Transformer Commissioning at Central India Oil Refineries Ltd (CIORL)

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Abstract

The case describes the uncertain and unavoidable events that delayed the commissioning of a transformer at Central India Oil Refineries Ltd. The project was not being executed as planned, resulting in the delay of almost all the activities. The commissioning of the transformer had become the bottleneck of the refinery because all the pre-commissioning and commissioning activities of the refinery required steam and power, which were in turn dependent on the transformer. Project management tools such as the critical path method and programme evaluation and review technique were used to analyze the time required for the completion of the commissioning of the transformer and resource reallocation for speeding up the project. A cost versus time trade-off analysis was applied to determine the activities to be crashed in order to produce the maximum overall job profit.

Keywords

Project management, refinery, commissioning, CPM, PERT, cost versus time trade-off analysis

(*Date: 16, May 2011, CIORL Head Office, Central India*)
A. K. Singh, Vice President of CIORL asked Manger Electrical, S. N. Sinha:

> Why can't the transformer be charged on time? It is expected that the transformer should be charged before monsoon and you are saying that you want two more weeks. Don't you know that the pre-commissioning activities of the refinery are dependent on this transformer? What is wrong with your planning? Why is this project getting delayed again and again? I want to know where we have gone wrong in the planning and monitoring and I want a complete analysis of what you do and just make sure that the transformer is charged before June 30, 2011.

Vice president of Central India Oil Refineries Ltd (CIORL), A.K. Singh, in-charge of commissioning 30 MVA/33/6.6 kV transformer (power rating 30 MVA; input voltage 33 kV; output voltage 6.6 kV,

This case was written by Research Scholar Nikunj Kumar Jain (f11nikunjk@iimidr.ac.in) and Assistant Professor Rohit Kapoor (rohitk@iimidr.ac.in) from Indian Institute of Management, Indore, India to serve as basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation. Data have been disguised for purposes of confidentiality.

i.e., step-down transformer), was wondering whether the commissioning work will be completed at all. He was beginning to realize that as a result of the inordinate delays faced at various stages of the project, it would be impossible to meet the 40-day deadline. Since the monsoon season was around the corner, the threat of rainfall loomed large. Rainfall would result in many undesirable outcomes as follows.

1. Crane march would be impossible because in a crane march, the transformer is erected by placing it on a concrete foundation.
2. Hydra march would be difficult because in a hydra march, various parts/components of the transformer are assembled on an erected transformer.
3. Since it would be an open-air transformer, testing would be blocked.
4. Trench cleaning work would not take place and, hence, cabling would not begin.

There were also many activities which would get delayed because of their strong interdependencies on the previous activities. For example, the fire-fighting system and soak pit (which was used for cleaning/emptying the oil from the transformer) may get delayed because of the delay in testing.

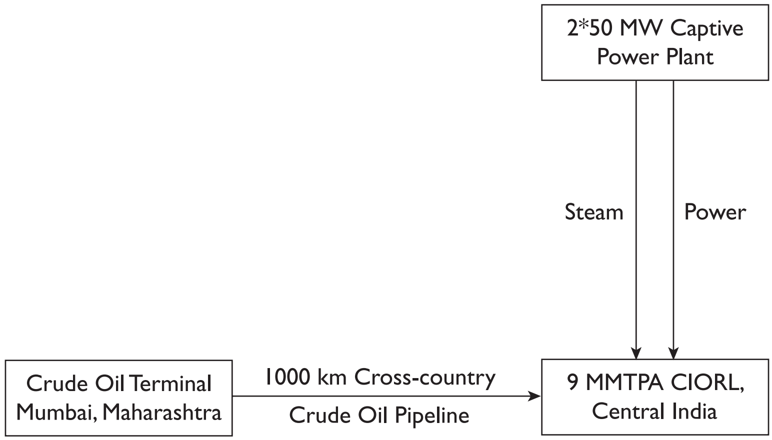
Singh was weighing various options. He was also getting worried about similar problems that he might face in commissioning the remaining seven transformers of similar ratings at captive power plant (CPP). He thought, 'I am not going to repeat the same mistakes again!' He called his sub-ordinate Mr S.N. Sinha (manager—electrical) to his office. Mr Sinha, a Graduate Engineer with specialization in electrical engineering from a reputed engineering college in central India has been working in CIORL for five years. He was recruited in the organization directly through campus recruitment from his engineering institute. He had been involved in the project from day 1.

> Sinha, we are getting late on all fronts in this transformer commissioning work. I don't think we can afford to repeat the same mistakes again for the remaining transformers. Kindly come up with a detailed analysis on whatever has happened by now and any suggestions for improvement.

