

# Myriad of quality challenges in the Koudiet Eddraouch GIS substation project in sub-Saharan Africa

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## 1. Introduction

Sharad, the project manager of Koudiet Eddraouch (KE) GIS Substation Project, was having severe headache since he got up. He found himself in a challenging predicament while overseeing a construction project in a remote corner of Algeria. Despite nine months of dedication to the project, Sharad is confronted with a storm of inner thoughts as he received a call from Mr Satish Rao, the country head for Africa operations, to arrange an urgent meeting with all concerned stakeholders. Doubts began to plague Sharad's mind as he questioned his decision to accept the role and reflected on his potential mistakes and oversights. He wondered why he remained silent for so long, hoping against hope for improvement. As he prepared to face Rao, Sharad grappled with crafting a strategy to address the escalating issues.

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### 1.1 The Bharat Bijlee Construction Limited

The Bharat Bijlee Construction Limited (BBCL) was one of India's largest construction companies, with a full range of development capabilities including engineering, procurement and construction. Top management at BBCL understood that most businesses cannot be expanded in their domestic markets and that, before it was too late, alternative possibilities needed to be investigated. The continuous fall in plant load factor factors for generating units was another signal for circumstances being dismal in near future. To sustain a competitive edge and increase shareholder value, companies needed to effectively redirect their focus toward the comparatively untapped global business landscape. Given the potential for future growth and business opportunities in the African region, the BBCL business development team was fully concentrated on Africa as their next area of expansion. The BBCL won the contracts worth \$85m for three substation projects to upgrade Algeria's power grid from Algerian electricity company "Shariket Karhaba Koudiet Eddraouch Spa," a state-owned company responsible for power generation, transmission and distribution in Algeria.

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## 2. The Koudiet Eddraouch GIS substation project

The "KE GIS substation" was a significant project involved in construction of an integrated solar combined cycle power station and substation, which represented a crucial development in the energy infrastructure of the region. The project was near Hassi R'Mel, a key urban center in the region; the strategic placement of project ensured optimal access to

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energy distribution networks and population centers. In addition, its location in the southern region enhanced its potential to harness solar energy efficiently, given the favorable climatic conditions prevalent in the area. This project stood as a testament to countries' commitment to advance clean energy initiatives and meeting the growing energy demands of both the local community and beyond. However, from a project execution perspective, the picture was not as rosy.

The Sahara desert experienced extreme temperatures, ranging from scorching heat during the day to cold nights. Dunes of enormous size and irregularly arranged patterns could be produced by the frequent winds and storms at the project locations. A sizable portion of northeast Algeria was covered in long, linear dunes that ran roughly from north to south across the Sahara desert's 140,000 square kilometer plain, as shown in [Figure 1](#). Sandstorms and dust could damage construction equipment, create visibility issues and pose respiratory health hazards for workers. The region was one of the dustiest in the world. Dust storms are capable of transporting sediment over thousands of kilometers, due to Algeria proximity to Sahara Desert. Also, due to sand dunes, maintaining the approach road and ensuring the stability of the trench during construction or installation might frequently impede progress on the project and necessitate rework. The construction and installation would require extensive rework due to the increased need for welding repairs caused by sand particles carried by strong winds.

These weather conditions could impact worker safety, health and affect the performance of construction equipment's as well. The quality of the products and services was a major challenge that BBCL faced during the project execution phase. These difficulties resulted from the tight deadlines and budget constraints, as well as from a lack of knowledge of the dynamics involved in executing the international projects, particularly in the difficult circumstances of the sub-Saharan desert.

### 3. Team development by Bharat Bijlee Construction Limited

BBCL had handpicked its best performing team for the Algeria site operation, be it Rao who headed the Algeria operation as country head for this and another anticipated project in pipeline. Rao, as the country manager, had a crucial role in ensuring seamless operations and securing significant orders in Algeria. His leadership, marked by strategic insight, exceptional communication and problem-solving skills, led to his appointment and was vital for the company's expansion in the Algerian construction sector. Rao's solutions-oriented approach ensured efficient project delivery along with full satisfaction of stakeholders. His contributions were pivotal in establishing and strengthening the company's presence in Algeria's competitive construction industry. Given the project dynamics, Rao chose a very

**Figure 1** Sand dunes in African region



**Source:** <https://www.worldatlas.com>

dynamic team led by Sharad as a project manager for a remote substation project, as shown in Figure 2, which embodied essential traits required for success in such challenging environments. His resourcefulness, adaptability and meticulous planning skills equipped him to navigate limited resources and unpredictable conditions. Clear communication, problem-solving ability and strong leadership ensured effective coordination in remote areas. Sharad’s technical expertise, emphasis on health and safety and proactive risk management underscored his commitment to project success.

Overall, his multifaceted skills and foresight enabled him to overcome the unique challenges of remote construction projects, ensuring efficient and quality-driven substation completion.

Sharad had more than 20 years of experience getting good exposure as site engineer, construction manager and project controller at various substation projects at various northeast states in India. The project was recently recognized by the Arunachal Pradesh Government with the Excellence in Project Delivery award.

