1 Power Generation and Economics of Generation

1.1 - Power Generation Methods

Multiple Choice Questions

Q.1 Consider the following statements:
Pumped storage plants when operated in interconnected power systems serve to
1. Increase load factor of steam plant.
2. Provide added capacity to meet peak loads.
3. Decrease load factor of steam plant.
4. Provide added capacity to meet base loads.

Which of the above statements are correct?
(a) 1, 2, 3 and 4 (b) 1 and 3 only
(c) 1 and 2 only (d) 3 and 4 only
[ESE-2010]

Q.2 One million cubic meters of water is stored in a reservoir feeding a water turbine. The density of water is 993 kg/m^3. If the centre of mass of water is 50 meters above the turbine and the losses are negligible, the energy produced by that volume of water is
(a) 135.3 MWhr (b) 130 MWhr
(c) 120 MWhr (d) 140 MWhr
[ESE-2011]

Q.3 Consider the following statements regarding the pumped storage plants:
1. A pumped storage plant is a peak load plant
2. The starting time of a pumped storage plant is very long.
3. Reversible turbines and pumps are very suitable for pumped storage plants.
4. Pumped storage plants can be used for load frequency control.

Which of the above statements is/are correct?
(a) 1 only (b) 1 and 2 only
(c) 1, 3 and 4 (d) 3 and 4 only
[ESE-2009]

Q.4 Match **List-I** (Classification of Head) with **List-II** (Type of Turbines) and select the correct answer using the code given below the lists:

List-I
A. Low head, 2 – 15 m
B. Medium head, 15 – 70 m
C. High head, 70 – 500 m
D. Very high head > 500 m

List-II
1. Propeller or Kaplan
2. Kaplan or Francis
3. Pelton
4. Francis or Pelton

Codes:

	A	B	C	D
(a)	1	3	4	2
(b)	4	2	1	3
(c)	1	2	4	3
(d)	4	3	1	2

[ESE-2005]

Q.5 **Assertion (A):** In a high-or medium-head hydroelectric power station having a long penstock, a surge-tank is provided near the turbine.
Reason (R): A surge-tank stores additional water to be released during the peak-load period
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT a correct explanation of A
(c) A is true but R is false.
(d) A is false but R is true
[ESE-2000]

Q.6 In a thermal power station, a typical heat balance sheet, for a large turbine and surface condenser taken together, is the percentage distribution of heat energy in
1. Work done or thermal efficiency
2. Friction and windage loss
3. Heat to circulating water
4. Heat in condensate to be retained to the boiler

The percentage amount of heat in the heads state above, in the descending order is
(a) 3, 4, 1 and 2 (b) 2, 1, 4 and 3
(c) 3, 1, 4 and 2 (d) 2, 4, 1 and 3
[ESE-2011]

Q.7 In a thermal nuclear reactor
1. the purpose of moderator is to slow down fast neutrons produced due to fission
2. the moderator material must have low molecular weight
3. ordinary water can be used as moderator with natural uranium as fuel
4. the multiplication factor is kept slightly greater than unity during its normal functioning

Of these statements:
(a) 1 and 3 are correct
(b) 3 and 4 are correct
(c) 1, 2 and 3 are correct
(d) 1, 2, and 4 are correct **[ESE-2001]**

Q.8 Which one of the following is employed as a moderator by CANDU type of slow thermal nuclear reactors?
(a) Water (b) Heavy water
(c) Graphite (d) Beryllium
[ESE-2006]

Numerical Data Type Questions

Q.9 A coal-fired steam power station working at a plant load factor of 80% has one 500 MW generating unit. If the heat content of coal is 2 kWh/kg, the overall plant efficiency is 40% and a train load of coal is 2000 metric tons, then the number of trains required daily for the plant is _____ . **[ESE-2000]**

1.2 - Economic Factors

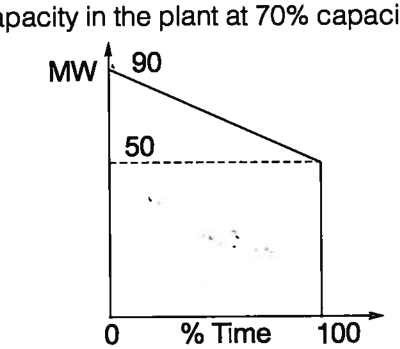
Multiple Choice Questions

Q.10 Out of the following plant categories
1. Nuclear 2. Run off river
3. Pump storage 4. Diesel

The base load plants are
(a) 1 and 2 (b) 2 and 3
(c) 1, 2 and 4 (d) 1, 3 and 4
[GATE-2009]

