

Enhancing Lean Six Sigma to Improve Capital Maintenance Projects Processes at Saudi Electricity Company

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Abstract: Six sigma is being implemented around the world as a strong and successful quality improvement methodology. Nowadays numerous companies are using the Six Sigma approach to move towards zero defects. The aim of this study is to develop the capital maintenance projects processes of the maintenance sector at Saudi Electricity Company by using Lean Six Sigma Methodology. Lean Six Sigma is a process-based methodology for pursuing continuous improvement. Lean Six Sigma includes five phases, which are DMAIC: Define, Measure, Analyze, Improve and Control. The study applies the Lean Six Sigma methodology to the maintenance sector at Saudi Electricity Company to determine which process parameters contribute most to time delays on capital projects to develop a work procedure that can be followed easily in the maintenance sector of the western operation area by all participants in the capital projects. The results show while the old process of capital maintenance projects had a duration of 192 days, the enhanced process using the output of this study had a duration of only 108 days.

Keywords: DMAIC; Six Sigma; Saudi Electricity Company.

I. INTRODUCTION

In the kingdom of Saudi Arabia, the annual population increases by large amounts every year. According to the General Authority for Statistics (2017), in 2017 the total population was approximately 30 million. Due to the regular huge increases in the population, the Saudi Arabian government has built companies to provide services for the people to make their life easier. Obviously with the regular increases in the population, the demand for electrical services by citizens is continually on the rise. These companies must provide several services in a short time period. To provide adequate service, companies must have a system that works smoothly to avoid any delay in providing services [1].

Saudi Electricity Company is one of these companies who are committed to providing the customers with secure and reliable electric services, meeting shareholders expectations, caring for their staff, and ensuring the available resources reach the optimum utilization.

The company has three business lines: generation, transmission and distribution. Each business line has its own organizational structure and specific processes to follow, and for each process several steps must be completed to reach target goals.

This study focuses on the undermaintained sector of the Western operations area, in an effort to make it possible to reduce the time spent on the capital projects and eliminate waste.

Each of the capital projects in the maintenance sector consists of five life cycles: planning, approval, bidding, execution and closing. The maintenance departments that report to the maintenance sector of the western operations area must get approval for proposed capital projects from an executive committee before starting any projects. The approval from the executive committee usually takes a long time to get because of the in-depth process involved. After a proposed capital project is approved, the second cycle, the bidding and execution cycle, begins. During this cycle, there are many processes that must occur between the departments and contractors. As a result, this is also a lengthy cycle. In the final cycle, the closing cycle, the contractors must provide many documents to the departments by contractors. These documents can't all be delivered at one time; they also need to undergo multiple processes to complete.

This study aims to reduce time spent and waste occurring in the first three cycles of capital maintenance projects (planning, approval and bidding).

II. LITERATURE REVIEW

Six Sigma first appeared in the 19th Century as a mathematical theory but found its way into the business world through the efforts of engineers at Motorola in the 1980s. Recently, six sigma has become a hot topic in many science and engineering fields. Organizations use six sigma to improve customer satisfaction and improve business processes. This section provides the reader with a general overview of previous research on six sigma applications.

One example of Six Sigma application is in Hung and Sung [2], who applied six sigma to manufacturing processes in the Taiwanese food industry. The aim of this application was to reduce the quality cost by solving the underlying problem of process variation and related with high defect rate via a DMAIC approach. The results showed that the DMAIC approach improvement actions, implemented during a six-month period, reduced process variation to below 0.141%

In another case, Ray et al, [3] employed six sigma to improve a customer complaint resolution process. The main goal of this study was to reduce the cycle time for the customer complaint resolution process using the DMAIC approach. Results include a reduction in the follow-up time for the customer complaint resolution, a reduction in the closure time and a decrease in the ratio of pending complaints.

