A Report on Industrial Visit to Sabarigiri Hydro Electric Power Plant

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ABSTRACT

This report presents a detailed account of the industrial visit undertaken to the Sabarigiri Hydro Electric Power Station, Kerala, as part of the internship programme. The objective of the visit was to gain practical exposure to large-scale hydroelectric power generation and to understand the real-time operation of turbines, generators, control systems, and protection equipment. Sabarigiri, being a high-head hydroelectric project utilizing Pelton turbines, provided valuable insights into impulse turbine operation, governing mechanisms, SCADA-based monitoring, and auxiliary systems such as lubrication, braking, and protection units. The visit helped bridge the gap between theoretical knowledge and practical application, enhancing understanding of hydroelectric plant operation, safety practices, and grid integration. This experience significantly contributed to the development of technical knowledge and professional awareness in the field of electrical power engineering.

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Chapter 1

Introduction

As part of our internship programme, an industrial visit was conducted to the **Sabarigiri Hydro Electric Power Station** on **19 December 2025**, which is one of the most important hydroelectric power generation facilities in the state of Kerala. The Sabarigiri Power House has a total installed capacity of 340 MW, generated through six generating units, making it the second largest hydroelectric power plant in Kerala. The project is also unique in that it operates under the highest hydraulic head in Kerala (approximately 714.7 metres), which enables highly efficient energy conversion using high-pressure water flow.

The power house utilizes Pelton turbines, which are specifically designed for high-head, low-discharge conditions, making Sabarigiri an excellent example of advanced hydroelectric engineering. Water from the reservoir is conveyed to the turbines through large-diameter steel penstock pipes, where the kinetic energy of water is converted into mechanical energy by the turbine runner. This mechanical energy is then converted into electrical energy by the generators installed in the powerhouse.

The visit was organized with the objective of gaining practical exposure to large-scale hydroelectric power generation, understanding the design and operation of high-head hydroelectric systems, and observing the real-time functioning of major power station components such as penstock pipes, turbines, generators, control panels, and protection systems. The visit also helped us understand how power generated at the plant is synchronized with the grid and monitored continuously from the control room to ensure safety, efficiency, and reliability.

Chapter 2

Sabarigiri Hydro Electric Project

Fig 2.1 : Sabarigiri Power Station

The Sabarigiri Hydro Electric Project is the second largest hydroelectric power plant in the state of Kerala, strategically located in the Pathanamthitta district and operated by the Kerala State Electricity Board Limited. The project harnesses the waters of the Pamba river and its tributary, the Kakki river, by creating two separate reservoirs which are interconnected through a 3.21 km long underground tunnel to form an integrated water system feeding the powerhouse. The Pamba Dam and Kakki Dam, along with the Anathode Dam, were completed in the mid-1960s, forming the principal reservoirs that supply water to the Sabarigiri powerhouse. Initially commissioned in 1966 with an installed capacity of 300 MW, the project underwent phased modernization and enhancement between 2005 and 2009, resulting in an increased capacity of 340 MW. The Pamba reservoir has a significant catchment area with its full reservoir level at approximately 3,236 feet above mean sea level, while the Kakki reservoir, providing major storage for power generation, has a much larger catchment and storage capacity, ensuring sustained water availability for electricity production. This integrated reservoir and powerhouse system plays a vital role in meeting

Kerala's power requirements by converting hydraulic energy into electrical energy through a set of vertical shaft Pelton type turbines connected to generating units.

2.1 Salient Features

The Sabarigiri power station comprises six generating units, originally commissioned between 1966 and 1967, each with an initial capacity of 50 MW. Unit-1, Unit-2, Unit-3, Unit-4, Unit-5, and Unit-6 were commissioned on 18.04.1966, 14.06.1966, 29.12.1966, 22.06.1967, 17.10.1967, and 25.11.1967, respectively. Following renovation and modernization carried out between 2005 and 2014, the unit capacities were uprated, with Units-1, 2, 3, and 5 upgraded to 55 MW, and Units-4 and 6 to 60 MW, resulting in the present installed capacity of 340 MW.

The station is equipped with vertical shaft, four-jet impulse-type Pelton wheel turbines, suitable for high-head operation. Turbines for Units-1, 2, 3, 5, and 6 were supplied by M/s VA Tech Hydro, while Unit-4 was supplied by M/s Harbin (Kunming) Electric Machinery Co. Ltd. The turbines are designed for a net head of 714.76 m, with rated outputs of 55 MW or 60 MW, a minimum operating output of 20 MW, a normal speed of 500 rpm, a runaway speed of 885 rpm, and a design discharge of 8.806 m^3/s per unit.

