

Photovoltaic Power Station Construction project in Riyadh, Saudi Arabia



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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

إِهْدَاء

إلى من أفضّلها على نفسي ، ولم لا؛ فلقد ضحّت من أجلي
ولم تدّخر جهداً في سبيل إسعادي على الدوام
(أُمِّي الحبيبة)

نسير في دروب الحياة ، ويبقى من يُسيطر على أذهاننا في كل مسلك نسلكه
صاحب الوجه الطيّب ، والأفعال الحسنة
فلم يخل عليّ طفلة حياته
(والدي العزيز)

إلى أصدقائي ، وجميع من وقفوا بجواري وساعدوني بكل ما يملكون، وفي أصعدة كثيرة
أقدم لكم هذا البحث، وأتمنى أن يحوز على رضاكم

الباحثين ،،،

سُرَّةُ الْقَلَمِ

الحمد لله الذي علّم بالقلم ، علّم الإنسان مالم يعلم ،
الحمد لله المنّان ، الملك القدّوس ، مُدبّر اللَّيالي والآيَّام ، مُصَرِّفَ الشُّهُور والأعوام ،
قَدَّرَ الأمور فأجراها على أحسن نظام ،
ماشاء الله كان ، ومالم يشأ لم يكن ،
الحمد لله على ما أنعم به علينا من فضله الخير الكثير ، والعلم الوفير ،
وأعاننا على إنجاز هذا العمل الذي نحتسبه عبادةً من العبادات ، جعلها الله خالصةً لوجهه الكريم .
وبعد حمد الله تعالى وشُكره على إنهاننا لهذه الرّسالة ،
نتقدّم بخالص الشُّكر وعظيم الامتنان للأستاذ الفاضل/ د. **وليد الصادق** على ماقدّمه لنا
من علمٍ نافع ، وعطاءٍ متميّز ، وعلى ما بذله من جهدٍ متواصل ،
ونُصحٍ وتوجيه من بداية مرحلة البحث حتّى إتمام هذه الرسالة ،
ومهما كتبنا من عباراتٍ وجُمَلٍ فإنّ كلمات الشُّكر تظلّ عاجزةً عن إيفاء حقّه ،
فجزاه الله عنّا خيرَ الجزاء ، وجعل ذلك في موازين حسناته .
ويسرّنا أن نتقدّم بالشكر الجزيل لمدير جامعة الجميع الذكيّة المستنشار/ **ناصر المحميد**
ورئيس مجلس الجامعة/ د. **عبدالرحمن المحميد** ، وعميد الجامعة/ د. **سارة عادل**
والحمد لله ربّ العالمين أوّلاً وآخراً ،
والصّلاة والسلام على نبيّنا محمد وعلى آله وصحبه أجمعين .

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1. Strategy

1.1 Mission and vision

In order to develop the mission and vision of the project it is important to understand to the mission and vision of the hypothetical company (or the project owner). This is followed by development of project mission vision and mission should be aligned to the mission and vision of the company. Therefore, vision and mission of the hypothetical company are as stated below.

1.1.2 Vision and mission of the company (hypothetical project owner)

Mission

The mission of the company is to supply to affordable high quality clean electrical power to our customers.

Vision

To be a world class company providing affordable renewable energy in the whole Saudi Arabia so as to make a major contribution towards reduction of greenhouse gas emissions into the environment. This will ensure that our customers, our communities, and the at nation at large is provided with clean, abundant, low-cost, distributed, and renewable energy.

1.1.3 Mission and vision of the Photovoltaic Power Station Construction project

The mission and vision of the proposed project of construction of a photovoltaic power station are therefore, stated as follows. These mission and vision align to the mission and vision and of the company.

Mission

To ensure that every project tasks and sub tasks are completed within the stipulated budget, schedule and the required quality. This will ensure that project overruns such as cost and time overruns are prevented.

Vision

To deliver a high-quality 20 MW photovoltaic power station in Riyadh which will be able to provide the customers with high quality affordable renewable source of energy.

1.2 Project Objectives

- i. To complete project tasks on time (within the scheduled duration), to quality and within the budget.
- ii. To identify project activities that fall within the critical path during the project planning stage.
- iii. To ensure that all the tasks that fall within the critical path are completed on time, within the budget and to required quality. Any disruption to such activities may have significant effect on the entire project.
- iv. To have a full project team assembled within the first two weeks of the project planning. Such a team will entail engineers, architects, technicians, financial officers, and others.
- v. To ensure that qualified and experienced suppliers are identified and selected within the first week of planning.
- vi. To ensure that project materials are delivered only when they are needed without any delay, and in such a manner that there will be no delay whatsoever.

1.3 Performance measurement indicators

In order to ensure that the project remains track, the following will be the project performance indicators.

- i. **Project task completion:** Completion of project tasks within the scheduled period, budget and to the required quality. Successful project task will be one that meets these criteria. In case, any of one of these criteria is not meet by a project task, then the project task will be considered not successful. As such, appropriate corrective

measures will be undertaken to ensure that downstream project activities are not affected.

- ii. **Project milestone:** A number of milestones will be developed, and these milestones will be geared towards completion of the project. Achieving a project milestone will indicate that the project is on track in terms of time management. Failure to achieve a milestone indicates the existence of a problem which must be identified and rectified before it is late.

1.4 Project charter model

Construction of Photovoltaic Power Station in Riyadh, Saudi Arabia-Project

Charter

Project Manager Name: YYYYYYY

Late revision data: 12/10/2021

Project purpose statement: The purpose of this project is to construct a 20 MW on behalf of the Saudi Arabia's Ministry of Energy to supply renewable source of power for the residents of Riyadh, Saudi Arabia.

Project Scope

Deliverables:

- i. Land preparation and site preparation.
- ii. Procurement and installation of an array of solar panels, power storage and related equipment capable of generating 20MW of electrical power for the residents of Riyadh, Saudi Arabia.
- iii. Testing of the installed power plant to ensure that it performs as it should.

Out of Scope

- i. Procurement and installation of transmission lines and associated equipment capable of transmitting 20 MW from the power plant to the national grid for onward transmission to the clients.
- ii. Maintenance of the installed power plant.

Resources: To be confirmed later.

Stakeholders:

- i. **Project sponsor:** Ministry of Energy, Saudi Arabia.
- ii. **Client:** Residents of Riyadh, Saudi Arabia.
- iii. **Ministry of Environment:** Interested party
- iv. **Landowners:** Those whose land will acquired for the construction of the power plant and associated facilities.

