EEE 102 Basic Electrical Engineering

Lecture 3: Generation II Hydro Power Plant

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Course Status

- Till Now
  - Basics of Energy
  - Basics of Electricity
  - Generation via Thermal Power Plants
  - Thermal Power Plant Efficiency
- Today
  - Hydro

What is Hydropower?

- Derived from the Greek word *hydor*, meaning water.
- Energy from the movement of water (falls, streams).
- Part of the natural water cycle powered by the sun.
- Renewable energy source as water is continuously replenished.

History of Hydropower

- Used for over 2,000 years (e.g., water wheels in Greece).
- First U.S. hydroelectric power plant: Fox River, Appleton, WI, 1882
- At its peak in the 1940s, hydropower provided 33% of U.S. electricity
- Reduced use due to inexpensive fossil fuels but revived interest in the 1970s
- First Indian hydropower plant– Sidrapong (Darjeeling) 130 kW in 1897

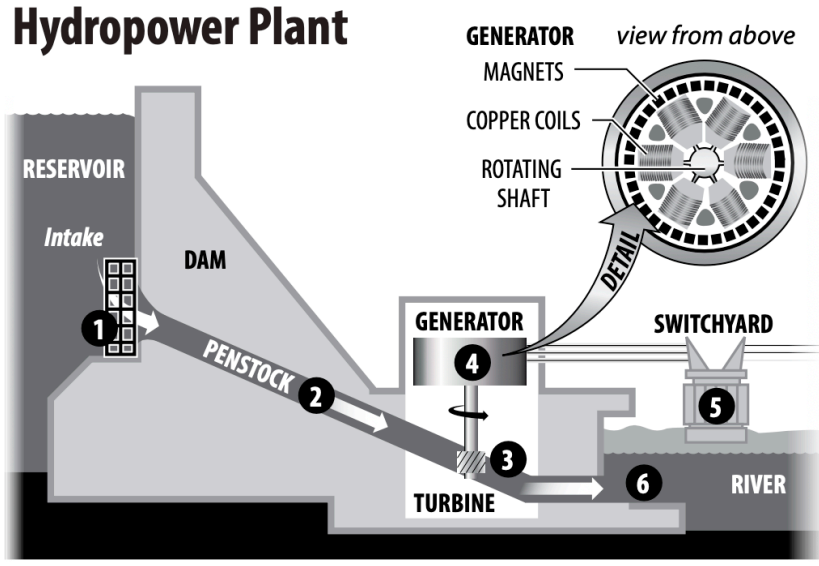
Power in Flowing Water

$$h = z + \frac{p}{\gamma} + \frac{V^2}{2g}$$

$$P = \frac{\text{Energy}}{\text{Time}} = \frac{\text{Weight}}{\text{Volume}} \times \frac{\text{Volume}}{\text{Time}} \times \frac{\text{Energy}}{\text{Weight}} = \gamma Q h$$

Where:

- h: Energy head (energy per unit weight)
- z: Elevation,
- p: Pressure,
- γ: Specific weight,
- V: Average velocity,
- g: Gravitational acceleration,
- P: Power
- Q: Volumetric flow rate,



Source: US Energy Hydropower Report

Hydro-Power Plant: Simple Operation

- Water stored in a reservoir behind a hydropower dam flows through an intake screen. The screen removes large debris while allowing fish to pass through safely.
- The filtered water enters a large pipe known as a penstock.
- The force of the water drives a turbine, spinning it at a low speed that ensures fish can pass through unharmed.
- Inside the generator, the turbine's shaft rotates copper wire coils within a magnetic field, generating electricity.
- The electricity is transmitted to a switchyard, where a transformer increases its voltage, enabling efficient transmission through the electric grid.
- After powering the turbine, the water exits the penstock and flows back into the downstream river.

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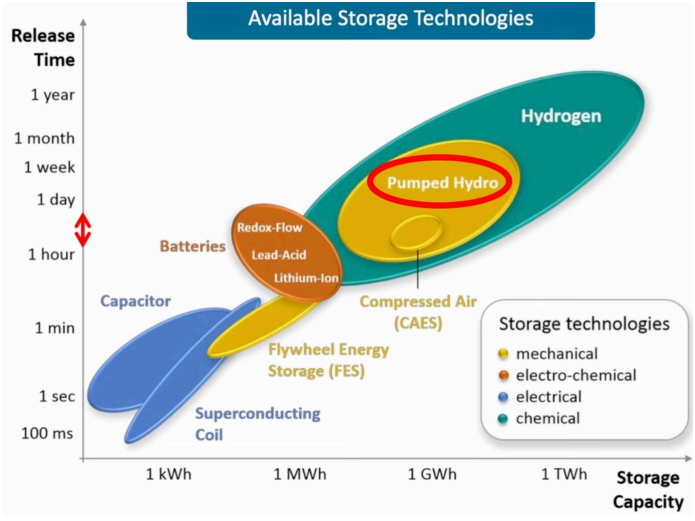
Types of Conventional Hydro Power Plants

- Run-of-River
- Storage
- Pumped Hydro

Hyrdo as Storage: Pumped Hydro is a Public Fountain



Source: Design and Performance Optimization of Renewable Energy Systems, Academic Press, 2021

Advantages & Disadvantages of Hydropower

Advantages

- Renewable and sustainable.
- Provides base-load and peak-load power.
- Ability to store energy in reservoirs.
- Produces no greenhouse gases during operation.

Disadvantages

- Environmental impact on aquatic ecosystems.
- High initial construction cost.
- Limited by geography and available sites.
- Vulnerable to seasonal and climate changes.

Homework

- On Course Website