UNIT-3

# UNIT COMMITTMENT

**Introduction:-** The economic dispatch problem assumes that all the 'N' units are already connected to the system. The unit commitment probleam is more difficult to solve.

To "commit" a generating unit is to turn it on i.e, synchronize it and connect it to the system so that it can deliver power to the load in the system

If the number of sets 'N' with their capacities are given and the daily (or) weekly load forecast is known. - including the details of the load curve.

The problem in unit commitment is that of to which is known including the details of the load. curve. The problem in unit commitment is that of to which of the units should be kept on (or) off for a certain given time during the day (or) the week in order to obtain the minimum operating cost.

**Constraints in unit commitment:-**

**Spinning Reserve:-**

This means the total generation available from all units synchronised on the system buyles the load and the losses at the particular time of operation.

There reverse should be sufficient to take up load incase of a generator unit failure.


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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.

* Spinning reserve = total generation output of all synchronized units at a particular time load at the time + losses.

→ let $P_{RSP}$ be the spinning reserve, $P_i$ is the power generation of the $i^{th}$ synchronized unit, $P_D$ total load on the system & the total losses of system.

$$P_{RSP} = \sum_{i=1}^{n} P_{RiS} - (P_D + P_L)$$

Thermal unit constraints :- A thermal unit can undergo any gradual temperature changes and thus transfers into a time period (of some hours) required to bring the unit on the line due to such limitations in the operation of a thermal point, the following constraints are to be considered

i, minimum uptime :-

The minimum up time, once the unit is operating (up-state), it should not be turned off immediately.

ii, minimum down time :-

The minimum down time is the minimum time during which the unit is in (down state) i.e, once the units is decommitted, there is a minimum time before it can be recommitted.


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iii, Crew Constraints :-

If a plant consist of two or more units, they cannot both be turned on at the same time Here are not enough crew members to attend to both units while starting up.

iv, Hydro Constraints :-

unit commitment cannot be completely separated from the scheduling of hydrounit

v, Must run :-

Some units are given a must run status during certain times of the year for reason of rtg support on the transmission N/w or for such purpose of supply of steam for uses outside the ~~System~~ steam plant itself.

Fuel Constraints :-

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 present a most challenging unit commitment problem.


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26/9/19 * Unit commitment soln methods :- The most important techniques for the soln of a unit commitment (UC) problem are

1. priority scheme (PS)
2. Dynamic programming method (DP)
3. Lagrangian relation method. (LR)

1. priority scheme :-

Enumeration scheme :-

Eg :- let us consider a plant having 3-units the cost characteristics and minimum and max limits of power generation (MW) of each unit are as follows

unit 1 : $C_1 = 0.002842\, P_{G_1}^2 + 8.46 P_{G_1} + 600$ Rs/hr

$200 \le P_{G_1} \le 650$

unit 2 : $C_2 = 0.002936\, P_{G_2}^2 + 8.32 P_{G_2} + 420$ Rs/hr

$150 \le P_{G_2} \le 450$

unit 3 : $C_3 = 0.006449\, P_{G_3}^2 + 9.884 P_{G_3} + 110$ Rs/hr

$100 \le P_{G_3} \le 300$

To supply a total load of 600 MW most economically the combinations of each unit and their generation states are tabulated in table.


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Sol:- $\frac{dC_1}{dP_1} = 0.005684 P_{G_1} + 8.46$

$\frac{dC_2}{dP_2} = 0.005832 P_{G_2} + 8.32$

$\frac{dC_3}{dP_3} = 0.0128 P_{G_3} + 9.884$

$\frac{dC_1}{dP_1} = \frac{dC_2}{dP_2}$

$0.00568 P_{G_1} + 8.46 = 0.005832 P_{G_2} + 8.32$

$0.005684 P_{G_1} - 0.005832 P_{G_2} = -0.14$

$\frac{dC_1}{dP_1} = \frac{dC_3}{dP_3}$

$0.005684 P_{G_1} + 8.46 = 0.0128 P_{G_3} + 9.884$

$0.005684 P_{G_1} - 0.0128 P_{G_3} = 1.424$

$P_{G_1} + P_{G_2} + P_{G_3} = 600 \Rightarrow P_{G_3} = 600 - (P_{G_1} + P_{G_2})$

