Electricity Generation Cost

1 Btu ~ 1.055 kJ

$HeatRate := 10800$ kJ/kWh

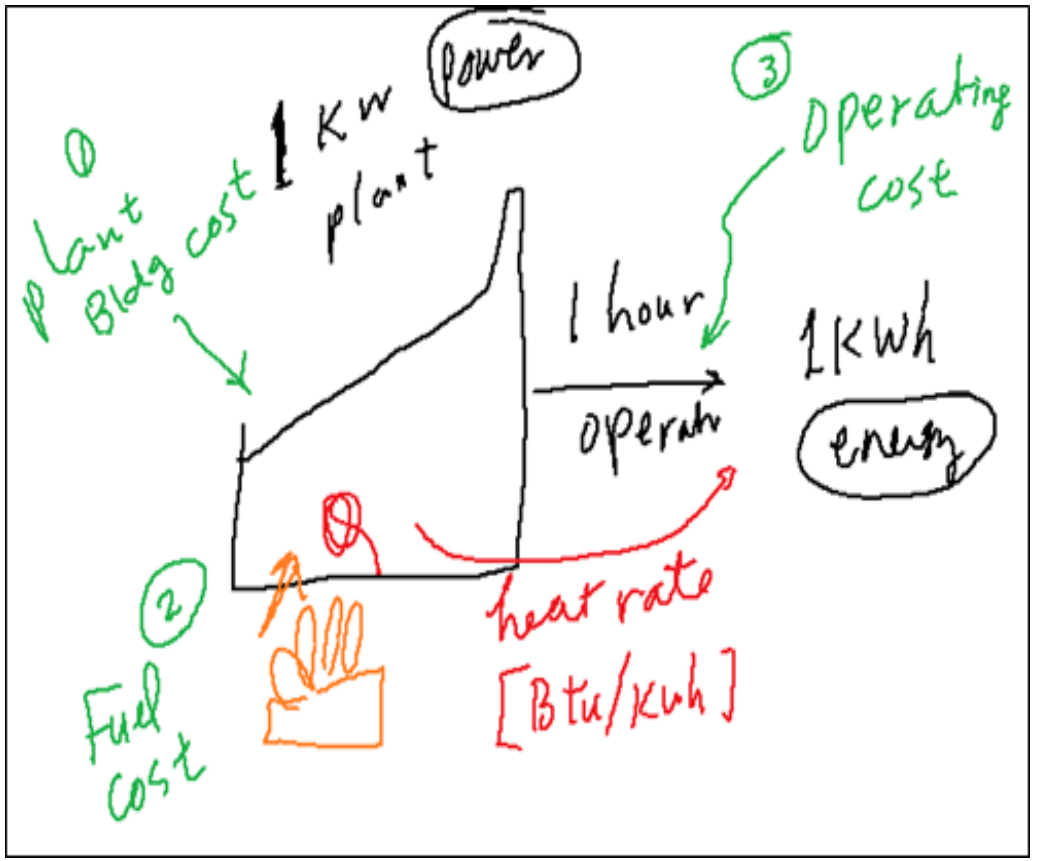
$HV := 27300$ kJ/kg

$$FuelRate := \frac{HeatRate}{HV} = 0.395604 \quad kg / kWh$$

$$HeatRate := \frac{HeatRate}{1.055} = 10236.966825 \quad Btu / kWh$$

$$HV := \frac{HV}{1.055} = 25876.777251 \quad Btu / kWh$$

$$FuelRate := \frac{HeatRate}{HV} = 0.395604 \quad kg / kWh$$



Technology	Fuel	Capital Cost ($/kW)	Heat Rate (Btu/kWh)	Fuel Cost ($/million Btu)	Variable O&M (¢/kWh)
Pulverized coal steam	Coal	1400	9,700	1.50	0.43

Electricity Generation Cost Parameters

- **(1) Fixed cost: [$/kW]**

  - **Annualized Fixed Cost** ($/kW-yr)

