University of Exeter

Centre for Smart Grid

Econ  c 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 generation under the constraint condition of the system load demands.

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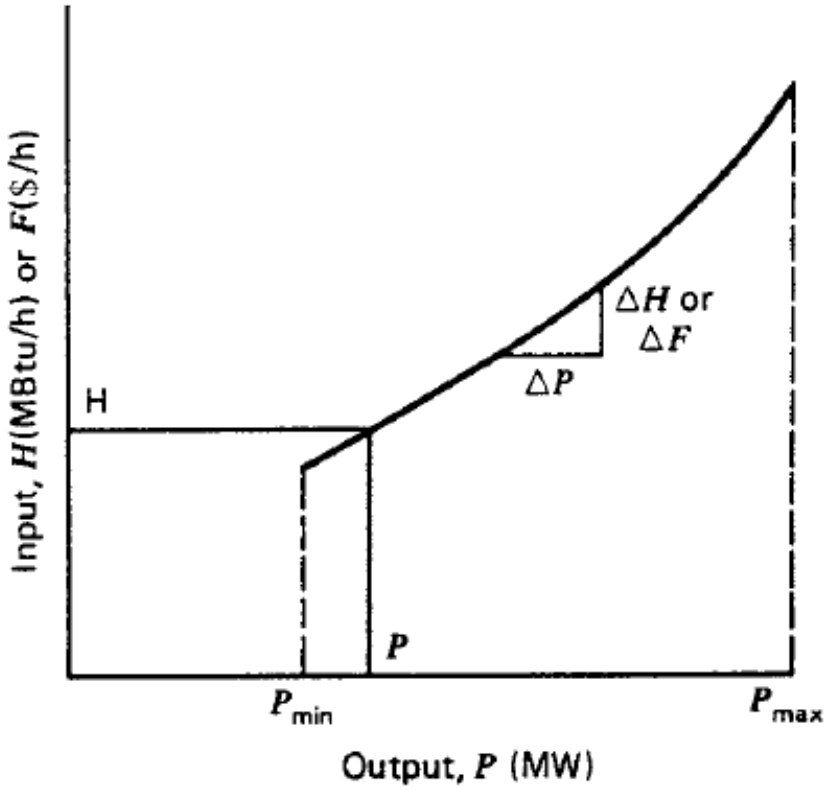
Input-output Characteristics Of Generator Units

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 input to the unit (or MBtu/h). The fuel cost rate times Btu/h is the $ per hour input to the unit for fuel. The output of the generating unit will be denoted by P_G megawatt net power output of the unit.



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

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

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

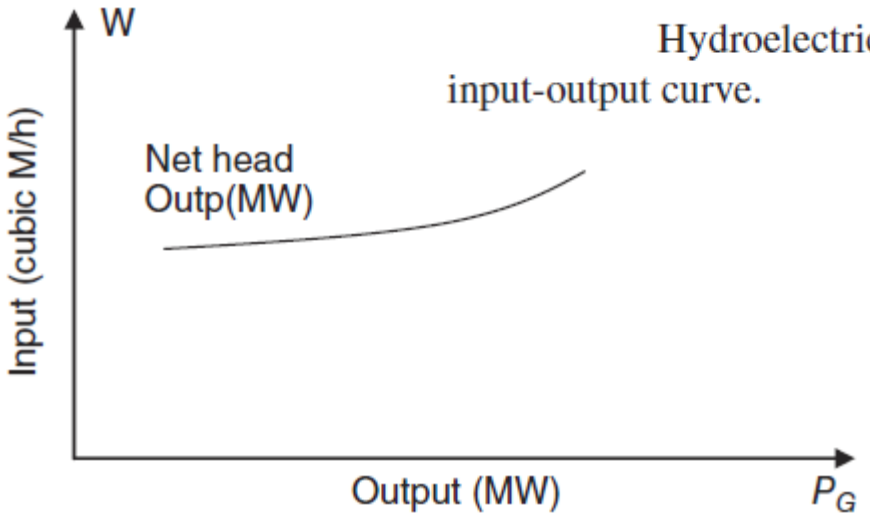
H = Btu per hour heat input to the unit (or MBtu/h)

