

An empirical study investigating the main causes of delay in power transmission construction projects in Saudi Arabia ¹

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1. Abstract

Delay in power transmission projects is a global problem. Within the Saudi construction market, time overrun seems to be a chronic issue.

This study aims to identify the major causes of delay in power transmission construction projects in Saudi Arabia and rank them based on their importance. The goal is to identify major causes of delay within this industry and propose recommendations to overcome these issues. This will help project management practitioners to focus their effort in managing the most critical causes of delay. It will aid the project team to prepare a realistic time schedule and handle delay risks properly.

First, the study identified 29 causes of delay through literature review. Second, a questionnaire survey of 42 experts in power transmission projects in Saudi Arabia is conducted and 41 valid responses are collected. Based on the survey output, the top causes of delay are determined and ranked based on the importance index. The top ranked overall causes are Right of Way problems, frequent transmission lines route changes, drawing/design related problems, late delivery of material, approval process for project documents and drawings, as well as the owner representatives identify accessibility to project location and shortage of labors as critical factors too.

Keywords: Power transmission projects, project delay, time overrun, schedule delay, construction management, project management, Saudi Arabia

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2. Introduction

2.1 Background

There are three main components comprised of the power sector: generation, transmission, and distribution (Pall et al., 2016). Power transmission grid is the link between the power generation and the distribution systems, without this link the system is not going to work. Therefore, the delay in completing the power transmission projects leads to disabling the whole power system. Power transmission projects are usually located in remote areas, away from facilities and services such as electrical and water supplies, that is why careful planning is required (Pall et al., 2019). Saudi Electricity Company (SEC) is the only utility company that provide electricity in Saudi Arabia. The transmission network in Saudi Arabia span more than 90,000 circular KM, covering more than 13000 cities and villages, NG manages fix assets that value more than 160 billion Saudi Riyal (43 billion USD) (SEC: NG, 2022).

In the context of Saudi Arabia, the power transmission construction projects go through chain of processes that can be summarized as:

- identifying the grid requirement,
- project approval,
- bidding and contract award,
- design phase,
- construction phase,
- commissioning,
- handover to operation team.

A typical power transmission project is:

- construction of a substation,
- overhead transmission line (OHTL),
- underground cables line or mix of all these elements.

2.2 Problem statement and objectives

Projects delay is a frequent problem within the construction industry in Saudi Arabia (Al-Kharashi and Skitmore, 2009). In fact, the delay of the power transmission project is a global problem (Pall

et al., 2019). This issue has a significant impact on the project performance and can hinder the ability to capture the economic value of these projects. Therefore, it is particularly important to identify the major causes of delay and prioritize them in the context of Saudi Arabia. The goal is to help the stakeholders who are involved in these projects to: prepare a realistic time schedule, avoid the potential causes of delay, pay close attention to the most critical causes, and subsequently deliver the projects on time.

The scope of this study covers the power transmission construction projects in Saudi Arabia and the main objectives are:

- Gathering a comprehensive list of the main factors behind the delay in the construction projects based on the literature review
- Identification of the top causes of project delay in power transmission projects in Saudi Arabia
- Rank the top causes based on importance
- Provide recommendations on how to overcome and mitigate these causes.

3. Literature review

This article aims to identify the major causes behind the delay on time schedule in power transmission projects in Saudi Arabia. The literature review is an essential step to fulfil the first objective of this report which is gathering a comprehensive list of the main causes of delay in the power transmission construction projects.

The literature review covered publications that focus on the delay factors of the power projects in general, construction projects in Saudi Arabia and construction projects in Gulf Cooperation Council (GCC) countries.

3.1 Previous studies on power construction projects

Power transmission systems are a key component of the power industry and play a key role in economic and social growth (Pall et al., 2019). Delay in power transmission projects is a common global phenomenon (Pall et al., 2016), yet there are a few studies about the delay in the power transmission construction projects. Pall et al. (2016) conducted comprehensive literature review focusing on delays of power transmission projects. After reviewing 74 published articles, the study revealed that there are seven articles related to power transmission projects covering several topics

but none of them searched specifically the causes of delay of power transmission projects. It was concluded that the power transmission literature lacks empirical study on this topic. Based on this fact, the study reviewed the delay factors on sectors which have similarity to the power transmission projects. As a result of this study, 82 causes of delay are identified and classified in nine groups.

In 2019, Pall et al. conducted first empirical study to identify the causes of delays in power transmission projects by using Bangladesh as a case study. The most critical factors leading to projects delay are comprised of sector specific factors such as the Right of Way (RoW) problems, frequent change on transmission lines (TL) routes, accessibility of the tower locations beside general factors like, the poor communication and coordination among the project parties and payment delay. The survey's result shows agreement between the project parties on identifying these critical factors (Pall et al., 2019).

Power projects are not limited only to power transmission projects, it includes power distribution and power generation projects. As part of this literature review, delays on power construction projects in general are investigated. A study about delay causes in Nigerian power construction projects identified 39 causes through literature review, the opinions of 84 experts in power transmission and power distribution are collected to help ranking these causes based on their importance. The top three critical factors are found to be: "corruption and bureaucracy in government, inadequate fund/budget allocation, and price fluctuation/inflation" (Ismaila et al., 2022).

