Micro Hydro Power

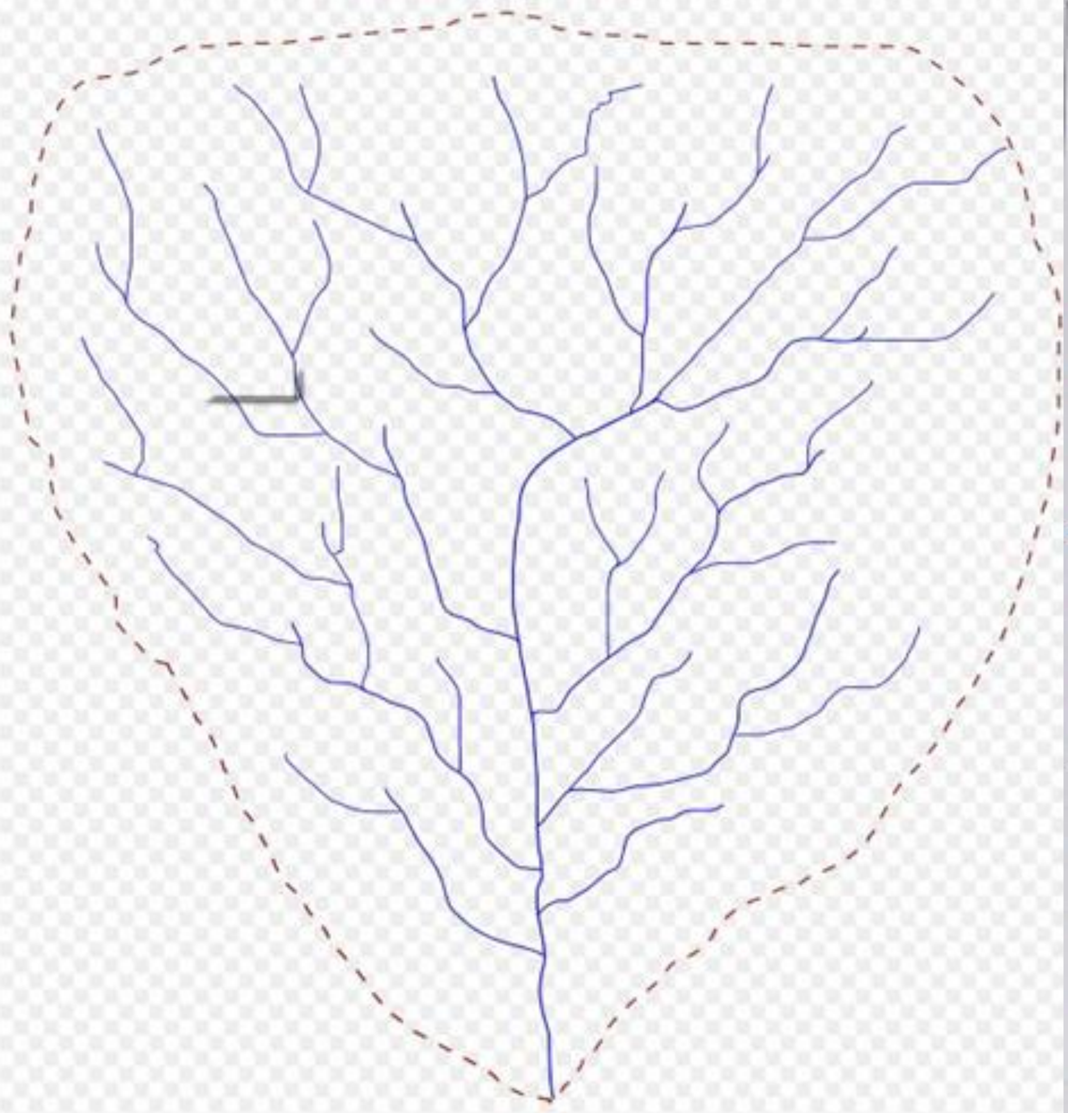
LECTURE 4:

PRINCIPLE OF POWER GENERATION

Definition of Head And Discharge

- In generation of hydroelectric power, water is collected or stored at a higher elevation (dam) and led downward through large pipes or tunnels (penstock) to a lower elevation (turbine); the difference in these two elevation is known as **Head.**
- Head is the change in water levels between the hydro intake and the hydro discharge point.
- It is a vertical height measured in meters.
- The two diagrams show how the head would be measured on a typical 'low head' and a typical 'high head' site.
- The more head you have the higher the water pressure across the hydro turbine and the more power it will generate.
- Higher heads are not only better because they generate more power, but also because the higher water pressure means you can force a higher flow rate through a smaller turbine, and because turbine cost is closely related to physical size, higher-head turbines often cost less than their low-head cousins even though they might generate the same power.

