Lecture 1.7

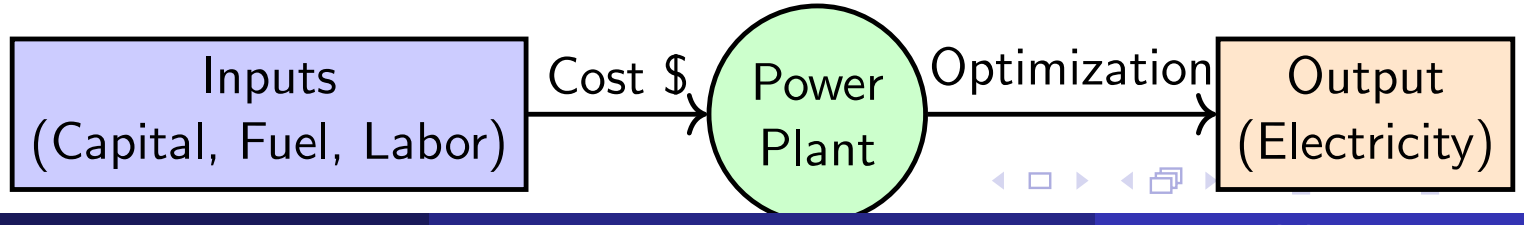
Economics of Power Generation: Cost Analysis and Financial Parameters

Agenda

- 1. Introduction to Power Plant Economics
- 2. Cost Analysis of Electrical Power
- 3. Capital and Fixed Costs Breakdown
- 4. Operating and Maintenance (O&M) Costs
- 5. Key Financial Parameters (Interest, Depreciation)
- 6. Summary and Next Steps

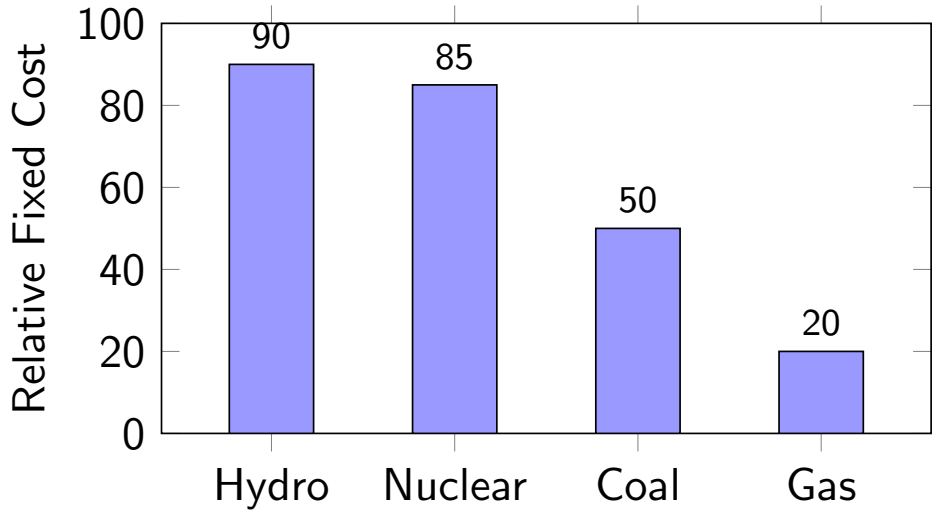
Introduction to Cost Analysis of Electrical Power

- The primary objective of power plant economics is to generate electrical energy at the lowest possible cost while maintaining reliability and safety.
- Cost analysis dictates the choice of plant type (e.g., Nuclear vs. Gas Turbine) based on the intended duty (base load vs. peak load).
- Total cost of electrical energy is generally divided into two main categories: **Fixed Costs** (Independent of energy generated) and **Running/Operating Costs** (Proportional to energy generated).
- Economic viability is assessed using metrics like Levelized Cost of Energy (LCOE), which normalizes costs over the plant's operational lifetime.



Capital / Fixed Costs: Definition

- Fixed costs remain constant regardless of the electrical energy generated (kWh) by the plant.
- They are incurred even if the plant is on standby or shut down for maintenance.
- These costs are intrinsically tied to the plant's maximum capacity (kW or MW) rather than its actual energy output.
- Higher capital intensive plants (like Hydro or Nuclear) have dominant fixed costs compared to their variable costs.