Electricity Generation Cost Parameters

- (2) Variable cost: [$/kWh]

  - Annualized variable cost [$/kW-yr]

Annualized Cost → Electricity Cost

- **Annualized fixed cost** ($/kW-yr)
  = Capital Cost ($/kW) x FCR(/year)

- **Annualized variable cost** ($/kW-yr)
  = {Material Cost [$/kWh] + O&M ($/kWh] }x Operating Hours [h/yr]

- **Annualized Total Cost for N- kW plant**
  = N[kW]*{Annualized fixed cost [$/kW-yr] + annualized variable cost [$/kW-yr]} **[$/yr]**

- **Total Yearly Generation from N-kW Plant [kWh]**
  = N[kW]*H [hours/yr] **[kWh/yr]**

- **Electricity Cost [$/kWh]**
  = Total Cost [$/yr] /Total Generation [kWh/yr] **[$/kWh]**

Electricity Energy Cost - Example

Technology	Fuel	Capital Cost ($/kW)	Heat Rate (Btu/kWh)	Fuel Cost ($/million Btu)	Variable O&M (¢/kWh)
Pulverized coal steam	Coal	1400	9,700	1.50	0.43
Advanced coal steam	Coal	1600	8,800	1.50	0.43

$N := 1$ 1 kW-power plant

$fuel\_cost := 1.50 \cdot 10^{-6}$

$heat\_rate := 9700$

$material\_cost := fuel\_cost \cdot heat\_rate = 0.01455$ $/kWh

$fcr := 0.16$

$H := 8000$ 8000 hours operations from max 8760 hours per year

$capital := 1400$ $OM := 0.0043$

⌘ **Annualized fixed cost** ($/kW-yr)

= Capital Cost ($/kW) x FCR(/year)

$afc := capital \cdot fcr = 224$

⌘ **Annualized variable cost** ($/kW-yr)

= {Material Cost [$/kWh] + O&M ($/kWh] }x Operating Hours [h/yr]

$avc := (material\_cost + OM) \cdot H = 150.8$

⌘ **Annualized Total Cost for N- kW plant**

= N[kW]*{Annualized fixed cost [$/kW-yr] + annualized variable cost [$/kW-yr]} **[$/yr]**

$atc := N \cdot (afc + avc) = 374.8$

⌘ **Total Yearly Generation from N-kW Plant [kWh]**

= N[kW]*H [hours/yr] **[kWh/yr]**

$aee := N \cdot H = 8000$

⌘ **Electricity Cost [$/kWh]**

= Total Cost [$/yr] /Total Generation [kWh/yr] **[$/kWh]**

$EC := \frac{atc}{aee} = 0.04685$ $/kWh

$EC \cdot 100 = 4.685$ c /kWh

Investigation of the Example Costs (1)

- Recall
- **Annualized fixed cost** [$/kW-yr]
  = Capital Cost [$/kW] x FCR[/yr]
  = 224 [$/kW-yr]
- **Annualized variable cost** ($/kW-yr)
  = {Material Cost [$/kWh] + O&M ($/kWh] }x Operating Hours [h/yr]
  =150.8 [$/kW-yr]