(Hermarij, 2013)

2. Governance, structure and process

2.1 Organizational structure for the teams and units of the project

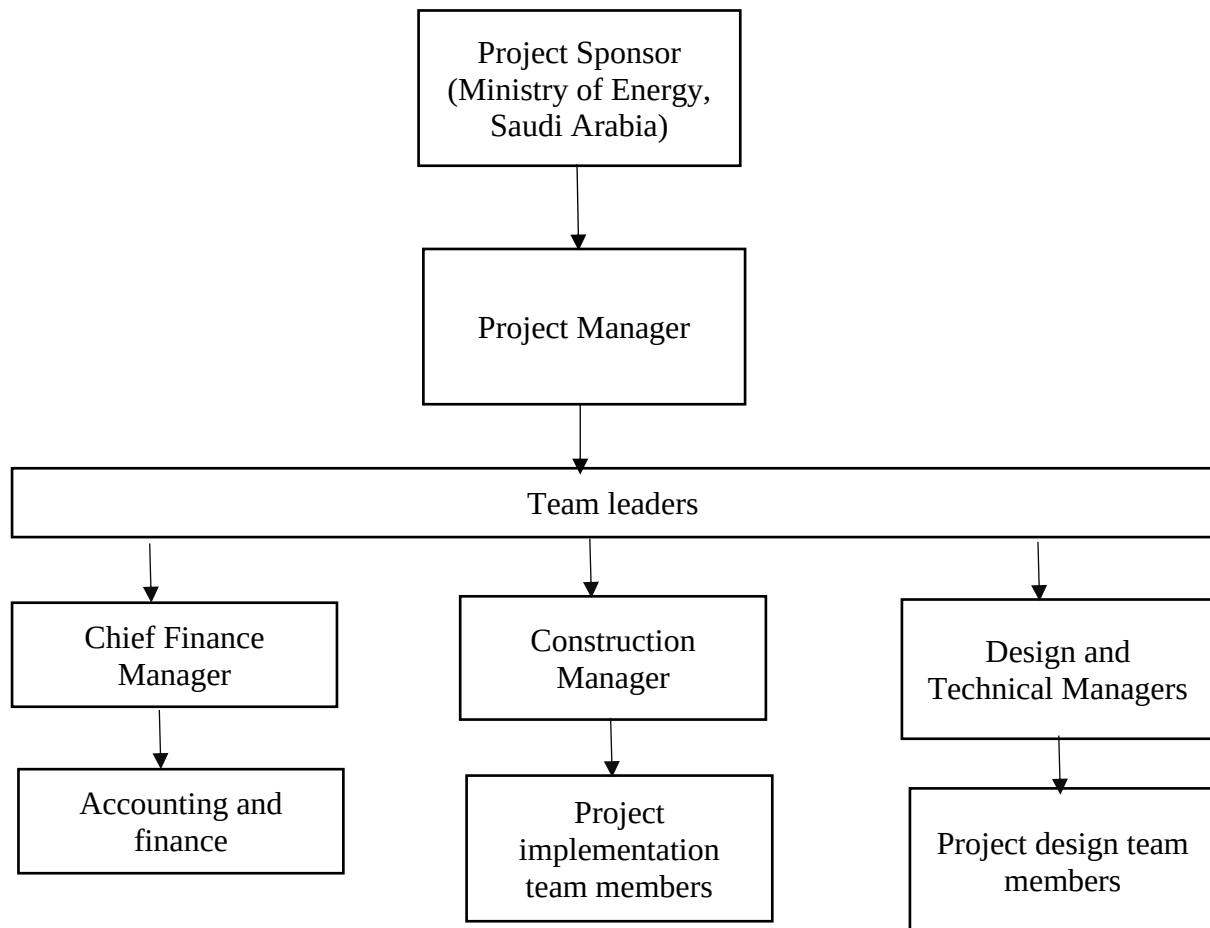


Figure 1: Organizational structure for the teams and units of the project

2.2 Practical and scientific base for developing the organization structure

This organization is made based decentralised organisation structure where decisions regarding can be made at by various team leaders. This involves departmentation of the project activities into specialised groups, and each group will responsible for what they qualified.

2.3 The selected projects office model

The selected project management office model is **Directive PMO** (Directive project management office model). This was selected because it gives powers and authority to a knowledgeable and experienced project manager to take full control of the project. This ensures

that great deal of professionalism is injected into the project. It also ensures that high level of consistency is maintained throughout the project.

3. Compliance and regulation

3.1 Check compliance model

Project activities will be checked for compliance in accordance with the following criteria

- i. Quality with respect to sponsor and client's specification.
- ii. Health and safety regulation.
- iii. Environmental risk
- iv. Social responsibility
- v. Process risk
- vi. Security and privacy
- vii. Anti-corruption

3.2 Check List model for the three stages of the project

Planning

Table 1A: Check List model for project planning

Project planning Check list			
S/No.	Task	Date	Status
1.	Detailed design		Open
2.	WBS prepared		Open
3.	Budgeting		Open
4.	Securing of project finance		Open
4.	Project kick-off meeting		Open
5.	Procurement and contracting		Open

6.	Securing of land and necessary approvals		Open
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Project Execution

Table 1B: Check List model for project implementation

Project implementation Check list			
S/No.	Task	Date	Status
1.	Site preparation		Open
2.	Equipment mobilization		Open
3.	Delivery of raw materials		Open
4.	Foundation works		Open
5.	Installation of solar power plant and associated facilities		Open
6.	Testing		Open

Project Closure

Table 1C: Check List model for project closure

Project closure Check list			
S/No.	Task	Date	Status
1.	Testing		Open
2.	Site cleaning		Open
3.	Disposal of waste		Open
4.	Handover		Open

4. Power and interest

4.1 Stakeholder register and group

Table 2: Stakeholder Register and group

Stakeholder Register						
Project Name: Construction of photovoltaic power station in Riyadh, Saudi Arabia						
Project Date:						
Stakeholder Name	Type of stakeholder	Role	Impact	Interest or and influence	Address	Remarks
Those who can influence the project (very important and have high influence)						
Ministry of Energy, Saudi Arabia	Project client	Project sponsor	Positive	High interest and high influence	Riyadh, Saudi Arabia	Very important stakeholder
Ministry of Environment, Water and Agriculture of Saudi Arabia	Environment protector	Ensures environmental protection during project implementation	Positive and negative	High interest, and high interest	Riyadh, Saudi Arabia	Very important stakeholder
Those are irresponsible and act on their interest						
Fantom Construction Company	Project contractor	Undertakes the project	Positive	High interest and high influence	Riyadh, Saudi Arabia	Very important stakeholder

Victims and beneficiaries						
Land owners		Need to be compensated	Negative	High interest, low influence	Riyadh, Saudi Arabia	Very important stakeholder
Residents of Riyadh Saudi Arabia	Project clients	Consumers of the electricity	Positive	High interest, low influence	Riyadh, Saudi Arabia	Very important stakeholder

