

7. PROJECT MANAGEMENT

Syllabus

Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification.

7.1 Introduction

Project management is concerned with the overall planning and co-ordination of a project from conception to completion aimed at meeting the stated requirements and ensuring completion on time, within cost and to required quality standards.

Project management is normally reserved for focused, non-repetitive, time-limited activities with some degree of risk and that are beyond the usual scope of operational activities for which the organization is responsible.

7.2 Steps in Project Management

The various steps in a project management are:

1. Project Definition and Scope
2. Technical Design
3. Financing
4. Contracting
5. Implementation
6. Performance Monitoring

7.2.1 Project Definition and Scope

What is a Project?

"A project is a one-shot, time-limited, goal-directed, major undertaking, requiring the commitment of varied skills and resources".

A project is a temporary endeavor undertaken to create a unique product or service. A project is temporary in that there is a defined start (the decision to proceed) and a defined end (the achievement of the goals and objectives). Ongoing business or maintenance operations are not projects. Energy conservation projects and process improvement efforts that result in better business processes or more efficient operations can be defined as projects. Projects usually include constraints and risks regarding cost, schedule or performance outcome.

Four Basic Elements of Project Management

A successful Project Manager must simultaneously manage the four basic elements of a project:

resources, time, cost, and scope. Each element must be managed effectively. All these elements are interrelated and must be managed together if the project, and the project manager, is to be a success.

Managing Resources

A successful Project Manager must effectively manage the resources assigned to the project. This includes the labor hours of the project team. It also includes managing labor subcontracts and vendors. Managing the people resources means having the right people, with the right skills and the proper tools, in the right quantity at the right time.

However, managing project resources frequently involves more than people management. The project manager must also manage the equipment (cranes, trucks and other heavy equipment) used for the project and the material (pipe, insulation, computers, manuals) assigned to the project.

Managing Time and Schedule

Time management is a critical skill for any successful project manager. The most common cause of bloated project budgets is lack of schedule management. Fortunately there is a lot of software on the market today to help you manage your project schedule or timeline.

Any project can be broken down into a number of tasks that have to be performed. To prepare the project schedule, the project manager has to figure out what the tasks are, how long they will take, what resources they require, and in what order they should be done.

Managing Costs

Often a Project Manager is evaluated on his or her ability to complete a project within budget. The costs include estimated cost, actual cost and variability. Contingency cost takes into account influence of weather, suppliers and design allowances.

How the 80/20 Rule can help a project manager?

The 80/20 Rule means that in anything a few (20 percent) are vital and many (80 percent) are trivial. Successful Project Managers know that 20 percent of the work (the first 10 percent and the last 10 percent) consumes 80 percent of your time and resources.

Project Management Life Cycle

The process flow of Project management processes is shown in Figure 7.1. The various elements of project management life cycle are

- a) Need identification
- b) Initiation
- c) Planning
- d) Executing
- e) Controlling
- f) Closing out

