

Electricity Generation:

- Basic Economics

Coal fired power plant

- Capital cost: Rs.5 cr
- Years to Commissioning: 4 years
- Life of a power plant: 20 years
- Fuel: Coal
- Thumb rule: 860 kcal = 1 kwh of electricity
- Station heat rate (SHR) indicates the amount of energy
 - required to generate 1 kwh of electricity
 - SHR lower the better
- Efficiency of a power plant: $860/\text{SHR}$ (higher the better)
- Coal required to generate 1 kwh = SHR/CV of coal
 - – Where CV of coal = calorific value of coal (kcal/kg)

Coal fired power plant – *the basics*

- Auxiliary consumption: 10%
- Loss of power due to maintenance shutdown: 8%
- Most coal power plants run on Rankine Cycle
- SHR for Rankine Cycle is about 2500 kcal/kwh
- Coal as a fuel has heat energy in the range of 2000 to 6500 kcal/kg

Coal fired power plant – an example

- Plant Size: 150 MW
- Capital Cost: Rs.750 cr
- Plant set-up: Rankine Cycle
- Station Heat Rate: 2500 kcal/kwh
- Coal: Indonesian Coal with a gross calorific value of 4500 kcal/kg. Usable of this is about 4150 kcal/kg (Net CV)
- **Power generation:**
 - Total power generation capacity: $150 \times 1000 \times 365 \times 24 = 131.4$ cr units
 - Plant maintenance & shutdown: 8%
 - Gross power generated: 121 cr units
 - Auxiliary consumption: 10%
 - Net saleable power generated: 109 cr units (**saleable PLF = 83%**)

Coal fired power plant

- **Fuel Cost:**

- Cost of imported coal from own mine: USD 45 per ton (Rs.2.0 per kg, including transportation cost)
- Coal consumption p.u. of electricity: $2500/4150 = 0.6$ kg/kwh
- Coal cost p.u. of electricity generated: $0.6 \times 2.0 = 1.2$ per kwh
- Since some of power is consumed for auxiliary consumption (@ 10%), the actual cost of fuel in terms of saleable power would be higher by 10 %, i.e. = 1.32 per kwh.

- **Labour, Repairs and maintenance:**

- R&M p.a.: 2% of fixed assets
- Labour and other gen exp: 3-4%
- On a p.u. of saleable power basis, this is around Rs.0.3 per unit.

Coal fired power plant – an example

- **Interest cost:**

- Capital cost for a 150 MW power plant – 750 cr
- Debt:Equity – 70:30 [Debt: 525 cr; Equity: 225 cr]
- Interest cost: 10%
- Annual interest outflow: 52.5 cr
- In terms of saleable power: Rs.0.5 per unit

- **Depreciation**

- Avg life of a coal fired power plant: 20 yrs
- GFA: 750 cr
- Depreciation: straight line for 20 yrs
- Annual Depcn: 37.5 cr
- In terms of saleable power: 0.35 per unit

Coal fired power plant – an example

- **Total pre-tax cost of generating power (per kwh):**
 - Fuel: Rs.1.22
 - Labour, R&M, others: Rs.0.3
 - Interest: Rs.0.5
 - Depreciation: Rs.0.35

- **Total cost: Rs.2.47 per unit.**

Coal fired power plant – an example

PRE-TAX Return on Equity (%)

Selling price (p.u.) >>	4.5	4.0	3.5	3.0	2.75	2.5
Saleable PLF (%)						
80.0%	95%	71%	48%	25%	13%	1%
82.5%	98%	74%	50%	26%	13%	1%
85.0%	101%	76%	51%	26%	14%	1%
87.5%	104%	78%	53%	27%	14%	2%
90.0%	107%	80%	54%	28%	15%	2%

N-Gas fired power plant – *the basics*

- Capital cost: Rs.3.5 cr
- Years to Commissioning: 2 years
- Life of a power plant: 20 years
- Fuel: Natural Gas
- Thumb rule: 860 kcal = 1 kwh of electricity
- Station heat rate (SHR) indicates the amount of energy required to generate 1 kwh of electricity
- SHR lower the better
- Efficiency of a power plant: $860/\text{SHR}$ (higher the better)
- N-Gas required to generate 1 kwh = SHR/CV of N-gas
 - Where CV = calorific value of N-gas (kcal/kg)

N-Gas fired power plant – *the basics*

- Auxiliary consumption: 3%
- Loss of power due to maintenance shutdown: 3-5%
- Most N-Gas power plants run on multiple cycles (Rankine & Brayton). These are called as Combined Cycle Power Plants.
- SHR for Brayton Cycle is about 2800 kcal/kwh, which is more than that of the coal plant.
- However, the Combined Cycle plant is more efficient with a SHR of 1800-2000 kcal/kwh
- N-Gas as a fuel has gross heat energy of about 9500 kcal/m³ but what is really usable is about 8750 kcal/m³ (7-8% less than the GCV).

