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Economic Dispatch

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Economic Dispatch: Concept

Real power economic dispatch (ED)

The aim of real power economic dispatch (ED) is to make the generator's fuel consumption or the operating cost of the whole system minimal by determining the power output of each generating unit under the constraint condition of the system load demands.

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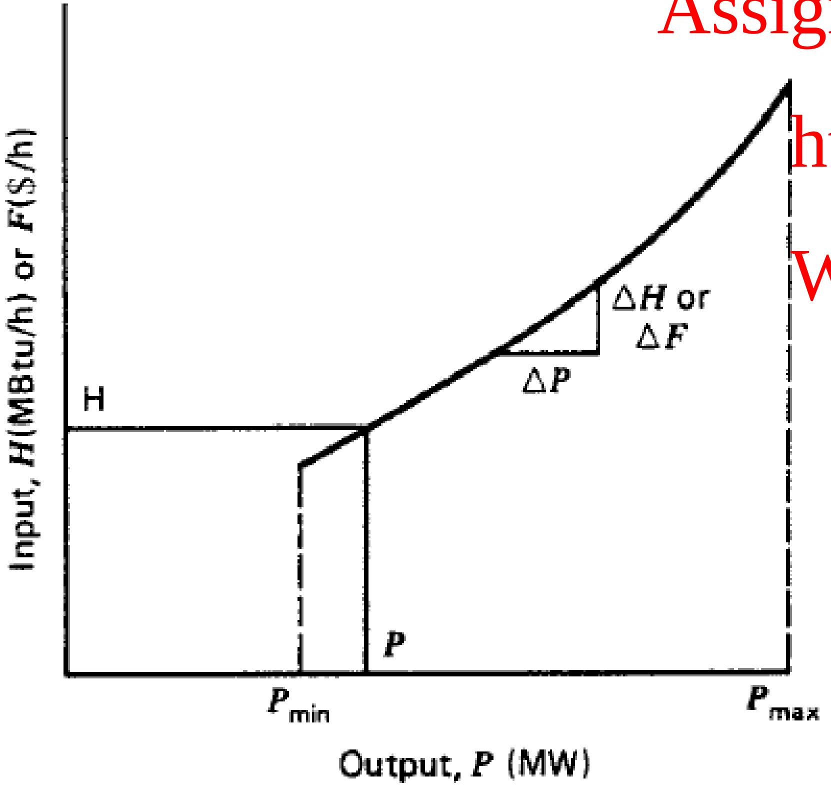
Input-output Characteristics Of Generator Units

Thermal Unit

For thermal units, we call the input–output characteristic the *generating unit fuel consumption function*, or *operating cost function*. The unit of the generator fuel consumption function is Btu per hour heat input to the unit (or MBtu/h). The fuel cost rate times Btu/h is the $ per hour ($/h) input to the unit for fuel. The output of the generating unit will be denoted by P_G, the megawatt net power output of the unit.



$$P_{G\min} \leq P_G \leq P_{G\max}$$

Generally, the input–output characteristic of the generating unit is nonlinear.

$$F = aP_G{}^2 + bP_G + c$$

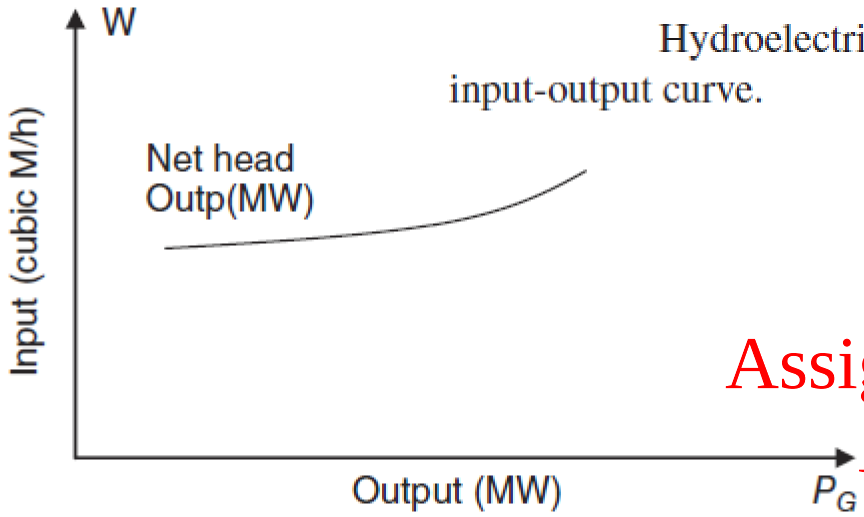
H = Btu per hour heat input to the unit (or MBtu / h)