In the Tanzanian power construction projects, there are other critical causes found, a case study investigated 82 owners and 106 contractors. The study has shown different views between the two parties. It identified the critical factors behind the time overrun in projects, especially in unsuccessful projects. However, in the projects with less than 10% time of delay which considered as successful projects, both parties identified vandalism and permit from authorities as a main causes of time delay. Overall, the top five causes identified to be: poor cost estimation, vandalism, late delivery of material and equipment, late procurement orders for material and equipment and additional work attributed to error (Banobi and Jung, 2019).

Batool and Abbas (2017) investigated the reasons of delay in selected hydro-power projects in Pakistan. The study concluded that, political will, Government regulations, law and order issues, poor time management are the major reasons behind the delays. Delays in power distribution substation projects in Taiwan are investigated by Yau and Yang (2012), their article highlights,

“public contending or political involvement” and “tedious review processes of government agencies” as the most common delay factors.

From the previous literature, the factors behind projects delay are influenced by the political environment, economic situation, and social culture. Therefore, in the next section, the causes of delay in construction projects are investigated within the Saudi Arabia construction market.

3.2 Previous studies on construction projects in Saudi Arabia

The search for previous studies in Saudi Arabia related to the delay in construction projects resulted on several articles covering delays in public construction projects such as petrochemical projects, manufacturing and industrial buildings, roads and bridges, public utilities, railway, and metro. However, no study has been made about the power transmission projects, which make this study as the first one within the Saudi market.

Reviewing the delay factors in such projects can be beneficial as there are common features between them and the power transmission projects (Pall et al., 2016). First, they are all classified as public projects. Moreover, Manufacturing, and industrial buildings construction projects share similar features with substations projects. Power transmission substation has control room building, gas insulation system (GIS) halls, switchgear building, pump house and guard room therefore, it is expected that both projects share similar causes of delay. Substations also have access roads, internal roads, pavement and drainage system, these requirements show the common aspects with the road and utilities construction projects. On the other hand, the right of way (RoW) is applicable on transmission line projects, railway/metro projects and highways construction projects, beside the fact that in the metro projects, substations construction is required as part of the system. For all these reasons it is justifiable to review the following literature to identify the common causes behind the project's delay.

(Alsuliman, 2019) A case study about Riyadh Metro project reveals that there are five top factors that leading to the delay in railways construction projects: client's decision-making process and changes in control procedures, design error, labors skills level, design changes by clients or consultant, permission, and approval issues from other stakeholders (Gopang et al., 2020).

Abdellatif and Alshibani (2019), identify the top causes of delay in industrial and manufacturing buildings construction projects, based on the impact and the frequency the causes are difficulties in financing project by contractor/manufacturer, late procurement and delivery of the materials,

delay in payment, slow process of decision making. Comparing these findings with Alhajri and Alshibani (2018) study about petrochemical construction projects as it represents type of industrial project, the only common factor is the delays in material or equipment delivery while other factors are introduced such as, poor site management by the contractor, conflict between the subcontractor and the main contractor, poor planning and scheduling, and delay of the site handover (Alhajri and Alshibani, 2018). However, one of the root causes for all these problems can be explained by the difficulties in financing a project as has been highlighted by Abdellatif and Alshibani (2019).

Public projects in Saudi Arabia are sponsored and financed by government under the national development plan over the last three decades (Alsuliman, 2019). Several articles investigate the delays on the public construction projects, all the papers which are reviewed here indicate that, time overrun is a widespread problem within the public construction projects in Saudi Arabia. One of the common delay factors is awarding the contract to the lowest bidders (Alsuliman, 2019; Assaf and Al-Hejji, 2006) As a result, financial and cash problems are expected and can eventually lead to delays in project progress. Also factors like change orders, delay in payment, poor planning and scheduling, shortage of workforce and inadequate labor skills are found (Al-Kharashi and Skitmore, 2009; Assaf and Al-Hejji, 2006; Assaf et al., 1995). It is interesting to see assorted studies conducted in a wide range of timeline come with similar delay reasons, this might indicate that some of these problems are chronic.

Al-Khalil and Al-Ghafly (1999), researched the delay factors in public utility projects specifically, cash flow and financial issues has been identified again as one of the crucial factors along with the difficulties in obtaining permits and selecting the lower bidder without regard to prequalification. However, in all these studies, there was disagreement in ranking the delay causes between the owners, the consultants, and the contractors. One of the articles which investigates the delay factors from the owner perspective only is a case study of road and bridge projects in Mecca city. Land acquisition is found to be the most critical factor which is leading to time overrun in projects (Elawi et al., 2016), this factor matches the RoW in the transmission projects. The case study identifies additional factors such as lack of expertise, re-designing, and issues with underground utilities.

3.3 Previous studies on construction projects in Gulf Cooperation Council (GCC) countries

GCC countries share common characteristics in terms of economy, social culture, and work culture. Therefore, investigating and reviewing the causes of delay in construction projects

featured in previous studies related to these countries is beneficial within the context of this study.

The poor planning and scheduling, lack of experience, and delay of decision making, these are the major causes behind delay in road projects in Bahrain (Hasan et al., 2014). The same reasons are found as significant causes of delay in United Arab Emirates (UAE) construction industry (Faridi and El-Sayegh, 2006).