Nagi and Altarazi [4] sought to improve the carpeting process of a company by integrating value stream mapping and strategic layout planning into the DMAIC approach. Reducing the occurrence of different types of nonconformities in the carpeting process was their main goal, using a facilities layout technique and lean tools of the DMAIC approach. At the end of the project, it was determined that the quality of the product, carpeting process capability, customer satisfaction and cost of bad quality significantly improved. Specifically, the six-sigma level was improved from 2.297 to 2.886 and the defect per million opportunities was reduced from 21,615 to 3905.

Miski [5] used Six Sigma Methodology to improve customer service at IKEA. The main goal of this study was to reduce revenue losses due to numerous customer complaints. Miski executed Six Sigma DMAIC methodology designed at revamping the existing business process. The results show that the number of complaints was reduced from 333 to 43 per month.

Kumar et al, [6] applied a Six Sigma DMAIC approach to improve the credit initiation process in a financial services operation. The credit initiation process for mid-level corporate credit card customers, a critical function for a financial services companies, depends on multiple people across sections considered as. The aim of this study was to analyze the credit initiation process by using Six Sigma DMAIC approach in order to reduce the number of days it takes from the time a firm submits a request to the time it is accepted from 20 days to 15 days. They found 25% improvement in throughput time, and they suggest changes to some processes and new measures which could be implemented to avoid variance in the process.

Qureshi et al, [7] developed a study to measure and analyze the customer satisfaction in a telecom sector in Pakistan. The goal of the study was to measure the customer satisfaction in telecom sector of Khyber Pakhtoon Khawa province of Pakistan through the use of six sigma. After using a Pareto chart, they found many problems facing the existing customers in the customer service center such as network problems, billing issues, sim blocking issues, sim registration problems, etc.

Abreu et al, [8] proposed a study to improve complaint handling in automotive industry. This study using Six Sigma was developed in response to a decrease in customer satisfaction according to the response time to complaints. The outputs of this study were positive, and they recommend the managers from other companies to develop their customer complaints by using Six Sigma.

Desai and Shrivastava [9] studies the quality and productivity improvement in a manufacturing enterprise. The goal of this study was to apply six sigma DMAIC in an industry “which provides a framework to identify, quantify and eliminate sources of variation in an operational process in question, to optimize the operation variables, improve and sustain performance”. They concluded that the six sigma process can improve the process performance, maintain consistent quality of the process output and decrease variations.

Ramly and Yaw [10] improved a process for IT customer support. They focused on reducing the number of IT infrastructure support issues through using six sigma DMAIC methodology. They found that the volume of customer complaints and requests were reduced to 75% of initial volume of the IT infrastructure ticket after applying the methodology.

III. METHODOLOGY

The methodology of this study was to apply the lean six sigma principles to improve the processes of capital maintenance at Saudi Electricity Company. Six Sigma today is used across a wide range of industries like banking, construction, healthcare, and software. Many global companies are using the Six Sigma methodology to improve the efficiency. The methodology of this research was carried out in the five Six Sigma phases: Define, Measure, Analyze, Improve, and Control.

- ***Define phase:***

In this phase, the problem was defined in terms of time consumption and waste of resources during the capital project at Saudi Electricity Company. This phase illustrated the processes of the capital project. The tools used to illustrate the process include critical to quality, flow chart, process map, value added, Pareto chart, affinity diagram, and tree diagram. The coordination and support division at Saudi Electricity Company is responsible for process improvement. However, the customer in this study would be the maintenance departments.

- ***Measure phase:***

Measured the existing system for defects, opportunities, units and metrics. A data collection plan was developed to measure the defects. This stage generally helps in monitoring the progress of the data collection towards the defined goals.

- ***Data Collection Plan and Execution***

The data was collected by interviewing many employees involved in the capital projects. Each department reported their responsibilities and duties for the capital projects at Saudi Electricity Company. They also explained the process flow as well as the time that it took to complete each task.

- ***Analyze phase:***

The analyze phase studied the current processes to remove any discrepancies between the current processes and target results. This phase used analysis techniques such as fishbone diagram, flow of work and nature of work.