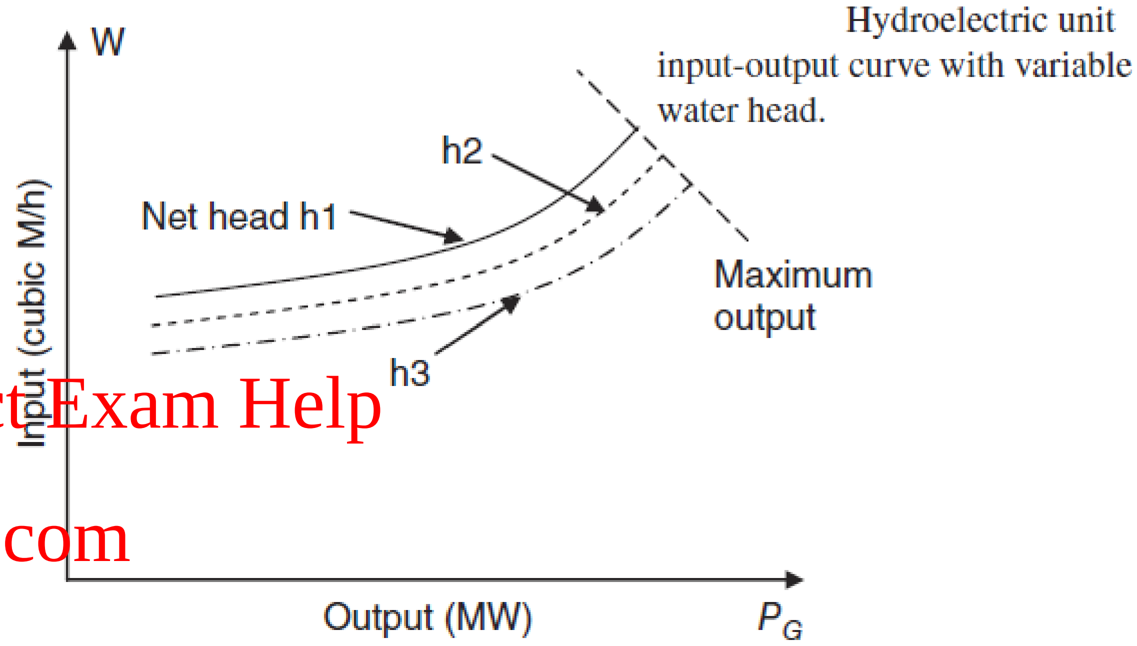
F = Fuel cost times H is the $ per hour ($ / h) input to the unit for fuel

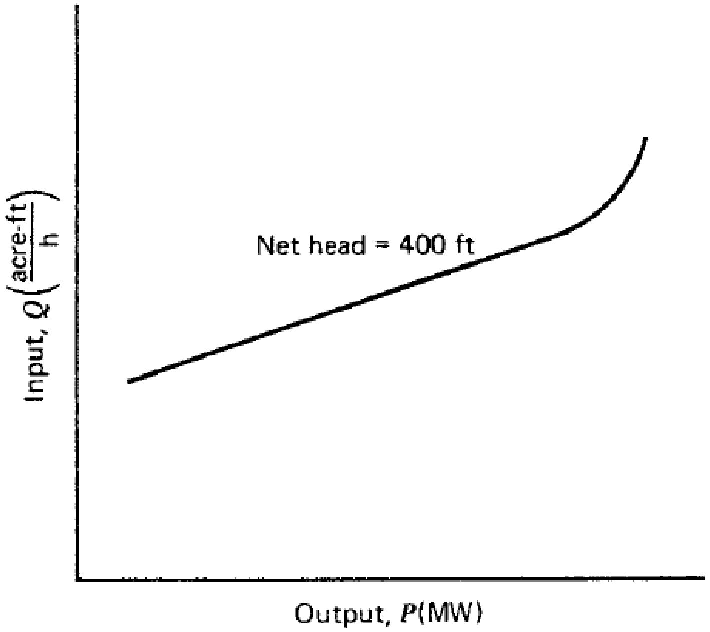
Calculation of Input–Output Characteristic Parameters