The turbines are coupled to salient-pole synchronous generators rated at 11 kV. Generators for Units-1, 2, 3, and 5 are supplied by M/s Allis Chalmers, Unit-4 by M/s Puissance De'Leau, and Unit-6 by M/s Allis Chalmers. The generators have rated capacities ranging from 55 MVA to 60 MVA, operate at 500 rpm, and have a power factor of 0.9.

Each generating unit is connected to a generator transformer stepping up the voltage from 11 kV to 220 kV. Transformers for Units-1, 2, 3, and 5 are WFOCB type manufactured by TELK, Unit-4 uses an OFWF type transformer manufactured by Crompton Greaves, and Unit-6 again uses a WFOCB transformer from TELK. Transformer ratings are 22,000 kVA × 3 or 25,000 kVA × 3, depending on the unit capacity.

Power evacuation from the station is carried out through a 220 kV and 66 kV transmission network, comprising feeders to Brahmapuram, Pallom, Edamon (1, 2, and 3), Theni, and a

66 kV Kochupamba feeder, ensuring reliable integration of the generated power with the state grid.

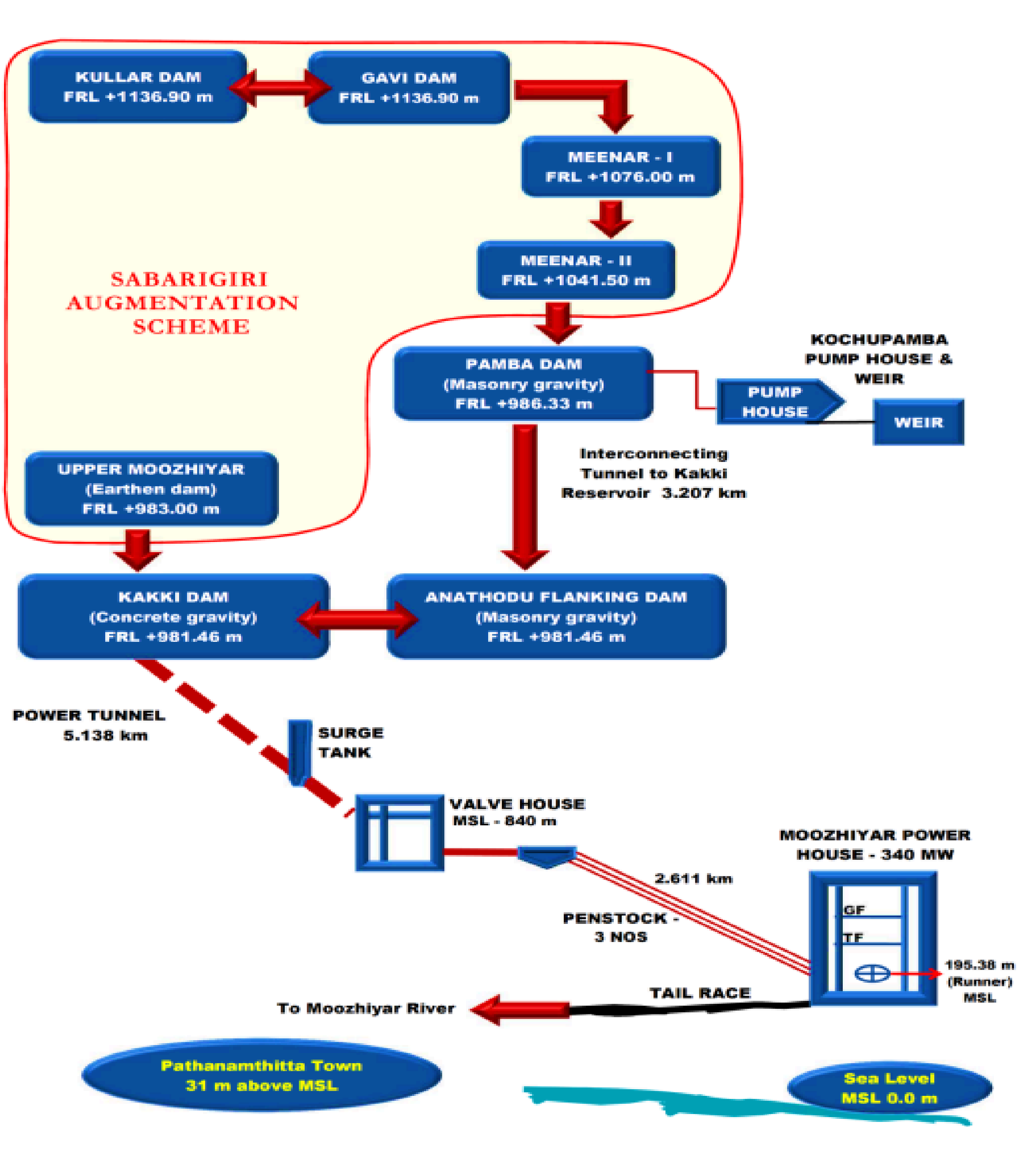

Fig 2.2: Sabarigiri Hydroelectric Project

Chapter 3

Learning Outcomes and Technical Observations

3.1. SCADA and Control Room Observations

Fig 3.1: Control Room

During the visit, the control room of the Sabarigiri plant showcased a SCADA (Supervisory Control and Data Acquisition) system, which continuously monitors and controls the entire plant operation. Parameters such as water level, flow rate, turbine speed, generator output, voltage, and frequency are displayed in real time. The system enables operators to make informed decisions, detect faults promptly, and perform remote control of turbines and gates for efficient energy production. Additionally, Programmable Logic Controllers (PLCs) are integrated to automate operational sequences, ensure synchronization of generating units, and provide protective interlocks for equipment. This combination of SCADA and PLC systems enhances operational safety, reliability, and efficiency of the hydroelectric plant.