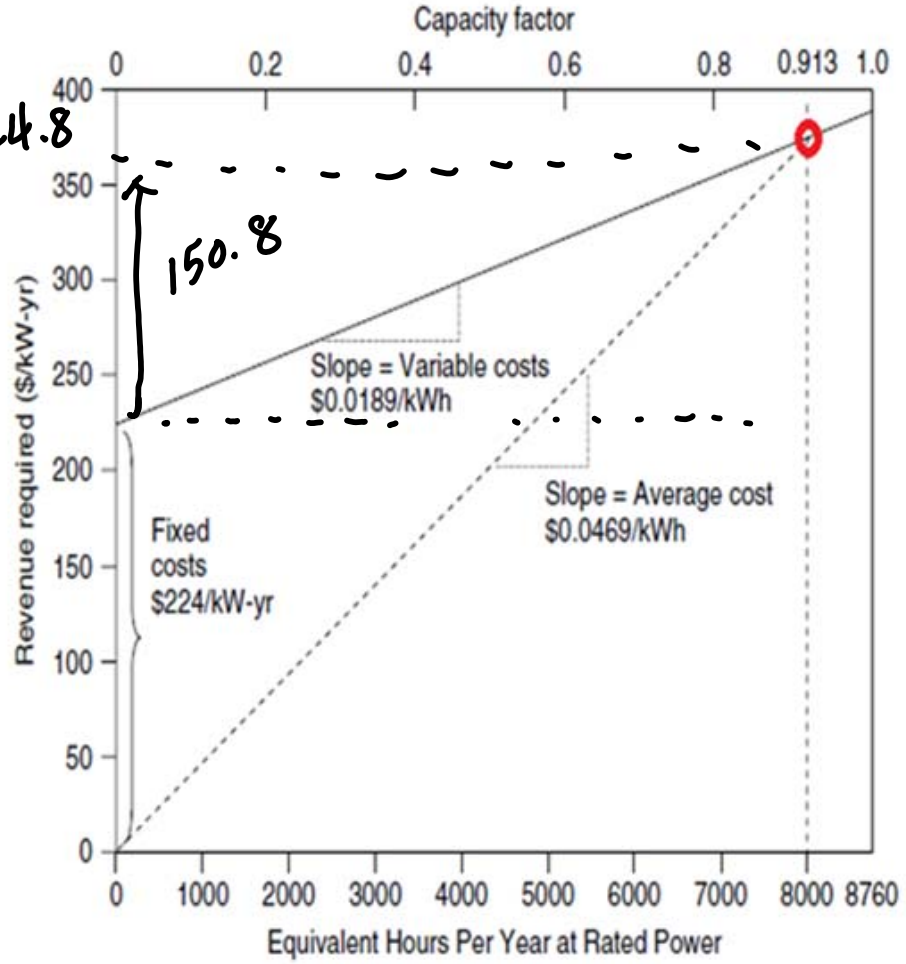
$$avc = 150.8 \quad \$/\ kW - yr$$

$$avcHour := \frac{avc}{8000} = 0.01885 \quad \$ / kWh$$

- **Electricity Cost [$/kWh]**
  =0.04685 [$/kWh]
- Operating hours = 8000

$$CF := \frac{H}{8760} = 0.913242$$

- **Capacitor Factor (CF):**
  "percentage usage of capacity"



Plant Operation and CF(Capacity Factor)

$N = 1$

- **Total Yearly Generation from N-kW Plant [kWh]**
  = N[kW]*H [hours/yr] **[kWh/yr]**