Q.11 The economics of power plant is greatly influenced by:
1. Load factor 2. Utilization capacity
3. Unit capacity 4. Type of load
(a) 1, 2, 3 and 4 (b) 1, 3 and 4
(c) 1, 2 and 3 (d) 2, 3 and 4
[ESE-2011]

Q.12 The load duration curve for a power station is as shown in the below figure. The reserve capacity in the plant at 70% capacity factor is



(a) zero (b) 10 MW
(c) 30 MW (d) 50 MW

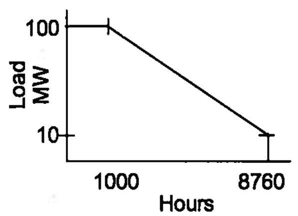
[ESE-2001]

Q.13 The daily energy produced in a thermal power station is 720 MWh at a load factor of 0.6. What is the maximum demand of the station?

(a) 50 MW (b) 30 MW
(c) 72 MW (d) 720 MW

[ESE-2008]

Q.14 The load curve of a system is shown in the figure. The load factor of the system is:



(a) 1.66% (b) 6.013%
(c) 16.6% (d) 60.13%

[ESE-1997]

Numerical Data Type Questions

Q.15 A thermal generating station has an installed capacity of 15 MW and supplies a daily load of 10 MW for 12 hours and 5 MW for remaining 12 hours. The plant capacity factor for this station is _____ .

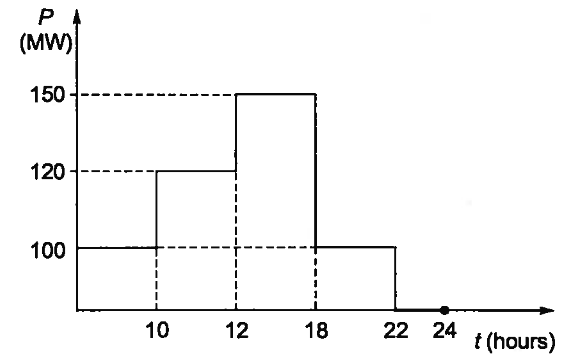
[ESE-1999]

Q.16 A power station has a maximum demand of 15000 kW. The annual load factor is 50% and plant capacity factor is 40%. The reserve capacity of the plant is _____ kW.

[ESE-2006]

Conventional Questions

Q.17 The load curve of a generator is shown in figure. The installed capacity of a generator is 200 MW. Find



(*i*) P_{max}
(*ii*) P_{avg}
(*iii*) Load factor
(*iv*) Plant capacity factor
(*v*) Plant usage factor
(*vi*) Reserve capacity
(*vii*) Utilization factor

1.3 - Economic Load Dispatch

Q.18 The incremental fuel costs for two generating units G_1 and G_2 are given by
$IC_1 = 25 + 0.2\ PG_1$ and $IC_2 = 32 + 0.2\ PG_2$
where PG_1 and PG_2 are real powers generated by the units. The economic allocation for a total load of 250 MW, neglecting transmission loss, is given by

(a) $PG_1 = 142.5$ MW and $PG_2 = 107.5$ MW
(b) $PG_1 = 109.75$ MW and $PG_2 = 1140.25$ MW
(c) $PG_1 = 125$ MW and $PG_2 = 125$ MW
(d) $PG_1 = 100$ MW and $PG_2 = 150$ MW

[ESE-2011]

Q.19 A lossless power system has to serve a load of 250 MW. There are two generators (G_1 and G_2) in the system with cost curves C_1 and C_2 respectively defined as follows:

$$C_1(P_{G1}) = P_{G1} + 0.055 \times P_{G1}^2$$

$$C_2(P_{G2}) = 3\ P_{G2} + 0.03 \times P_{G2}^2$$

Where P_{G1} and P_{G2} are the MW injections from generator G_1 and G_2 respectively. Thus, the minimum cost dispatch will be

(a) $P_{G1} = 250$ MW; $P_{G2} = 0$ MW
(b) $P_{G1} = 150$ MW; $P_{G2} = 100$ MW
(c) $P_{G1} = 100$ MW; $P_{G2} = 150$ MW
(d) $P_{G1} = 0$ MW; $P_{G2} = 250$ MW

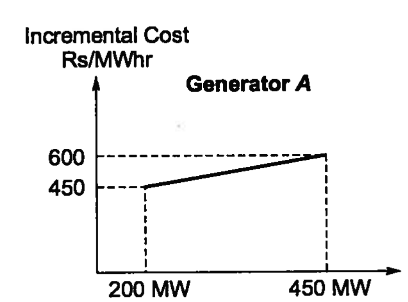
[GATE-2008]