- ***Improve phase:***

This phase helped the team to improve the process after studying and analyzing the current situation. The improvement phase eliminated all the waste and the extra steps in the process that the capital project was determined to have. Different tools and methods were used to reach the maximum benefit of this phase. In this phase, the team agreed on the new process flow by eliminating the non-value added and reducing the time as well as the number of tasks. A process map was also created at this time in order to specify each department and their responsibilities for the capital project. The team selected the solution that best encouraged movement towards the optimal route to complete the project.

- ***Control phase:***

In the control phase, the team created a complete document for the capital project. This document was approved by the higher management at Saudi Electricity Company. Also, this document was sent to each department involved in that project in order to be followed by all employees.

The document is expected to help the new employees to follow the new process for the capital project. It also insures that the improved process doesn't backslide and prevents any anything wrong happening in the process.

IV. RESULTS

The first part of the study involved determining the real situation of the processes of capital maintenance projects at Saudi Electricity Company. Capital maintenance projects go through many processes but capturing the processes could be done in the first three phases of six sigma: Define, Measure and Analyze.

The new modeling for capital maintenance projects was developed in the second part of the study. This part also involved a documentation of the process to be followed by Saudi Electricity Company. This part is considered a "to be" model. Improving the process using Six Sigma took place in the last two phases: Improve and Control.

- **Define Phase:**

Capital maintenance projects include many processes; these are laid out in the flow chart in figure 1.

Figure 1: Flow chart, define phase [Download]

- **Observed Issues:**

- Lack of budgets for projects due to fluctuations in the economy.
- Multi-Level Authorizations.
- Lack of communication between the departments.
- Large number of similar projects due to poor planning from the requesting departments.

- **Reducing cycle time through value-added flow charts:**

The total value-added time was 170 days, and the total non-value-added time was 22 days.

Pareto Charts:

Pareto charts were developed (figure 2); the problems that fall to the left of the 80% line are the few problems accounting for most of the effect process (Table 1).

