Project Management Approach To The Establishment Of Computer Assembly Plant In Ethiopia

By

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Abstract

The creation of the computer and the advancement in communication systems has led to the emergence of a new era called the information age. In the new era information is rapidly becoming the world's most valuable resources. The central part of the information technology (IT) is nothing but the computer. Due to its paramount importance the personal computer (PC) has become a part of day-to-day existence of people all over the world. As a result, the computer industry today is a trillion-dollar market.

In order to narrow down the gap between the developed and developing nations, countries like Ethiopia should work hard to improve the level of their information and communication technology (ICT). These days it is realized that ICT is a proven tool that one must be equipped with in the fight against poverty and in the effort to secure sustainable economic development. ICT may be composed of four elements: computer hardware, software, communication equipment and know-how.

The availability of PCs at cheaper prices and preferred designs would obviously enhance the development of ICT. It is seen that the demand for PCs in Ethiopia is increasing from time to time. But, the supply so far is from imports, with an expenditure of considerable sum of hard currency.

In this regard, this thesis research attempts to analyze the feasibility of building a PC assembly plant in Ethiopia applying modern project management techniques. The research applies the method of *trend analysis* as well as *market-buildup* methods to estimate the

present and future demand of PCs in Ethiopia. *Make or buy decision analysis* is carried out to indicate which components to make in-house and which ones to import form outside sources. The *technology, organization and implementation plans* are studied at the required depth. Finally, the *financial viability* of the project is analyzed with the help of appropriate software.

CHAPTER ONE: INTRODUCTION

1.1 Phases of a Project

All projects pass through at least four identifiable phases (fig.1.1). Theses are conception, development, realization, and termination [2][*]. Each of them is briefly described below.

1.1.1 Conception

This is considered as the most crucial phase of a project life where important decisions and commitments are made. A project idea is generated from any source and if the idea is found desirable a comprehensive feasibility study is made to determine whether the realization of the project is economically, technically and environmentally viable.

At the conclusion of the study, the following should have been determined as a minimum:

- Product specification
- The availability of potential market
- The availability of any items or services to be obtained from external sources
- Selling price for the product or service
- Technology & engineering aspects
- The budget requirement for the project
- Sources of capital outlays
- Financial viability of the project

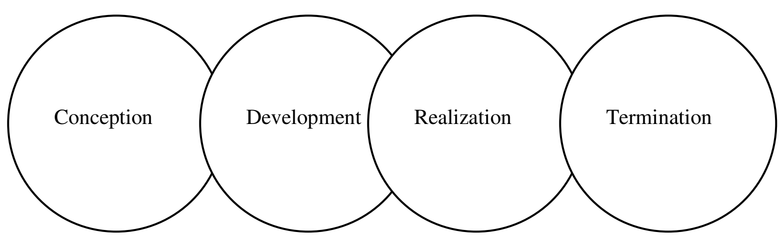


Fig. 1.1
The Four Phases of a Project

1.1.2 Development

Assuming the proposed project is acceptable, the next step is to setup a project management team and work out detail design activities. Also at this stage detailed project implementation plan is prepared

[*] Numbers in square brackets indicate the corresponding reference material as listed in the bibliography.

showing project activities, time frames, resources and their allocations, line of responsibilities and expenditure plans.

1.1.3 Realization

Once relevant designs and plans are in place, the project team has to transform the development into reality. Here, appropriate project monitoring and controlling system has to be provided as part of the project plan so as to follow up and report on:

- Project progress
- Expenditure
- Cost and Time variations
- Forecasted possible adverse events

1.1.4. Termination

This is the final phase of a project where proper analysis and evaluation have to be made to provide valuable information regarding the history of the project which can be helpful for other projects. This may include:

- Success of methods used
- Empirical work measurement formulations
- Performance records (of machinery and personnel)
- Reliability of suppliers, contractors, and other third parties

In addition to the above analysis, many projects will be completed with a residue of capital equipment. This has to be disposed off as rapidly and as profitable as possible.

The aim of this research thesis is therefore to discuss the above phases of a project in context to *the project of establishing a PC assembly plant in Ethiopia.* The research will particularly focus on the conception phase of the project under consideration. Some elements of the development, the realization as well as the termination phases will also be treated as required.

1.2 Background

There appears to be an ever-increasing demand for computers triggered by accelerated change in technology and reduced purchasing prices. During the past few years, computers, high-speed communication systems and computer software have become more powerful and more useful to people both at home and at work.

The worldwide growth and development of information technology (IT) is surprisingly high. According to some source, over 50 million personal computers (PC) were sold worldwide in 2000; and a recent survey shows the computer per household ratio for U.S.A has reached 1 to 3, Singapore 1 to 3, Taiwan 1 to 20 and for China 1 to 100 [22,30].

The international trend of IT development and PC market shows that developing countries like Ethiopia also need to develop their own IT network if they are to play an effective role in the global market. Today, globalization has forced every business to remain connected to the worldwide information network. The Ethiopian status is not any different. Ethiopian manufacturers, traders, importers, exporters, dealers, commission agents, and the business community in general, should have reliable information network and fast communication systems in order to remain competitive in the globalized nature of today's market. At present it can be said that effective communication is taking place almost exclusively by e-mail and the Internet. This means the market for computers is large, unsaturated and expanding in Ethiopia.

In this context some of the major government offices in Ethiopia are conducting fundamental restructuring programs that result in efficient and effective civil service activities. Computerization is one such area of attention. Here too IT plays a major role which ultimately opens up a big market for computers.

New training centers, schools, colleges, universities and research centers are being established and their number is increasing from time to time. These institutions would give fundamental and advanced courses related to computers for their students and trainees. Thus, even this sector is also another substantial market for PCs.

At present almost all the computers in the country are imported. This becomes a financial burden on the country's economy. It seems from all these discussion that there is a substantial market for PCs in the country. Moreover, considering the population size of the country and its development prospects and taking into account the role IT plays in the economic activities of a country, the future market for PCs is very promising. *Therefore, it may be more than justified to establish a computer assembly plant in Ethiopia.*

In addition to the financial benefits awarded to the promoters, the establishment of such plant contributes towards expanding the country's export, accrues substantial foreign exchange, creates backward and forward economic linkages, improves the IT network of the country by providing computers at a competitive price, and creates employment opportunities for people.

Therefore, the *objective* of this research thesis is to apply some of the aspects of project management in evaluation, planning, market analysis, and related issues for the establishment of a computer assembly plant in Ethiopia.

1.3 Objectives of the research

The *general objectives* of this thesis research are:

- To determine the present and future demand of PCs in the country with preliminary assessment of export market.
- To determine the technological and engineering aspects of the assembly plant with detail description of infrastructure and utility requirements.
- To determine the financial viability of the project using appropriate techniques of financial analysis.

The *specific objectives* are to carry out detail studies of the following aspects:

- Market and plant capacity
- Raw materials and inputs
- Technology and engineering

- Organization and manpower requirement
- Project management and Implementation Plan
- Project financing
- Financial and economic evaluation

1.4 Methodology Adopted

Literature survey

The research begins with literature survey on information technology, computer systems and project management concepts. Here emphasis will be given to the development of computer hardware (the architecture) and computer generations so as to identify the major components of a computer relevant to the state-of-the-art technology. Also, computer application in Ethiopia will be briefly assessed as background information to this research.

Market and Plant Capacity Study

The first stage in the market study will be the collection of direct and indirect data from relevant institutions such as the Customs office, Statistics Authority, Investment Office, Trade and Industry Bureau, Chamber of Commerce, Science and Technology Commission, wholesalers and selected end users such as business organizations, universities and colleges.

From these data the effective present demand and forecasts of future demand will be determined using appropriate techniques. Then the plant capacity will be determined together with recommended production program.

Raw Materials, Components, and Inputs

Every component required for the complete assembly of computers will be thoroughly studied. Then the possibility of making some of the components within the envisaged plant will be studied using *Make or buy Decision* analysis.

Finally components shall be classified as imported items and locally produced ones. Major specifications, important features and cost of each component shall be described. Source of data and information for this work will be relevant literatures, computer manufacturers, suppliers' manual, and the Internet. Inputs of any kind, if applicable, shall also be identified including utility requirements such as electric power, water, and air-conditioning facilities.

Technology and Engineering

In this section of the study, the production technology for PC will be discussed taking different alternatives, if applicable. Then for the selected technology, list of plant machinery and equipment will be given with important specifications. Also, auxiliary units such as air-conditioning will be specified. At the end of this section, estimates of the costs of all machinery and equipment will be determined. Source of information/data for this part of the study will be mostly machinery and equipment suppliers that are involved in the area of our interest. In the engineering part, estimates of total land and built-up area requirement as well as the costs of building construction will be analyzed.

Organization and Manpower Requirement

Here the organizational structure of the plant will be studied by identifying the necessary departments and sections. Also the manpower requirement of the plant will be studied including expected salaries and benefits of employees.

Implementation Plan

The implementation Plan will be worked out considering major activities, estimated durations by applying PERT (project evaluation and review technique). Also activity network diagram will be constructed to identify critical activities, the critical path and the project duration. Moreover, fundamentals of project control will be demonstrated using earned value analysis (the 'S' curve).

Project Financing

First general and comprehensive survey of source of project finance will be discussed and then possible sources of fund for PC assembly plant project shall be proposed.

Financial Evaluation

Finally, conducting financial evaluation and analysis using appropriate software shall conclude the study. Some of the important outputs of this part of the study will be the following:

- Determination of total investment cost
- Sources and means of financing
- Determination of profitability of the project in terms of NPV (net present value) and IRR (internal rate of return)
- Projected cash flow
- Projected balance sheet
- Break even analysis

1.5 Application of Results

The result of this thesis research shall be utilized to enlighten interested promoters (governmental or private) regarding the importance and benefits of establishing the envisaged computer assembly plant in the country.

Through further refinement of the study, the university may also be benefited from the research by selling the project idea to any interested party who wishes to invest on the project. As a result of this research, the project realization would bring a lot of advantages some of which are:

- Enhancement of the use and development of IT in the country
- Transfer of technology with possibilities of backward and forward economic linkages in the electronics, and plastic industries.

- Foreign currency saving and earning due to import substitution and export market respectively
- Creation of employment opportunities for citizens

Apart from the above applications, the study material can also be used as a reference for students who deal with project management and feasibility studies.

CHAPTER TWO: PRINCIPLES OF PROJECT MANAGEMENT

2.1 *What is a project?*

A project may be defined as a unique and time urgent work effort to provide a result according to a certain specification and within fixed time and budget limit. Table 2.1 shows the key elements of a project drawn up from this definition [43].

Table 2.1. Project definition.

What is project?
o A complex effort o Many tasks o Specific objectives o Unique, not repetitive o Start and End dates o Schedule and Budget

2.2 Fundamental Principles Of Project Management

2.2.1 Introduction

What is project management?

Project management is a process to achieve result per predetermined specification, schedule and budget. It is the taking part, the putting together of tasks, the assigning and reallocation of resources like time, labor and materials.

There are basic principles of project management that are applicable to numerous projects of all types, size and complexities. These are:

- Obtain management established objectives
- Develop work breakdown structure
- Develop an integrated project plan

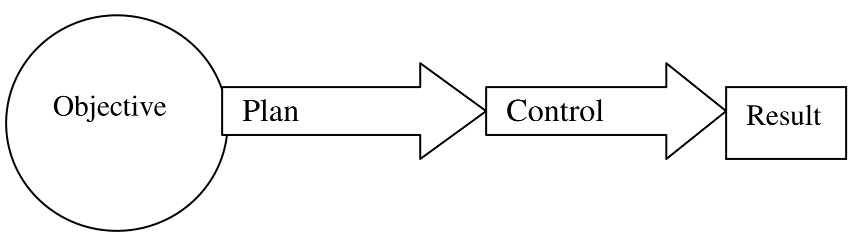
- Obtain approval of the plans
- Periodically, compare actual Vs plan
- Take actions, control deviations & follow-up
- Keep management informed

The approach is flexible; some of these elements can be used or not used depending on the needs and characteristics of the specific project and the discretion of the user.

In a simple language any project management deals with three activities that lead to a desired result. Figure 2.1 shows the flow of project management.

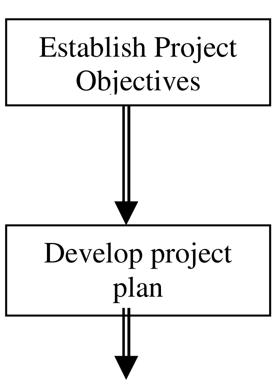
A project is defined by management- established objectives: a product/service with specification to be provided with a fixed time frame and budget. All three elements must be defined. Inadequately defined objective cannot achieve goals successfully. Figure 2.2(A and B) show a project graphically represented by an equilateral triangle and the three elements of project management as a continuous cycle of activities till the end result is successfully completed.

Fig. 2.1 Flow of project management



Without objective, you cannot plan; without plan, you cannot control; without control, you cannot achieve desired results.

<u>*What are the Key steps of project management?*</u>



Phase I - Initiate the work

- Identify the project
- Identify the approving authority
- Select and appoint a project manager
- Identify necessary functional departments
- Obtain approval of project objective

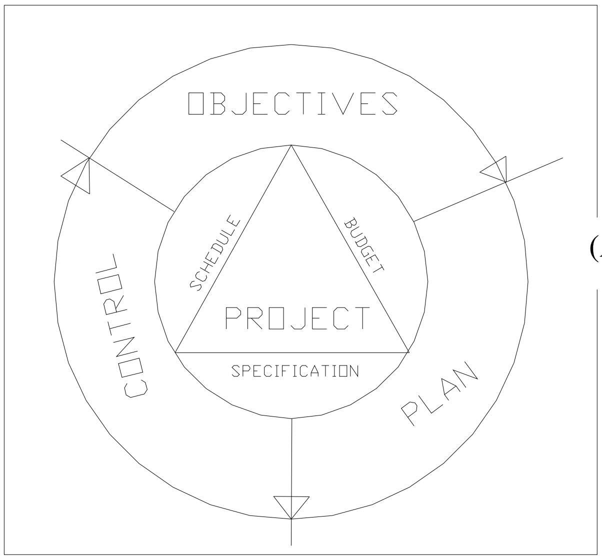
Phase II- Plan the WBS:

- Develop WBS
- Develop schedule and budget plans (manpower and and/or cost)
- Obtain commitments

Phase III- Work the plan:

Guide project plan

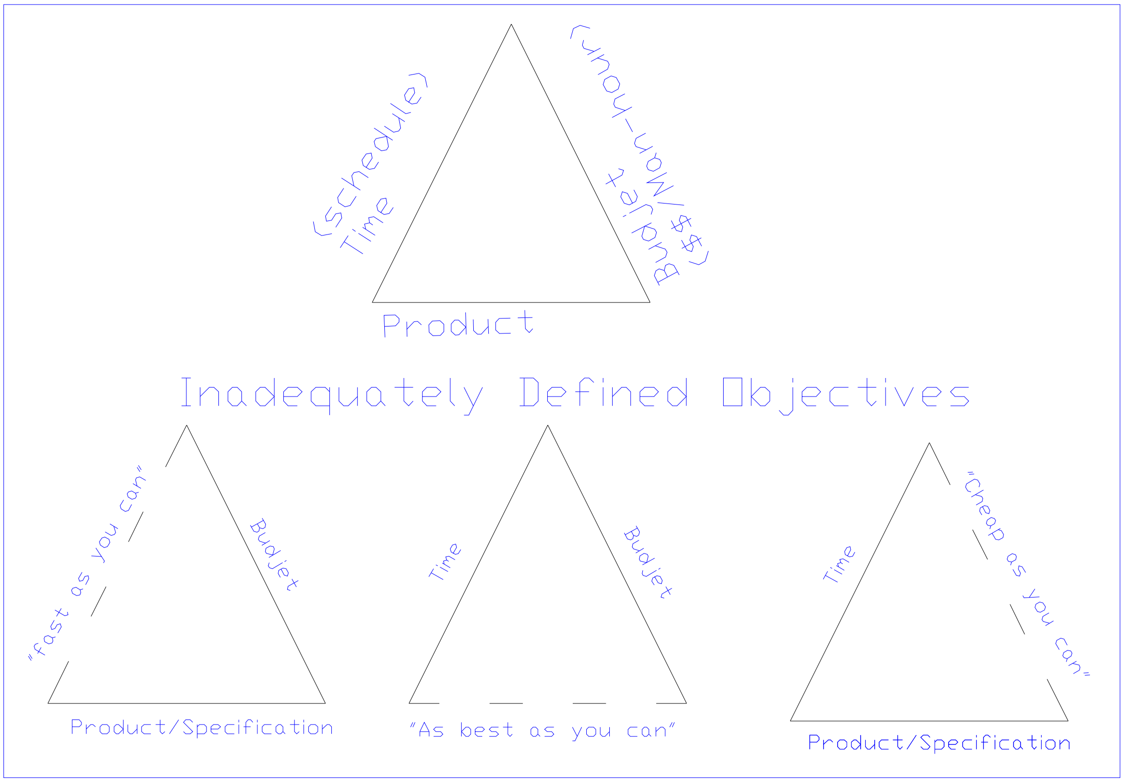
- Provide status information
- Conduct progress review meetings
- Analyze variance, take corrective actions
- Critique project upon completion



(A)

Figure 2.2 Components of project and project management [43].

(B)



2.2.2 Integrated Project Plan

The integrated project plan consists of four sub-plans: schedule plan, cost plan, manpower plan, and achievement plan. When fully developed and correctly used, the integrated project plan does more than just display information. It integrates personnel and organizational commitments and accountability, obtains management approvals and support, assures coordination and communication, provides a mechanism for setting baselines with which to control the project, and allows a simple narration free method of reporting project status to various level of management. In short the integrated plan is the tool where by the fundamental principles of project management are all brought together. Figure 2.3 shows the integrated project plan.

2.2.3 Project control

Project control is the process of monitoring project performance against approved project plans, comparing variances and taking corrective action to eliminate/reduce the impact of schedule, slippages and cost overruns on project objectives.

Fig. 2.4 show the project control cycle divided into mechanical process (production of reports) and human process (taking corrective actions)

Figure 2.3 Integrated project plans

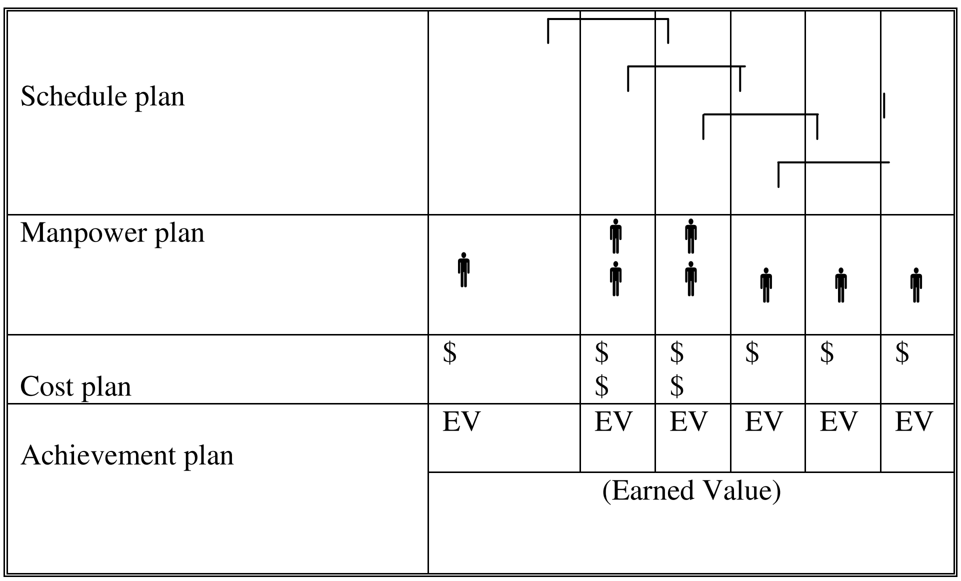
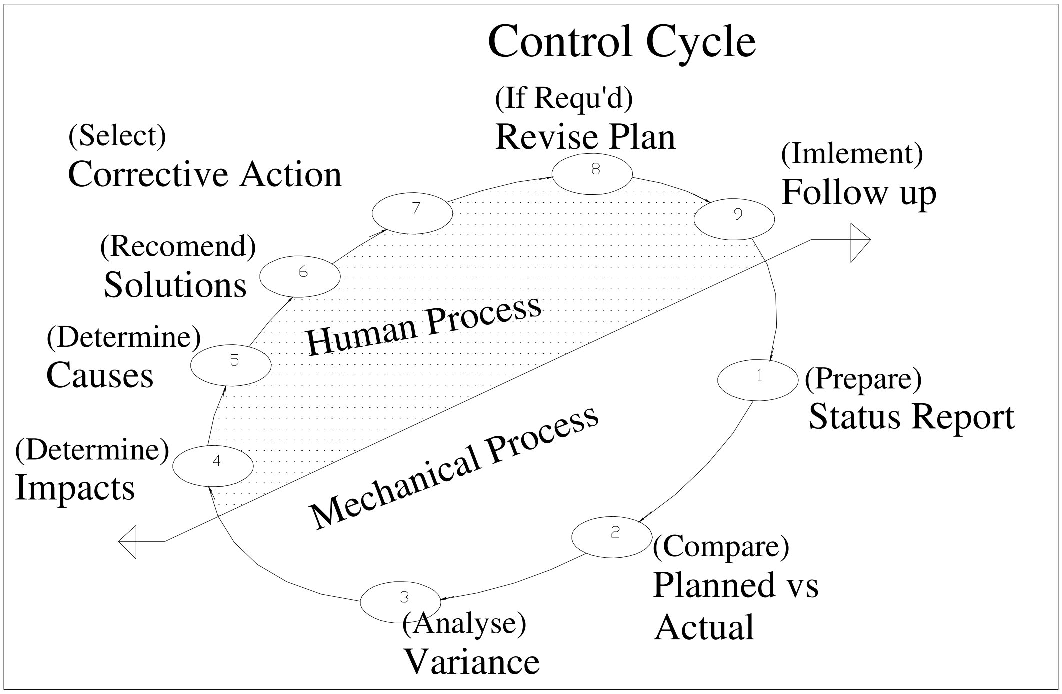


Figure 2.4 Project control cycle



2.2.4. Earned Value Analysis

The objective of project control is to know how a project is progressing in time and cost. In target plans, each planned task has costs allocated to it, generating a planned cash flow curve. When the actual monthly-spent costs are plotted on the planned cost graph we obtain a graph as shown in figure 2.5. Actual expenditure is considerably below planed expenditure. Does this tell good news or bad news?

Perhaps all kinds of cheap ways have been found of doing the tasks to date with an aim to finish the project having made substantial savings? Perhaps, however, work is way behind program and the project is likely to finish far behind schedule. The graph provides no conclusive information. The only thing it shows is that the project is not going according to plan: It is either better or worse; no one knows which.

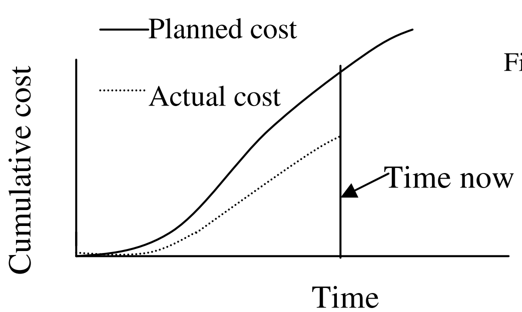


Figure 2.5 Planned and Actual Cost

What is needed, therefore, is a system that tells the true story in simple and quick way. The solution is what we call Earned Value Analysis (EVA). EVA is a method of understanding how a project is going and is constructed combining two things: progress monitoring and expenditure monitoring.

EVA suggests to compare the value of physical work done with the value of work that should have been done. One measures the actual amount of work completed at a given date and convert that amount to the corresponding value using the same cost rates used to produce the budget. To do this one need not know how much has been spent, just the amount of work done and the value of that work. This can be done for each task, group of tasks and a total of all tasks for a project overview.

This approach has many advantages. First, we only have to measure the physical amount work done-in many industries this is fairly easy. We are comparing identical terms. It is fast and by adding in actual costs, we can determine various ratios which are useful to describe the state of the project.

For any instant in the life of a project there should be the following information available:

(a) The total budgeted or planned cost of the scheduled activities,

(b) The known cumulative actual cost of work performed, the actual cost of work performed - ACWP;

(c) The know cumulative budget cost of work performed (or the earned value), the budgeted cost of work performed' - BCWP

These three parameters yield useful variances which give an indication to management of the magnitude, location and reasons for current and future problems:

- the schedule variance (in cost terms) = BCWP - BCWS
- the cost variance = BCWP - ACWP

Considering together these two variances provide a lot of useful information about the project, for example:

- a negative schedule variance with zero cost variance suggests a project running late with no over-spend;
- a negative cost variance with zero schedule variance suggests a project on time with an overspend.
- a negative schedule variance with a negative cost variance suggests a project running late which is also overspend.

If the data are plotted cumulatively as shown in figure 2.6 it can be revealing as it will display:

- the planned costs - the BCWS curve
- the incurred costs, the ACWP curve
- the budgeted (earned) value of the work actually performed - the BCWP curve.

The EVA combined with WBS can also be used to trace down where the variance comes from and who is responsible.

It should be noted that the BCWS curve is the 'baseline' for the account for which the data has been generated - it may be for a single activity, a work package, or the project. In practice this base line is not fixed, as it changes each time a modification is made to the project plan. These changes may be design or engineering changes or additional work, not included originally. Total cost to completion may be unaltered, but the shape of the curve will change [2,14,42]:

Forecasting

It may be required at any time to forecast the time and cost to complete the project. To do this we need to define two expressions:

(i) Cost performance index to date (CPI) = BCWP/ACWP;

(ii) Budgeted cost to completion (BCC) = BAC - BCWP

Then:

Estimated cost to complete (ECC) = BCC/CPI; and

Forecast cost at completion (FCC) = ACWP+ECC

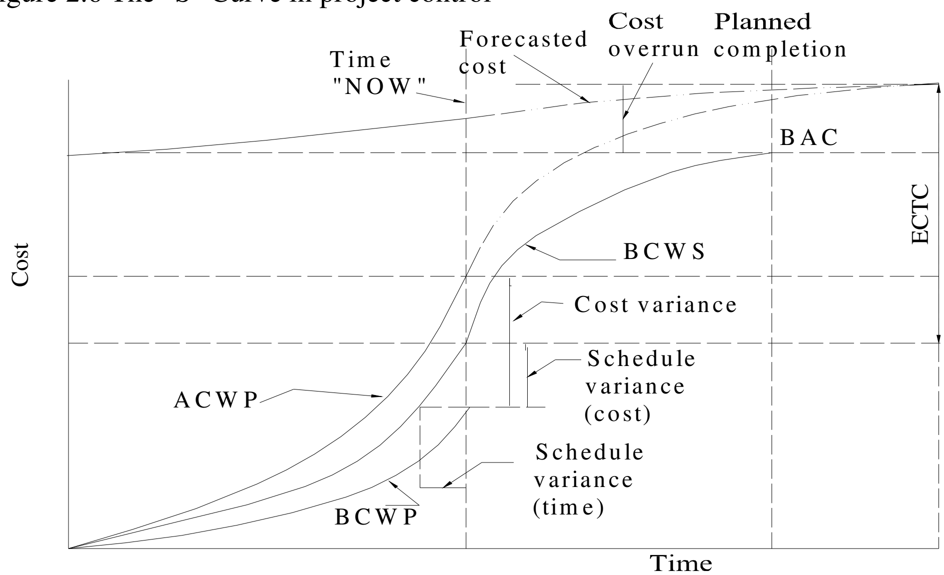
Similarly, the forecast project duration can be obtained as follows:

- Schedule performance index (SPI) = BCWP/BCWS

Then, the forecast project duration (FPD) = PD/SPI

Where, PD is the current planned project duration.