Definition of Head And Discharge



Definition of Head And Discharge

- **Discharge** is defined as the volume of water flowing through a given cross section per unit time.

- Hydroelectric discharge, also referred to as flow rate, is usually represented by Q, is the volume of water that pass through a hydroelectric power plant per unit time (like a second).

- Flow rate simply represents the volume of water that can be captured and then re-directed by a dam to flow across a turbine generator to move it and generate electricity.

- **Head and discharge** play an important role in determining the power output of a hydropower plant.
- **Higher head and discharge** results in higher generation of electric power.

Power Equation

- The main principal of power generation in any hydropower plant is that the potential energy of water stored in the dam is first converted into kinetic energy which is then used to drive the turbine.
- The turbine then drives the generator and an AC voltage is established across the generator terminals

Power Equation

Energy Source

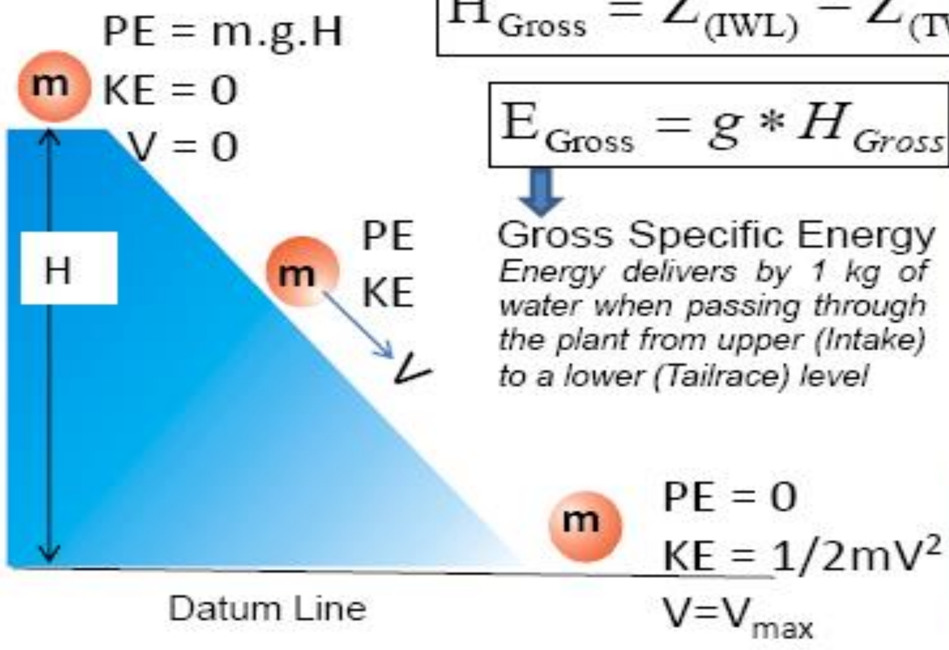
- Potential energy of WATER of certain mass (m) with reference to certain HEAD (H) is the basis for available power source for all Microhydro power plants.