In Oman, the poor planning, poor construction experience, and shortage of material are the top delays factors that hinder the completion of the construction projects (Alnuaimi and Mohsin, 2013). The financial issues, lack of experience beside the change orders are reoccurred as critical causes of delay in the construction of private residential projects in Kuwait (Koushki et al., 2005). As it can be seen, many of the delay factors are common between the GCC countries including Saudi Arabia.

3.4 Potential causes of delay in power transmission construction projects in Saudi Arabia

Based on the literature review a comprehensive list of 29 causes of delay is identified to fulfil the first objective of this project. The causes are categorized in owner related factors, contractors related factors, general and external categories, table 1 shows the list in detail. There are sector specific factors such as the RoW problems and the frequent TL route changes, however most of these causes are common within the public and industrial construction projects in Saudi Arabia.

No.	Delay cause	Category	Reference
1	Right of Way (RoW) problems of TL	General	Pall et al, 2019
2	Frequent TL route changes	General	Pall et al, 2019
3	Accessibility to the Project locations	General	Pall et al, 2019
4	Delay in payments	General	Pall et al, 2019; Gopang et al, 2020
5	Drawing and/or design related problems	General	Pall et al, 2019;
6	Delay in construction of dead-end towers of TL/gantries of substation	General	Pall et al, 2019
7	Shortage of material in the market	General	Ismaila et al,2022; Shash and AbuAlnaja, 2021

8	Shortage of equipment on site	General	Ismaila et al,2022; Alhajri and Alshibani, 2018; Alnuaimi and Al Mohsin, 2013
9	Workers' absenteeism	General	Ismaila et al,2022
10	Unreliable subcontractors	General	Abdellatif and Alshibani, 2019; Faridi and El-Sayegh, 2006; Alsuliman, 2019
11	Late delivery of materials	General	Abdellatif and Alshibani, 2019; Nundwe and Mulenga, 2017
12	Shortage of labors	General	Abdellatif and Alshibani, 2019
13	Conflict between the main contractor and subcontractor	General	Alhajri and Alshibani, 2018
14	change orders	General	Pall et al, 2019; Al Khatib, 2018
15	Contractor's poor communication and coordination among the project parties	Contractor	Al-Khalil and Al-Ghafly, 2010; Assaf and Al-Hejji, 2005; Abdellatif and Alshibani, 2019
16	Insufficient experience of the contractor's technical and management staff	Contractor	Pall et al, 2019; Faridi and El-Sayegh, 2006
17	Contractor's poor planning and scheduling	Contractor	Ismaila et al,2022; Banobi and Jung, 2019
18	Late procurement orders	Contractor	Ismaila et al,2022; Abdellatif and Alshibani, 2019
No.	Delay Cause	Category	Reference
19	Unqualified/inexperienced workers	Contractor	Abdellatif and Alshibani, 2019
20	Rework due to errors during construction	Contractor	Assaf and Al-Hejji, 2005
21	Improper construction methods implemented by contractor	Contractor	Assaf and Al-Hejji, 2005
22	Delay in performing inspection and testing	Owner	Abdellatif and Alshibani, 2019
23	Suspension of work by owner	Owner	Assaf and Al-Hejji, 2005
24	Approval processes of project documents and drawings	Owner	Pall et al, 2019; Gopang et al, 2020
25	Unrealistic contract duration	Owner	Ismaila et al,2022

26	Unforeseeable site conditions (i.e., (underground water...etc.)	External	Pall et al, 2019; Faridi and El-Sayegh, 2006
27	Rule and regulation changes	External	Pall et al, 2019
28	Accidents during construction	External	Pall et al, 2019
29	Act of God (Force Majeure)	External	Ismaila et al,2022; Banobi and Jung, 2019

Table 1: Comprehensive list of the potential causes of delay

4. Methodology

This project is based on pragmatism and value driven philosophy to identify the main causes of time overrun in power transmission construction projects in Saudi Arabia. An extensive literature review is used to identify 29 causes of delay in construction projects. The review covered the causes of delay in power construction projects, public construction projects in Saudi Arabia, public construction projects in GCC countries as it detailed in section 2.

The second step is to utilize a quantitative approach by developing questionnaires in order to assess the impact and the frequency for each factor. Statistical analysis techniques are used to rank the causes based on their importance. The ultimate goal is to help the project management practitioners to focus their effort in managing the most crucial factors. Experts in power transmission projects in Saudi Arabia from both contractors and owner sides are asked to participate in the survey.

In the power transmission construction projects setup in Saudi Arabia, there is no independent consultant body that participate in the project management, the project management team is consist of the contractor team and the owner team. Because the power transmission projects are solely owned by the Saudi Electricity Company (SEC), all the participants from the owner side are considered as representative of SEC.

The collected data were analyzed by using impact, frequency and importance indices, the view of the owner and contractor are considered, Figure 1 shows the research procedure. Finally, a recommendation is provided to help in managing the top delay factors.