$0.005684 P_{G_1} - 0.0128 (600 - (P_{G_1} + P_{G_2})) = 1.424$

$0.018484 P_{G_1} + 0.0128 P_{G_2} + 7.68 = 1.424$

$0.018484 P_{G_1} + 0.0128 P_{G_2} = 9.104$

$P_{G_1} = 284.9 MW$ $P_{G_2} = 299.7 MW$

$P_{G_3} = 15.4 MW$

$P_{G_3} = 100.$

$P_{G_1} + P_{G_2} + P_{G_3} = 600$

$P_{G_1} + P_{G_2} = 500$

$P_{G_1} = 241.9 MW$ $P_{G_2} = 258.04 MW$

$P_{G_3} = 100 MW$


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27/7/19 Combinations of the units & their status for the dispatch of a 600 mw load

| S.No | Combinations $2^n = 2^3 = 8$ | Status of units U-1 | U-2 | U-3. | $P_{max}$. | $P_{min}$. | $P_{G1}$ | $P_{G2}$ | $P_{G3}$ | $C_1$ | $C_2$ | $C_3$ | total load. $C_1+C_2+C_3$. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | off | off | off | 0 | 0 | unfeasible | unfeasible | unfeasible | — | — | — | — |
| 2 | 2 | off | off | ON | 300 | 100 | " | " | " | — | — | — | — |
| 3 | 3 | off | ON | off | 450 (300+150) | 150 (100+100) | " | " | " | — | — | — | — |
| 4 | 4 | off | ON | ON | 750 | 250 | 0 | 450 | 150 | — | 4758.5 | 1737.7 | 6496.24 |
| 5 | 5 | ON | off | off | 650 | 200 | 600 | unfeable | unfeable | 6699.12 | — | — | 6699.12 |
| 6 | 6 | ON | off | ON | 900 | 300 | 492.5 | — | 107.4 | 5455.89 | — | 1245.9 | 6701.8 |
| 7 | 7 | ON | ON | off | 1100 | 350 | 292.7 | 307.2 | — | 3319.7 | 3252.9 | — | 6572.6 |
| 8 | 8 | ON | ON | ON | 1400 | 450 | 241.9 | 255.04 | 100. | 2512.7 | 2762.58 | 1102.89 | 6737.97 |

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$$\frac{dC_2}{dP_2} = \frac{dC_3}{dP_3}$$

$$0.005872 P_{G_2} + 8.32 = 0.0128 P_{G_3} + 9.884.$$

$$0.005872 P_{G_2} - 0.0128 P_{G_3} = 1.564.$$

$$P_{G_2} + P_{G_3} = 600$$

$P_{G_2} = 495.07$ MW  $P_{G_3} = 104.93$ MW

replace, $P_{G_2} = 450$ MW

$$450 + P_{G_3} = 600$$

$P_{G_3} = 150$ MW

(4) $C_2 = 0.00296 P_{G_2}^2 + 8.32 P_{G_2} + 420$

$= 0.00296 (450)^2 + 8.32 (450) + 420$

$= 4758.54.$

(3) $C_3 = 0.006449 P_{G_3}^2 + 9.884 P_{G_3} + 110$

$= 0.006449 (150)^2 + 9.884 (150) + 110$

$= 1737.70$

(5) $C_1 = 0.002842 P_{G_1}^2 + 8.46 P_{G_1} + 600$

$= 0.002842 (600)^2 + 8.46 (600) + 600$

$= 6699.12$

$$\frac{dC_1}{dP_1} = \frac{dC_3}{dP_3}$$

$$0.005684 P_{G_1} - 0.0128 P_{G_3} = 1.424.$$

$$P_{G_1} + P_{G_3} = 600.$$

$P_{G_1} = 492.5$ MW

$P_{G_3} = 107.4$ MW


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(6) $C_1 = 0.00284 P_{G_1}^2 + 8.46 P_{G_1} + 600$

