Lecture 1.6

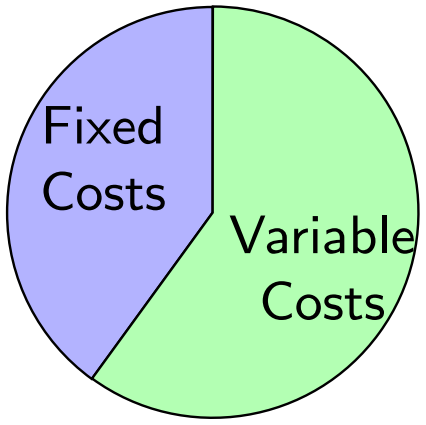
Economics of Power Generation

Agenda

- Introduction to Cost Analysis of Electrical Power
- Analysis of Capital and Fixed Costs
- Operating and Maintenance (O&M) Costs
- Key Financial Parameters and Factors
- Impact of Load and Diversity Factors on Cost
- Summary and Key Takeaways

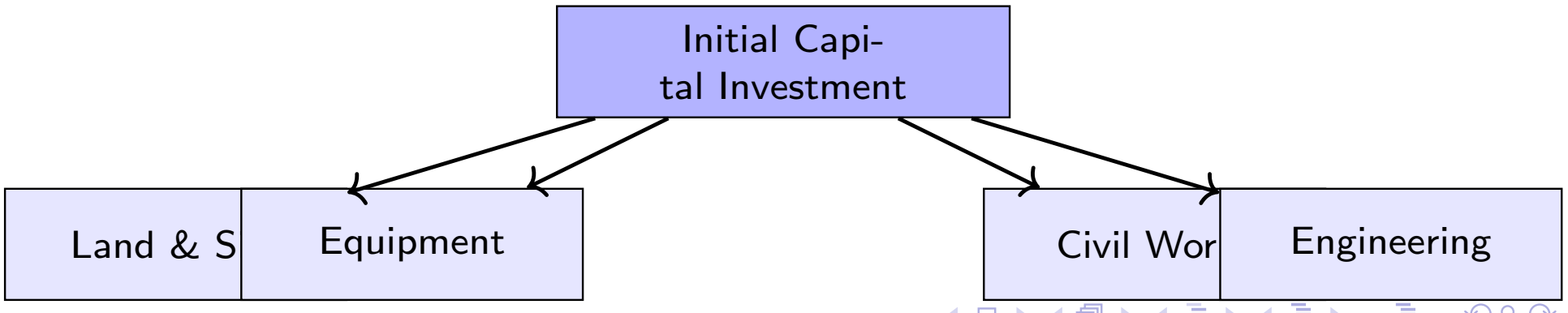
Cost Analysis of Electrical Power: Overview

- The fundamental goal of power plant economics is to minimize the cost of energy production while ensuring reliability.
- Total Cost of Generation (C) can be expressed as: C = Fixed Costs + Variable Costs.
- Cost per kWh is the primary metric for evaluating plant performance and setting tariffs.
- Factors influencing cost: plant location, fuel availability, technology choice, and financing rates.
- Accurate cost analysis is essential for capacity planning, tariff structuring, and investment decisions.



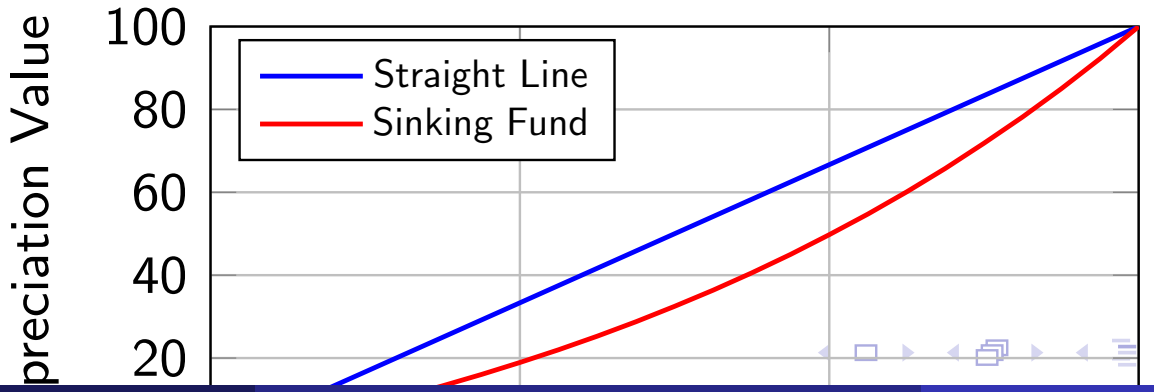
Capital / Fixed Costs (Part 1)

- Fixed costs remain constant regardless of the electrical energy generated by the plant.
- Land and Site Preparation: Cost of acquiring land, clearing, and developing infrastructure.
- Equipment Cost: Prime movers, generators, boilers, transformers, and switchgear.
- Civil Works: Construction of powerhouses, cooling towers, dams, and chimneys.
- Engineering and Project Management: Fees for design, consulting, and overseeing construction.