4.2 Logical diagrams

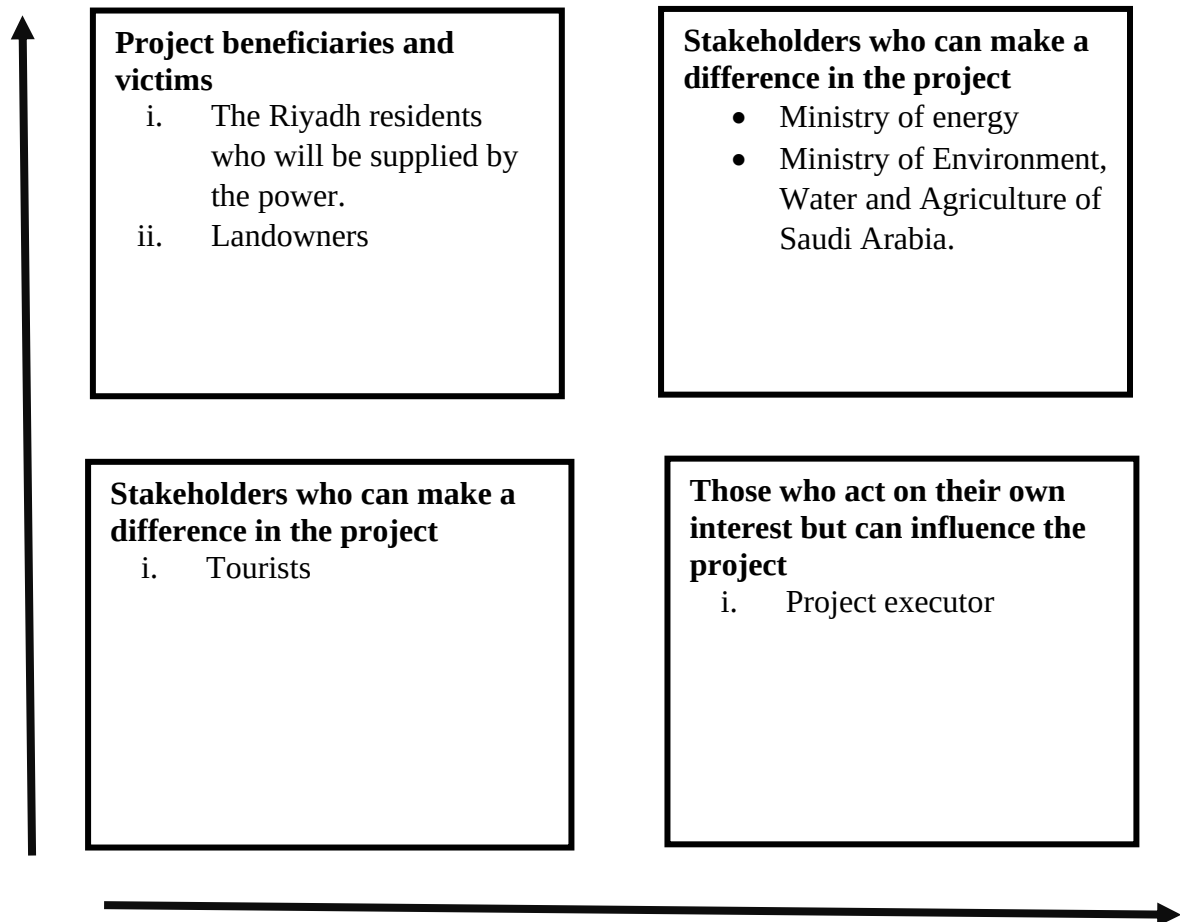


Figure 2: Logical diagrams

5. Organization culture and values

5.1 Organization culture

Hard work and employees' satisfaction. This where the focus will be given to employees (team project team members) as they are ones ensuring that the projects are delivered on time, within budget and to the required quality. A satisfied employee is happy and works towards attaining his or her organizational goals. This includes well remuneration of the employees, offering holidays and gifts for job well done, among others aspects of employee appreciation.

5.2 Values that can be adopted

- i. **Quality:** This ensures that the organization is committed to delivering high quality services. This enhances the satisfaction of the project clients and owners.
- ii. **Honesty and Transparency:** This ensures that problems are not hidden but revealed which helps in identification of solutions problems to projects the company has faced in undertaking projects and how to avoid recurrence of such problems in future projects. This improves the success rate of projects being undertaken by the company.
- iii. **Continuous improvement:** This cultivates the culture of hard work on the employees and wanting to always improve from the current situation. This ensures that next projects are performed better than previous projects. This in the end ensures that quality is always improved, and project completion rate is increased significantly.

6. Self-reflection and self- management

6.1 Personal behaviours that can affect project

- i. **Lack of communication skills:** An individual who lacks communication skills can be a problem. One of the major success factors for projects is communication. Therefore, an individual who is not open and does not communicate about problems they face when conducting their tasks may help the organisation achieve its objectives as problems cannot be easily identified and corrected on time.

- ii. Self-centeredness: An individual that does not embrace team work is threat to completion of the project activities according to scope, schedule, budget and quality. Embracing team work is often important, and the team members need to work together towards achieving a common goal.
- iii. Being jack of all trades: This is not good as it compromises of quality. One is good at everything, and no one can be good at everything. An individual that believes to know everything is always associated with low quality deliverables. Specialization is the key to producing high quality projects within the stipulated period of time. Therefore, individuals qualified and experienced in their fields should be involved project activities associated with their fields.

6.2 Self (personal) SWOT Assessment

- i. Strengths
 - a. Team work
 - b. Good communication skills.
 - c. Knowledgeable in project management areas
 - d. Socialization
- ii. Weakness
 - a. Short tempered.
- iii. Opportunities
 - a. Ready to expand communication by learning other languages
 - b. Ready to know more about project management.
- iv. Threat
 - a. Economic meltdown which may reduce the number of projects
 - b. Technology. Evolution of technology may render some of us jobless.

7. Personal integrity and reliability

7.1 Behaviours that contradict moral integrity

- i. **Dishonesty:** Not being honest, not keeping promises kills trust amongst those involved. Lack of trust results into non-commitment of project team members to project activities. Consequently, low quality product may be produced, or team may not be committed to project schedule and budget.
- ii. **Disrespect:** Mutual respect amongst the team members is extremely important in completion of project activities as it enhances mutual relationship and understanding amongst the members of the team. Lack of respect causes quarrels, disagreements and chaos amongst team members, and affecting the chance of completing the project according to scope, on time, within budget and to the required quality.
- iii. **Unfair treatment of people and team members:** Unfair treatment of project team members kills their morale and ability to deliver the tasks assigned to them. This consequently influences the delivery of the project.

8. Personal communication

8.1 Register of stakeholders

Table 3: Register of stakeholders

Stakeholder Register						
Project Name: Construction of photovoltaic power station in Riyadh, Saudi Arabia						
Project Date:						
Stakeholder Name	Type of stakeholder	Role	Impact	Interest or /influence	Address	Remarks
Ministry of Energy, Saudi Arabia	Project client	Project sponsor	Positive	High interest	Riyadh, Saudi Arabia	Very important stakeholder
Fandom Construction Company	Project contractor	Undertakes the project	Positive	High interest	Riyadh, Saudi Arabia	Very important stakeholder
Ministry of Environment, Water and Agriculture of Saudi Arabia	Environment protector	Ensures environmental protection during project implementation	Positive and negative	High interest	Riyadh, Saudi Arabia	Very important stakeholder
Land owners		Need to be compensated	Negative	High interest	Riyadh, Saudi Arabia	Very important stakeholder

Residents of Riyadh Saudi Arabia	Project clients	Consumers of the electricity	Positive	High interest	Riyadh, Saudi Arabia	Very important stakeholder
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8.2 Stakeholder assessment matrix

Table 4: Stakeholder assessment matrix

	Stakeholder Name	Contact person	Impact	influence	Stakeholder role	Remarks
 Rising importance	Ministry of Energy, Saudi Arabia	Ministry energy representative	High	High	Sponsors the project	Very important stakeholder
	Land owners	Contact person selected by the landowners	High	High	Give consent on their land to be used for the project	Very important stakeholder
	Ministry of Environment, Water and Agriculture of Saudi Arabia	Ministry of Environment representative	Moderate	High	Assess the environmental impact of the project	Very important stakeholder
	Fandom Construction Company	Project manager	Moderate	Moderate	Executes the project	Very important stakeholder

	Residents of Riyadh Saudi Arabia	Local community leaders	Moderate	Low	Will supplied with the electricity once the project is complete	Very important stakeholder
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9. Communication matrix and channel

9.1 Personal and effective communication

Interpersonal communication amongst the project team leaders is extremely important in the completion of the project activities. It enables the project team members exchange information, feelings and ideas amongst themselves which can be done via verbal methods or non-verbal methods. It involves face-to-face exchange of information, facial expression, gestures and body language, and form a voice. The level of interpersonal communication is measured in terms of how effective an individual is transferring information to others (Hermarij, 2013).