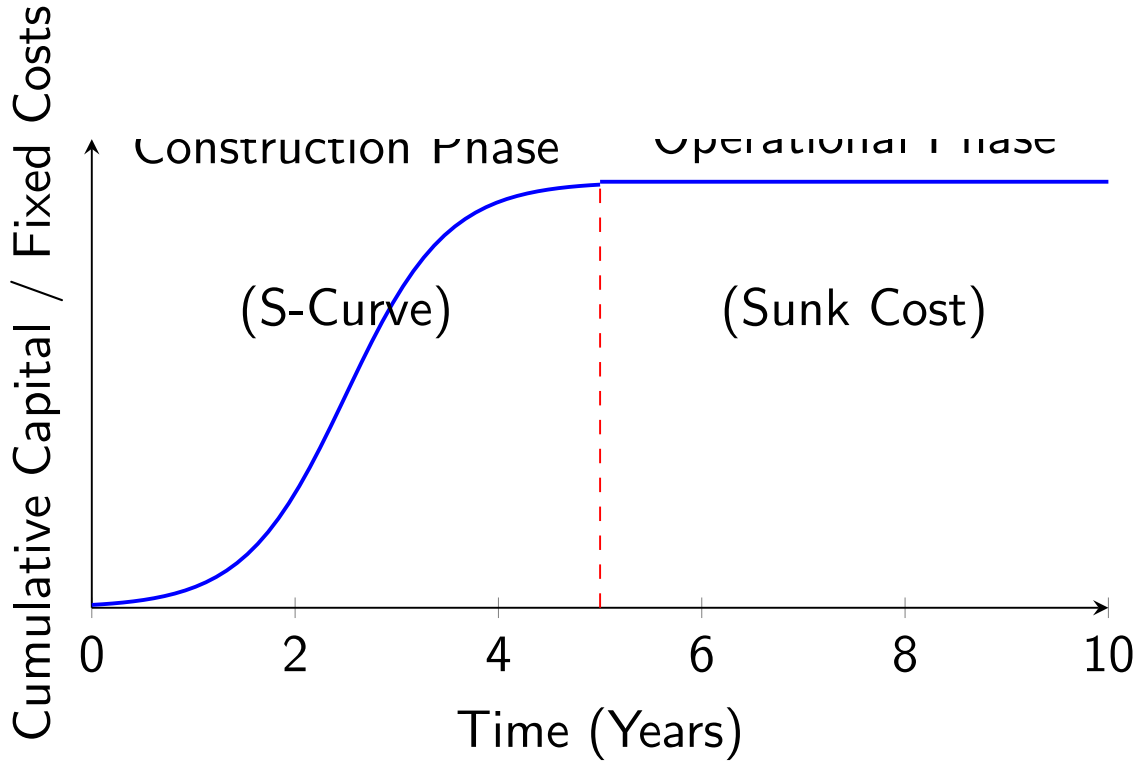
Elements of Capital / Fixed Costs

- **Initial Cost of Land and Site Preparation:** Securing the location, environmental clearances, and civil engineering groundwork.
- **Cost of Equipment and Machinery:** Boilers, turbines, generators, transformers, and switchgear (the largest component).
- **Interest on Capital:** The cost of borrowing funds to construct the plant, usually calculated annually over the loan tenure.
- **Depreciation:** The accounting allocation of the plant's initial cost over its useful life, reflecting wear and tear or obsolescence.
- **Insurance and Taxes:** Premiums to cover risks (fire, catastrophic failure) and statutory property/corporate taxes.