$= 0.00284 (492.5)^2 + 8.46 (492.5) + 600$

$= 5455.89$

$C_3 = 0.00644 (107.4)^2 + 9.884 (107.4) + 110$

$\boxed{C_3 = 1245.9}$

$\frac{dC_1}{dP_1} = \frac{dC_2}{dP_2}$

$0.005684 P_{G_1} - 0.005872 P_{G_2} = -0.14$

$P_{G_1} + P_{G_2} = 800$

$\boxed{P_{G_1} = 292.7 \text{ MW}}$ $\boxed{P_{G_2} = 307.2 \text{ MW}}$

(7) $C_1 = 0.00284 (292.7)^2 + 8.46 (292.7) + 600$

$\boxed{C_1 = 3319.72}$

$C_2 = 0.002936 (307.2)^2 + 8.32 (307.2) + 420$

$\boxed{C_2 = 3852.9}$

(8) $C_1 = 0.00284 (241.9)^2 + 8.46 (241.9) + 600$

$= 2812.7$

$C_2 = 0.002936 (258.04)^2 + 8.32 (258.04) + 420$

$= 2762.38$

$C_3 = 0.00644 (100)^2 + 9.884 (100) + 110$

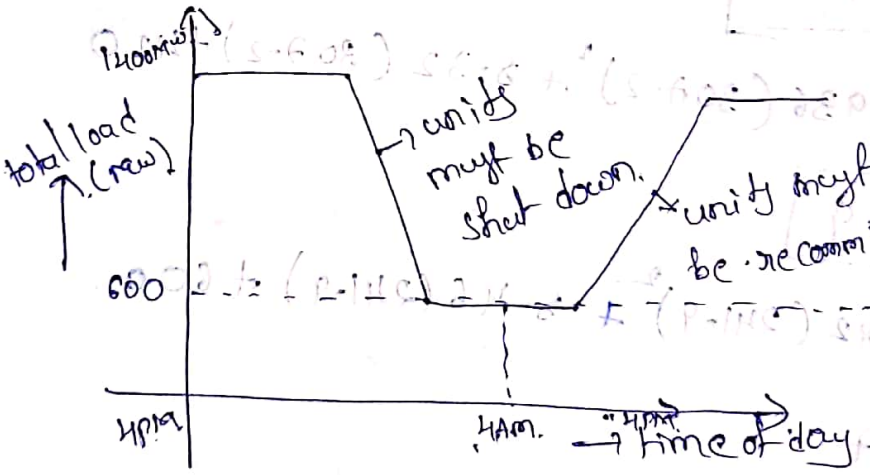
$= 1162.89$


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29 Shut down rule derration:-

| load | No. of combinations | | |
|---|---|---|---|
| | U-1 | U-2 | U-3 |
| 1400 | ON | ON | ON |
| 1350 | ON | ON | ON |
| 1300 | ON | ON | ON |
| 1250 | ON | ON | ON |
| 1200 | ON | ON | ON |
| 1150 | ON | ON | ON |
| 1100 | ON | ON | off |
| 1050 | ON | ON | off |
| 1000 | ON | ON | off |
| 950 | ON | off | ON |
| 900 | ON | off | ON |
| 850 | ON | off | ON |
| 800 | ON | off | ON |
| 750 | off | ON | ON |
| 700 | off | ON | ON |
| 650 | ON | off | off |
| 600 | ON | off | off |

Simple peak valley load pattern :-




→ let us assume that the load following a simple peak valley pattern as shown in above fig. To optimize the system operation some units must be shut down as a load decreases and recommitted as a


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goey back up.

→ A simple priority list scheme is to be developed from the shutdown rule.

Dynamic programming method (DP method):-

→ let a cost function $F_N(x)$ be the min cost in $/hr$ of generation of 'x' mw by 'N' no. of units.

→ $F_N(y)$ be the cost of generation of 'y' mw by the $N^{th}$ unit $F_{N-1}(x-y)$ is the min cost of generation of $(x-y)$ mw by remaining $(N-1)$ units.

→ The following recursive relation will result with the application of dynamic programing method i.e,

$$F_N(x) = \min_{y} \left\{ F_N(y) + F_{N-1}(x-y) \right\}$$

Similarly, the cost curve eqn is,

$$F_i = \frac{1}{2} a_i P_{Gi}^2 + b_i P_{Gi} + c_i$$

→ The most efficience ecanomical combination of units can efficently determind by the use of above two relations.

(ES) (P) (T). A simple system having 4 thermal generating units with parameters listed in table it is required to determine most ecanamical units to be committed for a load of 9mw. let the load changes be in steps of 1mw. Take general cost curve eqn is ($F_i = \frac{1}{2} a_i P_{Gi}^2 + b_i P_{Gi}$)


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| UNT NO | Capacity (MW) | | cost curve parameters | |
|---|---|---|---|---|
| | Min | Max. | $a_i$ Rs/MWhr | b Rs/MWhr |
| 1 | 1.0 | 12.0 | 0.77 | 23.5 |
| 2 | 1.0 | 12.0 | 1.60 | 26.5 |
| 3 | 1.0 | 12.0 | 2.00 | 30.0 |
| 4 | 1.0 | 12.0 | 2.50 | 32.0 |