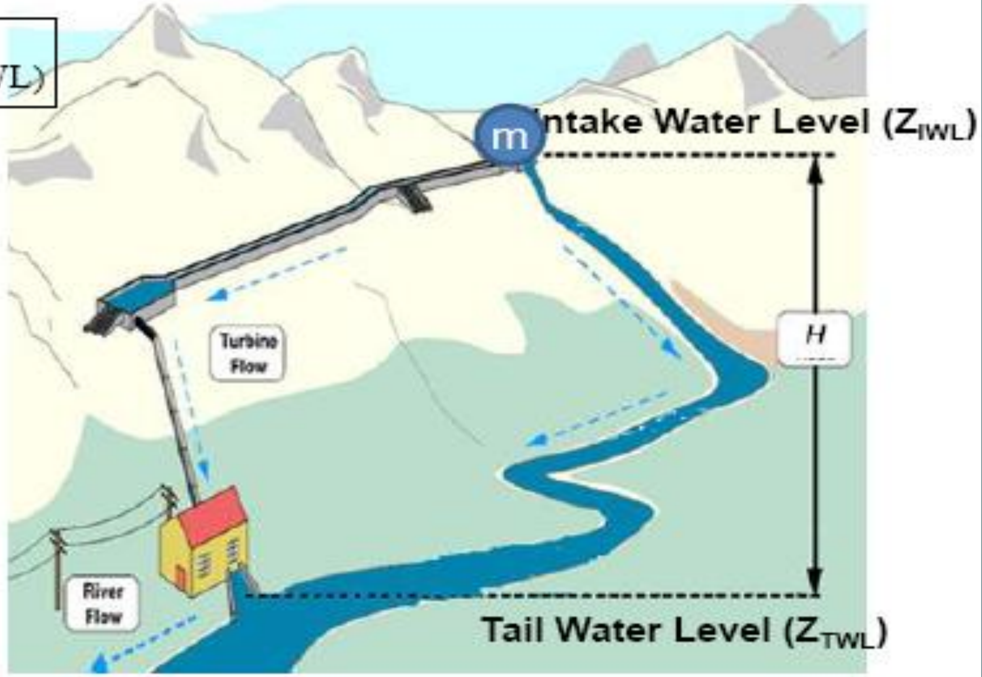
$$H_{Gross} = Z_{(IWL)} - Z_{(TWL)}$$

$$E_{Gross} = g * H_{Gross}$$

Gross Specific Energy

Energy delivers by 1 kg of water when passing through the plant from upper (Intake) to a lower (Tailrace) level





Energy Conversion

Potential Energy
(Mass of water located at higher elevation)

↓

Kinetic Energy
(Water flow as a result of mass being at higher elevation)

↓

Mechanical Energy
(Flowing mass of water turns a Turbine Runner)

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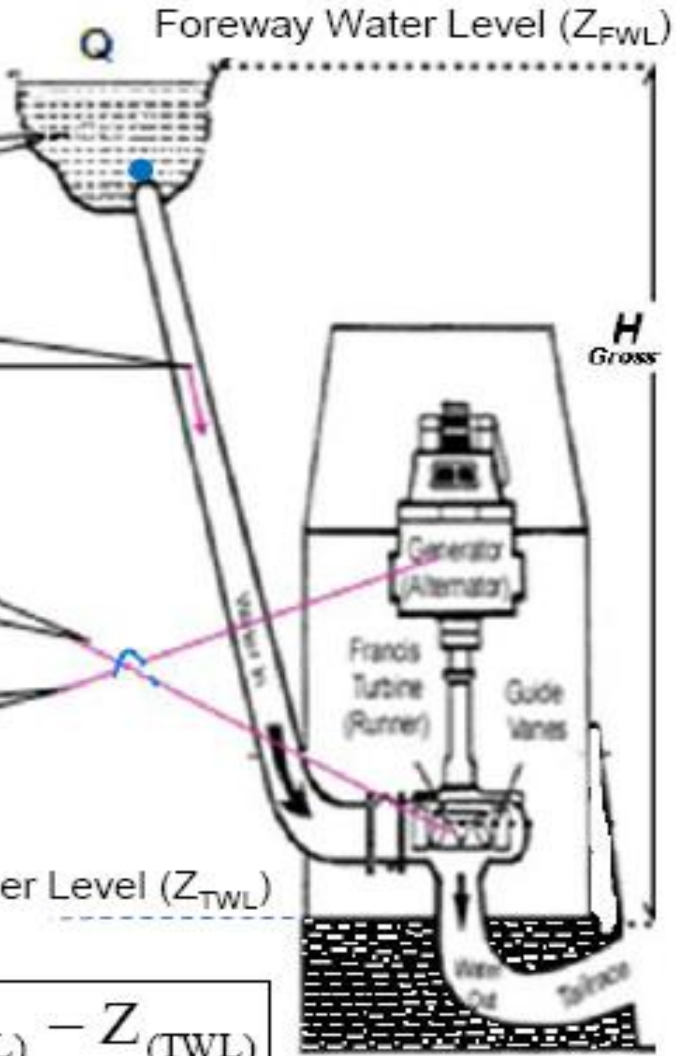
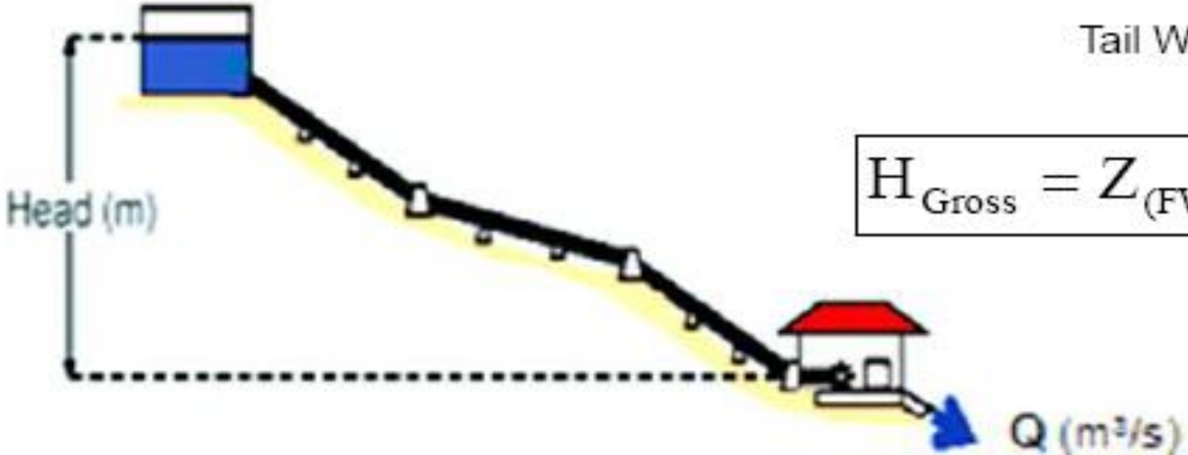
Electrical Power
(Turbine Runner turns a Electrical generator)