$aee := N \cdot H = 8000$

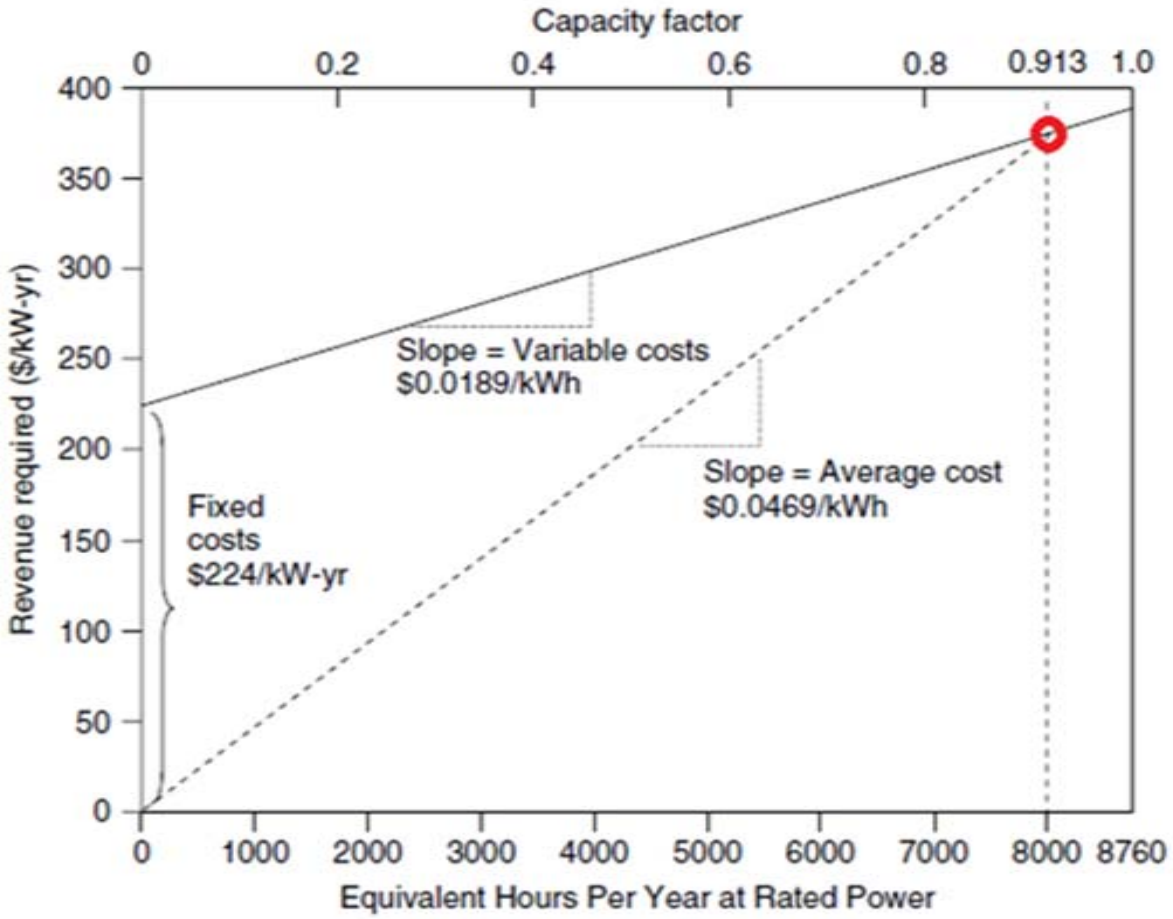
- Alternative formula for Total Yearly Generation [kWh/yr]
  = N [kW] x 8760 h/yr x CF (Capacity Factor)