Company Background (CIORL)

CIORL was setting up a 9 MMTPA[1] grass-root refinery in central India. The crude oil was to be imported from crude terminal coast, located at Mumbai and through 1,000 km cross-country pipeline; the crude was to be pumped to CIORL, central India. It consisted of complex hydrocarbons of carbon and hydrogen along with impurities like sulphur, nitrogen, etc. The refining process of crude oil involved primary, secondary and tertiary processing units. Primary processing involved separation (distillation) of crude oil into various products at different temperatures. Secondary processing involved upgrading of products from primary processing units into valuable products such as diesel, petrol, aviation fuel, liquefied petroleum gas (LPG), etc. The tertiary unit was basically a treatment unit, where impurities such as sulphur, nitrogen, etc. were removed from valuable products. A A co-generation based captive power plant (CPP) (CPP) was also planned for meeting the steam and power requirements of the refinery. An additional petroleum coke (petcoke) plant was installed to convert the residual of crude into petcoke, which would then be fed to the CPP.

Figure 1. CIORL Layout



CIORL employed around 160 executives which comprised five senior vice presidents, ten vice presidents, ten assistant vice presidents, ten managers, forty-five assistant managers and eighty assistant engineers for an on-site project department. The key activity of the CIORL refinery was refining crude oil into valuable products such as petrol, diesel, aviation fuel and LPG.[2] The project envisaged setting-up of the facilities as depicted in Figure 1.

Organizational Structure of CIORL

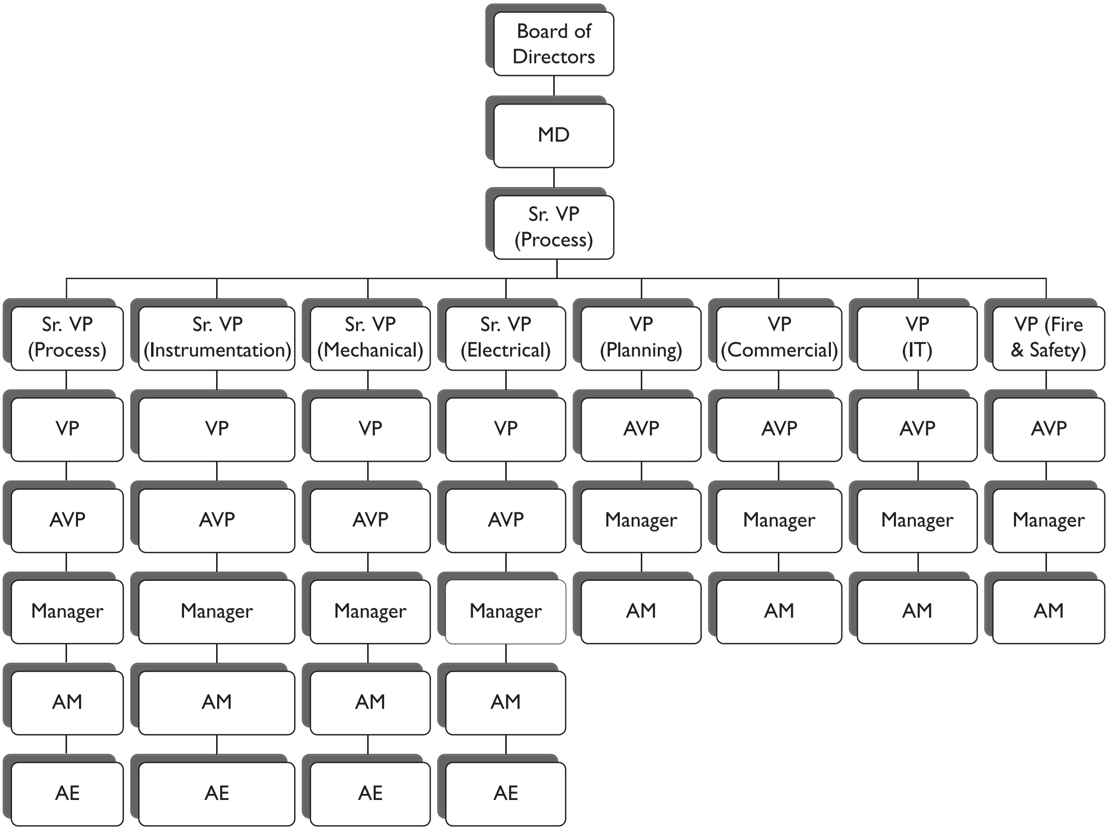
The organizational chart of CIORL is shown in Figure 2. The following eight departments are there in CIORL:

1. Process department
2. Instrumentation department
3. Mechanical department
4. Electrical department
5. Planning department
6. Commercial department
7. IT department
8. Fire and safety department

Out of these, four departments, namely process, instrument, mechanical and electrical were involved in field activities.

The electrical department had a senior vice president (Sr. VP), a vice president (VP), an assistant vice president (AVP), five managers, fifteen assistant managers (AM) and twenty assistant engineers (AE). The electrical department had allocated one manager along with two assistant managers and two

Figure 2. Organization Structure of CIORL



assistant engineers for the commissioning of the CPP. The company had one general shift of 8 hours from 8:30 a.m. to 5:30 p.m. but it often got extended to 10:00 p.m.