9.2 Channels or modes of interpersonal communication

In the proposed project, the modes or channel of communication amongst team members will be:

- i. Face-to-face exchange of information.
- ii. Giving instructions through voice
- iii. Gestures
- iv. Telephone calls
- v. Internal meetings

- vi. Performance review
- vii. Via social media platforms such as WhatsApp.

Some of the importance of effective communication in the project are:

- i. Enhancing problem solving. Effective interpersonal communication is extremely important as it will allow project team members to discuss problems, suggest solutions and weigh the pros and cons of the alternatives before deciding on a final solution to the problem. For instance, through brainstorming solutions to certain problems facing the project may be found.
- ii. Enhancing trust and transparency (Bartoška et al., 2012).

9.3 Communication matrix

Table 5: Communication matrix

Communication	Purpose	Medium	Frequency	Audience
Project commencement	Project introduction and review of the objectives and goals of the project	Face-to-face Or Virtual	Once	Project manager, Project team members, Project sponsor, Other shareholders
Project team meetings	Review of the status of various project activities	Face to face and virtual	Weekly	Project manager, project team leaders
Technical design meetings	Review of technical and design problems encountered as the	Face to face	As needed or when	Project technical team

	project implementation progresses		situation arises	
Project status meetings	Updating the leadership, client and stakeholders on the progress	Face to face or virtual	Monthly	Project sponsor, Project client, project manager, and other stakeholders interested in the project
Detailed project status report	Detailed report concerning the status of the project including the costs, milestones achieved, progress and problems encountered	Email and virtual meetings	Monthly	Project sponsor, and project manager

9.4 Three wrong scenarios of communication

- i. Interrupting others while communicating or giving their opinions or ideas regarding a problem.
- ii. Failing to listen
- iii. Blame game and unnecessary arguments.

10. Leadership

10.1 Preferred Leadership model

Affiliative leadership model

The preferred leadership model for this project is affiliative leadership model. This is a type of leadership style which puts people firsts and builds harmony and creates emotional relationship amongst project team members. Here team members come first, creates empathy, builds relationship and effective communication. This means that the leadership style enhances team building and effective communication which are ingredients to successful completion of the project. The leadership style also heals differences amongst the team members which is essential in conflict resolution and problem solving (Vukomanović et al., 2016).

10.2 Motivation proposals for this project

- i. Respectful, honest and supportive leadership
- ii. Offering rewards to best performing team members
- iii. Being transparent
- iv. Recognizing achievements
- v. Giving team members room to grow.

11. RACI model

RACI model for 3 administrative measures

	Ministry of Energy (Project Sponsor)	Project Manager	Ministry of Environment
Provide project funding	R	A	I
Executing construction	A	R/A	C
Defining performance requirements	C	R	C

Figure 3: RACI model (Bartoška et al., 2012)

12. Conflict and crisis

12.1 Examples of conflicts and crises

- Conflict amongst project team members (horizontal). Also, conflict among the employees
- Stakeholder conflict. Especially when interests of a stakeholder are not taken care of.
- Management and employees' conflict.

12.1 Expected scenarios of the conflict events in the project.

- Difference in the interest of the different project stakeholders
- Change in project scope
- Misunderstanding as result of miscommunication or poor communication.

12.2 Optimal strategies for deal with these conflicts

- i. Stakeholder involvement from the onset of the project. This will ensure that interest of each and every shareholder is taken care of from the planning to execution stage of the project.
- ii. Involving the customer and the sponsor from the beginning and ensuring that their all needs are captured in the design. This prevents the change of project scope at later stage.
- iii. Active listening. This helps in avoiding problems associated with miscommunication.
- iv. Mutual respect for individual viewpoints. Also prevents miscommunication and misunderstanding.
- v. Focus on solution. Prevents prolonged conflict situation as conflicts will solved quicker.

12.3 Root cause analysis

Root cause analysis will involve the following:

- i. **Assign resources.** This will involve assigning resources and people to situations as they arise during project execution so as to come up with a solution.
- ii. **Problem identification:** This will involve assessing the situation so as to identify the problem and its associated impact. It involves identifying what happened, where and when it happened, and who was involved or affected. A clear document with the result will be produced.
- iii. **This involves evaluation to so as to identify the root cause.** Tools such as a scatter diagram, Failure Modes and Effects Analysis (FMEA), a Pareto chart and/or a fishbone diagram maybe involved.
- iv. **Identifying and implementing corrective actions.** Once the cause of the problem is identified, appropriate solution is identified and implemented.

- v. **Verifying results.** Once solutions are implemented, measures will be taken to confirm whether or not the root cause issue is fixed. Documentation on finding and solutions will be kept for future reference (Eberle et al., 2011).

13. Resourcefulness

13.1 Distributing human resource and project functions

- i. Project manager: Responsible for all project activities
- ii. Chief finance manager: Responsible for finance related activities in the project, and heads a team of financial officers, accountants, economics and procurement department. Their role also includes project budgeting.
- iii. Construction manager: Responsible for all project implementation (construction of activities). All the contractors, and team leaders for various construction department report to him or her.
- iv. Technical team: Responsible for design of project products, reworks and other activities as assigned by the project manager
- v. Health and safety officer: Responsible for the safety and health of all project participants.

13.2 Crash and fast tracking on the schedule time table

Fast tracking: Fast tracking generally involves undertaking project activities that were initially scheduled to be performed sequentially in parallel with aim of compressing the schedule. This means that these activities are carried out simultaneously instead of being undertaken after each other (one another) (Hermarij, 2013).

Fast tracking process does not increase project cost. However, it may increase risks associated with the project such as increasing the risk of reworking which may result into increase project time and cost.

Crashing: Crashing involves addition of resources to project activities so as to compress schedule. It involves addition of resources to only activities that will result into reduction of project schedule (Hermarij, 2013). This means that it is applied on activities that fall within the critical path.

14. Negotiations

14.1 General rules for negotiation

- i. The general rule of negotiation is maintaining initial stance and persuading the other party to change or modify their original stance.
- ii. Always being ethical and respectful by both the parties.
- iii. Being assertive.