$gy := N \cdot 8760 \cdot CF = 8000$

$$CF = \frac{\text{Operating hours/year}}{8760 \text{ hours/year}}$$

$$CF = \left(\frac{8000}{8760}\right) = 0.913$$

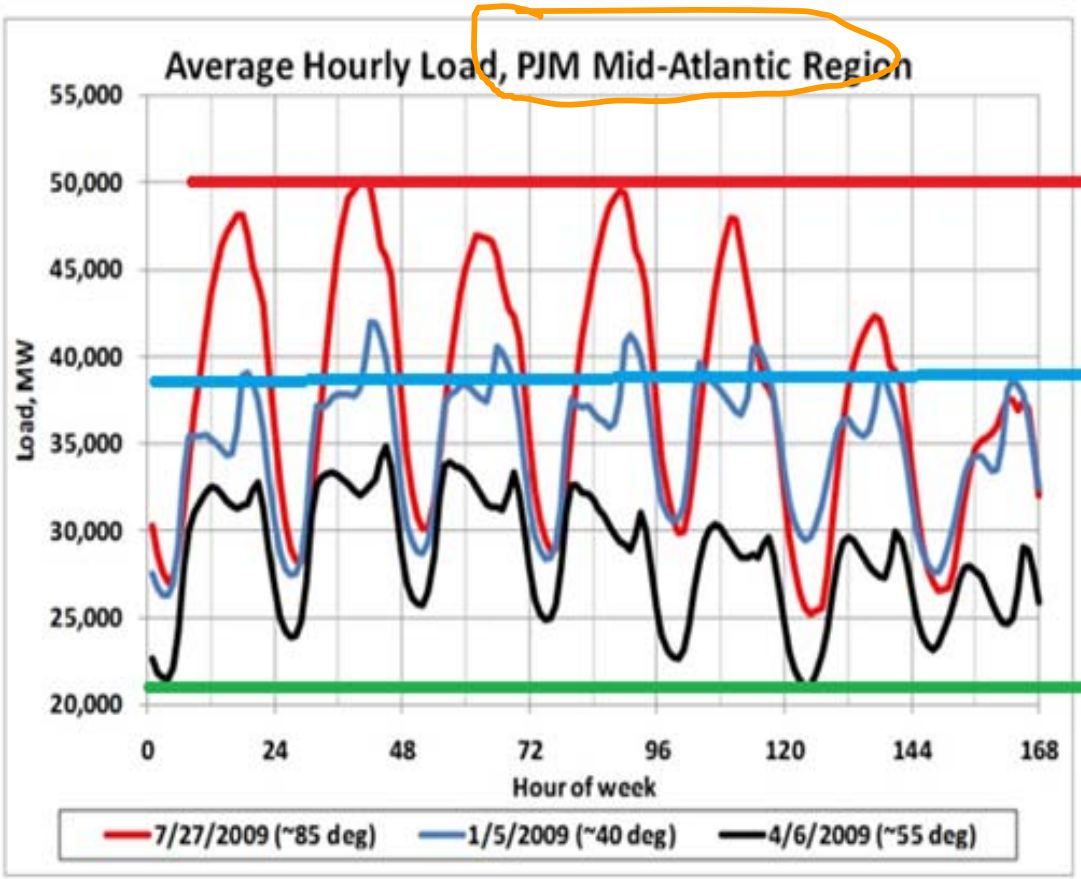
Investigation of the Example Costs (2)



Differnt cost curves for different type of fuel

Generation Mix and Economic Dispatch

- **Different fuels are used for power generation**
  - Cost of fuel
  - Operating cost
  - Response time to the changing load



