Hydropower – Smart Energy

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Agenda

1. Hydropower Overview
2. Types of hydropower projects
3. Community Hydro
4. Case Study
5. Community Benefits

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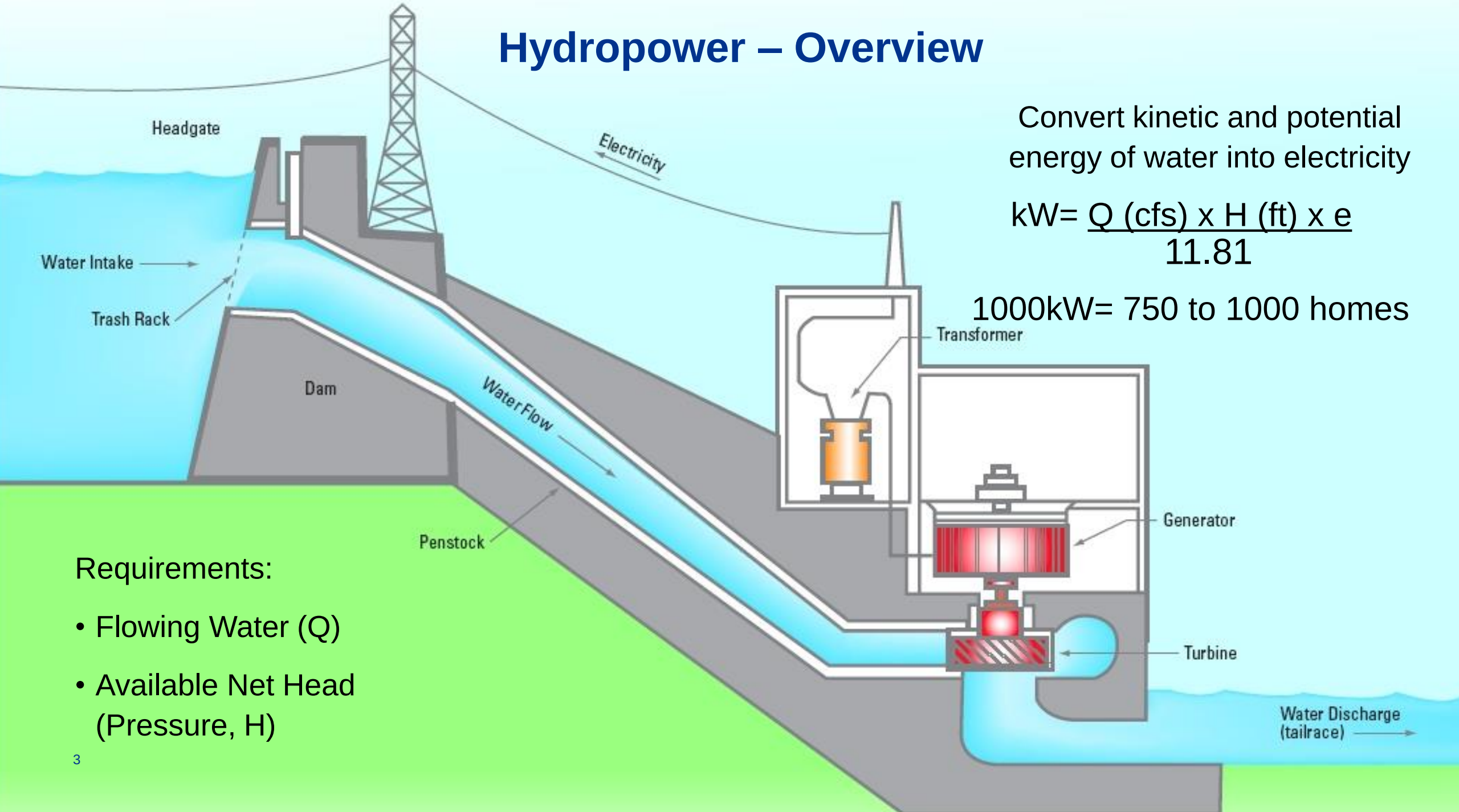
Hydropower – Overview



