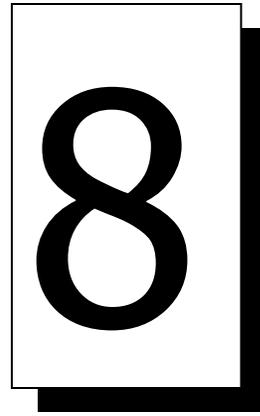


Capacity Planning



Unit Introduction

Capacity Planning is vital in operations management. Capacity is the rate of productive capability of a facility. Capacity decisions need acute and careful attention by concerned persons as almost everything of the operations is related with capacity. It is important as it determines the optimal level of production and uninterrupted production run. There are several other important causes, for which the entrepreneurs and managers must address capacity decisions. In this unit it has been tried deliberately to introduce important notions regarding these issues. Therefore this unit includes capacity, capacity planning and importance of capacity decision; capacity requirement, effective capacity determinants; capacity strategy.

Lesson One: Capacity and Capacity Planning

Lesson Objectives

After completing this lesson you will be able to:

- Explain the meaning of capacity
- Identify the system of capacity measurement and its effectiveness
- Meaning of capacity planning
- Identify the capacity planning activities
- Discuss the importance of capacity planning

The most fundamental decision in any organizations related to the products and services it offers. These decisions are relative to capacity, process, facilities, location and the likes are governed by product and service choices. Thus a decision to produce high quality product will necessitate certain types of processing equipment and certain kinds of labor skills, and it will suggest certain type of arrangement of facilities. It will influence size and type of building as well as the plant location. In some instances, capacity choices are made very infrequently; in others, they are made much more regularly, as part of an ongoing process. Generally, the factors that influence this frequency are the stability of demand, the rate of technological change in equipment, the rate of change in product design and competitive factors.

What is Capacity?

The upper limit or ceiling on the load that an operating unit can handle is called its capacity. Capacity is the rate of productive capability of a facility. The operating unit might be a plant, department, machine, store, or worker. The load can be specified in terms of either inputs or outputs. To understand these consider the following examples.

- *Capacity in respect of capability:* Airlines capacity measures their capacity in Available Seat Miles (ASMs) over a year. Or hospitals may measure its capacity in number of beds available. However this measure is incorrect, as it doesn't consider outpatient treated by the hospital.
- *Capacity in respect of inputs:* A machine is able to process 120 pounds of raw materials in every hour it works, so its input capacity is 120-pounds/hour.
- *Capacity in respect of outputs:* A machine can produce 20 units of finished goods in every hour it works, so its output capacity is 20 units/hour.

Capacity is the rate of productive capability of a facility.

The definition that has been provided earlier is a working definition of capacity; although it is functional, it can be refined into three useful definitions:

- *Design Capacity:* The maximum output that can possibly be attained.
- *Effective Capacity:* The maximum possible output given a product mix, scheduling difficulties, machine maintenance, quality factors, and so on.
- *Actual Output:* The rate of output actually achieved. It cannot exceed effective capacity and is often less than effective capacity due to breakdowns, defective outputs, shortage of materials, and similar factors.

Activity: Do you think in the operations management should measure the human capacity and the machine capacity with the same measurement? Discuss your opinion logically.

Measuring Capacity

No single measure of capacity will be appropriate in every situation. Rather the measure of capacity must be tailored to the situation. The following Table 8.1.1 provides some commonly used measure of capacity.

Table 8.1.1: Common measures of capacity

Business	Inputs	Outputs
Auto manufacturer	<ul style="list-style-type: none"> • Labor hours • Machine hours 	Number of cars per shift
Steel mill	<ul style="list-style-type: none"> • Furnace size 	Tons of steel per day
Oil refinery	<ul style="list-style-type: none"> • Refinery size 	Gallons of fuel per day
Farming	<ul style="list-style-type: none"> • Number of acres • Number of cows 	Bushel of grain per acre per year, Gallons of milk per day
Restaurant	<ul style="list-style-type: none"> • Number of tables • Seating capacity 	Number of meals served per day
Theater	<ul style="list-style-type: none"> • Number of seats 	Number of tickets sold per performance
Retail sales	<ul style="list-style-type: none"> • Square feet of floor space 	Revenue generated per day