The cross-country crude oil pipeline of CIORL was at the completion stage. The pumping of crude oil from Mumbai to central India was to commence once the pipeline had been completed. In order to commission the refinery, the Crude Distillation Unit plant needed to be commissioned first and in order to pre-commission activities*, steam and power* were required from the CPP. Further 6.6 kV voltage was required for starting the commissioning activities of the CPP. Subsequently, the charging of the transformer T-1 was required urgently.

Project Management

Projects with well-defined processes and control over development activities were expected to be completed on time. A refinery was a complex project involving various plants such as distillation units, catalyzers, sulphur recovery blocks, petrol and diesel manufacturing blocks, CPPs, etc. CIORL had categorized the grass-root refinery project into two phases: project phase and running phase. The project phase involved erection, testing and commissioning of the plant, whereas the running phase included operations and maintenance of the same. During the project phase, project management processes involved macro- and micro-activities for the project commencement, managing control over the on-going work effort and closure of the project. These activities needed to be performed daily, weekly or monthly depending on the project characteristics. CIORL chose to have a daily meeting for specific plant progress and a monthly meeting for the overall progress of the plant.

For a successful CIORL project, the project management team needed to foster effective communication and information flow among contractors, consultants and clients. The project management team had to provide enhanced focus on uncertain events that could occur and recommended actions, for proper planning, scheduling and utilization of project resources such as manpower, equipment, etc. Coordination among project managers of various plants and departmental managers within the same plant was essential for the smooth progress of the project. The project management team also needed to effectively share the knowledge between consulting and client project teams, and it needed to provide a basis for contractors and subcontractors along with ensuring the quality of project and client satisfaction.

2*50 MW (2 units of 50 MW each) CPP was required to meet the steam and power requirement of the refinery. CIORL had also employed a project management consultancy (PMC) headed by Mr M.N. Sharma, for the project. CIORL had outsourced the CPP to ABC Ltd.[3] (chief manager—Mr S.K. Ghosh) as Lump Sum Turn Key Contract (LSTK).[4] ABC had employed many sub-contractors[5] for the erection and support activities for the commissioning of the CPP.

The sub-contractors believed that they had quoted a reduced amount for the project during the bidding process; hence, they employed limited manpower. Bidding for such contractual works was very competitive and there was high pressure to win such contracts on part of contractors. The price to be quoted for contracts was arrived at by taking care of the men, material and machine requirements as per the scope of the work in addition to the profit margin. Sometimes, the price quotes could not take care of the subsequent increase in the price of men, material and machines.

Sub-contractors could get confused as they had multiple bosses. Hierarchy and co-ordination among contractor (ABC), consultant (PMC) and client (CIORL) was a big problem. Each had different goals. Under pressure, ABC stressed more on completing the project in minimum possible time and was pushing the sub-contractor to do the same. PMC, the consultant, was focused more on the specifications[6] to be followed and was less interested in pushing the project forward. CIORL was focused on the fast completion of the project taking care of all the required testing and safety norms. The challenge that CIORL faced was to manage the project with resource constraints such as manpower, funds, etc. and to ensure the quality of the project.

Project Plan

Consultants and contractors were employed to leverage the erection, testing and commissioning of transformer (Refer Table 1 for detailed role analysis). A phased approach was taken to ensure project completion by 8 July 2011. Mr Sinha made the planning schedule considering micro-activities for the charging of the transformer T-1. The original timeline of the project was as follows.

Table 1. Project Character and Project Scope Statement

Character	Scope
Vice President—Electrical of CIORL, Mr A. K. Singh	Responsible for Managing the Overall Electrical Activities of the Refinery.
Manager-Electrical of CIORL, Mr S. N. Sinha	Responsible for Electrical Department Project Activities of the CPP Site.
PMC Chief Manager, Mr M. N. Sharma	On-site Consultant Head for Overall Refinery Project Activities.
LSTK Contractor, ABC Ltd. Chief Manager, Mr S. K. Ghosh	Responsible for Erection, Testing and Commissioning Activities of the CPP Site.
Sub-contractor XYZ Ltd. Chief Manager, Mr S. K. Khurana	Responsible for Erection, Testing and Commissioning of Electrical Related Activities of the CPP Site.

Source: Authors.

Approximate project start date:	18 May 2011
Mobilizing of contactors and equipment:	15 May 2011
Erection and testing of transformer:	31 May 2011
Approximate project completion date:	8 July 2011

The original timeline of the project is shown in Table 2. Though the project started in accordance with the plan, due to various uncertainties, it was quite clear that the project was not going to be completed on time. Each and every activity was getting delayed and, hence, transformer charging became the bottleneck for the commissioning of the refinery.