$$H_{Gross} = Z_{(FWL)} - Z_{(TWL)}$$

$$E_{Gross} = g * H_{Gross}$$

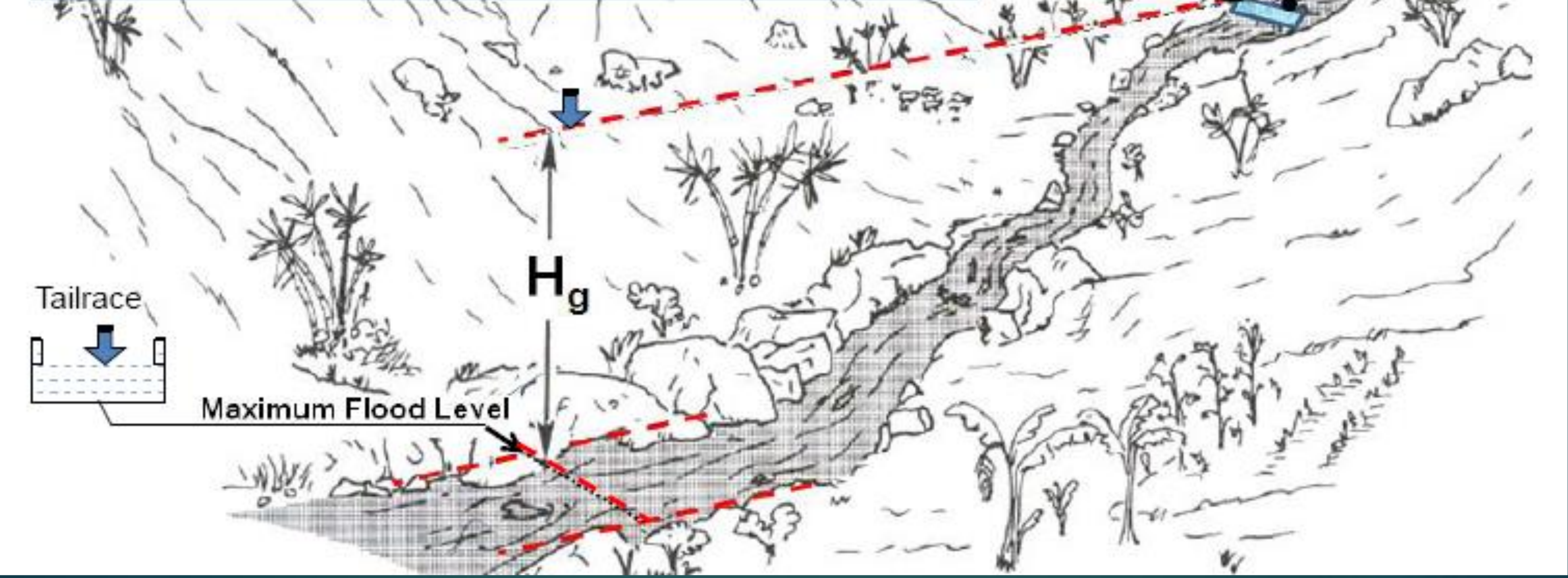
↓

Gross Specific Energy

Quantifying Energy Potential

$$\text{Power Potential P (kW)} = \frac{(g\rho)\, H_g\, Q_g}{1000`}$$