Figure 2.6 The "S" Curve in project control



ECTC: Estimated Cost to Complete
BAC: Budget at Completion (Current)
BCWS: Budgeted Cost of Work Scheduled
ACWP: Actual Cost of Work Performed

Here, it should be noted that the forecast obtained by the above mathematical techniques assume that the future will behave in a manner determined by the past, which may not be always true. The analysis must be modified by managerial judgment

2.2.5 Project Management Of The PC Assembly Plant Project

The above-discussed tools of project management could be effectively applied in our project of PC assembly plant. According to the practical experience of the researcher, several projects in Ethiopia fail or are subjected to complex technical as well as financial problems as a result of very poor project management.

Here in this thesis research we have outlined the modern techniques of project planning and control including the earned value (S-curve) analysis imagining that the tools will be applied in the implementation of the project.

CHAPTER THREE: COMPONENTS OF THE COMPUTER SYSTEM

3.1 The Information Age and Computers

We live in a society in which information is an essential resource and where knowledge is valuable. " Knowledge determines our supply of existing physical resources by determing both the efficiency with which we use resources and the ability to find, obtain, distribute and store them ".

Countries that are bestowed with the most natural resources are not likely to accumulate wealth as a result of the existence of the resource alone. The deriving force to wealth these days is knowledge and knowledge alone. The importance of knowledge in creating wealth is demonstrated by the following equation [43]:

$W = P.\,K^{n}$, where W = wealth

P = physical resource

K= knowledge

n = exponential effect of knowledge advancement

Information is rapidly becoming the world's most precious resource, creating wealth while replacing land, energy, labor, and capital.

The history of human civilization may be seen in three eras/ages:

- Agricultural Age: The period before the 1800s when the majority of workers were farmers whose lives revolved around agriculture.
- Industrial Age: The period that began in the 1800s when work processes were simplified through mechanization and automation.
- Information Age: The period that began in 1960 in which the

majority of workers (in the developed nation like U.S.A) are involved in the creation, distribution and application of information.

In developing countries like Ethiopia, agriculture is still the main source of income. Not only that most people are involved in agriculture but the means by which people do their agriculture is traditional and not knowledge based. The rest of the world has traveled two ages ahead and has now reached at an era known as the information age.

The information age came about the rise of an information society where more people (in the developed nations) work at handling information than at agriculture and manufacturing combined. In the information age business and other sectors depend on information technology [4].

Because we in developing countries are still in the agricultural age, we cannot say the information technology (IT) is irrelevant to us. Rather, it is believed that application of IT would improve the rate of development. On the contrary, however, not being able to use this technology would further widen the gap between developed and developing countries.

Information technology has three components: *computers, communication systems and know-how*. Therefore, the computer, which is an important component of the information technology, will be discussed in the sections that follow.

3.2 Computers

The computer is the most economically important technological innovation of the 20th century. In simplest terms, a *computer* is any electronic system that can be instructed to accept, process, and present data and information.

The computer has become part of the day-to-day existence of people around the globe. It is difficult to think of any filed that does not involve or is not affected by computers. Computers come in four different sizes: microcomputers, midrange/minicomputers, mainframes, and supercomputers. However, due to the rapid technological development, this classification does not have a firm base. Thus, a recently introduced small system can outperform the large models of a few years ago, and a new microcomputer can do the work of an earlier mini- computer at a much lower cost [4,9,10]. Any way let us discuss this classification briefly for the purpose of identifying the boundaries.

3.2.1 Microcomputers

Microcomputers (often called personal computers or PCs) are the most frequently used type of computer. They are relatively compact and are often found on a tabletop or desktop. A microcomputer system has all the functional elements found in any large systems, and is designed to be used by one person at a time that is, it is single-user-oriented. There are varieties of microcomputers.

Notebook Computers And Laptop Computers - are smaller versions of microcomputers designed for portability. People can carry these PCs in their car, on airplanes, or when walking from one location to another. Unlike desktop PCs, which may have detachable components, notebooks and laptops include all their components in a single unit.

Palmtop Computers, among the latest entries into the microcomputer market, are growing in popularity. About the same size as a pocket calculator, palmtops are the smallest and most portable computers; they are used for limited number of functions, such as maintaining personal calendars, name and address files, or electronic worksheets.

3.2.2 Midrange/Minicomputers and Mainframes

The computers most often associated with business, especially large business and data intensive applications, are *midrange computers* (also called *minicomputers*) and mainframes. These computers are used to interconnect people and large sets of information.

Mainframe computers are generally larger, more expensive, and faster than midrange computers. While there is a considerable overlap between the most powerful micro systems and the low-end minicomputers in terms of cost and processing capability, the typical mini system will surpass a micro in its storage capacity, speed of arithmetic operations, and ability to support a great variety of faster-operating peripheral devices.

3.2.3 Supercomputers

Supercomputers can perform millions and millions of calculations per second and their application is limited to organizations dealing with sophisticated scientific works and researches that involve thousands of variables. Thus only a few of these monsters are produced each year.

3.3 Computer Hardware

A computer system is composed of three components: *Hardware*, *software*, and the *data* that is being manipulated. In modern systems, there is also a third component to be considered-the *communication* component-which consists of hardware and software that transport data between interconnected computer systems [1,3,4,5]. Here, we will focus on the first component that is, the hardware.

Hardware is the general term for the machines (sometimes called the *devices*) that carry out the activities of computing, storing, and communicating data. Computer hardware falls into five categories (Fig.3.1):

- Input devices
- Processors (CPU)

- Memory
- Output devices
- Secondary storage devices

These components are part of most computer systems, regardless of the cost or size of the system.

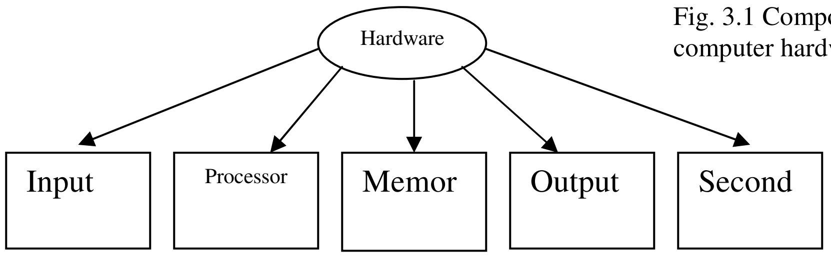


Fig. 3.1 Components of computer hardware

3.3.1 Input Devices

Seven different devices are commonly used to input data or information into a computer. These are:

- *Keyboards*: keyboards containing the letters of the alphabet, numbers, and frequently used symbols (such as $, & and #) are the most common input devices.
- *Point-of Sale Terminals*: A variation on the standard business cash register, these terminals typically do not contain alphabet letters. Rather, they consist of a numeric data pad and special purpose function keys. They are most often used at the point of contact between a business and its customers, hence the name "point-of sale."
- *Mice*: On the underside of the mouse is a ball that rotates, causing a corresponding movement of a pointer on the display screen. Mice offer the advantage of allowing people to control the computer system by pointing to commands rather than entering them through the keyboard.
- *Image Optical Character Recognition Scanners*: Image scanners can be used to input both words and images directly into a computer. A light illuminates the information one section at a time, with the information under the light being recognized and read into the computer.
- *Barcode Scanners and Wands*: A barcode is a computer-readable code consisting of bars or lines of varying widths or lengths. As the wand is waved across the bar code on a package, it recognizes the special letters and symbols in the barcode and inputs this information directly into a PC, midrange computer, or point-of-sale terminal. There the code is translated into product and price information.

Microphones, Prerecorded sources, Light pens, graphic tablets and *plotters* are also included in the list of common input/output devices. A typical hardware diagram is shown in Fig.3.2

3.3.2 The Processor

The center of action in a computer is the *processor*, also called the *central processing unit (CPU)*. In microcomputers, the processor is a *microprocessor* - a central processor contained on a single computer chip.

A *chip* is a collection of electronic components in a very small, self-contained package. Chips perform the computers processing actions, including arithmetic calculations and the generation of lines, images, and sounds. Some chips are general purpose and perform all types of actions; others have a special purpose. Sound chips for example, do exactly what their name suggests: they generate signals to be output as tones.

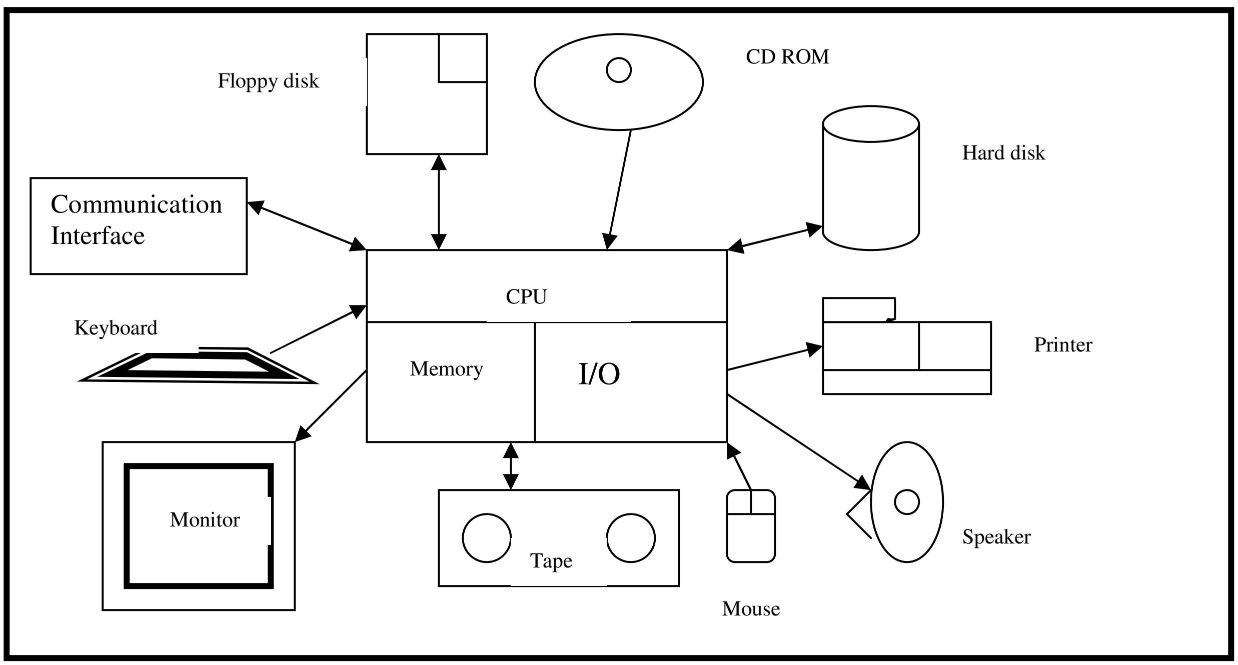


Fig.3.2 A typical Computer System

The CPU is itself composed of three primary sub-units:

1. The *arithmetic/logic unit*, or *ALU*, where arithmetic and Boolean logical calculations are performed.
2. The *control unit*, or *CU*, which controls the processing of instructions and the movement of data within the CPU parts.

3. The interface unit, which moves program, instructions and data between the CPU and other hardware components.

3.3.3 System Board/Mother board

The processor /CPU can take several forms. Microcomputers contain a specific microprocessor chip as their CPU. This chip is put into protective packages, and then mounted onto a board contained within the computer. This board is called a *system board or motherboard*. The system board also contain chips and other circuitry that carryout processing activities.

Larger computer systems may have separate cabinets or freestanding units that contain the chips and circuits that comprise the CPU. At one time all mainframes and supercomputers had separate units containing central processor. But today, thanks to the continued miniaturization of chips and circuits, separate units are not always necessary. Even in the most powerful central processors, chips and circuits can be integrated onto a few boards.

3.3.4 Memory

Both system boards and separate processing units include space for memory, sometimes called *primary storage* or *main memory* because it is used by the central processing unit in carrying out all computing activities. Processing does not occur in memory; rather, memory stores data, information, and instructions. When data enter the computer as input, they go into memory/primary storage until they are processed. After processing, the results are retained in memory.

3.3.5 Output Devices

People use computers for the output they generate that is, the results of inputting and processing data and information. Output falls into two categories: (1) information that is presented to the user of the computer, and (2) information in the form of computer commands that are input to another device. The most common forms of output geared to the user are reports, schedules, designs, budgets, newsletters, and correspondence. These results can be printed out, displayed on a computer screen and sometimes played through the speaker built in or attached to a computer.

Output form computer processing that is input to another device can perform various functions, including: *Controlling a printer, directing a display, controlling another device* (e.g., CNC machines), *generating sounds,* and *initiating transmission of information in data communication network.*

3.3.6 Secondary Storage Devices

Computers that run multimedia and other complex programs require great quantities of storage capacity. For this reason computer systems have several secondary storage options. Secondary storage provides the capability to store data, information, or programs outside of the central processor.

The most widely used types of secondary storage are:

- *Diskettes* - Flexible, flat, oxide-coated disks on which data and information are stored magnetically. For this reason, they are sometimes called magnetic disks. Diskettes are either 3.5 inches across (the standard size) or 5.25 inches across.
- *Hard disks* - Magnetic disks that are not flexible. Ranging from 2.5 to 14 inches across, with standard sizes of 3.5 and 5.5 inches, hard disks can store more data and provide for more rapid storage and retrieval of data than diskettes can. Hard disks are usually mounted inside the computer and, unlike diskettes, are not easily removed.
- *Optical disks*- a storage medium similar in design to the compact disks (CDs) played on stereo system. Many optical disks are read only, which means that they can only be played that is, data, information and instructions can be read from them but not written onto them. Because of this characteristic, optical disks are sometimes known as CD-Rom (compact-disk read-only memory). Other types of optical disks allow the writing of information under certain circumstances.

- *Magnetic tape* - used to store large quantities of data and information, often as a second copy of data or information that exists elsewhere. Unlike diskettes, hard disks, and optical disks, which are circular, magnetic tape is linear and comes in reels or cartridges.

3.3.7 Drive

Information is written to or read from each type of secondary storage medium by a read/write unit contained in a drive. The drive rotates the medium during the read/write process. Disks and tape drives read information magnetically in much the same way that stereo systems read information from cassette tapes. Optical drives use a laser beam to read information.

3.4 Software or Programs

By itself, hardware is a collection of computer apparatus. To be useful, hardware needs software or programs. The two terms are often used interchangeably but their meaning does vary slightly. Software is the general term for a set of instructions that controls a computer or a communication network. A program is a specific sequence of instructions that tells a computer how to perform a particular action or solve a problem.

At the center of a computer's activity is the *operating system*, a combination of programs that coordinates the actions of the computer, including its peripheral devices (input/output devices) and memory. One of the most common operating system some time before was *DOS*, a single-user personal computer operating system. (DOS is an acronym for *disk operating system*, which means that the operating system's components reside on a disk and are brought into computer memory as needed.) Gaining popularity now is *windows*, a single-user operating system that allows multitasking, in which several programs can be operated concurrently, each in its own *window*, or section of the computer screen. With this system, users direct the computer through the window created by the software. Using a mouse the user can point to icons that activate programs, rather than entering a command word to start processing.

Other popular operating system is UNIX for PCs, midrange systems, and mainframes; and MVS and VM, multi-user operating systems for IBM mainframe computers used in large business and other data-intensive applications.

Another important type of software is the *application program* (or *application* for short). These programs consist of several programs working together and are run to get ones work done. Examples are Microsoft Word, Netscape, etc.

Many of the applications used on computers today are purchased as software packages, applications that focus on a particular subject and are sold to business and the general public. All software packages are accompanied by *documentation*, an instruction manual for the software.

3.5 Programming Languages

Computer programs are not written in everyday language or as lines of text. Rather, they are created using a *computer programming language* - a series of commands and codes that the computer can translate into electronic impulses that underlie all computing activities.

Some tasks are performed frequently during processing that it would be extremely inefficient to code these activities into the program again & again. For this reason, programmers make use of special *utility programs* (sometimes called *utilities*) to perform such functions. Utilities can either be bundled into an operating system or purchased as software.

Many programming languages have been developed to suit the needs of people tackling different types of problems, with some more popular than others. Some common programming languages are: COBOL (Common Business oriented language), C, C++, BASIC, PASCAL and FORTRAN.

3.6. Inside The Computer

3.6.1 The Central Processing Unit (CPU)

We have seen that the CPU, sometimes called the processor, is the heart of the computer's hardware, which executes program instructions and perform the computer's processing actions.

The CPU is a collection of electronic circuits made of thousands, even millions, of transistors placed onto *integrated circuits*. Integrated circuits are also called *chips* or *microchips* because the transistors are imprinted onto a small silicon chip. Each transistor is an electrical switch that can be in one of two states: open or closed. (Numerically, a closed state is described by the number 0, an open state by the number 1).

Small transistors allow more transistors to be packed onto one chip. This process, called *integrating*, brought about the "*PC revolution*" in the 1980s and is the driving force behind many of the advances in today's information technology. Integrating means that many of the CPU's components can be placed onto a single chip, thus eliminating the need for separate chips. Integrating greatly increases the speed of the computer.

Processors are designed and constructed in different ways. In PCs the processor is a single microprocessor chip. In large systems, multiple circuit boards are used. The processor in microcomputers is composed of two parts: the control unit and the arithmetic/logic unit.

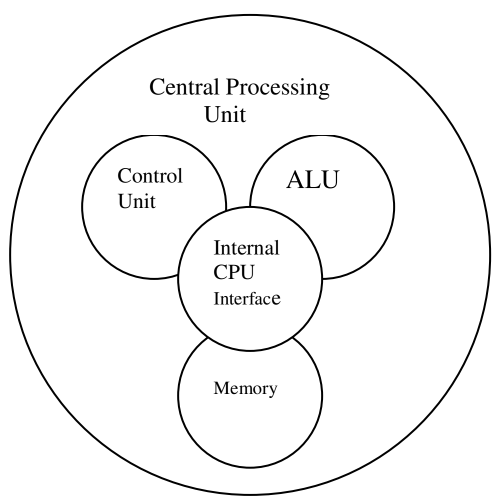
Control Unit

Computers "think" by using the on/off pulses of electric current. The *control unit* may be compared to the human brain, which overseas and controls all of our activities, whether we are working, playing, or exercising. All computer activities occur according to instructions the control unit receives. *Instructions* are detailed descriptions of the actions to be carried out during input, processing, output, storage, and transmission.

Arithmetic/Logic Unit (ALU)

The other component of the central processor is the *arithmetic/logic unit (ALU*). The ALU contains the electronic circuitry that performs the two activities that underlie all computing capabilities, arithmetic and logic operations. *Arithmetic operations* include addition, subtraction, multiplication and division. Logical operations compare one element of information to another. The comparison determines whether one item is greater than, less than, or equal to the other. Fig.3.3 depicts the structure of the CPU [6].

Fig. 3.3
The CPU



Memory unit

When the electronic calculator was first introduced in the 1930s it was viewed as a breakthrough because of its memory capability. Earlier machines did not have the capacity to store data and information, but calculators - and their descendants, the various kinds of computers - do. The memory, which is composed of computer chips, can be used repeatedly by different applications.

The CPU interacts closely with memory, referring to it both for instructions and data or information. However memory is separate from the CPU. People refer to computer memory by different names, including *primary storage, main memory, and internal memory*. The simple term "memory" is often used to mean primary memory. Memory space is used in five different ways:

(1) To hold the computer's operating system program - The software that overseas processing and acts as an interface between the hardware and application programs.
(2) To hold application programs - word processing, spreadsheet etc.
(3) To hold data and information temporarily (in "virtual memory"), receiving data from input devices and sending them to output devices during processing.
(4) To store data or information needed in processing in the *working storage* area.
(5) To provide additional space for programs or data, as needed. The amount of memory needed may changed during the processing of an application, so it is useful to have excess memory.

Memory Size

Computers vary widely in the amount of internal (primary/memory) they have. The memory size is measured by the number of storage locations it contains. Each storage location, or *byte* has a predetermined capacity. In simplest terms, a byte is the amount of memory required to store one digit, letter, or character.

Bytes are generally measured by *kilobyte (KB or k), megabyte (MB or meg), gigabyte (GB or gig)*, and *terabyte (TB),* which respectively represent thousands, millions, billions and trillions of bytes.

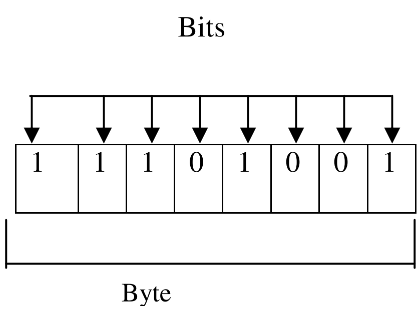
Personal computers have memory capacities in the megabyte range. Fore example most desktop PCs have now a main memory capacity of 64 to 128 megabytes. Midrange, mainframe, and supercomputers usually have substantially more.

Bytes and Number Systems

Computers use bits and bytes to process and store data. Because they run on electricity, computers know only two things: on and off. This two state system is called a binary system. Using single digits called bits (short for *bi*nary digi*ts*), the computer can represent any piece of data. The binary stem uses only two digits, 0 and 1. The 0 corresponds to the "off" state, the 1 to the "on" state.

Single bits are usually not enough to store all the numbers and characters that need to be processed and stored. For this reason seven or eight bits are usually grouped together into bytes (Fig. 3.4). Each byte generally represents one character.

Fig. 3.4 Bits and Bytes



When a character is entered through the keyboard, the processor accepts it into main memory and translates it into coded from. It simultaneously shows the character on the display screen.

Two standard systems for representing data have been developed. *EBCDIC* (Extended Binary Coded Decimal Interchange Code) uses eight-bit byte to represent a character. ASCII (American Standard Code for Information Interchange) uses seven-bit bytes to represent a character. All characters have a unique code in each system. EBCDIC is generally used in mainframes, ASCII in microcomputers (Table 3.1).

RAM and ROM

There are two types of main memory, random-access memory and read-only memory, with two variations on each type.

RAM*: Main memory, the largest area of memory within the computer, is composed of random-access memory, or RAM chips. "Random access" means that data or information can be written into or recalled (read) from any memory address at any time. With RAM, there is no need to start at the first location and precede one step at a time. Information can be written to or read from RAM in less than 100 billionths of a second. However, RAM stores data and information only as long as the computer is turned on. The electrical currents that comprise the data and information cease when the power is turned off.*

Table 3.1 Character Representation Standards

Character	EBCDIC	ASCII
A	1100 0001	100 0001
B	1100 0010	100 0010
C	1100 0011	100 0011
D	1100 0100	100 0100
E	1100 0101	100 0101
F	1100 0110	100 0110
G	1100 0111	100 0111
H	1100 1000	100 1000
I	1100 1001	100 1001
J	1101 0001	100 1010
K	1101 0010	100 1011
L	1101 0011	100 1100
M	1101 0100	100 1101
N	1101 0101	100 1110
O	1101 0110	100 1111
P	1101 0111	101 0000
Q	1101 1000	101 0001
R	1101 1001	101 0010
S	1110 0010	101 0011
T	1110 0011	101 0100

Character	EBCDIC	ACII
U	1110 0100	101 0101
V	1110 0101	101 0110
W	1110 0110	101 0111
X	1110 0110	101 1000
Y	1110 1000	101 1001
Z	1110 1001	101 1010
0	1111 0000	011 0000
1	1111 0001	011 0001
2	1111 0010	011 0010
3	1111 0011	011 0011
4	1111 0100	011 0100
5	1111 0101	011 0101
6	1111 0110	011 0110
7	1111 0111	011 0111
8	1111 1000	011 1000
9	1111 1001	011 1001
!	0101 1010	010 0001
$	0101 1011	010 0100
&	0101 0000	010 0110

Source: Senn, 1995

Two types of RAM are widely used. *Dynamic RAM (DRAM)* is the major memory component in virtually every computer. DRAM chips hold data and information "dynamically". This means that the computer does not hold data and information indefinitely. Rather, the computer must continually refresh the DRAM cell electrically - several hundred times per second. In contrast, *static RAM* chips retain their contents indefinitely without constant electronic refreshment. They are faster than DRAM, but are not as compact and use a more complicated design.

RAM chips technology is changing rapidly, both in capacity and packaging. RAM chips has increased rapidly in the past few years going from 64K bits to 64M bits in fewer than ten years. Currently most systems are built with chips that can hold 64M bits of data. These chips are also designed to be packaged together in convenient plug-in packages that can supply 128 megabytes of memory, or more, in a single unit.

ROM: *Like RAM, read only memory (ROM) offers random access to memory location. However, ROM chips are able to hold data and information even after the electrical current to the computer is turned off. Unlike the contents of RAM chip, the contents of ROM chip cannot be changed. Whatever is inserted into a location during manufacturing of the ROM chip cannot be altered.*

Typically, the start-up programs that run automatically when computers are first turned on are written into ROM. The instructions can be read again and again, but never changed. Thus ROM contents are not expected to change over the life of the computer, except perhaps very infrequently.

There are several variations on ROM: *Programmable read-only memory (PROM) chips (*developed as a tool for testing a new ROM design before putting it into mass production), *erasable programmable read-only memory (EPROM) chips* (can be erased by bathing the chip in ultraviolet light), and *Electrically erasable programmable read-only memory (EEPROM) chips* (can be reprogrammed by electronically reversing the voltage used to create the data). Only engineers and designers who develop devices that contain embedded computers generally use EPROM and EEPROM chips.

3.7 Modern computer systems

3.7.1 Elements of the system unit

Both CPU and memory units can be augmented by combinations of chips and boards. A board is a hardware device onto which chips and their related circuitry are placed.

In all computers the processor is housed inside a hardware unit called the *system unit*. On mainframe or midrange systems, the system unit is typically a cabinet filled with circuit boards. On microcomputers a single *system board* is mounted on to the computer case and attached to an electrical power supply that generates the electrical current needed to operate the computer. The system board of a personal computer contains the processor chip, memory chips, ports, add in boards, and circuitry that interconnects all these components. System units in large computers can also contain all these elements [1,4,5].

3.7.1.1 Processor Chips

The notion of a "computer on a chip" becomes reality when all of the processing capabilities of the control unit and ALU could be contained on a single computer chip. The smallest type of processor, a microprocessor, is exactly this kind of chip. Sealed in a protective package, the microprocessor is connected to a system board with pins. Microprocessors gave rise to microcomputers, which use microprocessors for their CPU. Microprocessors are rated by their speed measured in megahertz (MHz). The higher the megahertz (MHz), the faster the microprocessor. Intel manufactures the most popular processor chips for IBM compatibles. These chips have been evolved over time, with each new chip including more capability and greater speed than its predecessor.

3.7.1.2 Memory Chips

In the past memory chips were installed onto the system board eight chips at a time by connecting the chip to the system board with pins. Memory chips now often come in modules. *A single in line memory module* (SIMM) is a multiple chip "card" that is inserted as a unit into a predestinated slot on the system board. SIMM's of 1M, 2M and 4M are common. *Installed memory* is the amount of memory included by the computer's manufacturer on its memory board. *Maximum memory* is the highest amount of memory that a processor can hold.

Three memory allocation ranges are found in microcomputers. *Conventional memory* is the memory managed by the operating system and in which application programs run. Since the creation of the personal computer this has been limited to 640k, a barrier which these days is removed. Rom based instructions, the computers operating system and application and communication programs run in conventional memory. A limited number of operating systems use *expanded memory*, the usable memory beyond the 640k upper limit, up to 1-megabyte. Application software may also use expanded memory. *Extended memory* starts at the 1-megabyte boundary and extends upward to 16 or 32 megabytes. This memory is freely available to application programs (Note: These three memory allocations ranges pertain to the Intel line of chips, the most frequently used chips in PCs today).