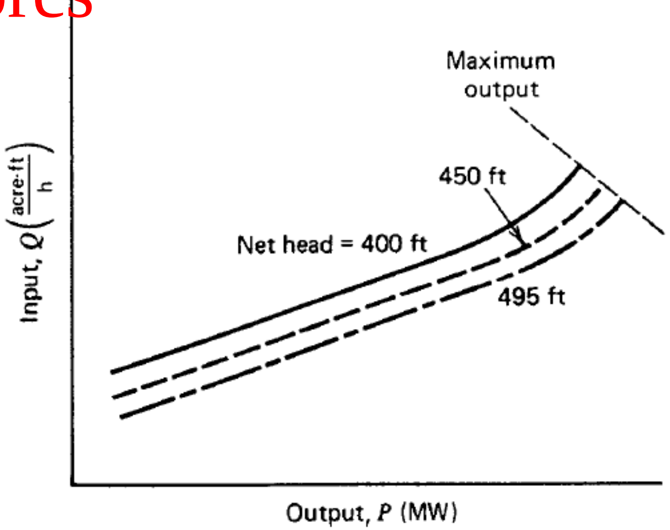
1. based on the experiments of the generating unit efficiency;
2. based on the historic records of the generating unit operation;
3. based on the design data of the generating unit provided by manufacturer.

Input–Output Characteristic of Hydroelectric Units









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THE ECONOMIC DISPATCH PROBLEM

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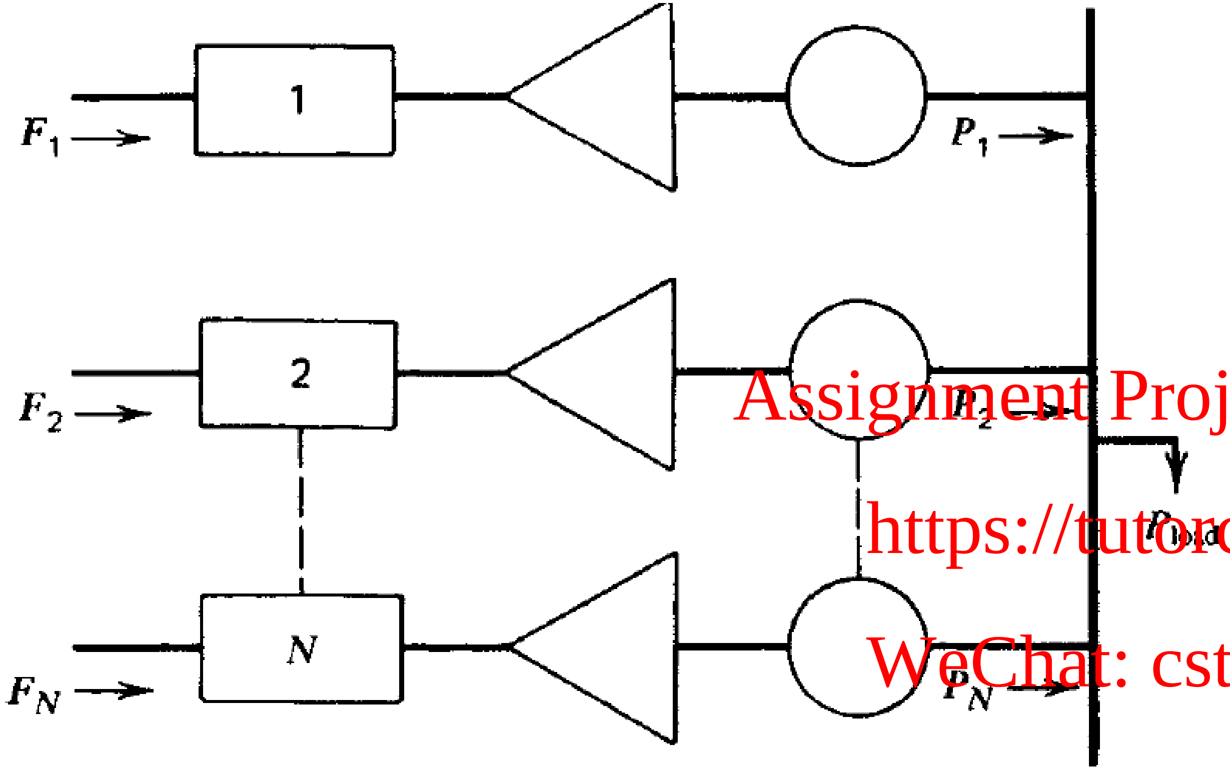