$(g.\rho)$ = Weight density of water = 9810 N/m^3
H_g = Level difference between Intake and Tailwater (m)
Q_g = Water flow rate at Intake (m^3/s)

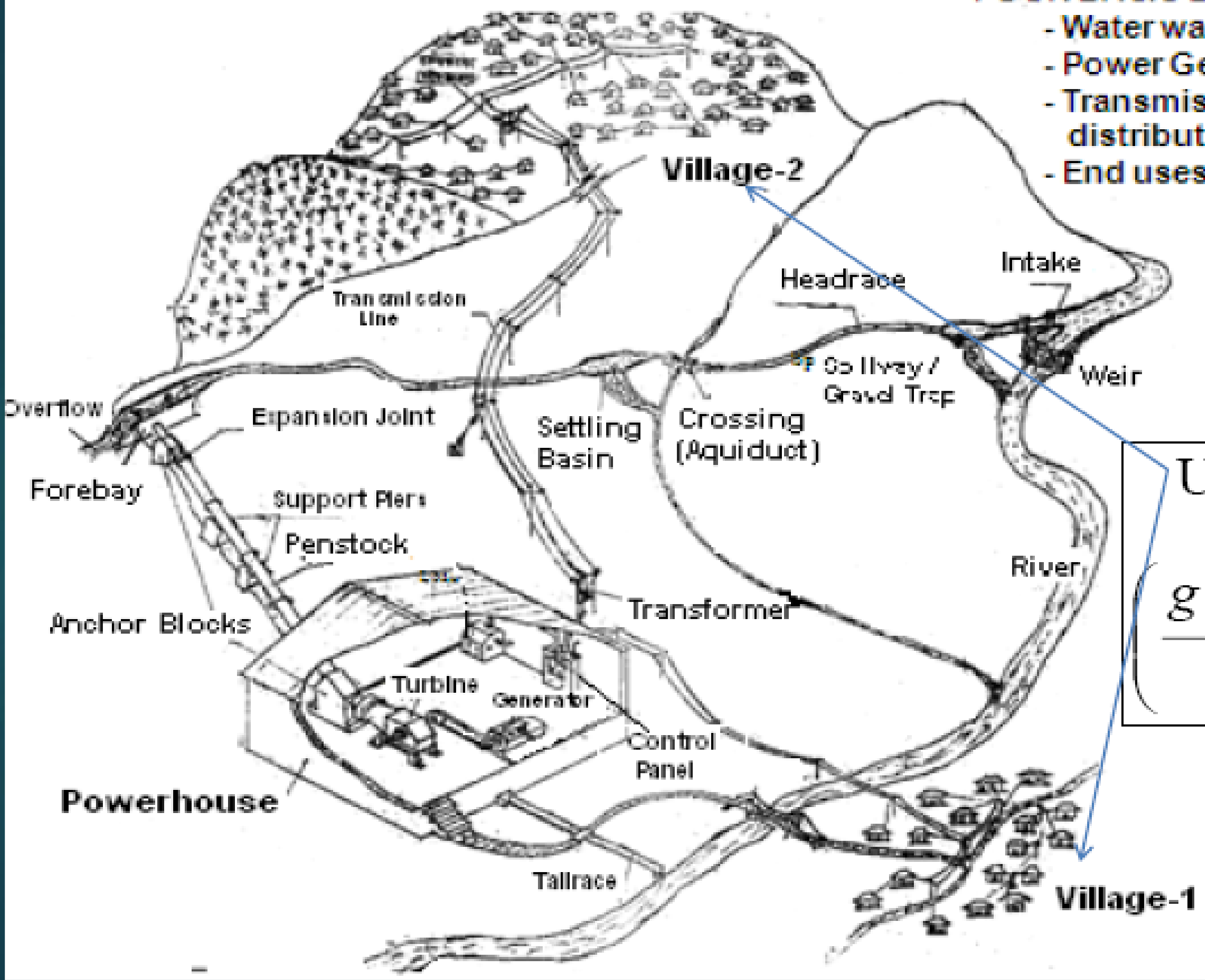


Micro-hydro plant: Typical System layout

MHP SYSTEM:

FOUR BASIC DIVISIONS

- Water ways system
- Power Generation system
- Transmission and distribution system
- End uses



$$\text{Usable Power (kW)} = \left(\frac{g \times \rho \times H_g \times Q_g}{1000} \right) \times \eta_o$$

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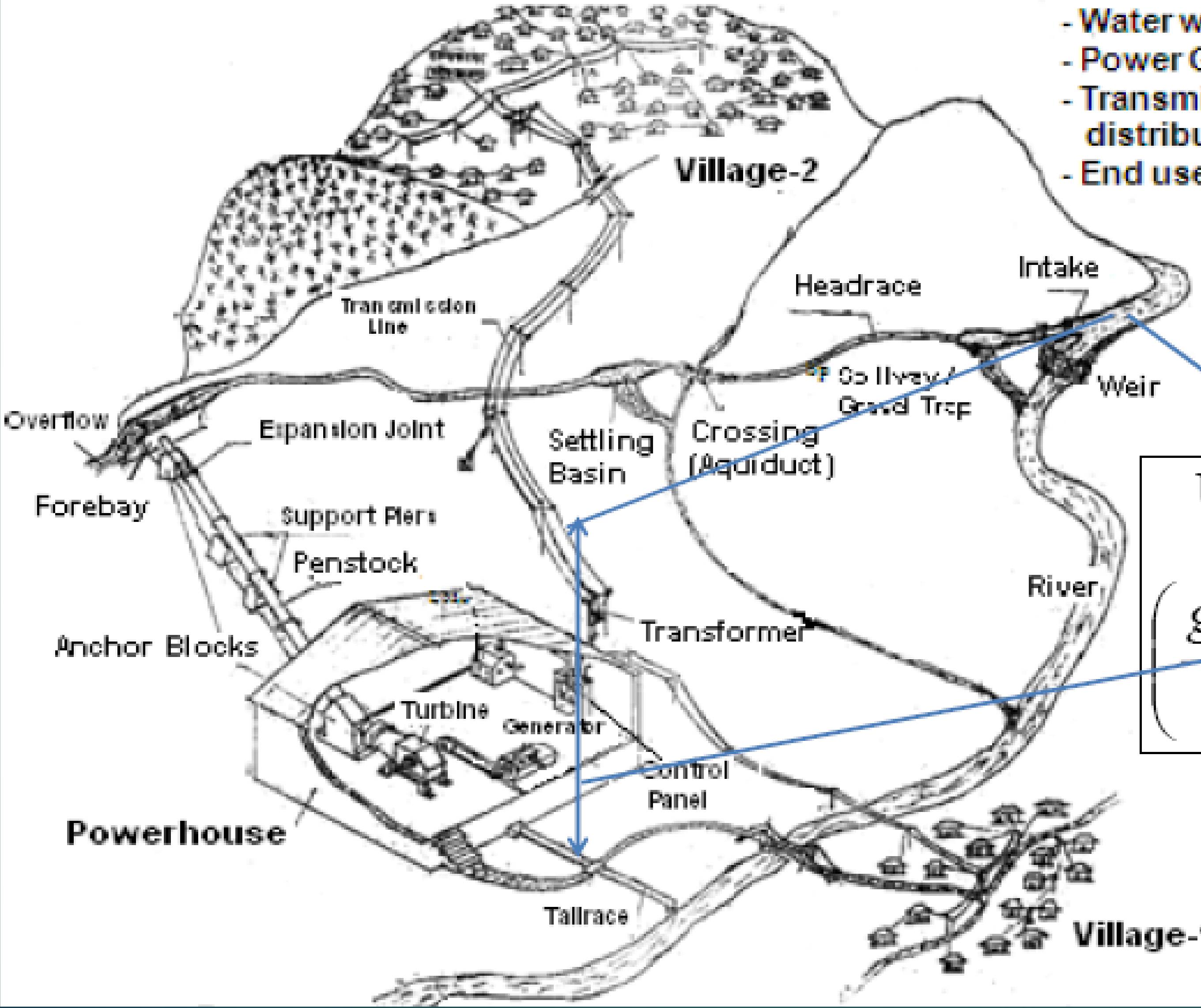