#### 4. Project kickoff

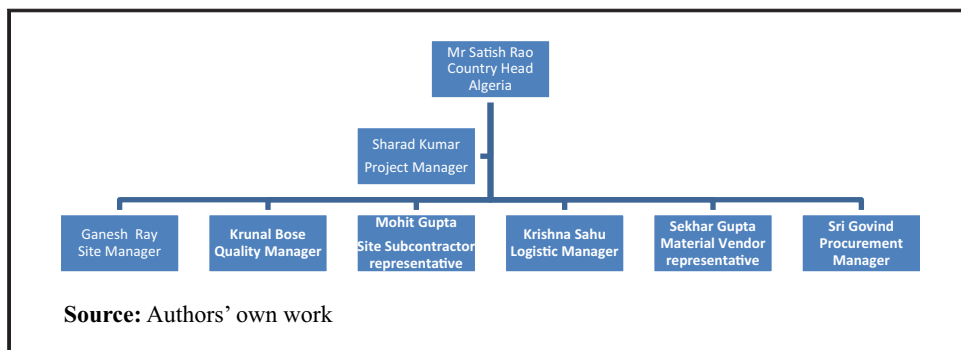
Sharad was taken aback by the management’s decision to consider him as a project manager for such a large international project in Algeria. Sharad proactively and succinctly began identifying challenges and risks that the project was likely to face given the international dynamics of the project and a foreign country to plan the project effectively and meticulously. Sharad believed in good planning before starting the work. He started making mental framework for entire project and how he would like to proceed. Considering the importance of the project for his organization, for the client and himself to boost his career, he took some major decisions at the start of the project to keep progress on right track. He stressed workforces at site, labor camp facilities at site, strong supervision, safety, design coordination and early procurement of vendors. However, after kickoff of the project he faced one or the other challenges never foresight at the beginning of the project.

#### 5. Sharad, project manager in catch 22 situation

For over nine months from the beginning of project, Sharad had been navigating the challenges of overseeing a construction project in a remote corner of Algeria. Yet, this period had proven to be unusually tumultuous, and it had been testing his resolve like never before. Last night, as he received a call from Rao, country head for Africa operations, a storm of inner thoughts began to brew within him.

Sharad could not help but question himself. Had he made a mistake in accepting the role of site manager for this project? Where, precisely, had he faltered? What had he overlooked,

**Figure 2** Organogram of BBCL team for KE GIS Substation Project, Algeria



and what were his lapses in judgment? These queries gnawed at him, and he wondered if he should have raised the alarm much earlier.

Why had he remained silent for this long, holding onto the hope that things would somehow improve against all odds? That optimism had waned, and now he grappled with the daunting task of how to face Rao, country head for Africa operations. What strategy should he craft to navigate this delicate situation?

The weight of responsibility and self-doubt bore heavily on Sharad as he contemplated the path forward in a project that had become far more challenging than he could have ever anticipated.

It appeared evident to Sharad that the catalyst behind these escalating issues was none other than the client head, Mr Nadir Mokrani. Sharad suspected that Mokrani had taken the initiative to compile a comprehensive list of quality-related concerns in the construction project and had subsequently dispatched this detailed dossier via email directly to BBCL's chairman and managing director (CMD) Mr Muthusami based at headquarter in Mumbai, India.

This move by Mokrani seemed to signal a shift in the dynamics of their working relationship, escalating the situation to a level that Sharad had not anticipated. It was now apparent that a critical turning point had been reached, and the challenges faced by the project had been magnified significantly due to this decisive action by the client.

## **6. Client head and his resolution for quality work**

Mokrani, the client head and chief engineer, faced persistent quality issues that tested his 35-year career. Trusting in BBCL's reputation, he awarded them the contract, but after nine months, he saw no improvement in their approach or work quality. Frustrated by the lack of progress, he instructed his executive manager to compile a detailed report outlining the project's myriad issues. This report, sent to BBCL's chairman and managing director, marked a critical moment in their relationship, highlighting Mokrani's determination to address the escalating problems.

Mokrani's frustration had reached its zenith, particularly concerning the work quality and the quality systems he had anticipated. Consequently, he took decisive action, instructing his executive manager to compile a meticulous and comprehensive report outlining the myriad quality and other issues that had plagued the project due to BBCL's performance. This report was promptly dispatched to the CMD of BBCL, signifying a critical juncture in their working relationship and underscoring Mokrani's unwavering commitment to resolving the escalating problems.

## **7. Letter to chairman and managing director of Bharat Bijlee Construction Limited**

In his letter to the CMD of BBCL, Mokrani expressed his deep disappointment with the quality of construction work, which had fallen far short of his expectations from a renowned company like BBCL. He underscored the urgent need for immediate action to rectify the prevailing issues. Here is an excerpt from his letter:

"Over the course of my long and distinguished career, I have had the privilege of working with many reputed construction firms. Thus, when we awarded this project to BBCL, we did so with the belief that we were partnering with an organization that upheld the highest standards of quality and professionalism. However, it is with a heavy heart that I must convey my profound disappointment at the quality of work we have witnessed thus far. The construction work on this project, which holds immense importance for our organization and the community it serves, has consistently fallen below the standards we expected. The numerous instances of subpar workmanship, deviations from design specifications, and a lack of adherence to quality control procedures have given rise to a litany of concerns. These issues not only compromise the

structural integrity of the project but also pose safety risks and undermine the very essence of our commitment to excellence.

As we approach a critical juncture in this project, I implore you to take immediate and comprehensive action to rectify these deficiencies. We entrusted BBCL with this endeavor in the belief that your organization possessed the expertise and dedication necessary to deliver a project of the highest caliber.

I urge you to review the attached report, which details the various quality-related issues we have encountered. It is my earnest hope that, together, we can swiftly address these concerns, restore our faith in BBCL's capabilities, and ensure the successful completion of this project in a manner that aligns with our uncompromising commitment to quality and excellence."

## **8. Highlighted quality issues**

In a letter to BBCL's CMD, Mokrani expressed his dissatisfaction with the quality of construction work, which fell far short of his expectations. He presented the following quality observations.

### ***8.1 Quality issues with construction materials***

The site grappled with a crucial issue of nonsequential material dispatch, causing delays and storage challenges. This included pending delivery of essential items, risk associated with storing packages in open sand and quality checks failure for certain imported electronic components.

### ***8.2 Inadequate quality systems in Bharat Bijlee Construction Limited***

While Brilliance Power possesses ISO and OHSAS certifications, they appeared more symbolic than substantive, raising concerns about their effectiveness as indicators of a quality-oriented culture. The absence of a well-defined field quality plan had contributed significantly to construction defects, notably highlighted through numerous failures in concrete cube tests, revealing a critical gap in oversight and supervision in the construction processes.

