanghai, 2011, pp. 1-4.
	Specify that project is within budget, moving according to schedule, and that all project green goals have been satisfied	F. E. Gould and N. E. Joyce, Construction Project Management, Ohio: Prentice Hall, 2002, pp. 55-268.
	Implement green management techniques such as lean construction, Monte Carlo, and just in time methods as well as enhance communication between project parties	J. Heagney, Fundamentals of project management, London: American management Association, 2012, pp. 1-22.
Resources Management on Green Basis (RM)	Utilize the company resources efficiently	S. M. Levy, Project Management in Construction, New York: McGraw-Hill, 2000, pp. 232-333.
	Measure company resource consumption during project execution	S. Kubba, Green Construction Project Management and Cost Oversight, London: Elsevier Inc., 2010.
	Provide enough physical resources and assign people to tasks for project execution, and ensure commitment of materials' vendors to the project delivery plan	J. Glasson, R. Therivel and A. Chadwick, Introduction to Environmental Impact Assessment; Principle and Procedures, Process, Practice and Prospects, London: UCL Press Limited, 1999, pp. 202-266.

Commissioning Phase		
Energy Management Systems (EMS)	Identify sets of computer systems which can be used for energy monitoring and controlling building systems	R. A. Panke, Energy Management Systems and Direct Digital Control, New York: The Fairmont Press, 2002, pp. 45-99.
	Check, assess, and test building equipment as well as building systems to identify their reliability, efficiency, and performance level	S. J. Wilkinson, H. Remoy and C. Langston, Sustainable Building Adaptation Innovations in Decision-Making, London: Wiley Blackwell, 2014, pp. 56-145.
	Develop a tailored energy management system software to control building operation sequences, and provide owner's staff with proper training to operate building systems	N. Djuric and V. Novakovic, "Review of Possibilities and Necessities for Building Lifetime Commissioning," Renewable and Sustainable Energy Reviews, vol. 13, pp. 486-492, 2009.
Systems Synergy (SS)	Integrate two or more systems to improve efficiency	Tseng and P. C, "Commissioning sustainable Buildings," ASHRAE JOURNAL, vol. 47, pp. 20-24, 2005.
	Measure the efficiency of system recovery during power failure simulation and identify the tolerance energy load for the building systems	M. Krarti, Energy Audit Of Building Systems An Engineering Approach, London: CRC Press, 2011, pp. 66-103.
	Evaluate and test function and operation of hardware, software, and subsystems of the building, and assess end-to-end spot checks system integrity to identify any problems	R. A. Panke, Energy Management Systems and Direct Digital Control, New York: The Fairmont Press, 2002, pp. 45-99.
Guidelines for Green Commissioning (GGC)	Define the processes which can be used to enhance building systems and, by extension, the building value for the owner will be improved	B. D. Wallace, M. J. Cash and S. w. Engineers, "Commissioning Takes Hold in the Construction Industry," EC & M, vol. 104, pp. 18-21, 5 Dec 2005.
	Specify overall system efficiency and fulfillment of the project's environmental goals	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Identify number of systems which require commissioning and specify the detailed requirements for commissioning test	S. J. Wilkinson, H. Remoy and C. Langston, Sustainable Building Adaptation Innovations in Decision-Making, London: Wiley Blackwell, 2014, pp. 56-145.

Decommissioning Phase		
Recycling Plan (RP)	Evaluate the process of reducing project waste	D. o. E. Services, "opala.org," Internet: www.opala.org/solid_waste/How_to_Set_up_a_recycling_program.html , Apr. 5 ,2005. [Oct.14 ,2014].
	Specify the efficiency of the recycle plan and measure preservation level for the project materials	C. H. Eccleston, Environmental Impact Statements; A Comprehensive Guide to project and Strategic Planning, Canada: John Wiley & Sons Inc., 2000, pp. 66-133.
	Identify a coordinator for recycling, waste auditing, and which materials will be recycled in the project	J. Yudelson, Green Building Through Integrated Design, New York: McGrawHill, 2009, pp. 69-135.
Environmental Remedy (ER)	Assess the remedy for the negative environmental impact caused by the project	S. Kubba, Green Construction Project Management and Cost Oversight, London: Architectural Press, 2010, pp. 99-300.
	Mitigate the permanent and temporary environmental impact	D. A. Vallero, Environmental Contaminants assessment and Control, Boston: Elsevier Academic Press, 2004, pp. 39-99.
	Utilize remediation technologies such as: thermal disruption, drilling ,pump and treat, and bioremediation	D. o. E. Services, "opala.org," Internet: www.opala.org/solid_waste/How_to_Set_up_a_recycling_program.html , Apr. 5 ,2005. [Oct.14 ,2014].
Managing Hazardous Materials (MHM)	Identify the process of collecting and treating project's hazardous materials	E. I. A, M. V. P, O. V, P. B. G, K. N. S and T. S. G, "Decommissioning of civil and military reactors," Atomic Energy, vol. 85, pp. 706-709, 1998.
	Provide protection for public health and company employees by effectively managing hazardous materials	D. o. E. Services, "opala.org," Internet: www.opala.org/solid_waste/How_to_Set_up_a_recycling_program.html , Apr. 5 ,2005. [Oct.14 ,2014].
	Specify the legal requirements for storing, treating, transporting, and disposing of those materials	D. A. Vallero, Environmental Contaminants assessment and Control, Boston: Elsevier Academic Press, 2004, pp. 39-99.

Vita

Mustafa Sahban Al-Tekreeti was born in 1986, in Baghdad, Iraq. Mr. Al-Tekreeti moved to the United Arab Emirates in 2007. He graduated with a Bachelor's of Science (BSc) in Civil Engineering from the University of Sharjah in 2011. Mr. Al-Tekreeti subsequently joined the Master's in Engineering Systems Management Program at the American University of Sharjah, and is currently working towards his degree.