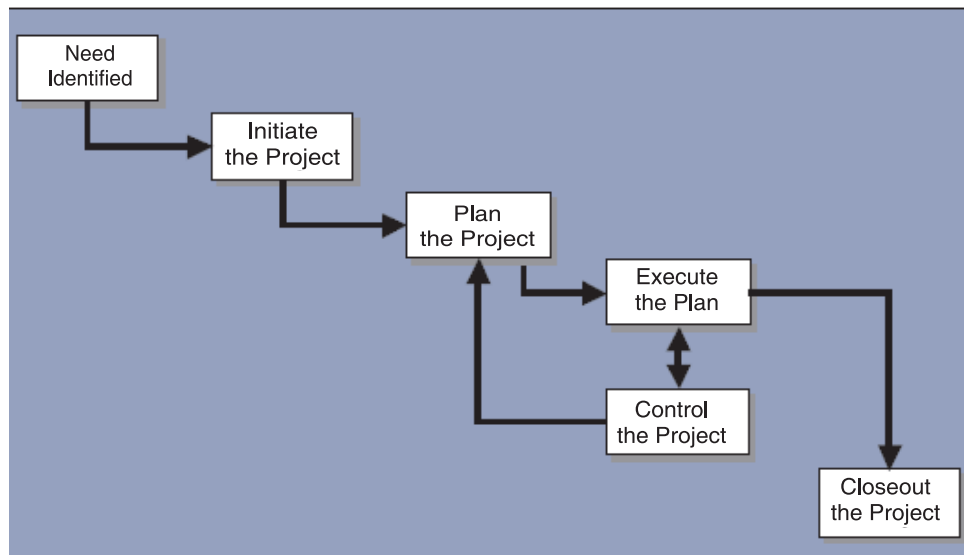


Figure 7.1 Process Flow of a Project Management Process

a) Need Identification

The first step in the project development cycle is to identify components of the project. Projects may be identified both internally and externally:

- Internal identification takes place when the energy manager identifies a package of energy saving opportunities during the day-to-day energy management activities, or from facility audits.
- External identification of energy savings can occur through systematic energy audits undertaken by a reputable energy auditor or energy service company.

In screening projects, the following criteria should be used to rank-order project opportunities.

- Cost-effectiveness of energy savings of complete package of measures (Internal rate of return, net present value, cash flow, average payback)
- Sustainability of the savings over the life of the equipment.
- Ease of quantifying, monitoring, and verifying electricity and fuel savings.
- Availability of technology, and ease of adaptability of the technology to Indian conditions.
- Other environmental and social cost benefits (such as reduction in local pollutants, e.g. SO_x)

b) Initiation

Initiating is the basic processes that should be performed to get the project started. This starting point is critical because those who will deliver the project, those who will use the project, and those who will have a stake in the project need to reach an agreement on its initiation. Involving all stakeholders in the project phases generally improves the probability of satisfying customer requirements by shared ownership of the project by the stakeholders. The success of the project team depends upon starting with complete and accurate information, management support, and the authorization necessary to manage the project.

c) Planning

The planning phase is considered the most important phase in project management. Project planning defines project activities that will be performed; the products that will be produced, and describes how these activities will be accomplished and managed. Project planning defines each major task, estimates the time, resources and cost required, and provides a framework for management review and control. Planning involves identifying and documenting scope, tasks, schedules, cost, risk, quality, and staffing needs.

The result of the project planning, the project plan, will be an approved, comprehensive document that allows a project team to begin and complete the work necessary to achieve the project goals and objectives. The project plan will address how the project team will manage the project elements. It will provide a high level of confidence in the organization's ability to meet the scope, timing, cost, and quality requirements by addressing all aspects of the project.

d) Executing

Once a project moves into the execution phase, the project team and all necessary resources to carry out the project should be in place and ready to perform project activities. The project plan is completed and base lined by this time as well. The project team and the project manager's focus now shifts from planning the project efforts to participating, observing, and analyzing the work being done.

The execution phase is when the work activities of the project plan are executed, resulting in the completion of the project deliverables and achievement of the project objective(s). This phase brings together all of the project management disciplines, resulting in a product or service that will meet the project deliverable requirements and the customers need. During this phase, elements completed in the planning phase are implemented, time is expended, and money is spent.

In short, it means coordinating and managing the project resources while executing the project plan, performing the planned project activities, and ensuring they are completed efficiently.

e) Controlling

Project Control function that involves comparing actual performance with planned performance and taking corrective action to get the desired outcome when there are significant differences. By monitoring and measuring progress regularly, identifying variances from plan, and taking corrective action if required, project control ensures that project objectives are met.

f) Closing out

Project closeout is performed after all defined project objectives have been met and the customer has formally accepted the project's deliverables and end product or, in some instances, when a project has been cancelled or terminated early. Although, project closeout is a routine process, it is an important one. By properly completing the project closeout, organizations can benefit from lessons learned and information compiled. The project closeout phase is comprised of contract closeout and administrative closure.