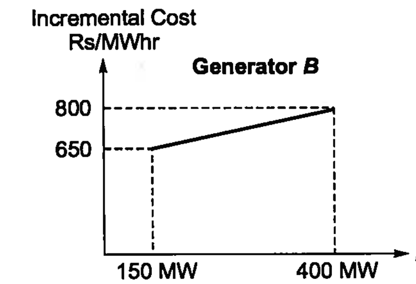
Q.20 Incremental fuel costs (in some appropriate unit) for a power plant consisting of three generating units are
$IC_1 = 20 + 0.3\ P_1$
$IC_2 = 30 + 0.4\ P_2$
$IC_3 = 30$
where P_i is the power in MW generated by unit i, for $i = 1, 2$ and 3. Assume that all the three units are operating all the time. Minimum and maximum loads on each unit are 50 MW and 300 MW respectively. If the plant is operating on economic load dispatch to supply the total power demand of 700 MW, the power generated by each unit is:

(a) $P_1 = 242.86$ MW; $P_2 = 157.14$ MW; and $P_3 = 300$ MW
(b) $P_1 = 157.14$ MW; $P_2 = 242.86$ MW; and $P_3 = 300$ MW
(c) $P_1 = 300.0$ MW; $P_2 = 300.0$ MW; and $P_3 = 100$ MW
(d) $P_1 = 233.3$ MW; $P_2 = 233.3$ MW; and $P_3 = 233.4$ MW

[GATE-2003]

Q.21 The incremental cost curves in Rs/ MWhr for two generators supplying a common load of 700 MW are shown in the figures. The maximum and minimum generation limits are also indicated. The optimum generation schedule is

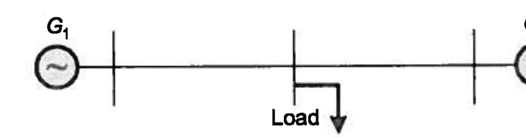




(a) Generator A : 400 MW, Generator B : 300 MW
(b) Generator A : 350 MW, Generator B : 350 MW
(c) Generator A : 450 MW, Generator B : 250 MW
(d) Generator A : 425 MW, Generator B: 275 MW

[GATE-2007]

Q.22 A load centre is at an equidistant from the two thermal generating stations G_1 and G_2 as shown in the figure. The fuel cost characteristics of the generating stations are given by:



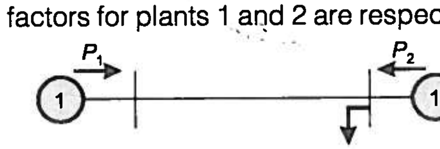
$F_1 = a + bP_1 + cP^2_1$ Rs/hour
$F_1 = a + bP_2 + 2cP^2_2$ Rs/hour
where P_1 and P_2 are the generation in MW of G_1 and G_2, respectively.

For most economic generation to meet 300 MW of load, P_1 and P_2, respectively, are:

(a) 150, 150 (b) 100, 200
(c) 200, 100 (d) 175, 125

[GATE-2005]

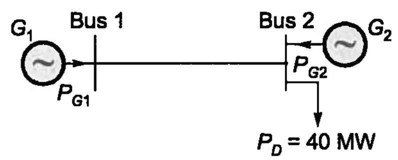
Q.23 Two power plants interconnected by tie-line as shown in the below figure have loss formula coefficient $B_{11} = 10^{-3}$ MW^{-2}. Power is being dispatched economically with plant '1' as 100 MW and plant '2' as 125 MW. The penalty factors for plants 1 and 2 are respectively



(a) 1 and 1.25 (b) 1.25 and 1
(c) 1 and zero (d) zero and 1

[ESE-2001]

Q.24 The figure shows a two-generator system supplying a load of P_D = 40 MW, connected at bus 2.



The fuel cost of generators G_1 and G_2 are:

$C_1(P_{G1})$ = 10,000 Rs/MWh

and $C_2(P_{G2})$ = 12,500 Rs/MWh

and the loss in the line is $P_{loss(pu)} = 0.5P^2_{G1(pu)}$, where the loss coefficient is specified in pu on a 100 MVA base. The most economic power generator schedule in MW is

(a) $P_{G1} = 20, P_{G2} = 22$
(b) $P_{G1} = 22, P_{G2} = 20$
(c) $P_{G1} = 20, P_{G2} = 20$
(d) $P_{G1} = 0, P_{G2} = 40$ [GATE-2012]

Q.25 The fuel cost functions of two power plants are:

Plant P_1 : $C_1 = 0.05\ Pg_1^2 + A\ Pg_1 + B$

Plant P_2 : $C_2 = 0.10\ Pg_2^2 + 3\ A\ Pg_2 + 2B$

where, Pg_1 and Pg_2 are the generated powers of two plants, and A and B are the constants. If the two plants optimally share 1000 MW load at incremental fuel cost of 100 Rs/MWh, the ratio of load shared by plants P_1 and P_2 is

(a) 1 : 4 (b) 2 : 3
(c) 3 : 2 (d) 4 : 1

[GATE-2014]

Numerical Data Type Questions

Q.26 The power generated by two plants are:

P_1 = 50 MW, P_2 = 40 MW

If the loss coefficients are:

B_{11} = 0.001, B_{22} = 0.0025 and B_{12} = – 0.0005, then the power loss will be____MW.

[ESE-1997]

Q.27 If, for a given alternator in economic operation mode, the incremental cost is given by (0.012 P + 8) Rs/MWh, dP_L/dP = 0.2 and plant λ = 25, then the power generation is_____ MW.

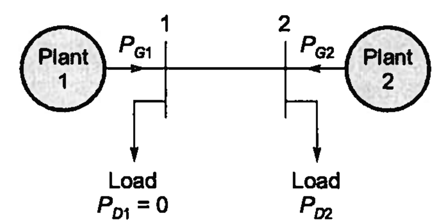
[ESE-1999]

Q.28 A two bus system as shown in figure. If 100 MW is transmitted from plant 1 to the load, a transmission loss of 10 W is incurred. The required generation from plant 1 when the system cost is Rs. 25/MWh is ______ MW.

The incremental fuel costs of the two plants are:

$$I_{C_1} = \frac{dF_1}{dP_{G_1}} = 0.02\ P_{G_1} + 16\ \text{Rs/MWh}$$

$$I_{C_2} = \frac{dF_2}{dP_{G_2}} = 0.04\ P_{G_2} + 20\ \text{Rs/MWh}$$



Try Yourself

T1. The maximum demand of a power plant is 40 MW. If the capacity factor is 0.5 and utilization factor is 0.8 then the load factor and reserve capacity in MW is

(a) 0.625 and 8 MW (b) 0.421 and 12 MW
(c) 0.51 and 12 MW (d) 0.625 and 10 MW

[Ans: (d)]

T2. The annual load duration curve of a small hydro plant shows 438 × 10^4 kWh of energy during the year. It is a peak load plant with 20 % annual load factor. If the plant capacity factor is 15 %, then the reserve capacity of the plant is___ MW.

[Ans: 0.83]

T3. A generating station has a connected load of 23 MW and a maximum demand of 20 MW, the units generated being 61.5 × 10^6 per annum, calculate:

(a) Demand factor
(b) Average demand
(c) Load factor.

[Ans: (a) 0.869, (b) 7020 kW, (c) 35.1%]

T4. An input output curve of a 10 MW thermal station is given by an equation

$I = (18 + 12L + 0.5L^2) \times 10^6$ kcal/h,

where I is in kcal per hour and L is load on the power plant in MW.

The load at which the efficiency of the plant will be maximum is

(a) 4 MW (b) 5 MW
(c) 6 MW (d) 7 MW

[Ans: (c)]

T5. Find the diversity factor of a power station whcih supplies the following loads:

Load A: Motor load of 150 kW between 10 a.m. to 7 p.m.

Load B: Lighting load of 50 kW between 7 p.m. and 11 p.m.

Load C: Pumping load of 55 kW between 3 p.m. and 10 a.m.

[Ans: (1.2439)]

T6. A power station supplies the peak loads of 25 MW, 20 MW and 30 MW to three localities. The annual load factor is 0.60 and the diversity of the load at the station is 1.65. Calculate:

(a) The maximum demand on the station
(b) The installed capacity, and
(c) The energy supplied in a year

[Ans: (a) 45.45 MW, (b) 75 MW, (c) 238909 MWh]

T7. The load on a power station on a typical day is as follows:

Time	Load
12 midnight to 6 a.m.	40
6 a.m. to 10 a.m.	60
10 a.m. to 6 p.m.	120
6 p.m. to 10 p.m.	180
10 p.m. to 12 midnight	40

Plot the chronological load curve and load duration curve. Determine the load factor of the power station and the energy supplied by the power station in 24 hours.

If the installed capacity of the plant is 200 MW, determine the capacity factor and the utilization factor.

[Ans. : 0.518, 2240 MWh, 0.4667, 0.9]