### ***8.3 Insufficient or poorly defined drawings and quality assurance plans***

Drawings and quality assurance plans were critical to construction projects, yet poor quality in these documents had led to misinterpretations by contractors, causing errors and costly rework. These deficiencies not only posed potential risks to structural integrity and safety but also created confusion among BBCL staff, demanding significant time and effort for resolution.

### ***8.4 Quality compromises***

Consistent reports from our site engineer highlighted compromised quality, exemplified by issues such as poor-quality fasteners and rusted structural steel components, emphasizing the imperative of upholding construction project quality standards to prevent costly delays and potential safety risks, as evidenced by the 15-day correction period for incorrect washers in the first tower.

### ***8.5 Poor workmanship on the site***

The construction site was marred by evident negligence in workmanship and a lack of commitment to quality management, resulting in a multitude of quality-related issues. These

included deficiencies in cable dressing, laying and cable tray installation, distributed proof test (DPT) activities conducted without quality engineers' supervision, unsatisfactory finishing of staircases, untraceable welding joints in the cooling water system, a significant failure rate in weld joints during radiography and hydro tests, noncompliance with approved vendor lists for glass procurement, poor foundation quality with honeycombing and potholes, expired calibration of welding machines, frequent breakdown of construction equipment, the use of sand with high silt content for concrete, inadequate adherence to approved job procedures for roof waterproofing, substandard backfilling, insufficient curing for finishing work, high worker attrition impacting progress and two fatalities within three months of site operation, highlighting a critical drawback in the safety system.

Despite our consistent efforts to communicate numerous quality issues to BBCL's site team, we believed the management's lackadaisical attitude toward prioritizing quality was evident. Urgently needed was a more proactive approach to quality management, placing it at the forefront of our operations, to rectify current issues, regain stakeholder trust and ensure successful project completion.

## **9. Rao, country head (BBCL) was in Algeria: meeting with internal stakeholders**

The country head Rao, acting on behalf of BBCL's CMD, swiftly traveled to the substation site in Algeria to assess the situation and chart the course of action for the future.

### ***9.1 Rao to project team***

As you are aware, the increasing number of instances of poor quality being detected at the site level, coupled with the client's escalation of these concerns to our senior management, necessitates urgent and decisive action. Failure to address this issue promptly could result in liquidated damages (LD) due to the subpar performance of our equipment arising from inadequate installation and poor workmanship. Moreover, if this pattern continues, there is a real risk of being blacklisted from future operations in the country, which would not only jeopardize our current project but also cast a shadow over our long-term plans. Therefore, I urge the Algeria project team to actively engage in finding solutions and resolving these quality-related challenges. Your insights and contributions are vital in ensuring the success of our endeavors and safeguarding our reputation.

### ***9.2 Kumar (project manager) on execution challenges and strategies for success***

Friends, being part of this international project has been great, and joining the prestigious project team is truly an honor. Despite challenges like location and language constraints, I am confident we can overcome them and deliver exceptional performance. However, my concern is that, even after 9 months since site operations began, our workmanship and service quality remain subpar. I've raised this concern before, and now a serious client complaint has reached our CMD office. This is not sustainable for our site work. We need to reassess our approach, aiming for full client satisfaction. It's crucial to address these issues promptly. Let's have a brainstorming session to find effective solutions and overcome the challenges we are facing. Otherwise, this situation may tarnish the company's reputation and affect poorly each of us individually. Can we collectively take responsibility and work toward rectifying the current situation? Let's commit to turning this situation around and ensuring our performance meets the high standards expected from us.

Satish, I'm currently dealing with a significant issue regarding the delayed handover of the construction site. Unfortunately, several work fronts are still pending handover, and once released, we are expected to swiftly mobilize our workforce across all fronts. Sourcing skilled labor in our current location poses challenges, leading us to partially rely on labor from Algeria, Egypt, and, to a larger extent, India, which introduces its own set of

challenges. Adding to these difficulties, our project is under substantial pressure to meet stringent turnover and cash collection targets.

### ***9.3 Ganesh Ray (site manager) on ripple effect of supply chain and labor management***

I am aware of site storage and electronic card failure issues, creating a nonsequential delivery problem. Items needed immediately are delayed, congesting the site store. Material quality is concerning, evidenced by last week's insulator consignment revealing cracks upon inspection. Customs clearance is taking longer than anticipated, causing delays. Visa processing for our labor force is a bottleneck, impeding project progress. These challenges collectively impact the timeline and demand urgent resolution.

*9.3.1 Rao to Ray on site quality issues.* Ganesh, hold on. The recent email from the client directly indicates lapses in our site quality. We've deployed a highly experienced quality manager on-site precisely to prevent such issues. I would appreciate hearing Krunal's perspective on this matter.

### ***9.4 Krunal Bose (quality manager): unveiling the layers of construction quality***

Satish, I want to express my gratitude for the opportunity to contribute to this international project, and I fully recognize the validity of the client's concerns. Issues such as inadequate curing, backfilling problems, and substandard materials have undoubtedly affected our project's quality and progress. However, it's essential to clarify my role in addressing these challenges and the limitations I face. While I have raised many of these issues and proposed solutions, my recommendations are often disregarded. Additionally, my authority over subcontractors is limited, making it challenging to enforce quality standards effectively. Despite my efforts to escalate concerns to Ganesh, the response has been inadequate, with a focus on meeting turnover targets at the expense of quality. I've taken steps to address issues such as instrument calibration and resource mobilization, but significant obstacles remain. Collaboration and urgent action are needed to overcome these challenges and ensure the success of our project.

### ***9.5 Mohit Gupta: insights from the subcontractor's perspective on navigating site realities***

(The subcontractor representative, who had maintained his composure thus far, now expressed his growing restlessness and concerns. He began by addressing the perception that all the problems at the site were solely the fault of the subcontractor, highlighting that the ground reality told a different story.)

