UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE

Assignment # 3

Economic Dispatch using Dynamic Programming

Course Title: Advanced Power System Operation and Control

Course Code: EE 641

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Problem Statement

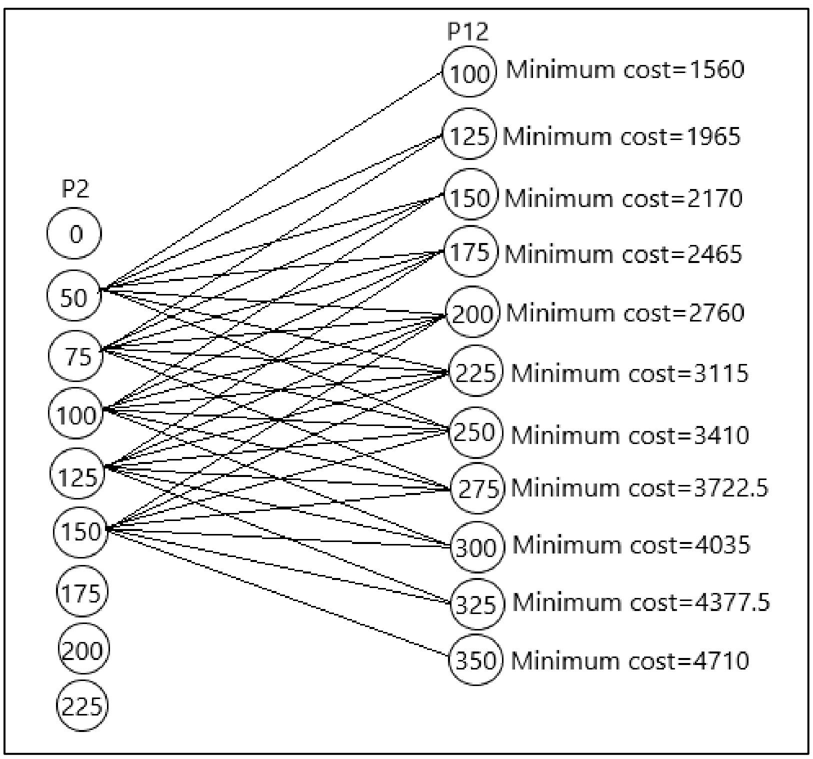
Three generator units with non-convex input output curves must be optimally scheduled to meet a load demand of D = 310 MW. The costs for different power levels are shown in the table below.

Power Levels (MW)	Costs ($/h)		
$P_1 = P_2 = P_3$	F_1	F_2	F_3
0	∞	∞	∞
50	810	750	806
75	1355	1155	1108.5
100	1460	1360	1411
125	1772.5	1655	1704.5
150	208.5	1950	1998
175	2427.5	∞	2358
200	2760	∞	∞
225	∞	∞	∞

Scheduling units 1 and 2, we find the minimum cost for the function

$$f_{12} = F_1(D - P_2) + F_2(P_2)$$

Over the allowable range of P_2 and for $100 \leq D \leq 350\ MW$. The results are shown in the Figure below and the MATLAB code is given as well.



