

Supply Chain Management in Building Commissioning Process in Accordance with the Leadership in Energy & Environmental Design (LEED) – A Case Study of KSA Construction Industry.

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Abstract- The commissioning procedure is one of the most effective processes used to improve the performance of building systems and equipment, and the supply chain management in construction industry is the main issue in its performance. Coincidentally, the Leadership in Energy and Environmental Design (LEED) values have the same core objective as of commissioning that is enlightening the building performance. The aim of the current research is to evaluate the building commissioning process in accordance with the Leadership in Energy & Environmental Design (LEED) requirements for the new construction projects from contractor's point of view in order to measure changes needed and spot on the shortcomings in the process requirements during the life cycle of a project. The building commissioning process is a tool to ensure that all building systems have been designed, installed, tested and operated in accordance with the original design and project scope, which ultimately results in producing a better product for the owner and society. A field survey was conducted through a structured questionnaire including 21 commissioning authority contractors (CxAs) who are specialized in building commissioning. SPSS has been used to analyze the data to present statistical measures. The research concluded that there are some contractors not complying with the building commissioning requirements steps process. The results of the data show that the most important requirements that have not adhered by the contractors during the life cycle of a project. Moreover, Performance in the extent and corroboration credit was similar for all owner types, whereas investors performed otherwise from companies and government agencies in the improved commissioning credit. Practitioners who identify these significances and differences are expected to be better placed to make sustainability-related decisions in building design and construction.

Keywords- LEED, Supply chain management, Building Commissioning Process, Environmental Sustainability, Energy Efficiency.

1. Introduction

With the emergence of Leadership in Energy Environmental Design (LEED) and Green Building Rating System, building commissioning has gained attention and become a potential concern in Saudi Arabia's construction Industry[1]-[2]. The mandates for this current system have been declared by the US Green Building Council (USGBC) via Leadership in Energy Environmental Design (LEED) rating program. It is mandatory to follow "fundamental commissioning of the building energy systems" in the quest of projects for LEED Green building Certification (USGBC) which can serve as a supplementary opinion for the performance of enhanced commissioning (Figure 1). Irrespective of recommendations are given by the LEED certification, commissioning proposes significant benefits including 10-20% fall in operating cost along with some extra benefits like reliability, purposeful functionality and efficiency of major systems set up in the building[3]. Consequently, the building systems are progressively gaining more complexity and gradually evolving with the passage of time. In order to meet the needs and expectations of the owners; the construction industry is striving hard to keep pace with the modifications that may fulfil the desired requirements. With regret, it is likely to say that many owners don't get what they expect and desires about their buildings. Furthermore, the repetitive commissioning sporadically increases the probability of maintenance and high performance of a building throughout its life (U.S. Department of Energy 1993) [4-6].

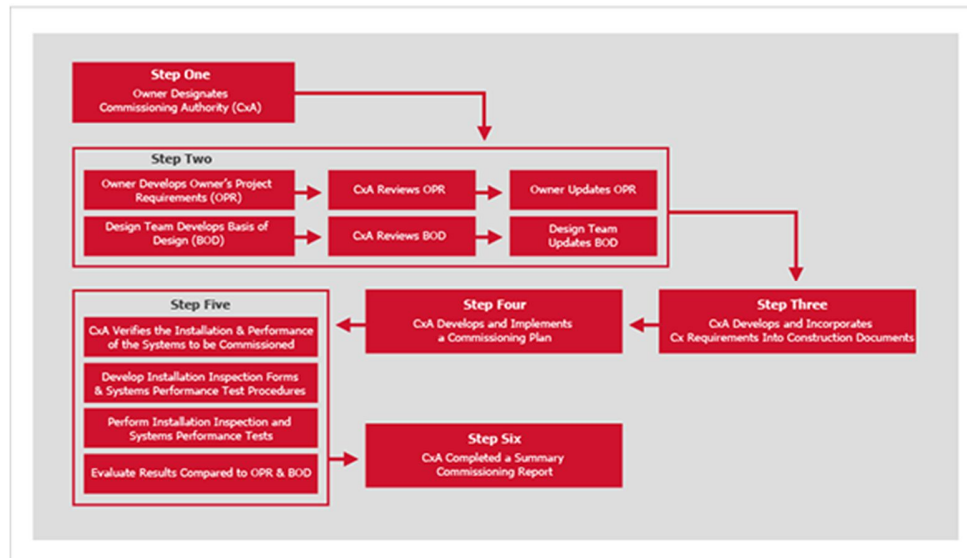


Figure 1. Fundamental commissioning of the building energy systems

Previous research studies depicted that the commissioning process is designed to function from the very scratch or earliest stage of projects and lasts till the completion of operationalization of the first year. The commissioning process was established to minimize the problems and resolve the matters, not allowing them to pile up and come as major problems. As a result of an exceedingly successful commissioning process, it is likely to reduce the conflicts, scheduling problems, request for information, the number of change orders and other issues. The need for the commissioning process is doubted by the owner when the project goes efficiently [7-12]. However, a large number of contractors are unaware of the significance of the inefficient commissioning of a building which results in the poor performance of many projects [13-18]. Defective constructions, faulty equipment, wrong configurations of control systems and inapt operating procedures realized that most of the buildings lack the ability to perform, as they were planned to do with the designers. In contrast, the problems that arise in the later phases of revenue, (including the turnover phase) can be resolved at two stages according to the solution of the problem. The solutions to the issues that are extended and identified this much late are very tricky, sometimes forcing the owner to keep them probably for a long time or throughout the operation and permanently compensating the cost again and again [19-23]. In the last thirty years, Saudi Arabia has undergone through a huge volume of work in the construction industry [24-32] and the core reason of utilization of the wealth or money created by the oil

industry which gives an economic impulse to the country. This has resulted in a very rapid growth and transformations during that period. The high living standards of the people of Saudi Arabia have generated much manufacturing and building employment opportunities. The growth of towns has accelerated due to high population growth. Large and complex projects have been built which not only becomes the attraction factor for the local contractors but also the worldwide construction companies and global contractors. Most of these contractors and their companies lack enough understanding of building commissioning process. This situation led to complex operational problems and initiating troublesome situation in constructed buildings in Saudi Arabia. Problems include comfort complaints, missing or malfunctioning equipment, malfunctioning controls, unexpected equipment failures, and excessive energy costs. Consequently, the only process is known as 'Building Commissioning' can be helpful to get rid of many problems (Figure 2). It is a quality assurance process that focuses on increasing the possibility of meeting client's demands and expectations about the newly constructed building [33-35]. The major objective of this research study is to address the commissioning issues faced by the construction industry of Saudi Arabia. Moreover, the study aims to hunt the incidence and the outcomes of the commissioning process. The research study directs the future perspective and solutions to the problems and challenges being faced related to progressively competitive market in building commissioning process.