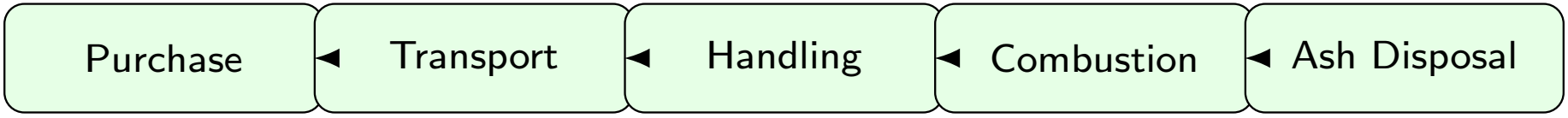
Capital / Fixed Costs (Part 2): Depreciation & Interest

- Interest on Capital: The cost of borrowing money to finance the plant construction.
- Depreciation: The decrease in value of equipment due to wear, tear, and obsolescence over time.
- Methods of calculating depreciation: Straight Line Method, Sinking Fund Method, and Diminishing Value Method.
- Taxes and Insurance: Annual property taxes, income taxes, and insurance premiums.
- Management and Administrative Salaries: Fixed payroll for higher management and essential staff.



Operating (Variable) Costs

- Variable costs are directly proportional to the amount of electrical energy generated.
- Fuel Cost: The most significant variable cost for thermal and nuclear plants. Includes purchasing, transportation, and handling.
- Fuel efficiency (Heat Rate) directly impacts this cost; higher efficiency means lower fuel cost per kWh.
- Consumables: Water for cooling and boiler makeup, lubricants, chemicals for water treatment.
- Ash and Waste Handling (for coal plants): Costs associated with safe disposal of byproducts.

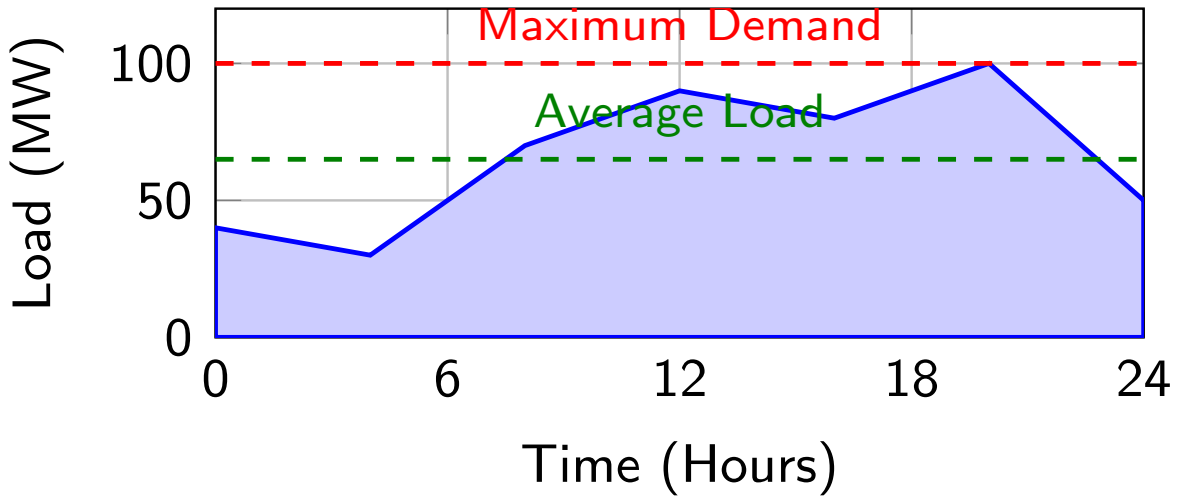


Maintenance Costs

- Maintenance costs can have both fixed (routine) and variable (wear-related) components.
- Routine Maintenance: Preventive checks, minor part replacements, cleaning, and lubrication to ensure continuous operation.
- Major Overhauls: Scheduled shutdowns (outages) for deep inspection and replacement of major components (e.g., turbine blades).
- Operating Labor: Wages for shift operators, technicians, and maintenance crew directly involved in daily running.
- Balancing cost: Skimping on maintenance reduces immediate O&M costs but accelerates depreciation and increases forced outage risks.