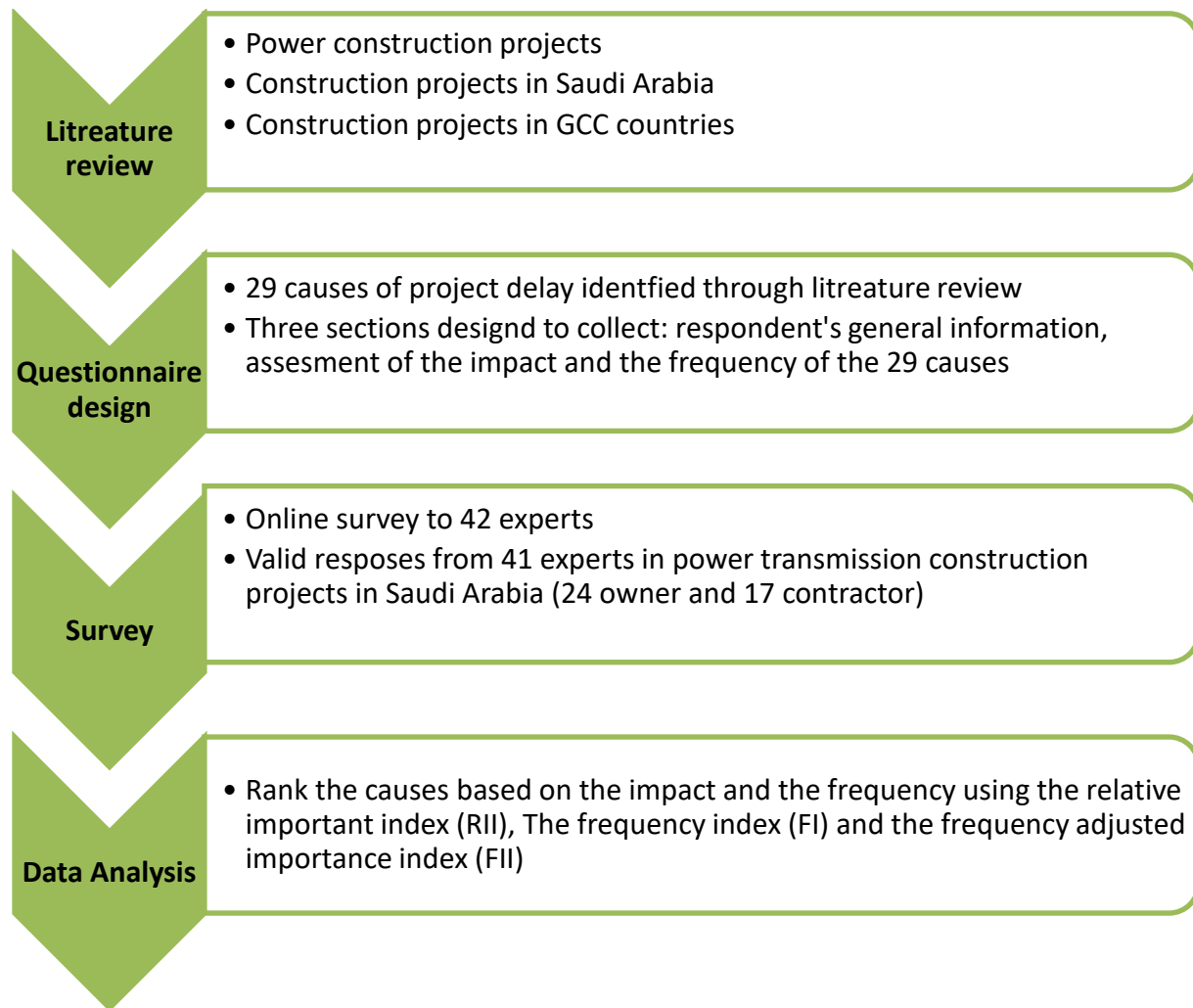


Figure 1: Research procedure

4.1 Questionnaire design and data collection

A questionnaire survey was used to collect the data from the targeted participants. It was developed based on the literature review to identify the main causes of delay in power transmission construction projects in Saudi Arabia. This was important because the causes which are identified through the literature review needed to be reviewed and verified by experts in power transmission projects in Saudi Arabia.

The questionnaire consisted of three sections: respondents' general information, the impact of the

potential causes of delay and the frequency of the potential causes of delay.

In section one, the first question is used to make sure that all participants are working or worked before in power transmission projects in Saudi Arabia. Also, information about respondent profile such as whether they work for contractor or client, job title, engineering discipline, and years of experience are collected. Finally, the participants are asked to identify the actual project completion time on average, this question is designed to figure out the criticality of the project delay problem.

Section two and three aimed to assess the impact and the frequency of 29 causes of delay identified through the literature review, the response was based on five points Likert scale. The participants were given the opportunity to add more causes in case they have other causes which are not mentioned in the list.

The first step before releasing the survey was to conduct a pilot study. Four experts in power transmission projects in Saudi Arabia were invited to review the questionnaire. Then they were asked to give feedback. All of them have provided positive feedback and agreed that the list of 29 causes of projects delay identified through literature review is comprehensive and relevant to the power transmission projects in Saudi Arabia.

Finally, the survey link was distributed through LinkedIn and WhatsApp groups. The author of this report used his network and his colleagues' network. The online survey process covered 4 weeks and 41 valid responses were collected.

4.2 Data analysis

The data collected via the online survey were analyzed using statistical techniques. The Likert scale which is shown table 2 helped the respondents to rate the impact and the frequency for the 29 causes of delay which are presented in the questionnaire. To minimize the bias, the respondents asked to rate the impact based on the following scale: Very Low = less than 2 weeks of delay, Low = less than 1 month of delay, Moderate = less than 3 months of delay, High = less than 1 year of delay, Very High = more than 1 year of delay.