Figure 2. Benefits of Building Commissioning

The aim of this research paper is to evaluate how the contractors comply with the commissioning process according to the Leadership in Energy Environmental Design (LEED) in building projects industry in the Saudi Arabia. This study guides the owners and contractors to plan effectively before initializing a project and during the early stages planning and design phase to improve energy efficiency, improve workplace performance with the high quality environments, and prevention of business losses. This study drafts a layoutor foundation for further research on this subject .

2. Research Methodology

This research is a field survey study through a structured questionnaire which is directed to the contractors within the defined scope limitations of this study in the LEED projects of Saudi Arabia. The survey will identify a frequency of occurrence, and the frequency index ranking of the commissioning process. Methodology includes the general study approach, the data collection, the survey, and the scoring system, the survey includes questionnaire development and design, sample size determination and selection.

2.1. Questionnaire Design

Great effort and brainstorming went into designing the questionnaire. Meetings with members of the industry were conducted to identify the right questions required and to present them in a clear and an unambiguous format. Special care also went into phrases the questions in a language that is easily understood by respondents. Various researches have been conducted to examine how commissioning contractors relate to the commissioning process in the building construction industry[36-38]. However, the questionnaire for this study was developed according to the required data: from the field survey. The LEED commissioning steps per phases of the building commissioning process.

2.1.1 Contents of the Questionnaire

Section I - Demographics: It includes instructions to respondents, defining the key terms in the study and providing respondents with instructions on completing the questionnaire also it contains general information about the respondents such as contact address, company size, type etc.

Section II-Phases of Building Commissioning:It addresses steps of building commissioning per phases. A list of the major steps like: frequency of occurrence of these commissioning steps in projects, Most frequent steps correspond to ‘always’, least frequent correspond to ‘never’ which denies the existence of the condition as steps. The steps were further grouped as contractor originated or others for ease of analysis [39,40].

Section III –Macro factors in Building Commissioning: It addresses the building commissioning concerning and the prevailing commissioning industry characteristics. These questions include a definition of building commissioning as it relates to the construction industry, and how involved the individual and their company is in the commissioning process. Questions in the last two sections are posed in a multiple-choice question format.

2.1.2 The Statistical Sample

Four restrictions were imposed on the selection process of respondents:

1. Restricted to LEED projects.
2. Restricted to commissioning authority contractor (CxA).
3. Restricted to building projects (excluding industrial, highway, and other types of construction)
4. Restricted to Saudi Arabia.

2.1.3 Sample Size Determination & Selection

The contractors were identified from the Contractors Directory published by the Saudi Aramco bid slate of classified contractors in the building commissioning works under the operation and maintenance , In the contractor directories, there are about 50 contractors classified that are working in operation and maintenance , but only 21 contractors are specialized as commissioning authority contractor. The size of the sample required for each population was determined based on statistical principles for this type of exploratory research. For such research, sample size was determined as follows;

$$n = (ts / d)^2 / (1 + (ts / d/N)^2)$$

Where:

n = sample size

N= sample population =200

ts :ta/2 is the abscissa of the normal curve that cuts off an

area of $\infty = 0.05$ at the tails.

$t_{\infty / 2} = 1.96$ from statistic Table.

d: is the expected error of the estimate. The amount of Accuracy $(1 - \infty) \% = 0.05$ for 95% confidence interval.

S: pq, p = 0.50 and q = 1- p = 0.50; maximum standard deviation in proportion of estimation.

Therefore, the sample size is calculated through the iteration process to determine a reasonable sample size for the survey as follows:

$$n = (ts / d)^2 / (1 + (ts / d/N)^2)$$

$$n = (1.96 * 0.50 / 0.05)^2 / (1 + (1.96 * 0.50 / 0.05)^2 / 200)$$

$$n = 131.56$$

$$n = 131.56 / (1 + 131.56 / 200) = 79.35$$

$$n = 79.35 / (1 + 79.35 / 200) = 56.88$$

$$n = 56.88 / (1 + 56.88 / 200) = 44.30$$

$$n = 44.30 / (1 + 44.33 / 200) = 36.25$$

$$n = 36.70 / (1 + 36.70 / 200) = 30.70$$

$$n = 30.70 / (1 + 30.70 / 200) = 26.60$$

$$n = 26.60 / (1 + 26.60 / 200) = 23.48$$

$$n = 23.48 / (1 + 23.48 / 200) = 21.02$$

Since the difference becomes smaller, the sample size is 21 contractors.

2.1.4 Scoring System

For part (B) of the questionnaire on causes, a 5-point scale is used to establish a quantitative measure of the frequency of occurrence. The values in the scale for the frequency will be as shown in Table 1. Moreover, based on a final frequency index are classified as shown in table 2.

Table1. Frequency of Occurrence Scale

if	OPTION	Wight (Aif)
1	Always	4
2	Often	3
3	Sometimes	2
4	Never	1
5	Do not know	-

Table2. Rating of Frequency Index

Level Range	Rating
100-90	Excellent
90-80	Very good
80-70	Good
70-60	Fair
60- below	poor

The frequency index (F.I) of each steps will be calculated by the following formula:

$$F. I. = \sum_{i=1}^5 \frac{(Aif * Xi)}{n * 4} * 100$$

Ai Constant expressing the weight assigned to option (i) on the frequency and the severity scales, as shown in Table 3.1 and Table 3.2.

Xi = Variable expressing number of respondents who selected option (i).

N = Total Number of respondents.

$$n = N - X5$$

An example is given for illustration of this scoring: Consider step No 1 (Document/Review Owner's Project Requirements). Assume the following answers:

Frequency index	
Option if	Respondents Xif
Always	0
Often	16
Sometimes	5
Never	0
Do not know	0

frequency index(F.I) = $(0*4)+(16*3)+(5*2)+(0*1)+(0*0) = 0+48+10+0+0 = 58 / (21*4)*100 = 58/84*100 = 69\%$, then the frequency index for this step is =69%. The questions in sections III of the questionnaire are either in ordinal scale or ratio scale. Ordinal scale questions will be transformed into interval scale. Ratio and interval scale questions will be used directly.No scoring will be used for questions in sections III of the questionnaire, since these sections contain general information and characteristics.