3.7.1.3 Ports

Any device that is not part of the CPU or the system board must somehow be attached to the computer. *Ports* are the connectors through which input/output devices and storage devices can be plugged into the computer.

Computers of all sizes are designed to accept additional circuit boards that serve as ports. When an input/output device needs to be plugged into the system unit and there is no a built in part for it a special add in board must be added. These extra boards are plugged into *expansion slot* on the system board. All systems have a practical limit to the number of ports that can be added.

3.7.1.4 Add-In Boards

Virtually all micro, midrange, and mainframe computers have an open *architecture*. That is additional boars called *add-in boards* can be added to the computer by way of its expansion slots, to customize its features and capabilities (computer that do not have this capacity are said to have a *closed* architecture.)

Table 3.2 lists several types of boards that can be added to microcomputers. The variety of add-in boards has continued to expand as people using computer seek more capabilities and as computer manufactures find ways to meet these demands.

Table 3.2 Common Add-in Boards

Board	**Function/Description**
Accelerator board	Increases the speed of a computer.
Controller board	Allows different printers and storage devices to be attached to a computer.
Coprocessor board	Includes special chips that speed up the system's overall processing capabilities.
Display adaptor board	Permits the use of computer displays by providing interconnection with the processor board.
Emulator board	Allows the computer to act like another type of device, usually a terminal.
Fax modem board	Enables the computer to send and receive facsimile images, data and information.
Memory expansion board	Extends the computer's memory capacity by adding additional cards for memory chips.
Modem board	Enables the computer to interconnect with telephone line to transmit and receive data and information.
Multifunction board	Includes several different functions (such as memory expansion and printer and display connections) of a single add-in board.

Sound board	Contains chips and circuitry that translate data and information into sound output, including music.
Voice board	Produce spoken output.

3.7.2 The Processing Sequence

All the functions of processing are directed by the control unit, which works with the ALU and memory to perform the following four steps:

- *Fetch* - obtain the next instruction from memory
- *Decode* - Translate the instruction into individual commands that the computer can process
- *Execute* - perform the actions called for the instruction
- *Store* - write the results of processing to memory.

Collectively, these four steps are known as the *machine cycle*. The first two steps, in which instructions are obtained and translated, are the *instruction cycle (I-cycle*). The last two steps, which produce processing results, are the *execution cycle (E-cycle*)

To execute the machine cycle, the control unit depends on *registers*, temporary storage areas in the processor (not in the main memory). Registers, which can move data and instructions more quickly than main memory, momentarily hold the data or instructions used in the processing and the results that are generated. They also assist the ALU in carrying out arithmetic and logic operations. There are four types of registers.

1. *Storage registers* - Temporarily store data that have been moved from memory and are awaiting processing or are about to be sent to memory
2. *Address registers* - Contains the address of the data to be used in executing an instruction.
3. *Accumulators* - Hold the results of computation as each arithmetic operation occurs. From the accumulator the results are moved into main memory or to another register for additional processing.
4. *General purpose registers* - Hold data, address, or arithmetic results.

Registers are like staging areas. They are a place in which preparations are made so that an activity, once underway goes smoothly. In other words registers assemble all data instructions so that the computer can perform its next machine cycle quickly and without a hindrance [1,4,6].

3.7.3 Processor Speed

Speed is one of the main reasons people use computers. Computer can perform millions of calculations per second consistently, accurately and reliably. Computer speeds are measured in *milliseconds*, *microseconds*, *nanoseconds* (billionths of a second), or *Pico seconds* (trillionths of a second). Processors and processor chips tend to operate at microseconds and nanoseconds speeds, though new chips are emerging with Pico second capabilities. Secondary storage and input/out devices function at millisecond speeds [4,8].

Another common way of describing speeds is by the number of instructions the processor can execute per second. *Millions of instructions per second (MIPS)* ratings range from approximately 1 to 50 MIPS for a typical desktop PC to 200 to 400 MIPS for a mainframe, to even higher speeds for supercomputers.

Computing speeds is sometimes also measured in *mega flops*, or millions of floating point operations per second. Floating point operations refers to the floating of the decimal point form calculation to calculation. A Mega flop is a measure of how many detailed calculations can be performed per second.

3.7.3.1 Determining Processor Speed

Three elements determine the computer speed: the system clock, bus width and word size [1,6].

System clock: Because computers work at high speeds, synchronization of task is essential to ensure that actions take place in an orderly and precise fashion. All computers have system clock, a circuit that generates electronic pulses at a fixed rate to synchronize processing activities. Each time a pulse is generated, a new instruction cycle begins.

Clock cycles are measured in megahertz (MHz), or millions of electronic pulses per second. The megahertz speed built into computers varies. Personal computers typically operate in the range of 20 MHz to approximately 1.8 GHz; and the higher the megahertz, the faster the computer.

Bus: For a computer to process information, the details must be moved internally with in the computer. Data are moved from input devices to memory, from the memory to the processor, from the processor to memory, from memory to storage, and from memory to input devices. The path over which data are moved is known as a bus. Like the system clock, the bus is an electronic circuit.

There are two types of bus. An *input/output (I/O) bus* moves data into and out of the processor - that is between peripheral units (such as input devices) and the central processor. A *data bus* moves data between the central processor and memory.

The width of the bus determines the amount of data that can be moved at one time. An 8-bit bus, for example, transmits eight bits of data at a time. Greater bus width means faster movement of data.

Most PCs have 16 - or 32-bit buses. Midrange and mainframe systems typically use 32 or 64 bits buses. Different bus standards exist. The *Enhanced Industry Standard Architecture* (EISA) is used on many MS-DOS microcomputers.

Word size: A word is the number of bits a computer can process at one time. Word size is measured in bit. An 8-bit word, for example, consists of eight bits (eight electronic circuits) Alternatively, words are sometimes expressed in bytes. A one-byte word contains eight bits; a two-byte word, 16 bits; and a four byte word, 32 bits.

The longer the word size, the faster the computer can process data and perform arithmetic and logic operations. Many micro and most midrange systems use 32 bits words; mainframes and supercomputer are built for 64 bit words. In contrast, most personal computers use 16 bit words (two eight bit bytes), with the most powerful built around 32-bit word structures.

3.7.3.2 Increasing Computer Speed

Processing and computer speed may be increased in six ways: through the use of cache memory, coprocessors, accelerator boards, greater chip density, RISC (Reduced instruction set computing), and parallel processing.

Cached Memory: A special form of high-speed memory called cache memory eliminates the need to move data to and from main memory repeatedly. It acts as a temporary holding/processing cell. As data requests pass between the CPU and main memory, they travel through cache memory and are copied there. Subsequent requests for the same data are recognized and captured by the cache memory cell. The cache cell then fulfils the data request with the CPU. By decreasing the number of data requests to main memory, processing time is cut in half.

Coprocessor: When a certain task is performed again and again special purpose chips can be designed to handle it quickly and efficiently. These chips, called coprocessor chips, are mounted on the processor board and function simultaneously with the primary processor chip. By taking processing work away from the main processor, they free the central processing unit to focus on general processing needs.

Accelerator boards: An accelerator board is an add-in circuit board that increases a computers processing speed by three methods: using a clock speed that is faster than the CPU's; by using a faster processor chip; or by using an arithmetic/logic unit that speeds up floating point calculations. Any combination of these three is also possible.

The characteristics of an accelerator board depend on the nature of the work that is designed to help accomplish. For example, floating point arithmetic is important to engineering and scientific applications. Thus a PC used in those areas may be outfitted with an accelerator board and with a faster ALU. Or the computer may be outfitted with a specialized accelerator board, such as graphics accelerator board. In most applications, accelerator boards can yield speed increases of 200 to 400 percent.

3.7.4 Increased Chip Density And Integration

Data moves through the computer at about one-third the speed of light. Thus, reducing the distance traveled, even a little, makes a tremendous difference in the computers speed. This fundamental principle underlies the continued emphasis on miniaturization of circuits and greater *chip density*, the number of circuits on a single chip.

The number of circuits that can be packed onto a chip has been continuously improved. The Intel 80386 chip (usually called a "386" chip), first introduced in 1985 holds quarter of a million transistors. The Intel 80486 (or"486", as it is commonly called), introduced in 1991, operates at speeds of 33 to 66 megahertz, executes at a speed of 54 MIPS; holds 1¼ million transistors; and integrates a CPU, input/output controller, high speed graphics support, a memory cache, and a math coprocessor– all on a chip the size of a finger nail. The "486" is compatible with all of its predecessors and thus can process applications software developed for earlier generations of chips and computers.

The Intel Pentium chip, the successor to the "486" was introduces in early 1993. This chip has more than 3 million transistor and operates at a speed of 112 MIPS Table 3.3 shows the evolution of microprocessors.

Currently chips are designed to hold up to 40million transistors. Specialized chips most likely operate at 250 MHz and provide a capability of 1billion instructions per second, interacting with 1gigabyte DRAM chips [1,4,6].

Table 3.3 Evolutions of Intel and Motorola Microprocessors

Microprocessor	Speed (MHz)	Computers using this chip	Word size (Bits)	Bus width (Bits)
Intel 8088	8	IBM PC	16	8
Intel 8086	8	IBM compatibles	16	16
Intel 80286 ("286)	8-12	IBM compatibles	16	16
Motorola 6800	12-20	Apple Macintosh Commodore Amiga	32	16
Motorola 68020	12-33	Apple Macintosh II	32	43
Intel 80386("386")	16-33	IBM compatibles	32	32
Motorola 68030	16-40	Apple Macintosh SE/30	32	32
Motorola 68040	25-33	Apple Macintosh, Quadra Engineering workstations	32	32
Intel 80486 ("486")	25-66	IBM-compatibles	32	32
Intel Pentium	66 and up	IBM-compatibles	35	64

3.7.5 Reduced instructions set computing (RISC)

The quest for greater speed has caused computer designers to rethink the manner in which computers process instructions. One type of processing, *complex instruction set computing (CISC*), has been used since the first days of computing. CISC moves data to and from main memory soften that it limits the use of registers to store temporary data values. Calling on the memory so frequently means slower overall performance, since a portion of the processor must coordinate the execution of the movement instructions, which are called *micro code*

Recently, a second type of processing has come popular. *Reduced instruction set computing (RISC)* process data more simply. With RISC, data for the execution of an instruction are taken only from registers. This simplifies (and accelerates) instruction processing greatly because the micro code is not needed. A separate set of instructions moves the data from memory to the registers.

3.7.6. Parallel Processing

Traditionally, computers have been designed for sequential processing, in which the execution of one instruction is followed by the execution of another. But in recent years computers handle different parts of problem by executing instructions simultaneously. Two types of parallel processing are emerging. *Single instruction/multiple data (SIMD) method* executes the same instruction on many data values simultaneously. *Multiple instruction/multiple data (MIMD) method* connects a number of processors that run different programs or parts of a program on different sets of data. Communications between the processors is essential to MIMD method.

3.7.7 Putting the Pieces Together

The blocks that make up the essential components of a personal computer are shown in fig. 3.5. The major components in this model are a CPU, memory, CD-ROM or DVD-ROM, one or more floppy disk drives, one or more hard disks, the keyboard, and built-in video display output. The unit typically also provides USB, parallel & serial I/O interface controllers and ports [1].

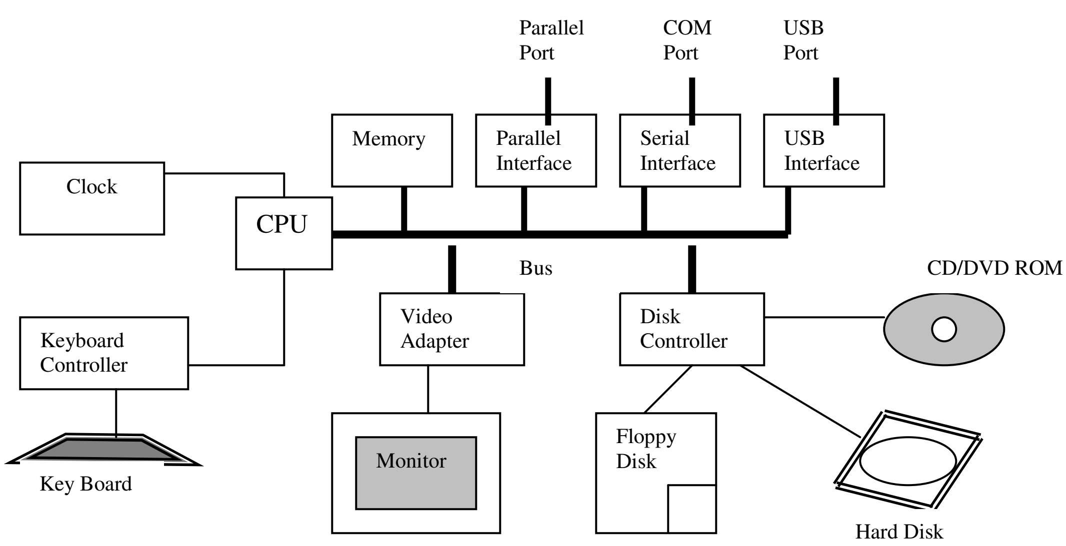


Figure 3.5. A Basic Personal Computer System.

A diagram showing more detail of a typical personal computers circuitry is shown in figure 3.6. In nearly every personal computer, all circuitry shown in the diagram is mounted on a motherboard in very-large scale integrated circuits, or VLSIS [1].

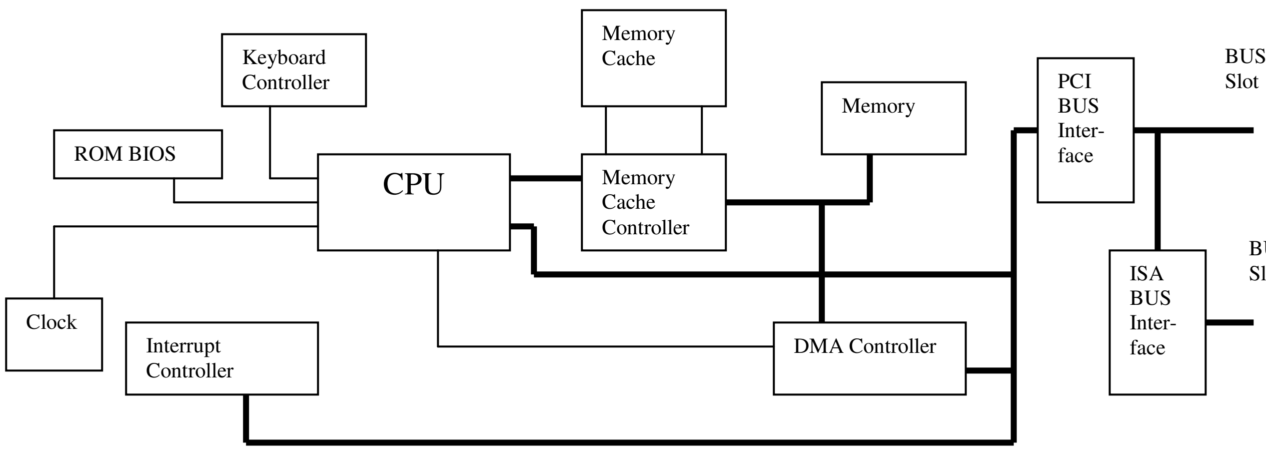


Figure 3.6 Major PC system components

The layout of a typical PC has the configuration of a rectangular box incorporating motherboard, case, and other components. The wiring of the primary buses that interconnect the CPU and its peripheral components is printed on the motherboard. Connectors on the motherboard combine with the frame of the case to hold the peripheral cards physically in place, and, of course, the connectors on the motherboard provide the electrical connection between the peripheral cards and the buses.

3.8. The Making of a Microprocessor

Microprocessors are built from silicon and are constructed in layers consisting of circuits and pathways: doped silicon substrate, and silicon dioxide. The main steps involved in making microprocessors are described below [4].

Step 1: Designing the microprocessor chip

A microprocessor design is created using a powerful computer equipped with a design program; and the design is transformed into a series of photo masks, one for each layer of the chip.

Step 2: manufacturing the chip

The entire process of manufacturing and testing the microprocessor takes place in a clean room, a workroom that is virtually free of dust. The first step in manufacturing is creating cylindrical silicon ingots. Silicon sand is heated until it melts. The molten silicon, which contains no impurities or contaminants, is then drawn into a cylindrical crystal that looks like a metal rode. A diamond - tipped saw slices the silicon rod into very thin (~0.07mm) discus, called wafers. The wafer, which may be 13cm to 20cm in diameter, is the base from which the microprocessor chips are built. Wafers are sterilized and their surfaces polished to a shiny, mirror like finish.

During photolithography, a gelatin like substrate called photo-resist, similar to the film used in ordinary photography, is deposited on the wafer's surface. A glass photo mask containing circuit patterns is held over the wafer and ultraviolet light is passed through the glass regions of the photo mask that do not contain the circuit pattern. A portion of the electric circuit will subsequently be placed everywhere that the light exposes the photo-resist on top of the wafer. After the resist is exposed, it is placed in chemicals to develop it. The exposed resist will remain on the wafer; and chemicals will remove the unexposed resist.

Next comes oxidation. Silicon heated and exposed to steam or dry oxygen will form silicon dioxide. Unexposed regions of the wafer can be oxidized to separate the electronic circuits. Following oxidization, special materials are diffused or implanted into the wafer. These materials change the electrical properties of the silicon so that the electronic circuits (or switches) can be made.

After implantation comes deposition, in which liquid metal or other films are "sprayed" on the wafer. These films will later be selectively patterned, following the photolithography steps described above.

In the final step called etching, chemicals that selectively remove one type of material or another are used to etch away patterned regions on the wafer, leaving only the required circuit patterns.

Step three: Testing the Microprocessor

Testing determines chip quality. During testing, large computer controlled electronic testers determine weather a chip functions as it was designed. The chips that function as designed are diced out of the wafers using diamond tipped saw. Defective wafers are discarded.

Step four: Packing the Microprocessor

By itself the microprocessor chip is too fragile to be handled or used. Hence, it is mounted in a protective package. Each chip is bounded to a plastic base and the chips wire-leads are in turn wired to the electrical gold or aluminum leads on the package. The wire leads of the chip are thinner than a human hair. The microprocessor package is generally shaped in a square as a result of the dicing process.

During assembly of system (mother) board the microprocessor package are inserted into holes in the circuit board. Each lead contacts an electrical lead on the board, which is used to transmit and receive electrical signals from other components mounted on the board.

3.9. A brief Architectural History of the computer

3.9.1 Mechanical And Electromechanical Ancestors

The history of the computer properly begins with the first electronic digital computer, built shortly after the end of World War II. But this history is predated by influential and significant work whose highlights are summarized in table 3.4. Much of the technical strategy for the modern computer was worked out in these mechanical ancestors [5,7].

Table3.4 Milestones in the development of mechanical computer

Date	Inventor: Machine	Capability	Technical Innovation
1642	Pascal	Addition, Subtraction	Automatic carry transfer, complement number representation
1671	Leibriz	Addition, Subtraction multiplication, division	"Stepped reckoner" mechanism
1801	Jacquard: Loom	Automatic control of weaving process	Operation under program control
1822	Babbage: Difference engine	Polynomial evaluation by finite differences	Automatic sequence control mechanism print-out of results
1834	Babbage: Analytical engine (never completed)	General purpose computation	Automatic sequence control mechanism print-out of results
1941	Zuse: Z3	General purpose	The first general purpose computers
1944	Aiken: Mark I	Computation	

Source [Stallings 1990]

In the 1600s appeared machines capable of automatically performing the four basic arithmetic operations. Blaise Pascal, a noted French mathematician, built a calculating machine in 1642. This was a mechanical counter for performing addition and subtraction.

In 1671, the German philosopher and mathematician Gottfried Leibniz constructed a calculator, which was a duplicate of the Pascal calculator, plus two additional sets of wheels that could perform multiplication and division. Leibniz's machine was the forerunner of many machines that are now called *four-function calculations*.

In 1801, Joseph Marie Jacquard invented a loom that used punched cards to control the patterns woven into cloth. The program provided by the punched cards controlled the movement of parts of the loom to create the desired pattern. This is the first documented application of the use of punched cards to hold a program for the use of a semi-automatic, programmable process control machine.

Charles Babbage, an English mathematician who lived in the early 1800s, might be considered the grandfather of modern computer. He designed two mechanical calculating machines: The Difference Engine and the Analytical Engine. The Difference Engine could perform computations of a large number of useful formulas using a mathematical technique known as finite differences. The Analytical Engine resembles the modern computer in many conceptual ways.

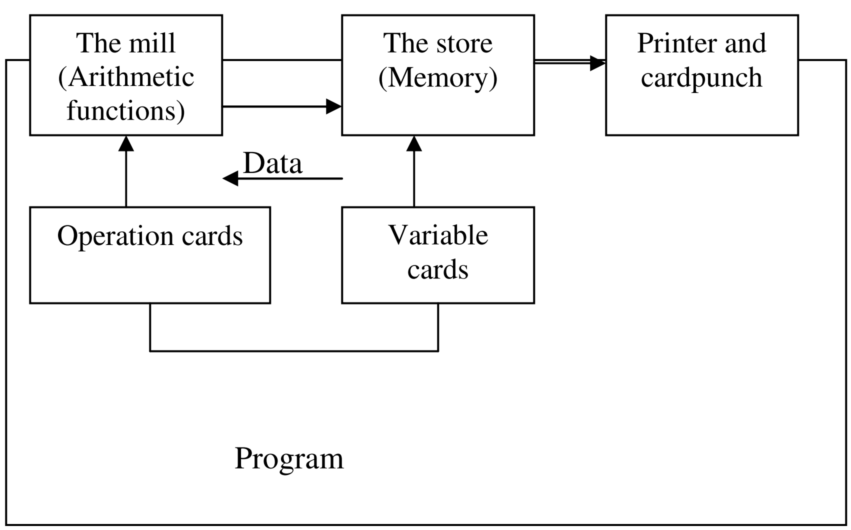
A block diagram of the Babbage analytical engine is shown in figure 3.8. The key components are:

- *The store*: A memory unit consisting of sets of counter wheels
- *The mill*: An arithmetic unit capable of performing the four basic arithmetic operations.
- *Operation cards*: These cards, of the type developed for the Jacquard loom, selected one of four arithmetic operations by activating the mill to perform the selected function.

- *Variable cards*: These cards selected the memory location to be used by the mill for a particular operation.
- *Output*: was to a printer or a card punch device

In the later 1930s and early 1940s,several researchers independently developed versions of the modern electronic computer. In 1941, Zuse, a German researcher, built a model computer known as Z3 which made use of electromechanical relays. For input, the Z3 used a punched tape mechanism and is believed to have been the first fully operational general-purpose program controlled computer.

At the time of Zuse's work in Germany, Howard Aiken was pursuing the same technology in the United States. The Mark I, built in 1944 at Harvard University with help and funding from IBM, used thousands of relays for its computational structure. It had a 72-storage capacity of 23-digit decimal numbers. The design appears to be based directly on Babbage's concepts of operation cards and variable cards.



Source: From complete organization and Architecture, Ze.S. William.

3.9.2 The First Electronic Computers

The ENIAC (Electronic Numerical Integrator and Computer), designed and constructed by J. Preseper Eckert and John Mauchly was the world's first operational electronic, general purpose computer.

ENIAC had very limited storage capability, 20 locations each capable of holding a 10-digit decimal number, calculations were performed using decimal system. This U-shaped computer was 24meters long by 2.5meters high, weighing 30 tons, occupying over 1,400 square meter of floor space, and containing over 18,000 vacuum tubes. When operating, it consumed 140kW of power [1,5,6].

ENIAC was programmable and programming was done manually by plugging cables and setting switches, and data was entered on punched cards.

In 1945, John Von Neumann, a consultant on the ENIAC project, proposed a computer that included a number of significant improvements over the ENIAC design. The most important of these were:

1. Memory that would hold programs and data, the so-called *stored program concept*. This solved the difficult problem of rewiring the control panels for changing programs on the ENIAC.
2. Binary processing of data. This simplified the design of the computer and allowed the use of binary memory for both instructions and data. It also recognized the natural relationship between the ON/OFF nature of switches and calculation in the binary number system, using Boolean logic.

The CPU was to include ALU, memory and CU components. The control unit read instructions from memory and executed them. A method of handling I/O (input/output) through the control unit was also established. Thus, von Neumann's machine contained every major feature considered essential to modern computer architecture.

Different versions of the Von Neumann's architecture were designed and built in 1951-1952. The success of these computers led to the development of many offspring and to several commercial computers, including the first IBM computers. At this stage Von Neumann's architecture was firmly established. It remains the prevalent standard to this day, with the essential hardware concepts that makeup today's digital computers.

3.9.3 Commercial Developments

The 1950s saw the birth of computer industry. UNIVACI (universal automatic computer) was the first successful commercial computer built by Remington-Rand in 1951, and was sold for about $1 million [6]. The first IBM computer, the IBM 701 appeared in 1953. In 1964, after investing $5billion, IBM made a bold move with the announcement of the sytetm/360. The system/360 and its successor dominated the large computer market.

Around 1965, the first commercial *minicomputer* came from DEC (Digital Equipment Corporation). This small machine was a breakthrough in low-cost design, allowing DEC to offer the PD8-8 computer for under $10,000. Minicomputers were the forerunners of microprocessors, with Intel inventing the first microprocessor in 1971 - the Intel 4004.

In 1976 came the announcement of Cray-1, by CDC (Control Data Corporation) a *supercomputer* which was simultaneously the fastest in the world, the most expensive, and the computer with the best cost/performance for scientific programs.

The *personal computer* was created by designers who were looking at using the microprocessor to create a computer so cheap that it could be used at home. In 1977, the apple II of Steve Jobs and Steve Wozniak set standards for low cost, high volume (mass production) and high reliability that defined the personal computer industry. The IBM personal computer, announced in 1981, became the best selling computer of any kind; its success made the Intel 80x86 the most popular microprocessor and made the Microsoft Disk Operating System (MS-DOS) the most popular operating system.

3.9.4 Computer Generations

Since 1952, there have been thousands of new computers using a wide range of technologies and having widely varying capabilities. To put these developments in perspective, the industry has tended to group computers into generations. This classification is often based on the implementation technology used in each generation, as depicted in table 3.5. Typically, each *computer generation* is eight to ten years in length, although the length and birth years, especially of recent generations, are debated. By convention, the first generation is taken to be commercial electronic computers, rather than the mechanical or electromechanical machines that preceded them [1,5,6].

3.9.4.1The First Generation: Vacuum Tubes

The computers of the mechanical era suffered from two serious drawbacks:

- The inertia of moving parts limited computing speed
- The movement of data by mechanical means (gears, levers, etc) was cumbersome and unreliable

What was needed was a switching and strong mechanism with no moving parts. The triode vacuum tube, invented in 1906, provided the basic building block. As these devices become less expensive and more reliable, the way was open for the development of the electronic computer. Therefore, the first-generation computers were constructed of vacuum tubes. Examples: ENIAC (1946), EDUAC and IAS (1951-1952), UNIVAC (1951), and IBM 701 (1953).

3.9.4.2 The Second Generation: Transistors

The first major change in the electronic computer came with the replacement of the vacuum tube by the transistor. Vacuum tubes were bulky, made of glass, and fragile and short lived and required large amount of power to operate. The transistor is smaller, cheaper and dissipates less heat than a vacuum tube but can be used in the same way as a vacuum tube to construct computers.