Measures of System Effectiveness

These different measures (Table 8.1.1) of capacity are useful in defining two measures of system effectiveness: *Efficiency* and *Utilization*. Where *efficiency* is the ratio of *actual output to effective capacity* i.e., (Actual output / Effective capacity) and the *utilization* is the ratio of *actual output to design capacity* i.e., (Actual output/Design capacity). It is common for managers to focus exclusively on efficiency, but in many instances, this emphasis can be misleading. This happens when effective capacity is low compared with design capacity. In those cases, high efficiency would seem to indicate effective use of resources when it does not. The following example illustrates this point:

Example:

Design capacity = 50 trucks per day
 Effective capacity = 40 trucks per day
 Actual output = 36 units per day
 Efficiency = Actual output / Effective capacity
 = 36 units per day/ 40 units per day
 = 90%
 Utilization = Actual output / Design capacity
 = 36 units per day/ 50 units per day
 = 72%

Thus, compared with the effective capacity of 40 units per day, 36 units per day (90%) looks pretty good. However, compared with design capacity of 50 units per day, 36 units per day (72%) is much less impressive although probably more meaningful.

Because effective capacity acts as a lid on actual output, the real key to improving capacity utilization is to increase effective capacity. Now assume that Mr. Rahim wants to travel from his home at Dhaka to his sister's home at Gazipur, 25 miles away. He could borrow his son's bicycle or his motorbike. Instead of using the bicycle and concerning himself with pedaling as efficiently as possible, he could make the trip in less time (same output in a shorter time) by using the motorbike. Hence, increasing utilization depends on being able to increase effective capacity, and this requires knowledge of what is constraining effective capacity.

Activity: Why term efficiency and utilization are important to measure the capacity of any business related issue? Choose any business issue of your choice and based on that justify your argument.

Capacity Planning

Capacity Planning or Aggregate Planning is defined as the process of aggregating (i.e., consolidating or grouping) all the requirements for fulfilling capacity requirements for each period in the intermediate horizon and determining the best way to provide the needed capacity. The objectives of capacity planning are *feasibility* i.e., the internal needs must be within the capability of the operations system and *optimality* i.e., it is desirable to determine the least costly way to meet the capacity needs.

Capacity planning is the process of aggregating all the requirements for fulfilling capacity requirements and determining the best way to provide the needed capacity.

Aggregate planning considers the variables that can be used to adjust the capacity within the intermediate horizon. The most common variables in *adjustable capacity* are the work force size, the production rate in terms of the number of hours worked per day or week (this amounts to the use of overtime work or idle time), and inventory if it can be used to *store capacity* in one period so it can serve demand in later one period (Services usually cannot store inventory of their output). Sometimes back-ordering and subcontracting are used. If only one variable is adjusted to deal with a non-uniform demand within the planning horizon, it is called the *pure strategy*; the adjustment of more than one variable is called a *mixed strategy*.

The capacity of an operating unit is an important piece of information for planning purposes. It enables managers to quantify production capability in terms of inputs and outputs, and thereby make other decisions or plans related to those quantities. There the basic questions in capacity planning of any sort are:

- What kind of capacity is needed?
- How much is needed?
- When is it needed?

The question of what kind of capacity is needed relates to the product and services that management intends to produce or provide. Hence, in a very real sense, capacity planning is governed by those choices.

Activity: Is there any relationship between consumer demand and production capacity of any manufacturing firm? Discuss from the point of any manufactured products of your choice.

Capacity Planning Activities

Capacity planning is the first decision of the organization regarding how much to produce.

Capacity planning is the first step when an organization decides to produce more of a new or existing product. Once capacity is evaluated and a need for new or expanded facilities is determined, facility location and process technology activities occur. Too much capacity would require exploring ways to reduce capacity, such as temporarily closing, selling, or consolidating that might involve relocation, combining of technologies, or a rearrangement of equipment and processes. Capacity planning normally involves the following activities:

- a) Assessing existing capacity
- b) Forecasting capacity needs
- c) Identifying alternative ways to modify capacity
- d) Evaluating financial, economical, and technological capacity alternatives
- e) Selecting a capacity alternative most suited to achieve strategic mission

a) *Assessing existing capacity & requirements*

Assessing starts with measurement. There is no single measurement technique customized for such decisions, rather a blend of different approaches is utilized when necessary. As noted, there are two systems of measurements of system effectiveness: efficiency and utilization. *Efficiency* is the ratio of actual output to effective capacity and *Utilization* is the ratio of actual output to design capacity.