14.2 Negotiation plans

- i. **Distributive negotiation:** This will be important cases involving single issue. It is win-lose situation especially when negotiating with the suppliers to ensure the lowest price possible for the project raw materials and services (Indeed, 2021). The plan will be as follows:
 - a. Being persistent
 - b. Making an offer first
 - c. Not communicating minimum favourable outcome.
- ii. **Integrative negotiation.** This is a win-win situation, and it will involve incidences with team members and external stakeholders such as environmentalists. This will ensure that the project progresses while conserving the environment, or team leaders getting their desired payments while the progress is within budget and time, and without compromising the quality of the products (Indeed, 2021). The plan for this type of negotiation will be as follows:

- a. Taking a principled approach
- b. Openly discussing needs and interests
- c. The use of bargaining to solve problems

15. Project design

15.1 Triple constraints of the project

The triple project constraint associated with the project are:

- a. Time: The project should be completed within the scheduled period of time.
This project is proposed to be completed in 1 year (12 months)
- b. Cost: The project should be completed within the budget. It is estimated that the project will cost
- c. Scope: The project should be completed within the scope and fulfils the required goals. Any activities outside scope must be avoided at all cost unless the customer (client) needs changes and will meet the additional costs associated with it.

15.2 List of the project success factors

The project success factors are:

- a. Clear communication amongst the stakeholders.
- b. Actionable results: Having measurable benchmarks, performance targets, and clear path towards success and achieving project objectives.
- c. Sufficient (intensive) project planning: All factors that may affect the project positively and negatively must taken care of during the planning stage. This involves agreeing on project goals and objectives.
- d. Strategy: This involves focusing on the best practices of project management.

15.3 Work Breakdown structure

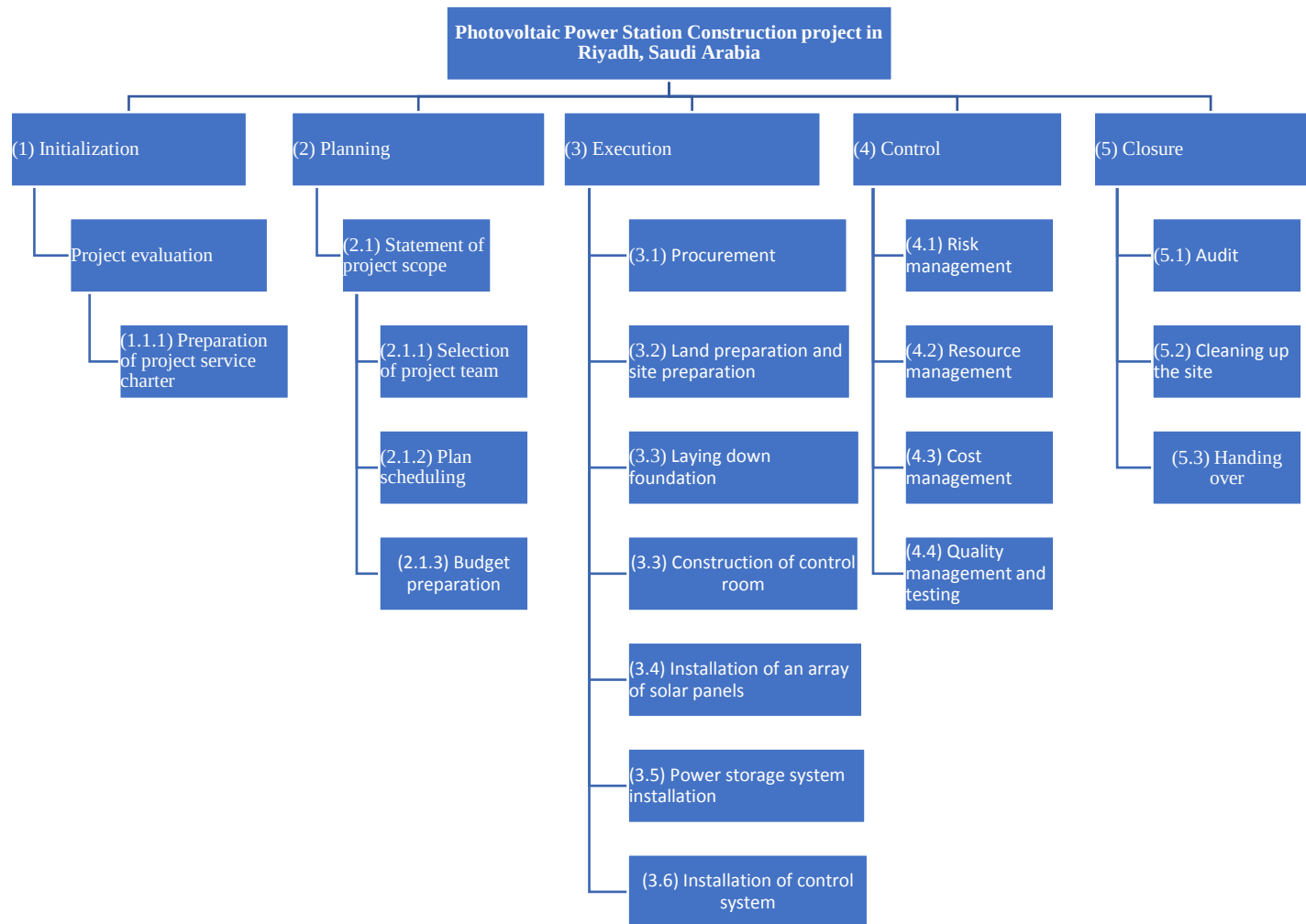


Figure 4: Work Breakdown structure

16. Requirements and objectives

16.1 Requirement traceability matrix

Table 6: Requirement traceability matrix

ID	Requirement description	Needs/Objectives	WBS deliverable	Requested by
1.	Confirmation of geotechnical conditions of the site	Making sure that the foundation is sufficient	Foundation construction	Chief engineer
2.	Status of approval of the project	Making sure that the project meets all the regulatory requirements	Planning and execution	Government ministry

16.2 Requirement collection methods

- i. Brain storming
- ii. Focus group
- iii. Document analysis
- iv. Observations
- v. Interviews
- vi. Prototyping

16.3 Hierarchical structure of the objectives

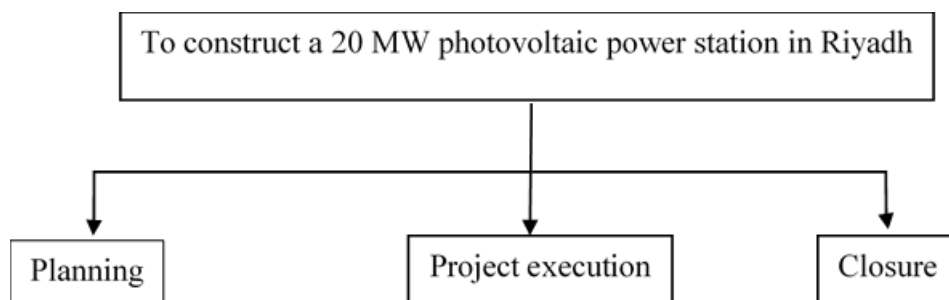


Figure 5: Hierarchical structure of the objectives

17. Project scope

17.1 Scope statement

Project purpose statement: The purpose of this project is to construct a 20 MW on behalf of the Saudi Arabia's Ministry of Energy to supply renewable source of power for the residents of Riyadh, Saudi Arabia.

Project Scope

Deliverables:

- i. Land preparation and site preparation.
- ii. Foundation layout
- iii. Building of control room and workers housing
- iv. Procurement and installation of an array of solar panels, power storage and related equipment capable of generating 20MW of electrical power for the residents of Riyadh, Saudi Arabia.
- v. Testing of the installed power plant to ensure that it performs as it should.