3. Results & Discussion

The questionnaire was sent out to a total of 21 commissioning authority contractors (CxA), asking their contribution in identifying importance index of building commissioning process 29 steps according to LEED requirements. Among all contractors, a total of 21 filled the questionnaire however, the response rate by the contractor's is 100%. The general information section contains information on a size of companies

working in the building commissioning industry, their level of experience, company annual volume projects, and several constant employees in the field of the building commissioning LEED projects in Saudi Arabia. Survey results on general characteristics in this section are presented in the graphical representation. The distributions of size and level of experience for contractors are shown in Figure 4.1.1 shows the respondents' in terms of working experience types in the building commissioning industry. Most of them, 71.4% have worked on whole building commissioning which includes all building systems and architecture systems. 28.6% of the respondents have experience in mechanical, electrical, plumbing, and fire systems (MEPF). However, none of them have worked on civil and architecture systems alone in the commissioning field. It means the contractors focused on this type of commissioning (whole building).

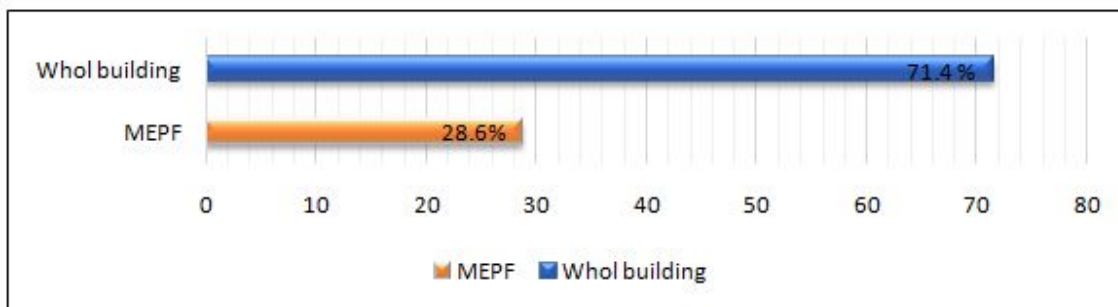


Figure3. Major type of building commissioning experiences

Figure 3 shows the distribution of respondents' in terms of experience is indicating that the majority of respondents i.e., 15 out 21 (71.4%) were experienced between 3-5 years in the commissioning industry project, while 6 respondents (28.6%) had more than 10

years' experience and only 5 (23.8%) respondents had experience of 5 to 10 years. It means the LEED building commissioning is a new trade in the Saudi Arabia.

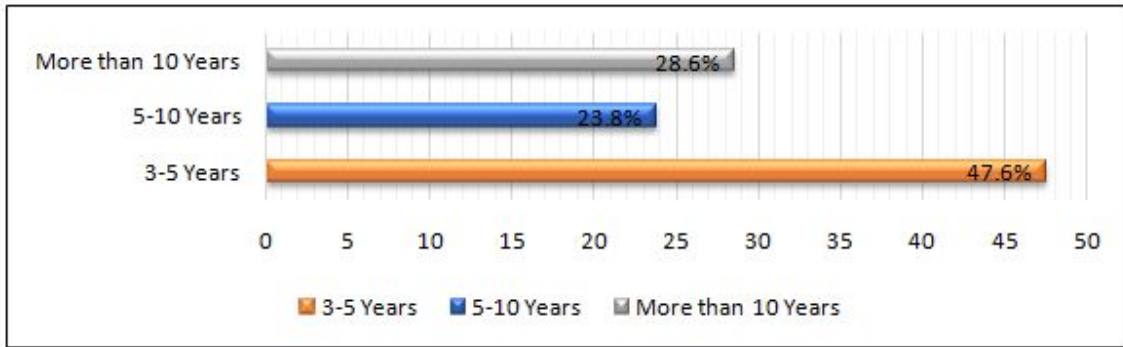


Figure4. Types of Building Commissioning Experiences

Figure 4 shows the respondents' in terms of projects average cost executed per year. A majority of them, 85.7% have executed projects more than 3 million US dollars, while (14%) have executed between 2-3

million US dollars. None of the contractors participating in the survey of projects executed per year experience of less than 1, and between 1-2 million dollars.

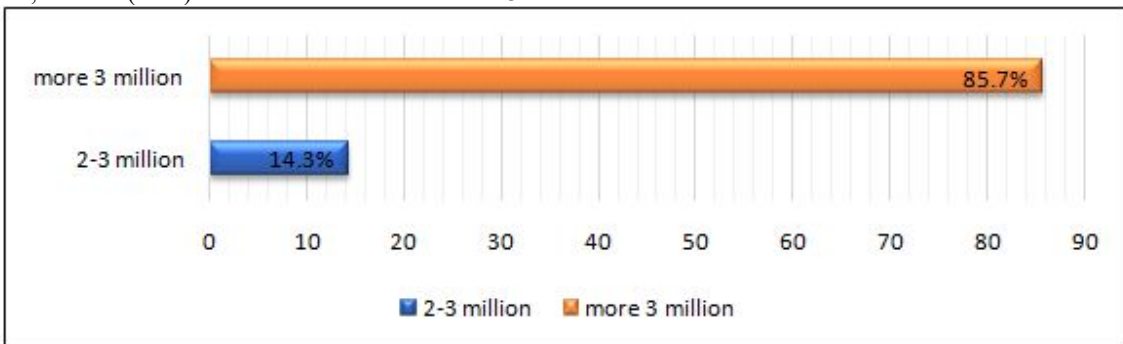


Figure5. Average Cost of Projects Executed per Year

Figure 5 shows the respondents' in terms of a constant number of employees. Most of them, 28.6% have more than twenty constant employees; while (23.8%) have between 15-20 constant employees. A Minimum of

them has between 0-15 constant employees. None of the contractors participating in the constant number of employees of less than 10 employees.

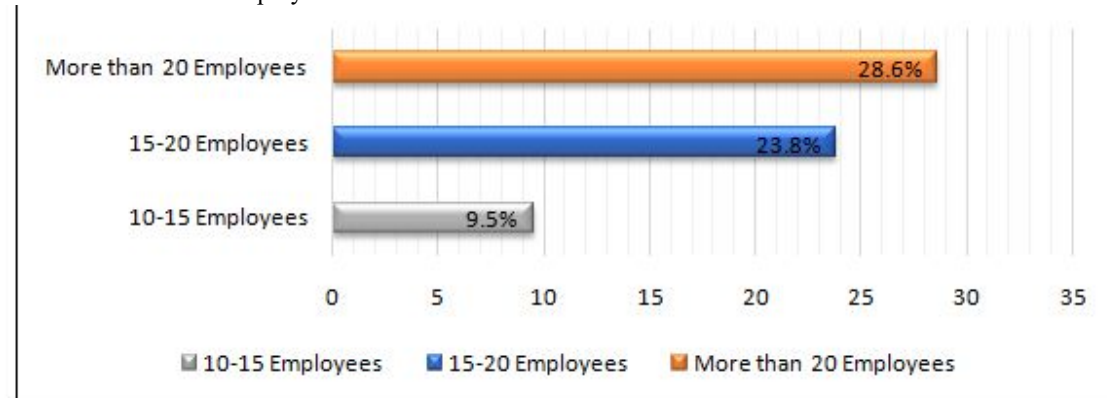


Figure 6. Constant number of employees

Figure 6 shows the respondents' in terms of nature types of commissioning projects involved in building commissioning. Types of projects as a percentage of the building commissioning are classified as follows:

1. Residential
2. Commercial
3. Educational
4. Transpersonal

Over 47.6% of the contractors worked for commercial commissioning projects and the same percentage is the observed in case of residential projects. While 4.8% of the contractors worked on Educational commission projects.