Table 2. Planning and Completion Dates of Various Activities

S. No.	Steps for HT Transformer Charging	Expected Date of Start	Expected Date of Completion
1	Placement on Foundation	18 May 2011	18 May 2011
2	Assembly of Cooling Bank, Conservator (Radiators)	19 May 2011	22 May 2011
3	Local Cabling Work from MK	19 May 2011	20 May 2011
4	Calibration of OTI and WTI	23 May 2011	23 May 2011
5	Filter Machine Set Up and Oil Filtration in Tank	23 May 2011	30 May 2011
6	Oil Circulation in T/F Tank	30 May 2011	02 June 2011
7	Oil Pushing in Radiator Circuit	02 June 2011	03 June 2011
8	HT Cable Laying	25 May 2011	05 June 2011
9	Control Cabling from SWGR to Transformer	20 May 2011	24 May 2011
10	Control Cabling from RTCC to Transformer	22 May 11	25 May 2011
11	LT Power Cabling from ACDB to Transformer	20 May 2011	22 May 2011
12	Erection and Connection of NGR	03 May 2011	05 June 2011
13	Earthing Pit making	07 June 2011	05 June 2011
14	Earthing of Transformer/NGR etc.	10 June 2011	12 June 2011
15	Testing of NCTs	26 May 2011	26 May 2011

S. No.	Steps for HT Transformer Charging	Expected Date of Start	Expected Date of Completion
16	Testing of NGR	27 May 2011	27 May 2011
17	Testing of Fan Motors and Trial Run	28 May 2011	28 May 2011
18	Testing and Commissioning of MK	29 May 2011	29 May 2011
19	OLTC Testing Commissioning	30 May 2011	30 May 2011
20	Electrical Testing Transformer	31 May 2011	31 May 2011
21	Final IR Value and BDV of T/F	10 June 2011	10 June 2011
22	HT Cable Termination (33 and 6.6 side)	05 June 2011	08 June 2011
23	HT Cable Hi-pot	09 June 2011	09 June 2011
24	Oil Testing from CPRI Bhopal	05 June 2011	10 June 2011
25	Fire-Fighting System	08 June 2011	20 June 2011
26	Soak-Pit Installation	15 June 2011	22 June 2011
27	Readiness for Charging	22 June 2011	23 June 2011
28	Protocol for Erection/Testing of Transformer and 6.6 KV HT Board	23 June 2011	30 June 2011
29	Electrical Clearance from Inspector for Charging	30 June 2011	07 July 2011
30	Charging of Transformer	07 July 2011	08 July 2011

Source: Authors.

Project Organization

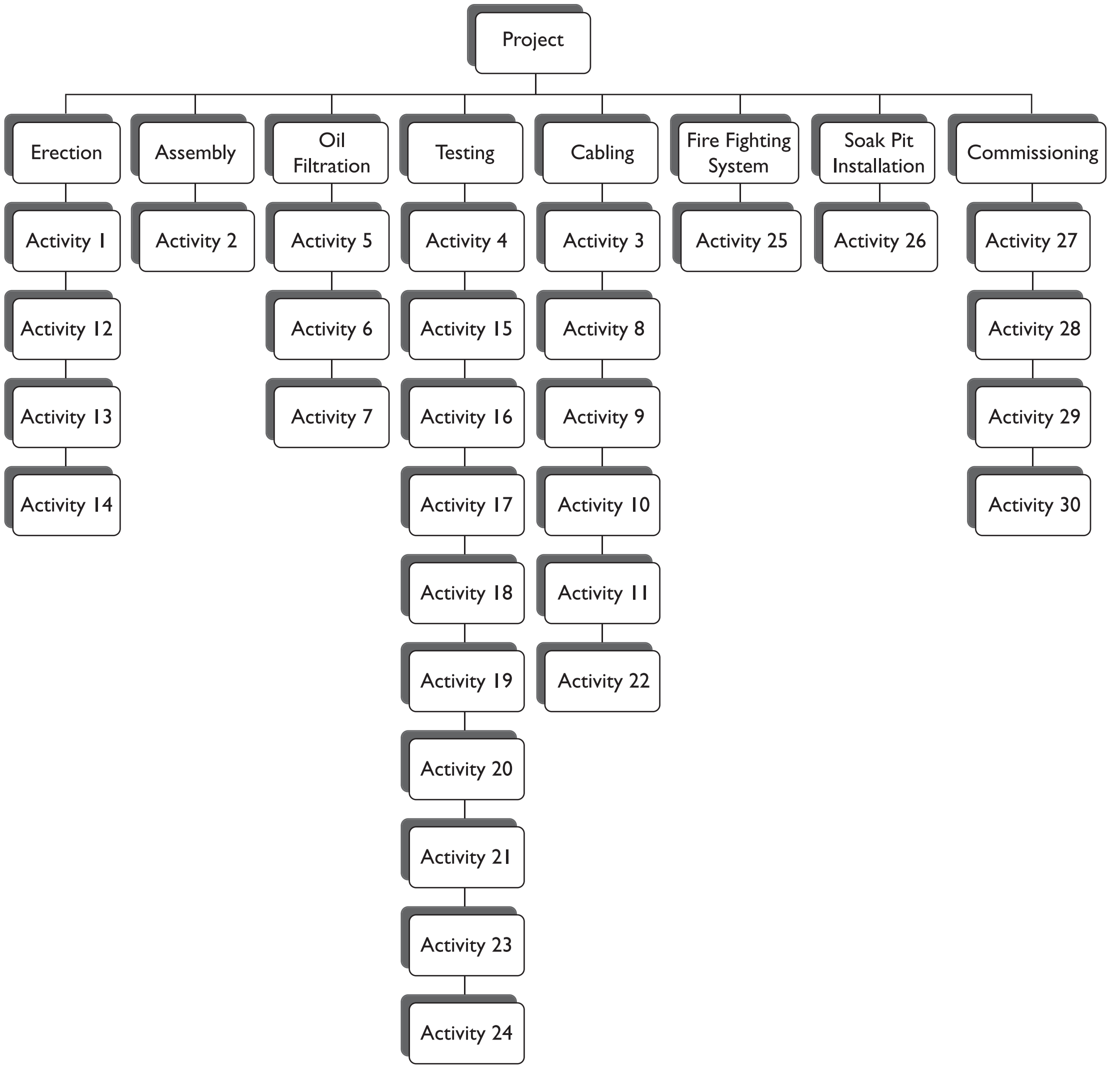
The project was allotted to the sub-contractor XYZ Ltd.[7] (chief manager—Mr S.K. Khurana) for carrying out the electrical related work of the project. In the initial phase, XYZ was effectively carrying out the various micro- and macro-level activities of the project. As the project progressed, XYZ started facing a lot of problems. According to them, manpower shortage was the biggest problem. There were only two testing engineers employed by the sub-contractor. As the electrical works required the testing of equipment, proper supervision was of utmost importance. While testing normally took less time, considerable time was being wasted in making arrangements such as shifting of testing equipment, power supply, discharge rod, etc. The testing needed to be monitored by both the consultant and the client. Most of the time improper coordination also delayed the testing works. All these factors were hampering the progress of the project.