Out of Scope

- i. Procurement and installation of transmission lines and associated equipment capable of transmitting 20 MW from the power plant to the national grid for onward transmission to the clients.
- ii. Maintenance of the installed power plant.

17.2 Scope creep

This generally refers to the continuous or uncontrolled changes or growth of project's scope at a point after the start of project execution. For example, in this current project, it includes construction of roads within the staff quarters if such an activity was not defined in the project

scope. This does not stop there, other additional changes which are not specified in the project scope may continue to crop in as the project progresses.

17.3 Product analysis management (transformation of WBS package into activities)

Table 7: Product analysis management

WBS Package	Project activities
Project initialization	Evaluation of the project
	Preparation of project service charter
Project planning	Evaluation of the project design
	Statement of project scope
	Selection of project team members
	Preparation of project schedule
	Budgeting
	Procurement and contract award
Project execution	Mobilization of site equipment
	Land and site preparation
	Laying of foundation
	Installation of solar panel holders
	Delivery of the solar panels and associated equipment into the construction site
	Installation of the solar panels
	Construction of the control room
	Construction staff houses
	Fencing of the facility

	Installation of power storage facility for the staff houses and site/plant needs
	Testing of the system to ensure it works as designed
Closure	Site clean up
	Handing over

18. Time

18.1 Project activities

Table 8: Project activities

No.	Project Activity	Predecessor/dependence
1.	Evaluation of the project design	
2.	Preparation of project service charter	1
3.	Statement of project scope	2
4.	Preparation of project schedule	3
5.	Budgeting	4
6.	Selection of project team members	5
7.	Procurement and contract award	6
8.	Securing of construction site	1,2
9.	Mobilization of site equipment	7,8
10.	Land and site preparation	8,9
11.	Laying of foundation	10
12.	Installation of solar panel holders	11
13.	Delivery of the solar panels and associated equipment into the construction site	8, 7

14.	Installation of the solar panels	12,13
15.	Construction of the control room	1,2,10
16.	Construction staff houses	1,2,10
17.	Fencing of the facility	1,2,10
18.	Installation of power storage facility for the staff houses and site/plant needs	14,15,16
19.	Testing of the system to ensure it works as designed	18
20.	Site clean up	19
21.	Handing over	20

18.2 Relationship between project activities and schedule

Table 9: Relationship between project activities and schedule

Task ID	Task description	Predecessor	Duration (days)	Start date	End date
1.	Evaluation of the project design		5	20-12-21	25-12-21
2.	Preparation of project service charter	1	5	26-12-21	31-12-21
8.	Securing of construction site	1,2	10	26-12-21	05-01-22
3.	Statement of project scope	2	10	01-01-22	11-01-22
4.	Preparation of project schedule	3	10	12-01-22	22-01-22
5.	Budgeting	4	5	23-01-22	28-01-22
6.	Selection of project team members	5	5	29-01-22	03-02-22
7.	Procurement and contract award	6	5	04-02-22	09-02-22
13.	Delivery of the solar panels and associated equipment into the construction site	8, 7	20	10-02-22	02-03-22
9.	Mobilization of site equipment	7,8	5	10-02-22	15-02-22

10.	Land and site preparation	8,9	30	16-02-22	18-03-22
11.	Laying of foundation	10	100	19-03-22	27-06-22
12.	Installation of solar panel holders	11	100	28-06-22	06-10-22
14.	Installation of the solar panels	12,13	60	07-10-22	06-12-22
15.	Construction of the control room	14	50	07-12-22	26-01-23
16.	Construction staff houses	15	90	27-01-23	27-04-23
18.	Installation of power storage facility for the staff houses and site/plant needs	14,15,16	30	28-04-23	28-05-23
17.	Fencing of the facility	16	60	28-04-23	27-06-23
19.	Testing of the system to ensure it works as designed	18	10	29-05-23	08-06-23
20.	Site clean up	19	10	28-06-23	08-07-23
21.	Handing over	20	2	09-07-23	11-07-23