b) *Forecasting capacity needs*

Capacity requirements can be evaluated from two extreme perspectives – short term and long-term capacity needs:

- *Short-term Requirements:* Managers often use forecasts of product demand to estimate the short-term workload that the facility must handle. By looking ahead up to 12 months, managers anticipate output requirements for different products or services. Then they compare requirements with existing capacity and detect when adjustments are necessary.
- *Long-term Requirements:* Long-term capacity requirements are more difficult to determine as future demand and technologies are uncertain. Forecasting five or ten years ahead is a risky and difficult task. Important questions include what products and services will the firm produce then for today's product may not even exist in the future. Obviously, long-term capacity requirements are dependent on marketing plans, product development, and the life cycle of products. Changes in process technology must also be anticipated. Even if products remain unchanged, methods for generating them may change dramatically. Capacity planning thus must involve forecasts of technology as well as product demand.

Long-term capacity is dependent on marketing plans, product and life cycle of the products.

c) *Identifying ways to modify capacity*

After existing and future capacity requirements are assessed, alternative ways of modifying capacity either short-term or long term must be identified. Short-term responses to *capacity modification* include the Table 8.1.2.

Table 8.1.2: Temporary Capacity Changes

Type	Actions
Inventories	Stockpile of finished goods should be built during slack periods to meet later demand.
Backlogs	During peak demand periods, willing customers may be requested to wait some time before receiving their product. Their orders may be filed and be fulfilled after the peak demand period.
Employment levels	Additional employees be hired or be laid-off as demand for output increases or decreases.
Work force utilization	Employees may be asked to work overtime during peaks and can be allowed to work fewer hours during slack demand periods.
Employee training	Instead of having employees specialized in one task, each of them should be trained in several tasks. Then as skill requirement changes employees be rotated among different tasks. This is an alternative to hiring and layoffs for getting needed skills.
Process design	Job contents may be changed at each workstation to increase productivity. Work methods analysis and redesign of jobs are suggested there.
Subcontracting	During peak periods, temporarily another firm might be hired to make the product or some of its components.
Maintenance	Routine preventive maintenance programs on facilities and equipment be discontinued temporarily so that during peak periods the facility can be operated when it would otherwise be idle.

On the other hand to consider the long-term responses to capacity modification management of any organizations today should not only consider expansion of their resource bases but also consider optimum approaches to contracting it. The costs, benefit, and risks of expansion pose an interesting decision problem. By building the entire addition now, the company avoids higher building costs, the risks of accelerated inflation (and even higher future construction costs), and the risk of losing additional future business because of inadequate capacity. But there may also be disadvantages to this future alternative. First, the organization may not be able to muster the financial investment. Second, if the organization expands now, it may find later that its demand forecasts were incorrect; if ultimate demand is lower than expected, the organization has overbuilt. Finally, even if the forecasted demand is accurate it may not fully materialize until the end of the five-year planning horizon. If so, the organization will have invested in an excess-capacity facility on which no return is realized for several years. Since it could have been invested in other ways, the firm has foregone the opportunity of earning returns elsewhere on its investment.

Contraction and Constant Capacity: Capacity contraction most often involves selling of existing facilities, equipment, and inventories, and firing employees. As serious declines in demand occur, we may gradually terminate operations. Permanent capacity reduction or shutdown occurs only as a last resort. Instead, new ways are sought to maintain and use existing capacity otherwise great deals of effort, capital, and human skills used in

Capacity contraction often involves selling of existing facilities, equipment, inventories, and firing employees.

producing the particular technologies have become wasted. Often these technology and skill bases are transferable to other products or services. As one product reaches the decline phase of its life cycle, it can be replaced with others without increasing capacity (Table 8.1.2). This phasing in and out of new and old products is not by accident. Staff for product research and development and market research engages in long-range planning to determine how existing capacity can be used and adapted to meet future demand.

Activity: From the point of current market trends of Bangladesh garment sector do you think the manufacturer should think about the modification of their capacity of production? Why or why not? Discuss.