Peak load

Intermediate Load

Base load

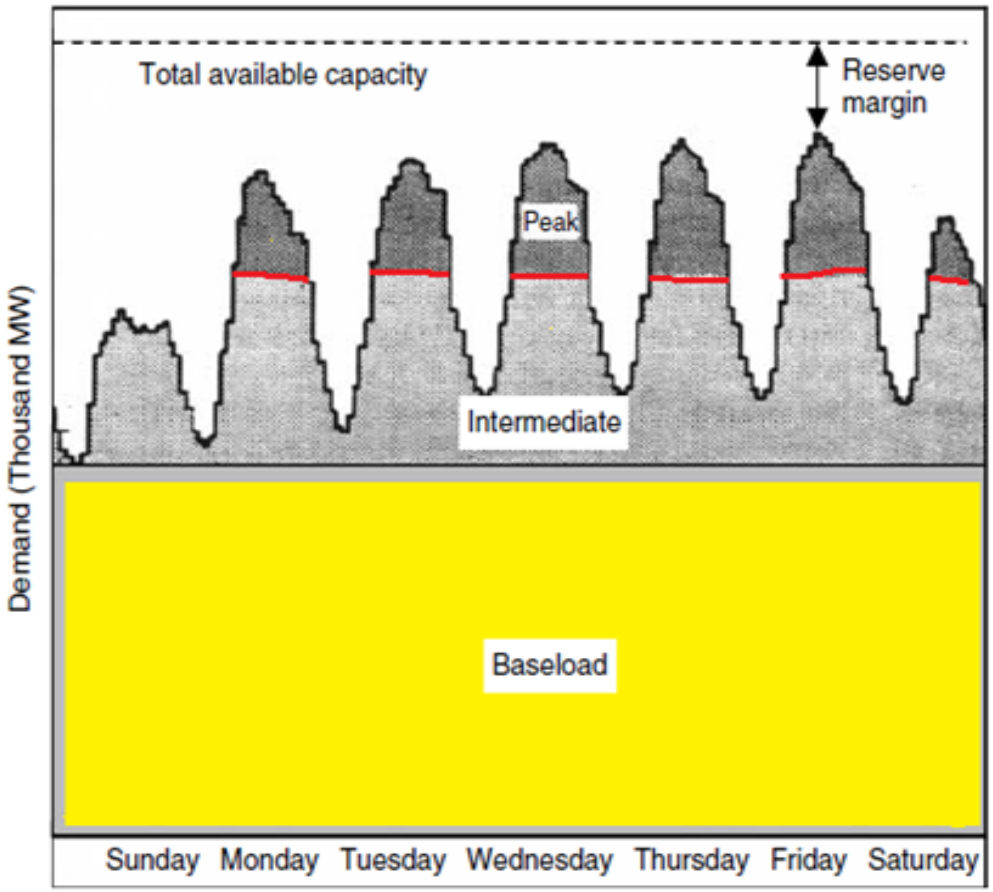
Generation Mix and Economic Dispatch

- **Dispatch:**

- **Economic dispatch**

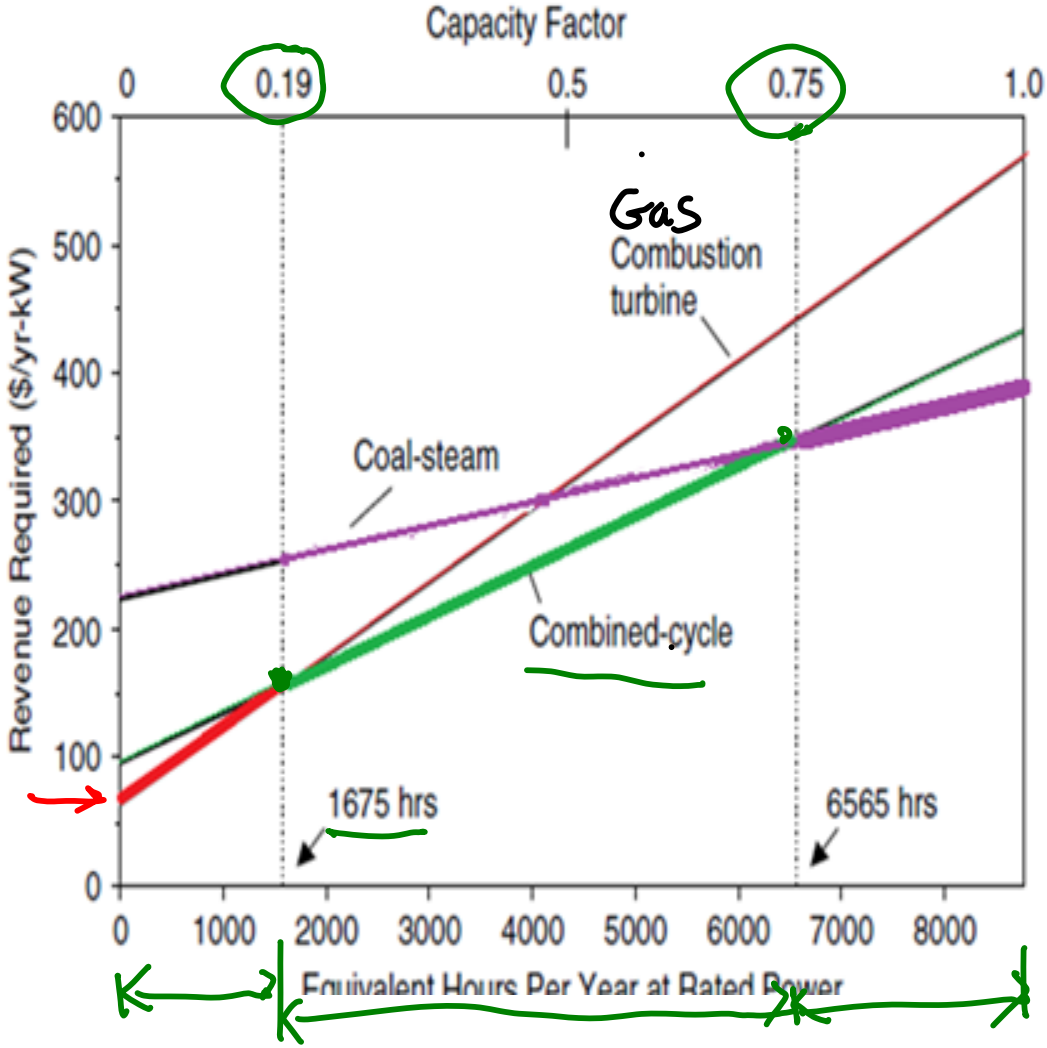
- **Coal**
- **Gas**
- Nuclear
- **Renewables**
- **Hydro**

