Online Preparatory Training Course
For
BEE Energy Managers /Energy Auditors
Certification Exam 2020

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EnSave Consultancy and Training Pvt. Ltd.
Chennai-600037, www.ensaveindia.com

Chapter-8 Project Management

Contents

8.1 What is a Project?

A **project** is a "temporary endeavor undertaken to create a unique product or service".

- ❑ Projects are temporary because they have a definite beginning and a definite end. They are unique because the product or service they create is different in some distinguishing way from others.

Example: Design, installation& commissioning of a **cogeneration plant**.

- ❑ Projects are means for change. Changing practices or investing money for energy efficiency is an occurrence of change.
- ❑ The energy manager should seek opportunities to save energy & influence all projects in which energy is a significant factor.

What is a Project Management?

- ❑ Project management is a set of principles, methods, and techniques that people use to effectively plan and control project work.
- ❑ Project management techniques help complete projects on schedule, within budget, and project specifications.

The objective of project management is to optimize project **cost, time, and quality**.

8.2 Project Development Cycle (PDC)

❑ Project Identification and Screening

Identify components of the project

- Internal identification- by Facility manager/Energy manager
- External identification- by AEA/ESCO/ Consultants

Screening projects

- Economic feasibility of energy savings measures (IRR,NPV,SPP)
- Sustainability of the savings (life of the equipment).
- Ease of monitoring for verifying energy savings.
- Availability of technology/ease of adaptability
- Environmental and social cost benefits/ legal compliance

❑Technical Design

- Technical feasibility study identifies the following
- The proposed new technologies, process modifications, equipment replacements included in the project.
- Product/technology/material supply chain (e.g., locally available, imported, reliability)
- Special technical difficulties (installation, repair, skills)
- Preliminary designs, 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.

❑ Financing

Normally , top management may give approval to one, which gives the best return on the investment, and which is best presented. (based on priority list which gives preference to projects offering certain advantages or removing particular disadvantages. Project funds can be obtained from either internal or external sources

Internal sources include:

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

External sources of funds include:

- Bank loans
- Leasing arrangement
- Energy services contract
- Private finance initiative

Bank requirements : company assets / financial feasibility report/worksheet that presents project cash flows, NPV &IRR.

❑ Contracting

✓Traditional Contract

✓Extended Technical Guarantee/Service

✓Extended Financing Terms

✓Guaranteed Saving Performance Contract

✓Shared Savings Performance Contract

Competence/capability of contractors
Proper discipline ,Penalties, incentives
Help to contractors for their genuine problems and
Retain independence to off-load contracts to others

❑ Implementation

The following needs to be thought ahead and anticipated.

- Extent of measurements needed to control
- cooperation of key personnel involved.
- Timely and frequent communication

❑ Performance Monitoring

In developing a system of monitoring, the following points to be consider

- It should focus sharply on the critical aspects of project implementation.
- more emphasis on physical milestones and not on financial targets.
- Monitoring must be kept simple.

Project Review

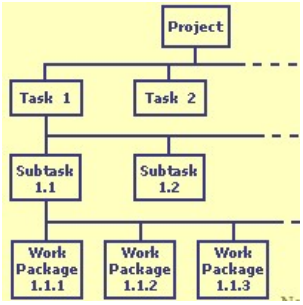
Performance review should be done periodically to compare actual performance with projected performance. A feedback is useful

- ✓ It throws light on how realistic were the assumptions underlying the project
- ✓ It provides a documented log of experience for future decision making
- ✓ It suggests corrective action to be taken
- ✓ It helps in uncovering judgmental biases

8.3 Project Planning Techniques

Work Breakdown Structure (WBS)

A complex project is made manageable by first breaking it into individual components in a hierarchical structure, known as the work breakdown structure, or the WBS.