Project Scope

Mr Singh re-classified the activities into eight major work packages as shown in Figure 3. They were as follows.

1. *Erection:* Placing the transformer on the concrete foundation.
2. *Assembling of various parts of transformers such as conservator, HV box, etc.*: Attaching various components of the transformer once the transformer is kept on foundation.

Figure 3. Activity and Work Packages Chart



3. *Oil filtration:* Filtering and adding oil to the main tank and conservator of the transformer. Removal of moisture and dust from the transformer oil by using an oil filtration machine.
4. *Testing:* Performing various on-site tests of the transformer for checking the healthiness of the transformer.
5. *Cabling:* Connecting high-voltage and low-voltage cables to the transformer.
6. *Fire-fighting system:* Installing the fire-fighting system on the transformer.
7. *Soak pit:* Digging and covering of the soak pit; required for emptying oil of the transformer in the future.

8. *Commissioning:* Charging of transformer for the first time; electrical inspector approval was required for this step.

For the first activity, that is, erection of transformer, statement of work was: 30 MVA transformer T-1 (50 Tons Weight) to be placed on concrete foundation. For this activity, 120 Tons Crane was required and manpower comprising two groups of five labourers each was required. If all the resources were available, then it would take only one day to place the transformer on its foundation. The cost of this activity would be ₹ 80,000. It normally took fifteen days to manage the payment of this amount which included approval from the top management. It also accounted for the payment to the contractor. Similar statements of work for all the activities are shown in Table 3.

Table 3. Statement of Work for All the Micro-Activities

S. No.	Work Package	Activities	Requirements		Time (in days)	Cost (in ₹)
			Specific	Manpower		
1	Erection	1	120 Tonnes Crane	2 Rigor Gang of 10 People	1	80,000
		12	12 Tonnes Crane	1 Rigor Gang of 10 People	3	
		13 and 14	Front Availability for Digging Earth Pits	10	7	13,000
2	Assembling of Various Parts of Transformers	2	12 Tonnes Crane	1 Rigor Gang of 7 People	4	20,000
3	Oil Filtration	5	Oil Filtration Machine	4 Labours	8	20,000
		6 and 7	Oil Filtration Machine with 24 Hours Observation	5 Labours	5	
4	Testing	4, 15 and 16	Testing Equipments like Megger, Multimeter, etc	6 People Comprising of 2 Testing Engineers and 4 Electricians	4	
		17, 18 and 19	Testing Equipments like Megger, Multimeter, etc	6 People Comprising of 2 Testing Engineers and 4 Electricians	9	
		20, 21, 23 and 24	Testing Equipments like Megger, Multimeter, etc	6 People Comprising of 2 Testing Engineers and 4 Electricians	9	115,000
5	Cabling	8 and 12	Front Requirement and Trench should be Cleaned before Laying of Cables	16 People Comprising of 2 Rigor Gangs	15	150,000
		3, 9, 10 and 11	Front Requirement and Trench should be Cleaned before Laying of Cables	32 People Comprising of 6 Rigor Gangs	14	

(Table 3 continued)

(Table 3 continued)

S. No.	Work Package	Activities	Requirements		Time (in days)	Cost (in ₹)
			Specific	Manpower		
6	Fire-Fighting System	25	Front Requirement	8 Labours	14	300,000
7	Soak-Pit Installation	26	Front Requirement and Trench should be Cleaned before Laying of Cables	5 Labours	8	21,000
8	Commissioning	27 and 28	Front Requirement and Trench should be Cleaned before Laying of Cables	10 Labours	8	
		29 and 30	Front Requirement and Trench should be Cleaned before Laying of Cables	10 Labours	8	

Source: Authors.