Sir, blame for site issues is often placed on us, the subcontractors, but the reality is different. We receive the site late without notice, requiring immediate mobilization of a significant workforce. Sourcing manpower in Algeria is exceptionally challenging, compounded by government regulations, the booming construction industry in India adds to the difficulty of finding skilled labor. Further elaborating on challenges; once on-site, mandatory one-week induction training is needed. The project drawings arrive late, disrupting planning, and reallocation of resources based on new design input. The rework due to frequent change in work instructions impact resources and contribute to overall project delays.

### ***9.6 Krishna Sahu (logistic manager): unlocking logistics dilemmas***

The ongoing logistics challenges cannot be solely blamed for material consignment delays. Despite directing transporters based on dispatch calls, the actual clearance is often delayed, leading to returns or extended wait times for loaded vehicles, rescheduling



promptly after a vehicle's return becomes highly challenging. Consequently, our transporters seek compensation, specifically requesting demurrage for delays in loading, unloading and waiting time – a valid claim, in my opinion. However, the contract lacks clear demurrage terms. I'll forward additional invoices to you, Sharad, for review and payment processing. Regarding late material receipts, dispatch clearance delays are prevalent. To address this, engaging with the client to understand and resolve dispatch clearance delays may enhance this aspect of our logistics.

### ***9.7 Krunal Bose (quality manager): prioritizing quality amid operational challenges***

(Interrupting [. . .] Krishna Sahu, let me finish first)

Sharad, while I value your insights into logistics and procurement challenges, I need to highlight site and departmental issues affecting our project quality. The broad scope given to subcontractors, covering welding, paint, varnish, and manpower, raises concerns within our quality team. Loose specifications allow subpar materials, compromising construction quality and leading to over-consumption and waste. Inadequate site supervision, particularly for skilled labor, causes client visit unpreparedness, causing delays and disrupting critical activities. The subcontractors prioritize headcount over skill screening, jeopardizing project quality and progress. If these issues are not resolved and further Nonconformance Reports are filed, the project's success and reputation may be in danger.

### ***9.8 Sekhar Gupta (material vendor representative): manufacturing hurdles amid delayed orders and unclear instructions***

I understand your perspective, and it's essential to acknowledge that while some delays may have occurred due to manufacturing issues on our end, most instances were a result of late purchase orders and unclear work orders. In many cases, we were informed by procurement to be prepared for the work, and we ensured that our manufacturing capacity was ready. However, the actual purchase orders arrived late, which created a lag in our production schedule. Additionally, the lack of clarity in the work orders necessitated multiple requests for clarification, further extending the time required to commence manufacturing.

### ***9.9 Sri Govind (procurement manager): procurement challenges in global projects***

Satish, I partially agree with our site manager's perspective, but it's crucial to grasp the challenges we are navigating. The project schedule is demanding for procurement, involving a lengthy process from collecting technical requirements to floating inquiries to various vendors. Our scope extends beyond local Algerian vendors due to the less matured market and high costs. Many orders are placed with Chinese and European vendors, who take their time to respond, even with continuous reminders. Last month, delays occurred due to the Chinese festival. Additionally, our cost reduction target in procurement pushes us toward L1 vendors, only to later realize they may struggle with production or deliver poor-quality products, as observed on-site. Despite placing orders ahead of schedule and ensuring materials reach the site well in advance, these efforts often go unnoticed (refer [Exhibit 9](#) for procurement related delays).

### ***9.10 Satish Rao (country head): transforming our project approach for success***

Team, thanks for considering the challenges our project faces. We need a comprehensive overhaul of our systems and processes to address these issues effectively. Whether it's ensuring timely site availability, streamlining procurement, or resolving quality concerns, decisive action is required. Let's work together diligently to overcome these obstacles, upholding our organization's high standards. Through collective effort, we can successfully



navigate these challenges. Your understanding and recognition of the importance of addressing these critical issues are valued, and we are committed to working collaboratively for positive changes and project success.

After interacting with project team members and understanding the myriad interconnected project issues leading to quality noncompliance, Mr Rao instructed Sharad Kumar to identify the root causes and propose a future course of action. He also directed him to prepare a report for submission to the CMD office.

## 10. Questions

- Q1. What are the project quality challenges that have frustrated the client in this substation construction project? Categorize these challenges as per fishbone framework of construction quality management, USA? Draw the Pareto diagram to see the most critical factor contributing to the poor quality?
- Q2. What are the dimensions of quality on which a project quality can be measured? Please map the project quality issues of KE substation project on quality dimension framework of PMBoK? Draw the Pareto diagram to see the most critical quality dimensions prevailing in the project?
- Q3. Does the current procurement process possess the capability to fulfill the construction requirements effectively? Develop and analyze control chart for major factor for delay of material receipt at site?
- Q4. What steps should Rao take to get out of the current quagmire, based on the analysis above?

*Keywords:*  
Quality, Quality tools, Quality dimensions, Control chart, Substation project, Construction, Construction engineering, Construction management, Project management, Quality management

## References

- Pollack, J., Helm, J., & Adler, D. (2018). What is the iron triangle, and how has it changed? *International Journal of Managing Projects in Business*, 11(2), 527–547. doi: 10.1108/IJMPB-09-2017-0107.
- Rumane, A. R. (2013). *Quality tools for managing construction projects*, CRC Press.

## Further reading

- ABC AMEGA. (2021). Country risk: Algeria. Retrieved from <https://www.abc-amega.com/articles/country-risk-algeria> (accessed 26 November 2023).
- Algeria energy information. (2021). ENERDATA. Retrieved from <https://www.enerdata.net/estore/energy-market/algeria> (accessed 26 November 2023).
- Fish bone diagram. (2024). Construction quality management tool. Retrieved from <https://cqm.us/cqm-root-causes> (accessed 20 December 2023).
- International trade administration. (2023). Algeria country commercial guide. Retrieved from <https://www.trade.gov/country-commercial-guides> (accessed 26 September 2023).
- Pheng Low, S., & Faizathy Omar, H. (1997). The effective maintenance of quality management systems in the construction industry. *International Journal of Quality & Reliability Management*, 14(8), 768–790. doi: 10.1108/02656719710181303.
- Pmi, A. (2021). Guide to the project management body of knowledge (PMBOK guide)-the standard for project management.
- Which Countries Does The Sahara Desert Cover?. (2019). Retrieved from <https://www.worldatlas.com/articles/which-countries-does-the-sahara-desert-cover.html> (accessed 26 November 2023).
- World Bank. (2023). The world bank in Algeria. Retrieved from <https://www.worldbank.org/en/country/algeria/overview> (accessed 26 September 2023).