7.2.2 Technical Design

For a project to be taken up for investment, its proponent must present a sound technical feasi-

bility study that identifies the following components:

- ❑ The proposed new technologies, process modifications, equipment replacements and other measures included in the project.
- ❑ Product/technology/material supply chain (e.g., locally available, imported, reliability of supply)
- ❑ Commercial viability of the complete package of measures (internal rate of return, net present value, cash flow, average payback).
- ❑ Any special technical complexities (installation, maintenance, repair), associated skills required.
- ❑ Preliminary designs, including schematics, for all major equipment needed, along with design requirements, manufacturer's name and contact details, and capital cost estimate.
- ❑ Organizational and management plan for implementation, including timetable, personnel requirements, staff training, project engineering, and other logistical issues.

7.2.3 Financing

When considering a new project, it should be remembered that other departments in the organization would be competing for capital for their projects. However, it is also important to realize that energy efficiency is a major consideration in all types of projects, whether they are:

- Projects designed to improve energy efficiency
- Projects where energy efficiency is not the main objective, but still plays a vital role.

The funding for project is often outside the control of the project manager. However, it is important that you understand the principles behind the provision of scarce funds.

Project funds can be obtained from either internal or external sources.

Internal sources include:

- Direct cash provision from company reserves
- From revenue budget (if payback is less than one year)
- New share capital

Funding can become an issue when energy efficiency projects have previously been given a lower priority than other projects. It is worth remembering that while the prioritization of projects may not be under our control, the quality of the project submission is.

External sources of funds include:

- Bank loans
- Leasing arrangement
- Payment by savings i.e. A deal arranged with equipment supplier
- Energy services contract
- Private finance initiative

The availability of external funds depends on the nature of your organization. The finance charges on the money you borrow will have a bearing on the validity of your project.

Before applying for money, discuss all the options for funding the project with your finance managers.

It is reiterated that energy savings often add substantially to the viability of other non-energy projects.

7.2.4 Contracting

Since a substantial portion of a project is typically executed through contracts, the proper management of contracts is critical to the successful implementation of the project. In this context, the following should be done.

- The competence and capability of all the contractors must be ensured. One weak link can affect the timely performance of the contract.
- Proper discipline must be enforced among contractors and suppliers by insisting that they should develop realistic and detailed resource and time plans that are matching with the project plan.
- Penalties may be imposed for failure to meet contractual obligations. Likewise, incentives may be offered for good performance.
- Help should be extended to contractors and suppliers when they have genuine problems.
- Project authorities must retain independence to off-load contracts (partially or wholly) to other parties where delays are anticipated.

If the project is to be implemented by an outside contractor, several types of contract may be used to undertake the installation and commissioning:

- **Traditional Contract:** All project specifications are provided to a contractor who purchases and installs equipment at cost plus a mark-up or fixed price.
- **Extended Technical Guarantee/Service:** The contractor offers extended guarantees on the performance of selected equipment and / or service/maintenance agreements.
- **Extended Financing Terms:** The contractor provides the option of an extended lease or other financing vehicle in which the payment schedule can be based on the expected savings.
- **Guaranteed Saving Performance Contract:** All or part of savings is guaranteed by the contractor, and all or part of the costs of equipment and/or services is paid down out of savings as they are achieved.
- **Shared Savings Performance Contract:** The contractor provides the financing and is paid an agreed fraction of actual savings as they are achieved. This payment is used to pay down the debt costs of equipment and/or services.

7.2.5 Implementation

The main problems faced by project manager during implementation are poor monitoring of progress, not handling risks and poor cost management.

- a) **Poor monitoring of progress:** Project managers some times tend to spend most of their time in planning activity and surprisingly very less time in following up whether the implementation is following the plan. A proactive report generated by project planner software can really help the project manager to know whether the tasks are progressing as per the plan.
- b) **Not handling risks:** Risks have an uncanny habit of appearing at the least expected time. In spite of the best efforts of a project manager they are bound to happen. Risks need immediate and focused attention. Delay in dealing with risks cause the problem to aggravate and has negative consequences for the project.
- c) **Poor cost management:** A project manager's success is measured by the amount of cost optimization done for a project. Managers frequently do all the cost optimization during the planning stages but fail to follow through during the rest of the stages of the project.