18.3 Logical diagram

Critical path is shown by grey

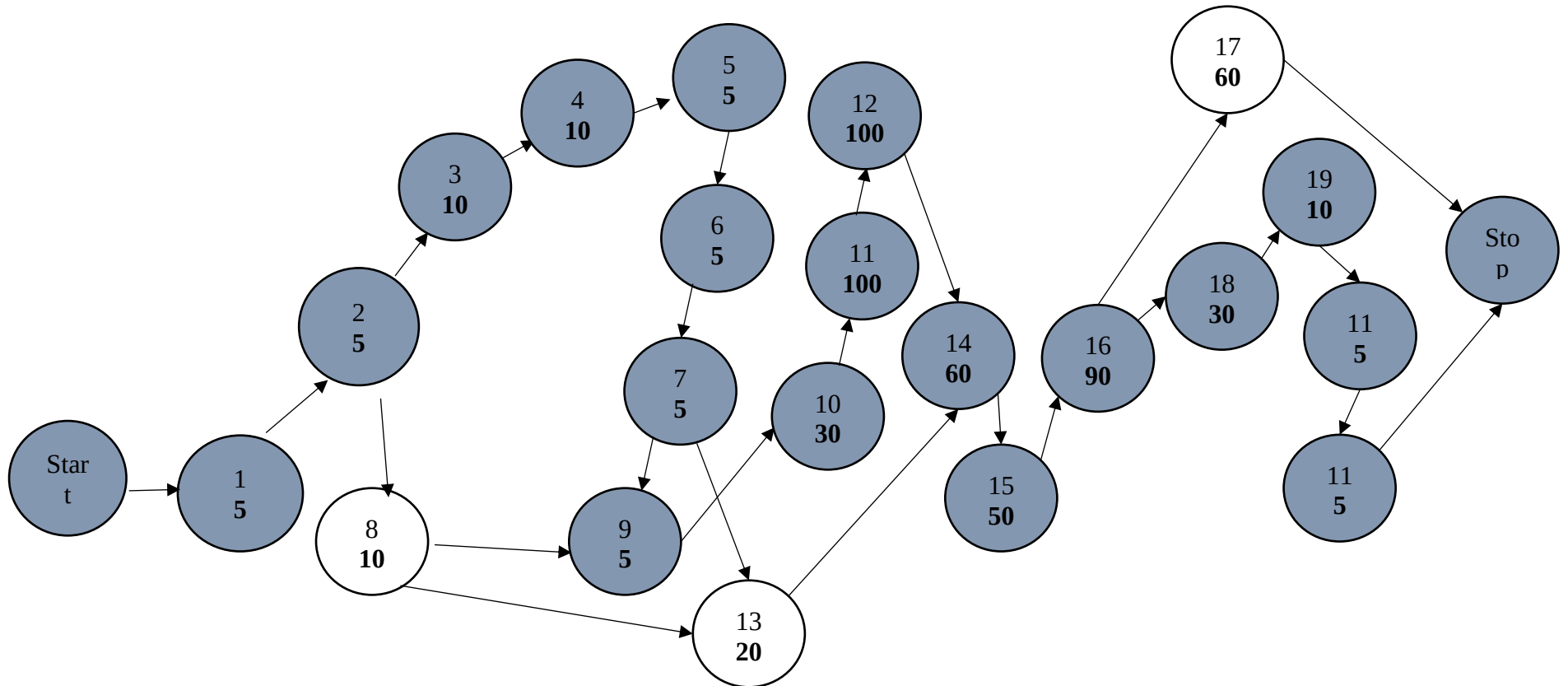


Figure 6: Logical diagram

18. 4 Gantt Chart

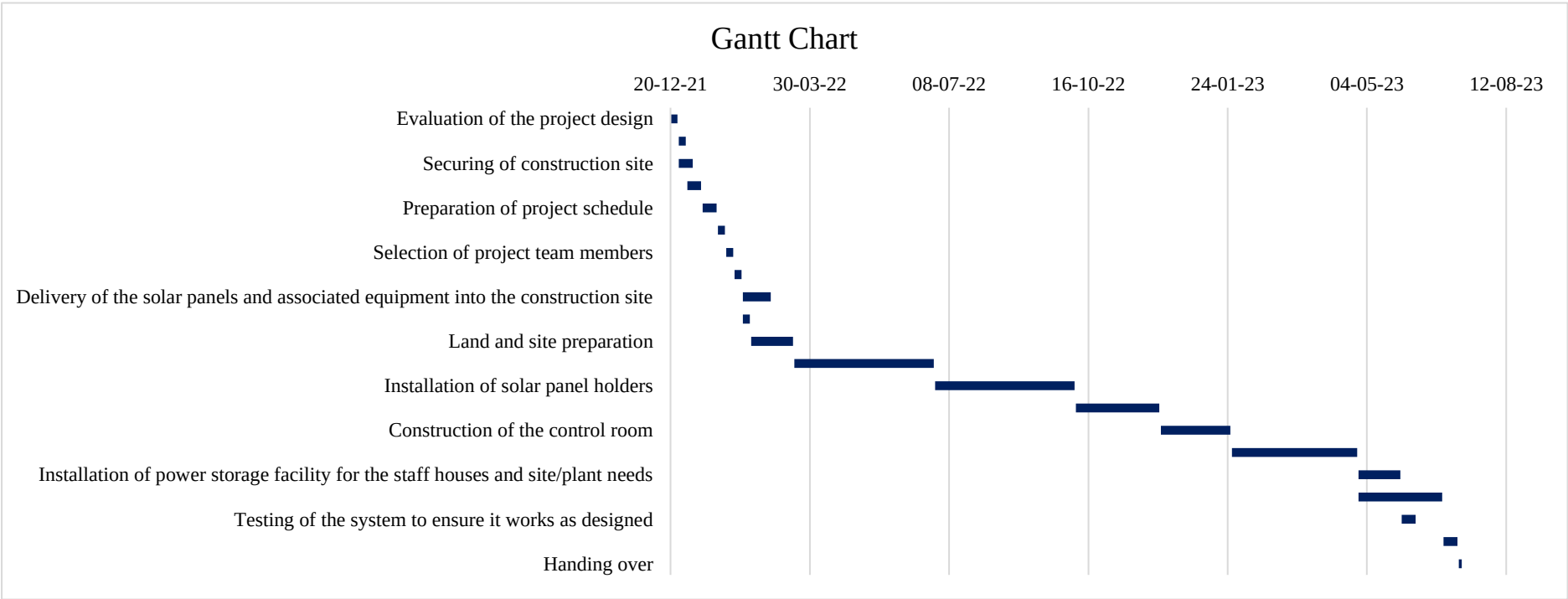


Figure 7: Gantt Chart

19 Quality

19.1 Deming Model for Quality

Quality management will be done using the Deming model which consist of:

- i. Planning
- ii. Doing
- iii. Studying
- iv. Acting.

19.2 SIPOC model and Shikawa

Table 10: Relationship between project activities and schedule

S	I	P	O	C
Supplier	Input	Process	Output	Customers
• Contractors • Subcontractors	• Design • WBS • Duration • Budget • Team members	Assigning team members tasks ↓ Task execution ↓ Installed solar power plant	20 MW Solar power plant	The residents of Riyadh, Saudi Arabia

20 Finance

20.1 Cost Breakdown structure

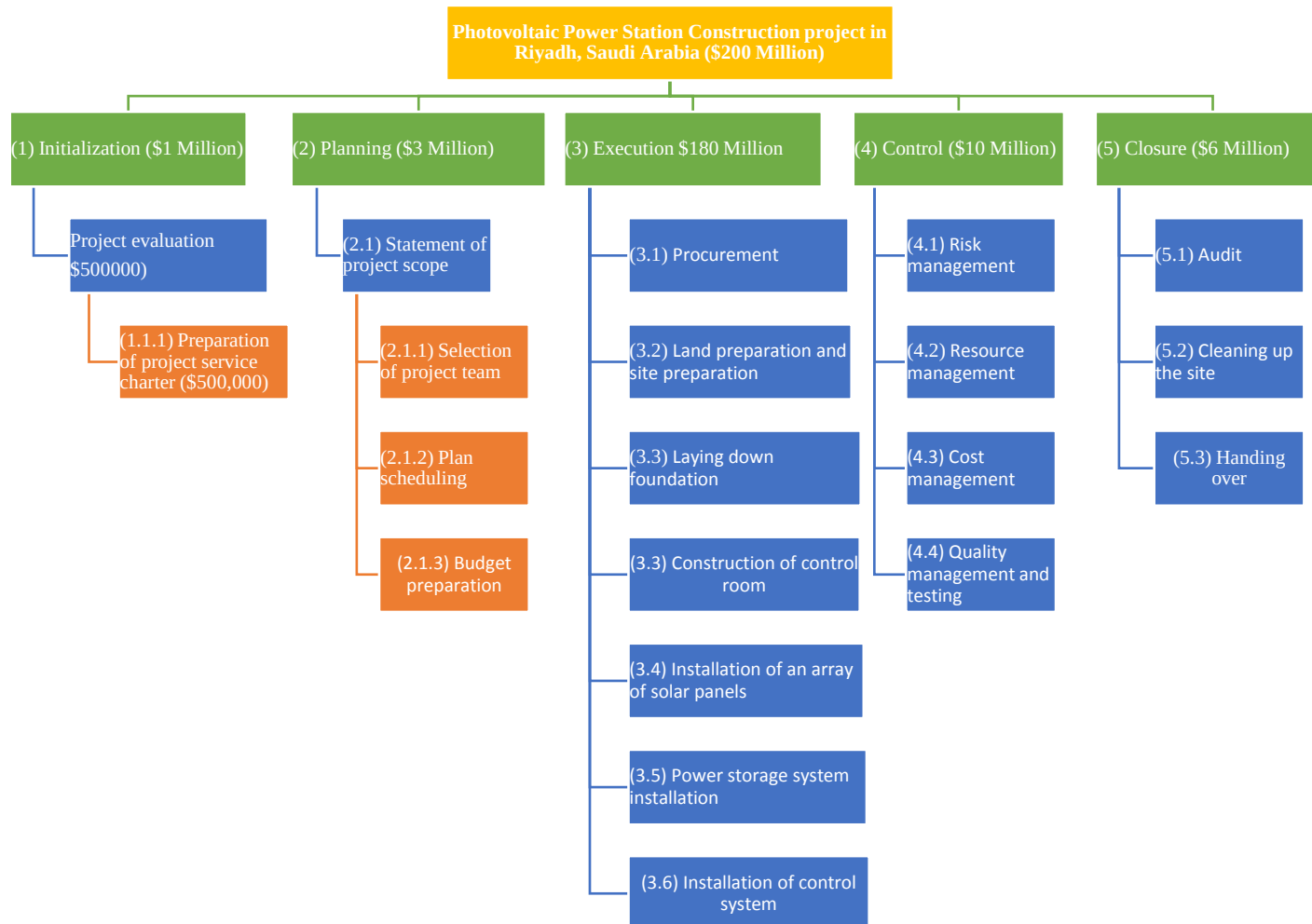


Figure 8: Cost Breakdown structure

20.2 Earned Value Management

Earned value = Percent complete $\times$ Task Budget

Total budget = \$200 Million

Earned value at 20% complete = $(20 \div 100) \times 200$ Million = \$ 40 Million

Earned value at 50% complete = $(50 \div 100) \times 200$ Million = \$ 100 Million

21. Resources

21.1 Resource Leveling and Smoothing

Resource levelling is used when there are limited resources. The project duration may be increased so as to fit the available resources. It answers the question: “With the available resources, how long will it take to complete the project?”