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

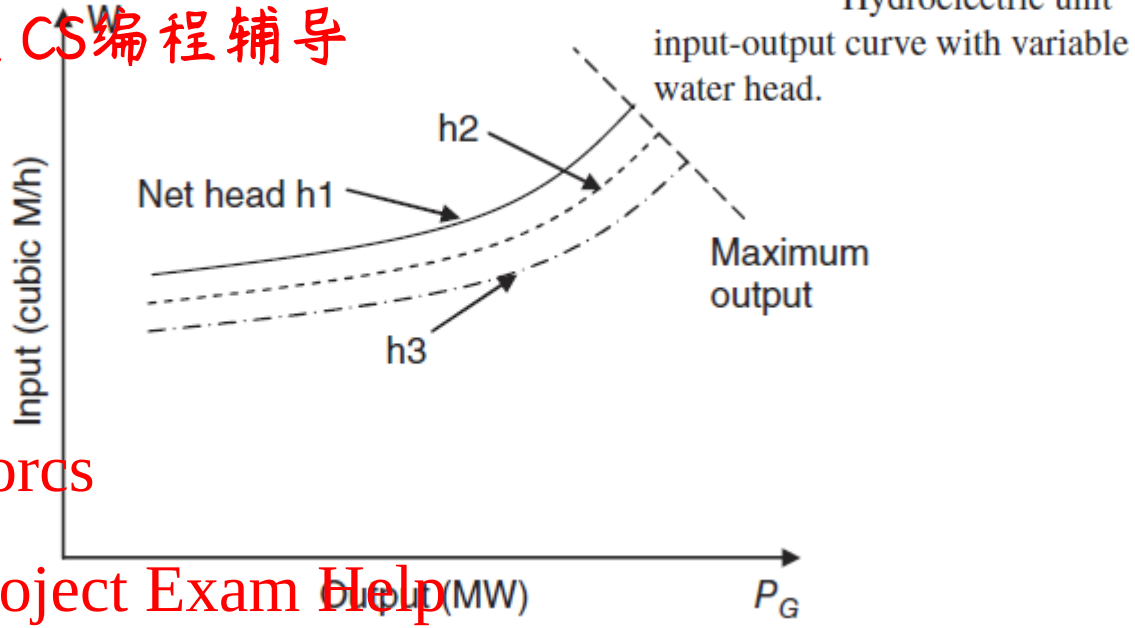
Calculation of Input–Output Characteristic Parameters

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

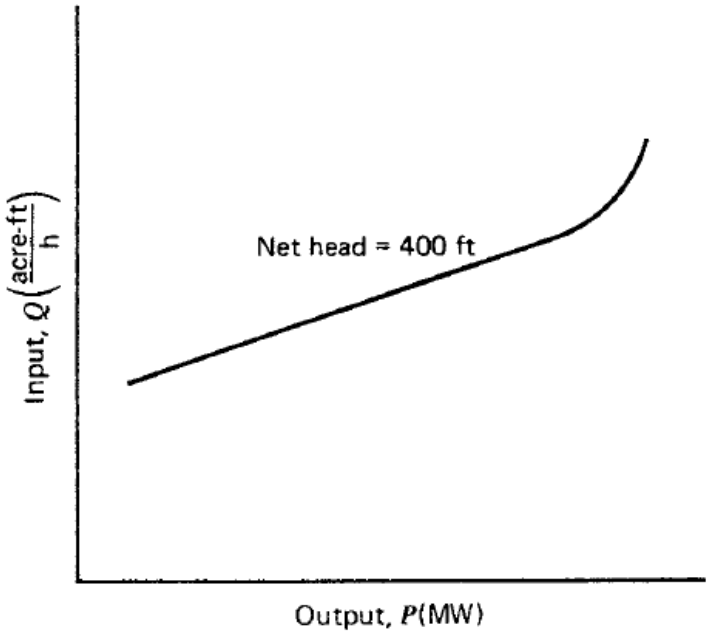
Input–Output Characteristic of Hydroelectric Units

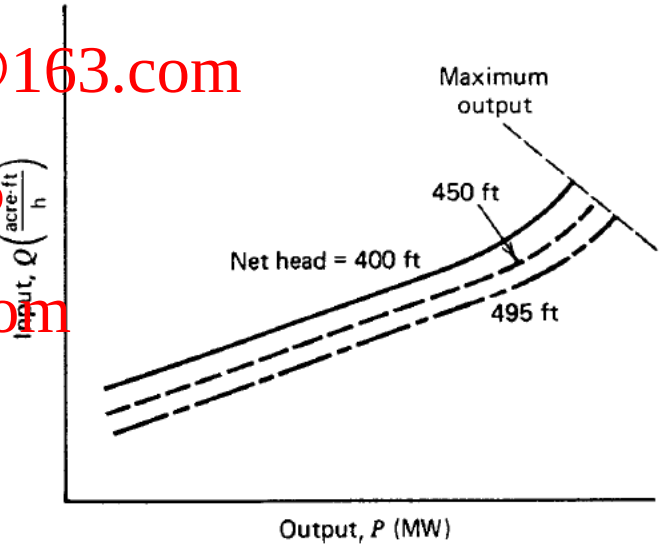


Hydroelectric unit input-output curve.



Hydroelectric unit input-output curve with variable water head.