Convert kinetic and potential energy of water into electricity

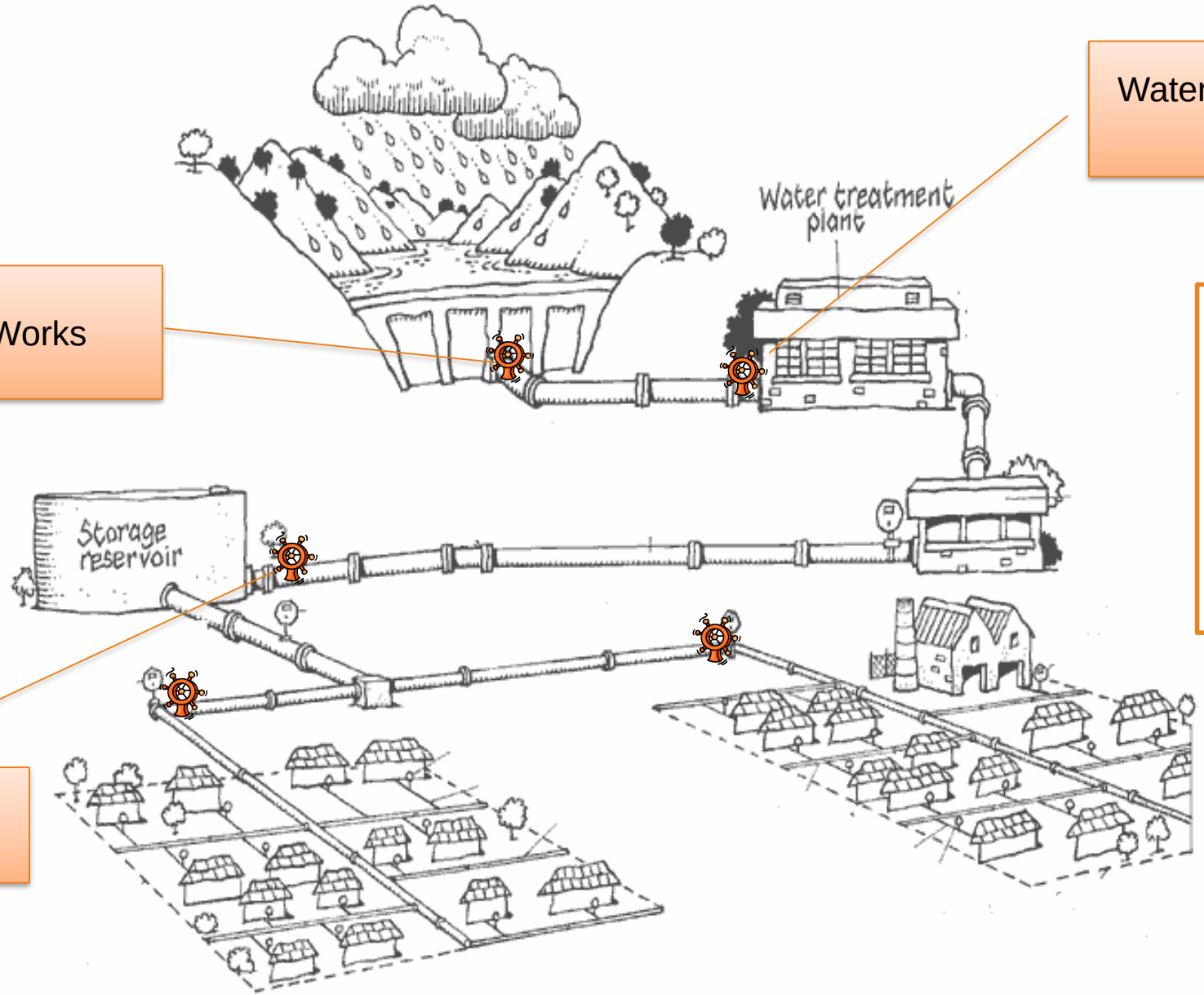
$$kW = \frac{Q\ (cfs) \times H\ (ft) \times e}{11.81}$$

1000kW= 750 to 1000 homes

Requirements:

- Flowing Water (Q)
- Available Net Head (Pressure, H)

Types of Hydropower – Multipurpose Project



Water Treatment Plant or WWTP

Dam Outlet Works

Hydroelectric energy generation can be a secondary benefit of a water storage or water delivery project