Resource smoothing is mainly applied in situations where there is time constraint. Its objective is to work within the available time while avoiding troughs and peaks associated with resource demand. It is often achieved through delaying some work, and removing schedule flexibility.

21.2 Distributing the project resources of equipment and tools

This is done based on the scope of the activity, schedule of activity and amount of resources needed to complete the project tasks.

22. Procurement execution and contractor selection

The following are procurement and contractor selection techniques used in the construction industry.

- i. Traditional procurement and contract methods
 - a. Lump sum contracts
 - b. Cost reimbursement contracts
 - c. Re-measurable contracts
- ii. Alternative procurement techniques

- a. Design and build
- b. Management contracting

23. Plan and control

23.1 Agenda, invitation and record for virtual meeting

With COVID-19 pandemic, one-one-one meetings will be avoided. These will meetings will be replaced by virtual meetings where necessary. The process of organizing the meeting will involve:

- i. Preparation of the Agenda
- ii. Scheduling the meeting
- iii. Notifying and inviting the attendees
- iv. Circulation of the agenda to the attendees on or before the meeting day depending on the urgency and type of meeting
- v. Creating the meeting links and sharing with the attendees
- vi. Holding meeting
- vii. Recording the virtual meeting as it progresses

23.2 Performance measurement course

The performance of the project will be measured in terms of:

- i. Completing the project within the schedule
- ii. Completing the project on budget
- iii. Producing the intended product. That is, achieving the project objectives.

A project is said to have performed well when all the above constraints are meet. Otherwise, the project is referred to as unsuccessful. Based on the above factors, a report is created outlining the performance of the project, challenges, success and lessons learnt. These are used

in the next project to improve the performance of project by avoiding the challenges experienced in the first project.

23.3 Change request model

It is proposed the request for change will take the following steps:

- i. Proposing change
- ii. Summary or assessment of impact of the proposed change
- iii. Making decision whether the change will be conducted or not
- iv. Making the proposed change
- v. Closure.

24. Risk and opportunities

24.1 Risks and opportunities

Risks

- i. Project not being completed on time
- ii. Project not being completed on budget
- iii. Product (Solar power plant) not meeting the intended objective
- iv. Land owners refusing to surrender their lands
- v. Government failing cancelling the project while in progress
- vi. Ground conditions turning out to be unusual.

Opportunities

- i. Challenges experienced and lessons learnt during project execution can be used to improve next projects.

24.2 Risk register

Table 11: Risk register

Risk ID	Risk	Likelihood	Impact	Severity	Who is responsible	Mitigation
3.	Project not being completed on time	Medium	High	High	Contractor	
4.	Project not being completed on budget	Medium	High	High	Contractor	
5.	Product (Solar power plant) not meeting the intended objective	Low	High	Moderate	Contractor	
6.	Land owners refusing to surrender their lands	Low	High	Moderate	Government	
7.	Government failing cancelling the project while in progress	Low	High	Moderate	Government	
8.	Ground conditions turning out to be unusual	Low	Moderate	Moderate	Contractor	

24.4 Risk response strategies

Table 12: Risk response strategies

Risk ID	Risk	Mitigation
1.	Project not being completed on time	• Fast tracking tasks especially tasks that fall within the critical path • Sufficient planning • Giving allowance during scheduling • Resource smoothing
2.	Project not being completed on budget	• Resource levelling
3.	Product (Solar power plant) not meeting the intended objective	• Selecting qualified contractors and suppliers • Thorough testing before handing over

4.	Land owners refusing to surrender their lands	• Sufficient consultation and stakeholder involvement • Compensation before the project commencement
5.	Government failing cancelling the project while in progress	• Working within regulations • Continuously involving the government in the project execution
6.	Ground conditions turning out to be unusual	• Extensive geotechnical assessment

24.3 Qualitative risk analysis

Table 13: Qualitative risk analysis

Risk ID	Risk	Likelihood	Impact	Severity
1.	Project not being completed on time	Medium	High	High
2.	Project not being completed on budget	Medium	High	High
3.	Product (Solar power plant) not meeting the intended objective	Low	High	Moderate
4.	Land owners refusing to surrender their lands	Low	High	Moderate
5.	Government failing cancelling the project while in progress	Low	High	Moderate
6.	Ground conditions turning out to be unusual	Low	Moderate	Moderate

25. Stakeholder engagement assessment matrix

Table 14: Stakeholder engagement assessment matrix

Stakeholder	Unaware	Resistant	Neutral	Supportive	Leading
Ministry of Energy, Saudi Arabia					C, D
Fantom Construction Company					C, D
Ministry of Environment, Water and Agriculture of Saudi Arabia				D	
Land owners		C			
Residents of Riyadh Saudi Arabia				D	

26. Conclusion and recommendation

26.1 Conclusion

This project includes the construction of a 20 MW on behalf of the Saudi Arabia's Ministry of Energy to supply renewable source of power for the residents of Riyadh, Saudi Arabia. The project scope includes: land preparation and site preparation; procurement and installation of an array of solar panels, power storage and related equipment capable of generating 20MW of electrical power for the residents of Riyadh, Saudi Arabia; and testing of the installed power

plant to ensure that it performs as it should. The project will not include the following: procurement and installation of transmission lines and associated equipment capable of transmitting 20 MW from the power plant to the national grid for onward transmission to the clients, and maintenance of the installed power plant. The project is expected cost \$200 million, and will take 1.5 years to complete. It is expected to begin on 20th December, 2021 and completed on 11th, July 2023.

26.2 Recommendation

The success of this project depends on stakeholder involvement, availability of funds and knowledge and experience of the contractor. Therefore, the following recommendations are for the project to be completed on time and within budget.

- i. All the stakeholders including local community, land owners, ministry of the environment, contractors and subcontractors, designers, and others must be involved at all stages of the project. All their interests must be taken care of at all project stages. This will prevent conflicts which may disrupt the project progress.
- ii. Funds should be availed whenever needed by the contractor to prevent delays.
- iii. Geotechnical study should be properly carried out to minimise the risk of the project being out of budget.
- iv. Project manager should be experienced and knowledgeable in the projects of such a scale.
- v. Only knowledgeable and experienced contractors and subcontractors should be selected to undertake the project.

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