The invention of the transistor was a major breakthrough in the technology of computers. The transistor was invented at Bell Labs in 1947 and by the 1950s had launched an electronic revolution. Fully transistorized computers were commercially available in the late 1950s. Thus, the use of transistor defines the second generation of computers. Examples are IBM 7000 series (1964), and DEC PDP-1 (1957).

3.9.4.3 The Third Generation: Integrated Circuits

A single self-contained transistor is called a discrete component. Throughout the 1950s and early 1960s electronic equipment was composed largely of discrete components transistors, resistors, capacitors, and so on. Discrete components were manufactured separately, packaged in their own containers, and soldered or wired together onto masonite-like circuit boards, which were then installed in computers and other electronic equipment.

The fact that the entire manufacturing process was expensive and cumbersome created problems in the computer industry. The making of more powerful computers, which contained hundreds of thousands of transistors, was practically difficult.

In 1958 came the achievement that revolutionized electronics and started the era of microelectronics: the invention of the integrated circuit (IC). This new technique exploits the fact that such components as transistors, resistors, and conductors can be fabricated from a semiconductor such as silicon. It means to fabricate an entire circuit in a tiny piece of silicon rather than assemble discrete components made from separate pieces of silicon into the same circuit. Hundreds and even thousands of transistors can be produced at the same time on a single wafer of silicon chip. Equally important these transistors can be connected with a process of metallization to form circuits (refer to section 3.8).

The early integrated circuits are referred to as small-scale integration (SSI). As time went on it became possible to pack more and more components on the same chip. For the computer manufacturer, the use of ever-more densely packed ICs provides many benefits:

- The cost of computer logic and memory circuitry has fallen at a dramatic rate;
- Logic and memory elements are placed together on more densely packed chips increasing operating speed;
- The computer becomes smaller, making it more convenient to place it in a variety of environments; and
- The interconnection on the IC are much more reliable than solder connections. With more circuitry on each chip, there are fewer inter-chip connections.

Therefore, it is the integrated circuit that defines the third generation of computers. Examples are IBM system/360 (1964), and DEC PD8-8 (1964).

Table 3.5 Computer Generations

Generation	Dates	Technology	Typical speed operation/sec.	Principal new product
1	1946-1957	Vacuum tube	40,000	Commercial electronic computer
2	1958-1964	Transistor	200,000	Cheaper computers
3	1965-1971	Integrated circuit	1,000,000	Minicomputer
4	1972-199?	LSI and VLSI	100,000,000	Personal computers and workstations
5	199?-20??	Microprocessors?	?	Personal portable computing devices and parallel processors

Source: Patterson, 1994

3.9.4.4 Later Generations

Beyond the third generation there is less general agreement on defining generations of computers. Table 3.5 suggests that there have been a fourth and a fifth generation, based on the advances in integrated circuit technology.

With the introduction of new products, and the importance of software and communication, the classification by generation becomes less clear and less meaningful.

The fifth generation may be defined on two fronts: portable communications/computing devices at the low end and parallel computers at the high-end. The same microprocessor architecture drives both the high-end parallel machines and the low-end portable computers [6].

CHAPTER FOUR: MARKET STUDY OF PC IN ETHIOPIA

4.1 Computer Application In Ethiopia-Background Information

4.1.1 Introduction

Computers were introduced in Ethiopia about half a century ago in the early 1960's. International companies that introduced computers into the country were IBM, NCR and BURROUGHS. They were involved in marketing, training and maintenance of computer related business in the country [44].

Not only IBM was the first to enter the Ethiopian market but also was popular in the early years. IBM was first introduced in 1962 with model 421/814-wired-panel computer. The first users of this model were the Ethiopian Airlines (EAL), the Ethio-Djibouti Railway Company (EDJRC) and the municipality of Addis Ababa. All mainly used the system for billing activities.

Later in 1964 IBM announced the introduction of model 1440 360/20 computers. This model was an auto coder that replaced model 421. IBM model 360/20 was one of the early card based computers which showed a true sense of electronic data processing system. They were installed in such organization like Ministry of Finance (MOF), Ethiopian Telecommunication Authority (ETA), EDJRC, and the Economic Commission for Africa (ECA).

In 1970s IBM system/3 series computes were introduced. This version marked the transition from card-based system to tape/disk system. Such units were installed in EDJRC, ETA, EELPA (Ethiopian Electric Light and Power Authority), Central Statistics Office (CSO) and the Ethiopian Air force.

The announcement of IBM system 34b was a migration to eliminate card systems from the information technology (IT) of the country. Such systems had the capacity of being used as multi-programming and multi-tasking systems. They were installed in such organizations like Shell Ethiopia, ETA, Addis Ababa Master Plan Project, Ethiopian Air Force and Kuraz Publishing Center. Later in 1984, system36, the next line to 34b, was introduced to the market and the users of this system were: Relief and Rehabilitation Commission (RRC), Addis Ababa Hilton, Ethiopian Import Export Corporation, Petroleum Corporation and EELPA.

4.1.2 Early Computer Users in Ethiopia

The major early computers users in the country were very few in number, mostly governmental institutions. Let us see how the start-up looked like in these organizations.

Central Statistics Authority (CSO):

CSO first started using automatic data processing in 1964 using IBM 421 model 14 mechanical machine for processing statistical data. In 1968 it acquired IBM system 360 model 20 card oriented electronic computer system. In 1973 CSO rented IBM system 3, which marked the transition from card-based to magnetic tape system. This unit had increased processing power and performance. The first census made in 1968 was conducted with the system 3 computers. In 1980, CSO installed NCR 8455, a multi-programming and multi-tasking system with virtual storage capacity. In 1983 the organization purchased the HP 3000 series computers, where at this stage its computer center was highly organized with trained staff and expatriate consultants. Library of software used by the center include FORTRAN, COBOL, RPGII, SPL, BASIC, PASCAL, and packages like SPSS, CONCOR, X TALLY and CO X TALLY report generation.

Ministry of Finance:

The ministry was first introduced to office automation in 1968 through the installation of IBM system 360. In 1976 the ministry shifted to Burroughs B3700 model, which had been the change from tape-oriented computer to disk-based computer.

Ethiopian Airlines (EAL):

EAL is considered as one of the earliest organizations which introduced modern information management system and office automaton. It started data processing in 1961 with IBM class 421 for financial operations. In 1964, EAL replaced its aging and outdated 421 with IBM 1440 card reader system for asset and inventory control applications. In 1970 EAL installed B3500 Burroughs computers. The increased work volume and competition in the industry called for the purchase of highly advanced HP computers in 1981. Ethiopian further consolidated its computer systems obtaining IBM 4361 in 1984 with sophisticated package applications such as:

CPATA - Airlines Revenue and Accounting system
EMPACS - Engineering and Maintenance Planning
IPOCS - Integrated Flight Operation System

Ethiopian Electric Light and Power Authority (EELPA)

The Authority started using computers first with NCR class 299 and IBM 421 for head office book-keeping in 1962. Then a data processing center was established in 1964 by installing IBM 1140. In 1973, EELPA rented IBM system 3/20 at a monthly charge of US$15,000. The system was utilized for general accounting and inventory system including payroll and billing preparations. In 1982, NCR V8455 computer was rented for use in engineering designs. Further, the organization enhanced its computer center by purchasing IBM 36/D21 computers in 1987.

Ethio-Djibouti Railway Company:

In 1969 the company bought IBM system 360/20 which had been effectively used for the preparation of payroll only. System 3 IBM computers were installed in 1972 to support the company's inventory control, general accounts and movement of trains and locomotives.

4.1.3. User Attitude

At the early days of the introduction of computers to the country things were extremely odd. Most people had a wrong impression about computers and as a result changes towards computerization were extremely challenged. This was so for three main reasons. Firstly, computers of those days were physically giant & scaring and cost wise very expensive. Secondly, there was no trained local manpower that could prove the benefits of computers and their sustainable effective usages. Thirdly, the computer centers of those days, or otherwise called electronic data processing (EDP) center, have conveyed the wrong attitude to the general employees. Such centers were represented as a scared place with "NO ENTRY" big posters which scared people to remain away.

Therefore, despite its immense benefits the pace of development of computer application in the country had remained for so long as one of the slowest. A survey made in 1989 showed that only about 80PCs existed throughout Addis Ababa. And most of them were available in international organizations and NGOs [44]. Some were available at educational institutions and in the hands of individuals. Thus, it can be said that most organizations installed computer systems in the last ten to twenty years.

Today's computers contain very powerful processors having a very low cycle time. Computer hardware has become so powerful and cheaper that virtually most centers and individuals can afford. Decades ago, giant computers were scaring to people. Now their miniaturized physical size makes people look friendly. Computer software's as well had advanced to the point where we can finally have confidence in using computers towards result-oriented applications.

As we can see in the next section, the application of PCs in Ethiopia is now expanding. With the introduction and wide spread use of the Internet the demand for PCs is increasing from time to time.

4.2. Determination Of Effective Present Demand

As discussed in section 4.1, the introduction of computer technology to Ethiopia dates back to the 1960s. Nevertheless the technology has remained confined to few organizations. It is only in the last ten to twenty years that we have seen relatively expanded use of computers particularly personal computers, which is the subject of this study.

In this section, the study attempts to quantity the effective present demand of personal computers (PCs) in the country. In doing so, we shall apply two methods: the method of *trend analysis* and the method of *market-buildup* based on sample survey [11,12,14].

4.2.1The Method of Trend Analysis

This method requires the formation of an estimating equation which describes the relationship between an independent variable, in this instance time, and a dependent variable, PC demand at a given particular time. For simplicity, let us represent the independent variable by the letter 'x' and the dependent variable by 'y'. Therefore, the estimating equation usually takes any of the following form:

a) $y = ax + b$, linear relationship

b) $y = ae^{bx}$, exponential relationship

c) $y = ax^{b}$, power relationship

Also, there could be other relationships based on polynomials of second, third and higher degrees. The quadratic $(y = ax + bx^2 + c)$, and the cubic $(y = ax + bx^2 + cx^3 + d)$, are commonly used polynomial equations in trend analysis. The best relationship is then selected using a best-fit curve approach that yields better coefficient of determination (R^2).

In Ethiopia, the application of PCs in the past was very limited and there is no well-recorded data and information that shows the rate of development of the technology since its first introduction in the 1960s.

Although a governmental regulatory body named the National Computer Center (NCC) was established in 1987, there is no comprehensive work done in the area that could be used as reference in determining the past demand of PCs in the country.

The only source this study found relevant was the record compiled by the Ethiopian Customs Authority but only for the past five years (table 4.1). According to this source, the import of computers in 1996 was 2,087 units and after five years the quantity of import reached more than 24,000 units in the year 2001. AS shown in figure 4.1 and 4.2, the import quantity showed rapid progress which almost doubled each year till 1999 where there was a record of more than 16,000 units of imports. In fact the demand in 2000 has only increased by only 49% as compared to the previous years of increment which was near to 100%.

The reason for the rapid increase of the demand for PCs observed between 1996 and 1999 could be explained by the following two facts. First, the price of computers has continuously declined substantially that many users were encouraged to purchase some units. Secondly, the widespread use of information technology in the country including the Internet has called for the availability of more and more PCs.

Here it should be emphasized that the total number of import of PCs indicated for each year under consideration does not necessarily mean that computer vendors provided the whole amount commercially. To the contrary, considerable amount of the import may have been attributed to donations and grants provided by different sources to various organizations such as higher learning institutions, research centers and NGOs.

Import of Computers (1996-2000)			
S.N	Year	QTY, unit	CIF Value, ETB in millions
1	1996	2,087	51
2	1997	4,732	47
3	1998	9,319	65
4	1999	16,356	120
5	2000	24,442	122
Total		56,936	415

Table 4.1
Import of Computers
Source: Ethiopian Customs Authority (ECA)

As one can observe from figure 4.2, the country has imported PCs of worth more than 415 million Birr in CIF values during the time between 1996 and 2000. The average price of a PC observed during this period was Birr 24,000 in 1996 and Birr 8,000 in the year 2000, values taken considering only CIF at the port of Assab or Djibouti. At the market place in Addis Ababa, the price of an average brand of PC was some 30,000 Birr in the year 1996 which then showed a sharp decline to less than 15,000 Birr in the year 2000.

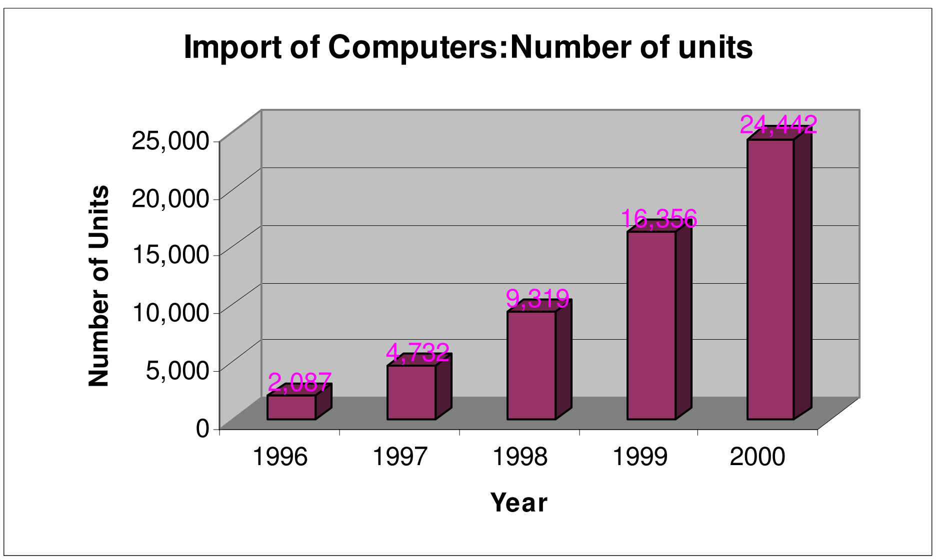


Fig.4.1 Import of Computers in Quantities
Source: ECA

Source of import to the country are largely from Asia (Japan, Singapore, Thailand, Taiwan, China, South Korea, Indonesian and Saudi Arabia), Europe and North America (U.S.A and Canada). From the African continent, imports from South Africa, and Egypt were recorded although the amount was not so big as compared to the other sources, Fig.4.3 (a). As shown in figure 4.3 (b), the five years average import statistics indicate that imports from Asia accounted for about 38% followed by imports form Europe and North America, which respectively accounted for 35% and 25%. The import from African countries constituted for only 2% which was mostly covered by South Africa.

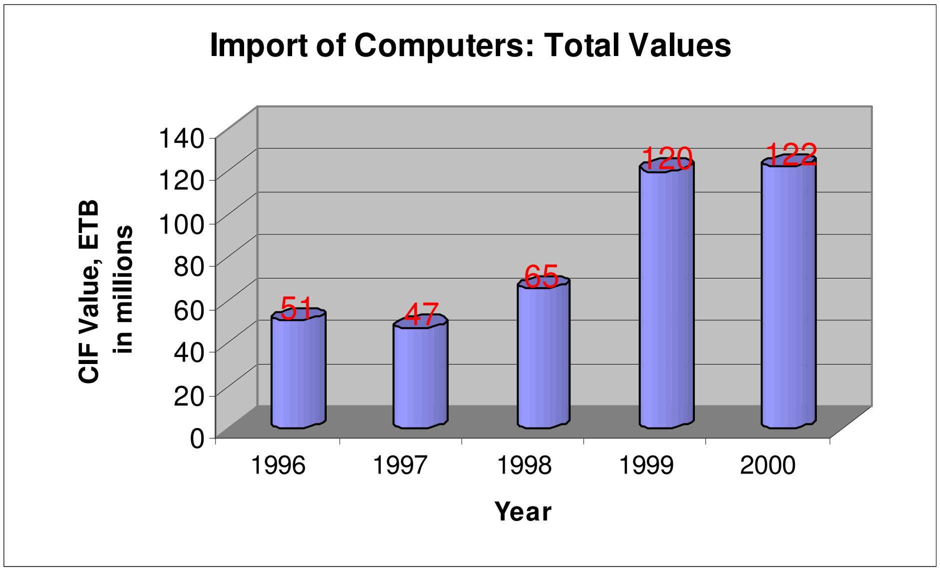


Fig. 4.2 Import of Computers in CIF Values
Source: ECA

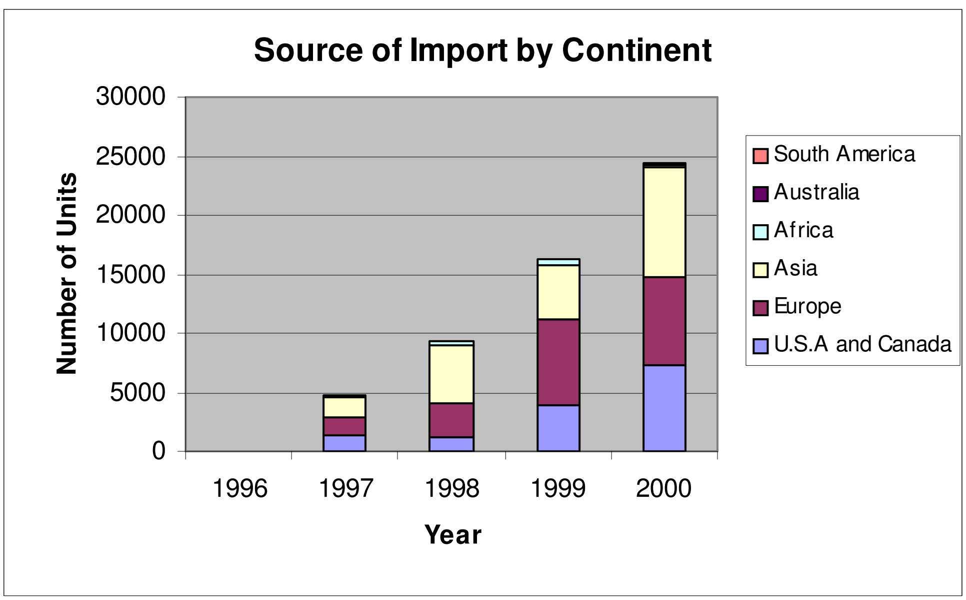


Fig.4.3 (a)

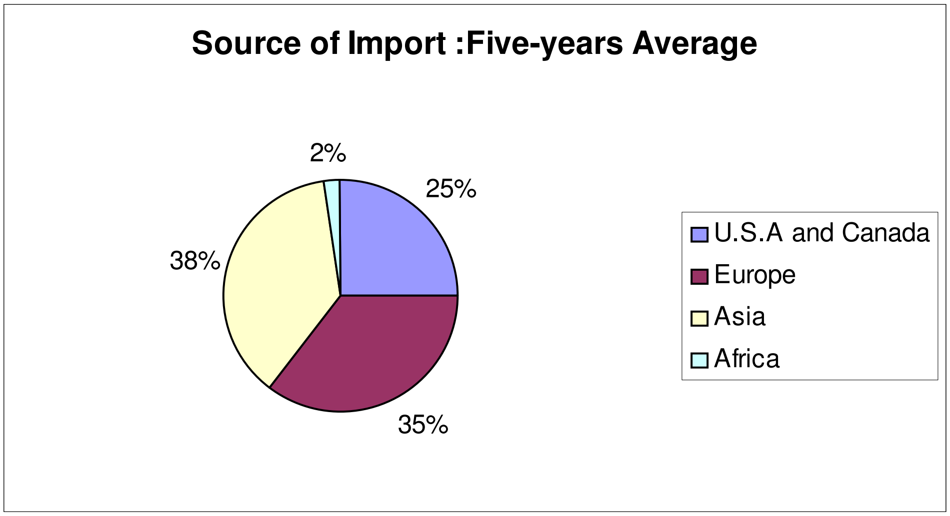


Fig.4.3 (b)

With the five years import data for personal computers, regression analysis is made considering three different models to describe the trend. The result is as follows:

Model relationship considered	Estimating equation obtained	Coefficient of determination or correlation R^2
Linear	y = 5633.4x-5513	0.9611
Power	$\boldsymbol{y=1880.8x^{1.5362}}$	***0.9875***
Exponential	$y=1289.4e^{0.6161}$	0.9833

The choice of which estimating equation describes best the given data is determined considering the test made by the coefficient of determination (R^2).

R^2 is defined as [13]:

R^2 = (SS due to regression)/(total SS, correlated to the mean ỹ);

Where SS = sum of squared deviations. Or, R^2 can be expressed as

$$R^2 = \frac{\sum(\hat{y}_i - y)^2}{\sum(y_i - y)^2}$$, $\hat{y}_i$ = calculated value

ỹ = mean data value

R^2 measures the proportion of total variation about the mean ỹ explained by the regression. In fact R is the correlation between y and ŷ and is usually called the multiple correlation coefficient.

The value of R^2 ranges from 0 to 1. The higher the value of R^2 the better the data is represented by that equation. At the lower extreme, zero value of R^2 means there is no correlation at all, and at the other extreme a value of unity means there is 100% correlation.

According to this criterion, therefore, the power model of relationship shown above is taken as the best estimating equation for the data in question. That is the estimating equation can be described as:

$y = 1880.8x^{1.5362}$, with $R^2 = 0.9875$

Where y= the demand for PC in number of units; and

x= the length of time in years taking year 1996 as the base year

Figure 4.4, 4.5, and 4.6 respectively show Linear, Power and Exponential regression analysis graphically.

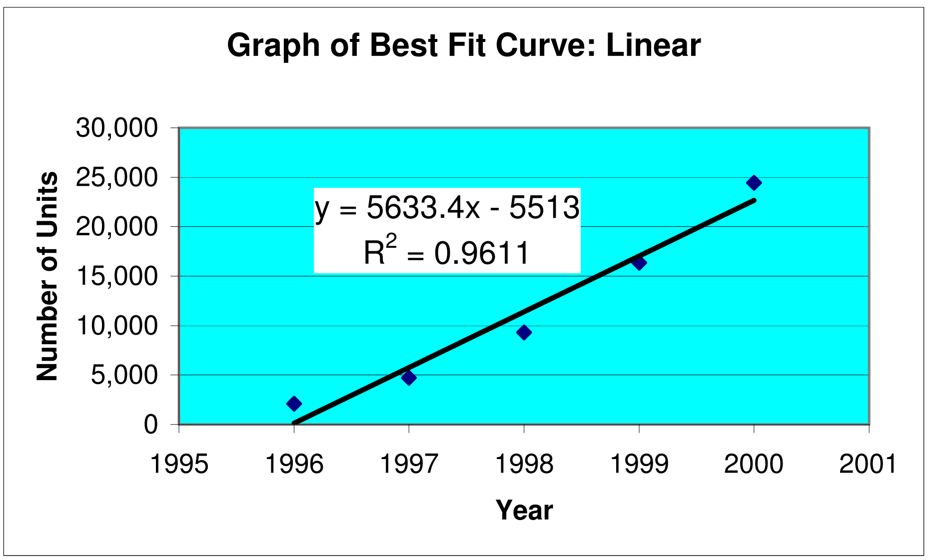


Fig. 4.4

4.2.2 Future Forecast

Therefore, according to the estimating equation established above the present effective demand as well as the future projection can be worked out straight forward by substituting values of x (the required period taking year 1996 as the reference year). Projection made in this way are depicted in table 4.2 where one can see the demand for the current year is in the order of 37,000 number of units. After some ten years form now, the demand forecast (in year 2010) is shown to be about 120,000, Fig.4.7. In fact, future forecasts cannot be exclusively determined by the above estimating equation alone. The mathematical relationship should be supplemented by realistic situations such as the pace of economic development of the country and the rate of growth of information technology in the country which is directly related to the demand of PCs.

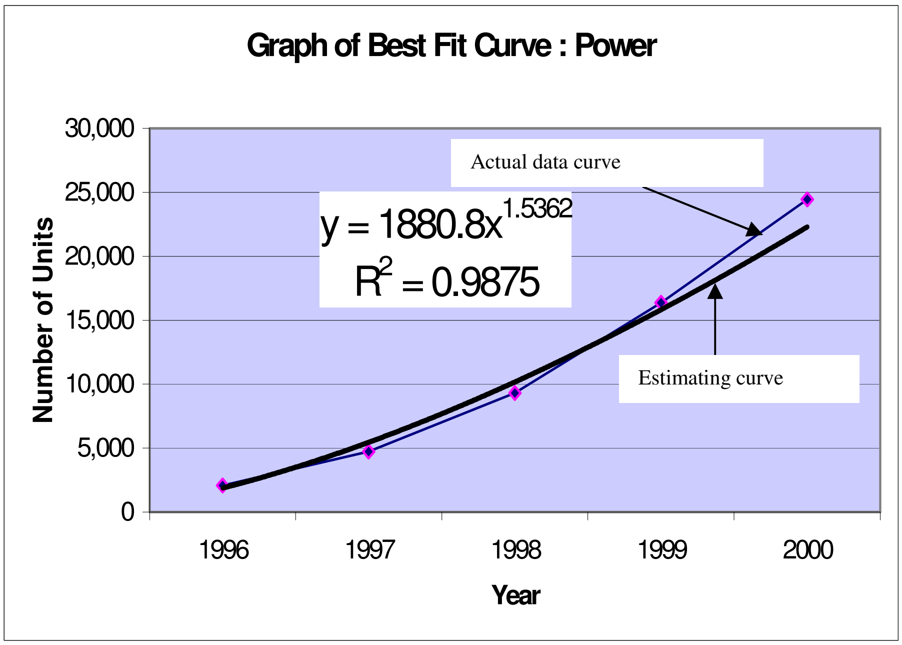


Fig. 4.5

Also, the nature of architectural changes in the hardware technology of computers might influence the trend of future demand of PCs.

Table 4.2 Forecasts of Computer demand

Projections based on the power equation $y = 1880.8x^{1.5362}$

x	Year	y (QTY, unit)
6	2001	29,494
7	2002	37,375
8	2003	45,885
9	2004	54,986
10	2005	64,646
11	2006	74,839
12	2007	85,542
13	2008	96,735
14	2009	108,399
15	2010	120,519

y : represents Number of Computers
x: represents the period in years

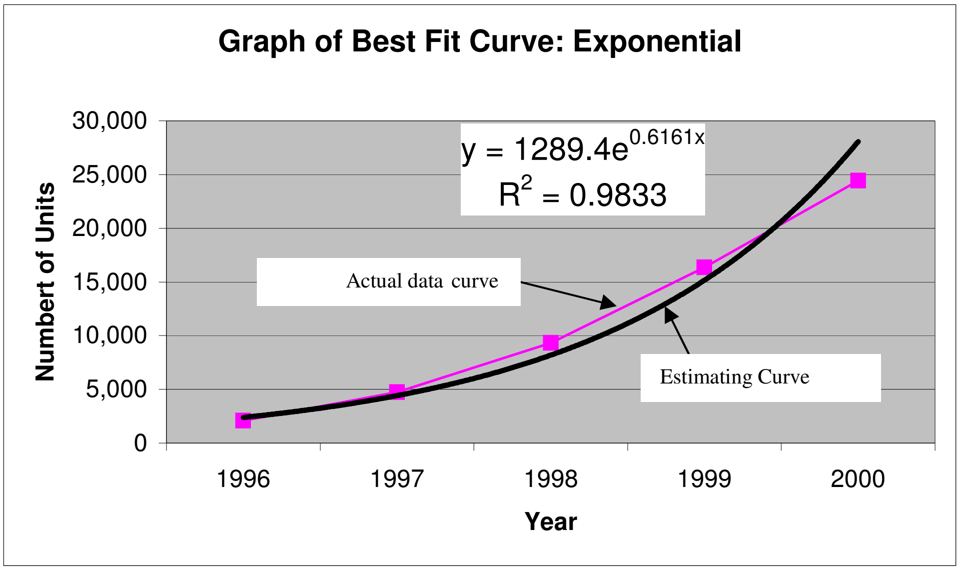


Fig. 4.6

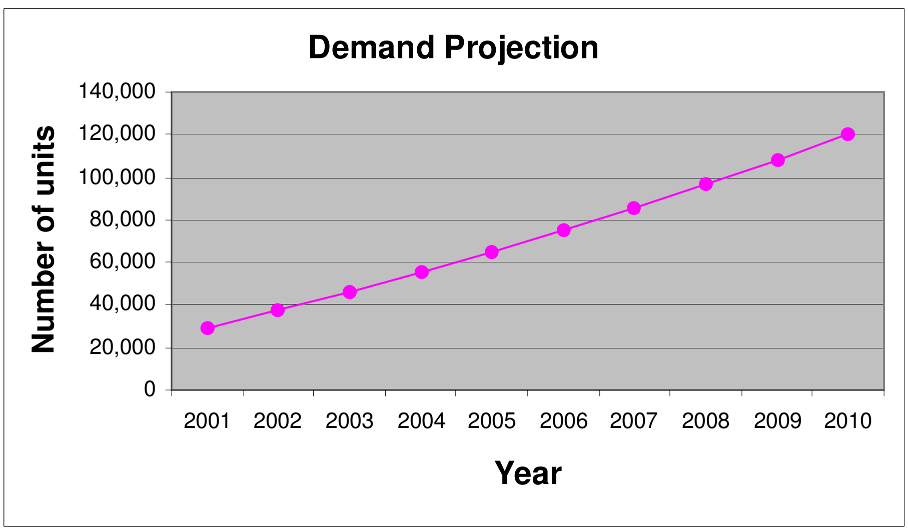


Fig. 4.7

4.2.3 Market-Buildup Method Based on Sample Survey

The determination of total market potential for personal computer is not a simple task. We need to estimate the market potential of different group of users. Two major methods are available: *the market buildup method*, which is used primarily by business marketers, and the *multiple-factor index* method, which is used primarily by consumer marketers [11].

