Sri Venkateswara College of Engineering

(An Autonomous Institution)

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SOCIETY OF MECHANICAL ENGINEERS (SME)

GUEST LECTURE – 1 : AY 2024 - 2025

Prepared by	Approved by
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Date of Lecture : 29th August 2024

Venue: Library Seminar Hall

Time: 10:30 AM to 12:00 PM

Power Plant Economics

1. Introduction

This report summarizes key aspects of power plant economics, focusing on thermal power plants and pumped storage facilities. It incorporates insights from a guest lecture by Dr. Sriraja Balaguru on August 29, 2024, as well as information from provided visual aids. The report aims to provide a comprehensive overview of current practices and future trends in power generation.

2. Types of Power Generation

2.1 Firm Power

- Primarily provided by thermal power plants
- Examples: Ennore, Mettur, and Tuticorin power plants
- Characterized by consistent and reliable output
- Essential for maintaining base load in the power grid

2.2 Infirm Power

- Includes solar and wind plants
- Characterized by variable output dependent on environmental conditions
- Requires advanced forecasting and grid management techniques
- Plays a crucial role in the transition to renewable energy sources

3. Thermal Power Plants

3.1 Key Characteristics

- Synchronization time: 48 hours from cold start to hot start
- Frequency maintenance: Target of 50 Hz
- Load Dispatch Centre: Critical for grid management
- Requires complex startup procedures to ensure equipment safety
- Continuous monitoring of multiple parameters for optimal operation

3.2 Plant Overview

Based on the "Plant Overview" diagram:

- Major components: Boiler, High Pressure Turbine (HPT), Intermediate Pressure Turbine (IP), Low Pressure Turbine (LPT), Generator
- Auxiliary systems: Economizer, Air Preheater, Electrostatic Precipitator
- Cooling systems: Cooling towers, condensers
- Each component plays a vital role in the overall efficiency of the plant
- Regular maintenance and upgrades are essential for optimal performance

3.3 Operational Aspects

- SCADA (Supervisory Control and Data Acquisition) used for monitoring
- Capital overhauling of turbine every 5 years
- Economic load dispatch principles applied
- Paddo Technology implemented
- Real-time data analysis for predictive maintenance
- Continuous training of operators for handling various operational scenarios

3.4 Ramp Rates

- Thermal plants: 50% in 1 minute
- Combined Cycle Gas Turbine: 30% ramp-up
- Rapid response capability crucial for grid stability
- Advanced control systems enable faster and more precise ramp rates

4. Pumped Storage Power Plants

4.1 Advantages

- Cheapest power source: ₹1.78 per unit
- Helps maintain grid frequency at 50 Hz
- Reversible turbine for pumping and generation modes
- Acts as a large-scale energy storage solution
- Provides grid stability during peak demand periods

4.2 Operational Characteristics

- VAR (Volt-Ampere Reactive) increases during pumping mode
- Useful for sudden ramp-up and ramp-down scenarios
- Acts as energy storage system
- Capable of black start operations during grid failures
- Helps in integrating higher percentages of renewable energy into the grid

5. Power Plant Economics

5.1 Cost Comparison

- Thermal power: ₹5 per unit
- Hydropower: ₹3 per unit
- Wind power: ₹3.25 per unit
- Solar power: ₹2.8 per unit
- Costs continue to evolve with technological advancements
- Government policies and subsidies significantly impact cost structures

5.2 Capacity Factors

- Wind and Solar: 19-20% Capacity Utilization Factor
- Thermal stations: Measured by Plant Load Factor
- Capacity factors crucial for determining overall plant economics
- Improvements in technology are steadily increasing capacity factors for renewables

5.3 Economic Considerations

- CAPEX (Capital Expenditure) and OPEX (Operational Expenditure)
- Fixed costs vs. Variable costs
- Economic load dispatch and merit order dispatch
- Long-term power purchase agreements impact economic viability
- Carbon pricing and emissions trading schemes affect overall economics

6. Grid Management

6.1 Load Balancing

- Base load: Thermal power plants
- Peak load: Hydropower plants
- Increasing role of demand response in load management
- Smart grid technologies enabling more dynamic load balancing

6.2 Frequency Control

- Target: 50 Hz
- If generation > demand: Frequency > 50 Hz
- Continuous monitoring and adjustment required
- Advanced control systems for faster frequency response
- Integration of battery storage for frequency regulation

6.3 Forecasting

- Types: Generation and demand forecasting
- Day-ahead forecasting crucial for planning
- Weather data integration for renewable sources
- Machine learning algorithms improving forecast accuracy
- Integration of IoT devices for real-time data collection

7. Environmental Considerations

7.1 Emissions Control

- Flue Gas Desulfurization in thermal plants
- Continuous emissions monitoring systems (CEMS) for real-time data
- Exploration of carbon capture and storage technologies

7.2 Renewable Integration

- Solar production: 1 unit = 3 kW, 5-7 sun hours per day
- Net-zero targets: Countries aiming for 2070
- Development of advanced energy storage solutions
- Exploration of hybrid power plants combining renewables with storage

8. Future Trends

8.1 Energy Storage

- Battery Energy Storage Systems (BESS)
- Pumped storage as a cost-effective large-scale solution
- Research into novel storage technologies like flow batteries and hydrogen storage
- Integration of distributed energy storage at grid edge

8.2 Smart Grid Technologies

- Advanced forecasting methods
- Real-time economic dispatch systems
- Implementation of blockchain for peer-to-peer energy trading
- Development of self-healing grid technologies

9. Research Gaps

9.1 Flexible Power Generation

- Minimizing time from cold start to hot start in thermal plants
- Developing new materials and processes for rapid thermal cycling
- Exploring hybrid systems to maintain readiness while reducing fuel consumption

9.2 Alternative Fuels

- Working on Compressed biogas as an alternative to CNG, LPG, LNG
- Investigating the integration of biogas into existing natural gas infrastructure
- Developing efficient purification and compression technologies for biogas

10. Conclusion

The power generation landscape is evolving, with a mix of traditional thermal plants and increasing renewable sources. Pumped storage emerges as a crucial technology for grid stability and economic operation. As the sector moves towards net-zero goals, balancing economic considerations with environmental impacts will be key to sustainable power generation. Future research should focus on enhancing flexibility in power generation and exploring alternative fuel sources to meet the challenges of a rapidly changing energy landscape.