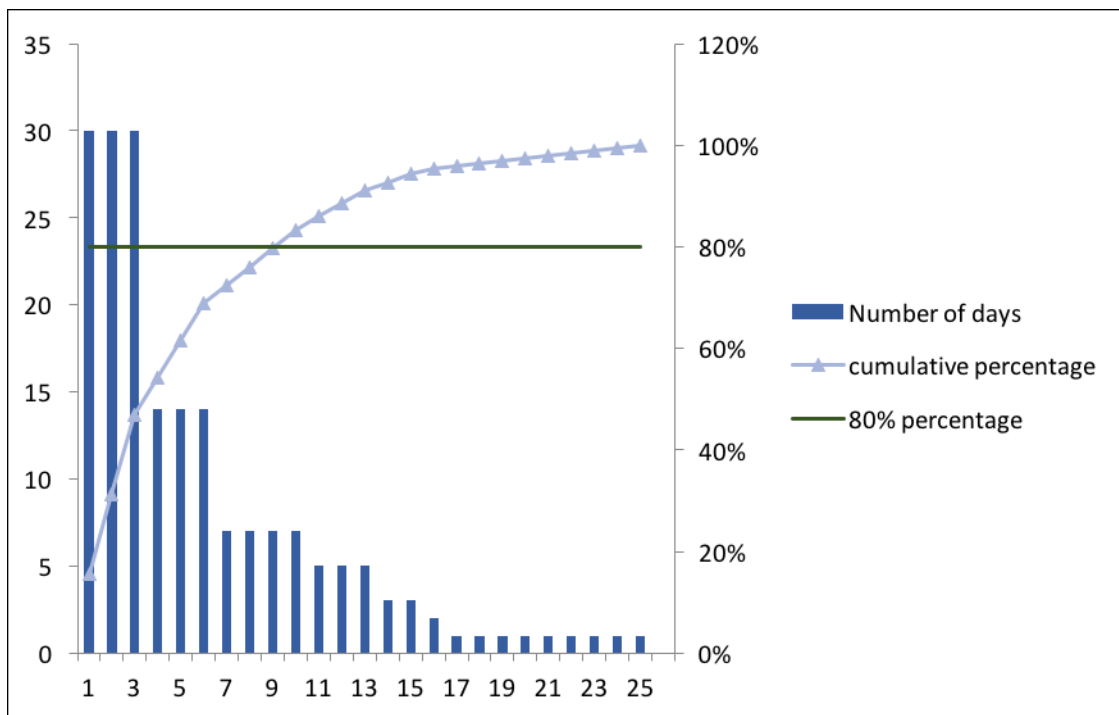


Figure 2: Pareto chart

Table 1: Pareto table

<i>S.N.</i>	<i>Process</i>	<i>Day</i>	<i>Cumulative of days</i>	<i>(% age)</i>
1	The requesting departments fill out the forms and send them back to the CSD	30	30	16%
2	Requesting departments come up with detailed scope of work and pre- appropriation for expenditure in the CLM1 system	30	60	31%
3	The contracting department sends bid invitations to all contractors for bidding purposes	30	90	47%
4	Capital planning department extract a report related to all data of the proposed projects	14	104	54%
5	Data is completed at the investment system?	14	118	61%
6	Technical and financial requirements reviewed via requesting departments and award the appropriate bid	14	132	69%
7	conduct a meeting attended by specialists from the TSD, CSD and a representative from each department	7	139	72%
8	CSD send the proposed projects to the PCD to get it approved by the vice head of the maintenance sector	7	146	76%
9	Data of the proposed projects will be insert by the CSD at [SAP]	7	153	80%

• **Meaure Phase:**

Measure phase is the second step in implementing Lean Six Sigma. The objective of this phase is to measure the existing system for defects, opportunities, units and metrics.

Data Collection Plan and Execution:

The data was collected by interviewing many employees related to the capital projects. Each department had to report their responsibilities and duties for the capital projects at Saudi Electricity Company. The departments included the coordination and support division, technical support division, coordination and planning division, contracting department, requesting departments and capital planning department. They were also required to explain the process flow, along with the time that it took to complete each task. After that, the representative from each department met to discuss the final shape of the process flow for the project and specify the role of each department.

The following is a list of the individual role played by each department and division involved in the capital projects.

- The coordination and support division were responsible for receiving the project’s request from the requesting department.
- The requesting department was responsible for filling out the requirements of the project.
- The technical support division was responsible for the approval of the project in terms of technical issues.
- The coordination and plan division were responsible for sending the requirements of the project to the vice head of the maintenance sector in order to get the project approved.

- The contracting department was responsible for preparing the project in order to launch for the bid invitation.
- The capital planning department was responsible for presenting the projects to the executive committee.
- **Analyze Phase:**

The objective of this phase is to analyze the current processes to eliminate differences between the current processes and the target results. For this phase, we used analysis techniques such as fishbone diagram, flow of work and nature of work.

Fishbone Diagram:

The fishbone diagram was developed after brainstorming to find the possible causes of existing problems (figure 3).

- Fish head: Capital Maintenance Projects Processes (effect).
- Fish spine: Time, Process, Quality and Efficiency (causes).
- Fish bone: the problems related to the fish spine (figure 3).

Figure 3: Fishbone Diagram [[Download](#)]

- **Improve Phase:**

In this phase, the analysis is used to improve the existing system by removing the identified flaws. It is used to generate new, innovative process and ideas for the project and implement them.

In this phase, the best process that Saudi Electricity Company should follow to improve the process was selected. The implementation of this process was also accomplished. The improvements made satisfied the company.

Figure 4: Flow chart, improve phase [[Download](#)]

Process Mapping:

Process mapping is a well-known technique which is frequently used to create a common vision to improve new model results. This process map was created in the improve phase of this study (figure 5).

- Added new process where the executive committee set a fixed budget every year to use for the urgent capital maintenance projects only in order reduce costs and time expenditure.
- Eliminated the process of filling out the forms from requesting departments due to reduce time.
- Require departments that request a project to come up with justification for the project and a detailed scope of work of the project and send them to the division of technical and support to be studied clearly.