Likert scale	Impact/Frequency
1	Very low
2	Low
3	Moderate
4	High
5	Very High

Table 2: Likert scale

The relative importance index (RII), The frequency index (FI) and the frequency adjusted importance index (FII) are used to analyze the data. These indices are used because they are easy to understand and effective in ranking the delay causes based on impact and frequency. Much research has used this method i.e. (Assaf and Al-Hejji, 2006); (Abdellatif and Alshibani, 2019); (Alhajri and Alshibani, 2018); (Al-Khalil and Al-Ghafly, 1999). The RII equation is:

$$RII = \sum \frac{SR}{W(N)} \quad (1)$$

Where SR represents the scale factor based on the participant responses, basically it is the weight factor (1- 5) given by participant multiplied by the frequency of the responses, W denotes the highest weight, which is 5 in this case, N is the number of the survey's participants. Similarly, the FI equation is:

$$FI = \sum \frac{SF}{W(N)} \quad (2)$$

Where SF is the scale factor (1-5) multiplied by frequency of the responses, W is the highest weight, which is 5, N is the number of the survey's participants. The FII is calculated as can be seen in equation (3):

$$FII = RII \times FI \quad (3)$$

4.3 Limitation

This project is limited to identify the main causes of project delay in power transmission projects in Saudi Arabia. A comprehensive literature review is used to collect a list of 29 causes of delay in construction projects, however it might still be some causes which are not listed. The participants were given the opportunity to identify other causes based on their practical experience. The simple statistical analysis used in this study aimed to rank the causes of the delay based on their impact and, frequency. The root cause analysis of these factors, interrelationship, and correlation between the ranking of the two project's parties for a single cause of delay are not investigated.

5. Results

5.1 Respondents' profile and general information

The first question in the questionnaire designed to ensure that all the participants work or have worked in power transmission projects in Saudi Arabia. 41 valid responses are collected, almost 60% of the respondents are owner or owner representative, the remaining 40% are contractors or subcontractors. Table 3 depicts the respondents' profile, it worth noting that more than 70% of the respondents have more than 10 years of experience in power transmission construction projects. In terms of discipline, most of the participants come from electrical background which is understandable as the majority of the scope in this type of projects is electrical scope.

	No. of respondent s	Percentage (%)
Type of organization		
Owner/Owner representative	24	58.5
Contractor	16	39
Other	1	2.5
Role		
Project manager	10	24.4
Site manager	12	29.3
Engineer	18	43.9
Other	1	2.4
Discipline		
Electrical	23	56.1
Civil	7	17.1

Mechanical	6	14.6
Communication	4	9.8
Protection	1	2.4
Other	0	0
Year of experience		
1-5 years	3	7.3
6-10 years	9	22
More than 10 years	29	70.7

Table 3: Respondents' profile

To evaluate the criticality of the time overrun in the power transmission construction projects in Saudi Arabia, the participants are asked to determine on average the actual project completion time. More than 80% of those who answered this question acknowledged that there are 10% increase of the original contract duration. Almost 45% of the respondents indicate that there are more than 30% of time overrun compared to the original duration Figure 2.

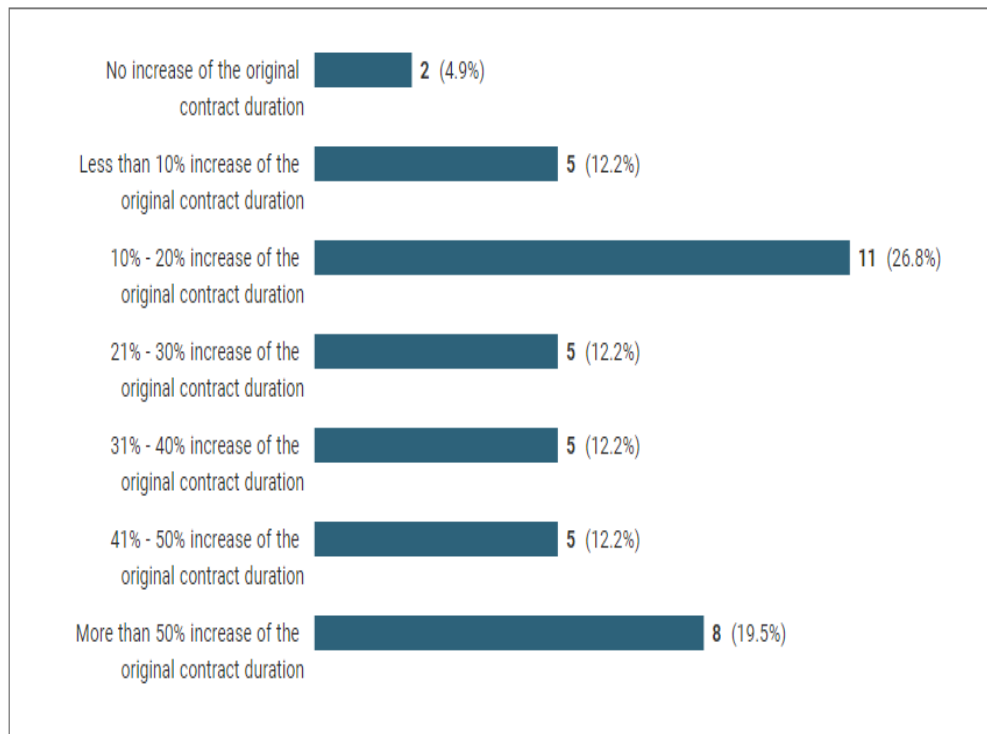


Figure 2: Average delay on project completion

5.2 Ranking of the delay causes based on the input from the overall project parties

The collected data from all project's parties (Owner/ owner representative, contractors) is used to rank the delay causes based on impact (RII), frequency (FI), and the adjusted frequency importance index (FII). Table 4 shows the rank based on the FII, the top five causes are: RoW, Frequent TL route changes, drawing/design related problem, late delivery of material, approval process for project documents.