## Exhibit 1. Brief information of project

Owner/Client: "Shariket Karhaba Koudiet Eddraouch Spa" (SKD), a state-owned government company responsible for power generation, transmission and distribution in Algeria

Contractor: Bharat Bijlee Construction Limited (BBCL)

Type of contract (lumpsum): Lumpsum for civil and installations lot items

Remeasurable contract

Brief scope of work: engineering, designing, manufacturing, factory testing, site delivery, civil works, erection, testing and commissioning at site, for S4 550/210 kV GIS substation

Original contract value: US\$61,301,297

Revised contract value: US\$63,300,307

Project LOA date: November 25, 2017

Project completion date: January 10, 2019

Commissioning date: (expected) February 20, 2021

Project manager: Sharad Kumar

Key stakeholders

Owner: SKD, a state-owned company responsible for power generation, transmission and distribution in Algeria

Ministry of electricity and renewable energy: Competent Ministry sets national energy policy, oversees government agencies/owned entities in the sector

Consultant: Electrify Consultancy Group

Source: Authors' own work

## Exhibit 2. Scope of work

Brief scope: Engineering, designing, manufacturing, factory testing, site delivery, civil works, erection, testing and commissioning at site, setting to work, putting in operation, insurance till provisional acceptance, warranty, technical assistance during warranty period.

*Electrical and mechanical*

- No. of 550 kV GIS Bays – 8; Double Bus Double Breaker Scheme
- No. of 210 kV GIS Bays – 14; Double Bus Single Breaker Scheme
- 250 MVA, 550/210 kV 1Ph Autotransformer – 10 Nos.

Associated works

- Firefighting system of 250 MVA power transformers, HVAC, fire protection and alarm system, erection, T&C of SS including 7 × 250 MVA transformers.
- Supply of associated 550 and 210 kV line outdoor equipment.
- Supply of control and protection system, telecom system.
- Design and supply of auxiliary power supply, earthing protection materials.

Civil

- Civil works for construction of GIS/control buildings substation and other foundation works
- Foundation, structural and miscellaneous steel work: 500 and 210 kV outdoor equipment
- 550 kV GIS building, 210 kV GIS building and control building
- Main and second roads, boundary wall fencing, water supply system including the underground water tank, pumps room and fire hydrant system
- Sanitary installation and sewerage system, earthing system, indoor and outdoor lighting systems, ventilation and air-conditioning system, fire alarm and fire detection system for the S/s building, guardroom and guard towers

- Transformer foundations, firefighting rooms and RC foundation for firefighting tanks
- Outdoor cable tranches, ducts power cable and control cables
- Steel fence around the whole area of the outdoor equipment and power transformers

*Source:* Authors' own work

### Exhibit 3. Mapping of various issues faced by the project as per Ishikawa PMBoK framework

**Table E1**

*Quality issues faced by Koudiet Eddraouch GIS substation project*

<i>Sr</i>	<i>Issues</i>	<i>People</i>	<i>Process and policy</i>	<i>Design</i>	<i>Material</i>	<i>Environment</i>	<i>Management</i>
1	Inadequate quality systems		1				
2	Quality assurance plans		1				
3	Nonremoval of slush						1
4	Poor quality of cable tray work	1					
5	Frequent change in task allocation						1
6	Defective supply of material				1		
7	Delay in project delivery under tight schedule and geography						1
8	DPT carried out without the supervision						1
9	Honeycombing in duct support foundation concreting						1
10	Expired calibration of testing equipment		1				
11	Fatality at site						1
12	Frequent breakdown of equipment						1
13	High worker attrition	1					
14	Inadequate adherence to approved job procedures for roof waterproofing treatment		1				
15	Inadequate curing for finishing work		1				
16	Increased quality standard/requirement			1			
17	Insufficient or poorly defined drawings			1			
18	Lack traceability for joint		1				
19	Lack of quality initiative due to poor quality culture		1				
20	Quality issues in finishing; surface undulations and cracks	1					
21	Late procurement				1		
22	Nonavailability of work front for mobilized team		1				
23	Noncompliance with approved vendor lists				1		
24	Nonsequential dispatch of materials				1		
25	Poor documentation		1				
26	Poor planning for season					1	
27	Poor skill of craft man	1					
28	Poor workmanship on the site	1					
29	Poor quality of fasteners and rusted structural steel components				1		
30	Poor quality of incoming material				1		
31	Roof water proofing procedure		1				
32	Significant honeycombing and potholes	1					
33	Slow reaction to client input						1
34	Soil back filling deviation				1		
35	Staircases surface has undulations and cracks	1					
36	Structural deficiency			1			
37	Unforeseen weather condition					1	
38	Sand with high silt content for concrete				1		
	<i>Total issues</i>	7	10	3	8	2	8

Source: Authors' own work

Exhibit 4.