Conveyance System

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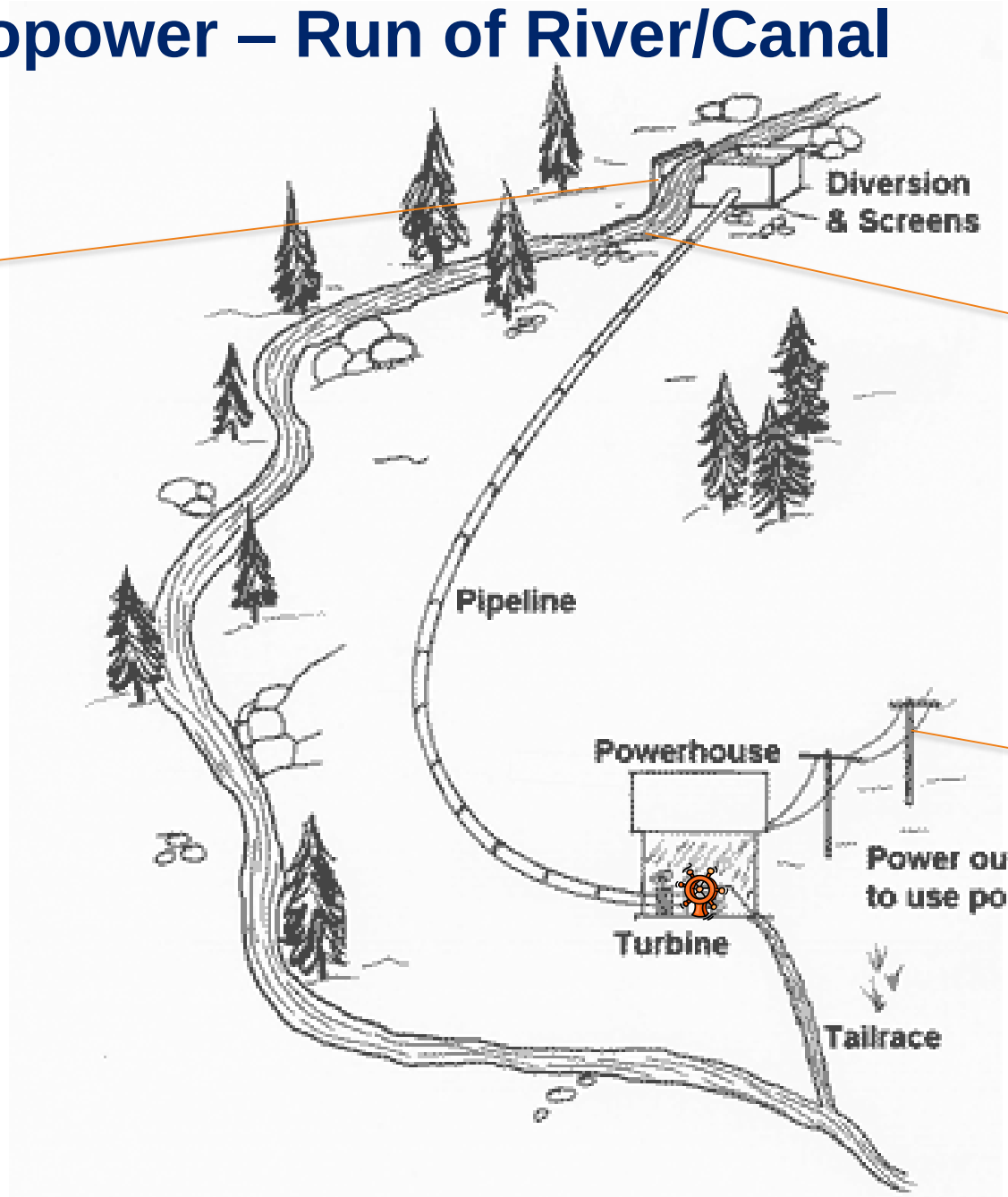
Types of Hydropower – Run of River/Canal

Run of River hydropower Diversion structure



Environmental Mitigation Fish Passage

Water can be diverted from a river or canal and put back in the river downstream at a lower elevation to generate hydroelectric energy