Delay factor	FII	Rank
Right of Way (RoW) problems of TL	0.427	1
Frequent TL route changes	0.392	2
Drawing and/or design related problems	0.363	3
Late delivery of materials	0.340	4
Approval processes of project documents and drawings	0.333	5
Accessibility to the Project locations	0.325	6
change orders	0.310	7
Shortage of labors	0.303	8
Unreliable subcontractors	0.299	9
Unrealistic contract duration	0.298	10

Table 4: The overall ranking of major delay causes based on FII

5.3 Ranking of delay causes based on the input from the owner representatives

By filtering the responses of the survey, the owner's responses were collected. This step was necessary to compare the owner's representative responses versus the contractors' responses. Table 5 shows ranking of the delay causes using the FII based on the owner's input. Compared to the overall ranking, there is a slight difference in the top five factors. For instance, accessibility to

project location appears at number four instead of the late delivery of material. Also, shortage of laborers took the fifth place instead of approval process of project documents and drawings.

Delay factor	FII	Rank
Right of Way (RoW) problems of TL	0.442	1
Frequent TL route changes	0.429	2
Drawing and/or design related problems	0.360	3
Accessibility to the Project locations	0.333	4
Shortage of laborers	0.318	5
Approval processes of project documents and drawings	0.312	6
Unrealistic contract duration	0.305	7
Late delivery of materials	0.300	8
change orders	0.298	9
Contractor's poor communication and coordination among the project parties	0.294	10

Table 5: The owner’s ranking of major delay causes based on FII

5.4 Ranking of delay causes based on the input from the contractors’ representatives

Table 6 shows the contractors’ ranking of delay causes based on FII. RoW and drawing/design related problem have the same rank as the previous lists. Frequent TL route changes took the fifth place in this list, the only added items which are not in the previous lists are: late procurement orders and contractors’ poor planning. However, there are seven common delay causes in both contractors and owner lists although they are not all in the same order.

Delay factor	FII	Rank
Right of Way (RoW) problems of TL	0.408	1
Late delivery of materials	0.392	2
Drawing and/or design related problems	0.367	3
Approval processes of project documents and drawings	0.359	4
Frequent TL route changes	0.351	5
Late procurement orders	0.344	6
change orders	0.327	7
Accessibility to the Project locations	0.315	8
Unreliable subcontractors	0.312	9
Contractor's poor planning and scheduling	0.304	10

Table 6: The contractors' ranking of major delay causes based on FII

5.5 Other causes of delay identified by the participants

The participants have been asked to identify other causes if it is not listed. Table 7 shows the causes which are identified by the respondents. All these causes can be categorized under one of the main factors which are already identified through the literature review, this point will be elaborated in the discussion section.

No.	Cause of delay
1	Different telecommunication standard for the same type of substation- it should be unified to avoid complications and work delay
2	Management problems
3	Bad weather- rocky area – tough site conditions
4	Material procurement and delivery
5	People's attitude
6	Shutdown approval process

Table 7: Causes of delay identified by the participants

6. Discussion

Delay in power transmission projects has been identified as a global issue (Pall et al., 2019). The result of this study shows that Saudi Arabia is not an exception. 80% of the respondents pointed out that there is a 10% time overrun compared to the baseline duration while 45% of respondents estimated the delay at 30%. This reinforces the fact that, the delay in the public construction projects in Saudi Arabia is a chronic problem (Al-Kharashi and Skitmore, 2009).

The delay causes are ranked based on frequency (FI), impact (RII) and frequency adjusted importance index (FII). FII is used as the primary index because it is a combination of both frequency and impact. Table 8 introduces the top five delay causes according to overall responses, owner's responses and contractors' responses based on FII. Because 60% of the respondents are owners, the overall ranking and the owner's ranking are almost typical, except the late delivery and approval process of project document took the fourth and the fifth place in the overall list while, accessibility to project location and shortage of labors replace them in the owner's list. However, there are three causes which exist in all lists:

RoW problems,
drawing/design related problem
frequent TL route changes.

Accessibility to the project locations took the fourth place in the owner's list but it is not mentioned in the contractors' list. Same for shortage of labors, as it is only listed in the owner classification

while, delay in approval process of project documents and late delivery of material are included in the contractors' list.