MATLAB Code for f_{12}

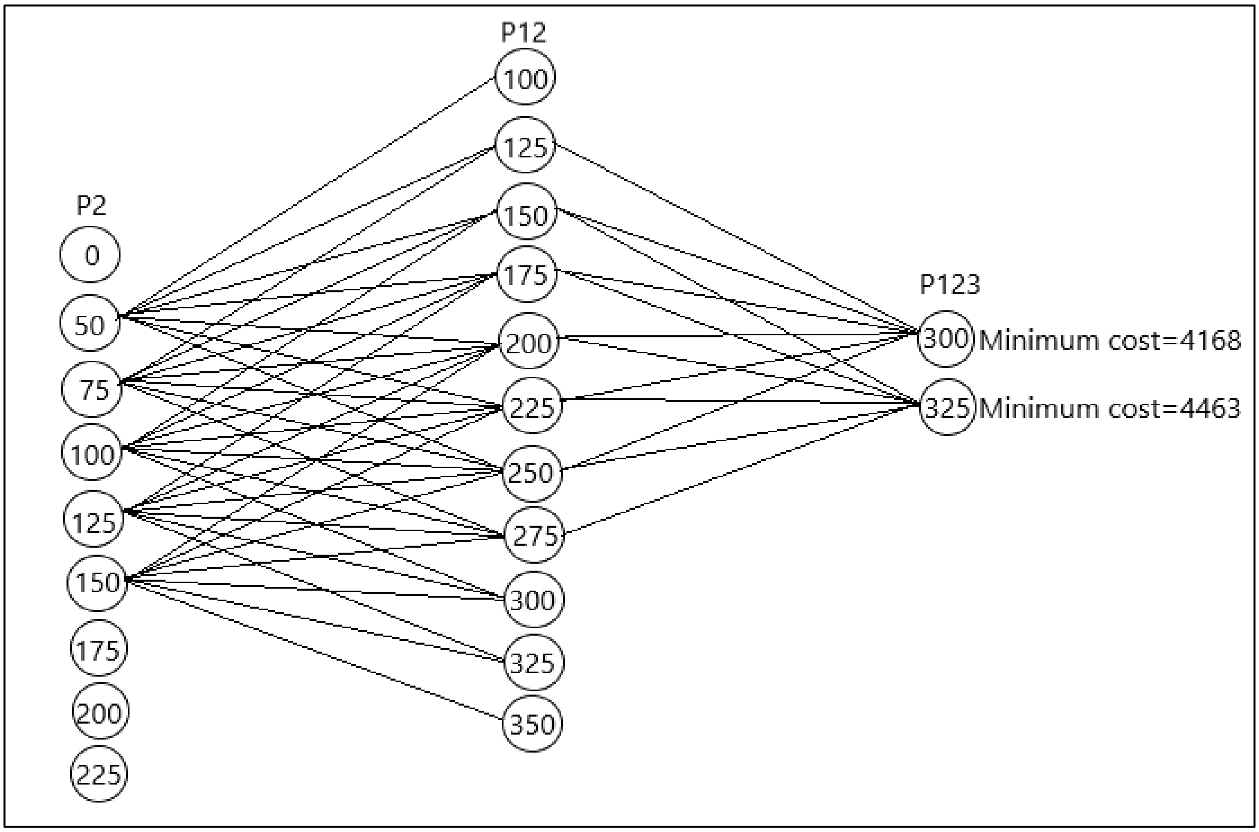
```
clc;clear all;
D12=zeros(27,1);
Ans12=zeros(27,1);
D123=zeros(27,1);
Ans123=zeros(27,1);
Powers=[0;50;75;100;125;150;175;200;225];
Costs=[ inf    inf  inf;
        810    750  806;
        1355   1155 1108.5;
        1460   1360 1411;
        1772.5 1655 1704.5;
        2085   1950 1998;
        2427.5 inf  2358;
        2760   inf  inf;
        inf    inf  inf];
for r=1:9
    for c=1:9
        D12(r,1)=Powers(r,1);
        D12(r+c,1)=max(D12(r+c,1),Powers(r)+Powers(c));
        D12(r,2)=Costs(r,1);
        D12(r+c,c+2)=Costs(r,1)+Costs(c,2);
    end
end
for r=1:18
    for c=1:8
        if (D12(r,c+1)==0)
            D12(r,c+1)=inf;
        end
        if (D12(r,10)==inf)
            D12(r,10)=0;
        end
    end
end
for r=1:18
    for c=3:8
        D12(r,9)=min(D12(r,3:8));
        if (min(D12(r,3:8))~=inf)
            if (D12(r,9)==D12(r,c))
                D12(r,10)=Powers(c-2);
            end
            if (D12(r,9)==D12(r,c))
                D12(r,11)=D12(r,1)-D12(r,10);
            end
        end
    end
end

D12(1:14,:)
Ans12=[D12(:,1) D12(:,9) D12(:,10) D12(:,11)];
Ans12(1:15,1:3)
```

Next, we minimize

$$f_{123} = f_{12}(D - P_3) + F_3(P_3)$$

The results are shown in the Figure below and the MATLAB code is given as well.



MATLAB Code for f_{123}

```
for r=1:18
    for c=1:9
        D123(r,1)=Ans12(r,1);
        D123(r+c,1)=max(D123(r+c,1),Ans12(r,1)+Powers(c));
        D123(r,2)=Ans12(r,2);
        D123(r+c,c+2)=Ans12(r,2)+Costs(c,3);
    end
end

for r=1:27
    for c=1:8
        if (D123(r,c+1)==0)
            D123(r,c+1)=inf;
        end
        if (D123(r,10)==inf)
            D123(r,10)=0;
        end
    end
end

for r=1:27
    for c=3:8
        D123(r,10)=min(D123(r,3:9));
        if (min(D123(r,3:9))~=inf)
            if (D123(r,10)==D123(r,c))
                D123(r,11)=Powers(c-2);
            end
        end
    end
end

for r123=1:27
    for r12=1:18
        if ((D123(r123,1)-D123(r123,11))==Ans12(r12,1))
            D123(r123,12)=Ans12(r12,3);
            D123(r123,13)=Ans12(r12,4);
        end
    end
end

D123(12:13,1:11)
Ans123=[D123(:,1) D123(:,10) D123(:,11) D123(:,12) D123(:,13)];
Ans123(12:13,:)
```

The results show

D (MW)	Cost ($/h)	P_3^* (MW)	P_2^* (MW)	P_1^* (MW)
300	4168	150	100	50
325	4463	150	125	50

Between 300 MW and 325 MW levels, the marginal unit is unit 2. We can therefore interpolate to find a cost at a load level of D = 310 MW. This corresponds to an output level of 110 MW on unit 2. The results of D = 310 MW are

$$P_1 = 50\ MW, P_2 = 110\ MW, P_3 = 150\ MW$$
$$for\ a\ total\ cost\ of\ 4168 + 118 = 4286\ \$/\mathrm{h}$$