3.1 Frequency Indexes of Cx Process Steps per Phase, Contractors View's

The questionnaire provided respondents to measure the commissioning process as it relates and adhere to the contractor views, for which they were to assign a frequency of occurrence. The following section presents and discusses the results concerning the frequency to the commissioning process from contractor's views then it describes the frequency index of the commissioning process steps and it concluded that the sources groups of these causes are based on their frequency index. The frequency of occurrence of the commissioning process steps is measured by the scores given to each step by the respondents as described in Sec. 3.4 (Scoring system).

Statistical techniques are used to analyze and interpret the collected data concerning the frequency scores of the commissioning process steps. Both of these scales are 5-point scale ranging between zero and four. These techniques will include calculations of weighted means, standard deviations, standard error, the coefficient of variation, and confidence intervals. Table 3 shows the frequency index, mean, error of mean, stander deviation and ranking of each step under the planning phase. Four steps are identified during this phase. The table shows that the most frequent step under this phase reviews the owner's project requirements (OPR), and create a commissioning plan. While the lowest frequent step is select commissioning authority.

Table 3. Frequency Indexes of Cx Process Steps planning phase – Contractors View

CommissioningProcessSteps /Planning phase	Frequency Index (%)	Mean	Error Mean	Std. Deviation	Rank
Document/Review , OPR	69%	2.2381	.09524	.43644	1
Scope& budget for commissioning	60%	2.5714	.21349	.97834	2
Select Commissioning Authority	50%	3.0000	.00000	00000	3
Create Commissioning Plan	69%	2.2381	.22788	1.04426	1
Overall Ranking	62%				

Table 4. shows the frequency index, mean, the error of mean, and stander deviation and ranking of each step under the design phase. Nine steps are identified during this phase. The table shows that the most frequent step under this phase has updated

commissioning plan and refines the scope of commissioning. While the lowest frequent step is to develop construction checklists and functional performance test procedures.

Table 4. Frequency Indexes of Cx Process Steps, design phase

Commissioning Process Steps/Design phase	Frequency Index (%)	Mean	Error Mean	Std. Deviation	Rank
Update Commissioning Plan	83%	1.6667	.18687	.85635	1
Refinescopeof commissioning	83%	1.6667	.18687	.85635	1
Perform Cx Focused Design Reviews	64	2.4286	.21349	.97834	5
Include commissioning requirements in construction document	70%	2.1905	.22487	1.03049	3
Define training requirements	74%	1.9524	.27147	1.24403	2
Define format and content of systems manual	47%	3.0952	.11761	.53896	
Develop construction checklists and functional performance test procedures	53%	2.8571	.07825	.35857	7
Develop commissioning specifications	67%	2.2857	.26853	1.23056	4
Develop roles and responsibility for all stakeholders	53%	2.8571	.12509	.57321	6
Overall Ranking	66%				

Table 5 shows the frequency index, mean, error of the mean, stander deviation, and ranking of each step under the construction phase. The twelve steps are identified during this phase. The table shows that the most frequent step under this phase is correct

deficiencies and retest, prepare to commission final report, and update commissioning plan & schedule. While the lowest frequent step is to update functional performance test procedures.

Table5. Frequency Indexes of Cx Process Steps, Construction Phase

Commissioning Process Steps /construction phase	Frequency Index (%)	Mean	Error Mean	Std. Deviation	Rank
Train O&M Personnel	51%	2.9524	.04762	.21822	7
Complete Construction Checklists	57%	2.7143	.20866	.95618	5
Perform Functional Performance Testing (FPT)	56%	3.0952	.24789	1.13599	6
Document deficiencies found during FPT's (Issues Log)	82%	1.7143	.28571	1.30931	3
Correct deficiencies and retest	100%	1.0000	.00000	.00000	1
Prepare commissioning Final Report	100%	1.0000	.00000	.00000	1
Review Submittals against Cx Plan, OPR, and BOD	46%	3.1429	.17301	.79282	8
Update Commissioning Plan & schedule	100%	1.0000	.00000	.00000	1
Review control sequences	69%	.26641	.26641	1.22085	4
Update functional performance test procedures	42%	3.3333	.19920	.91287	9
Document construction observations	82%	1.7143	.25951	1.18924	3
Review O&M Manuals	95%	1.1905	.19048	.87287	2
Overall Ranking	65%				

Table 6 shows the frequency index, mean, error of mean, stander deviation, and ranking of each step under the handover phase. Four steps are identified during this phase. The table shows that the most

frequent step under this phase is correct to provide the O&M staff documentations. While the lowest frequent step is complete warranty follow-up.

Table6. Frequency Indexes of Cx Process Steps, Handover Phase

Commissioning Process Steps /Handover Phase	Frequency Index (%)	Mean	Error of Mean	Std. Deviation	Rank
Provide ongoing guidance to assist Operations and Maintenance	65%	2.3810	.27147	1.24403	3
Complete Seasonal Testing	94%	1.2381	.13636	.62488	2
Complete warranty follow-up	64%	2.4286	.13041	.59761	4
Provide the O&M staff documentations	100%	1.0000	.00000	.00000	1
Overall Ranking	80%				

3.2 Building commissioning concerning and the prevailing industry characteristics.

In this section, there are questions aimed at establishing that how the individuals and company are involved in the commissioning process. It also includes

certain trend question to check whether there is an increase of commissioning in LEED. The results concerning the building commissioning process in the new construction projects are presented and discussed. Survey results on in this section are presented in the graphical representation. Figure 7 shows the

respondents' in terms of systems influential systems in building commissioning from contractor views. The systems are classified as follows:

1. Electrical
2. Mechanical
3. Controls

Over 47.6% of the contractors considered that the mechanical systems are most affected by building commissioning. While 38.1% considered that the control systems are most affected systems in building commissioning. Only 14.3% of respondents said that the electrical systems are most affected by building commissioning.