Sol?:-

$F_1(x) = P_1(x)$

$F_1(9) = P_1(9)$

$F_1(9) = \frac{1}{2} a_1 (9)^2 + b_1(9)$

$= \frac{1}{2}(0.77)(9)^2 + 23.5(9)$

$\boxed{F_1(9) = 242.6 \text{ Rs/hr}}$

3) ~~$F_2(9) = \frac{1}{2} a_2 (9$~~

$F_2(9) = \min \{ (F_2(0) + P_1(9)) + (F_2(1) + P_1(8)) + (F_2(2) + P_1(7)) + (F_2(3) + P_1(6)) + (F_2(4) + P_1(5)) + (F_2(5) + P_1(4)) + (F_2(6) + P_1(3)) + (F_2(7) + P_1(2)) + (F_2(8) + P_1(1)) + (F_2(9) + P_1(0)) \}$

① $\boxed{F_2(0) + P_1(9) = 0 + 242.6 = 242.6 \text{ Rs/hr}}$

$F_2(0) = \frac{1}{2} a_2 PG_1^2 + b_2 PG_1$

$= 0$

② $\boxed{F_2(1) + P_1(8) = 27.3 + 212.64 = 239.94 \text{ Rs/hr}}$

$F_2(1) = \frac{1}{2} a_1 PG_1^2 + b_1 PG_1$

$= \frac{1}{2} a_2 (1)^2 + b_2 (1) = \frac{1}{2}(1.60)(1)^2 + (26.5)(1)$

$= 0.8 + 26.5 = 27.3.$


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$F_1(8) = \frac{1}{2}(0.77)(8)^2 + 23.5(8)$

$= 24.64 + 188.$

$F_1(8) = 212.64$ ₹/hr.

③ $F_2(2) = \frac{1}{2}(1.60)(2)^2 + (26.5)(2)$

$= 56.2$ ₹/hr.

$F_1(7) = \frac{1}{2}(0.77)(7)^2 + 23.5(7)$

$= 183.36$ ₹/hr

$F_2(2) + F_1(7) = 239.56$ ₹/hr

④ $F_2(3) = \frac{1}{2}(1.6)(3)^2 + (26.5)(3)$

$= 86.7.$

$F_1(6) = \frac{1}{2}(0.77)(6)^2 + 23.5(6)$

$= 154.86.$

$F_2(3) + F_1(6) = 241.56$ ₹/hr

⑤ $F_2(4) = \frac{1}{2}(1.6)(4)^2 + 26.5(4)$

$= 118.8.$

$F_1(5) = \frac{1}{2}(0.77)(5)^2 + 23.5(5)$

$= 125.62$

$F_2(4) + F_1(5) = 244.425$ ₹/hr

⑥ $F_2(5) = \frac{1}{2}(1.6)(5)^2 + 26.5(5)$

$= 152.5$

$F_1(4) = \frac{1}{2}(0.77)(4)^2 + 23.5(4) = 100.16$

$F_2(5) + F_1(4) = 252.66$ ₹/hr


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(8) $F_2(6) = \frac{1}{2}(1.6)(6)^2 + (26.5)(6)$

$= 187.8$

$F_1(3) = \frac{1}{2}(0.77)(3)^2 + (23.5)(3)$

$= 73.96$

$F_2(6) + F_1(3) = 261.76$ rs/hr.

(8) $F_2(7) = \frac{1}{2}(1.6)(7)^2 + (26.5)(7)$

$= 224.7$

$F_1(2) = \frac{1}{2}(0.77)(2)^2 + (23.5)(2)$

$= 48.57$

$F_2(7) + F_1(2) = 273.24$ rs/hr

(9) $F_2(8) = \frac{1}{2}(1.6)(8)^2 + (26.5)(8)$

$= 263.2$

$F_1(1) = \frac{1}{2}(0.77)(1)^2 + 23.5(1)$

$= 23.88$

$F_2(8) + F_1(1) = 287.38$ rs/hr.

(10) $F_2(9) = \frac{1}{2}(1.6)(9)^2 + (26.5)(9)$

$= 303.3$

$F_1(0) = 0$

$F_2(9) + F_1(0) = 303.3$ rs/hr.

$F_2(9) = \text{min}\{242.6 + 239.94 + 239.56 + 241.56 + 244.42,$
$252.66 + 261.76 + 273.24 + 287.38 + 303.3\}$


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$F_2(9) =$ 239.5 Rs/hr

from ① to ⑩ combinations comparing we get min of '$F_2(9)$' is 239.5 Rs/hr similarly $F_3(9) = 239.5$ Rs/hr & $F_4(9) = 239.5$ Rs/hr.

⇒ To conclusion that optimum unit to be committed for 9MW load are ① & ② sharing the load by 2MW & 7MW respectively.

→ with a min operating cost of 239.5 Rs/hr


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