- Eliminated all meetings as the approval of the project can be done by the division of technical and support due to their technical competence.
- Added a new process of initiating a capital project claim via the SAP system for faster and computerized approvals to reduce time.

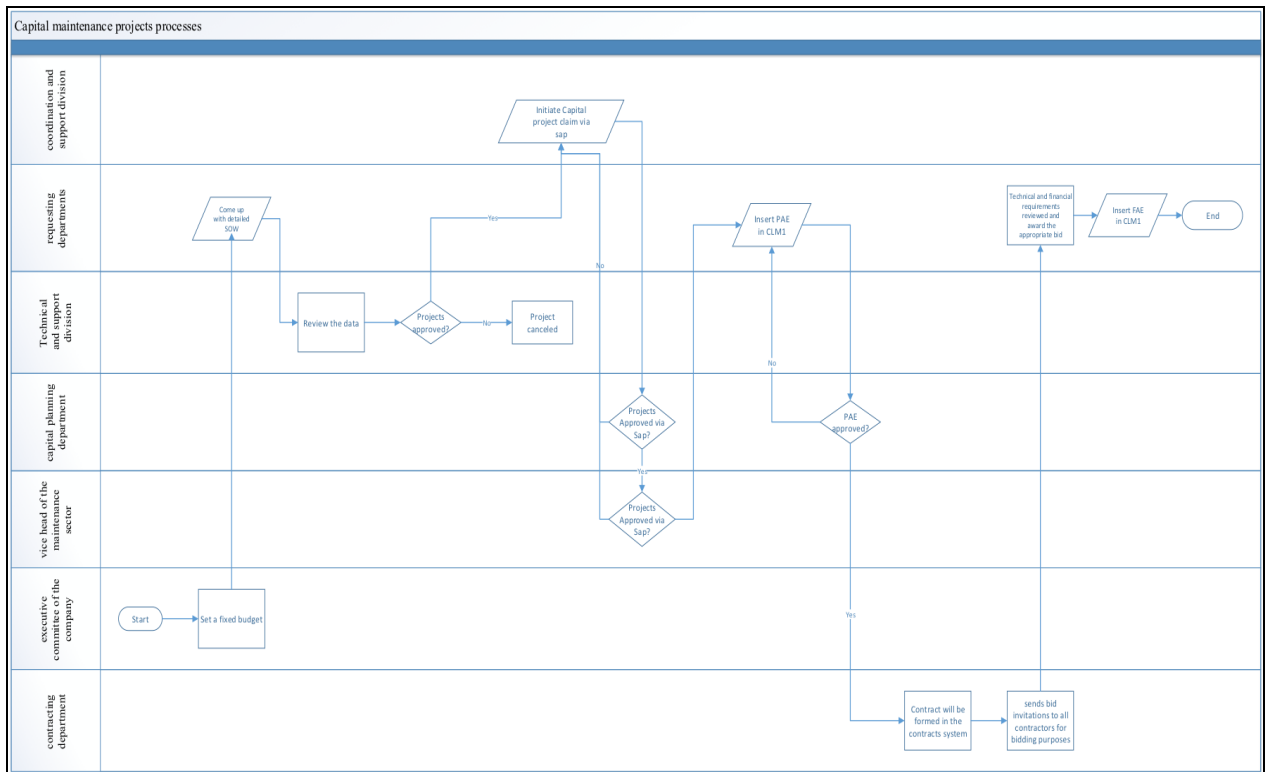


Figure 5: Process mapping for the improve phase

Notes Regarding Capital maintenance projects processes after improvements:

- **Control Phase**

After the improvements have been made in the improve phase, they need to be controlled to keep the new standardized process on the right track and prevent it from reverting back to the previous situation. This requires development, documentation and implementation of the new model. The control phase has verified long term process capability.

The Saudi Electricity Company should be careful to ensure that the new processes for the maintenance projects don't back slide. That is, in order to ensure the gains are permanent, Saudi Electricity Company has to ensure there is process stability. Enacting the control phase is essential for this. A solution is of little or no value if it isn't sustained over a long period of time. To correct the problems and maintain the performance the control phase should establish standard measures as required for the maintenance projects of Saudi Electricity Company.