3.2. Pelton Turbine

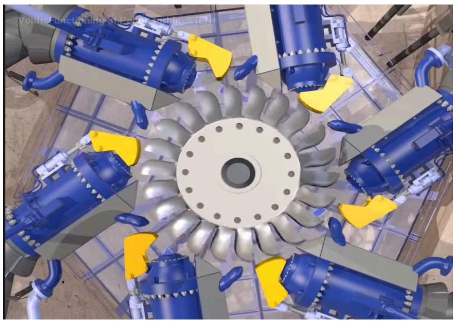

Fig 3.2: Pelton Turbine

The Pelton turbine, also known as the Pelton wheel, is an impulse-type water turbine invented by American engineer Lester Allan Pelton in the 1870s. Unlike traditional overshot water wheels, which rely on the weight of water, the Pelton turbine extracts energy from the impulse of a high-velocity water jet. Its design features specially shaped paddles such that when the turbine rim rotates at approximately half the speed of the incoming water jet, the water leaves the wheel with minimal residual velocity. This design ensures that almost all of the water's kinetic energy is converted into mechanical energy, making the Pelton turbine highly efficient.

In the Sabarigiri Hydro Power Plant, vertical shaft Pelton turbines are employed to convert the kinetic energy of water from the Pamba and Kakki reservoirs into mechanical energy, which is then converted into electrical energy through synchronous generators. The Pelton turbine is particularly suitable for high-head, low-flow conditions, which aligns with the operational characteristics of the Sabarigiri project. Its efficiency, reliability, and ability to operate under variable flow conditions make it an ideal choice for hydroelectric power generation at this plant.

During the visit, we observed the actual Pelton turbine assembly and understood how high-head conditions at Sabarigiri justify the selection of impulse turbines

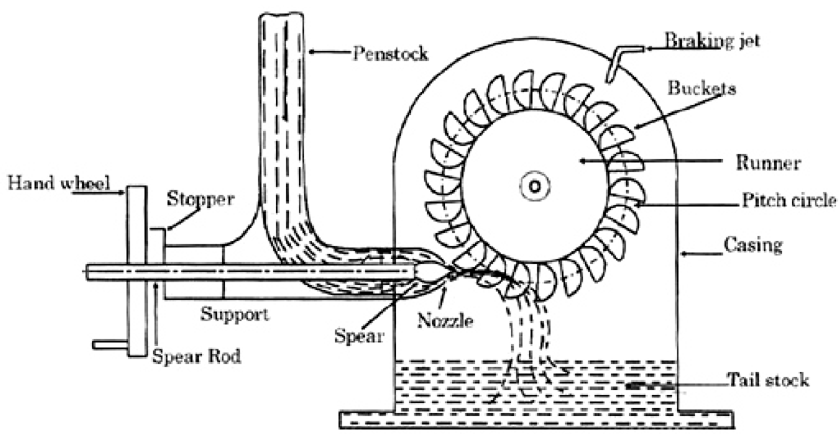

Fig 3.3: Flow Control Mechanism of a Pelton Turbine

The figure illustrates the working of a Pelton turbine, an impulse-type water turbine used in high-head hydroelectric power plants such as the Sabarigiri Hydro Electric Power Station.