- d) *Evaluating financial, economical, and technological capacity alternatives:*
For evaluation purposes of capacity planning activities different modeling alternatives are available. These are,
- *Present Value Analysis*, for instance, is helpful whenever the time value of capital investments, and fund flows are considered.
 - *Aggregate Planning Models* are useful for examining how best to use existing capacity in the short term.
 - *Breakeven Analysis* can identify the minimum breakeven volumes when comparing projected costs and revenues. In the short-term capacity utilization: linear programming and computer simulations are very useful.
 - *Decision Tree Analysis* is useful to the long-term capacity problems of facility expansion.

- e) *Selecting a capacity alternative most suited to achieving strategic mission:*
As it has been mentioned, the three types of modeling- decision tree analysis, linear programming, and computer simulation- all needs to be used selectively to determine the most suited capacity alternatives. The proper choice among them depends on the type of capacity problem. Other models, too, are sometimes beneficial. Selecting and using models for managing capacity requires a good understanding of the environment within which the organization is operating, including current demands on existing operations, and a vision of future business conditions.

Selecting models for capacity management require better understanding between environment and organization.

Importance of Capacity Planning

For a number of reasons, capacity decisions are among the most fundamental of all the design decisions that managers must make. These include:

- The importance of capacity decisions relates to their potential impact on the ability of the organization to meet future demand for products and services; capacity essentially limits the rate of output possible.
- The importance of capacity stems from the relationship between capacity and operating costs. Ideally, capacity and demand requirements will be matched, which will tend to minimize operating costs.
- The importance of capacity decisions also lies in the initial cost involved, of which capacity is usually a major determinant. Typically the greater the capacity of a productive unit, the greater its costs. This does not

necessarily imply a one-for-one relationship; larger units tend to cost proportionately less than smaller units.

- The importance of capacity decisions stems from the often required long-term commitment of resources and the fact that, once they are implemented, it may be difficult or impossible to modify those decisions without incurring major costs.

Like many other things, managers have to take decisions regarding the capacity of their operating units and these decisions are very important because:

- In today's competition, any profit-making organization would like to keep its existing customers and have new ones as well. If capacity decision contains flaws, the sales team may desperately want to take a particular order, while the operations team may struggle to meet the demand. Hence it is very easy to lose customers if their demand is not fulfilled. For example, think of a situation when you bring your car to a car service center and learn that due to equipment and staff limitations your car will be serviced in about a week.
- Capacity planning involves different cost considerations. One type of such cost is operating cost. If, for example, the capacity of ABC footwear factory is 100,000 units per year and demand for their product is 50,000 units for the same period, then their operating cost will be higher than it would be if the capacity and demand were the same. Another type of cost is cost of building the operating unit. Once this cost is decided upon and the unit is built there is no turning back, it becomes fixed cost. So, if afterwards management finds out that capacity of the unit is lower or higher than required, any modification is likely to incur major costs.

Activity: Do you think Bangladesh should manufacture automobiles in the country? Why or why not? Discuss your opinion incorporating the concept of public demand and capacity of production in Bangladesh.

It is important to note that the workload required by the *Master Production Schedule* (MPS), a summary of planned end product needs for specific future time periods, is within the capacity of the company and that it makes wise use of the company's capacity. Since MPS is developed to fit the production plan, it is advisable to check the amount of capacity required by the production plan in certain periods while those periods are *far enough* in the future to change the capacity in some departments, if necessary. This is particularly true for business that has significant seasonal variations in demand.

Discussion questions

1. Define and describe the operating capacity of a college of business administration. How should its capacity be measured?
2. Discuss the fundamental differences between long term and short term capacity decisions.
3. Capacity will be modified in response to demand. Demand will be modified in response to capacity. Which statement is correct? Why?
4. What is capacity planning?
5. Discuss the fundamental differences between long term and short term capacity decisions.

Lesson Two: Capacity Requirement, Effective Capacity Determinants and Capacity Strategy

Lesson Objectives

After completing this lesson you will be able to:

- Highlight and determine capacity requirement
- Identify determinants of effective capacity
- Explain the capacity requirement strategy

Capacity Requirement

Capacity planning decisions involve both long term and short-term considerations. Long-term consideration relates to overall level of capacity, such as facility size; short-term consideration relates to probable variations in capacity requirements created by things like seasonal, random, and irregular fluctuations in demand.