Interconnection and Controls

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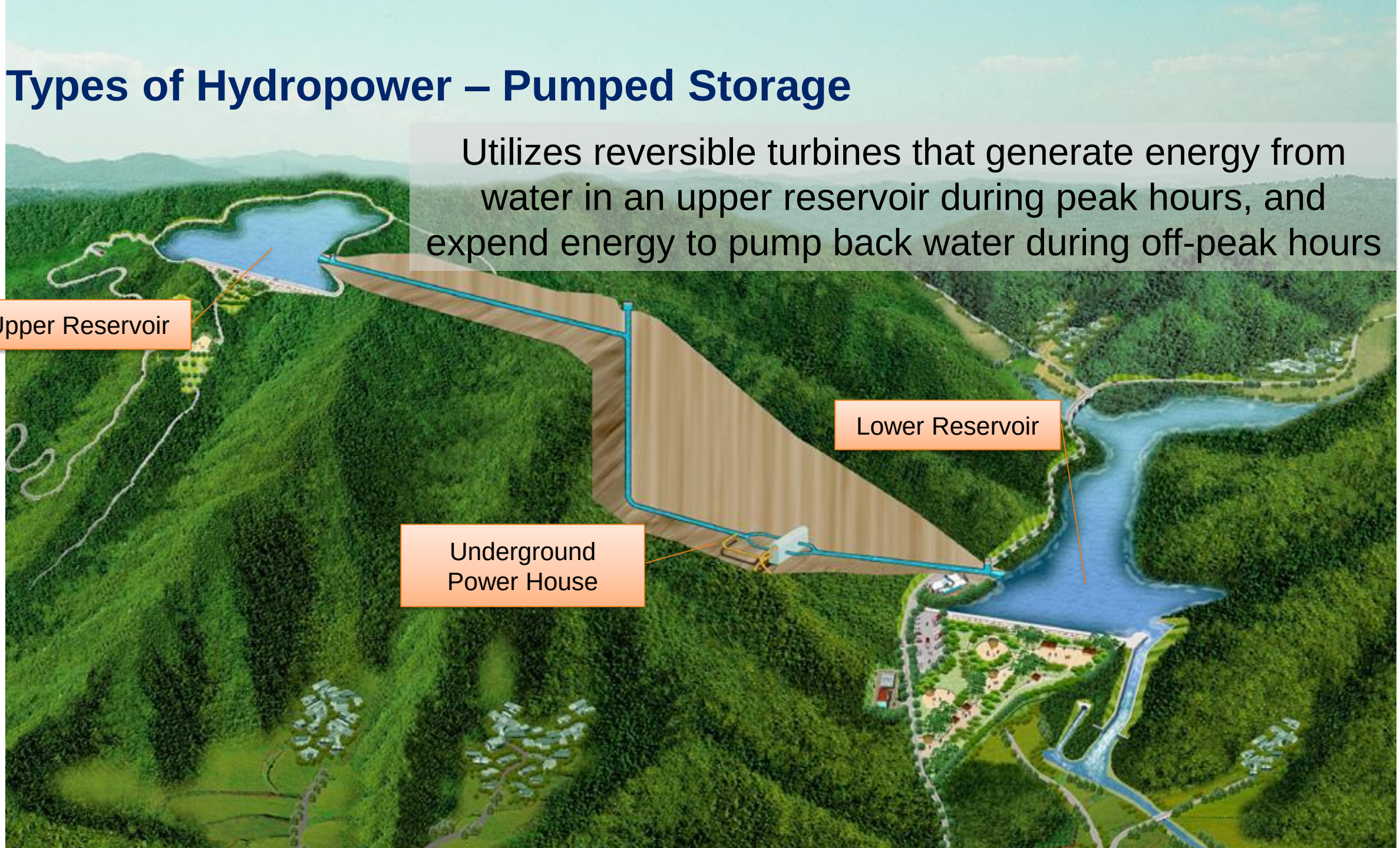
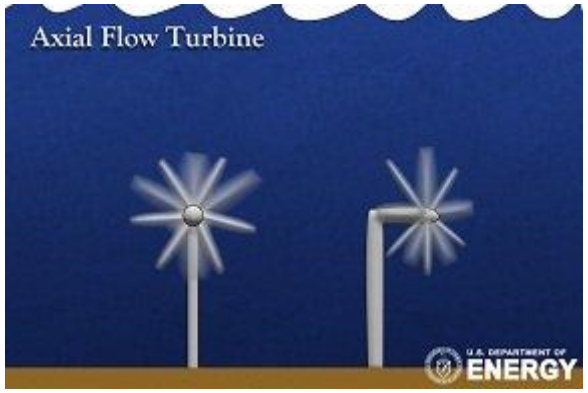
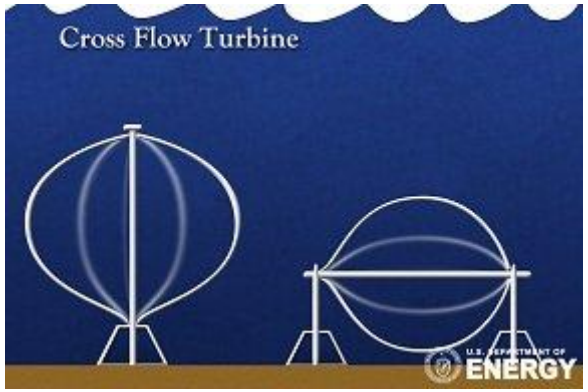
Types of Hydropower – Pumped Storage