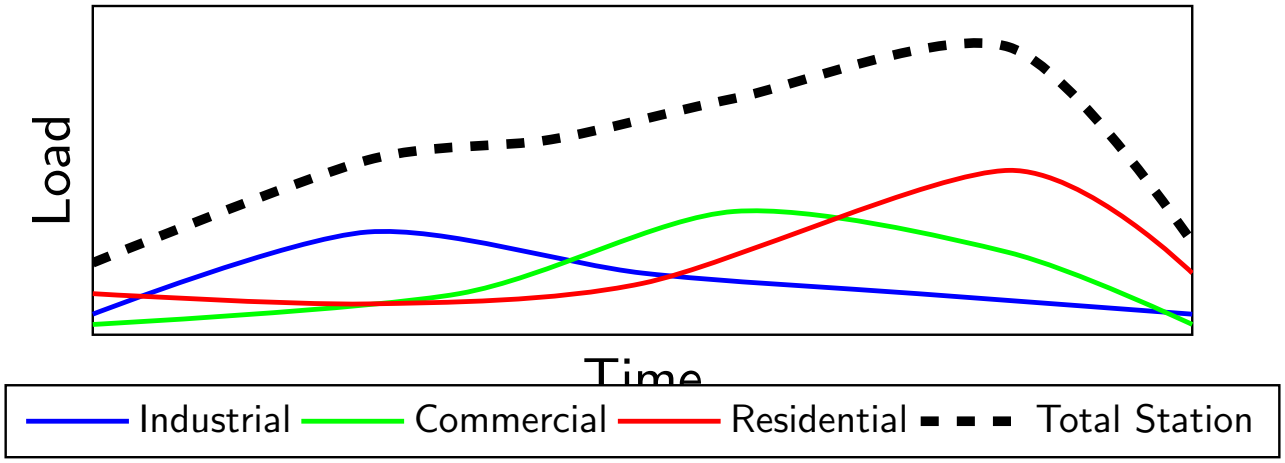
Financial Parameters: Load Factor

- Load Factor = (Average Load) / (Maximum Demand) over a given period.
- A higher load factor means the plant is utilized more consistently near its maximum demand.
- Economic Impact: High load factor spreads the fixed costs over a larger number of generated units (kWh).
- This directly reduces the overall cost of generation per unit.
- Base load plants are designed to operate at very high load factors (e.g., nuclear, large coal).



Financial Parameters: Diversity Factor

- Diversity Factor = (Sum of Individual Maximum Demands) / (Simultaneous Maximum Demand on the station).
- Always greater than 1.0 because different consumers peak at different times.
- Economic Impact: A high diversity factor reduces the required installed capacity of the power plant.
- By not having to build capacity for the sum of all individual peaks, capital (fixed) costs are significantly reduced.
- Tariff structures often aim to improve diversity factor by incentivizing off-peak usage.



Other Key Financial Parameters

- **Capacity Factor (Plant Factor)** = (Actual Energy Produced) / (Maximum Possible Energy at rated capacity). Indicates how much of the plant's total capacity is actually being used over time.
- **Plant Use Factor** = (Actual Energy Produced) / (Plant Capacity $\times$ Operating Hours). Useful for plants that don't run 24/7.
- **Utilization Factor** = (Maximum Demand) / (Rated Plant Capacity). Indicates how close the peak load comes to the plant's limit.
- These factors are used by investors and grid operators to assess the operational and financial health of the asset.

Parameter	Formula
Load Factor	$\frac{\text{Average Load}}{\text{Maximum Demand}}$
Diversity Factor	$\frac{\sum \text{Individual Max Demands}}{\text{Simultaneous Max Demand}}$
Capacity Factor	$\frac{\text{Actual Energy Produced}}{\text{Max Possible Energy at Rated Capacity}}$
Plant Use Factor	$\frac{\text{Actual Energy Produced}}{\text{Plant Capacity} \times \text{Operating Hours}}$

Summary

- Total generation cost is the sum of Fixed (Capital) and Variable (Operating) costs.
- Fixed costs include land, equipment, interest, and depreciation, and do not vary with generation output.
- Variable costs depend entirely on output, with fuel being the dominant expense for thermal plants.
- High Load Factor reduces the per-unit cost by distributing fixed costs over more generated units.
- High Diversity Factor reduces the required capital investment by lowering the simultaneous peak demand.

Next Lecture Preview

- Next time, we will delve into Tariffs and Power Pricing.
- We will explore how the costs calculated today are translated into the bills paid by consumers.
- Topics will include Flat Rate, Block Rate, and Two-Part Tariff structures.
- We will also discuss how power factor penalties are applied to industrial consumers.