Rank	Overall	Owner	Contractor
1	Right of Way (RoW) problems of TL	Right of Way (RoW) problems of TL	Right of Way (RoW) problems of TL
2	Frequent TL route changes	Frequent TL route changes	Late delivery of materials
3	Drawing and/or design related problems	Drawing and/or design related problems	Drawing and/or design related problems
4	Late delivery of material	Accessibility to the Project locations	Approval processes of project documents and drawings
5	Approval processes of project documents and drawings	Shortage of labors	Frequent TL route changes

Table 8: Rank of the delay factors considering overall responses, owners' responses and contractors' responses based on FII

These differences are attributed to the fact that project parties' priorities some causes over the others based on the challenges that hinder their ability to manage project properly. These challenges might not be the same for all project parties.

In the next part of the report, an overview is given for each one of these causes, comparing the results of this study with the previous studies related to the delay in construction projects.

6.1 RoW and frequent TL route changes

Pall et al. (2019) classified RoW and TL route changes as sector specific factors and ranked them on the top of the major delay causes indicated by the project parties in their study. Interestingly, this study replicated the same result. The main reason is because both problems are interrelated, unpredictable and common in power transmission projects. Due to the nature of these problems, it is difficult to forecast and plan for them properly. The regulatory issues and the change in land demographics are the main sources of the RoW problems (Pall et al., 2019). The regulations forbid TLs from crossing existing structures such as: education institutes, religious establishments,

households, public markets.... etc. (Pall et al., 2019). The lengthy legal procedure for land acquisition presents a major obstacle and can have a negative impact on the project time schedule (Pall et al., 2019). RoW problems can also be found in road construction projects. Elawi et al. (2016) ranked land acquisition as the top delay factor in road and bridge construction projects in Mecca province in Saudi Arabia, they estimate the delay caused by this factor by 35% of time extension out of the original contract duration.

On the other hand, TL route changes come on the second overall rank in this study and in Pall et al. (2019) study too. The main causes of the route changes are the RoW problems, inaccurate route survey, public resistance, and other unavoidable circumstances (Pall et al., 2019).

6.2 Drawing/ design related problem

This cause has been ranked in the third place by all parties in this study. Pall et al. (2019) ranked this cause as the sixth overall factor of delay, it also has the same rank in the study carried out by Ismaila et al. (2022) about the delay causes in Nigerian power construction projects. Referring to the studies related to construction project delay in Saudi Arabia, there are many factors associated with design/ drawing problems classified as major delay factors and ranked on the top of the lists. Design errors and design changes (Gopang et al., 2020), mistakes and discrepancies in design documents (Assaf and Al-Hejji, 2006), changes of design during construction (Alhajri and Alshibani, 2018), design changes by owner (Abdellatif and Alshibani, 2019), re-designing (Elawi et al., 2016), these are all design related problems, ranked among the top of delay factors in Saudi Arabia construction market. In EPC type of contracts, the main contractor plays vital role in drawing/ design related issues, and this is the case within the context of this study. However, the owner can have negative influence in the design procedure too. For instance, unclear owner specifications and slow design review process by owner can complicate and delay project progress.

6.3 Late delivery of material

This problem is significant in industrial, petrochemical and manufacturing construction projects in Saudi Arabia. This is attributed to the fact that purchasing and installing heavy equipment is part of these projects and most of the equipment is delivered from overseas. In the context of this study, heavy equipment is considered as long lead materials, which means it takes months to be delivered. Delay in delivering the materials will lead to delay in installation which is leading to delays in the commissioning and testing phase. Therefore, materials delivery is a critical activity in the project critical path. That means the delay in material delivery is going to delay the entire

project.

Alhajri and Alshibani (2018) identified delay in material or equipment delivery as the first cause of delay in petrochemical projects. In industrial/ manufacturing construction projects in Saudi Arabia, Abdellatif and Alshibani (2019) ranked this issue among the top six factors causing projects delay. In this study, the contractors ranked this cause in the second place while the owners rate it in the eighth, this apparently because this item is under the contractor's responsibility and mostly affected by it. Both studies provided suggestions to overcome this problem and they are highlighted in the recommendation section.

6.4 Approval process of project documents and drawings

Expediting documents approval is crucial for the progress of the project. However, bureaucratic organisational procedures can slow down the decision-making process. Pall et al (2019) considered this issue as the most critical delay factor in the owner related factors group, it is ranked as the eighth overall in their study. This factor is also common within Saudi construction industry. Client's decision-making process and changes in control procedures identified as the first cause of delay in Riyadh metro project (Gopang et al., 2020).

Late in reviewing and approving design documents by owner raised by the contractors as the third cause of delay in large construction projects in Saudi Arabia (Assaf and Al-Hejji, 2006). Long time for approval and decision making by owner ranked as the fifth cause of delay in petrochemical projects (Alhajri and Alshibani, 2018). Delay in approving design documents took the fourth place in delaying manufacturing and building projects in Saudi Arabia (Abdellatif and Alshibani, 2019). In this study, the owners ranked this factor in the sixth place, contractors placed it in the fourth while it is rated in the fifth by overall. This high ranking by all project parties shows how much significant this factor is.

6.5 Accessibility to project location

The access to the site location is a frequent problem in power transmission projects. Many of these projects are located in remote areas. The OHTL and the high voltage substations, both are used to transmit the power for long distances cross over the country. In wide country like Saudi Arabia with rugged terrain in some areas, it is possible to see many projects suffer from this issue. It is ranked in the fourth place by owner and sixth overall. Surprisingly, the contractors' representative ranked it in eighth place, excluding it out of their top five causes. However, it is still considered a

crucial factor. Pall et al. 2019 ranked this cause as the third top overall factor in their study. They highlight the fact that logistic arrangement might pose huge challenges when TL runs across water bodies or hilly areas. Floods and heavy rain can also block access to site location and cause delays in project progress. The author of this report has witnessed many such cases.