Capacity planning decisions involve both long-term, short-term & irregular fluctuations in demand.

For long-term consideration some sorts of trend analyses are required.

1. When trends are identified, the fundamental issues are:
 - a) How long the trend might persist, since few things last forever
 - b) The slope of the trend
2. If cycles are identified, interest focuses on:
 - a) The approximate length of the cycles, since cycles are rarely uniform in duration, and
 - b) The amplitude of cycles, (i.e., deviations from average).

Determinants of Effective Capacity

- a) *Facilities factors:* The design of facilities, including size and provision for expansion, is very important. Location factors, such as transportation costs, distance to market, labor supply, energy sources, and room for expansion, are also important.
- b) *Product/service factors:* Product and service design can have a tremendous influence on capacity. For example, when items are similar, the ability of the system to produce those items is generally much greater than when successive items differ. A restaurant that offers a limited menu can usually prepare and serve meals at a faster rate than a restaurant with an extensive menu.

Table 8.2.1: Factors that determine effective capacity

Factors	Sub-factors
a) Facilities	Design, Location, Layout
b) Product/Service	Design, Product or service mix
c) Process	Quantity capabilities, Quality capabilities
d) Human Factors	Job content, Job Design, Training and experience, Motivation, Compensation, Learning rates, Absenteeism and labor turnover
e) Operational	Scheduling, Materials management, Quality assurance, Maintenance politics, Quality assurance
f) External Factors	Product Standards, Safety regulations, Unions, Pollution control standards

- c) *Process factors*: The quantity capability of a process is an obvious determinant of capacity. A subtler determinant is the influence of output quality. For instance, if quality of output does not meet standards, the rate of output will be slowed by the need for inspection and rework activities.
- d) *Human factors*: The tasks that make up a job, the variety of activities involved, and the training, skill, and experience required to perform a job all have an impact on the potential and actual output.
- e) *Operations factors*: Scheduling problems may occur when an organization has differences in equipment capabilities among alternative pieces of equipment or differences in job requirements. Inventory stocking decisions, late deliveries, acceptability of purchased materials and parts, and quality inspection and control procedures also can have an impact on effective capacity. Many decisions made concerning system design have an impact on capacity; the same is true for operating decisions. Some of these factors that determine effective capacity are summarized in the Table 8.2.1.
- c) *External Factors*: External factors like product standards, safety regulations, unions, pollution control standards etc are also the determinant factors in the production operation efficiency of a business organization.

Capacity planning for the long term is a strategic decision.

Capacity Strategy

Capacity requirements can be evaluated from two extreme perspectives – short-term and long-term. After existing and future capacity requirements are assessed, alternative ways of modifying capacity must be identified.

Strategic aspects of capacity: Capacity planning for the long term is a strategic decision. If capacity is too small, an organization may,

1. Lose customers
2. Allow competitors to enter the market
3. Unable to provide timely service.

If capacity is too large, an organization may,

- have difficulty in controlling the operations
- glut the market and drive down the price, or
- be unable to pay off a loan obtained to build capacity.

Some organizations increase capacity to attempt to dominate an industry. One way to do that is to have the largest capacity. If the industry now has only 80% of the needed capacity, building a facility that can supply 25% more makes it unprofitable for a competitor to expand. To do so, the competitor would have to cut the price (starting a price war), so that a high return could not be earned. By being first, a company can impose a *barrier to entry*. Of course, there are risks in selecting capacity strategically. Someone else may have the same idea. Imagine all the key players in the market each adding 25% to the market supply.

Evaluation of capacity strategy: Among different evaluation alternatives processing requirements: break-even analyses, and financial analyses, decision theory, etc., are utilized.

● **Breakeven analysis**

The introduction of a new output into the organization’s existing output mix should only be implemented if a complete economic analysis has been conducted beforehand. This analysis would consider the fixed cost of existing capacity, the variable costs of the output, the return from the output, and the effect of different volumes of demand. Such an evaluation is called breakeven analysis. All the financial analysis is used to rank investment proposals.