In connection to our case the market-buildup method can be applied to estimate the demand of PCs in all potential institutional buyers. The multiple-factor index method would be appropriate to estimate the demand of computers for household applications. However, the present reality in the country will dictate us to automatically discard the second assumption, as the number of computers used as household objects is negligible.

For the purpose of comparison the computer per household ratio for U.S.A and Singapore have reached 1to3, Taiwan 1to20 and for China 1to100 [22,30]. The present status in our country is very far behind that one cannot talk in terms of computer per household ratio index. But it is obvious that this method provides a straightforward approach, for example in our case the demand of PCs would be directly related to the size of a country's population. Thus to estimate the potential demand of PCs in the country, we will use the market buildup method which is discussed in the following section.

4.2.3.1 Brief Status of Information Technology (IT) in Ethiopia

Before we go into the discussion of the potential computer users in Ethiopia let us briefly review the present status of information technology in the country.

Information technology has three components: computers, communication system and know-how. The integration of these three elements will lead to the effective use of IT in problem solving. The primary purpose of IT, therefore, is problem solving. Opportunities come form having the know-how to apply the capabilities of computers and communication system to solve problems and to help people and organizations reach their potential there by bringing positive contribution to economic development.

The problem of IT in Ethiopia is reflected in all the three individual elements and in their integrity. There is no well-established policy which aims in shaping the computer technology compatible to the country, in terms of hardware and software, towards the provision of the country's need in socio-economic development. The know-how had also been another barrier to IT development. In the past few years the problem was so acute that many computer centers were facing serious manpower problems.

Communication system is now a vital element in the network of IT system. Particularly, the telecommunication system is a basic factor that determines the use and expansion of wide-area network IT systems and the Internet services. Despite the long history of the telecommunication sector in Ethiopia, its service coverage has remained as one of the least in the world. Information obtained from the Ethiopian Telecommunication Corporation (ETC), the regulatory body responsible for pricing, tariff of telecommunications services, licensing, frequency management and Internet functions, reveals that there are now 283,683 telephone subscribers in the country. On the other hand, there is a waiting list of more than 155,000 for telephone lines [23]. Currently, 127 towns and cities have been interconnected within the country. The data from ETC further indicate that Ethiopia currently has a tele-density of 0.43. The level of growth of the Internet is also found at the lowest stage. It is estimated that the current number of subscribers does not exceed 4,000. If we assume five persons per Internet account the total number of Internet users in the country could not exceed 20,000 (out of a population of 65 million!).

The above data clearly indicate that the ETC has a lot to do to meet the growing demand of the population for telecommunications services.

In conclusion, the increasing demand for personal computers and related hardware and software applications, the digitalization of telecommunications and the rapid expansion of the Internet should be taken into consideration in the formulation of a comprehensive national ICT (Information Communication Technology) policy. In addition, the policy should address the issue of building local capability to develop and manufacture ICT related items such as computer hardware, software and telecommunications equipment.

Ethiopia is now in a process of establishing an ICT policy which is believed to tackle the above mentioned inherent problems. AT this stage every one has realized that ICT is no more considered as an instrument of luxury but a proven tool that one must be equipped with in the fight against poverty and in the effort to secure sustainable economic development [17,27]. In this regard, as pointed out above, the local production of computers and their expanded use in the framework of ICT should be one area of concern of the existing government. Therefore, ***it can be said that the subject of this research is fortunately timely and inherently relevant.***

Having said this regarding the general situation of the ICT in the country now let us come back to the point of discussion of this section, that is identifying potential computer users in Ethiopia.

4.2.3.2 Identification of Potential Users

The market-buildup method calls for identifying all potential users and estimating their potential demand. The problem here is we have no exhaustive list of all potential computer users. But not only that we also have no readily made available estimates of what each potential user will demand. Therefore, first the study will attempt to identify all possible potential institutional computer users and then a sample survey analysis shall be carried out to estimate the demand in each category of users that will finally lead us to come to the aggregate demand.

Up to now computers and information technology have been largely used for improving productivity or making life of the office worker or of management easier. Almost all of the computers in Ethiopia are used for office automation or other management-oriented applications, like payroll, sales accounting, stores accounting, word processing, etc.

Recently some organizations have come up with new breed of application, still related to data processing that support management decision systems. These are such applications like computer aided production planning, computer-aided inventory control, computer aided project management, computer-aided design, etc.

Therefore, it is in the above sense that we will try to identify the potential computer users in the country. Accordingly, the general classification relevant to our objective would be as follows:

- Manufacturing sector
- Government (offices) sector
- Business (including service) sector
- Education (including research sector)
- Others (NGOs, ICT companies, e-mail/Internet service centers, consultants)

Next, we need to describe each sector taking relevant measuring parameters that will lead us to a reasonable estimate of the demand of computers in each sector. But, before that let us discuss the basic principles of sampling plan applicable to market analysis.

Sampling plan in market research involves three decisions [11,14]:

1. *Sampling unit* - This defines the target population that must be sampled.
2. *Sample size* - Though large samples give more reliable results, it is costly and not necessary to sample the entire population or a substantial portion to achieve reliable results. There is a famous saying that it is not necessary to eat the whole ox to test the quality of meat.
3. *Sampling procedure* - To obtain representative sample, a probability sample of the population should be drawn. When the cost or time involved in probability sampling is too high, non-probability samples can be quite useful. Table 4.3 describes both types of sampling procedures. Some marketing researchers feel that non-probability samples can be very useful, even though the sampling error cannot be measured. In this study too it is preferred to follow the non-probability method of sampling.

Table 4.3 Types of probability and non-probability samples

Method	Type	Description
Probability sample	Simple random	Every member of the population has a known and equal chance of selection.
	Stratified random	Population divided into mutually exclusive groups and random samples drawn from each group
	Cluster	Population divided into mutually exclusive groups and the researcher draws a sample of the groups for analysis
Non- probability sample	Convenience sample	Most accessible members of the population selected to obtain information
	Judgment sample	Population members selected based on judgment for accurate information
	Quota sample	Prescribed number of samples taken from each of several categories

Contact Methods:

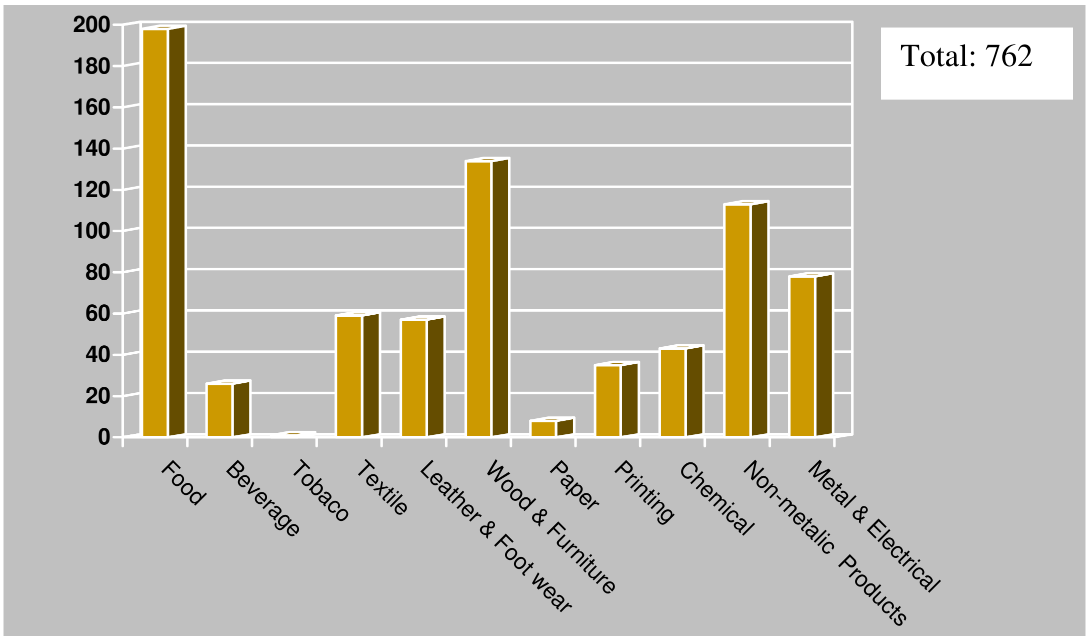
The choices through are mail, telephone, or personal interviews. Each has its own advantages and disadvantages. In this study the researcher has used all the three contact methods as found convenient.

a) The Manufacturing Sector

The manufacturing sector in Ethiopia is found in an early stage of development contributing 10% to the GDP and holding only 9.5% of employment. Products of this sector include textiles, foodstuff, tobacco, beverages, cement, leather products, wood, metallic and non-metallic products, paper and plastics. Main exports from this sector are leather and leather products, canned & frozen meat and sugar [32].

According to the information obtained from the Central Statistics Authority (CSA), the total number of manufacturing industries in 1997/98 was 762 (figure 4.8). Also, the same source has indicated that the total value of production by this sector in that period was about 6.4 billion Birr (figure 4.9). The total number of industries operating in the country has now reached 800 or so, the majority of which are involved in the supply of consumer goods mostly to the domestic market.

Figure 4.8 Manufacturing Industries by Type (1997/1998)

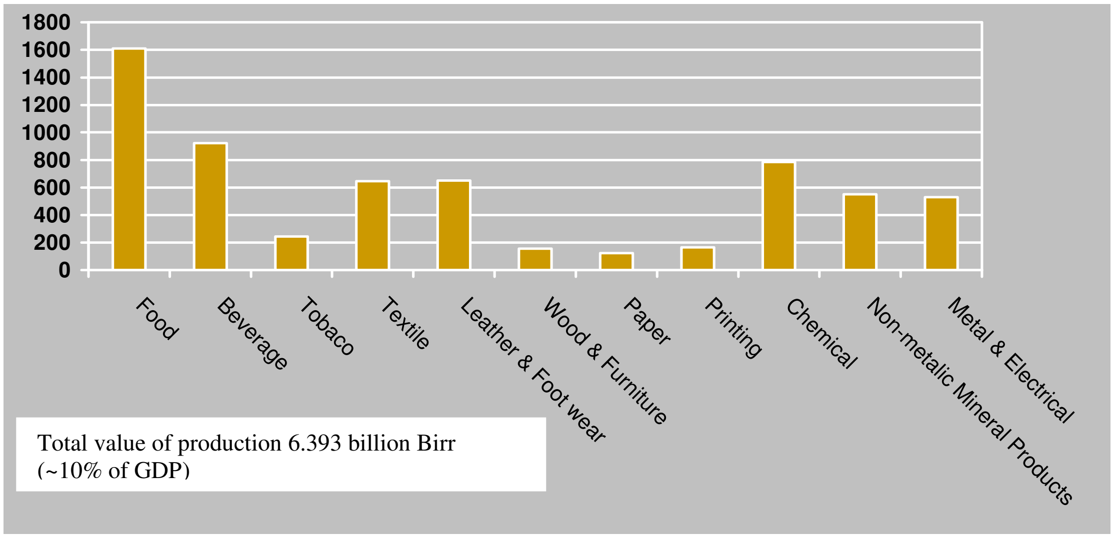


Source: CSA Statistical Abstract 2000

Taking the value of total asset owned, annual volume of production and number of employees into consideration the manufacturing industries can be relatively classified into three groups: large scale, medium scale and small scale. Accordingly the 800 industries in the country are distributed in the following manner. The largest number, about 405 accounts for small scale, 245 for medium scale and only 150 industries can be categorized as large scale.

A survey made in this study to assess the status of computer application in some of the industries here in the capital (randomly selected 10% samples from each group) shows that almost all the enterprises in study use computer for office automation. Very few firms apply computer to control inventories and to produce some general plans. Some have connections to the Internet and use it for e-mail correspondence. No company was seen to have its own web site. The only difference observed among the three classes of industries regarding their computer application was in the number of computers they own.

Figure 4.9 Manufacturing Industries of Ethiopia by Gross Value of Production for the year 1997/98 (in millions of Birr)



Source: CSA Statistical Abstract 2000

All of them have desktop personal computers and on the average the large scale companies possess or demand more than 10PCs,the medium scale up to 5PCs and small scale 2 PCs per firm.

Although the samples taken cannot be argued as sufficient and well representative, it could serve the purpose of estimating the demand of computer in the sector. Therefore, according to the above analysis the total present number of computers demanded by the manufacturing sector could be estimated between 3000 to 4000 (see table 4.4)

Table 4.4 Estimates Of Computer Demand In The Manufacturing Sector

Description	*Small Scale*	*Medium Scale*	*Large scale*	*Grand total*
Sample size = 10% of population	40	25	15	80
No. of respondent	32 (80%)	19 (76%)	11(73%)	62(77.5%)
Ave. number of computer per sample	2	5	10	-
Total population size	405	245	150	800
Total estimates of number of computers	810	1225	1500	**3535**

Note: Format of the questionnaire used in the sample survey is shown at the end of this chapter

b) Government (offices sector)

The size of this sector is so big that it is difficult to reach every office and assess the demand for computers. Therefore, the methodology applied here too is first to quantify the size of work force in this sector and then determine the number of civil service offices both at the federal and regional levels. In doing so, information obtained from the Federal Civil Service Commission (CSC) have been used as the main source (table 4.5). Next, some randomly selected offices which are located in Addis Ababa were visited to gather data concerning the use and demand of computers in the respective offices.

The information obtained from the Federal Civil Service Commission shows that there are nine National Regional States (Tigray, Amhara, Oromya, Somale, Benshangul Gumuz, Hareri, Addis Ababa City Administration, and Diredawa Administration Council) that have complete manpower data. Each of these states comprises 15 offices of different duties and responsibilities. Thus the number of government offices in the Regional States would be about 135 [33]. From table 4.5 we see that the number of Federal government offices is 93, which brings the number of government offices all over the country to 228.

According to the survey made in the capital (in 11 offices, which represent about 5% of the total population) a single government office needs 30 to 50 PCs on an average. This will lead us to the conclusion that government offices all over the country currently demand about 6,840 numbers of computers. Here, we have made two assumptions. First, a function below a department level is less likely to use a computer and hence not taken into considerations. Second, some offices like the customs office, statistics office, meteorology, etc are believed to have a substantial number of computers, but no special treatment is made with regard to this institutions. The purpose, therefore, is to come up with at least the minimum estimate of computers needed and to reach into fair estimate of the current demand.

c) Business (Including Service) Sector

This sector incorporates a large number of firms both small and big ones in terms of asset ownership and turnover of capital. By business sector it is meant that those who are involved in the trading activities (import, export distribution and retailing), hotel services, banking and insurance, travel and tourism services, etc.

Obviously the list under this category could reach tens of thousands if not hundreds of thousands. However, the study has found it reasonable to consider those business entities that are organized in trade associations such as the chambers of commerce. In this respect according to data obtained from the Addis Ababa Chamber of Commerce (AACC), which have the largest number of membership than any of the other chambers in the country, there are about 7,500 companies involved in different business lines. This figure refers only to the size of business firms in Addis Ababa and at the same time those who are members of the Addis Ababa Chamber of commerce.

Table 6.6 shows the classifications of these companies in terms of range of capital, and we see that the grouping constitutes eleven ranges. The first groups of companies have capital ownership of above 1,000,000 Birr and are about 300 in number. The last group, on the other hand is with a capital of 1,000 to 2,000 Birr and their number is about 80.

The same source also shows that currently, the numbers of traders that are connected to the Internet are not more than 1000. However, because of the growing importance of *e-commerce* (electronic-commerce) the number of Internet users is expected to increase along with the expansion of Internet service in the country. To understand how e-commerce is getting importance world wide let us see the situation in some details.

E-commerce is the process of business transactions carried out through the Internet technologies. In simple terms it is business that runs 24 hours a day throughout the year where trade can happen from any country or continent in the world.

Table 4.5 a number of offices and employees of the Federal State

No.	Name of Organization	Number of other units reporting to the organization	Number of permanent employees
1.	House of peoples representative	3	639
2.	Office of the president	1	712
3.	Office of the Prime Minster	1	333
4.	Ministry of Justice	2	1,275
5.	Ministry of Education	-	324
6.	Ministry of Agriculture	8	2,440
7.	Ministry of Information & culture	4	769
8.	Ministry of National Defense	-	4,941
9.	Ministry of Finance	-	760
10.	Ministry of Works & Urban Dev.	4	446
11.	Ministry of Foreign Affairs	-	539
12.	Ministry of Health	5	1,872
13.	Ministry of Transport & communication	2	638
14.	Ministry of Labour & Social Affairs	1	888
15.	Ministry of Mines & Energy	2	1,147
16.	Ministry of Water Resource	1	1,265
17.	Ministry of Economic Development & Cooperation	2	2,168
18.	Ministry of Trade & Industry	-	320
19.	Ethiopian Science & Technology Commission	3	285
20.	Tourism Commission	1	148
21.	Disaster Prevention and Preparedness Commission	1	1,166
22.	Federal Civil Service Commission	-	272
23.	Sports Commission	-	246
24.	Federal Government Revenue Board	1	286
25.	The National Election Board	-	85
26.	Environmental Protection Authority	-	87
27.	Coffee & Tea Authority	-	440
28.	Federal Offices Administered by Board	26	9,710
Total		***65***	***34,201***

* Education sector is already considered as a separate section; here only the Ministry office is taken into account.

E-commerce is preferred to a conventional trading because of the tremendous saving it provides. It is shown that the cost of full-service traditional trading transaction is about $150 whereas doing the same using the Internet is less than $10. As a result companies in the developed nations are on the verge of a total shift to doing business electronically.

Table 4.6 numbers of Business firms in Addis Ababa in range of capital.

Group	Range of Capital (Birr)	No. of Companies
1.	1,000,001 and above	301
2.	500,001-1,000,000	114
3.	200,001-500,000	212
4.	100,001-200,000	212
5.	50,001-10,000	349
6.	30,001-50,000	417
7.	20,001-30,000	233
8.	10,001-20,000	751
9.	4,001-10,000	3938
10.	2,001-4,000	135
11.	1,000-2000	84
Total		***7504***

Source: A.A Chamber of Commerce

Currently e-commerce activity has reached more than $200 billon a year worldwide. (Table 4.7.) The estimated e-commerce revenue will reach a total of $1,442 billion by 2003. Africa will benefit only about 2% of that amount; and only those countries that make a move towards establishing e-commerce will get their share from this revenue generation [24,35,41].

Therefore, the global trend shows that e-commerce is not only getting wide acceptance but is also the best way of getting involved in the global trade for countries like Ethiopia because it provides less expensive but efficient means of reaching a wider market scope, while shortening the chain of contact by cutting out middle brokers.

Table 4.7 Status Of World E-Commerce Revenue In Billions Of US Dollars Per Year

	1999	2000	2001	2002	2003
North America	82	179	334	565	905
Europe	16	34	67	168	420
Asia	6	15	30	53	88
Rest of world	2	5	13	19	29
Global total	106	233	444	805	1442

Source: http://www.ethiopiaknowledge.org/links.htm

If developing countries fall further behind the ICT development, there is a general fear that e-commerce would widen the gap between developed and developing countries.

Coming back to the estimates of PCs currently needed in the business sector the methodology pursued was as follows. First, it is assumed that only those which are members of AACC would utilize computers. Second, considering the opinions gathered from experts of the chamber, companies with a capital of Birr 500,000 and above would possess at least four computers, those in command of capital between 100,000 and 500,000 Birr would possess at least two computers and the rest only one computer.

This analysis has consciously undermined the demand of a large number of computers in such companies like the banking, insurance, travel and tourism services. This is done so in order to compensate for the possibility of the inclusion of companies running with out employing computers at all. With this understanding and the above expert's opinions and in consultation to the data given in table 4.6 the total number of computers currently demanded in the business sector of Adds Ababa are estimated to the order of 8,500 PCs.

Addis Ababa is the center of business in the country; moreover, it is only in the city that we have full service of the Internet. Taking this fact into account business firms outside the city who are supposed to use computers in their activities could not be as such significant. To estimate their number one may use the ratio of industries in the city to that of outside the city. According to this index, more than 80% of the manufacturing firms are located in Addis Ababa. If we apply this comparison to the possible computer users outside the city, the number could not surpass 20% of the users in Addis. With this analysis the total number of computers needed by the business sector of the country would be around 10,000 PCs.

d) Education (including research) sector

Primary & Secondary Education:

According to the projections made by the Central Statistics Authority (CSA) the population of Ethiopia at present is around 65 million. The same source also indicates that the total school age population for the primary and secondary levels is about 13.5 million and 5.8 million respectively. On the other hand, data obtained from the Ministry of Education (MOE) reveals that the current enrolment ratio is 45.8% and 9.7% respectively for the primary and secondary levels [34].

The above data show that access to the primary and secondary education should be expanded by raising the rate of enrolment from time to time. Currently the national education expenditure stand at 15 Billion Birr per year. The information obtained from the MOE further reveals that there are 11,952 primary (1-8) schools and 418 Senior Secondary (9-12) schools all over the country (table 4.8)

The present day situation of global trend demands IT education to develop right from the grass root level that is primary and secondary schools. This means every school must be supplied with perhaps 5 or 10 computers.

And this will only be possible if the computers and software are cost effective, which can be realized by investing on computer hardware and promoting the development of the right software for the purpose.

Table 4.8 Primary And Secondary Level Schools By Year

Year	*Primary (1-8)*	*Secondary (9-12)*
1995	9,463	329
1996	9,874	346
1997	10,394	369
1998	10,752	382
1999	11,051	386
2000	11,493	401
2001	11,952	418

Source: Ministry of Education,

Annual abstract, 1998/99

If we assume that 5 computers will be supplied to each secondary school [18] in the country, then the total amount required will be 2,100 PCs. There is now a strong initiative by the government that IT education has to be included in the curriculum of secondary schools that the above estimate of demand is not far from realistic. The introduction of computers to the primary school, on the other hand, though essential, will not happen even in the long-term given the current economic situation of the country.

Training Institution:

Table 6.9 shows Technical and vocational schools as well as teacher training institutions (TTI) in Ethiopia. The total number in the respective order is 16 and 11. According to the new policy of education put in practice starting this year, we will have many more additional technical and vocational school that train students in 10+1 and 10+2 programs.

Table 4.9 Technical/Vocational Schools and TTI

Type	*Number*	*Total enrolment capacity*
Technical/vocational	16	3,374
TTI	11	5,678
Total	27	9,052

Source: Ministry of Education,
Annual abstract, 1998/99

Assuming at the minimum that these institutions will have 10PCs each, about 270 computers will be in demand. In fact some of the technical schools like the Don-Bosco Technical School at Mekalle and Zeway Technical Center at Zeway do have a well organized computer labs equipped with more than 20PCs that give intensive IT training for students. Thus an average assumption of 10 PCs per institution is just logical.

Higher Learning Institutions:

Most Higher Learning Institutions in Ethiopia are publicly owned. Recently private investors are entering the sector, which is a good start that could alleviate the burden on the government on the one hand and provide the required training for those who are able to pay there by improving the problem of skilled manpower on the other hand. Among the recently established private institutions, the Unity College is becoming famous and currently has 10,000 enrolments with more than 300 teaching, administrative and support staff.

In this study, however, we will not consider privately owned higher learning institutions but focus on the public ones. At present there are five universities including Addis Ababa University (A.A.U). The A.A.U is the largest of all which was established more than half a century ago. In addition, there are a number of colleges that give various training in different fields of studies. Table 6.10 shows the universities and colleges in the country. The current level of total enrolment in the regular program in all universities and colleges across the country is in the order of 31,000 with close to 2,250 teaching staff.

With the above general information we can estimate the present number of computers demanded by the higher learning institutions. A survey made in some of the colleges and faculties in Addis Ababa indicates that at least 20 to 30 PCs are demanded in each colleges & faculties for teaching activities. Moreover, it could be straight forward assumption that each and every instructor needs a PC both for the preparation of teaching materials and doing researches. Altogether, therefore, the higher learning institutions all over the country need some 3000 or 4000 computers. Presently the availability of computers in those institutions is substantially less than this estimate except in some particular faculties that provide training in computer science and IT related subjects.

On the average estimate the present demand of PCs in the education sector (secondary schools, Technical/Vocational schools, TTI and higher learning institutions) is about 5000units. According to recent information from the MOE, preparations have been completed to double the capacity of enrolment in all the universities. Therefore, shortly afterwards the demand of computers in this sector would be doubled to a level 8000 or 10,000 PCs.

e) Others

Apart form the major computer demand areas discussed in the previous sections, there are also some users whose consideration is worthwhile in reaching the total present demand for the item. Among these are NGOs (non governmental organizations) operating in the country, training centers that are exclusively involved in computer and IT training, e-mail/Internet service providers and consulting firms. Obviously, every one of them cannot be dealt with in this research thesis. Only two of them, namely NGOs and ICT companies shall be considered, and based on this result a percent estimate shall be made for the remaining groups in this category.

NGOs:

NGOs, particularly those with international network, are found to have been utilizing computers effectively. Information obtained from the Federal Disaster Prevention and Preparedness Commission (DPPC) reveal that currently 416 NGOs are operating in the country involved in various activities including health, education, environment, infrastructure, etc [28].

Table 4.10 Universities and Colleges in Ethiopia.