Capital Cost Breakdown

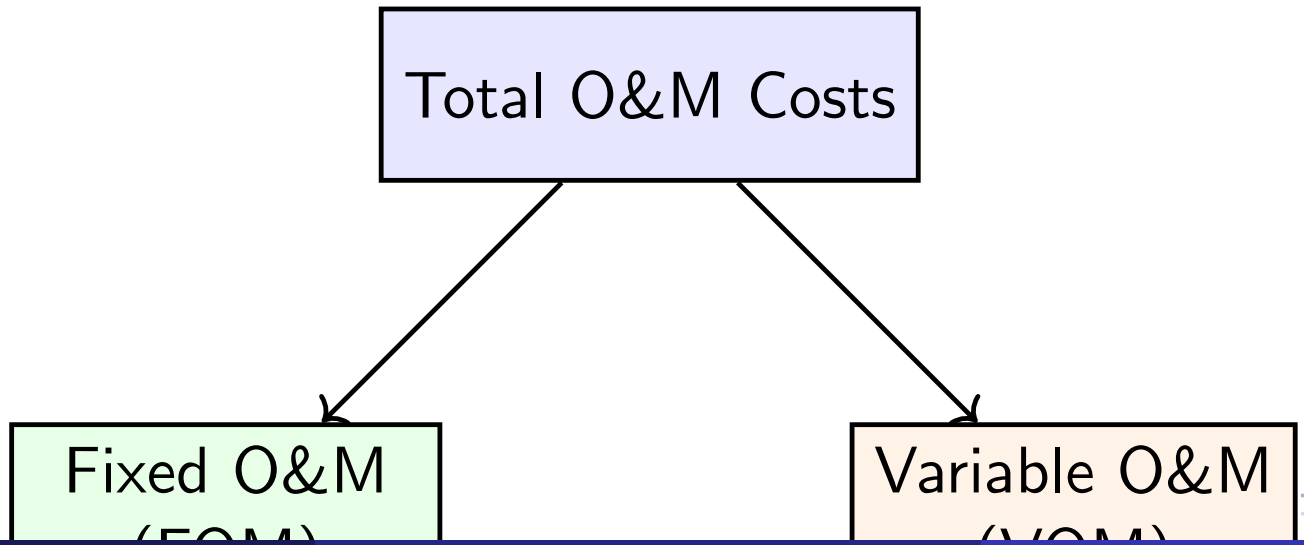
Construction vs. Operation Phase

Diagram illustrating the timeline of capital expenditure during the construction phase (S-curve) transitioning into the operational phase where fixed costs persist as interest and depreciation.



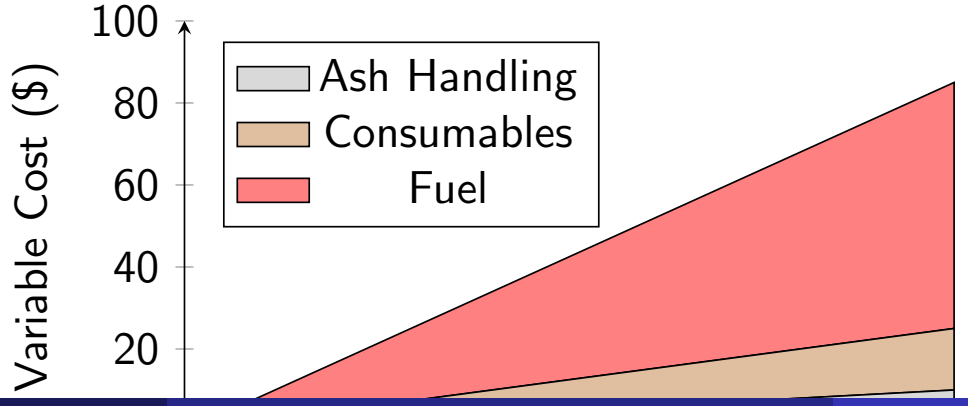
Operating and Maintenance Cost (O&M)

- O&M costs are the recurring expenses required to keep the power plant running and generating electricity.
- They are typically subdivided into Fixed O&M (FOM) and Variable O&M (VOM).
- **Fixed O&M** costs occur regardless of generation level (e.g., permanent staff salaries, routine facility maintenance).
- **Variable O&M** costs are directly proportional to the amount of energy generated (e.g., fuel consumption, water usage, waste disposal).



Variable Operating Costs: The Dominance of Fuel

- **Fuel Cost:** The single largest component of operating costs for thermal power plants (Coal, Gas, Oil). It scales directly with MWh produced.
- Fuel handling, transportation, and preparation (e.g., coal crushing and pulverizing) add to this cost.
- **Consumables:** Costs for raw water treatment chemicals, lubricating oils, and emission control reagents (like limestone for desulfurization).
- **Ash Handling and Waste Disposal:** Costs associated with safely removing and storing bottom ash and fly ash in coal plants.



Financial Parameters: Interest on Capital

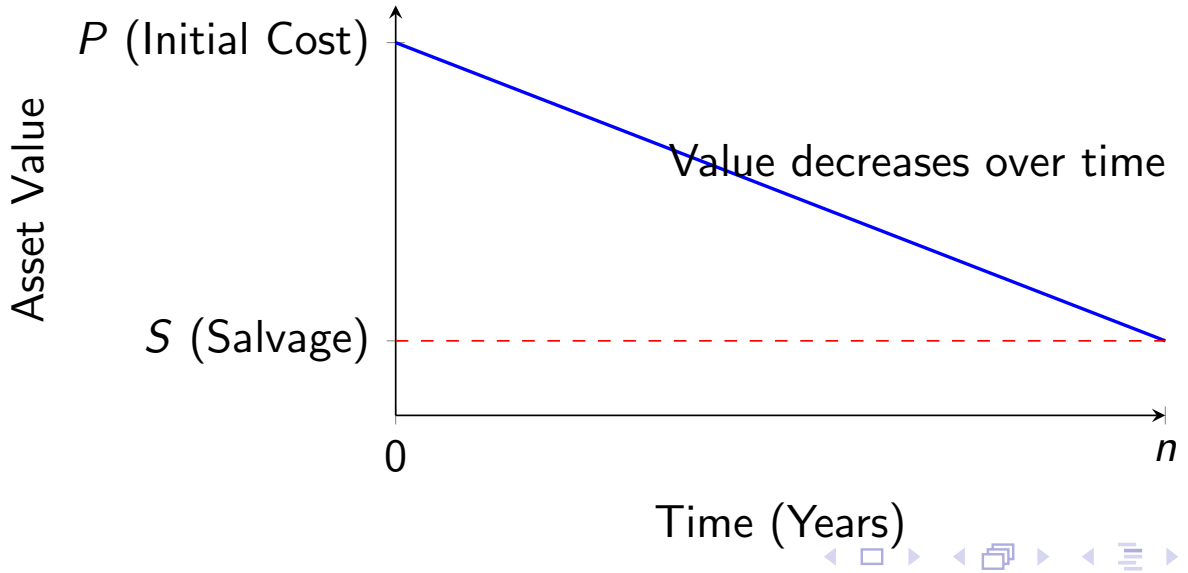
- Power plants are highly capital-intensive, often requiring external financing (debt) and equity.
- Interest is the financial charge for borrowing this capital.
- **Interest During Construction (IDC):** Interest that accrues before the plant becomes operational and starts generating revenue. IDC is capitalized and added to the total initial cost.
- **Annual Interest Rate (r):** Typically 8% to 12% depending on economic conditions and perceived risk of the project.