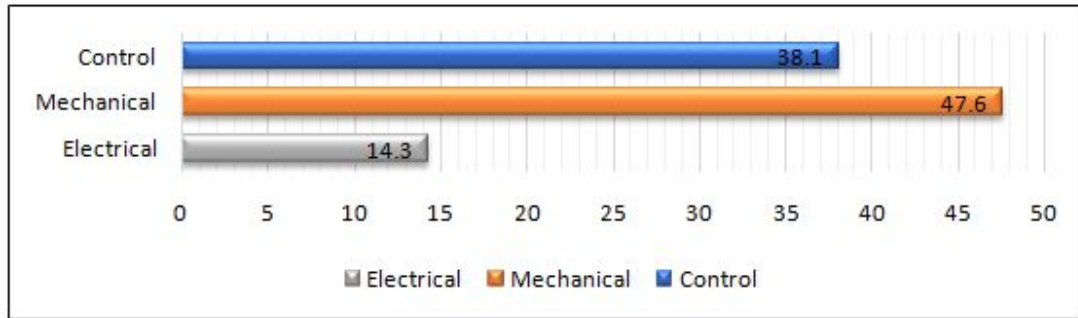


Figure7. The most systems affected in building commissioning

Figure 8 shows the respondents' in terms of most systems challenge in building commissioning from contractor views. The systems are classified as follows:

1. Electrical

2. Mechanical
3. Controls

All contractors' responses agreed that the control systems are most challenged in building commissioning.

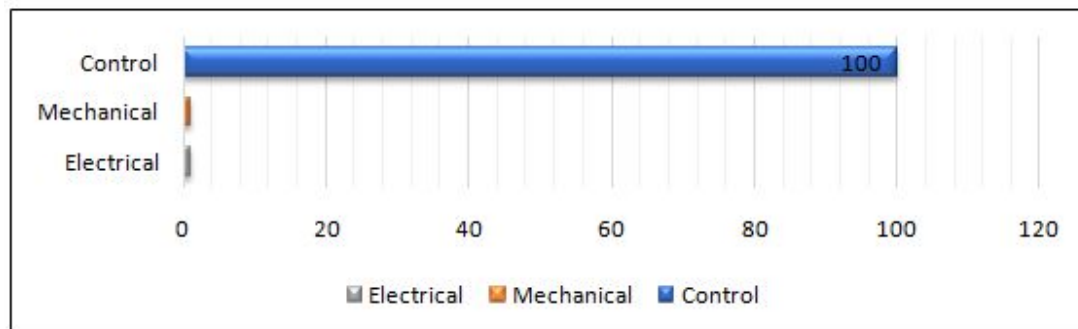


Figure8. The most systems challenge in building commissioning

Figure 9 shows the respondents' in terms of right timing for the Operation and Maintenance staff to engage in the commissioning phases. The timing phases are classified as follows:

1. Pre-commissioning
2. Commissioning
3. Handover

Over 52.4% of the contractors considered that the pre-commissioning phase is the right timing to engage the operation and maintenance staff. While 47.6% considered that the commissioning phase is the right timing. None of the respondents reported to handover timing.

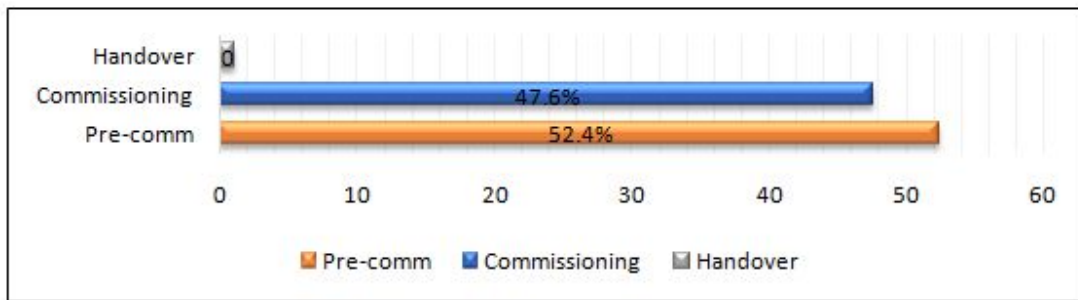


Figure 9. The right timing for the Operation and Maintenance staff

Figure 10 shows the respondents' in terms of energy consumption amount that the owners saving after using the commissioning guideline. The energy consumption is classified as follows:

1. 0-5%
2. 6-10%
3. 11-15%

4. 16-20%

Over 52.4% of the contractors found 0-5% saving on energy consumption when they used the commissioning guideline. While 47.6% they save between 6-10% of energy consumption when they used the commissioning guideline. None of the respondents answered to 11-15% and 16-20%.

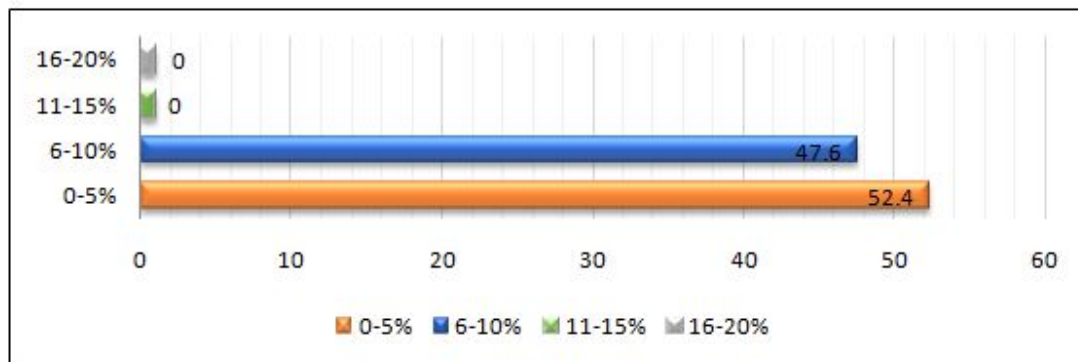


Figure10. Saving of energy consumption

Figure 11 shows the respondents' in terms of suitability commissioning process standard in Saudi Arabia. The commissioning process standards are classified as follows:

1. LEED
2. ASHRAE
3. GSA

4. Their own standard standalone

Over 85.7% of the contractors have pursued the ASHRAE commissioning process standard guideline. While 14.3% they pursued a LEED commissioning process standard guideline. None of the respondents answered to GSA and standalone.