Utilizes reversible turbines that generate energy from water in an upper reservoir during peak hours, and expend energy to pump back water during off-peak hours



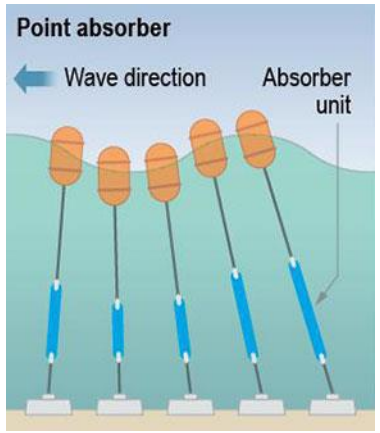
Types of Hydropower - Hydrokinetic

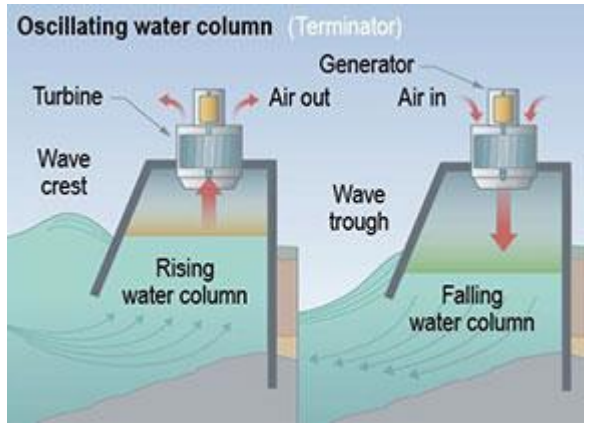


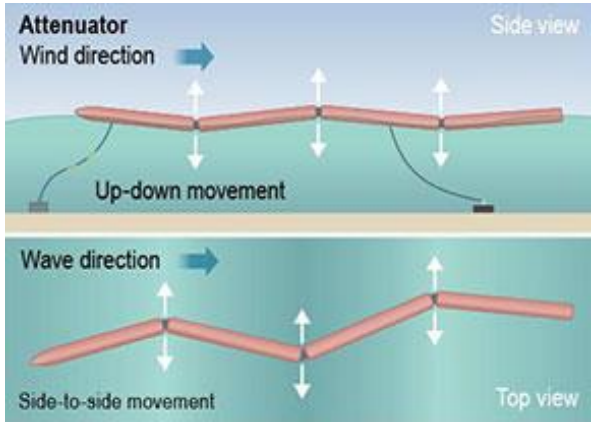


Hydrokinetic energy generation

- Tides
- Waves
- Current







Installation

- Surface
- Submerged

https://www.energy.gov/eere/water/marine-and-hydrokinetic-technology-glossary

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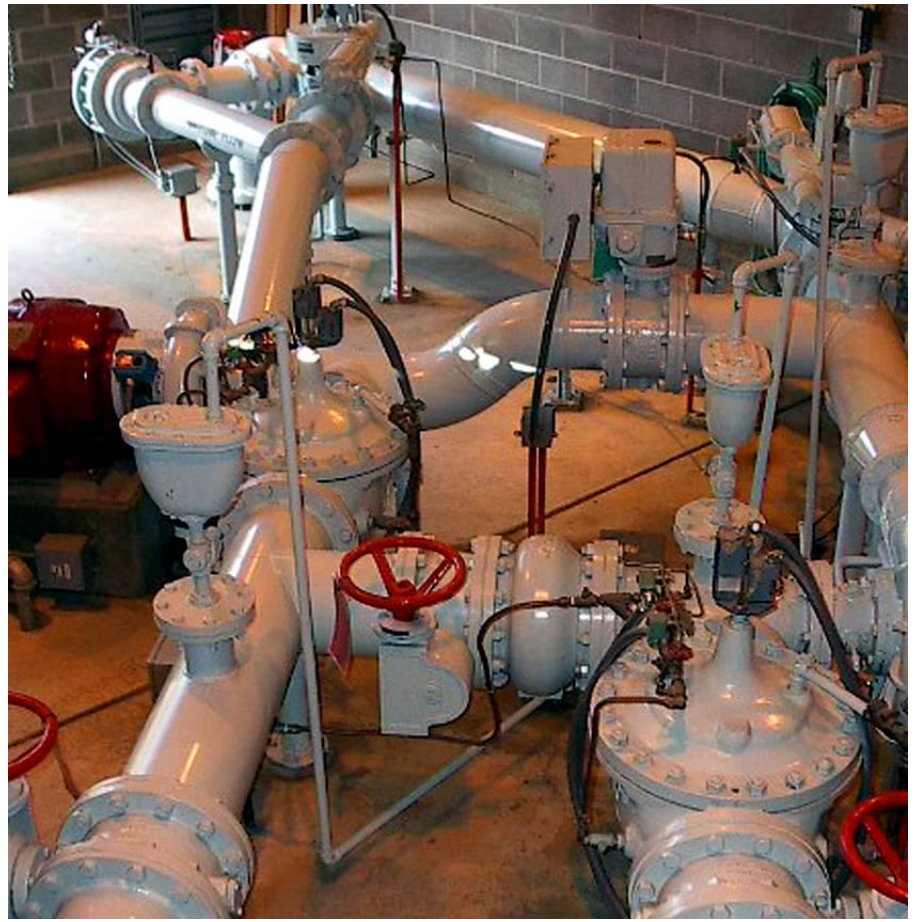
Smart Grid Integration