Action Plans and Critical Success Factors

Mr Sinha and his team (Mr Sharma, Mr Ghosh and Mr Khurana) for the transformer commissioning project came up with inter-relationships and time estimates for each of these activities. The estimates are shown in Table 4. While making an estimate for an activity, Mr Sharma considered the following points:

Table 4. Interrelationship between Various Work Components and Time Analysis

S. No.	Steps for HT Transformer Charging	Immediate Predecessor(s)	Estimated Time Duration, Days
1	Placement on Foundation	–	1
2	Assembly of Cooling Bank, Conservator (Radiators)	1	4
3	Local Cabling Work from MK	2	2
4	Calibration of OTI and WTI	3	1
5	Filter Machine set-up and Oil Filtration in Tank	4	8
6	Oil Circulation in T/F Tank	5	3
7	Oil Pushing in Radiator Circuit	6	2
8	HT Cable Laying	1	11
9	Control Cabling from SWGR to Transformer	1	5
10	Control Cabling from RTCC to Transformer	1	4
11	LT Power Cabling from ACDB to Transformer	1	3
12	Erection and Connection of NGR	1	3
13	Earthing Pit Making	1	4
14	Earthing of Transformer/NGR etc.	1,13	3

S. No.	Steps for HT Transformer Charging	Immediate Predecessor(s)	Estimated Time Duration, Days
15	Testing of NCTs	12	1
16	Testing of NGR	12	1
17	Testing of Fan Motors and Trial Run	9, 10, 11	1
18	Testing and Commissioning of MK	3,9 10,11	1
19	OLTC Testing Commissioning	2, 9, 10, 11	1
20	Electrical Testing Transformer	2, 9, 10, 11	1
21	Final IR Value and BDV of T/F	7, 8, 12, 20	1
22	HT Cable Termination (33 and 6.6 Side)	9	4
23	HT Cable Hi-pot	8	1
24	Oil Testing from CPRI Bhopal	7	6
25	Fire-Fighting System	19, 20, 23	14
26	Soak-Pit Installation	25	8
27	Readiness for Charging	24	2
28	Protocol for Erection/Testing of Transformer and 6.6 KV HT Board	25, 26, 27	6
29	Electrical Clearance from Inspector for Charging	28	6
30	Charging of Transformer	29	2

Source: Authors.

- Adequate information was collected for the sequence of activities.
- Past experience regarding the time taken for each of the activities was incorporated.
- In case, past data were not available for an activity, guesstimate was made.
- Uncertain elements that delayed the activities were factored in by adding buffer time subjectively.

An important requirement for the project was the availability of resources. In this project, a critical resource was the manpower required for all these activities. Mr Khurana and Mr Ghosh calculated manpower requirements which are provided in Table 5. Mr Sinha thought that they could now use this information to reallocate resources based on most critical activity to least critical activity.

Table 5. Resource (Manpower) Analysis

S. No.	Steps for HT Transformer Charging	Immediate Predecessor(s)	Required No. of Labour for the Activity
1	Placement on Foundation	–	10
2	Assembly of Cooling Bank, Conservator (Radiators)	1	7
3	Local Cabling Work from MK	2	2
4	Calibration of OTI and WTI	3	3

(Table 5 continued)

(Table 5 continued)

S. No.	Steps for HT Transformer Charging	Immediate Predecessor(s)	Required No. of Labour for the Activity
5	Filter Machine set up and Oil Filtration in Tank	4	4
6	Oil Circulation in T/F tank	5	3
7	Oil Pushing in Radiator Circuit	6	2
8	HT Cable Laying	1	15
9	Control Cabling from SWGR to Transformer	1	10
10	Control Cabling from RTCC to Transformer	1	10
11	LT Power Cabling from ACDB to Transformer	1	10
12	Erection and Connection of NGR	1	5
13	Earthing Pit Making	1	5
14	Earthing of Transformer/NGR etc.	1, 13	5
15	Testing of NCTs	12	3
16	Testing of NGR	12	3
17	Testing of Fan Motors and Trial Run	1, 9, 10, 11	3
18	Testing and Commissioning of MK	3, 9 10, 11	3
19	OLTC Testing Commissioning	2, 9, 10, 11	3
20	Electrical Testing Transformer	2, 9, 10, 11	5
21	Final IR Value and BDV of T/F	7, 8, 12, 20	5
22	HT Cable Termination (33 and 6.6 side)	9	6
23	HT Cable Hi-pot	8	5
24	Oil testing from CPRI Bhopal	7	2
25	Fire-Fighting System	19, 20, 23	8
26	Soak-Pit Installation	25	5
27	Readiness for Charging	24	5
28	Protocol for Erection/Testing of Transformer and 6.6 KV HT Board	25, 26, 27	5
29	Electrical Clearance from Inspector for Charging	28	5
30	Charging of Transformer	29	5

Source: Authors.