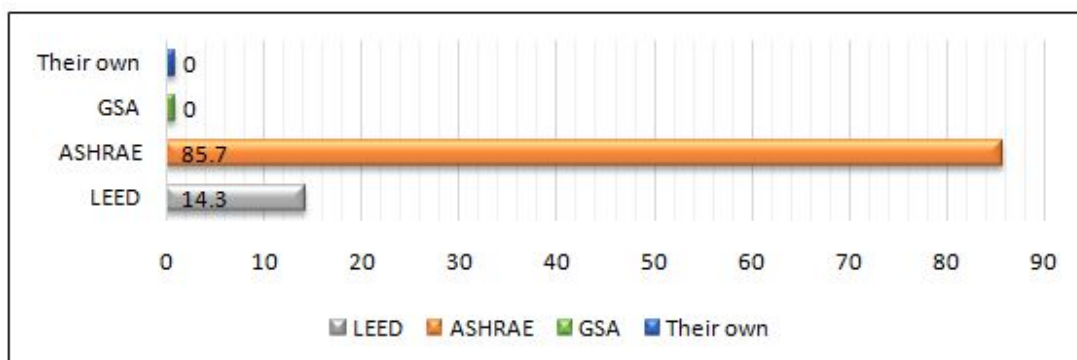


Figure 11. Suitability commissioning process standard in Saudi Arabia

Figure 12 shows the respondents' in terms of contractor's involvement in their own projects in the

building commissioning life cycle. The commissioning phases are classified as follows:

1. Planning
2. Design
3. Pre-commissioning
4. Commissioning
5. Handover

Over 57.1% of the contractors are involved and designated by the owner in the commissioning phase. While 38.1% there are involved in the pre-commissioning phase. Only 4.3% there are involved in the design phase. None of the respondents answered to the planning and handover phases.

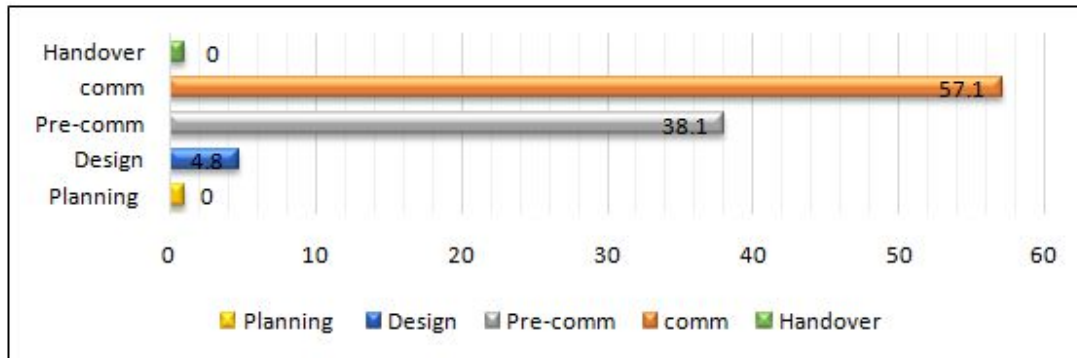


Figure12. contractor's involvement in commissioning life cycle

Figure 13 shows the respondents' in terms of the type of commissioning contract payments scope. The contract payments are classified as follows:

1. lump sum
2. Man days
3. Unit price

Over 47.6 % of the contractors said that commissioning contracts of their projects are lump-sum, also in the same percentage of contractor respondents said that are man days. Only 4.8% of the contractors said that commissioning contracts of their projects are the united price.

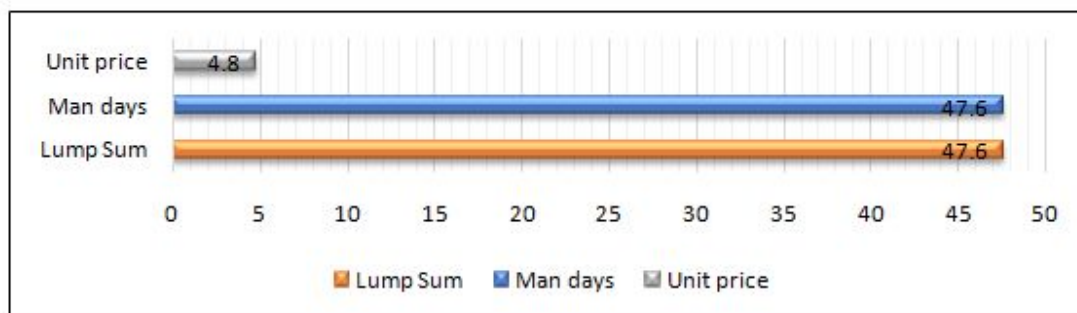


Figure13.Commissioning contracts

Figure 14 shows the respondents' in terms of a level of reliance on subcontractors during the commissioning process. The level of reliance is classified as follows:

1. Non
2. Below average
3. Average
4. Above Average

Over 85.7 % of the contractors said that level reliance on the subcontractors of their projects is above average. While 14.3% of the contractors said that the level of reliance to the subcontractors of their projects is below average. None of the respondents reported none and average in the types of reliance.

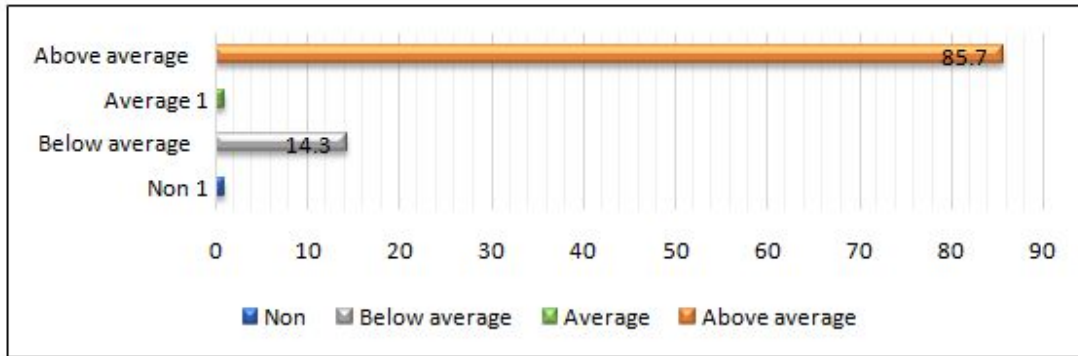


Figure14. Level of reliance on subcontractors

Figure 15 shows the increasing trend towards to LEED-commissioning project in Saudi Arabia. Where all contractors' responses agreed that the LEED-

commissioning projects are increasing in Saudi Arabia.