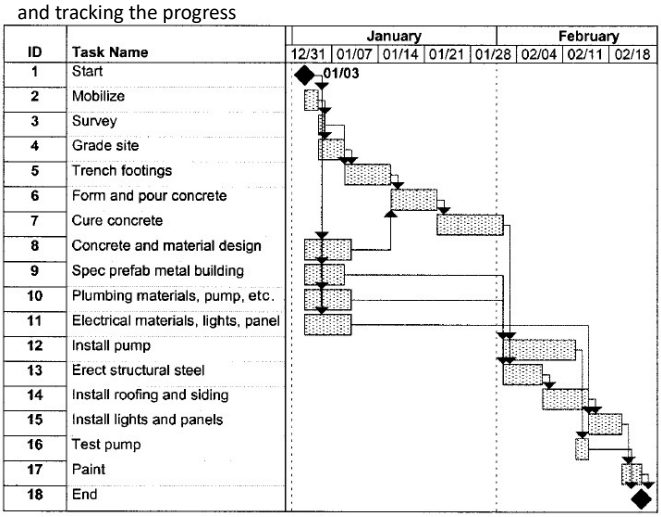
Work Breakdown Structure Diagram

Level 1	Level 2	Level 3
Task 1		
	Subtask 1.1	
		Work Package 1.1.1
		Work Package 1.1.2
		Work Package 1.1.3
	Subtask 1.2	
		Work Package 1.2.1
		Work Package 1.2.2
		Work Package 1.2.3
Task 2		
	Subtask 2.1	
		Work Package 2.1.1
		Work Package 2.1.2
		Work Package 2.1.3

The WBS can be used to identify the tasks before constructing **Gantt chart** and networks such as **Critical Path Method** - CPM or **Program Evaluation and Review Technique-** PERT.

Gantt chart

Gantt chart is now commonly used for scheduling the tasks and tracking the progress



ID	Task Name
1	Start
2	Mobilize
3	Survey
4	Grade site
5	Trench footings
6	Form and pour concrete
7	Cure concrete
8	Concrete and material design
9	Spec prefab metal building
10	Plumbing materials, pump, etc.
11	Electrical materials, lights, panel
12	Install pump
13	Erect structural steel
14	Install roofing and siding
15	Install lights and panels
16	Test pump
17	Paint
18	End

Gantt Chart for a Pumping Station Project

Limitation of Gantt chart

- Not shown the logical interdependencies between the predecessor and successor activities very well.
- Such requirements are shown clearly in **network diagram but does not have a time scale axis like the Gantt chart.**

Gantt Chart Enhancement

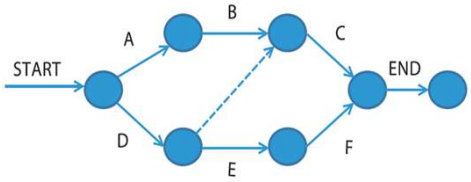
- A **vertical marker/line** can used to mark the present point in time (activities scheduled simultaneously- need for simultaneous resources can clearly be seen).
- The progression of each activity may be shown by **shading** the bar as progress is made
- **Dependencies** can be depicted using **link lines** or color codes.
- Resource allocation can be specified for each task.
- **Milestones** can be shown.

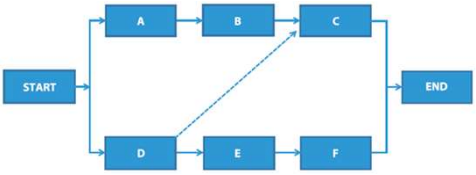
Project Networking Techniques

1. **Critical Path Method. CPM**
2. **Program Evaluation and Review Technique. PERT**

- Powerful tool for planning and controlling project
- Dependency relationships between tasks/activities of the **project** are shown **in a graphical view.**
- It shows clearly tasks that must precede or succeed other tasks in a logical manner.

Two ways of representing activities are activity-on-arrow (AOA) and activity-on-node (AON).