**Table E2** Pareto analysis of various non-compliance faced by the project

Major causative factor for poor quality	Nonconformance report (NCR)	% NCR
People	7	18
Process and policy	10	26
Design	3	8
Material	8	21
Environment	2	5
Management	8	21
<i>Total</i>	<i>38</i>	

Source: Authors' own work

**Figure E1** Pareto analysis of various non-compliance faced by the project

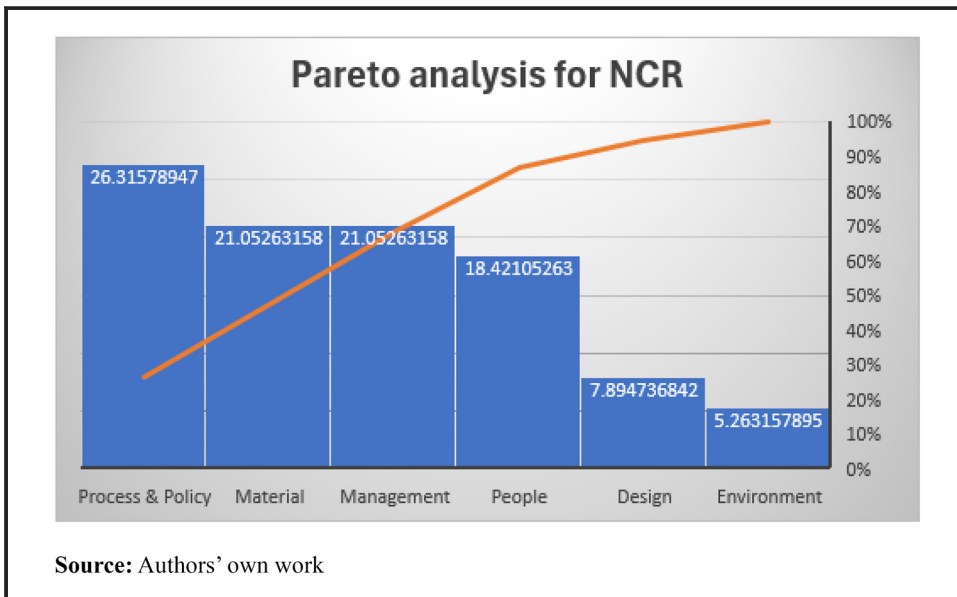
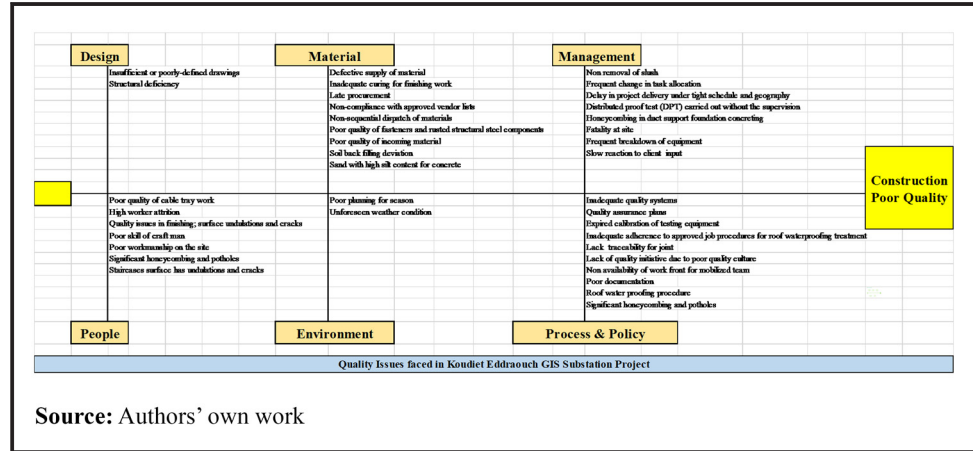


Exhibit 5. Fishbone diagram of quality issues faced in the project

Figure E2



## Exhibit 6. Mapping of quality dimension for project

**Table E3**

<i>Issues related to poor quality (NCR)</i>	<i>Performance</i>	<i>Conformity</i>	<i>Reliability</i>	<i>Resilience</i>	<i>Satisfaction</i>	<i>Uniformity</i>	<i>Efficiency</i>	<i>Sustainability</i>
Inadequate quality systems					1			
Quality assurance plans					1			
Nonremoval of slush		1						
Poor quality of cable tray work						1		
Frequent change in task allocation					1			
Defective supply of material		1						
Delay in project delivery under tight schedule and geography	1							
DPT carried out without the supervision					1			
Honeycombing in duct support foundation concreting		1						
Expired calibration of testing equipment			1					
Fatality at site								1
Frequent breakdown of equipment			1					
High worker attrition					1			
Inadequate adherence to approved job procedures for roof waterproofing treatment		1						
Inadequate curing for finishing work		1						
Increased quality standard/requirement					1			
Insufficient or poorly defined drawings	1							
Lack traceability for joint							1	
Lack of quality initiative due to poor quality culture					1			
Quality issues in finishing; surface undulations and cracks		1						
Late procurement				1				
Nonavailability of work front for mobilized team				1				
Noncompliance with approved vendor lists		1						
Nonsequential dispatch of materials						1		
Poor documentation			1					
Poor planning for season				1				
Poor skill of craft man							1	
Poor workmanship on the site		1						
Poor quality of fasteners and rusted structural steel components		1						
Poor quality of incoming material		1						
Roof water proofing procedure					1			
Significant honeycombing and potholes	1							
Slow reaction to client input							1	
Soil back filling deviation		1						
Staircases surface has undulations and cracks						1		
Structural deficiency	1							
Unforeseen weather condition				1				
Sand with high silt content for concrete			1					
	4	11	4	4	8	3	3	1

