Power Systems I

EE342

ECONOMIC DISPATCH(3)

Outline

- Generation Optimization.
- Generation Operating Costs Optimization.
- Economic Dispatch
  - Minimize the total generation operating cost (Objective function) subject to;
    - Equality Constraints; Load demand plus system losses ***equal*** to the total generation.
    - Inequality Constraints; The generator power ***NOT*** less min. and ***NOT*** more than its max. limits.

7.4 ECONOMIC DISPATCH NEGLECTING LOSSES AND NO GENERATOR LIMITS

The simplest economic dispatch problem is the case when transmission line losses are neglected. That is, the problem model does not consider system configuration and line impedances. In essence, the model assumes that the system is only one bus with all generation and loads connected to it as shown schematically in Figure 7.5.

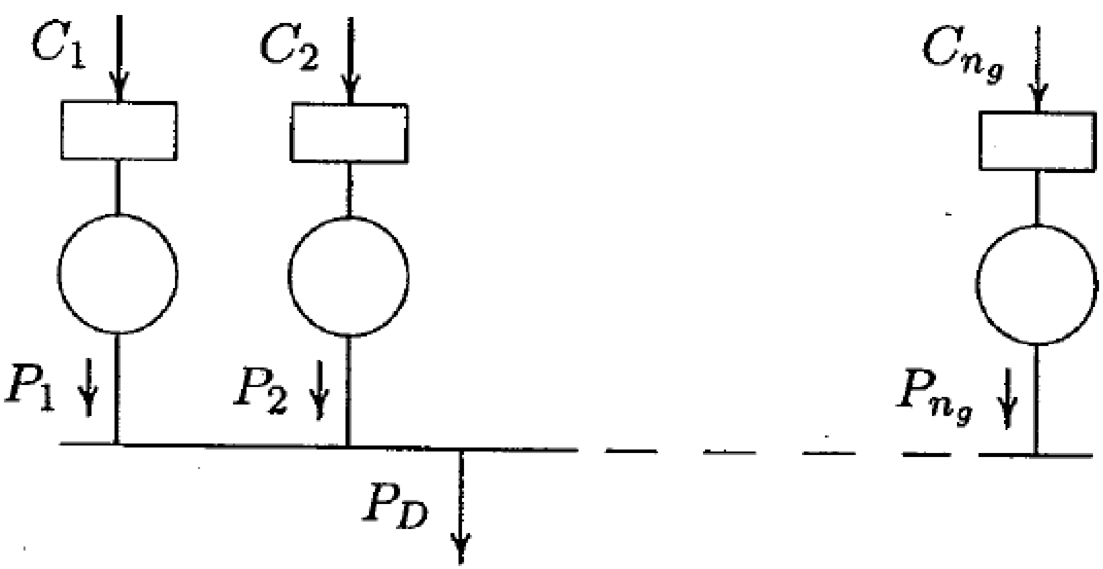

FIGURE 7.5
Plants connected to a common bus.

$$C_i = \alpha_i + \beta_i P_i + \gamma_i P_i^2 \tag{7.21}$$

$$\frac{dC_i}{dP_i} = 2\gamma_i P_i + \beta_i \tag{7.22}$$

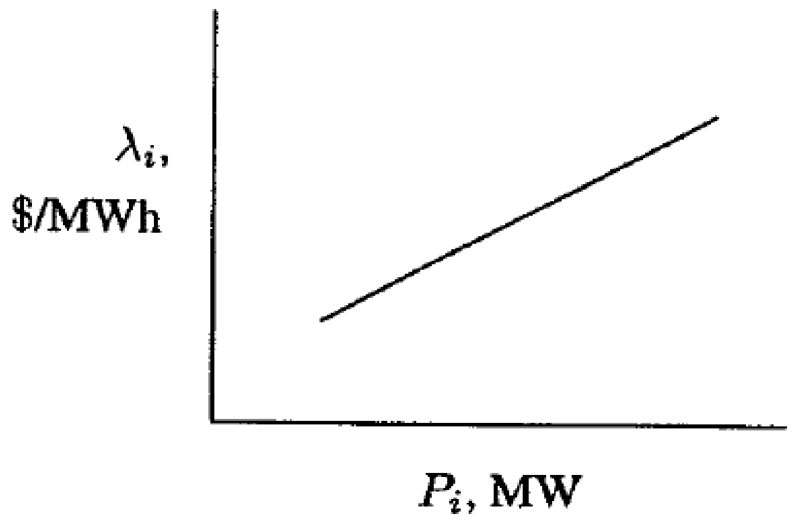

FIGURE 7.4
Typical incremental fuel-cost curve.

Economic Dispatch Problem

$$C_t = \sum_{i=1}^{n_g} C_i$$
$$= \sum_{i=1}^{n} \alpha_i + \beta_i P_i + \gamma_i P_i^2 \qquad (7.23)$$

is minimum, subject to the constraint

$$\sum_{i=1}^{n_g} P_i = P_D \qquad (7.24)$$

Lagrange Solution

$$\mathcal{L} = C_t + \lambda \left(P_D - \sum_{i=1}^{n_g} P_i \right) \tag{7.25}$$

$$\frac{\partial \mathcal{L}}{\partial P_i} = 0 \tag{7.26}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = 0 \tag{7.27}$$

The solution steps when system losses and generator limits are *neglected*

$$\lambda = \frac{P_D + \sum_{i=1}^{n_g} \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^{n_g} \frac{1}{2\gamma_i}} \qquad (7.33)$$

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i} \qquad (7.31)$$

The simplest problem is when system losses and generator limits are neglected

Example 7.4

The fuel-cost functions for three thermal plants in \$/h are given by

$$C_1 = 500 + 5.3P_1 + 0.004P_1^2$$
$$C_2 = 400 + 5.5P_2 + 0.006P_2^2$$
$$C_3 = 200 + 5.8P_3 + 0.009P_3^2$$

where P_1, P_2, and P_3 are in MW. The total load, P_D, is 800 MW. Neglecting line losses and generator limits, find the optimal dispatch and the total cost in \$/h

(a) by analytical method using (7.33)

(b) by graphical demonstration.