No.	*Name of Institution*	*Number of faculties*	*Estimated enrolment (regular)*	*Number of teaching staff (regular)*
1.	Addis Ababa University	14	11,000	750
2.	Gonder College of Medical Science	1	850	90
3.	Bahir Dar Teacher's College	1	1,100	65
4.	Awassa College of Agriculture	1	800	95
5.	Alemaya University of Agriculture	3	2,200	165
6.	Ambo College of Agriculture	1	470	45
7.	Addis Ababa College of Commerce	1	2,000	80
8.	Jimma College of Agriculture	1	510	50
9.	Bahir Dar Polytechnic Institute	1	630	60
10.	Kotebe College of Teacher Education	1	600	95
11.	Wondo Genet College of Forestry	1	240	25
12.	Arba Minch Water Technology	1	830	70
13.	Mekele Business College	1	620	40
14.	Ethiopian Civil Service College	1	1,600	115
15.	Jimma Institute of Health Science	1	2,000	230
16	Nazareth Technical College	1	800	110
17.	Mekele University College	1	650	70
18.	Dilla College of Teacher Education	1	1,220	90
19.	Colleges of Teacher Education *	5	3,000	NA
Total		**38**	**31,120**	**2,245**

Source: Ministry of Education, Annual abstract, 1998/99 NA: Data not available

* Found at various locations

Computer application in these organizations ranges from office automation to data processing in a wide-area network. The NGOs are of varying capacity in terms of size of employment, budget and geographical service coverage. Fore example, the International Committee for Red Cross (ICRC), the United States Agency for International Development (USAID) and the Catholic Relief Service (CRS) are among the big NGOs. Such organizations deploy a considerable number of computers, up to 20 PCs each.

However, an interview made by the researcher with most of the office selected for ample survey has confirmed that 5 PCs are the average number frequently encountered. Hence the total number of computer in all the NGOs, estimated to the lower side, is about 2100 PCS.

ICT Companies:

At present there are over 120 ICT companies all over the country, the majority of which, about 100, are located in the capital. These companies provide a combination of services including computer training, sales of computer and computer accessories, web site development, networking, software development and maintenance.

ICT companies involved in the business of providing computer-training courses need the greater number of PCs than the other ICT companies. According to ICT focus, a local magazine on information and communication technology, issue of Feb. 2002, the number of ICT training companies at present in Addis Ababa only is 75. On the other hand, information obtained from the Trade and Industry Bureau of the Tigray National Regional State shows that two ICT companies are currently operating at Mekale, the capital of the region. This number could be safely applied to the other six major towns in the country, namely, Bahir Dar, Gondar, Nazareth, Awassa, Dire Dawa and Harar. This would bring the current total number of ICT training companies in Ethiopia to about 89 [23,29].

A survey made in some of the training firms in Addis Ababa shows that on the average there are about 10PCs per firm. This would give us an estimated quantity of PCs currently in use in the ICT training companies to be around 890. Therefore it can be said that the number of PCs demanded by all the ICT companies in the country is in the order of 1000 PCs.

Based on the above analysis, therefore, the current demand of PCs in NGOs and ICT companies combined together reaches some 3100 PCs. At the beginning of this section, we have defined the group referred to as "others" would include computer users such as NGOs, ICT companies, e-mail/Internet service centers, consultants, etc. We have already determined the demand existing in NGOs and ICT companies. For the rest in this group, we will apply percent estimates based on the findings of the first two. Accordingly, just taking an assumption of 10% to 20%, the estimated numbers of PCs demanded in this group referred to as "others" is about 3500 PCs.

4.2.3.3 The Present Aggregate Demand

Summing up the estimates provided above, according to market-buildup method, table 3.11 shows the aggregate present demand of computers in the country, which is in the order of 29,000 PCs.

Table 4.11 Aggregate Present Demand of Computer in Ethiopia

No.	User sector	Quantity demand in number of PCs
1.	Manufacturing	3,580
2.	Government offices	6,840
3.	Business	10,000
4.	Education & research	5,000
5.	Others (NGOs, etc)	3,500
	Total	***28,920***

The demand analysis made by the method of trend analysis of computer imports as well as sample survey according to market build-up method have resulted in a variation of only about 4,500 PCs for the current demand. The method of trend analysis seems to have overestimated the market to some extent. The reason, in the opinion of the researcher, could be the registration of some electronic equipments, say like industrial microprocessors, lumped together in the list of personal computers. Even so, however, the import of such PC related items is not as such large that basically it will not create data disagreement.

Thus based on the results of both methods of market analysis, the present demand for personal computers in Ethiopia is in the range of 25,000 to 30,000 PCs. For the purpose of future projections the import statistics can be relied upon which taking the recent 3-years average, gives an annual market growth rate of 50%. This growth rate can be considered applicable for the coming five to ten years. Projections made this way are shown in Table 4.12

As a final remark to the market analysis, computer demand depends on the user acceptance of computer technology. Studies made on the subject show that users accept computer technology and start to use it when they perceive it to be useful and when they feel personally involved with computers. As the extent of use increases, users start to become dependent on computers. Thus when the acceptance and dependence on computers increase, there will be more and more demands for PCs [20]. By now the level of acceptance and dependence on computers in Ethiopia is low; but present realties indicate both the acceptance and dependence on computers will grow very fast. In the near future, not only will computers be important at the offices but also in the households. Individuals, especially in the middle- and high-income group of the society, will have a PC for personal uses as is the case now in the developed countries.

Table 4.12 Projected Demand for Personal computers

Year	Number of PCs
2002	25,000
2003	37,500
2004	56,250
2005	84,375
2006	126,562

Annex I

Format of Questionnaire used in the Market Research

1. Name of company/organization: ______________________________________

   Address: P.O. Box ________Tel. _________________Town/City _____________

2. Do you have computers in your company/organization?

   Yes ☐ No ☐

   If "yes" answer 3 to 7; If "No" answer 8 to 12.

3. Which models do you use?

PC model	Quantity
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________

4. Average year a PC has been in service? _______ Years

5. How do you utilize your PCs?

Office Automation:		Other Applications:	
Word processing	☐	Production/project planning	☐
Spreadsheet	☐	Inventory control	☐
Others	☐	Computer aided design	☐
		Others	☐

6. Do you plan to replace the existing PCs or buy additional ones?

Yes ☐ No ☐

If "yes", How many? _______

When? In near future ☐

In two years time ☐

In five years time ☐

7. Do you have Internet account?

Yes ☐ No ☐

****

8. Do you think computers are useful for your job?

Yes ☐ No ☐

9. If "Yes", do you plan to purchase some?

Yes ☐ No ☐

10. If "Yes", when? In near future ☐

In two years time ☐

In five years time ☐

11. How many PCs do you plan to purchase? ________

12. Do you want to have Internet connections?

Yes ☐ No ☐

4. 3 Plant Capacities and Production Program

4.3.1 Plant Capacity

In determining the plant capacity there are several factors that must be given due consideration. Some of these are:

- Demand - supply gap and demand projection
- Market penetration
- Investment outlays
- Economic scale of production [19].

In our case the demand-supply gap and market penetration problems would be more important. According to the information obtained from the Investment office of Ethiopia two investors with a combined production capacity of only 3500 PCs per year, have registered to carry out investments on computer Assembly plant. Thus it can be said that so far there are no well-organized PC assembly plant in the country. Until now the greater portion of the supply for PCs is met though imports.

According to the market study discussed in section 4.2, the present demand is estimated in the range of 25,000 to 30,000 PCs per year. On the conservative estimate the demand after five years and ten years respectively reaches 65,000 and 120, 000. One may consider the demand between the current year and five years down the line to propose a proper plant capacity. Thus starting with a capacity of 15,000 PCs a year and expanding the plant to a double capacity of 30,000 PCs per year at the end of the fifth year of operation could be a good strategy. The selection of 15,000 PCs per year plant capacity has left a room, amounting to 50% of the total demand, for other competitors from imports and/or local suppliers.

4.3.2. Production Program

For reasons of market penetration and technical skill requirements the production program is proposed to start by 75% in the initial year and progressively increase to 85% and 100% in the following years respectively. Table 4.13 shows the production program. Implementation of the project will take 3.5 years time. Thus assuming project implementation will begin in 2003 the start-up of operation of the plant will be in the year 2006.

Table 4.13 Production Program

Year	*Operating capacity*	
	%	*No. Of PCs*
2006	75%	11,250
2007	85%	12,750
2008 and beyond	100%	15,000

4.4. Pricing

The prices of computers depend on the make, specification (particularly processor type & speed, memory capacity and drives capacity) accompanying accessories and loaded software. At present a PC of average specification is sold for less than US$1000 at the global level; and the price of a PC here in Ethiopia ranges from Birr 4500 to 12,000 depending upon the specification. Thus it is essential to classify PCs into appropriate type of product ranges before discussing prices. The plant under consideration shall assemble three types of PCs based on the capacity of the processor and hard drive: lower-capacity, medium capacity and higher-capacity computers. Average specification and prices of each type is sown in table 4.14 [27,41].

Table 4.14 Average specifications of three types of PCs

Specifications	Tyep-1 Lower capacity	Type-2 Medium capacity	Type-3 Higher capacity
Processor	Intel "486" 1000MHz	Intel Pentium IV 1.4GHz	Intel Pentium 1.7GHz
RAM	128 MB	128MB	256MB
Hard drive	20GB	40GB	60GB
CD-ROM	-	52x	52x
Floppy drive	3.5"	3.5"	3.5"
Monitory	15" color	15" color	15" color
Peripherals	Key board & mouse	Keyboard, mouse stereo speakers	Keyboard, mouse stereo speakers
Average price, Birr	4,500	6,300	8,100
% of total production	40	30	30

4.5 Preliminary Assessment Of Export Market to neighboring Countries

The computer industry is a trillion- dollar market. In the United States alone, information technology grosses $865biliion a year and is Americas largest industry [36].

The PC sales figure for the African Market is not exactly known. However, the African market will explode in a few years as local users start using the Internet.

Therefore, the envisaged PC assembly plant can have a wide opportunity to take advantage of the growing African market in general and that of COMESA (common market for eastern and southern Africa) in particular. Cost of labor is relatively cheap in Ethiopia and if we can manage to have adequately trained workforce, computers assembled in Ethiopia may have competitive cost advantage. It has been found that approximately 40% of the cost of a computer is in the assembly of the components [15].

The COMESA market alone is very large with 20 member states namely, Angola, Burundi, Comoros, D.R. Congo, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Namibia, Rwanda, Seychelles, Sudan, Swaziland, Uganda, Zambia, and Zimbabwe. The total annual trade transaction between the member states is of about 4.2 billion US dollars. Table 4.15 shows the total import-export trade among member states form 1991-1998 [38].

As we have seen in the market study (section 4.2.1), the import of computers to Ethiopia largely comes from Asian countries. Only about 2% is imported from South Africa where there might be local PC assembly/manufacturing plants. But, so far, the researcher has confirmed that there is no PC assembly plant within the east African countries. However, in the near future we may be forced to import PCs assembled or manufactured in any of our neighboring countries unless we take the first initiative to invest on the computer industry.

Table 4.15 Total Intra-COMESA Trade (FOB Value Million US$)

	Member State	1991	1992	1993	1994	1995	1996	1997	1998*
1	Angola	9	6	5	13	15	19	21	23
2	Burundi	41	51	46	45	45	25	16	24
3	Comoros	5	9	9	12	16	18	18	22
4	Congo (D.R)	40	39	39	84	90	122	129	158
5	Djibouti	33	39	46	50	63	73	81	90
6	Egypt	149	232	124	130	189	171	181	194
7	Eritrea	-	-	-	-	-	1	1	-
8	Ethiopia	52	46	75	88	129	138	153	165
9	Kenya	322	369	472	549	684	748	813	894
10	Madagascar	29	37	5	49	70	89	101	116
11	Malawi	91	71	77	126	151	240	260	282
12	Mauritius	63	73	47	85	110	132	142	159
13	Namibia	11	5	7	31	40	48	56	64
14	Rwanda	69	63	61	72	88	104	114	129
15	Seychelles	16	8	7	8	10	13	14	15
16	Sudan	58	93	81	76	82	104	118	137
17	Swaziland	23	37	22	21	26	39	46	53
18	Tanzania	108	137	189	247	320	361	387	429
19	Uganda	64	98	147	181	225	255	277	305
20	Zambia	189	205	127	164	187	307	359	384
21	Zimbabwe	252	204	202	337	380	451	489	555
	Total	**1,624**	**1,822**	**1,788**	**2,368**	**2,920**	**3,458**	**3,776**	**4,200**

Source: Direction of Trade Statistics, IMF; Selected Statistics on African Countries

CHAPTER FIVE: ASSEMBLY COMPONENTS AND INPUTS

5.1 Assembly Components

The current architecture of personal computers has three main components. These are the CPU, monitor and input/output (I/O) devices. The sub-assemblies in each of these components are listed below.

5.1.1 System Unit Components

The system unit, nowadays is designed as a tower form, is housed in a metallic case (front part plastic) or in a casing of all plastic material. Within the system unit it is common to incorporate the following sub-assemblies [37]:

1. Mother board - the large flat green board in the center of the case. There are two types of motherboard designs standards: AT and Baby AT; and a third one, the ATX board now included as Intel's new standard. The following are socketed or soldered onto the motherboard: Processor, BIOS, PC chipset, Cache RAM, Expansion bus slots, keyboard and mouse sockets, video and Internet.

2. Processor - Considered as "brain" of the computer and plays a major part in determining how "powerful" a computer is. Traditionally produced by Intel Corporation (U.S.A) although now other chip manufacturers are on the increase. There have been several developments since the first generation of Intel 8088 processor manufactured in 1982. Today, we have the seventh-generation Pentium IV with many advanced features.

3. VGA card - a unit called video graphics adapter (array), which is responsible for graphics display of data, characters, images, etc. on the screen.

4. Floppy disk drive - A drive for external storage medium, current standard 3½" high density (1.44KB)

5. Hard disk drive - built in storage medium with its drive; hard (as opposed to floppy), sealed metal platters coated in magnetic material. There are different types: 20GB, 40GB, 60GB and more.

6. CD- Rom drive - Optical devices that read data from compact disks.

7. Memory modules - System memory units, RAM: 32MB, 64MB, 128MB, and 256MB

8. Data Bus - Data transfer line between the processor, RAM and other motherboard components (SCSI and USB types)

9. Expansion slots - Several different types of cards that support the application of I/O systems. Such as modems, sound card, graphics card, etc. ISA or PCI are commonly encountered connectors of these cards.

10. Power supply unit - consists of transformer, circuit board, and cooling fan, all- in- one, housed in sheet metal casing.

11. I/O interface - Input/output connections such as Universal Serial Bus (USB) ports, parallel ports, serial port, line-in/out jack, microphone jacks, Game port, etc.

12. Housing - Metallic or plastic casing with modular design that houses the motherboard and other components of the CPU. The state of the art design is a tower type that stands alone on a desktop or at the floor. The front part where the drives are accessed from is made of plastic and here are attached plastic power button.

5.1.2 Monitor

The monitor of a PC can be treated as peripheral equipment. But most PC are sold together with a monitor that it can be considered as part of the system. Despite its larger size, the monitor consists of few elements:

- CRT (Cathode Ray Tube) consisting of three electronic color guns for generating colors.
- Circuitry board
- Housing (plastic), and
- Stand frame (plastic)

5.1.3 Peripherals

The most common peripheral equipments of a PC are keyboard, mouse and speaker each of these are described below.

Keyboard:

The keyboard is all plastic material and consists of:

- main frame
- letter, symbol, numeric and function knobs
- small spring elements
- circuit board

Mouse:

This is also made of plastic material. It consists of a rotating ball, wheel, circuit card and housing.

Speaker:

Recently computers are marketed with a sound system. Speakers can be either built inside the monitor case or manufactured as a separate unit. The latter types are common. A speaker consists of an electro-magnetic component and a plastic housing.

5.2. Analysis of Buy or Make Decision

The computer is a high-tech product. A high tech product is one that involves a significant amount of research and development (R&D) costs than is normally expended for industry in general. Therefore, to be the first on this industry requires huge investment. On the other hand, to be totally dependent on importing technology from other countries means not only cost wise expensive but also one will never get a chance to develop the technology.

The researcher proposes three consecutive phases that must be implemented to develop the electronics industry in Ethiopia in general and the computer technology in particular. These are:

Phase I. Start assembling the products by importing the circuit elements from a known supplier by entering into a contractual license agreement for labels and brand names and make in house all simple components such as monitor cases, computer cases, frames and supports.

Phase II. By giving the necessary manpower training make components and circuit board both for local consumption and for other users who need low cost supplies of the same.

Phase III. Develop and design own products and become a competitor in the global market for electronics and computers.

In all of the above phases, however, one has always to deal with Make or Buy decision analysis. The essence of this analysis is discussed below.

Once a product is studied to be manufactured or assembled, the next step is to identify the process by which it is to be made. After the necessary process information is obtained the next task is to decide if the product or some components are to be made in house or are to be purchased from external sources.

Usually, the Make or Buy decision is made by considering economic evaluations. However, apart from the economic evaluation one has also to assess strategic considerations because of its influence on the competitive position of a given company.

5.2.1. Strategic Analysis

There are three key decision variables that determine whether a product should be purchased or made in-house. These are:

a) The role of the process technology in providing a competitive advantage;
b) The maturity of the process technology; and
c) The competitors' technology position [39].

The outsourcing of process technology can often lead to the creation of suppliers who have the ability to become competitors in the market place. In this regard a supplier may internalize enough of the process technology to start doing R & D on the process. With the improved technology, the supplier may then move to using the technology to emerge as one competitor.

The maturity of the technology also plays a key role in the make-or-buy decision. If the technology is matured there is not much to be gained by investing in R&D since a competitor can simply acquire this technology from other sources.

Finally, it is critically important to weigh the ability of competitors to develop, acquire and assimilate the new technology. If proprietary technology is involved or if the technology represents a core competency of the company, special emphasis should be given to the outsourcing decision.

Once assessment is made of the key decision variables the make-or-buy decision falls into one of the following categories:

- Make,
- Marginal Make,
- Develop Internal Capability,

- Buy,
- Marginal Buy, and
- Develop suppliers

Figure 5.1 shows the different choices based on the values of the decision variables. It can be observed that mature technologies are generally outsourced although they have high significance today and in the future; emerging and growing technologies, however, should be kept in house.

The marginal make and buy decisions require careful considerations of overall organizational priorities and economics. For the marginal buys it is important to ensure that outsourcing does not lead to any loss of competitiveness.

5.2.2. Economic Considerations

Having resolved the strategic issues, it is still necessary to study the economics of make-buy decision. The kind of analysis that is done in this case is typical for most project justification studies. Figure 5.2 explains the step involved in such analysis.

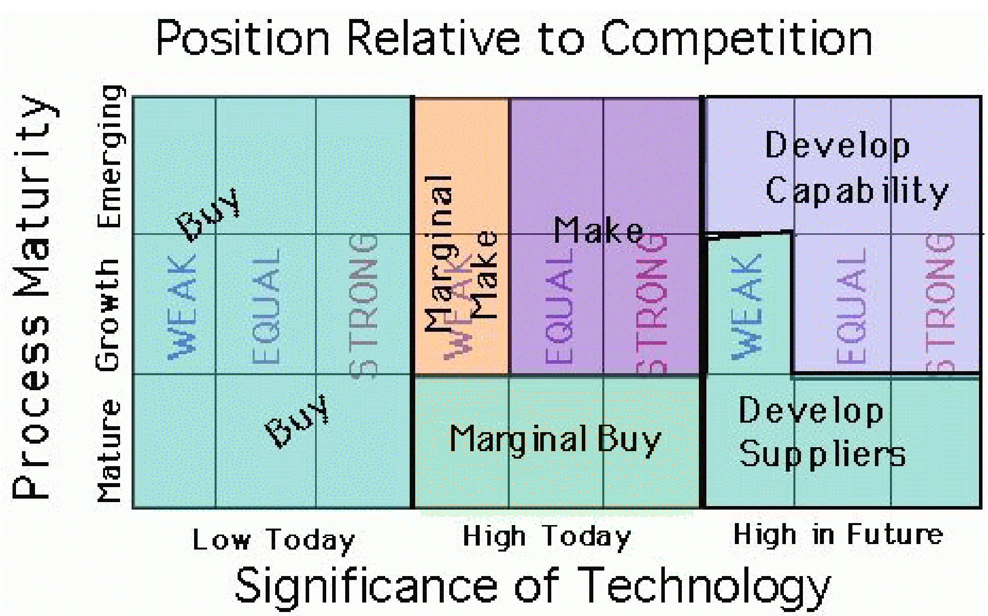


Figure 5.1 Strategic Considerations for Make or Buy Decision

The answer for first two steps depends on the result of the strategic analysis discussed above. The last three steps require some technical (engineering) and economic analysis. For example, it is common to consider one or more alternative sources for procuring the parts and several methods by which the part can be made in house. These different methods are then compared based on the initial investment and the annual cost over the life of the product. Given the demand for the part over its lifetime, the best method is selected based on an economic criterion such as:

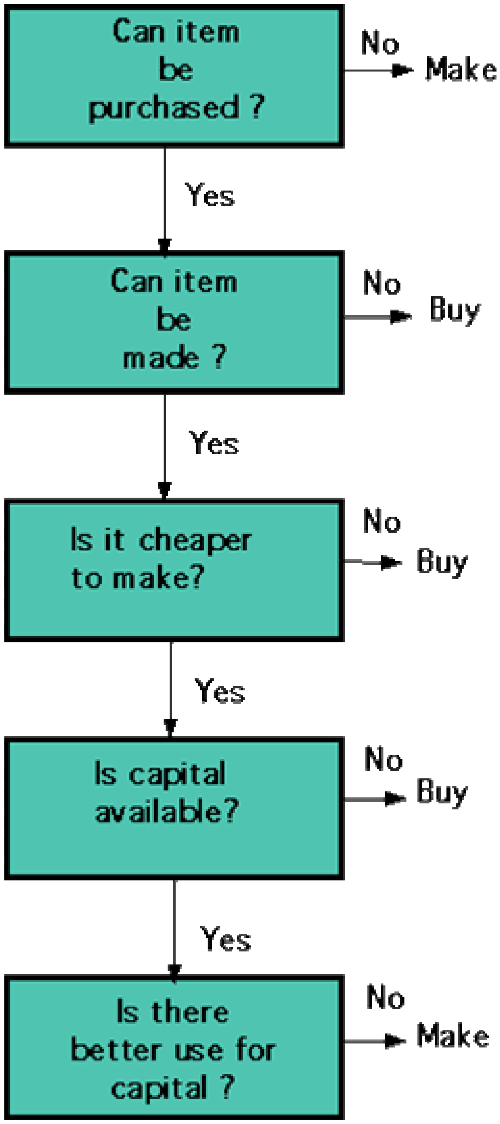
- Pay back period
- Net present value (NPV)
- Return on Investment
- Internal Rate of Return (IRR)

In order to apply the strategic as well as economic considerations to our project of computers assembly plant, we need to visualize the PC in terms of three systems that are technologically distinct. These are:

1. The processor and memory chips
2. The circuitry elements
3. The housing or cases

The technology of making a processor chip is a highly advanced, which is not only knowledge-intensive but also capital-intensive.

Figure 5.2 Make or Buy Flow Chart



It requires considerable investment outlay for R&D works carried out by highly trained professionals aided by sophisticated equipment. In fact there are only a few processor manufacturers in the world, Intel Company taking the lead. Suppose we claim that the necessary knowledge and skill is in place, chip factories have a very high initial investment estimated in the order of over 100 million US Dollars.

The circuitry elements of the computer can be represented as a second level in terms of their technological complexity. If a country has a well developed, electronics industry, these items could be produced at low cost. The product groups under this category may include:

- Active components (semiconductors)
- Passive components (e.g. capacitors, inductors, resistors)
- Electromechanical components
- Electronic assemblies
- Printed circuit boards (PCB) [31]

The housing or case for computer, monitor and other peripheral equipment is a simple mechanical item made from plastic or metallic material at a given design modules. One point of importance here is the mould design consideration. Design and manufacture of such moulds requires special skill. However, the experience from other countries (e.g. Taiwan, China and India) shows that such technologies can be easily developed in collaboration with overseas engineering companies.

The following PC components are made from plastic raw materials (ABS grade HI: 121 and ABS grade SG-175) by injection moulding process:

- Front panel of computer
- Front cabinet of monitor
- Back cabinet of monitor
- Stand base for monitor
- Swivel table for monitor
- Top and bottom cover of keyboard
- Keys for keyboard
- Power button

While the cost of injection molding machines for the above is about US$ 255,000, the cost of molds needed for all the items is about US$350,000. The injection-moulding machine is a universal machine that can be used to manufacture a variety of products by changing only the mould. Thus in order to compensate the high cost of moulds, one should produce mouldings of higher quantities, both for internal consumption and for export market.

5.3. Subassemblies Requirement and Estimated Costs

Based on the previous discussion of make-or-buy decision, the assembly components for PC are divided into two groups as imported components and in-house manufactured parts.

As pointed-out earlier, engineering plastic moulding is costly than ordinary plastic moulding because of the complexity of moulds. Hence, the decision of installing injection-moulding unit only for a self-supply of the components, at a plant capacity of 15,000 PCs per year, will not be economically viable. Therefore, the production of computer case, monitor case and other plastic components like the keyboard (upper and lower covers), letter knobs, etc. should target export markets. Accordingly, the production volume of in-house manufactured components is proposed taking into account this fact. Table 5.1 shows the list of in-house made sub-assemblies and their respective estimated prices; and table 5.2 shows sub-assemblies that are going to be imported from external sources. List of potential suppliers of PC components [40]

Table 5.1. In-house made sub-assemblies, yearly production and estimated Prices in '000 Birr.

S.N	Name of sub-assembly	Qty PCs	Unit price	Total price
1.	Computer cases	135,000	170	22,950
2.	Monitor cases	135,000	525	70,875
3.	Key board (frame, cover and knobs)	135,000	55	7,250
4.	Mouse cases	135,000	15	2,025
			Total	**103,100**

5.4. Raw Materials and Inputs

The major raw material required for manufacturing of computer and monitor cases, keyboard, speaker case, and mouse case is a plastic polymer known as ABS (Acrylo Butadiene Styrene). ABS is an engineering plastic polymer available from the petrochemical processing industries. The current price of ABS is in the order of US$ 850 per ton.

Table 5.2 Imported subassemblies, yearly requirement and estimated costs in Birr

S.N	*Sub-assembly*	*Qty*	*Unit cost*	*Total cost*
1.	Motherboard	17,000	650	11,050,000
2.	Processor (1.1 to 1.7GHz)	17,000	1080	18,360,000
3.	VGA	17,000	420	7,140,000
4.	Floppy disk drive	17,000	180	3,060,000
5.	Hard disk drive (20-60GB)	17,000	1300	22,100,000
6.	CD-Rom drive	17,000	300	5,100,000
7.	Memory modules (128-256 MB)	17,000	1020	17,340,000
8.	Data bus	17,000	60	1,020,000
9.	Add-in boards (multi media + modem)	17,000	1440	24,480,000
10.	Power supply unit, 300 watt	17,000	540	9,180,000
11.	I/O interface (ports)	17,000set	90	1,530,000
12.	CRT tubes and display equipment for 15" color monitor	17,000	2160	36,720,000
13.	Key board circuit	17,000	60	1,020,000
Other accessories*		Lot	-	2,000,000
			Total	**174,220,000**

**Fixtures, mouse pad, labels, cards, etc. Source [25, 26, 40]

The average PC (with 15" monitor, keyboard, speaker and mouse) weighs about 30 kg. Out of this 10% or about 3kg is a plastic component. Accordingly worked out annual requirement of ABS resin is given in table 5.3.

In addition to ABS, inputs such as cleaning and processing chemicals, printing chemicals and packing materials are also required. Estimated annual consumptions and costs are given in table 5.3

Table 5.3 Raw Materials and Inputs, Annual Consumption and Costs in Birr

S.N	*Material Description*	*Qty*	*Unit cost*	*Total cost*
1.	ABS	405 ton	8,950/ton	3,624,750
2.	Cleaning & processing chemicals	1.5 ton	50/kg	75,000
3.	Printing chemicals & labels	0.5 ton	100/kg	50,000
4.	Packing materials	15 ton	10/kg	150,000
	Total			**3,899,750**

4.5 Utilities

The utilities required for the plant are electric power and water. Of these Electric power is vital for the operation of the plant and is required for driving the various machines and equipment, welding, etc. Based on the power demand of production machines and equipment the total annual power requirement, including lighting and service facilities is estimated at 600,000 kWh.