The cost requirements for the work packages (Table 6) were also estimated so as to mobilize the funds as per the requirements. Mr Sinha was taking care of everything so that the project could be completed on time, but there were a lot of uncertainties that were troubling him such as:

Table 6. Funds Flow Analysis

S. No.	Steps for HT Transformer Charging	Duration (Time) of Requirement of Fund (in days)	Total Fund Needed (₹)	Requirement Pattern
1	Placement on Foundation	15	80,000	Uniform
2	Assembly of Cooling Bank, Conservator (Radiators)	30	20,000	Non–uniform
3	Local cabling work from MK		–	–
4	Calibration of OTI and WTI		–	–
5	Filter Machine Set Up and Oil Filtration in Tank	7	20,000	Uniform
6	Oil Circulation in T/F tank		–	–
7	Oil Pushing in Radiator Circuit		–	–
8	HT Cable Laying	30	150,000	20% in the First Period, 80% in the Last Period
9	Control Cabling from SWGR to Transformer		–	–
10	Control Cabling from RTCC to Transformer		–	–
11	LT Power Cabling from ACDB to Transformer		–	–
12	Erection and Connection of NGR		–	–
13	Earthing Pit making	10	8,000	Non–uniform
14	Earthing of Transformer/NGR etc.		5,000	
15	Testing of NCTs		50,000	
16	Testing of NGR		–	–
17	Testing of Fan Motors and Trial Run		–	–
18	Testing and Commissioning of MK		–	–
19	OLTC Testing Commissioning		–	–
20	Electrical Testing Transformer	15	1,00,000	20% in the first period; 80% in the last period
21	Final IR Value and BDV of T/F		–	–
22	HT Cable Termination (33 and 6.6 side)	10	50,000	Uniform
23	HT Cable Hi-pot	5	5,000	Uniform
24	Oil Testing from CPRI Bhopal	5	10,000	Uniform
25	Fire-Fighting System	20	3,00,000	Non–uniform
26	Soak-Pit Installation	10	21,000	Non–uniform
27	Readiness for Charging		–	–
28	Protocol for Erection/Testing of Transformer and 6.6 KV HT Board		–	–
29	Electrical Clearance from Inspector for Charging		–	–
30	Charging of Transformer		–	–

Source: Authors.

- Absenteeism of engineers and labourers
- Unavailability of temporary manpower
- No route for crane to march due to excavation (since other works such as drainage, underground piping for fire fighting, etc. were in progress resulting in the digging of roads)
- Strikes
- Possibility of rain
- Testing-related problems (for this, a vendor was required to resolve the problem).

He realized that he was not going to meet the scheduled tasks as had been planned. He was wondering which activities were critical and should be paid more attention to. He was not able to identify the critical activities of the project. He also realized that there were many uncertainties involved in the project. He called Mr Sharma, Mr Khurana and Mr Ghosh for estimating the date for project completion. Mr Khurana gave optimistic estimates, whereas Mr Sharma gave pessimistic estimates for the project. Mr Sinha found Mr Ghosh's estimates very realistic (most likely) for the completion of the project (Table 7).

Table 7. Three Estimate Approach

S. No.	Steps for HT Transformer Charging	Immediate Predecessor(s)	Optimistic Time (days)	Most Likely Time (days)	Pessimistic Time (days)
1	Placement on Foundation		1	1	2
2	Assembly of Cooling Bank, Conservator (Radiators)	1	3	4	7
3	Local Cabling Work from MK	2	1	2	3
4	Calibration of OTI and WTI	3	1	1	2
5	Filter Machine Set-up and Oil Filtration in Tank	4	5	8	10
6	Oil Circulation in T/F Tank	5	2	3	6
7	Oil Pushing in Radiator Circuit	6	2	2	3
8	HT Cable Laying	1	8	11	15
9	Control Cabling from SWGR to Transformer	1	4	5	7
10	Control Cabling from RTCC to Transformer	1	3	4	7
11	LT Power Cabling from ACDB to Transformer	1	3	4	6
12	Erection and Connection of NGR	1	3	2	3
13	Earthing Pit Making	1	4	4	6
14	Earthing of Transformer/NGR etc.	1,13	3	3	5
15	Testing of NCTs	12	1	1	3
16	Testing of NGR	12	1	1	2
17	Testing of Fan Motors and Trial Run	1, 9, 10, 11	1	1	3
18	Testing and Commissioning of MK	3, 9, 10, 11	1	1	2
19	OLTC Testing Commissioning	2, 9, 10, 11	1	1	3
20	Electrical Testing Transformer	2, 9, 10, 11	1	1	2
21	Final IR Value and BDV of T/F	7, 8, 12, 20	1	1	1
22	HT Cable Termination (33 and 6.6 side)	22	3	4	6