The cost graphs in the Project planner software can help a manager to get a update on project cost overflow. The cost variance (The difference between approved cost and the projected cost should be always in the minds of the project managers).

Project Planning Techniques

The three basic project planning techniques are Gantt chart, CPM and PERT. All monitor progress and costs against resource budgets.

Gantt Chart

Gantt charts are also called Bar charts. The use of Gantt charts started during the industrial revolution of the late 1800's. An early industrial engineer named Henry Gantt developed these charts to improve factory efficiency.

Gantt chart is now commonly used for scheduling the tasks and tracking the progress of energy management projects. Gantt charts are developed using bars to represent each task. The length of the bar shows how long the task is expected to take to complete. Duration is easily shown on Gantt charts. Sequence is not well shown on Gantt Charts (Refer Figure 7.2).

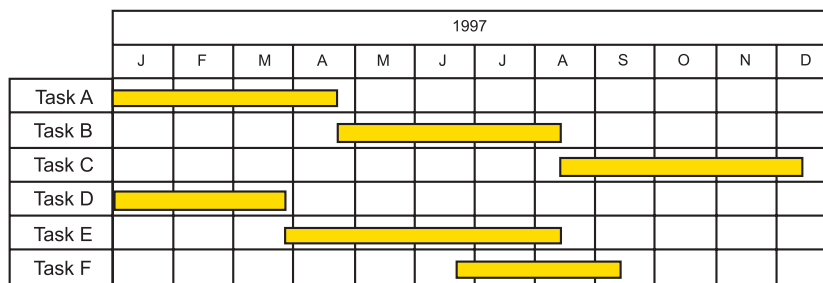


Figure 7.2 Gantt Chart

If, for example, the start of Task C depends on both Activity B and Activity E, then any delay to Task E will also delay Task C. We just don't have enough information on the Gantt chart to know this information.

CPM - Critical Path Method

DuPont developed a **Critical Path Method** (CPM) designed to address the challenge of shutting down chemical plants for maintenance and then restarting the plants once the maintenance had been completed.

Complex project, like the above example, require a series of activities, some of which must be performed sequentially and others that can be performed in parallel with other activities. This collection of series and parallel tasks can be modeled as a network.

CPM models the activities and events of a project as a network. Activities are shown as nodes on the network and events that signify the beginning or ending of activities are shown as arcs or lines between the nodes. The Figure 7.3 shows an example of a CPM network diagram:

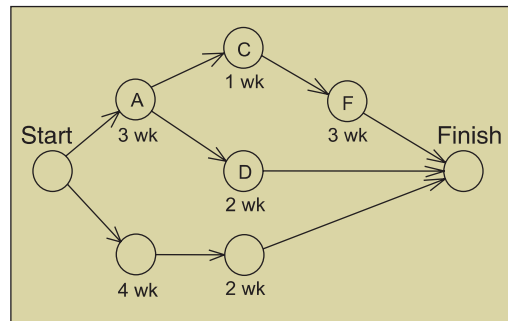


Figure 7.3 CPM Diagram

Steps in CPM Project Planning

1. Specify the individual activities.
2. Determine the sequence of those activities.
3. Draw a network diagram.
4. Estimate the completion time for each activity.
5. Identify the critical path (longest path through the network)
6. Update the CPM diagram as the project progresses.

1. Specify the individual activities

All the activities in the project are listed. This list can be used as the basis for adding sequence and duration information in later steps.

2. Determine the sequence of the activities

Some activities are dependent on the completion of other activities. A list of the immediate predecessors of each activity is useful for constructing the CPM network diagram.

3. Draw the Network Diagram

Once the activities and their sequences have been defined, the CPM diagram can be drawn. CPM originally was developed as an activity on node network.

4. Estimate activity completion time

The time required to complete each activity can be estimated using past experience. CPM does not take into account variation in the completion time.