6.6 Shortage of labors

This issue has been quoted and ranked among the key factors of project delay in several studies within Saudi Arabia construction market (Gopang et al., 2020), (Assaf and Al-Hejji, 2006), (Alhajri and Alshibani, 2018), (Al-Khalil and Al-Ghafly, 1999). However, there is pattern shown in many studies including this one that, the contractors underrate this problem while owners and consultants give it higher rank. In Assaf and Al-Hejji (2006) study, owners and consultants ranked the shortage of labors in the top three factors while the contractors have not included it even in their top ten causes. The owners in Alhajri and Alshibani (2018) article put the factor in fourth place while the contractors placed it in the 11th. The owners' ranking was seventh in Al-Khalil and Al-Ghafly (1999) article for this cause while the contractors place it at 30th. In this study, owners place it at fifth while the contractors rate it at 15th. So, there is disagreement between project's parties in prioritizing this issue. This can be explained by the different perspective in evaluating the quality of work and the workers' performance between the owners and the contractors.

6.7 Additional causes of delay highlighted by the survey's participants.

Table 7 shows the identified causes by the participants. However, all these causes are either too specific technical issue or, general problem that can be breakdown to sub causes. In general, all these causes can be classified under one of the factors in the comprehensive list which is collected for this study. As example, the first cause in table 8, identify the differences in telecommunication standard as a major problem, after consulting telecom expert, this issue found to be design related problem. Management problem is a broad issue, many of the listed causes can be attributed to mismanagement. Harsh weather and tough site condition is already listed as unforeseeable site condition. People attitude can be attributed to poor communication or conflict between project parties. Delay in shutdown approval can also be explained by the lengthy approval process of project documents. Table 9 summarizes the relation between the participants causes and the comprehensive list causes.

No	Participant's causes	Related comprehensive list causes
1	Different telecommunication standard for the same type of substation	Drawing/ Design related problems
2	Management problems	Poor communication, poor planning and scheduling, late material delivery. Etc.
3	Bad weather- rocky area – tough site conditions	Unforeseeable site condition
4	Material procurement and delivery	Late material delivery - Late procurement
5	People's attitude	Poor communication and coordination - Conflict between project parties
6	Shutdown approval process	Approval process for project documents

Table 9: Relation between the participants’ causes and comprehensive list causes.

8. Conclusion and recommendations

This study addresses the delay of the power transmission construction projects in Saudi Arabia. Literature review is used as a secondary source of information. The review covers previous studies in power projects, construction projects in Saudi Arabia and, construction projects in GCC countries. The primary data is collected through survey of experts who work in Saudi power transmission projects.

The first step in the study was to fulfil the first objective by conducting literature review to identify the main causes behind transmission projects delays. 29 causes of projects delay are identified as an output of this step. Second, a questionnaire is developed based on the output of the literature review and distributed through social media such as LinkedIn and WhatsApp to 42 experts. 41 valid responses are collected, 24 from the owner representatives and 17 from contractors. The respondents come from diverse backgrounds in terms of role, engineering discipline and experience. Statistical indices are used to analyze the collected data. Based on the respondents’ feedback and the statistical analysis, the top causes of delay are identified and ranked based on their importance. The most important findings can be summarized as follows:

80% of respondents estimated the delay by 10% compared to the baseline duration while 45% of the participants estimated the delay by 30%.

Both owners and contractors ranked RoW problems, frequent TL route changes and design related problems in their top five causes of project delay. However, the owners identify the accessibility to the project location and shortage of labors in their top five while the contractors have approval processes of project documents, and late delivery of materials in their list. Anyhow, all these causes should be considered as critical factors. They should be monitored and managed carefully.

The findings of this study are reinforced by some of the previous studies. For instance, specific sector factors such as RoW problems and frequent TL route changes are identified by Pall et al (2019) as the top causes of delay in power transmission projects in their empirical study. The rest of the causes are cited several times in many articles as major causes of delay in construction projects in Saudi Arabia. It can be concluded that, there are common factors of delay between public construction projects and power transmission projects in Saudi Arabia.

The following recommendation can be utilized as mitigation strategies to overcome the delay factors which are identified in this study:

- The TL route should be finalized during the initiation and the design phase of the project. This is important to avoid delay during construction phase
- The asset management department in SEC should contact landlords during project initiation phase to negotiate about the compensation required for the RoW
- Recruit expert team members from both owner and contractor to deal with design/drawing related issues
- The contractor should issue the purchase orders (PO) for the long lead items directly after signing off the contract
- The owner should review submitted documents and drawings as soon as possible and discuss any related issue to expedite approval
- It is especially important to consider the time incurred to pave access road, cut the rock in a hilly area or to deal with obstacles imposed by weather during rainy seasons. It is good practice to benchmark the time estimation based on similar projects which have similar conditions

- It is recommended to ensure that the contractor has the ability to recruit the required number of laborers for the project and to motivate them to enhance productivity. The criteria for selecting a contractor should not only be based on the lower bid price.

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