Roles of Different Power Plants



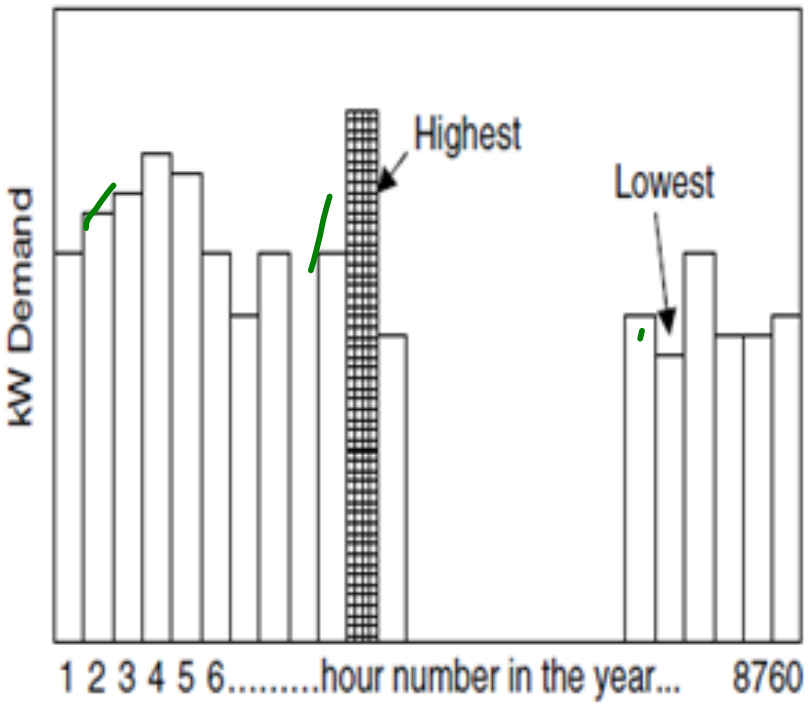
- Baseload plants:
- Intermediate load plants
- Peak load plants