N_{gen} thermal units committed to serve a load of P_{load}.

$$F_T = F_1 + F_2 + F_3 + \cdots + F_{N_{gen}}$$

$$F_T = \sum_{i=1}^{N_{gen}} F_i(P_i)$$

$$\phi = 0 = P_{load} - \sum_{i=1}^{N_{gen}} P_i$$

This is a constrained optimization problem that may be attacked formally using advanced calculus methods that involve the Lagrange function.

THE ECONOMIC DISPATCH PROBLEM

$$\mathcal{L} = F_{\mathrm{T}} + \lambda\phi \qquad \frac{\partial \mathcal{L}}{\partial P_i} = \frac{\mathrm{d}F_i(P_i)}{\mathrm{d}P_i} - \lambda = 0 \qquad 0 = \frac{\mathrm{d}F_i}{\mathrm{d}P_i} - \lambda$$

$$\begin{cases} \dfrac{\mathrm{d}F_i}{\mathrm{d}P_i} = \lambda & N_{\mathrm{gen}} \text{ equations} \\ P_{i,\min} \le P_i \le P_{i,\max} & 2N_{\mathrm{gen}} \text{ inequalities} \\ \displaystyle\sum_{i=1}^{N} P_i = P_{\mathrm{load}} & 1 \text{ constraint} \end{cases}$$

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Example

Example

Unit 1: Coal-fired steam unit : Max output = 600 MW
Min output = 150 MW

Input–output curve:

$$H_1\left(\frac{\text{MBtu}}{\text{h}}\right) = 510.0 + 7.2P_1 + 0.00142P_1^2$$

Unit 2: Oil-fired steam unit : Max output = 400 MW Min output = 100 MW

Input–output curve:

$$H_2\left(\frac{\text{MBtu}}{\text{h}}\right) = 310.0 + 7.85P_2 + 0.00194P_2^2$$

Unit 3: Oil-fired steam unit : Max output = 200 MW
Min output = 50 MW

Input–output curve:

$$H_3\left(\frac{\text{MBtu}}{\text{h}}\right) = 78.0 + 7.97P_3 + 0.00482P_3^2$$

Example

Example : Suppose that we wish to determine the economic operating point for these three units when delivering a total of 850 MW. Before this problem can be solved, the fuel cost of each unit must be specified. Let the following fuel costs be in effect.

$$\textbf{Unit}1: \quad \text{fuel cost} = 1.1 \ \$/\text{MBtu}$$

$$\textbf{Unit}2: \quad \text{fuel cost} = 1.0 \ \$/\text{MBtu}$$

$$\textbf{Unit}3: \quad \text{fuel cost} = 1.0 \ \$/\text{MBtu}$$

$$F_1(P_1) = H_1(P_1) \times 1.1 = 561 + 7.92P_1 + 0.001562P_1^2 \ \$/\text{h}$$

$$F_2(P_2) = H_2(P_2) \times 1.0 = 310 + 7.85P_2 + 0.00194P_2^2 \ \$/\text{h}$$

$$F_3(P_3) = H_3(P_3) \times 1.0 = 78 + 7.97P_3 + 0.00482P_3^2 \ \$/\text{h}$$

Example

$$0 = \frac{dF_i}{dP_i} - \lambda \quad \begin{cases} \dfrac{dF_1}{dP_1} = 7.92 + 0.003124 P_1 = \lambda \\ \dfrac{dF_2}{dP_2} = 7.85 + 0.00388 P_2 = \lambda \\ \dfrac{dF_3}{dP_3} = 7.97 + 0.00964 P_3 = \lambda \\ P_1 + P_2 + P_3 = 850 \text{ MW} \end{cases}$$

$$\boxed{\lambda = 9.148 \text{ \$ / MWh}}$$

$$\boxed{\begin{aligned} P_1 &= 393.2 \text{ MW} \\ P_2 &= 334.6 \text{ MW} \\ P_3 &= 122.2 \text{ MW} \end{aligned}}$$

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Questions and answers