Water stored at a high elevation flows through the penstock and reaches the nozzle, where its pressure energy is completely converted into kinetic energy. The spear (needle) inside the nozzle regulates the flow of water by controlling the jet area. The high-velocity water jet emerging from the nozzle strikes the splitter of the double-cupped buckets mounted on the runner. The splitter divides the jet into two equal streams, and the water is deflected through nearly 180°, resulting in a change in momentum. This change in momentum produces an impulse force on the buckets, causing the runner to rotate. The rotating runner transmits mechanical energy to the turbine shaft, which is coupled to a generator for electricity generation. After transferring its energy, the water falls into the tail race and is discharged. The turbine speed is controlled by adjusting the spear position using the spear rod and hand wheel, while a braking jet is provided to stop the runner quickly and safely when required.

3.3. Turbine Governing System

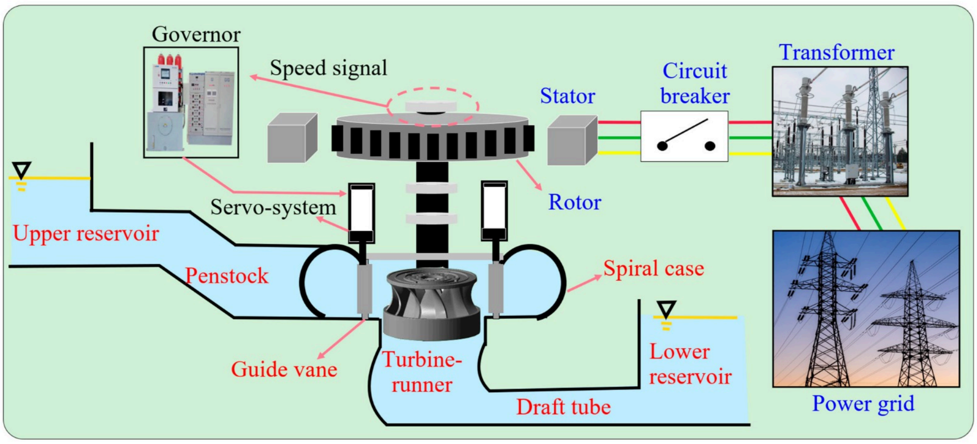

Fig 3.4: Governing System

The governing unit is responsible for regulating the turbine speed and power output by controlling the water flow to the turbine. During load rejection conditions, when the electrical load on the generator suddenly decreases or is disconnected, the governing system acts rapidly to prevent a sudden rise in turbine speed. This is achieved through coordinated operation of the deflector and needle mechanism, where the deflector immediately diverts the water jet away from the runner while the needle gradually reduces the water flow. This sequential action ensures smooth control without causing excessive pressure fluctuations in the penstock. By maintaining stable turbine speed and preventing overspeed conditions, the governing system plays a critical role in ensuring safe operation of the turbine and contributes significantly to overall grid stability by enabling quick response to load variations and maintaining frequency control.

3.3.1 Local Control Panel (LCP)

The Local Control Panel (LCP) is an essential component of the control and monitoring system used in the hydroelectric power plant. It is installed near the turbine-generator unit and provides local-level control, protection, and indication facilities for safe and efficient operation of plant equipment.

The LCP enables operators to perform manual control operations directly at the site during commissioning, maintenance, emergency conditions, or when the central control system is unavailable. It acts as an interface between field instruments and higher-level control systems such as the Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) system.

The panel houses various control switches, push buttons, selector switches, indication lamps, meters, and protective relays. Parameters such as turbine speed, generator status, bearing temperature, vibration levels, oil pressure, and water flow conditions are monitored through indications provided on the panel. Emergency stop and trip mechanisms are also integrated to ensure rapid shutdown during abnormal operating conditions. The Local Control Panel is electrically interconnected with the PLC and SCADA systems, allowing seamless data transfer and coordinated control. While normal operation is carried out from the central control room, the LCP serves as a reliable backup control station, thereby enhancing operational safety, reliability, and flexibility of the power plant.