Source: Authors' own work



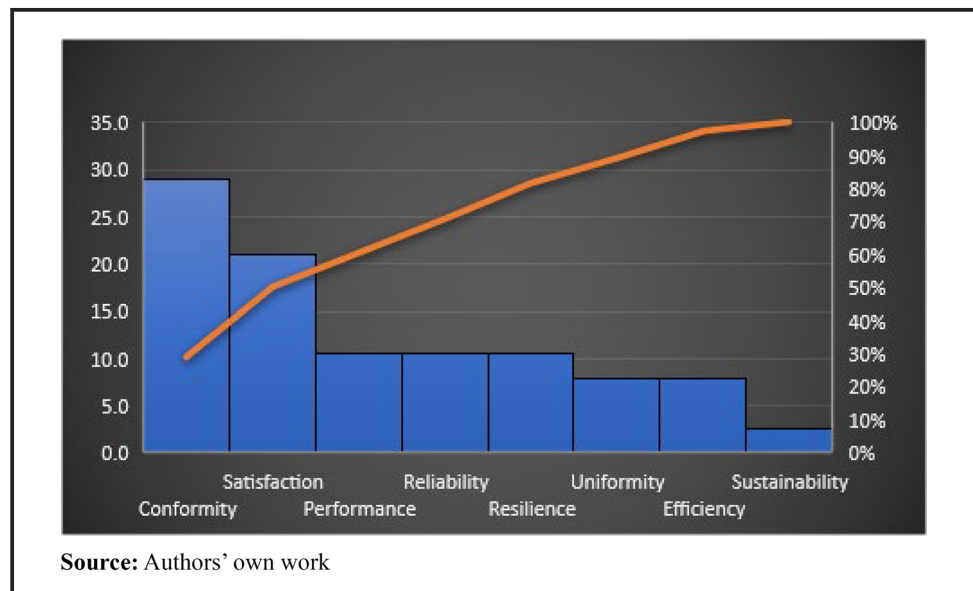
## Exhibit 7. Pareto analysis of mapping of quality dimension

**Table E4** Categories of issues on project quality dimensions

Project quality dimension	No. of noncompliance (NCR)	% of NCR	Cumulative of % NCR
Performance	4	10.5	10.5
Conformity	11	28.9	39.5
Reliability	4	10.5	50.0
Resilience	4	10.5	60.5
Satisfaction	8	21.1	81.6
Uniformity	3	7.9	89.5
Efficiency	3	7.9	97.4
Sustainability	1	2.6	100.0
	38		

Source: Authors' own work

**Figure E3** Pareto analysis for NCR on quality dimensions



## Exhibit 8. Procurement delays

**Table E5**

<i>Sr no.</i>	<i>Order</i>	<i>Vendor</i>	<i>Supply time (days)</i>	<i>Difference in contractual vs actual receipt (days)</i>	<i>Reasons</i>
1	ALG-B0L000078	INDE002	29	-5	Logistic delay
2	ALG-B0L000080	SRIP003	7	-5	Logistic delay
3	ALG-T0L000707	STYL001	28	-39	Manufacturing delay
4	ALG-P0L001801	DIVI003	3	-32	Manufacturing delay
5	ALG-P0L001829	EXCE004	31	-22	Design phase delay
6	ALG-B0L000085	UNIK003	30	13	Early
7	ALG-B0L000088	MATR004	21	-22	Logistic delay
8	ALG-B0M000009	LCOM001	7	-98	Manufacturing delay
9	ALG-B0M000010	ROHD001	90	-67	Manufacturing delay
10	ALG-B0M000011	ROHD001	120	-69	Payment delay
11	ALG-P0L001924	PURS001	29	-31	Manufacturing delay
12	ALG-B0L000089	VITR001	14	-11	Logistic delay
13	ALG-B0M000012	AVNE001	21	-51	Payment delay
14	ALG-T0L000802	NARA007	7	-33	License delay
15	ALG-B0M000013	REDI002	35	-119	Manufacturing delay
16	ALG-B0L000096	ANTE001	21	0	On time
17	ALG-B0L000098	JYOT003	23	-122	Manufacturing delay
18	ALG-B0M000014	SERV005	35	-122	Manufacturing delay
19	ALG-B0L000104	PLUS001	27	10	Early
20	ALG-B0L000106	PALA001	7	-36	Development delay
21	ALG-B0L000107	PARK003	153	-127	Design phase delay
22	ALG-P0M000038	NATI008	21	-118	Payment delay
23	ALG-B0M000016	MINI006	14	10	Early
24	ALG-B0L000114	PLUS001	7	-54	Logistic delay
25	ALG-B0L000116	RADI003	88	4	Early
26	ALG-B0L000119	VSEM001	14	0	On time
27	ALG-B0L000118	CATA001	21	-5	Logistic Delay
28	ALG-B0M000017	AQER001	150	-60	Manufacturing delay
29	ALG-T0L000943	EXCE004	72	-119	Manufacturing delay
30	ALG-P0M000041	YOKO002	60	-61	License delay
31	ALG-B0L000127	CYRO002	21	-63	Manufacturing delay
32	ALG-B0M000019	APPL008	42	-96	Design phase delay
33	ALG-B0L000126	HIND007	42	-99	Design phase delay
34	ALG-B0M000018	STAN011	35	-66	Payment delay
35	ALG-P0M000044	SIEM003	114	-56	Logistic delay
36	ALG-B0M000020	AQER001	153	-98	Manufacturing delay
37	ALG-P0L002624	FLYJ001	1	-37	Payment delay
38	ALG-P0M000045	VOES002	31	-66	Manufacturing delay
39	ALG-T0L001196	PREC016	92	-63	Manufacturing delay
40	ALG-B0L000167	UNIK003	70	-38	Manufacturing delay
41	ALG-P0L002994	DIVI003	7	-46	Manufacturing delay
42	ALG-P0L003121	SHIV041	7	-58	Payment delay
43	ALG-P0L003156	ACRO001	7	0	On time
44	ALG-B0M000023	BIRD001	70	-21	Logistic delay
45	ALG-B0M000024	KONT002	70	-57	Payment delay
46	ALG-B0M000025	VOCA001	70	27	Early
47	ALG-B0L000191	COHE001	15	-7	Logistic delay
48	ALG-B0L000194	THRI001	70	29	Early
49	ALG-B0L000197	SANK004	30	-58	Payment delay
50	ALG-P0L003335	KINT001	2	-40	Payment delay
51	ALG-B0L000209	ZING001	15	-13	Logistic delay
52	ALG-B0L000208	ALLI021	15	-6	Logistic delay

(continued)