For a particular site

H_g is fixed (for run-off system)

Q_g is minimum dry season flow

$$\text{Usable Power (kW)} = \left(\frac{g \times \rho \times H_g \times Q_g}{1000} \right) \times \eta_o$$

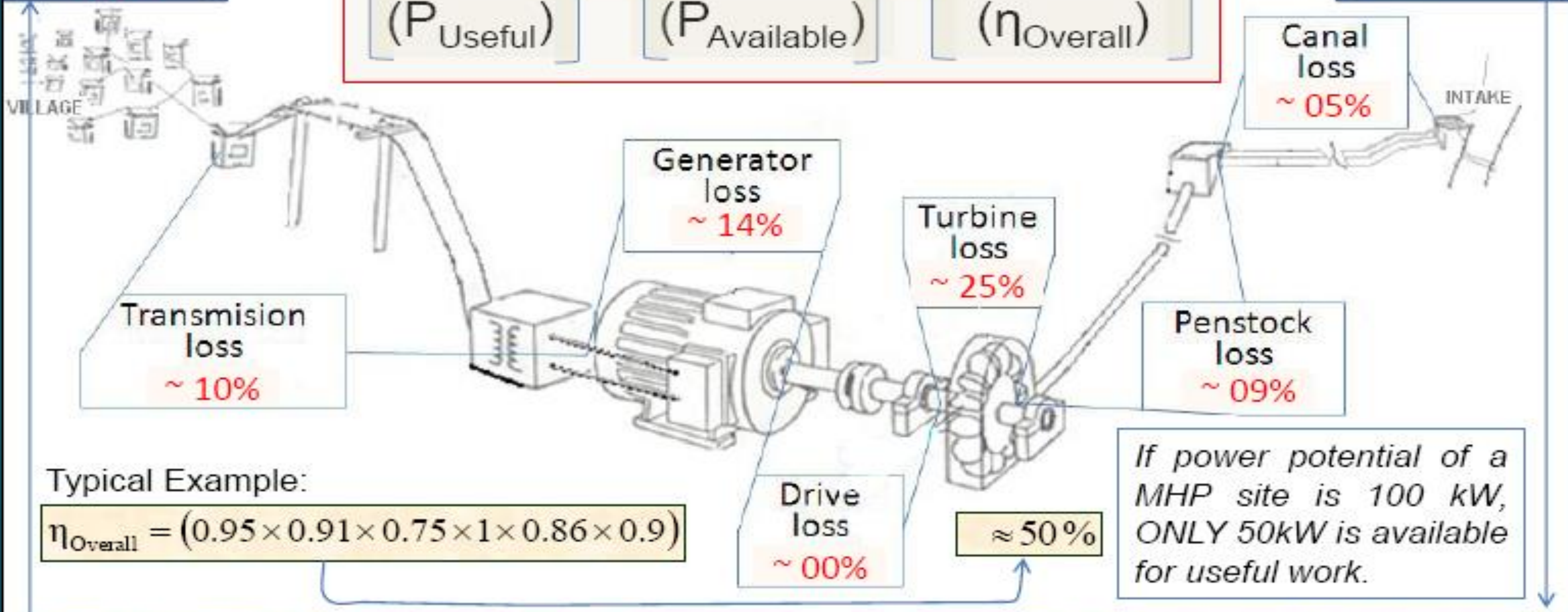
η_o = Overall (or) Combine efficiency

Overall Efficiency

USABLE POWER ($P_{USA.}$)

Useful Power (P_{Useful}) = Available Power ($P_{Available}$) x Overall Efficiency ($\eta_{Overall}$)

AVAILABLE POWER ($P_{AVA.}$)



Typical Example:

$$\eta_{Overall} = (0.95 \times 0.91 \times 0.75 \times 1 \times 0.86 \times 0.9) \approx 50\%$$

If power potential of a MHP site is 100 kW, ONLY 50kW is available for useful work.

$$\eta_{Overall} = (\eta_{Canal} \times \eta_{Penstock} \times \eta_{Turbine} \times \eta_{Drive} \times \eta_{Generator} \times \eta_{Transmission})$$

THANK YOU