3.4. Unit Control Board

Fig 3.5: Unit Control Board

The Unit Control Board acts as the central control panel for monitoring and controlling turbine and generator parameters such as speed, load, voltage, current, and temperature. It enables both manual and automatic operation of the unit.

3.5. Hydraulic and Mechanical Systems

- Hydraulic Jack (Oil Pressure System)

Used for lifting and positioning heavy turbine components during maintenance operations using high-pressure oil.

- Brake System (Compressed Air)

An air-pressure-operated braking system is used to safely stop the turbine during shutdown or emergency conditions.

- Brake Jet

A dedicated water jet system used to rapidly decelerate the turbine runner during emergency stopping.

3.6. Turbine Flow Control Mechanism

- Needle and Deflector Mechanism

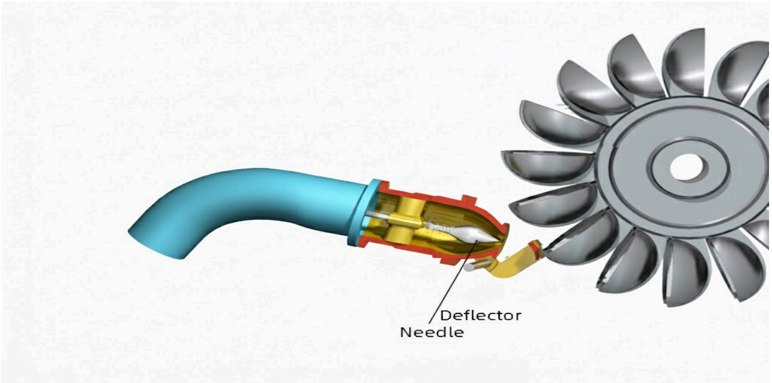

Fig 3.6: Needle and Deflector

The needle controls the water flow rate to the Pelton turbine, while the deflector temporarily diverts the water jet away from the runner during sudden load rejection to prevent overspeed. The deflector is faster than the needle mainly because of hydraulic safety and mechanical limitations in high-head Pelton turbine systems

- **LVDT (Linear Variable Differential Transformer)**

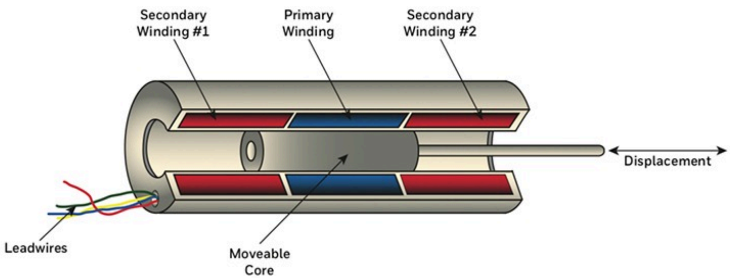

Fig 3.7: Linear Variable Differential Transformer

An LVDT is used to measure the precise position of the needle, providing accurate feedback to the governing system.

3.7. Sensors and Instrumentation

- Displacement Sensor
  Used to measure shaft movement and alignment variations.

- Vibration Sensor
  Continuously monitors turbine and generator vibrations to detect mechanical faults and ensure safe operation.

- Analog Transducers
  Convert physical parameters such as pressure, temperature, and speed into electrical signals suitable for monitoring and control systems.

3.8. Lubrication and Oil Systems

- Oil Pumping Unit
  The oil pumping unit supplies clean and pressurized lubricating oil to turbine bearings and other moving parts to reduce friction and wear. Maintaining oil cleanliness is critically important, as the presence of contaminants such as dust, metal particles, or moisture can lead to increased friction, bearing damage, overheating, and premature failure of mechanical components. Clean oil ensures smooth operation of bearings, improves heat dissipation, and enhances the overall efficiency and reliability of the turbine system. Proper filtration and regular oil monitoring also help in extending equipment life, reducing maintenance requirements, and preventing unexpected shutdowns of the generating unit.

- LGB (Lower Guide Bearing) Vapour Exhaust System
  Used to safely remove oil vapours generated in the bearing system, ensuring proper ventilation and preventing overheating.