Water is required for cooling moulds and other machine tools, cleaning and for general sanitation and drinking purposes. The total annual requirement is estimated at 150,000m^3. Table 5.4 shows the estimated annual cost of utilities.

Table 5.4 Annual Utility consumption

Type	*Quantity*	*Unit cost Birr*	*Total cost*
Electric power	600,000 kWh	0.4736	285,000
Water	150,000 m^3	1.5	225,000
Total			**510,000**

CHAPTER SIX: TECHNOLOGY AND ENGINEERING

6.1. Requirements of Line flow (Assembly) production

In line flow or assembly type of production the requirement is the production of mostly standardized products with some opportunities for selected options with product lines.

An assembly type operation, in general, involves many discrete parts and components that may need specialized, large, expensive and technologically advanced equipment. Therefore, there must be a good balance between equipment speed and level of operator skill. Thus, competition is based on performance, price, reliability, quality and delivery.

The production plan in assembly system consists of the following:

- Sales forecast (annual or longer);
- Product specification and bills of materials (BOM);
- Standard processing sequence;
- Production run length for various components;
- Any expected change in long-term suppliers commitments and contract terms;
- Effective handling system for materials and components; and
- Detailed production plan [45]

The relationship between these inputs is shown in figure 6.1

Also, the production and purchase of components should be based on economic lot size (ELS) considering the trade off between setup cost and inventory carrying.

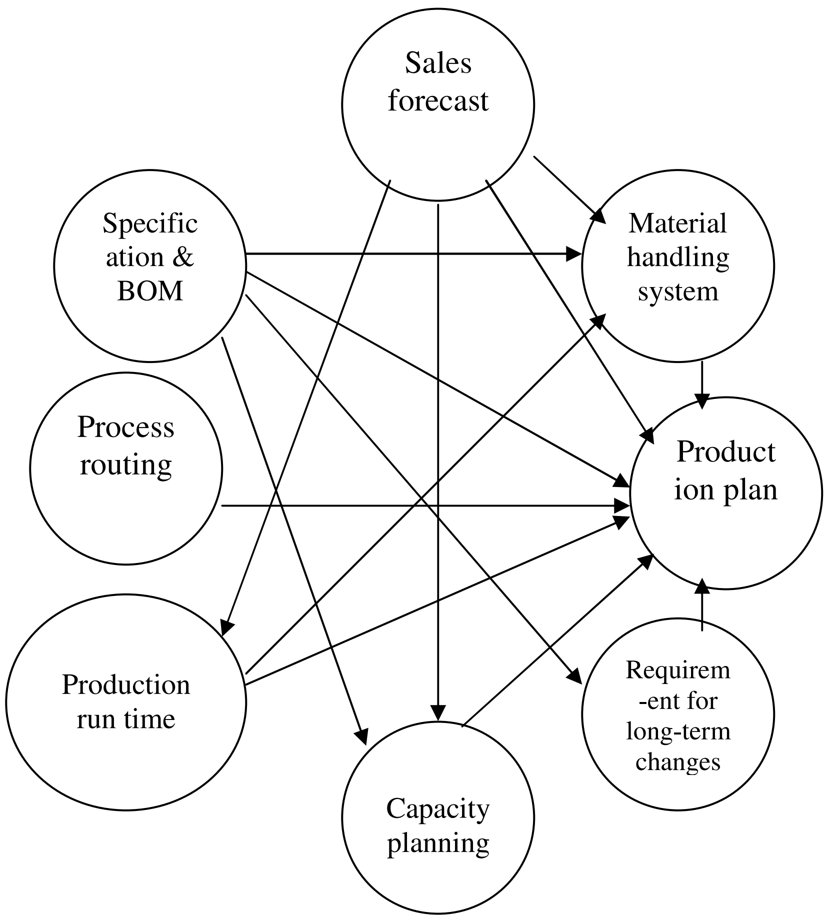
6.2. Process Description

6.2.1 Injection Moulding Unit

All plastic cases are manufactured in the plant by means of injection moulding machines (IMMs). An injection-moulding machine consists of two main parts: the plasticizing unit and the clamping unit.

Raw material in the form of plastic granules is fed to the plasticizing unit. The plasticizing unit is made up of an electrically heated barrel and motorized screw fitted inside the barrel. The plastic material melts by means of electrical heat conducted through the barrel as well as by friction heat developed as a result of the compression action developed by the screw.

Figure 6.1 Planning Scheme in Assembly Type of Production



Homogenized and molten plastic is then injected by transilational motion of the screw to a preloaded mould supported by the clamping unit. After the molten plastic is cured and shaped inside the mould, the clamping mechanism opens the mould and the mouled article drops to a conveyor belt.

The moulding is tested for the required strength and shape and passed to a painting unit for necessary painting and labeling.

The operation of the injection-moulding unit should be supported by means of computer-aided design (CAD) and computer-aided manufacturing (CAM) to ensure the manufacturing of standard quality products. Computer aided stress analysis and modeling are made to evaluate the correct shape and pattern of moulding products.

The machinery and equipment required for the plastic injection moulding of the plant are given in table 6.1 The total cost of main production machinery, moulds and equipment for quality control is estimated at Birr 7,450,000 more than 90% of which is required in foreign currency.

Table 6.1 List of machinery and equipment for the injection-moulding unit

S.N	***Description of Item***	***Qty***	**Total cost, Birr**
1.	Injection molding machines	3	3,500,000
2.	Molds	Set	3,600,000
3.	Material loading system	Set	150,000
4.	Quality control & Design equipment	Lot	200,000
		Total	**7,450,000**

6.2.2. Assembly of PC components

6.2.2.1 Introduction

Electronics manufacture can be classified into three types:

(a) The manufacture of printed circuit boards (PCBs) and electronic components;

(b) The placement of components into PCBs; and

(c) The assembly of boards into a plastic/metal box or case [15].

In case of this project processes (b) and (c) would be relevant as all the PCBs and electronic components are to be imported in SKD (Semi Knocked Down) form.

The placement of components into PCBs has been made for several years by the method known as *through-hole components technology*, (THT) but now there is a growing trend where this method is replaced by *surface mounting technology* (SMT) in which the component leads or terminals are soldered to the top surface of the board.

SMT offers the advantage of reduced cost, size and improved reliability. The new volume - efficient designs for integrated circuits (ICs) and the use of passive chip components allow more dense circuit packing, permitting either in increase in function for a given equipment size or a reduction in equipment size and lower system costs.

It has been found that approximately 40% of the cost of an electronic product is in the assembly of components onto a PCB (printed circuit board). Therefore, it is essential to select the appropriate assembly method to minimize the cost of manufacture of a product [21]. Below are described various component assembly techniques that are currently used in the electronics industry including the assembly of PCs.

6.2.2.2 Manual Assembly Of Through-Hole Components

Depending on the quantity and variety of boards required, three types of manual production are commonly used.

Low Throughput Manual Assembly

In this type of assembly an operator completes the entire board, including soldering. The board may consist of through-hole and surface-mounted components. The reason for applying this type of production line is usually that either the board to be produced is very densely populated with components or the board contains delicate or sensitive components.

Medium Throughput Manual Assembly

A cell is set up consisting of several operators and each person is trained to assemble up to 10 components manually onto the PCB. When the board reaches the end of the line, it is complete and, after visual inspection, is ready for wave soldering. To aid insertion of components a master board is usually made available to each operator.

Manual Assembly With The Aid Of An Assembly Director

In the above methods the operators are required to memorize the component locations and it is inevitable that mistakes may happen. To reduce misinsertion of components, a machine called "assembly director" is employed. In the normal mode of operation of the assembly director machine, a beam deflection system of helium-neon laser displays on the surface of the board to be assembled one or more component locations. At the same time various component-dispensing machines can be driven to dispense the appropriate component. To advance to the next programmed location a foot switch is incorporated, thus leaving the hands free for the insertion of components. The method may not substantially increase the production rate, but it certainly reduces rework.

Automated Assembly Of Through-Hole Components

Automatic insertion machines are available that are capable of inserting axial, dual in line (DIL), radial components at a rate of about 1200 components per hour. Machines that are dedicated to insert one or two types of the above components can operate at a much faster rate.

6.2.2.3 Surface Mount Technology

Surface mount technology (SMT) is defined as the placement of components on a printed circuit planar surface with component leads or terminals being soldered to that surface.

Surface mount components (SMCs) are employed in various electronic products, including disc drives, personal computers, digital watches, communication equipment, television, etc.

Surface mount components are classified as passive and active as follows:

Passive components	Active components
Resistors	Diodes
Capacitors	Transistors
Inductance	Thyristors
Connectors	Integrated circuits

Component Packaging

In surface mount assembly, the components must be packaged such that they can be handled by automatic equipment. The components must be presented to the assembly machine in a way that the machine tooling can locate and pick up the part.

6.2.2.4 Assembly of PCBs

A typical assembly sequence of a printed circuit board (PCB) is as follows:

(1) Insert pins/connectors,
(2) Insert electronic components,
(3) Solder PCB,
(4) Clean PCB with solvent,
(5) Inspection, and
(6) Test

Depending upon whether SMCs are used exclusively or in combination with through-hole components gives various configurations and assembly procedures. The possible configurations are:

(a) Single-sided PCB with SMCs,
(b) Double-sided PCB with SMCs on both sides,

(c) Mixed assembly, double-sided PCB with SMCs on one side only
(d) Mixed assembly, double sided PCB with SMCs on both sides.

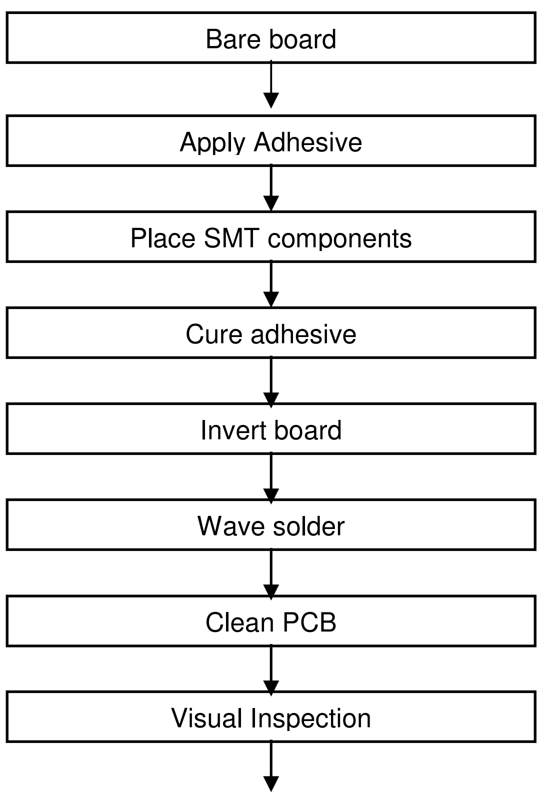
In case of personal computers the first type of configuration, that is single-sided PCB with SMCs is commonly applied. The steps involved in this type of assembly are shown in figure 6.2 [15]

6.2.2.5 Machinery and Equipment

The machinery and equipment required for the component assembly plant are generally those used for electronic assembly plant. The major units are dispensing units, pick and place units, soldering equipment, testing and quality check instruments, mechanical assembly tools, conveyor belts, etc.

A list of machinery and equipment required for the plant and estimates of the respective costs is provided in table 6.2 Accordingly, the total cost of machinery & equipment of the assembly unit is about Birr 6,583,000. Thus, the total investment of plant machinery and equipment, including the injection-moulding unit amounts to Birr 14,033,000.

Figure 6.2. The steps involved in the assembly of single sided PCB with SMCs.



Test populated board

Table 6.2 List and cost of machinery and equipment for PC assembly plant.

S.N	***Item***	***Qty***	***Unit cost, Birr***	***Total cost, Birr***
1.	Electronic test banks	2	220,000	440,000
2.	Protocol analyzer	1	170,000	170,000
3.	Oscilloscope	2	8,500	17,000
4.	Color generator	1	190,000	190,000
5.	Conveyor system	1	1,000,000	1,000,000
6.	Pick and place robot	1	2,920,000	2,920,000
7.	Power supply tester	2	275,000	550,000
8.	Soldering equipment	10	5,000	50,000
9.	Mounter	2	95,000	190,000
10.	Technician carry on items	120	300	36,000
11.	Power supply equipment	2	210,000	420,000
12.	Generator	1	600,000	600,000
	Total			**6,583,000**

6.3 Building and Civil works

The total area requirement of the plant including reserve area for future expansion is about 10,000m^2. Out of this, the built-up area for factory building (two halls, each 25m X 50m), warehouses (two, each 20m X 30 m and offices (40m X 5m) is estimated to be 4050m^2.

Land acquisition by means of lease may cost some 100,000 Birr as a down payment. The construction cost including factory building, warehouses, offices, site preparation and development as well as out-door works is estimated at 8.1million Birr.

6.4 Plant Location

In the selection of a suitable plant location for industrial projects, one has to consider the following factors [16]:

- Market;
- Raw materials;
- Infrastructure (transportation, power, telecommunication);
- Climatic conditions;
- labour and labour cost; and
- Laws and Taxation.

The best location among alternatives is, therefore, selected based on factor-analysis by assigning relative weight-factor to the criteria and evaluating each prospective location accordingly. This is shown below.

Factors	**Relative Weight**	**Addis Ababa**	**Kombolcha**	**Awasa**	**Mekele**
Vicinity to Market	50	50	40	30	20
Vicinity to raw material	10	6	10	5	6
Infrastructure	20	20	15	15	12
Manpower availability	10	10	5	5	5
Climatic condition	10	10	8	10	5
Total	100	96	78	65	48

In case of the project under consideration, the market factor outweighs all the other factors. In other words, since the project is a market-oriented one its location should be as near to the market center as possible. In this respect, the location should be in the vicinity of Addis Ababa, which absorbs more than 80% of the PC market in the country.

Besides, Addis Ababa possesses relatively good infrastructure and other facilities; and skilled lobour is easily available. Even the climate of the city is suitable for electronics manufacturing in general which demands dust-free and less humid working environment.

6.5 Organization and Manpower

6.5.1 Organization

There will be three functional departments subdivided into seven sections as shown in figure 6.3. The departments are Manufacturing, Marketing & Supplies and Administrative & Finance.

Based on the nature of stakeholders of the project there may be a Board of owners as a supreme body of the organization responsible for the overall policy matters and that overseas the performance of the company. The General Manager of the plant will take care of the short-term as well as day-to-day affairs of the company.

6.5.2 Manpower

The plant needs qualified electrical engineers, manufacturing engineers and technicians.

Due to the nature of the process the injection moulding unit must operate in three-shifts. The assembly unit, however, is going to be a one-shift operation. As the market grows up, this unit also could be upgraded to run in two-or three-shift basis by employing additional workforce.

With this in mind, the total personnel requirement of the plant is estimated to be about 86 persons. The list as well as estimated salaries is given in table 6.3

Figure 6.3 Organizational Chart

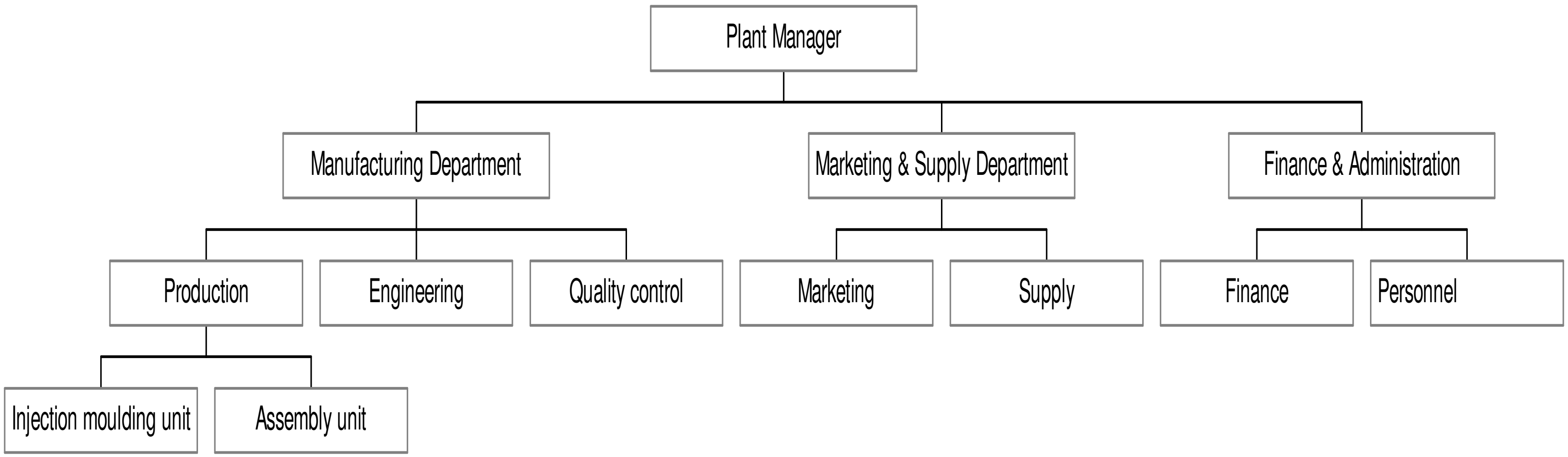


Table 6.3. Manpower Requirement and Estimates of Salary Expenses

S.N	Department/position	Required No.	Salary estimates, Birr	Yearly
			Monthly	
1.	General manager	1	3,500	42,000
2.	Secretary	1	1000	12,000
	Manufacturing dept.			
3.	Manufacturing head	1	3000	36,000
4.	Engineers	4	2500	120,000
5.	Supervisors	14	2000	336,000
6.	Technicians	25	1500	450,000
7.	Operators	15	1000	180,000
	Marketing & supply			
8.	Department head	1	2500	300,000
9.	Marketing head	1	2000	24,000
10.	Supply head	1	2000	24,000
11.	Inventory controllers	3	1500	54,000
12.	Sales	3	1500	54,000
13.	Clerks	5	1000	60,000
	Finance & Administration			
14.	Department head	1	2500	30,000
15.	Personnel	1	2000	24,000
16.	Finance	1	2000	24,000
17	Accountants	3	1500	54,000
18	Clerks	5	1000	60,000
Total		**86**		**1,884,000**

CHAPTER SEVEN: IMPLEMENTATION PLAN

7.1 Project Activities

The implementation of the proposed computer assembly plant constitutes a number of activities ranging from project engineering, contracting, construction, manpower training, to erection and commissioning.

The list of major activities and their precedence relationship is provided in table 7.1. The purpose of doing this is to estimate the project duration as well as the implementation cost.

The project duration is estimated by considering probabilistic time estimates based on PERT (Project evaluation and Review Technique). PERT considers three time estimates in order to arrive at the most likely time which is given by the following relation:

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

Where, t_o = optimistic time

t_m = most likely time

t_p = pessimistic time

t_e = estimated time [2,14]

These time estimates and accordingly calculated time duration for each activity are shown in table 7.1

7.2 Network Diagram And Project Duration

The network diagram (drawn according to the precedence relationship of the project implementation activities shown in table 7.1) for the project is provided in figure 7.1. The bold arrows show the critical path which gives a project duration of 42 months or about 3.5 years. The same schedule is also represented in the form of Gantt chart in figure 7.2 Given this project duration, the project management cost can be estimated at Birr 2.1 million taking an average cost Birr 50,000 per month for salary expenses, office rent, correspondence, travel, stationery and other overhead costs.

Table 7.1 List of activities, relationship and time estimates

S.N	***Activity***	***Preceding activity***	***Time estimates, in months***			
			t_o	t_m	t_p	t_e
I	***Phase-I Project preparation***					
1.	Raising necessary fund	-	3	4	6	4.2
2.	Tender preparation	1	2	3	4	4
3.	Tender evaluation	2	3	4	5	4
4.	Contract agreement	3	1	2	3	2
5.	License and trade mark agreement	3	1	1.5	2	1.5
6.	Engineering design	4,5	1	2	3	2
II	***Phase-II Civil work & shipment of machinery***	-				
7.	Tendering for construction works	6	2	3	4	3
8.	Land acquisition	1	3	4	6	4.2
9.	Site development	7	1	2	3	2
10.	Installation of infrastructure	6	2	3	5	3.2
11.	Building construction	9	12	14	18	14.3
12.	Out door works	9	3	2	5	2.7
13.	Shipment of machinery and equipment	6	3	4	6	4.2
III	***Phase-III Erection, commissioning and termination***	-				

14.	Mechanical erection	11,13	2	3	4	3
15.	Electrical installation	14	1	2	3	2
16.	Procurement of raw materials, components, and inputs	6	3	4	5	4.2
17.	Recruitment of manpower	9	2	3	4	3
18.	Manpower training	17	3	4	6	4.2
19.	Commissioning	15,17	2	3	4	3
20.	Market promotion	19	1	2	3	2
21.	Final project evaluation and termination	19	2	2.5	3	2.5

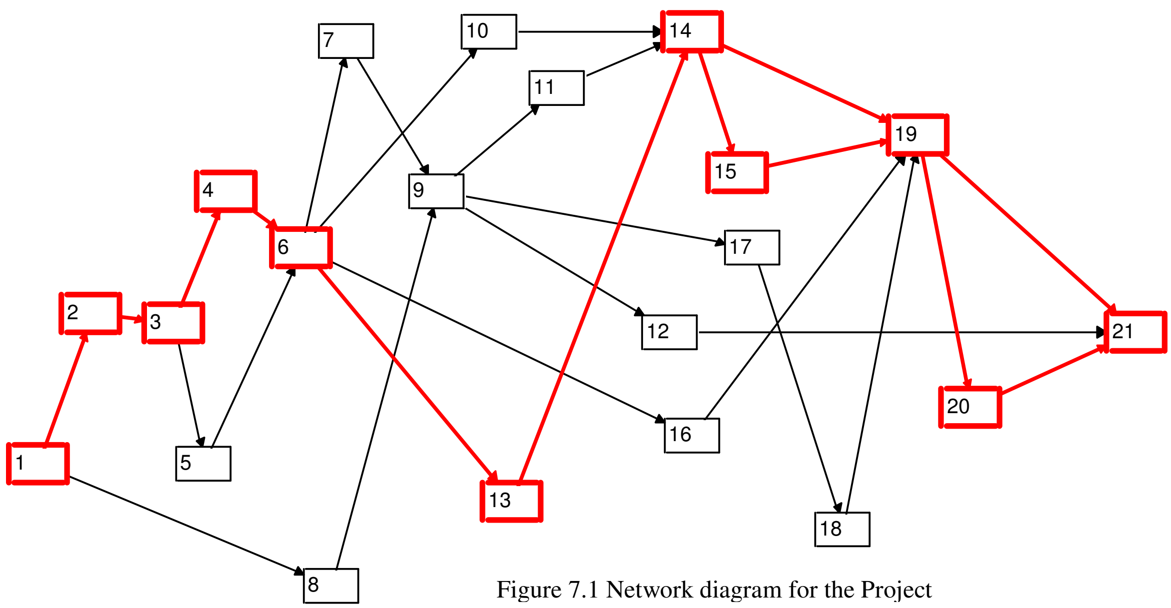


Figure 7.1 Network diagram for the Project

CHAPTER EIGHT: PROJECT FINANCING & FINANCIAL ANALYSIS

8.1. Financing Projects

In developing countries like Ethiopia, many projects remain in shelf due to lack of finance. On the other hand, a large number of projects fail either in the implementation phase or right at the beginning of the operation phase as a consequence of improper or poor project financing schemes. The financial plan of a project will often have a greater impact on its success than the physical design and construction costs.

In this chapter the source of finance, method of project financing, types of loans, financial risks and appraisal of finance for projects are described in general. At the end a proposal of financing mechanism for the envisaged PC assembly plant is suggested.

8.1.1 Sources of Finance

In most projects finance is usually provided by a lender in the form of a commercial bank, a pension fund, an insurance company an export credit agency or a development bank. Other project finance sources include institutional investors, large corporations, investment banks, niche banks and developers, utility subsidiaries and vendors and contractors. The more attractive, in the form of potential retains, the project may attract a number of sources of finance. Figure 8.1 shows different sources of project funding for projects.

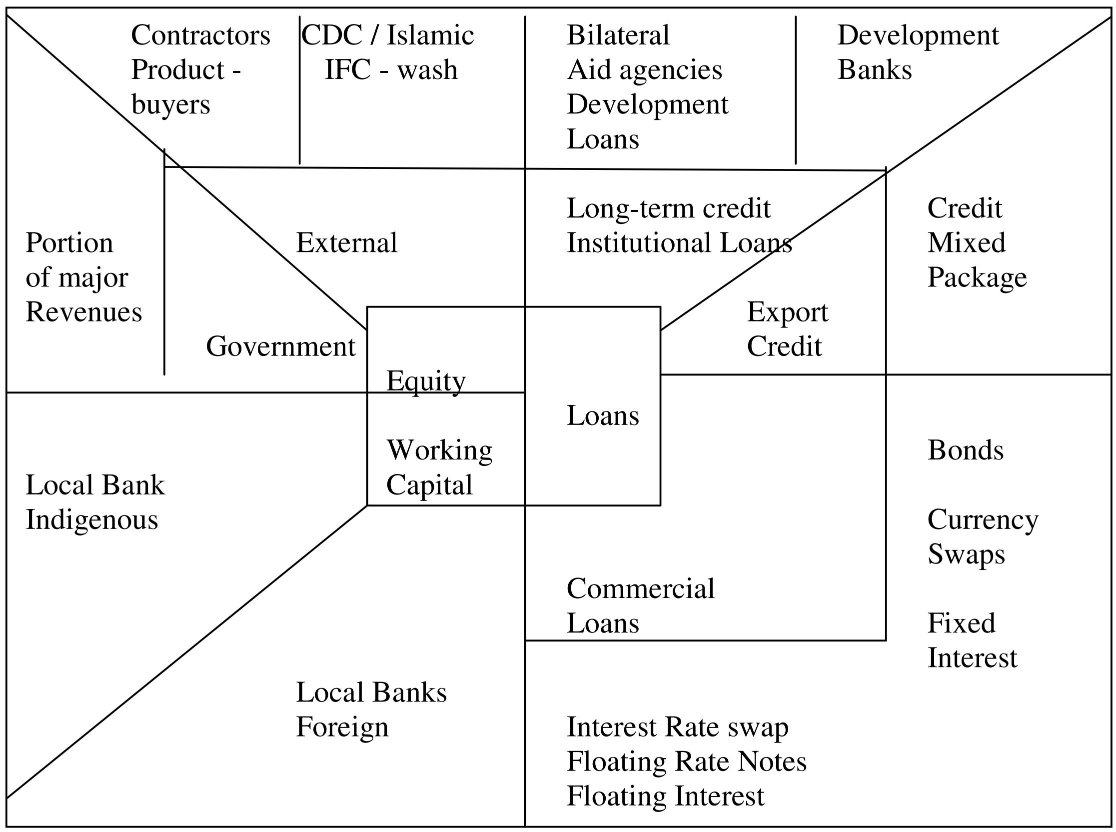
The experience so far in Ethiopia regarding source of project financing is very limited. Local financial sources are not yet developed. Many organizations that possess considerable amount of fund are not seen to have been involved in the project financing businesses that could have been a means of prosperity and development both for themselves and the nation at large.

8.1.2 Project Financing

Project financing may be defined as:

> The financing of a particular economic unit in which the lender is satisfied to look initially to the cash flows and earnings of that unit as the source of funds from which the loan will be repaid and to the assets of the economic unit as collateral for the loan.