S. No.	Steps for HT Transformer Charging	Immediate Predecessor(s)	Optimistic Time (days)	Most Likely Time (days)	Pessimistic Time (days)
23	HT Cable Hi-pot	8	1	1	2
24	Oil Testing from CPRI Bhopal	7	3	6	7
25	Fire-Fighting System	19, 20, 23,	10	14	20
26	Soak-Pit Installation	25	5	8	10
27	Readiness for Charging	24	2	2	4
28	Protocol for Erection/Testing of Transformer and 6.6 KV HT Board	25, 26, 27	5	6	7
29	Electrical Clearance from Inspector for Charging	28	4	6	8
30	Charging OF Transformer	29	1	2	4

Source: Authors.

The top management realized that this was the month of May and monsoon rain was expected by 30 June 2011. Mr Singh was asked to complete the project before the monsoon. He informed the management that it was difficult to charge the transformer on time. Since the project was getting delayed and there was an urgency to complete the project before deadline due to weather conditions, additional funds were required to speed up the project. Considering the situation, top management allotted ₹ 1 lakh (₹ 100,000) and gave full authority over resources and planning to Mr Singh for completing the project before the rainy season could begin.

Mr Singh called Mr Sinha to find out what could be done. First of all both realized that under these uncertainties it was difficult to charge the transformer on time. Next, speeding up the project would be extremely difficult. The extra amount allocated also seemed insufficient (Table 8) to expedite any activities.

Singh was wondering what he should do. He was also worried about facing similar problems in the future.

Table 8. Time–Cost Trade-Offs

S. No.	Steps for HT Transformer Charging	Normal Time (in days)	Normal Cost (in ₹)	Crash Time (in days)	Crash Cost (in ₹)
1	Placement on Foundation	1	80,000	1	
2	Assembly of Cooling Bank, Conservator (Radiators)	4	20,000	3	35,000
3	Local Cabling Work from MK	2	–		
4	Calibration of OTI and WTI	1	–		
5	Filter Machine Set up and Oil Filtration in Tank	8	20,000	6	35,000
6	Oil Circulation in T/F Tank	3	–		
7	Oil Pushing in Radiator Circuit	2	–		
8	HT Cable Laying	11	150,000	8	200,000
9	Control Cabling from SWGR to Transformer	5	–		

(Table 8 continued)

(Table 8 continued)

S. No.	Steps for HT Transformer Charging	Normal Time (in days)	Normal Cost (in ₹)	Crash Time (in days)	Crash Cost (in ₹)
10	Control Cabling from RTCC to Transformer	4	–		
11	LT Power Cabling from ACDB to Transformer	3	–		
12	Erection and Connection of NGR	3	–		
13	Earthing Pit Making	4	8,000	2	15,000
14	Earthing of Transformer/NGR etc.	3	5,000		
15	Testing of NCTs	1	50,000		
16	Testing of NGR	1	–		
17	Testing of Fan Motors and Trial Run	1	–		
18	Testing and Commissioning of MK	1	–		
19	OLTC Testing Commissioning	1	–		
20	Electrical Testing Transformer	1	1,00,000		
21	Final IR Value and BDV of T/F	1	–		
22	HT Cable Termination (33 and 6.6 side)	4	50,000	2	70,000
23	HT Cable Hi-pot	1	5,000		
24	Oil Testing from CPRI Bhopal	6	10,000		
25	Fire-Fighting System	14	3,00,000	10	3,50,000
26	Soak-Pit Installation	8	21,000	5	30,000
27	Readiness for Charging	2	–		
28	Protocol for Erection/Testing of Transformer and 6.6 KV HT Board	6	–		
29	Electrical Clearance from Inspector for Charging	6	–		
30	Charging of Transformer	2	–		

Source: Authors.

Notes

1. Million Metric Tons Per Annum (MMTPA): Unit to measure crude oil intake into the refinery. India's largest Refinery—Reliance, Jamnagar (Gujarat) is having the capacity of 33 MMTPA.
2. Liquefied petroleum gas (LPG) is used for domestic purposes.
3. PMC and ABC Ltd. are large consultants and contractors have country-wide presence.
4. LSTK is a contractual agreement in which a large amount (lump sum) is agreed for the execution of a project or part of project (turnkey). In this contract, once the project is completed, the finished functioning project is handed over to the client in 'ready to operate' mode by the contractor.
5. Sub-contractors were selected based on their expertise and previous experience. The sub-contractors were chosen by ABC Ltd. in accordance with consultant PMC and client CIORL.
6. Consultant, PMC has their specifications (technical details) sheet-documentation standards regarding quality, according to which the commissioning should be carried.
7. A small sub-contractor with annual turnover of ₹ 10 million.