(c) by iterative technique using the gradient method.

7.5 ECONOMIC DISPATCH NEGLECTING LOSSES AND INCLUDING GENERATOR LIMITS

$$P_{i(min)} \leq P_i \leq P_{i(max)} \qquad i = 1, \ldots, n_g \tag{7.40}$$

$$\begin{aligned} \frac{dC_i}{dP_i} &= \lambda && \text{for} \quad P_{i(min)} < P_i < P_{i(max)} \\ \frac{dC_i}{dP_i} &\leq \lambda && \text{for} \quad P_i = P_{i(max)} \\ \frac{dC_i}{dP_i} &\geq \lambda && \text{for} \quad P_i = P_{i(min)} \end{aligned} \tag{7.41}$$

The solution steps when generator limits are *considered* *and losses neglected*

Iterative solution

- Assume $\lambda^{(1)}$ = the integer value of **max.** β_i, then calculate

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i} \qquad (7.31)$$

$$\Delta P^{(k)} = P_D - \sum_{i=1}^{n_g} P_i^{(k)} \qquad (7.39)$$

$$\Delta\lambda^{(k)} = \frac{\Delta P^{(k)}}{\sum \frac{1}{2\gamma_i}} \qquad (7.37)$$

$$\lambda^{(k+1)} = \lambda^{(k)} + \Delta\lambda^{(k)} \qquad (7.38)$$

Repeat until $\Delta\lambda$ and $\Delta P_i \cong 0$ OR less than specified accuracy

The ~~simplest~~ problem when the system with generator limits and losses are neglected

Example 7.6

Find the optimal dispatch and the total cost in \$/h for the thermal plants of Example 7.4 when the total load is 975 MW with the following generator limits (in MW):

$$200 \leq P_1 \leq 450$$

$$150 \leq P_2 \leq 350$$

$$100 \leq P_3 \leq 225$$

7.6 ECONOMIC DISPATCH INCLUDING LOSSES

$$C_t = \sum_{i=1}^{n_g} C_i$$
$$= \sum_{i=1}^{n} \alpha_i + \beta_i P_i + \gamma_i P_i^2 \tag{7.44}$$

subject to the constraint that generation should equal total demands plus losses, i.e.,

$$\sum_{i=1}^{n_g} P_i = P_D + P_L \tag{7.45}$$

satisfying the inequality constraints, expressed as follows:

$$P_{i(min)} \le P_i \le P_{i(max)} \qquad i = 1, \ldots, n_g \tag{7.46}$$

The solution steps **when system losses and generator limits are *considered***

- **Assume $\lambda^{(1)}$ = the integer value of *max.* β_i**
- **Calculate $P_i^{(1)}$ using;**

$$P_i^{(k)} = \frac{\lambda^{(k)} - \beta_i}{2(\gamma_i + \lambda^{(k)} B_{ii})} \qquad (7.70)$$

- ***Calculate* $P_L^{(1)}$ using**

$$P_L = \sum_{i=1}^{n_g} B_{ii} P_i^2 \qquad (7.69)$$

The solution steps when system **losses and generator limits** are ***considered***

$$\Delta P^{(k)} = P_D + P_L^{(k)} - \sum_{i=1}^{n_g} P_i^{(k)} \tag{7.68}$$

$$\sum_{i=1}^{n_g} \left(\frac{\partial P_i}{\partial \lambda}\right)^{(k)} = \sum_{i=1}^{n_g} \frac{\gamma_i + B_{ii}\beta_i}{2(\gamma_i + \lambda^{(k)} B_{ii})^2} \tag{7.71}$$

$$\Delta \lambda^{(k)} = \frac{\Delta P^{(k)}}{\sum \left(\frac{dP_i}{d\lambda}\right)^{(k)}} \tag{7.65}$$

$$\lambda^{(k+1)} = \lambda^{(k)} + \Delta \lambda^{(k)} \tag{7.67}$$

Repeat until $\Delta\lambda$ and $\Delta P_i \cong 0$ OR less than specified accuracy

Example 7.7

The fuel cost in \$/h of three thermal plants of a power system are

$$C_1 = 200 + 7.0P_1 + 0.008P_1^2 \quad \$/\text{h}$$
$$C_2 = 180 + 6.3P_2 + 0.009P_2^2 \quad \$/\text{h}$$
$$C_3 = 140 + 6.8P_3 + 0.007P_3^2 \quad \$/\text{h}$$

where P_1, P_2, and P_3 are in MW. Plant outputs are subject to the following limits

$$10 \text{ MW} \leq 85 \text{ MW}$$
$$10 \text{ MW} \leq 80 \text{ MW}$$
$$10 \text{ MW} \leq 70 \text{ MW}$$

For this problem, assume the real power loss is given by the simplified expression

$$P_{L(pu)} = 0.0218P_{1(pu)}^2 + 0.0228P_{2(pu)}^2 + 0.0179P_{3(pu)}^2$$

where the loss coefficients are specified in per unit on a 100-MVA base. Determine the optimal dispatch of generation when the total system load is 150 MW.

Now it's over
we finally reach the end


Thanks


Any Questions...
Just Ask!