- Other renewable energy (solar, wind, geothermal, waste to energy)
- Connection to utility distribution or island mode operation
- Full system monitoring and controls
- Bypass to minimize system disruptions

Hydropower Project Considerations

- Regulatory
  - FERC / BOR
- Environmental Permitting
- Site Infrastructure
  - Existing or Greenfield
- Revenue
  - Time of day operations (peak vs base demand)
  - Net-metering
- Equipment Selection
  - Turbines: Reaction or Impulse
  - Generators: Induction or Synchronous



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Advantages of Community Hydropower

- Minimal regulatory requirements
- Little to no Environmental permitting
- Existing Infrastructure reduces capital cost:
  - Vault or building
  - Electric utility tie-in
  - Controls and Communication
- Revenue – peak $/kW rate period same as peak water use
- Equipment Selection
  - Turbines: newer technology for inline projects

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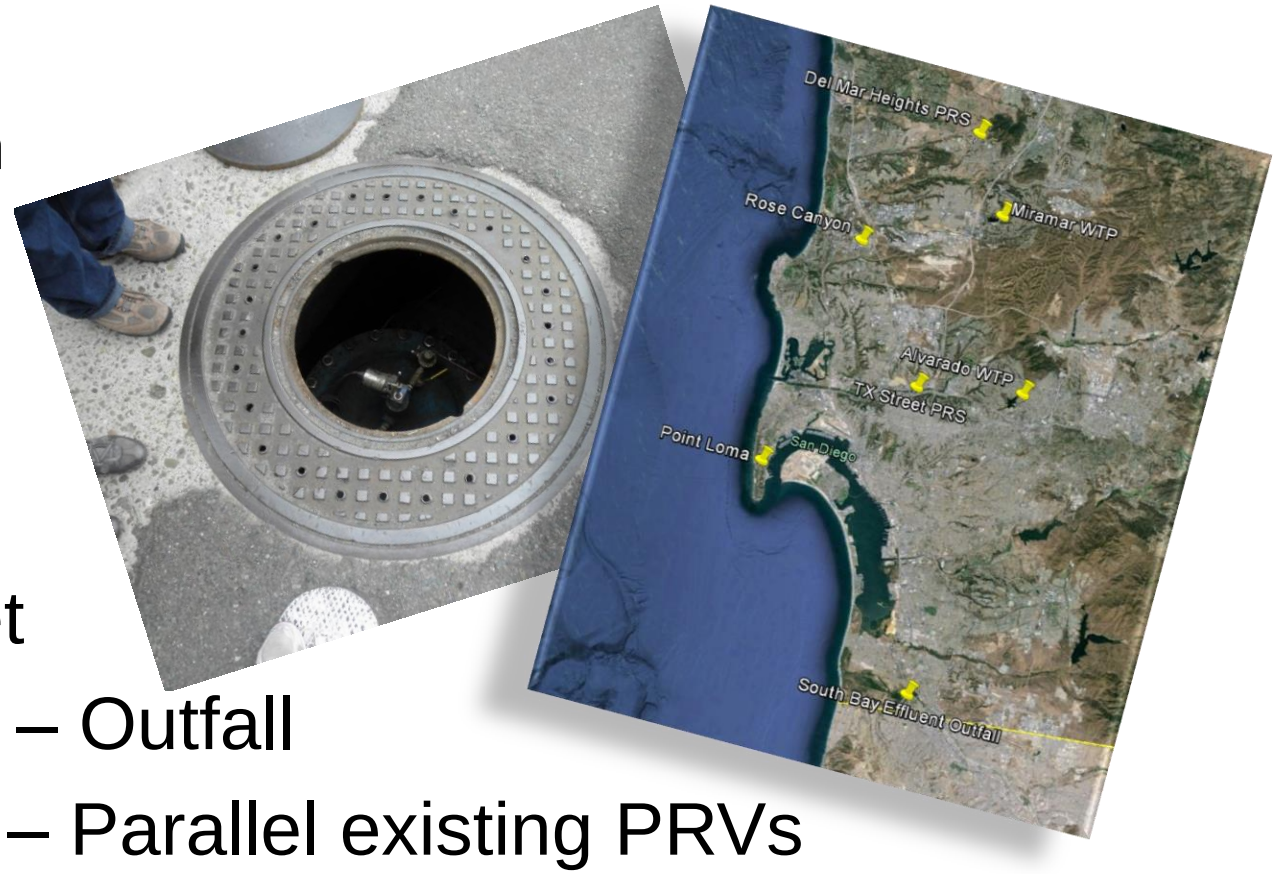
Case Study: System-Wide Feasibility Study