Figure 8.1. Source of finance [42]



Project financing provides no recourse and if project revenues are not sufficient to cover debt service, lenders have no claim against the owner beyond the assets of the project, in effect being self-funding and self-liquidating in terms of financing.

Unlike traditional public sector projects whose capital costs are largely financed by loans raised by government, privately financed projects are financed by a combination of debt and equity capital; the ratio between these two types of capital varies between projects.

In debt financing, lenders assess the viability of the project by considering key parameters including:

- *Total size of the project*: the size of the project determines the amount of money required and the effort needed to raise the capital, internal rate of return on the project and equity.
- *Break even dates*: critical dates when equity investors see a return on their investments
- *Milestones*: critical dates related to the financing of the project
- *Loan summary:* the cost of each loan, the amount drawn and the year in which drawdowns reach their maximum.

In order to manage various types of risk a lender will often prepare a term sheet to be agreed upon by all participants. The term sheet defines rights and obligations of lenders and describes default conditions and remedies. The components of a term sheet may include the following financial parameters:

> Bank loan, bonds, draw-down of loans, equity, dividends, preferred share, interest during construction, interest during operation, lenders fees, IRR, NPV, coverage ratio, payback period of loans, standby facility, working capital and debt service ratio.

In assessing the adequacy of projected cash flows the parameters may be:

a) The debt service ratio (defined as annual cash flow available for debt service divided by debt service), and

b) The coverage ratio (defined as NPV of future after-tax cash flows over either the project life or the loan life divided by the loan balance outstanding).

For example in a project when the coverage ratio is 1:1 the debt will be repaid with no margin of error in the cash flow projections. Ratios less than 1 mean that debt will not be repaid over the term of the calculation and ratios in excess of 1 provide a measure of comfort should variations from the assumptions occur.

8.1.2.1 Types of loans

The loan structure of a finance package is often the most important ingredient to the success of a project. The structure of the loan may take several forms based on the type of project considered

Loan repayment method

The conditions of loan finance will depend on the criteria of the lender and sponsor. The main features that need to be agreed are loan repayment method, which may be either of the following:

Mortgage - repayments calculated so that the total amount paid at each installment is constant. This form of loan is suitable for projects where no revenue is generated until the project is operational.

Equal installments of principal - the amount of principal repaid is constant with each payment; the total amount paid decreasing over time as it consists of a constant principal plus interest on outstanding principal.

Maturity - the principal is repaid at the end of the loan period in one sum. This form of loan is most suitable for projects which generate a large capital sum on completion and could only be considered for projects if the sponsor intends to sell the facility immediately after commissioning.

Interest rate

Interest rate will often be governed by the money market rates which may vary considerably. Interest rates may be fixed for the period of the loan or expressed as a percentage of the standard base rate. Sometimes a floating rate with upper and lower limits may be negotiated between the sponsor and the lender.

8.1.2.2 Counter trade

Another type of finance that may be considered for projects, especially in developing countries, is counter trade. Under this form of agreement goods are exchanged for goods. An example of this form of agreement is the use of oil used as payment for goods and services supplied. In such a project the oil for example would be sold on the open market under a sales contract to generate revenues for payments of capital and interest.

8.1.2.3 Other Forms Of Lending

Other forms of lending may include debentures, export credits, currency swaps and revenue bonds. There are also other alternative finance packages based on royality agreements, unsecured loan stock, convertible unsecured loan stock, redeemable preference shares, and convertible preference shares.

8.1.2.4 Equity finance

Equity finance is usually an injection of risk capital into a project. Providers of equity are compensated with dividends from profits if a project is successful. Debt service in the majority of cases takes first call on profits whether or not profits have been generated; dividends are paid after debt claims have been met. In the event of a project becoming insolvent equity investors rank last in the order of repayment and may lose their investment.

The amount of equity provided is considered as the balance of the loan required to finance the project. The total financial package is often described in terms of debt equity ratio. In projects considered to have a large degree of risk a larger proportion of equity is normally provided.

The advantages of an equity investment are:

- Equity may be used as a balancing item to accommodate fixed repayments;

- Equity investors are often committed to the success of a project as organizations involved is realizing a project.

Provides of equity fall into two categories, those with an interest in the project (contractors, vendors, operators) and pure equity investors (shareholders).

Sources of equity include: public share issue, financial institutions such as pension funds, companies and individuals, participants such as contractors, suppliers, operators, vendors and government and international agencies such as IFC (International Finance Corporation) IBRD, (International Bank for Reconstruction and Development) and EIB (the European Investment Bank).

8.1.3 Appraisal and Validity of Financing projects

The financial viability of a project over its life must be clearly demonstrable to potential equity investors and lending organizations. In assessing the attractiveness of a financial package project sponsors should examine the following elements:

- Interest rate,
- Debt / equity ratio,
- Repayment period,
- Currency of payment,
- Applicable charges (legal, management fees)
- Guarantees, and
- Documentation

The project must have clear and defined revenues that will be sufficient to service principal and interest payments on the project debt over the term of the loans and to provide a return on equity which is proportional with development and log term project risk taken by equity investors.

8.1.4 Project Risks

The identification of risks associated with any project is a necessary step to be carried out at the early stage of project appraisal.

A project often has a number of risks, (a) those which are identifiable and within the control of one or more of the parties to the project, (b) risks which may not be with in any parties reasonable control, but may be insurable at a cost, and uninsurable risks.

By identifying risks at the appraisal stage of a project a realistic estimate of the duration and final costs and revenues of a project may be determined.

Financial Risks

Financial Risks are associated with the mechanics of raising and the delivery of finance and the availability of working capital. Financial risks may include foreign exchange risks, off take agreements, take or pay terms, the effect of escalation and debt service risk that may arise during operation phase when machinery is running to specification but does not generate sufficient revenue to cover operating costs and debt service.

Commercial Risks

Commercial risks are considered when determing the commercial viability of a project. Commercial risks are those affecting the market and revenue streams which may include risks associated with access to new markets, size of existing markets, pricing strategy and demand.

Market risks prior to completion of a project would normally include:

- Raw materials not available when required during the construction phase;
- The market price of raw materials increases during the construction phase;
- The market price of the project's product falls or fails to rise as anticipated during the construction phase; and
- Market forces change leaving no receptive market for the projects product once production commences.

Lenders and investors should evaluate the above risks to determine the commercial viability of a project. If, from a financial point of view, a project seems to be commercially viable then additional risk areas associated with construction, operation and maintenance, political, legal and environmental should be identified and appraised.

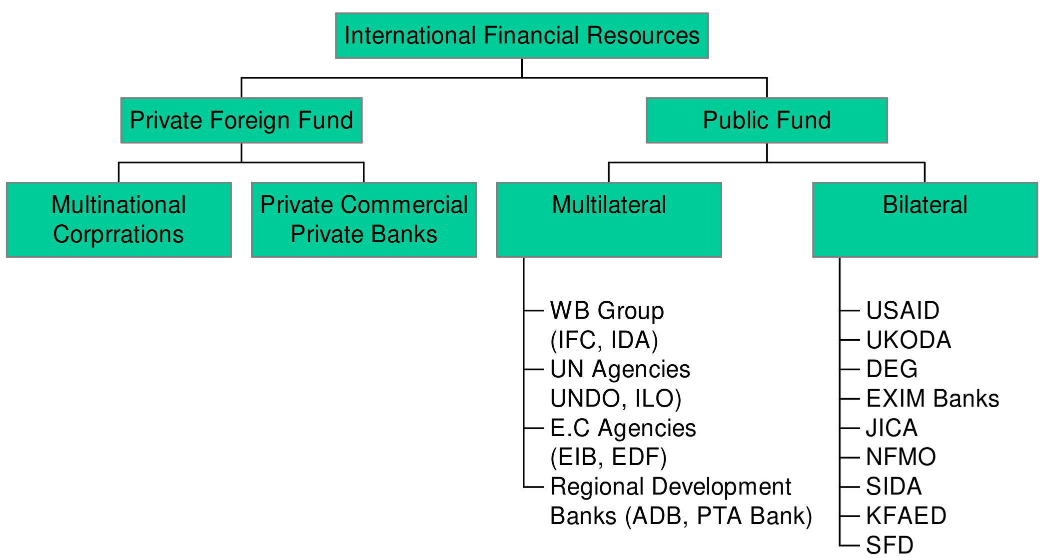
8.1.5 International Funds

The international flow of financial resources takes two main forms:

- Private foreign investment, mostly foreign direct investment by large multinational corporations with headquarters in developed nations and flow of financial capital by private international banks; and
- Public development assistance, both from individual national governments and multinational donor agencies

Figure 8.2 shows different sources of international financial resources.

Figure 8.2 International Funds



8.1.6 Proposal of Financial scheme for the PC Assembly plant project

Since this project is believed to generate considerable amount of foreign currency savings as well as earnings the government should take a vital role either by way of providing necessary securities or guaranty for lenders or by getting directly involved in the project as an equity investor. Organizations such as the Ethiopian Science and Technology commission may represent the government in the project.

Institutions with substantial reserve funds such as the Nation Social Security Authority, insurance companies and others could also be partners in this project by contributing some amount of equity sums.

The private sector (public share issue & individuals) is also assumed to take the leading initiative by investing in the equity part with special interest on the project and committing itself to the success of the project.

Multinational corporations could also be attracted by the project, as the demand of PC in the African market will explode in a few years as local users start using the Internet.

Multilateral international financial resource can also be obtained as the export market and foreign currency earning of the project seems to have a good potential.

The availability of personal computers at an affordable price can improve the system of education in the country. Therefore this project can have access to bilateral development funds extended for technical and training assistances.

The remaining equity investment could be arranged by means of export (suppliers) credit with soft loan arrangements from countries of source of technology for the project.

The other major investment, which is long-term and short-term loans, may be covered from local and foreign banks at cost. Local banks such as the Development Bank of Ethiopia (DBE) may lend for part of the investment that is needed in local currency. Foreign banks such as the African Development Bank (ADB) may participate in covering part of the investment which is required foreign currency.

Local commercial Banks may also cover short-term loans such as working capital and contingency requirements.

Table 8.1. Summaries the proposed sources of finance for the project divided between equity and debt sources.

Raising such funds would not be a simple task. It requires preparing full-fledged feasibility study by further refining this research thesis with clearly established financial strategies. This task would be the responsibility of the project promoters who might be individual equity investors or a government organ such as the National Computer Center, a department working under the umbrella of the Ethiopian Science and Technology commission.

Table 8.1 Proposed Sources of finance in % of Total Investment

Equity				**Loan**			
Participant	**LC**	**FC**	**Total**	**Lender**	**LC**	**FC**	**Total**
Government	20	-	20	Suppliers credit	-	20	
Institutional investors	20	-	20	Local Dev. Bank	-	40	
Share issue	20	-	20	Foreign Dev. Bank	-	20	
Individual sponsors	20	-	20	Local Comm. Bank	20	-	
Multinational corporations	-	10	10	-	-	-	
Multilateral funds	-	10	10	-	-	-	
Total	80	20	100	**Total**	20	80	100

LC= Local Currency; FC = Foreign Currency

8.2. Financial Analysis

To evaluate a project financially, we need to have information about the following:

a) Total investment costs
b) Project financing
c) Total production costs

Once all the elements of the above are prepared we need to test the financial viability of the project by a number of commercial profitability criteria including:

- Net present value
- Internal rate of return
- Pay back period
- Break-even analysis
- Sensitivity analysis

This chapter, therefore, discusses the financial evaluation of the PC assembly plant project interms of the above-mentioned points.

8.2.1 Investment Costs

The investment cost is a sum of various investment outlays. Most of these are described in chapter 5, 6, and 7. The investment cost is broken down into three main components namely, fixed investment costs, pre-production expenditures and working capital requirement. Each one of these is discussed below.

8.2.1.1 Fixed Investment Costs

This refers to the cost of land, site preparation and development, structures and civil work, incorporated fixed assets, plant machinery and equipment, and auxiliary and service plant equipment. These costs were covered in chapter 5; and the summary is given in table 8.2. As shown is the table the total fixed investment cost of the project amounts to Birr 28.5 million, of which 60% will be required in foreign currency.

Table 8.2 Fixed investment costs, in'000 Birr

S.N	Description	FC	LC	Total
1	Land purchase	-	100	100
2	Site preparation and development	-	810	810
3	Civil works, structures and buildings	-	8,100	8,100
4	Plant machinery & equipment	14,033	-	14,033
5	Auxiliary & service plant equipment	1,000	1,500	2,500
6	Environmental protection		500	
7	Contingency	2,000	500	2,500
	Total	**17,033**	**11,510**	**28,543**

Note: FC = foreign currency; LC = local currency

8.2.1.2 Pre-Production Expenditures

These cost components refer to all project expenses occurring during project conception and development phases. Most part of this is associated with project management, detail engineering design, training, supervision of erection and commissioning as well as arrangements for supplies and marketing. Also interest costs during construction period is capitalized as pre-production expenditures. As shown is table 8.3, the total pre-production expenditures for the PC assembly project is estimated at Birr 16.78 million; about 35% or Birr 5.8million will be required in foreign currency.

Table 8.3. Pre-production expenditures, is '000 Birr

S.N	**Description**	**FC**	**LC**	**Total**
1	Pre investment studies	-	100.00	100.00
2	Project management	-	2,100.00	2,100.00
3	Detail engineering	450.00	280.00	730.00
4	Training	500.00	25.00	525.00
5	Supervision of erection and commissioning	1,000.00	50.00	1,050.00
6	Arrangements for supplies, marketing	3,857.28	500.00	4,357.28
7	Interest	-	7,818.12	7818.12
	Grand total	**5,807.28**	**10,873.12**	**16,680.4**

Note: FC = foreign currency; LC = local currency

8.2.1.3 Working Capital Requirement

Working capital indicates the financial means required to operate the project according to its production program. Working capital requirement in the context of the PC assembly project consists of the following:

- Capital for Raw materials
- Capital for Component sub-assemblies
- Capital for Work-in-process
- Finished goods
- Accounts receivable
- Cash in hand

To calculate the working capital requirement, the following assumptions of minimum days of coverage (MDC) are made:

Raw materials:	90 days
Components:	90 days
Work-in process:	5 days
Finished products:	30 days
Cash in hand:	30 days
Accounts receivable:	30 days
Accounts payable:	30 days

Based on these assumptions, table 8.4 shows the steps of determining the working capital requirement. Accordingly, during the first year of operation, the plant requires a working capital of about Birr 51.2 million. At full capacity operation, the working capital requirement is estimated at Birr 67.5 million.

8.2.1.4 Total Investment Cost

The total investment cost of the project is estimated to be Birr 96.43 million, of which 65% will be required in foreign currency. Table 8.5 shows the summary of total investment cost.

Table 8.4. Working capital requirement in '000 Birr

			Year of operation

Item	MDC	COT	2006 (75%)	2007 (85%)	2008 (100%)
Accounts receivable	30	12	13,155.67	14809.79	16,895.07
Raw materials	90	4	14,359.60	15,795.56	18,164.9
Components	90	4	21,539.40	23,693.34	27,247.34
Work-in process	5	72	2,506.80	2,757.48	3,171.10
Finished products	30	12	12,987.71	14,286.54	16,429.52
Cash in hand	30	12	1,866.76	1,877.06	1,902.53
Accounts payable	30	12	15,209.43	13,285.84	15,718.24
Net working capital	-	-	51,206.56	59,122.4	67,504.27
Increase in working capital	-	-	51,206.56	7,915.85	8,381.87

Note:

MDC=minimum days of coverage

$$COT = \text{coefficient of turnover} = \frac{360 \text{ days}}{\text{days of coverage}}$$

Table 8.5 Total Investment Cost, '000 Birr

Item	Investment category	FC	LC	Total
1	Fixed investment costs	17,033.00	11,510.00	28,543.00
2	Pre-production expenditures	5,807.28	10,873.12	16,680.40
3	Working capital	40,965.25	10,241.31	51,206.56
	Total	**63,805.53**	**32,124.43**	**96,429.96**

8.2.2. Sources of finance

Sources of finance for the project have been broadly discussed in section 8.1.5. Here again we would follow the same assumption. The total investment cost as specified in section 8.2.1 amounts to Birr 96,429,960.00

Assuming equity to loan ratio of 40: 60, the sources of finance for the project are outlined in table 8.6. Accordingly, total equity amount will be Birr 38,571,980.00 while the required term loan will be Birr 57,857,980.00.

Table 8.6 Source of finance,' 000 Birr

Source	Amount		
	Foreign currency	Local currency	Total
Equity -total	*7,714.00*	*30,857.60*	*38,571.60*
• Government	-	7,714.40	7,714.40
• Institutional investors	-	7,714.40	7,714.40
• Share issue	-	7,714.40	7,714.40
• Individual sponsors	-	7,714.40	7,714.40
• Multinational corporations	3,857.00	-	3,857.00
• Multilateral fund	3,857.00	-	3,857.00
Loan - total	*52,558.61*	*1,766.83*	*57,858.36*
• Suppliers credit	11,571.60	-	11,571.60
• Development bank	23,143.19	-	23,143.19
• Foreign bank	11,571.60	-	11,571.60
• Local commercial bank	9,805.14	1,766.83	11,571.97
Grand total	**63,805.53**	**32,624.43**	**96,429.96**

8.2.2.1 Interest On Term Loan

The term loan is supposed to finance the working capital requirement while most of the fixed investment outlays will be covered by equity capital. The interest on term loan is calculated based on the following assumptions:

- Repayment period: an average of five years
- Interest rate: 7.5%
- Loan installment: equal installment of principal plus interest, annually starting from first year of production.

According, the schedule of installments and interest are shown is table 8.7

8.2.3 Production Costs

Production cost is the aggregated costs of raw materials, supplies and utilities, factory overheads, labor and administrative overheads, interest, and depreciation expenses. The total production cost at full capacity operation is estimated at Birr 209.5 million. Table 8.8 indicates annual production cost estimates.

Table 8.7 Loan repayment schedule,'000 Birr

Year	Installment	Outstanding principal	Interest
2003	-	-	-
2004	-	-	-
2005	-	57,857.98	4,339.35
2006	11,571.59	46,286.39	3,471.48
2007	11,571.59	34,714.80	2,603.61
2008	11,571.59	23,143.21	1,735.74
2009	11,571.59	11,571.62	867.87
2010	11,571.59	-	-
Total	**57,857.98**	**-**	**13,018.05**

Depreciation

Depreciation costs are calculated taking into account the following assumptions

- Method of depreciation: straight line method
- Depreciation rates:

  Building: 5%

  Machinery & equipment: 20%

  Auxiliary equipment (vehicles): 20%

  Pre - production costs: 20%

Based on the above assumptions the annual depreciation cost is estimated to be Birr4.3 million.

Table 8.8 Annual production cost estimates. '000Birr

Cost item	Start-up		Full capacity
	2006 (75%)	2007 (85%)	2008 (100%)
Raw materials inputs	143,595.22	153,722.22	176,732.58

Supplies and Utilities	978.55	1,008.78	1,077.45
Repair and maintenance	500.00	500.00	500.00
Spare parts	2000.00	2000.00	2000.00
Royalities	18,000.00	18,000.00	18,000.00
Labor and Adm. over head	3,383.11	3,494.75	3,748.44
Operating costs (sum above)	**168,974.94**	**179,255.66**	**202,615.32**
Financial costs (interest)	6,250.9	5,010.72	3,770.54
Depreciation	4,326.26	4,326.26	4,326.26
Total manufacturing cost	**179,552.10**	**188,592.64**	**209,471.93**

7.2.2. Sales Revenue

In addition to assembled PCs the plant is assumed to produce PC components such as computer cases, monitor cases and keyboard frames. Thus the estimated annual sales revenue according to the proposed production program will be as indicated in table 8.9.

Table 8.9 Annual sales revenue at full capacity, ' 000 BIrr

Item	**Year**		
	2006	2007	2008
Higher capacity PC	20,250.00	22,950.00	27,000.00
Medium capacity PC	21,262.50	24,097.50	28,350.00
Lower capacity PC	30,375.00	34,425.00	40,500.00
Accessories	31,278.00	35,448.40	41,704.00
Computer case	17,212.50	19,507.50	22,950.00
Monitor cases	53,156.25	60,243.75	70,875.00
Keyboard parts	5,437.50	6,162.50	7,250.00
Mouse cases	1,518.75	1,721.25	2,025.00
Total	**180,490.50**	**204,555.90**	**240,654.00**

8.2.3 Investment Evaluation

The most traditional and widely used techniques for investment evaluation in general are characterized by a cost- benefit analysis expressed in financial terms. The basic methods used include: the payback period; the accounting rate of return; the net present value (NPV); and the internal rate of return (IRR).

The first two of these methods disregard the time value of money and thus are called imperfect criteria. The payback period is defined as the time period needed to compensate for the initial investment expenditure using the money flow generated as a result of the investment, with a rate equal to zero. The accounting rate of return is defined as the ratio of the mean annual net income of the investment over the initial investment cost or over the mean logistic value of the investment.

The NPV method calculates the present value of the investment's money flow, using a given rate, and the higher (positive) the NPV the better the project. The IRR corresponds to the rate for which the present value of the investment's money in-flows is equal to the present value of the money-outflows [14]. These methods are summarized in table 8.10.

Financial evaluation of this project considers the payback period, the NPV, and the IRR. Although the NPV is theoretically considered superior to all, practically the IRR method is used more frequently because it is easier to make a comparison based on rates.

Financial evaluation of the PC assembly project is done using software known as CMFAR III Expert (developed by UNIDO for the appraisal of industrial projects). The result shows that the envisaged project is financially viable with the following measuring parameters:

- IRR on total investment = 22.39%

- IRR on equity =31.16%
- NPV at 7.5% interest rate = BIRR 119.6 million
- Payback period = 8-years

Table 8.10 Investment evaluation Methods

uation Meted	Formula	Definition
ɔd	)	enditure. w during period t. ɛriod
ıte of return (ARR)	$- F_o$ $\overline{\quad}$ $_o$	enditure. w during period t. ıe since beginning of investment
alue (NPV)	$F_t (1+i)^{-t}$	w during period t.
ɔf Return (IRR)	$F_t (1+i^*)^{-t} = 0$	w during period t.

Cash flow projections

The cash flow statement on loan and equity financing, with a ratio of 60:40 respectively, shows cumulative net cash balance of Birr 325.2 million by the end of the project life. The internal rate of return is 22.39% with a net present value of Birr 119.6 million indicating the viability of the project as the IRR is greater than the on going interest rate.

Break-even

The break-even point of the PC assembly plant is 60.22 % at the first year of operation; it reduces to 52.48% at the fifth year and is constant at 45.17% afterwards.

Sensitivity

The project is tested for supposed variations in fixed investment, operational costs and sales revenues. It is found that the project is much more sensitive to variations in operating costs than the others. Table 8.11 shows the sensitivity result.

Table 8.11 Sensitivity test

Condition	**RR, %**
mal estimates taken in the study)	22.39
in fixed investment cost	18.52
in operating cost	14.32
in sales revenue	16.30

CHAPTER NINE: CONCLUSIONS AND SUMMARY

9.1 Summary

9.1.1 General

In this thesis an attempt has been made to apply the concepts of project management to the project of establishing a PC assembly plant in Ethiopia. The four phases of a project namely, the conception, development, realization and termination were described in the respective chapters of the thesis.

Chapter one has covered the introductory part of the thesis describing topics such as project phases, thesis background, objective, methodology adopted, and application of thesis results. Chapter two has dealt with literature survey of the computer system where the following topics have been given an in-depth coverage: classification of computers, computer hardware, elements of the system unit, the making of a microprocessor and computer generations.

In chapter three an extensive analysis has been made to quantify the present and future demand of PCs in Ethiopia. Identification of the assembly components of a PC and analysis of buy or make decision is discussed in chapter four. Chapter five dealt with the technology of electronics assembly in general and PC assembly in particular. Also study of plant engineering, location as well as manpower requirement is discussed in chapter five.

The implementation plan of the project is described in chapter seven. Also in this chapter modern techniques of project management have been discussed in general. Project financing, both as a general discussion and in the context of the PC assembly project, is covered in chapter seven. Also in this chapter detail financial analysis work is done with the help of relevant software.

8.1.2. Results of the Market Study

The PC market at the global level is estimated to be over 50million units per year. With the widespread use of the Internet in general and the e-commerce in particular the demand for PCs is increasing from time to time. At present the world e-commerce transaction is estimated at US$ 805 Billion.

According to the findings of this study, the present demand for PCs in Ethiopia is estimated in the range of 25,000 to 30,000 units per year. The annual rate of growth is more than 50%. Five years from now, the forecasted demand reaches more than 120,000 units.

Considering such factors like the demand-supply gap as well as market penetration the capacity of the PC assembly plant is selected to be 15,000 PCs per year. However, the plant is supposed to produce casings and other plastic components both for self-consumption and for export markets.

9.1.3. Technology and Engineering

Generally, electronics manufacture consists of three stages: (a) the manufacture of PCBs, (b) the placement of components in to PCBs' and (c) the assembly of boards into a case or housing.

The proposed strategy here is to start assembly of PC by importing components in SKD form and develop stage-by-stage to a level of producing PCBs and ultimately manufacture own electronic products both for local as well as export markets.

Two types of placement of components into PCBs have been discussed: through-hole components technology and surface mount technology. The necessary machinery and equipment have been identified; those needed for the injection moulding unit and those for the assembly unit.

The land area requirement of the plant including future expansion is estimated to be 10,000 m^2. Engineers' estimate of the cost of factory building, warehouse and offices is about 8.2million Birr. The location is proposed to be in the vicinity of Addis Abba and manpower requirement of the plant is about 86 persons.

9.1.4. Project Financing & Financial Analysis

The financial plan of a project will often have a greater impact on its success than the physical design and construction costs.

The source of finance for the envisaged project has been analyzed taking into account both local and international sources of fund. The proposal is made by a combination of sources such as the government, institutional investors, public share issue, individual sponsors, multinational corporations, multilateral funds, suppliers credit, local and foreign development banks and commercial banks.

The financial analysis of the project shows an estimated total investment cost of Birr 96.43 million. The internal rate of return (IRR) is found to be 22.39 %, and the net present value (NPV) at a rate of 7.5% is about Birr 119.6 million. The project is highly viable with a payback period of seven or eight years and a total cumulative cash balance of Birr 325.2 million.

9.2 Conclusion

It can be said that the computer is the most economically important technological innovation of the 20^{th} century. The creation of the computer has led to the appearance of a new era called the information age. In the new era information is rapidly becoming the world's most precious resource, creating wealth more than any other physical resources. The central part of the information age is nothing but the computer.

The computer has become a part of day-to-day existence of people around the globe. It is difficult to think of any field that does not involve or is not affected by computers. As a result, the computer industry today has become a trillion-dollar market.

In the developing countries like Ethiopia, the demand for PCs now may be relatively low; but the market will explode in a few years time as information technology grows and local users start using the Internet.

In order to narrow down the gap between the developed and developing nations, countries like Ethiopia should work hard to develop the condition of their information and communication technology (ICT). These days it is realized that ICT is a proven tool that one must be equipped with in the fight against poverty and in the effort to secure sustainable economic development.

In this regard, the policy makers should focus on building local capability to develop and manufacture ICT related items such as computer hardware, software and telecommunications equipment.

The preliminary assessment of building a PC assembly plant in Ethiopia, as carried out in this research, has shown the viability of the project in terms of market, technical requirements and financial measurements.

The researcher, therefore, urges any interested parties to further refine and go-ahead with this project in the effort to develop the ICT status of our country and generate hard currency by means of import substitution and taking part in export markets. If we fail to take this initiative, sooner or later we will be forced to import computers and accessories from other African countries, possibly from the COMESA region, who might take such initiatives and stay ahead of us in the ICT technology in general and the computer industry in particular.