UNIT COMMITMENT

Introduction:

- In power systems, demand variation is associated with human activities. Load is always light during night hours and it starts increasing right from morning and usually readies its peak level in the evening, and again falls during late evening period.
- The demand is also affected during weekends as well as by weather. Hence, many methods have been developed for load forecasting.
- The methods for load forecasting can predict the load for period varying from as small as few seconds to days. Based on these load forecasts, the usual practice is to prepare a commitment schedule of start-up and shut-down of units.
- The commission of a generating unit means to bring it to speed, synchronize it to the system and then connect it to the system so that it can deliver the load reliably.
- In the early stages, the main criteria of unit commitment were efficiency of units. Units used to be ordered as per efficiencies.
- The most efficient unit used to be committed first and then the next unit, if necessary to meet the load demand, from priority list used to be committed.
- Soon, it was realized that optimum unit commitment may be obtained using input-output characteristics, termed as cost curves; and today all commitment techniques are based on these cost curves.
- Classically, unit commitment is the determination of optimal schedule and generation level of each unit over a specific time horizon. Time horizon may be hours or a week.
- Baldwin (Scientist name) was the first to report the study of economic shut down of generating units. Since then, many optimization techniques have been used to obtain solution of unit commitment problem prominent among these are dynamic programming, branch and bound, Lagrangian relaxation.

STATEMENT OF UNIT COMMITMENT (UC) PROBLEM

- The unit commitment problem (UC) in electrical power production is a large family of mathematical optimization problems where the production of a set of electrical generators is coordinated in order to achieve some common target, usually either match the energy demand at minimum cost or maximize revenues from energy production.
- The total load of the power system is not constant but varies throughout the day and reaches a different peak value from one day to another.
- It follows a particular hourly load cycle over a day. There will be different discrete load levels at each period.
- Due to the above reason, it is not advisable to run all available units all the time, and it is necessary to decide in advance which generators are to start up, when to connect

them to the network, the sequence in which the operating units should be shut down, and for how long.

- The computational procedure for making such decisions is called unit commitment (UC), and a unit when scheduled for connection to the system is said to be committed.
- The problem of UC is nothing but to determine the units that should operate for a particular load. To commit‘ a generating unit is to turn it on‘, i.e., to bring it up to speed, synchronize it to the system, and connect it, so that it can deliver power to the network.

COMPARISON WITH ECONOMIC LOAD DISPATCH

- Economic dispatch economically distributes the actual system load as it rises to the various units that are already on-line.
- However, the UC problem plans for the best set of units to be available to supply the predicted or forecast load of the system over a future time period.

NEED FOR UC

- The plant commitment and unit-ordering schedules extend the period of optimization from a few minutes to several hours.
- Weekly pattern scan be developed from daily schedules. Likewise, monthly, seasonal, and annual schedules can be prepared by taking into consideration the repetitive nature of the load demand and seasonal variations.
- A great deal of money can be saved by turning off the units when they are not needed for the time. If the operation of the system is to be optimized, the UC schedules are required for economically committing units in plant to service with the time at which individual units should be taken out from or returned to service.
- This problem is of importance for scheduling thermal units in a thermal plant; as for other types of generation such as hydro their aggregate costs (such as start-up costs, operating fuel costs, and shutdown costs) are negligible so that the iron-off status is not important.

CONSTRAINTS IN UC

There are many constraints to be considered in solving the UC problem.

Spinning reserve

It is the term used to describe the total amount of generation available from all Synchronized units on the system minus the present load and losses being supplied. Here, the synchronized units on the system may be named units spinning on the system.

$$\text{Spinning Reserve} = \begin{bmatrix} \textit{Total generation output oa} \\ \textit{all synchronized units at a} \\ \textit{particular time} \end{bmatrix} - \begin{bmatrix} \textit{Present} \\ \textit{Load + Losses} \\ \textit{at that time} \end{bmatrix}$$

Static reserve:

- To meet the load demand under contingency of failure of a generator or its derating caused by minor defect, it is made so that the total installed capacity of the generating station greater the yearly peak load by certain margin. This is called static reserve.

Thermal Unit Constraints

- Thermal units require crew to operate them especially where turned on or off. A thermal unit may undergo only gradual temperature changes and this translates into increased number of hours required to bring it on line. Therefore the various constraints that arise one.

a)Minimum Up time

- Once the unit is running, it should not be turned off immediately.

b)Minimum Down Time

- Once the unit is decommitted, there is a minimum time before it can be recommitted.

c)Crew Constraints

- If a plant consists of 2 or more units, they cannot be turned on at the same time
- since there are not enough staff to attend all the units at a time.

d) Start Up Cost

- A start-up cost is incurred when a generator is put into operation. The cost is dependent on how long the unit has been inactive.
- While the start-up cost function is nonlinear, it can be discretized into hourly periods, giving a stepwise function.
- The start-up cost may vary from a maximum _cold start‘ value to a very small value if the unit was only turned off recently, and it is still relatively close to the operating temperature.
- Two approaches to treating a thermal unit during it‘s _down‘ state:
- The first approach (cooling) allows the unit‘s boiler to cool down and then heat back up to a operating temperature in time for a scheduled turn-on.
- The second approach (banking) requires that sufficient energy be input to the boiler to just maintain the operating temperature.

- Similarly, shut-down cost is incurred during shutting down generating units. In general, it is neglected from the unit commitment decision.

OTHER CONSTRAINTS

In addition to system and unit constraints, there are other constraints that need to be considered in the UC decision. They are described as follows:

A.Fuel Constraints:

- Due to the contracts with fuel suppliers, some power plants may have limited fuel or may need to burn a specified amount of fuel in a given time.
- A system in which some units have limited fuel, or else have constraints that require them to burn a specified amount of fuel in a given time, presents a most challenging unit commitment problem.

B.Must Run Units:

- Some units are given a must-run status during certain times of the year for reason of voltage support on the transmission network or for such purposes as supply of steam for uses outside the steam plant itself.
- The must run units include units in forward contracts, units in exercised call/put options, RMR units, nuclear power plants, some cogeneration units, and units with renewable resources such as wind- turbine units and some hydro power plants.

C.Must-off Units:

- Some units are required to be off-line due to maintenance schedule or forced outage. These units can be excluded from the UC decision.

D.Emission Constraints:

- There are some emissions like sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and mercury which are produced by fossil-fuelled thermal power plants.
- The amount of emission depends on various factors such as the type of fuel used, level of generation output, and the efficiency of the unit.
- The production cost minimization may need to be compromised in order to have the generation schedule that meets the emission constraints.

Unit Commitment Solution Methods

The Unit commitment problems are very difficult to solve, for that consider the following situation,

1.A loading pattern for the M periods using load curve must be established.

2.Number of units should be committed and dispatched to meet out the load.
3.The load period and number of units should supply the individual loads and any combination of loads.

There are many classical approaches have been developed and implemented successfully. Some of the approaches are

1. Enumeration Technique or Brute Force technique
2. Priority List Method
3. Dynamic Programming
4. Lagrange Relaxation
5. Integer and Mixed integer programming
6. Benders decomposition
7. Branch and Bound

Other non – classical approaches are

1. Genetic Algorithms
2. Greedy random adaptive search procedure
3. Particle swarm optimization
4. Simulated annealing