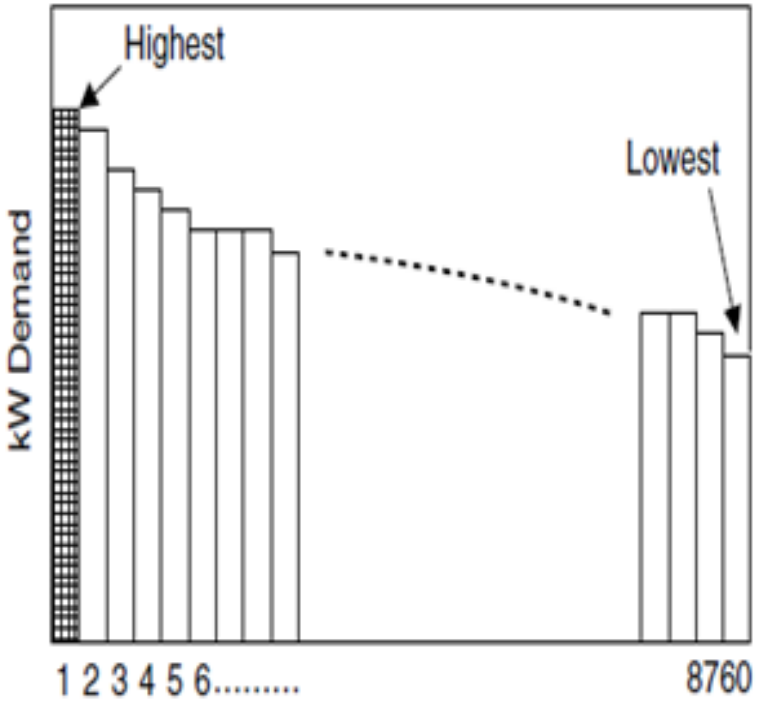
Screening Curves



Load-Duration Curves

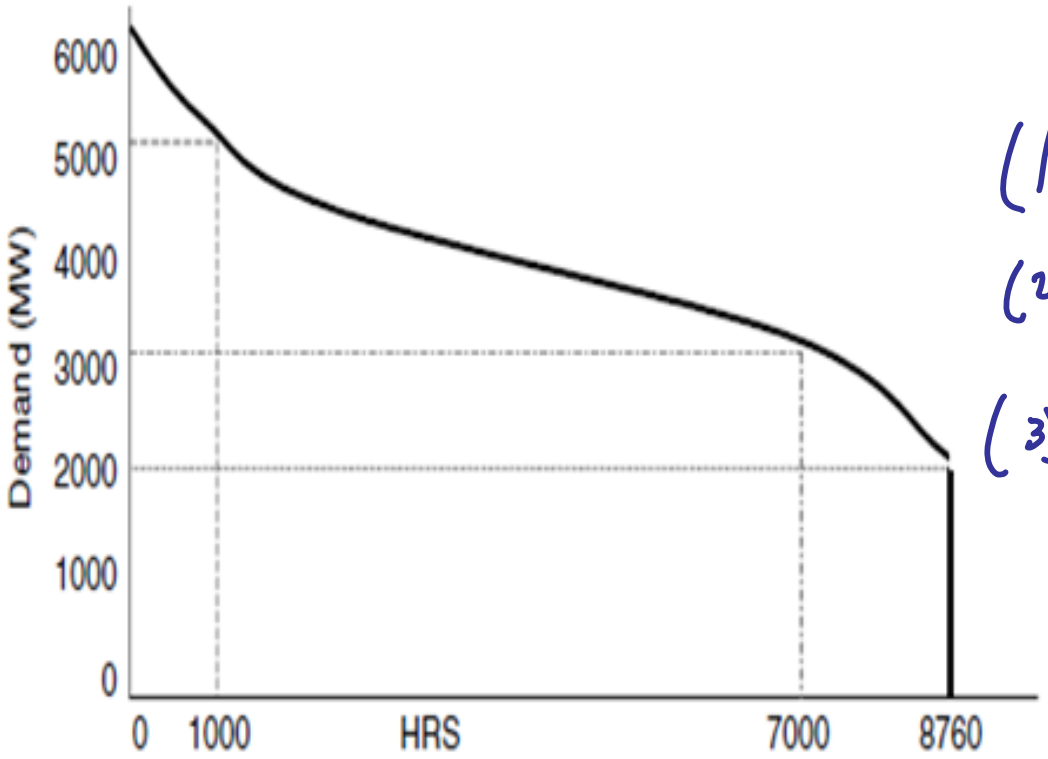
① Hourly Load Curve ⟶ ② Load Duration Curve





⌘ We plan to connect the screening curve of power plant and the load duration curve for (a) capacity of different power plants and (b) allocation of power plants for economic dispatch

Load Duration Curve



Interpretation

MW

(1) Load is between ( ) and ( )

(2) Load > 5000 MW for ( ) hours

(3) Load > 3000 MW for ( ) hours

3000 < Load < 5000 for ( ) hours

Optimum Mix through Screening Curve and Load-Duration Curve

- Determination of on **optimum mix** of power plants
- Crossover Points for the first Cut Estimate of Generation Mix