5. Identify the Critical Path

The critical path is the longest-duration path through the network. The significance of the critical path is that the activities that lie on it cannot be delayed without delaying the project. Because of its impact on the entire project, critical path analysis is an important aspect of project planning.

The critical path can be identified by determining the following four parameters for each activity:

- ES - earliest start time: the earliest time at which the activity can start given that its precedent activities must be completed first.
- EF - earliest finish time, equal to the earliest start time for the activity plus the time

required to complete the activity.

- LF - latest finish time: the latest time at which the activity can be completed without delaying the project.
- LS - latest start time, equal to the latest finish time minus the time required to complete the activity.

The *slack time* for an activity is the time between its earliest and latest start time, or between its earliest and latest finish time. Slack is the amount of time that an activity can be delayed past its earliest start or earliest finish without delaying the project.

The critical path is the path through the project network in which none of the activities have slack, that is, the path for which $ES=LS$ and $EF=LF$ for all activities in the path. A delay in the critical path delays the project. Similarly, to accelerate the project it is necessary to reduce the total time required for the activities in the critical path.

6. Update CPM diagram

As the project progresses, the actual task completion times will be known and the network diagram can be updated to include this information. A new critical path may emerge, and structural changes may be made in the network if project requirements change.

CPM Benefits

- Provides a graphical view of the project.
- Predicts the time required to complete the project.
- Shows which activities are critical to maintaining the schedule and which are not.

CPM Limitations

While CPM is easy to understand and use, it does not consider the time variations that can have a great impact on the completion time of a complex project. CPM was developed for complex but fairly routine projects with minimum uncertainty in the project completion times. For less routine projects there is more uncertainty in the completion times, and this uncertainty limits its usefulness.

PERT

The *Program Evaluation and Review Technique* (PERT) is a network model that allows for randomness in activity completion times. PERT was developed in the late 1950's for the U.S. Navy's Polaris project having thousands of contractors. It has the potential to reduce both the time and cost required to complete a project.

The Network Diagram

In a project, an activity is a task that must be performed and an event is a milestone marking the completion of one or more activities. Before an activity can begin, all of its predecessor activities must be completed. Project network models represent activities and milestones by arcs and nodes.

PERT is typically represented as an activity on arc network, in which the activities are represented on the lines and milestones on the nodes. The Figure 7.4 shows a simple example of a PERT diagram.

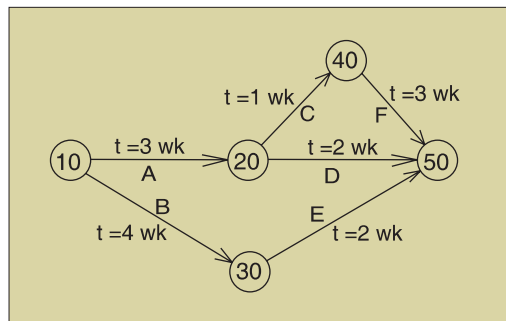


Figure 7.4 PERT Diagram

The milestones generally are numbered so that the ending node of an activity has a higher number than the beginning node. Incrementing the numbers by 10 allows for new ones to be inserted without modifying the numbering of the entire diagram. The activities in the above diagram are labeled with letters along with the expected time required to complete the activity.

Steps in the PERT Planning Process

PERT planning involves the following steps:

1. Identify the specific activities and milestones.
2. Determine the proper sequence of the activities.
3. Construct a network diagram.
4. Estimate the time required for each activity.
5. Determine the critical path.
6. Update the PERT chart as the project progresses.

1. Identify activities and milestones

The activities are the tasks required to complete the project. The milestones are the events marking the beginning and end of one or more activities.

2. Determine activity sequence

This step may be combined with the activity identification step since the activity sequence is known for some tasks. Other tasks may require more analysis to determine the exact order in which they must be performed.

3. Construct the Network Diagram

Using the activity sequence information, a network diagram can be drawn showing the sequence of the serial and parallel activities.