Total Capital Cost Formula

$$\text{Total Capital Cost} = \text{Direct Construction Cost} + \text{Interest During Construction (IDC)}$$

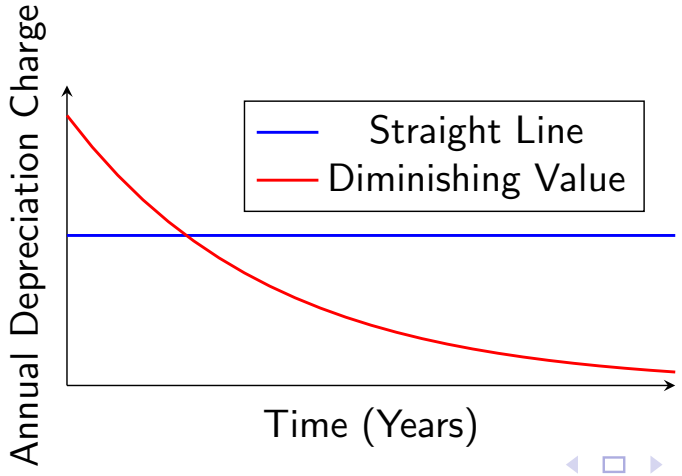
Financial Parameters: Depreciation

- Depreciation represents the decrease in value of the plant equipment over time due to wear and tear, physical decay, and technological obsolescence.
- It is an accounting mechanism to recover the initial capital investment over the useful life of the asset.
- **Salvage Value (S):** The estimated residual value of the plant at the end of its useful life (n years).
- **Total depreciable amount** = Initial Capital Cost (P) - Salvage Value (S).



Methods of Calculating Depreciation

- **Straight Line Method:** The simplest approach. Annual depreciation (D) is constant. $D = (P - S)/n$.
- **Sinking Fund Method:** Assumes a fixed sum is deposited annually into a fund earning interest (r), which will accumulate to $(P - S)$ by the end of life.
- **Sinking Fund Formula:** Annual deposit $q = (P - S) \times \frac{r}{(1+r)^n - 1}$.
- **Diminishing Value Method:** A fixed percentage is applied to the remaining book value each year, leading to higher depreciation in early years.



Total Annual Cost and Specific Cost

- **Total Annual Cost (C_t)** = Total Fixed Charges + Total Operating Expenses.
- C_t = (Interest + Depreciation + Taxes + Insurance + FOM) + (Fuel Cost + VOM).
- **Specific Cost of Generation** (Cost per unit): Calculated by dividing Total Annual Cost by the total energy generated in the year.

Specific Cost Equation

$$\text{Cost per kWh} = \frac{C_t}{\text{Maximum Demand} \times 8760 \times \text{Load Factor}}$$

Higher load factor significantly reduces the specific cost by spreading fixed charges over more generated units.

Summary

- ✓ Power generation costs are broadly classified into Fixed (Capital) Costs and Variable (Operating) Costs.
- ✓ Capital costs include equipment, land, and critical financial parameters like Interest During Construction (IDC).
- ✓ Variable costs are dominated by fuel expenses in thermal plants.
- ✓ Depreciation is an accounting method to allocate capital costs over the plant's useful life.
- ✓ Maximizing the plant load factor is the most effective way to reduce the per-unit cost of electricity.

Next Lecture Preview

- In the next lecture, we will explore Electrical Tariffs.
- We will learn how utilities price electricity for consumers based on the cost analysis we discussed today.
- Topics will include Flat rate, Block rate, Two-part tariff, and Maximum Demand tariffs.