Process Documentation

Creating documentation of the whole process means writing down the improvements in such a way that everybody involved in the project is doing things similarly. This documentation must be written

so that fresh employees without formal training can implement the changes or improvements in the process. The following process documentation, extending from this point until the end of next paragraph, clearly shows the process flows of the new modeling:

The executive committee of the Saudi Electricity Company set a fixed budget every year to spend on capital maintenance projects to control expansion in order to not exceed the budget limit. When the requesting departments need a project, they should come up with justification for the project and a detailed scope of work of the project and send them to the division of technical and support. The data of the project will be reviewed via the division of technical and support. In cases where a project gets approved by the division of technical and support, the division of coordination and support will initiate a capital project claim into the SAP system and enter the data of the project in the investment system [IMA11] and in cases where a project is not approved, the project is canceled. After the approval is gained, the claim of the project will be reviewed by the Capital Planning Department. If the claim is approved by the Capital Planning Department via SAP, the claim will be automatically transmitted to the vice head of the maintenance sector for approval. If not approved, the division of coordination and support will do the required modification. If the claim is approved by the vice head of the maintenance sector via SAP, the requesting department will initiate a claim of pre-appropriation for expenditure via the SAP system, and if not approved, the division of coordination and support will do the required modification. If the claim of pre-appropriation for expenditure is approved, the claim will then be formed in the contracts system and the contracting department will send bid invitations to all contractors for bidding purposes. If the claim of pre-appropriation for expenditure is not approved, the requesting department will do the required modification. At the end of this process, all technical and financial requirements will be reviewed, and all information will be checked and verified to ensure that it complies with the required description via requesting departments, with the company making the most appropriate bid being awarded the project. Subsequently, a final appropriation for expenditure is established by the requesting departments to order the project via the SAP system where all information is attached in the CLM1 system to sign the contract.

V. CONCLUSION

After applying DMAIC methodology to capital maintenance projects processes at Saudi Electricity Company, the processes improved to 56%. The Pareto analysis determined which process parameters had the greatest impact on the time delays, which processes included the process of filling out forms from the requesting departments, the process of the requesting departments coming up with the detailed scope of work, and the process of the contracting department sending the bid invitations to all contractors for bidding purposes. The third objective in this study, to develop a work procedure that can be followed easily by all participants in the capital projects and also written in the process documentation, was accomplished in the control phase.

The improved model required adding a new process whereby the executive committee must set a fixed budget every year to spend on the urgent capital maintenance projects only in order reduce costs and time expenditures. The process of filling out the forms from requesting departments was eliminated. A new process was added where if the requesting departments must come up with justification for the project and a detailed scope of work of the project and then send them to the division of technical and support to be studied clearly. Allowing approval of the project by the division of technical and support to be sufficient due to their technical competence in projects enabled the elimination of all meetings for approval. Adding the new process of initiating capital

project claims via the SAP system enabled faster and computerized approvals in order to reduce the time.

The concluding remarks based on the study can be summarized as below:

- The old process was very long, with a duration of 192 days, while the new process has a duration of only 108 days.
- The number of activities in the old process was 24, while the number of activities in the new process is 12, so 12 activities were eliminated.
- It is the policy of the contracting department of Saudi Electricity Company to require 30 days for bidding purposes, so we were unable to make any change to this policy.

VI. RECOMMENDATIONS

First, due to fluctuations in the economy, the executive committee of Saudi Electricity Company should reduce the budgets for projects based on the volume of each sector in terms of the number of substations in each sector. Second, the requesting departments should study all the urgent projects carefully and give a clear justification for doing these projects. Third, the coordination and support division should develop a manual of the procedure for initiating a capital project claim to make the process clear for the newcomers; also, the requesting departments should develop a manual of the procedure for initiating pre-appropriation for expenditures with considering the claim documents.

Conflict of interest: The author declare that he has no conflict of interest.

Ethical statement: The author declare that he has followed ethical responsibilities

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