4. Estimate activity times

Weeks are a commonly used unit of time for activity completion, but any consistent unit of time can be used.

A distinguishing feature of PERT is its ability to deal with uncertainty in activity completion times. For each activity, the model usually includes three time estimates:

- *Optimistic time (OT)* - generally the shortest time in which the activity can be completed. (This is what an inexperienced manager believes!)
- *Most likely time (MT)* - the completion time having the highest probability. This is different from expected time. Seasoned managers have an amazing way of estimating very close to actual data from prior estimation errors.
- *Pessimistic time (PT)* - the longest time that an activity might require.

The expected time for each activity can be approximated using the following weighted average:

$$\text{Expected time} = (OT + 4 \times MT + PT) / 6$$

This expected time might be displayed on the network diagram.

Variance for each activity is given by:

$$[(PT - OT) / 6]^2$$

5. Determine the Critical Path

The critical path is determined by adding the times for the activities in each sequence and determining the longest path in the project. The critical path determines the total time required for the project.

If activities outside the critical path speed up or slow down (within limits), the total project time does not change. The amount of time that a non-critical path activity can be delayed without delaying the project is referred to as slack time.

If the critical path is not immediately obvious, it may be helpful to determine the following four quantities for each activity:

- ES - Earliest Start time
- EF - Earliest Finish time
- LS - Latest Start time
- LF - Latest Finish time

These times are calculated using the expected time for the relevant activities. The ES and EF of each activity are determined by working forward through the network and determining the earliest time at which an activity can start and finish considering its predecessor activities.

The latest start and finish times are the latest times that an activity can start and finish without delaying the project. LS and LF are found by working backward through the network. The difference in the latest and earliest finish of each activity is that activity's slack. The critical path then is the path through the network in which none of the activities have slack.

The variance in the project completion time can be calculated by summing the variances in the completion times of the activities in the critical path. Given this variance, one can calculate the probability that the project will be completed by a certain date.

Since the critical path determines the completion date of the project, the project can be accelerated by adding the resources required to decrease the time for the activities in the critical path. Such a shortening of the project sometimes is referred to as *project crashing*.

6. Update as project progresses

Make adjustments in the PERT chart as the project progresses. As the project unfolds, the estimated times can be replaced with actual times. In cases where there are delays, additional resources may be needed to stay on schedule and the PERT chart may be modified to reflect the new situation.

Benefits of PERT

PERT is useful because it provides the following information:

- Expected project completion time.
- Probability of completion before a specified date.
- The critical path activities that directly impact the completion time.
- The activities that have slack time and that can lend resources to critical path activities.
- Activities start and end dates.

Limitations of PERT

The following are some of PERT's limitations:

- The activity time estimates are somewhat subjective and depend on judgment. In cases where there is little experience in performing an activity, the numbers may be only a guess. In other cases, if the person or group performing the activity estimates the time there may be bias in the estimate.
- The underestimation of the project completion time due to alternate paths becoming critical is perhaps the most serious.

7.2.6 Performance Monitoring

Once the project is completed, performance review should be done periodically to compare actual performance with projected performance. Feedback on project is useful in several ways:

- a) It helps us to know how realistic were the assumptions underlying the project
- b) It provides a documented log of experience that is highly valuable in decision making in future projects
- c) It suggests corrective action to be taken in the light of actual performance
- d) It helps in uncovering judgmental biases
- e) It includes a desired caution among project sponsors.

Performance Indicators (PIs) are an effective way of communicating a project's benefits, usually as part of a performance measuring and reporting process. Performance Indicators are available for a wide range of industries and allow a measure of energy performance to be assigned to a process against which others can be judged.

Depending on the nature of the project, savings are determined using engineering calculations, or through metering and monitoring, utility meter billing analysis, or computer simulations.

Implementation Plan for Top Management

As a result of energy audit, many energy saving opportunities would emerge. These could be classified broadly as measures with and without investment. House keeping measures and moderate cost measures need no intervention from top management. However, top management need to be appraised of these measures.