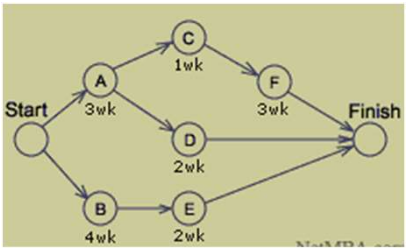




Network Definitions

Activity: Any portions of project (tasks) which required by project, uses up resource and consumes time.
Event: Beginning or ending points of one or more activities are called 'nodes'
Network: Combination of all project activities and the events

Critical Path Method (CPM)



CPM provides the following **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.

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. (Fixed time)
5. Identify the critical path (longest path through the network)
6. Update the CPM diagram as the project progresses.

Determination of Critical Path

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 **total float (*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.

Example 8.1: Illustration of CPM

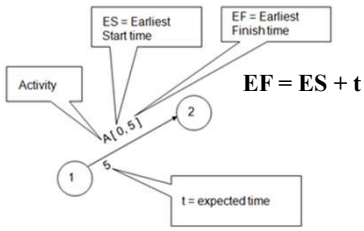
WBS of a project is given in Table below

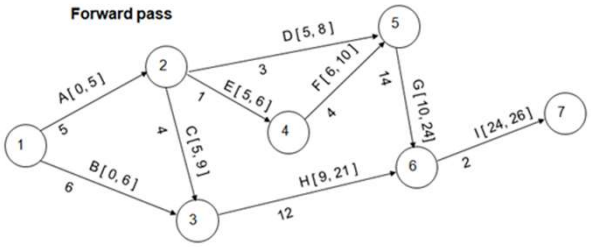
Activity	Immediate Predecessor	Completion Time (weeks)
A	-	5
B	-	6
C	A	4
D	A	3
E	A	1
F	E	4
G	D,F	14
H	B,C	12
I	G,H	2

Earliest start time rule:
The earliest start time for an activity leaving a particular node is equal to the **largest** of the earliest finish times for all activities entering the node.

Completing the network from start based on above (Forward pass), we can calculate all ES and EF time

Earliest Start Time and Earliest Finish Time



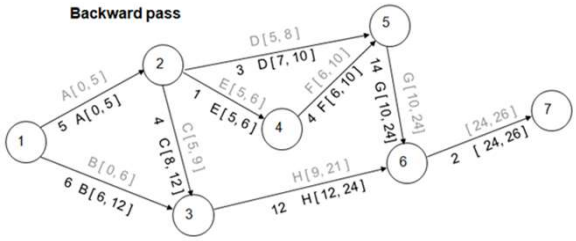


Network with ES and EF time in Forward Pass

Latest finish time rule:
The latest finish time for an activity entering a particular node is equal to the **smallest of the latest start times** for all activities leaving the node

Float or Slack or Free Time
Slack is the length of time an activity can be delayed without affecting the completion date for the entire project.
slack for C = 3 weeks, **LS (8 weeks) – ES (5 weeks)**

Critical path is a sequence of activities from start to finish with zero slack. Critical path identifies the minimum time to complete project.
Project crashing. If any activity on the critical path is shortened, project time will be shortened accordingly. Such shortening or project in critical path by adding resources is called project crashing. If resources have to be saved by lengthening some activities, it should be only for non-critical activities, up to the limit of float.



Activity	Duration (weeks)	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Float or Slack LS-ES or LF-EF	Critical Path
A	**5**	**0**	**5**	**0**	**5**	**0**	**Yes**
B	6	0	6	6	12	6	
C	4	5	9	8	12	3	
D	3	5	8	7	10	2	
E	**1**	**5**	**6**	**5**	**6**	**0**	**Yes**
F	**4**	**6**	**10**	**6**	**10**	**0**	**Yes**
G	**14**	**10**	**24**	**10**	**24**	**0**	**Yes**
H	12	9	21	12	24	3	
I	**2**	**24**	**26**	**24**	**26**	**0**	**Yes**

1. Total time to complete the activities = 26 weeks.
2. Critical Path = A, E, F, G, and I

Program Evaluation and Review Technique (PERT)

PERT is a *probabilistic* network model that allows for randomness in activity completion times. It has the potential to reduce both the time and cost required to complete a project.