- Reconnaissance-level assessment of hydropower feasibility
  - Evaluate basic technical feasibility
  - Estimate annual energy generation
  - Review institutional requirements
  - Order-of-magnitude costs
  - Simple Benefit/Cost assessment
  - Identify fatal flaws
- 2 Water Treatment Plants – Inlet
- 2 Wastewater Treatment Plants – Outfall
- 3 Pressure Regulating Stations – Parallel existing PRVs



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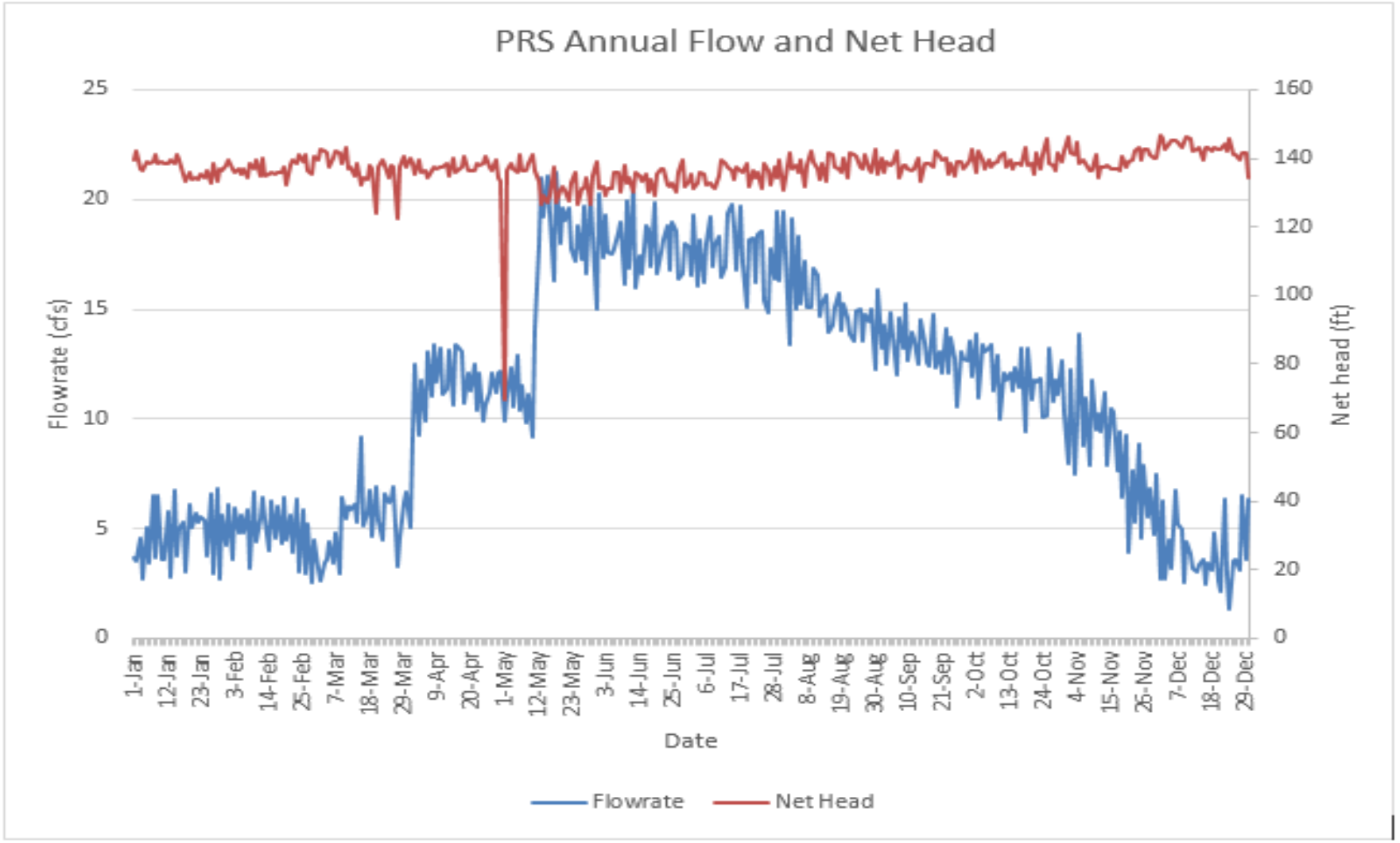
Data Analysis – Historic Flow and Head