In case of projects where considerable investment are required, project manager has to rank the list of projects based on the technical feasibility and financial analysis indicated in the previous chapter (Simple payback, IRR, ROI etc.) and submit the same to the top management for appraisal and approval. This will help top management in allocating resources and other facilities.

Planning Budget

Budget requirement varies depending upon the duration and size of the project. For projects involving long duration with multiple tasks and procurements, resources have to be allocated judiciously as and when required. Top management should ensure that this is done to ensure successful completion of project.

Procurement Procedures

Having identified the material and equipment required for the project, the next step is to identify the various vendors, provide specifications, invite quotations, and carryout discussions with select vendors. For medium to high value items, tendering process can be adopted. Tenders have to be evaluated for technical and financial aspects. It would be desirable to have purchase manager as part of energy efficiency team to facilitate smooth procurement process.

Construction

During the construction phase, plant may need to be shutdown. Careful planning is required, so that the task is carried out without affecting the production. Project manager has to be aware of the annual maintenance schedule, holidays, annual maintenance or any major breakdown period during which anyway plant will be shutdown. Construction activity should be carefully supervised by energy and project manager so as to ensure quality and safety.

Measurement & Verification (M&V)

Facility energy savings are determined by comparing the energy use before and after the installation of energy conservation measures. The "before" case is called the baseline; the "after" case is referred to as the post-installation or performance period. Proper determination of savings includes adjusting for changes that affect energy use but that are not caused by the conservation measures. Such adjustments may account for differences in capacity utilization, raw material quality, product mix and other parameters, between the baseline and performance periods.

In general,

$$\text{Savings} = (\text{Baseline Energy Use})_{\text{adjusted}} - \text{Post-Installation Energy Use}$$

For example in a paper mill a variety of products depending on thickness (Grams per Square meter) are made. If energy consumption is evaluated as kCals or kWh per tonne of paper the figures could be misleading. Under these circumstances the measurement and verification system is to be designed accounting for these variations.

Case Example

Replacing an existing boiler with an energy efficient boiler.

Activity Code	Activity	Duration in days	Depends on
A	Prepare technical specifications	10	-
B	Tender Processing	25	A
C	Release of work orders	3	B
D	Supply of Boiler equipment	60	C
E	Supply of Auxiliaries	20	C
F	Supply of Pipes & Pipe fittings	10	C
G	Civil Work	15	C
H	Installation of Auxiliary equipment & piping	5	E, F&G
I	Installation of Boiler	10	D & H
J	Testing and Commissioning	2	I

A. Gantt Chart

The Figure 7.5 shows a Gantt chart for a simple energy management project, i.e. Replacing an existing boiler with an energy efficient boiler.

As already mentioned, Gantt chart is the simplest and quickest method for formal planning. Gantt charts can be very useful in planning projects with a limited number of tasks and with few inter-relationships. This chart typically depicts activities as horizontal lines whose length depends on the time needed to complete the activities. These lines can be progressively over-printed to show how much of activity has been completed.

Drawing a Gantt chart requires information on:

- The logic of the tasks;
- The duration of the tasks;
- The resources available to complete the tasks.