THE ECONOMIC DISPATCH PROBLEM

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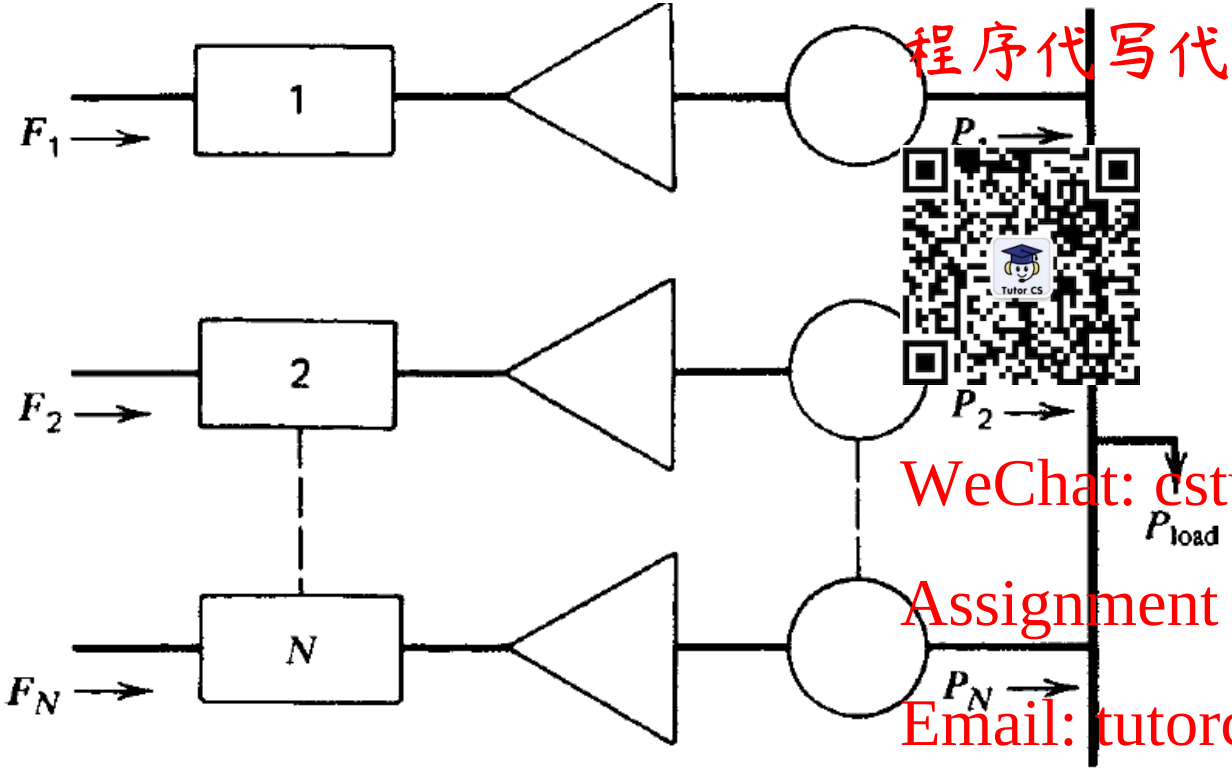

N_{gen} thermal units committed to serve a load of P_{load}

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

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

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

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

THE ECONOMIC DISPATCH PROBLEM

$$\mathcal{L} = F_T + \lambda\phi$$

$$\frac{\partial \mathcal{L}}{\partial} = \frac{dF_i(P_i)}{dP_i} - \lambda = 0 \qquad 0 = \frac{dF_i}{dP_i} - \lambda$$

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

Example

Example

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

Input–output curve:

$$H_1\left(\frac{\text{MBtu}}{\text{h}}\right) = 510.0 + 7.2P_1 + 0.001$$

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

Input–output curve:

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

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

Input–output curve:

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

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 s[illegible]et the following fuel costs be in effect.

Unit1 : [illegible] = 1.1 $/MBtu

Unit2 : fuel cost = 1.0 $/MBtu

Unit3 : fuel cost = 1.0 $/MBtu

$$F_1(P_1) = H_1(P_1) \times 1.1 = 561 + 7.92P_1 + 0.00156P_1^2 \$/\text{h}$$

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

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

Example

$$0 = \frac{dF_i}{dP_i} - \lambda$$

$$\begin{cases} \dfrac{dF_1}{dP_1} = 7.92 + 0.003124P_1 = \lambda \\ \dfrac{dF_2}{dP_2} = 7.85 + 0.0[illegible] = \lambda \\ \dfrac{dF_3}{dP_3} = 7.97 + 0.00964P_3 = \lambda \\ P_1 + P_2 + P_3 = 850 \text{ MW} \end{cases}$$

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

$$P_1 = 393.2 \text{ MW}$$
$$P_2 = 334.6 \text{ MW}$$
$$P_3 = 122.2 \text{ MW}$$

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Questions and answers