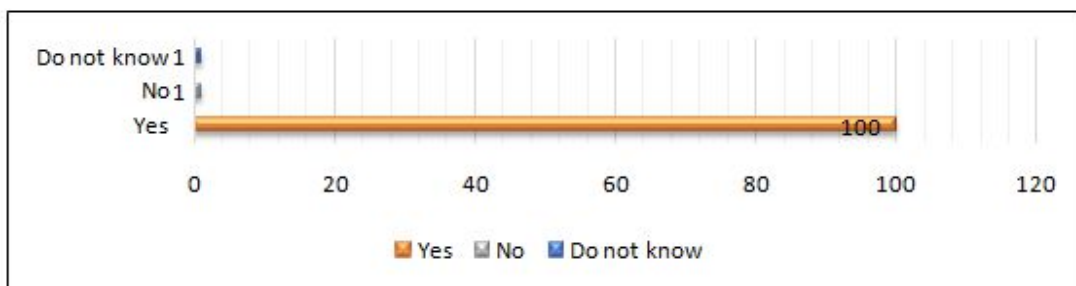


Figure15. Trend towards to LEED projects

Figure 16 shows the respondents' in terms of percentage LEED projects in order to receive the Enhanced Commissioning LEED credit (EA 3).The percentage LEED projects are classified as follows:

Over 66.7 % of the contractors said that percentage LEED projects in Enhanced Commissioning LEED credit (EA 3) of their projects are 70-90%, while 23.8% of the contractors said that percentage LEED projects in Enhanced Commissioning LEED credit (EA 3) of their projects is 40-60%. Only 9.5% of responses of their projects are indicating 10-30 %. None of the respondents reported to 100% in types of percentage.

- 1- 10-30%
- 2- 40-60%
- 3- 70-90%
- 4- 100%

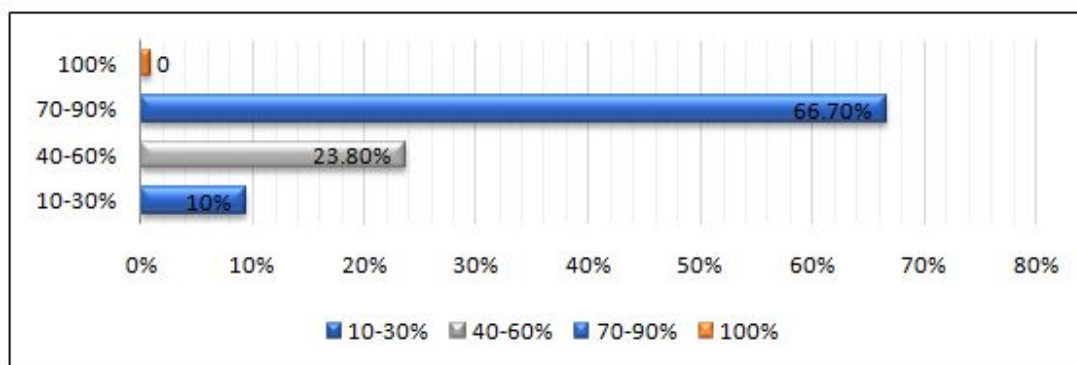


Figure16. LEED projects in Enhanced Commissioning LEED credit (EA 3)

Figure 17 shows the respondents' in terms of percentage LEED projects in order to receive the Fundamental Commissioning. The percentage LEED projects are classified as follows:

- 2- 40-60%
- 3- 70-90%
- 4- 100%

- 1- 10-30%

Over 66.7 % of the contractors said that percentage LEED projects in Fundamental Commissioning credit

of their projects are 70-90%, while 23.8% of the contractors said that percentage LEED projects in Fundamental Commissioning LEED of their projects

are 40-60%. Only 9.5% of responses of their projects are indicating 10-30%. None of the respondents reported to 100% in types of percentage.

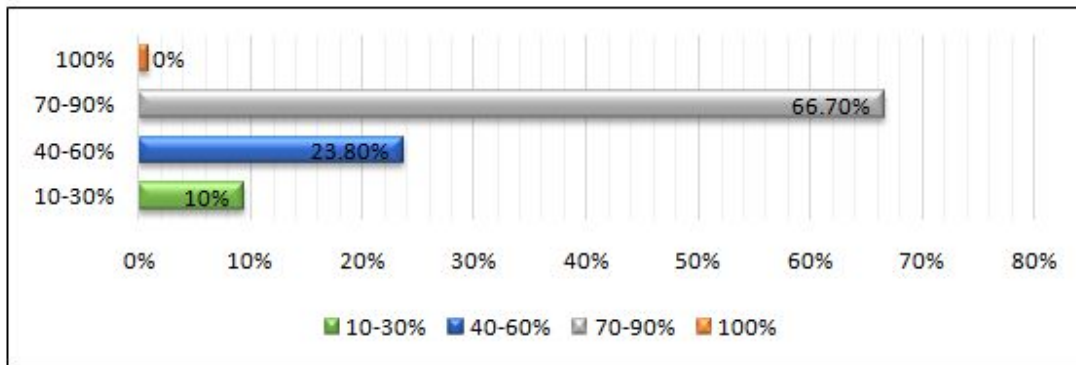


Figure17. LEED projects in Fundamental Commissioning

Figure 18 shows the respondents' in terms of the commissioning process that helping to meet the owner's expectations. Where all contractors' responses

agreed that the commissioning process in helped and supported the owner's expectations.

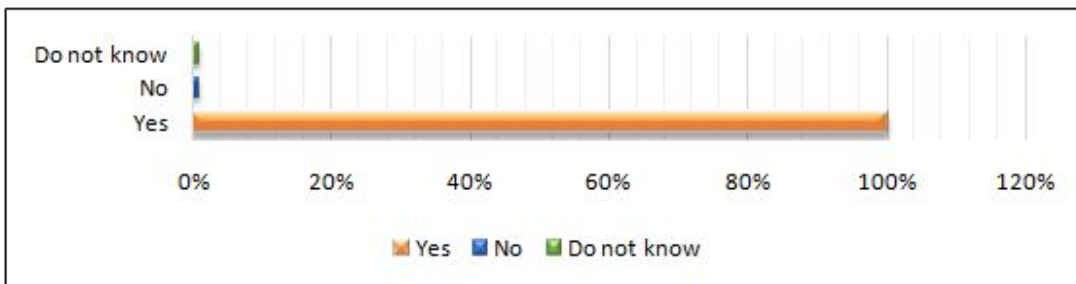


Figure18. Commissioning process, helping to meet the owner's expectations

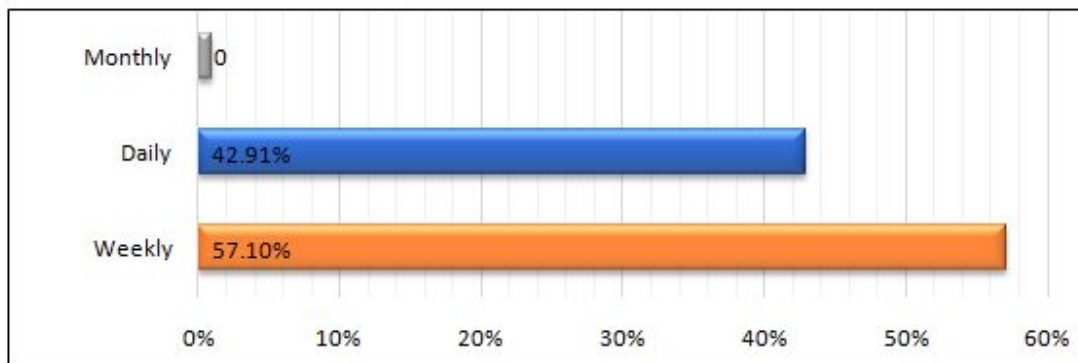


Figure19. Commissioning team meeting mechanism

Figure 19 shows the respondents' in terms of commissioning team meeting mechanism for discussion of monitoring, updating and controlling the progress. The commissioning meetings mechanisms are classified as follows:

1. Daily
2. Weekly

3. Monthly
Over 57.1% of the contractors have a weekly meeting. While 42.91% of them have a daily meeting in order for monitoring, updating and controlling the commissioning progress there are involved in the pre-commissioning phase. None of the respondents answered to the monthly.

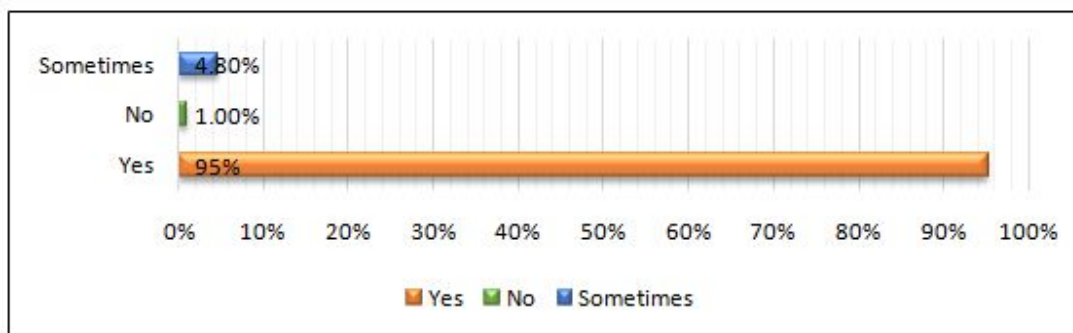


Figure20. Commissioning integrated into construction schedule

Figure 20 shows the respondents' in terms of delay due to commissioning was not integrated into construction schedule. Over 95.2% of the contractors are agreed for

this reason. While 4.8 % of contractor's responses said sometimes. However, none of them reported to No.

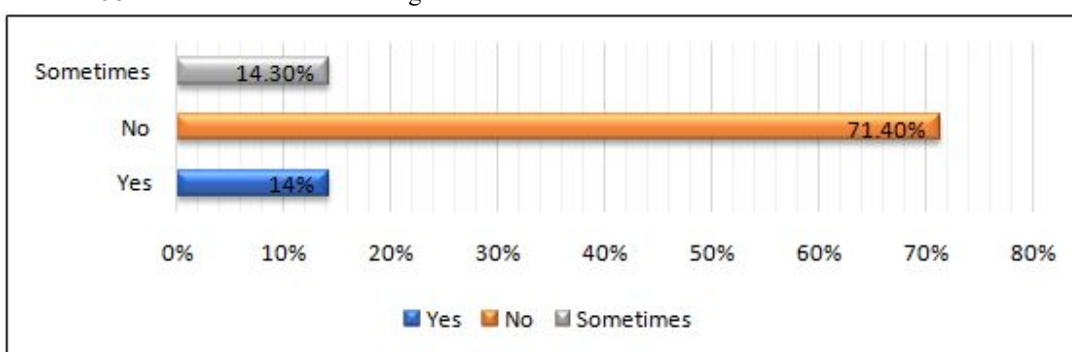


Figure21. Involvement the Operation & Maintenance personnel

Figure 21 shows the respondents' in terms of involvement the Operation & Maintenance personnel in the commissioning meeting. Over 71.4% of the contractors have not involved the operation & maintenance personnel in the commissioning meeting. Also, 14.3% of the contractors they said sometimes they involved the operation & maintenance personnel in the commissioning meeting. Only 14.3% of them, they involved the operation & maintenance personnel.

4. Conclusions

Based on the field survey conducted and the results presented, the following can be concluded:

1. Building Commissioning for LEED new construction is a new concept to the building commissioning contractors in Saudi Arabia. It is noticed that the majority of contractor's respondents had experienced between 3-5 years only, which mean they establishing their firms before three years ago.
2. Lack of commissioning authority firm in Saudi Arabia. It is noticed a shortage of commissioning authority contractors in Kingdom due to the construction industry is booming nationally, with both commissioning projects. As a result, there is a tremendous need for commissioning authority

contractors in the construction industry in Saudi Arabia.

3. The commissioning authority contractors in Saudi Arabia focused, and preferred on the contract that covers whole building commissioning Services (WBCx).

4. Lack of commissioning services for the Architecture systems. Architectural Commissioning has generally covered the technical architectural systems (building envelope and interior assemblies that are environmental separators).

5. Increase in the amount of LEED commissioning in the commercial projects, it is clear that there is a perceived notion that there is a trend towards of LEED projects in Saudi Arabia. It is noticed that the majority of contractors are implemented the primary LEED commissioning required, which covered the Fundamental Commissioning credit, and Enhanced Commissioning LEED credit in order to receive the LEED certification.

6. Lack of awareness and understanding of the LEED commissioning process by contractors. The survey results on the chapter four parts, two for frequency indexes of LEED commissioning Process

Steps. It was noticed that the contractors are not complying with the most mandatory LEED commissioning process steps practices these steps are included the following:

7. The mechanical systems are most affected systems in building commissioning in Saudi Arabia. In addition, the control system is a most challenged system in the building commissioning industry.

8. The "ASHRAE" guideline for the commissioning process is most suitability in Saudi Arabia.

9. From the research, it was noticed that the building owners are saving between 0-5percent from the energy consumption because they are implemented the commissioning guideline.

10. Implementing commissioning LEED process can help reduce the number of call-backs and operation and maintenance cost.

11. From the research, it was noticed that the major reason for the construction projects delay is commissioning programs are not integrated into construction schedule. Most respondents feel that construction schedule and commissioning should be merged schedule.

12. Lack of or poor coordination and communications between the construction parties, and with operation & maintenance personnel in the commissioning meeting involved, are also important causes that create some problems, which lead to a delay in progress. All the parties should make continuous coordination to attending the meeting and direct communication avoid those problems that may arise during the commissioning. It was noticed that most contractors were not involved in the commissioning meeting.

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