3.9. Electrical Protection and Auxiliary Equipment

- Pole Strainer

A mechanical filter used to remove debris and impurities from water before it enters critical turbine components.

- Neutral Grounding Transformer (NGT)

Provides controlled grounding of the generator neutral point, limiting earth fault currents and enhancing system protection.

3.10. Fire Safety Measures

During the industrial visit to the hydroelectric power plant, fire safety measures adopted in various plant areas were observed and studied. Due to the presence of high-voltage electrical systems, lubricating oil circuits, transformers, and rotating machinery, appropriate fire extinguishers are installed to control different types of fire hazards.

Fig 3.8: Fire Extinguishers

- **Foam type fire extinguishers** are provided in areas where flammable liquids such as turbine oil and transformer oil are present. These extinguishers are mainly used for Class B fires. Foam forms a blanket over the burning oil surface, thereby cutting off the oxygen supply and preventing re-ignition. Such extinguishers are commonly installed near oil storage areas, turbine lubrication systems, and transformer yards.

- **Dry Chemical Powder (DCP) fire extinguishers** are widely used in the plant due to their versatility. They are suitable for Class A, Class B, and Class C fires. DCP extinguishers rapidly suppress flames by interrupting the chemical reaction of fire. These extinguishers are installed near generator units, cable galleries, control panels, and auxiliary equipment areas.

- **Carbon Dioxide (CO_2) fire extinguishers** are specifically used for electrical fires involving generators, control panels, PLC systems, and switchgear. CO_2 is a non-conductive gas that displaces oxygen and extinguishes fire without leaving any residue, making it suitable for sensitive electrical and electronic equipment.

Chapter 4
Conclusion

The industrial visit to the Sabarigiri Hydro Electric Power Station proved to be a highly valuable and insightful learning experience. The visit offered a comprehensive understanding of the practical aspects involved in the generation of hydroelectric power, including water management, turbine operation, electrical generation, control, and protection systems. Direct observation of Pelton turbines, generators, auxiliary systems, and the integration of SCADA and PLC-based automation provided clarity on how theoretical concepts are implemented in real-time industrial environments.

Furthermore, the visit highlighted the importance of safety measures, protection systems, and maintenance practices essential for the reliable operation of a large-scale power station. The interaction with experienced engineers and technical staff helped in understanding operational challenges, system coordination, and the role of renewable energy in meeting the growing electricity demand sustainably. The visit also reinforced the significance of hydroelectric power as a clean and efficient energy source, contributing to grid stability and environmental conservation.

Overall, the industrial visit successfully bridged the gap between academic learning and practical application by providing valuable exposure to the key operational systems of a high-head hydroelectric power plant. Although the complete operation of the plant could not be observed, the visit offered meaningful insights into critical components, control mechanisms, and safety practices through guided explanations and demonstrations. The study of Pelton turbines operating under a net head of approximately 714.7 m enhanced our understanding of impulse turbine principles, jet velocity control using needle and deflector mechanisms, and speed regulation through advanced governing systems, while observations of real-time SCADA and PLC-based automation systems demonstrated how continuous monitoring of voltage, frequency, turbine speed, vibration, temperature, and oil pressure ensures safe, efficient, and reliable power generation. The visit also strengthened our knowledge of auxiliary and protection systems such as lubrication and oil pumping units, hydraulic jacks, compressed-air braking systems, neutral grounding transformers, and filtration mechanisms, along with sensors and instrumentation including LVDTs, vibration sensors, displacement sensors, and analog transducers, emphasizing the importance of condition monitoring and predictive maintenance. Additionally, exposure to fire safety arrangements using foam, dry chemical powder, and CO_2 extinguishers improved our understanding of industrial safety standards and emergency response practices. Overall, the experience enhanced our technical knowledge, professional awareness, and appreciation for industrial discipline and coordinated system operation, thereby providing a holistic understanding of power system engineering and a strong foundation for future academic pursuits and professional development in electrical engineering, particularly in the areas of power generation, automation, and renewable energy systems. The visit was conducted in a highly welcoming and supportive manner, with plant officials and engineers offering clear technical explanations and patiently addressing queries, which significantly enriched the overall learning experience.

References

1) Kerala State Electricity Board Limited (KSEB), *Sabarigiri Hydro Electric Project – Technical and Operational Details*, KSEB official website.
2) Wikipedia contributors, *Sabarigiri Hydro Electric Project*, Wikipedia.