N-Gas fired power plant – an example

- Plant Size: 150 MW
- Capital Cost: Rs.525 cr
- Plant set-up: Brayton Cycle
- Station Heat Rate: 1900 kcal/kwh
- N-Gas: Net Calorific value of 8750 kcal/m³
- **Power generation:**
 - Total power generation capacity: $150 \times 1000 \times 365 \times 24 = 131.4$ cr units
 - Plant maintenance & shutdown: 5%
 - Gross power generated: 124.8 cr units
 - Auxiliary consumption: 3%
 - Net saleable power generated: 121 cr units (**saleable PLF = 92%**)

N-Gas fired power plant – an example

- **Fuel Cost:**

- Cost of Natural Gas: USD 4.2 per MMBTU = Rs. 189 per mmbtu
- 3.98 btu = 1 kcal
- 1 mmbtu = 26.448 m³ of gas (for N-gas with 9500 kcal/m³)
- Cost of N-Gas per m³ = 189/26.448 = Rs.7.1 per m³
- Pipeline transportation cost = Rs.1.15 per m³
- Sales tax (@ 22%) = Rs.1.8 per m³
- Total Cost of N-Gas = Rs.10 per m³
- N-Gas consumption : SHR / CV of N-Gas = 1900/8750 = 0.217 m³ per kwh
- Cost of generating 1 kwh of power = 10 x 0.217 = Rs.2.17 per kwh
- The above is for total power generated
- However, in case of fuel cost per unit of saleable power, the cost per unit will increase by 3%, which is equal to **Rs.2.24 per kwh**

- **Labour, Repairs and maintenance:**

- R&M p.a.: 2% of fixed assets
- Labour and other gen exp: 3-4%
- On a p.u. of saleable power basis, this is around Rs.0.2 per unit.

N-Gas fired power plant – an example

- **Interest cost:**

- Capital cost for a 150 MW power plant – 525 cr
- Debt:Equity – 70:30 [Debt: 365 cr; Equity: 160 cr]
- Interest cost: 10%
- Annual interest outflow: 36.5 cr
- In terms of saleable power: Rs.0.31 per unit

- **Depreciation**

- Avg life of a coal fired power plant: 20 yrs
- GFA: 525 cr
- Depreciation: straight line for 20 yrs
- Annual Depcn: 26.25 cr
- In terms of saleable power: 0.225 per unit

N-Gas fired power plant – an example

- **Total pre-tax cost of generating power (per kwh):**
 - Fuel: Rs.2.06
 - Labour, R&M, others: Rs.0.2
 - Interest: Rs.0.31
 - Depreciation: Rs.0.225

- **Total cost: Rs.2.98 per unit.**

Coal v/s N-Gas power plants

- N-Gas fired

- N-Gas expensive than Coal (after the recent increase by GOI to \$4.2 mmbtu. At earlier price of \$ 2.34 mmbtu, N-Gas was cheap).
- Capital cost @ 3.5 cr per MW (30% less than Coal)
- Commissioning time ~ 2 yrs
- Auxiliary cons ~ 3%
- Lower maintenance shutdowns (3-5%)
- Carbon emissions less than Coal
- No Ash handling
- Gas turbines work best in a temperature or around 18-20 deg Celsius. Operating in places where average temperature is around 30-40 deg Celsius will result in lower

Coal fired

- Cheaper fuel
- Capital cost higher by 30% than N-Gas @ 5 cr
- Commissioning time ~ 4 years
- Auxiliary cons ~ 8-10%
- High maintenance shutdown (6-8%)
- Higher Carbon emissions (more polluting)
- Ash handling & disposal a big nuisance; environmentally
- Can operate in any environment

operational efficiencies. Addnl capex in terms of Air Intake Chilling System may be reqd. **(To find the cost of this)**

few conclusions...

- Coal-fired power plants are a cheaper alternative
- Gas-fired power plants will be cheaper only if N-Gas sells @ less than \$3-3.25 per mmbtu
- However, there could be an opportunity right now over the next 2 years during which power prices are expected to remain around Rs.4 p.u. As at that those levels N-Gas power plants can make a lot of money given lower initial capex and faster commissioning time.
- The most critical aspects of power business are:
 - Assured offtake (as power once generated can't be stored)
 - Assured supplies (disruptions in fuel supply could cause the PLF's to go for a toss)
 - Access to owned mines is critical, as any sharp increase in fuel cost can cause the economics of a power plant to go out of whack!