Unlike CPM where times can be estimated with relative certainty, confidence,
PERT uses 3 time estimates.

T_m = most likely time estimate
T_o = optimistic time estimate
T_p = pessimistic time estimate

Expected time = (Optimistic + 4 x Most likely + Pessimistic) / 6

Expected Time (T_e) = $(T_o + 4T_m + T_p)/6$

Standard Deviation (σ) = $(T_p - T_o)/6$

Variance (V) = $((T_p - T_o)/6)^2$

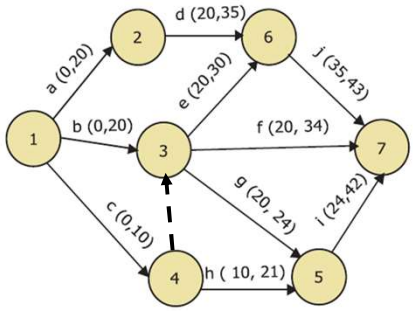
Example 8.2: Illustration of PERT

For the following project details , PERT chart has to be prepared.

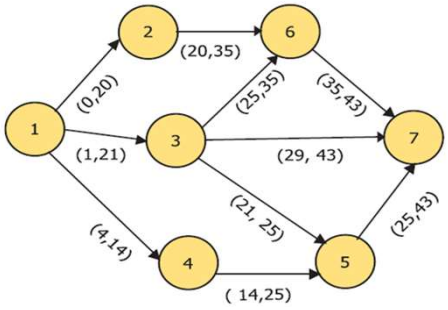
Table 8.4 Project Details

Activity	Immediate Predecessor	Optimistic Time T_o	Most Likely Time T_m	Pessimistic Time T_p	Expected Time T_e	σ	V
(a)	-	10	22	22	20	2	(4)
b	-	20	20	20	20	0	0
c	-	4	10	16	10	2	4
(d)	a	2	14	32	15	5	(25)
e	b,c	8	8	20	10	2	4
f	b,c	8	14	20	14	2	4
g	b,c	4	4	4	4	0	0
h	c	2	12	16	11	2.32	5.4
i	g,h	6	16	38	18	5.33	28.4
(j)	d,e	2	8	14	8	2	(4)

PERT Network diagram showing activities, ES, EF in *forward pass* is shown in Figure



PERT Network diagram showing LS, LF in *backward pass* is shown in the Figure.



Activity	Immediate Predecessor	Expected Time T_e
(a)	-	20
b	-	20
c	-	10
(d)	a	15
e	b,c	10
f	b,c	14
g	b,c	4
h	c	11
i	g,h	18
(j)	d,e	8

The details of network calculations from forward and backward pass are summarized in Table.

Summary of Project Calculations

Activity	Expected Time	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Float or Slack LS-ES or LF-EF	Critical Path
a	**20**	**0**	**20**	**0**	**20**	**0**	**Yes**
b	20	0	20	1	21	1	
c	10	0	10	4	14	4	
d	**15**	**20**	**35**	**20**	**35**	**0**	**Yes**
e	10	20	30	25	35	5	
f	14	20	34	29	43	9	
g	4	20	24	21	25	1	
h	11	10	21	14	25	4	
i	18	24	42	25	43	1	
j	**8**	**35**	**43**	**35**	**43**	**0**	**Yes**

Critical path: a, d, j = 43 days

Solved Example:

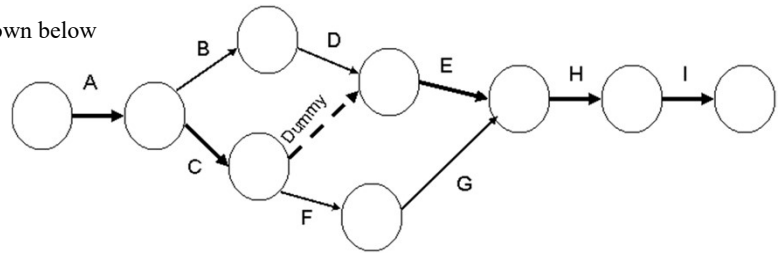
For the **following tasks**, **durations**, and **predecessor** relationships in the following activity table,

a) Draw the network
b) Calculate expected time for all tasks
c) Calculate variance for all tasks
d) Determine all possible paths and their estimated durations
e) Identify the critical path

Activity Description	Immediate Predecessor(s)	Optimistic (Weeks)	Most Likely (Weeks)	Pessimistic (Weeks)	Expected Time T_e
A	---	4	7	10	7
B	A	2	8	20	9
C	A	8	12	16	12
D	B	1	2	3	2
E	D, C	6	8	22	10
F	C	2	3	4	3
G	F	2	2	2	2
H	E, G	4	8	12	8
I	H	1	2	3	2

Ans:

a) Network diagram is shown below



Activity Description	Immediate Predecessor(s)	Optimistic (Weeks)	Most Likely (Weeks)	Pessimistic (Weeks)	Expected Time T_e	Variance (V)
A	---	4	7	10	7	1.00
B	A	2	8	20	9	9.00
C	A	8	12	16	12	1.78
D	B	1	2	3	2	0.11
E	D, C	6	8	22	10	7.11
F	C	2	3	4	3	0.11
G	F	2	2	2	2	0.00
H	E, G	4	8	12	8	1.78
I	H	1	2	3	2	0.11

(b) & (c) Expected Time & Variance

$T_e = (T_o + 4\,T_m + T_p)/6$

$\sigma = (T_p - T_o)/6$

$V = ((T_p - T_o)/6)^2$

d)

The critical path is A – C – E – H – I

A - B – D – E – H –I	7+9+2+10+8+2 = 38
A – C – E – H – I	**7+12+10+8+2 = 39**
A – C – F – G – H – I	7+12+3+2+8+2 = 34

e) Duration of critical path is 39 weeks.

Objective Type

1	An activity in a project has an optimistic time of 10 days, a most likely time of 15 days and a pessimistic time of 20 days. Its expected time of completion is------- a) 10 days b) 15 days c) 30 days d) 35 days.
2	Network diagrams show logic clearly but does not have -------- like Gantt chart. a) nodes b) arrows c) time scale d) events
3	To judge the attractiveness of any investment, the project manager must consider: a) Initial capital cost b) Net operating cash inflows c) salvage value d) all the above
4	The Critical Path in PERT indicates _____. a) minimum time required for the completion of the project b) delays in the project c) maximum time required for the completion of the project d) none of the above
5	The time between its earliest and latest start time, or between its earliest and latest finish time of an activity is a) delay time b) slack time c) critical path d) start time

1b,2c,3d,4a,5b

Construct a PERT Diagram for the following project and find out the critical path.

L1

Activity	Duration in weeks	Precedent
A	7	Start
B	3	A
C	1	B
D	8	A
E	2	D,C
F	1	D,C
G	1	D,C
H	3	F
I	2	H
J	1	E,G,I

i)Draw the PERT network,
ii)What is the critical path?
iii)What is the total duration required to complete the project?
iv)What is the available slack in each of the activity?

L-2

(i) Construct a PERT diagram for the data given below
(ii) Identify the critical path.

Activity	Precedent	Time, weeks
A	Start	3
B	A	4
C	A	1
D	C	3
E	Start	2
F	B	2
Finish	D, E, F	--

Thank You

Dr.P.Dharmalingam
Accredited Energy Auditor
pdlingam@gmail.com
9444177914
www.ensaveindia.com
EnSave Consultancy & Training Pvt Ltd, Chennai

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