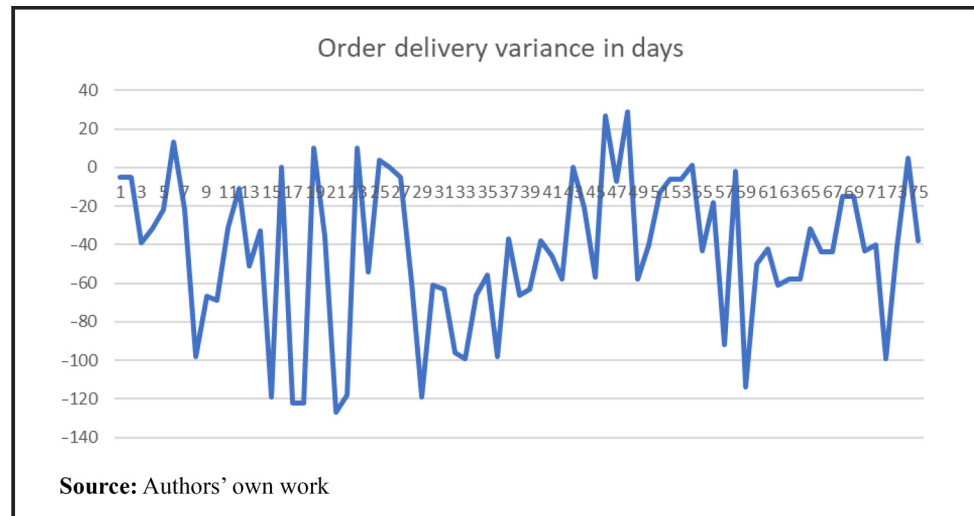
**Table E5**

Sr no.	Order	Vendor	Supply time (days)	Difference in contractual vs actual receipt (days)	Reasons
53	ALG-P0L003420	EPOC001	6	-6	Logistic delay
54	ALG-P0L003418	LOGI001	7	1	Early
55	ALG-B0L000213	DYNA013	21	-43	Logistic delay
56	ALG-B0L000217	CLIM002	14	-18	Design phase delay
57	ALG-T0L001636	PROF002	182	-92	Manufacturing delay
58	ALG-P0L003609	FLYJ001	7	-2	Payment delay
59	ALG-B0L000229	CLIM002	21	-114	Manufacturing delay
60	ALG-B0L000231	RSCO001	15	-50	Manufacturing delay
61	ALG-T0L001805	TECH019	5	-42	Payment delay
62	ALG-B0L000240	SICK002	28	-61	Manufacturing delay
63	ALG-P0M000051	DRJO001	84	-58	License delay
64	ALG-B0M000028	NORD003	56	-58	Design phase delay
65	ALG-B0L000254	TEEM001	52	-32	Logistic delay
66	ALG-P0L003951	DRUP001	92	-44	Manufacturing delay
67	ALG-B0L000261	TECO002	51	-44	Logistic delay
68	ALG-B0M000031	MAST010	60	-15	Logistic delay
69	ALG-T0L001921	TECH019	3	-15	Payment delay
70	ALG-P0M000054	SIEM003	123	-43	Logistic delay
71	ALG-P0M000055	SIEM003	139	-40	Logistic delay
72	ALG-H0L007496	ANVI002	74	-99	Manufacturing delay
73	ALG-H0L007698	AMIN001	120	-41	Manufacturing delay
74	ALG-H0L007723	ANVI002	104	5	Early
75	ALG-07L003501	EXCE004	61	-38	Design phase delay

Source: Authors' own work

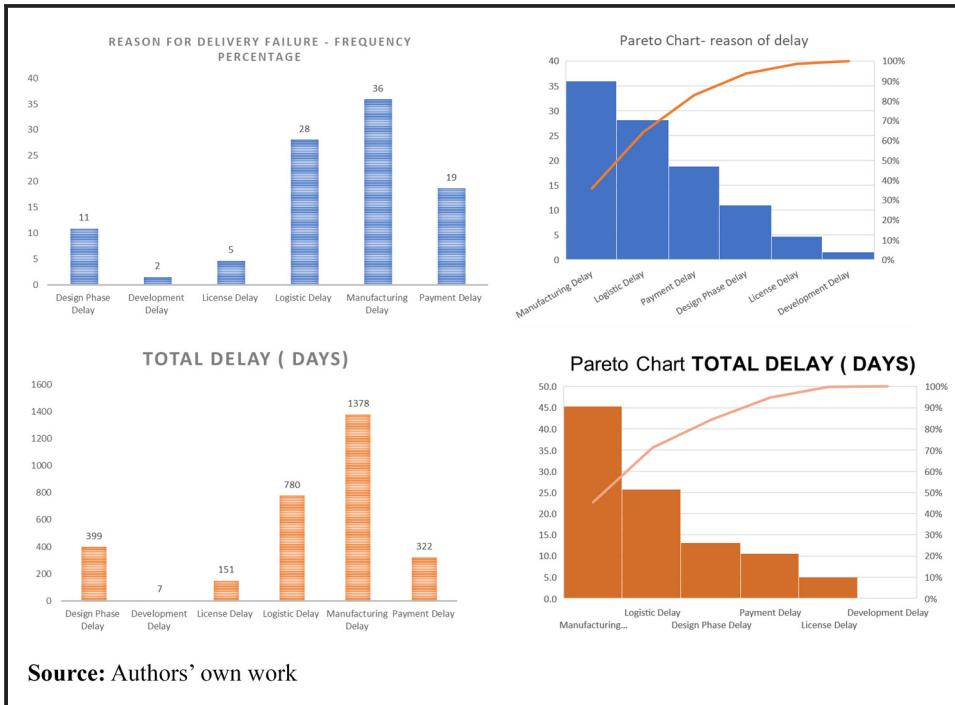
**Exhibit 9. Procurement delays**

**Figure E4** Control chart



Source: Authors' own work

**Figure E5** Pareto analysis



### About the authors

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