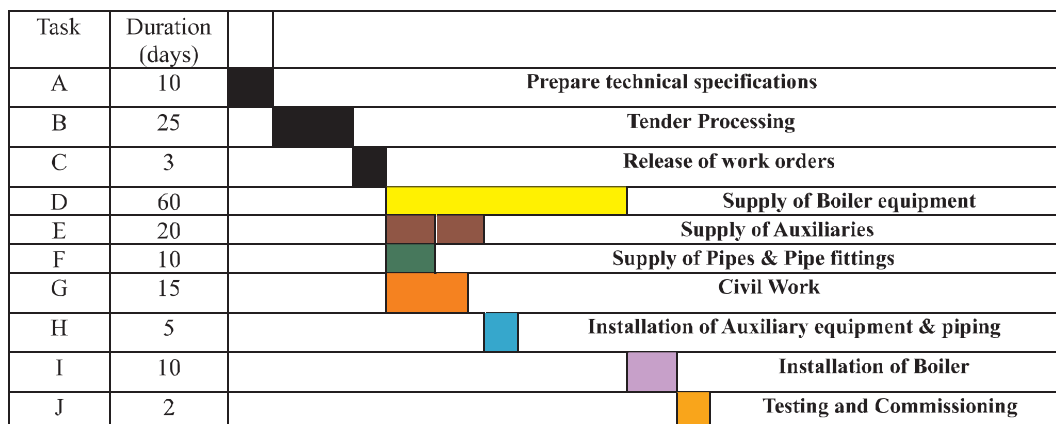


Figure 7.5 A Simple Gantt Chart for Boiler Replacement

B. PERT / CPM Technique:**A PERT/CPM network for Boiler Replacement (Refer Figure 7.6)**

Activity on Arrow: Activity and duration of the activity are shown in arrow.

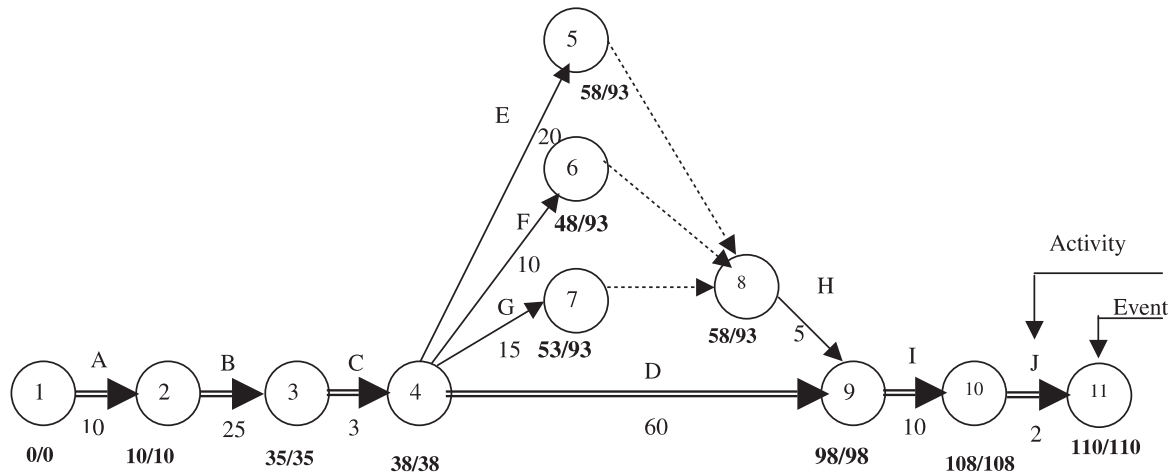


Figure 7.6

- ✓ 10/10: In this Numerator denotes the Earliest Event Occurrence Time and Denominator is the Latest Event Occurrence Time.
- ✓ The Critical Path for this network is: **⇒ A-B-C-D-I-J.**
- ✓ The events on the critical path have zero slack.
- ✓ Dummy activity has no duration ----->
- ✓ The total duration for the completion of the project is 110 days based on the critical path.

QUESTIONS	
1.	List down various steps in project management.
2.	Describe briefly any of the projects you have undertaken and how was the project managed?
3.	What are the criteria for screening of projects?
4.	What are the aspects you would look for in the technical design of the project?
5.	What are the ways in which financing can be enabled for an energy efficiency investment?
6.	What are the aspects to be considered in the management of contract?
7.	Briefly explain the different types of contracts.
8.	What are the hurdles faced in the implementation of a project?
9.	Make a Gantt chart for your preparation of energy manager/energy auditor examination. Split into to as many components as possible.
10.	In project management PERT refers to (a) Project Energy Rating Time (b) Projected Energy Rating Terms (c) Petroleum Energy Revolutionary Technology (d) Program Evaluation and Review Technique.
11.	Explain the importance of performance monitoring.
12.	Explain the need for measurement and verification.

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