● **Decision theory**

Decision theory approach involves the following steps:

- i. Identification of possible future conditions (these are beyond the control of the decision maker).
- ii. Development of possible alternatives, one of which may be to do nothing
- iii. Estimation of the payoff associated with each alternative for every possible future condition
- iv. Estimation (if possible) of how likely each possible future condition is.
- v. Evaluation of alternatives according to some decision criteria and selection of the best alternative.

● **Short-term Responses**

Managers often use forecasts of product demand to estimate the short-term workload that the facility must handle. By looking forward managers anticipate output requirements for different products or services. Then they compare requirements with existing capacity and detect when capacity adjustments are needed. For short-term periods of up to one year, fundamental capacity is fixed. Major facilities are seldom opened or closed on a regular monthly or yearly basis. However, many short-term adjustments for increasing or decreasing capacity are possible. Which adjustments to make depend on whether the conversion process is primarily labor or capital intensive, and whether the product is one that can be stored as inventory.

Managers often use forecasts of product demand to estimate the short-term workload that the facility must handle.

Capital-intensive processes rely heavily on physical facilities, plant, and equipment. Operating these facilities more or less intensively than normal can modify short-term capacity. The costs of setting up, changing over, and maintaining facilities, procuring raw materials and manpower, managing inventory, and scheduling can also be modified by such capacity changes. In labor-intensive processes, short-term capacity can be changed by laying-off or hiring people or by having employees work overtime or keeping idle. These alternatives are expensive, since hiring costs, severance pay, or premium wages may have to be paid, and scarce human skills may be lost permanently. Strategies for changing capacity also depend upon how long the product can be stored in inventory. For products that are perishable (raw foods) or subject to radical style changes, storing in inventory may not be feasible. This is also true for many service organizations (e.g., insurance, taxi, barber, etc.). Instead of storing output in inventory, input can be expanded or shrunk temporarily in anticipation of demand.

In the labor-intensive processes, short-term capacity can be changed by laying-off or hiring people or by employees overtime &/or keeping idle.

Activity: How the garment sector of Bangladesh should respond to any short-term environmental changes? Present an example of your plan and justify your opinion.

Long-term responses

Long-range capacity requirements dependent on marketing plans, product development & life cycles of products.

Due to uncertain future demand and technologies long-term capacity requirements (5-10 years) are more difficult and risky to determine. With the fast technological developments it is difficult to say whether the existing products will continue at that period or not. Obviously, long-range capacity requirements are dependent on marketing plans, product development, and the life cycles of the products. It is important to anticipate the process technology also. Even if product remains unchanged, the method for generating them may change dramatically. Hence, capacity planning must involve forecasts of technology as well as demand.

Economies undergo both growth and recession. Organizations today cannot be locked into thinking only about *expanding* the resource base; they must also consider optimal approaches to *contracting* it. Let's consider two examples of expansion and contraction. A warehousing operation foresees the need for an additional 100,000 square feet of space by the end of the next five years. One option is to add an additional 50,000 square feet now and another 50,000 square feet two years from now. Another option is to add entire 100,000 square feet now. Estimated costs for building the entire addition now are 50/square foot. If expanded incrementally, the initial 50,000 square feet will cost \$60/square foot. The 50,000 square feet to be added later are estimated at \$80/square foot. The operations manager must consider the costs, benefits, and risks of each option. At a minimum, the lower construction cost plus excesses capacity costs of total construction now must be compared with higher costs of deferred construction.

Capacity contraction most often involves selling off existing facilities, equipment, and inventories.

Capacity contraction most often involves selling off existing facilities, equipment, and inventories, and firing employees. As serious decline in demand occurs, we may gradually terminate operations. Permanent capacity reduction or shutdown occurs as a last resort. Because a great deal of effort, capital, and human skills have gone into building up a technology. Often this technology and skill base is transferable to other products or services

Discussion question

1. Two manufacturing firms in the same industry develop capacity plans. They will each add one plant. Firm A decides to build a plant with capacity less than their forecast of demand and to have it produce only a few products from the line. Firm B decides to build a plant with capacity far in excess of their forecast demand. How can you explain their plans?
2. What is capacity strategy? Why is it important for any business organization? Justify your answer.
3. Do you think management responses to the short term and long term requirement should be same? Discuss.
4. Is there any relationship between capacity planning and capacity requirement? If any – justify.