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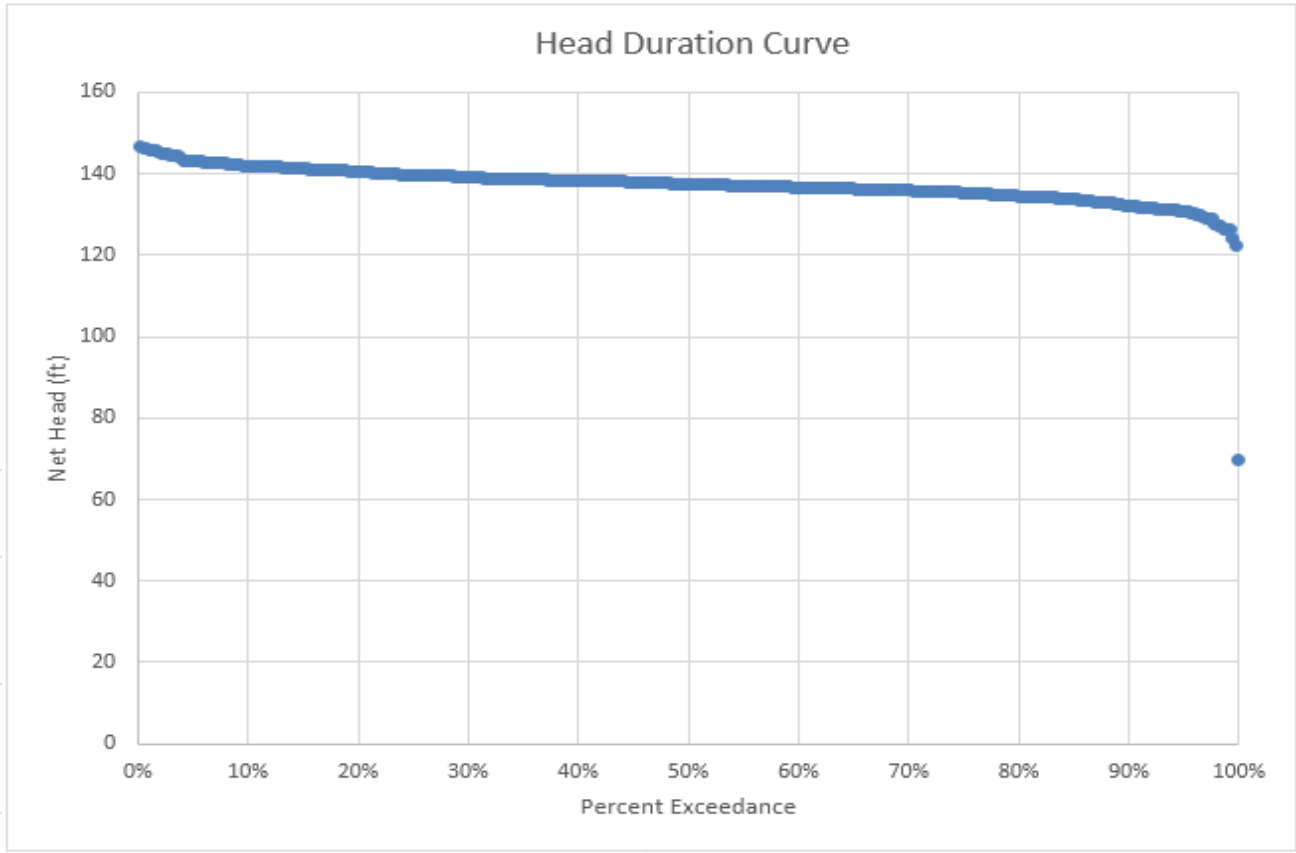
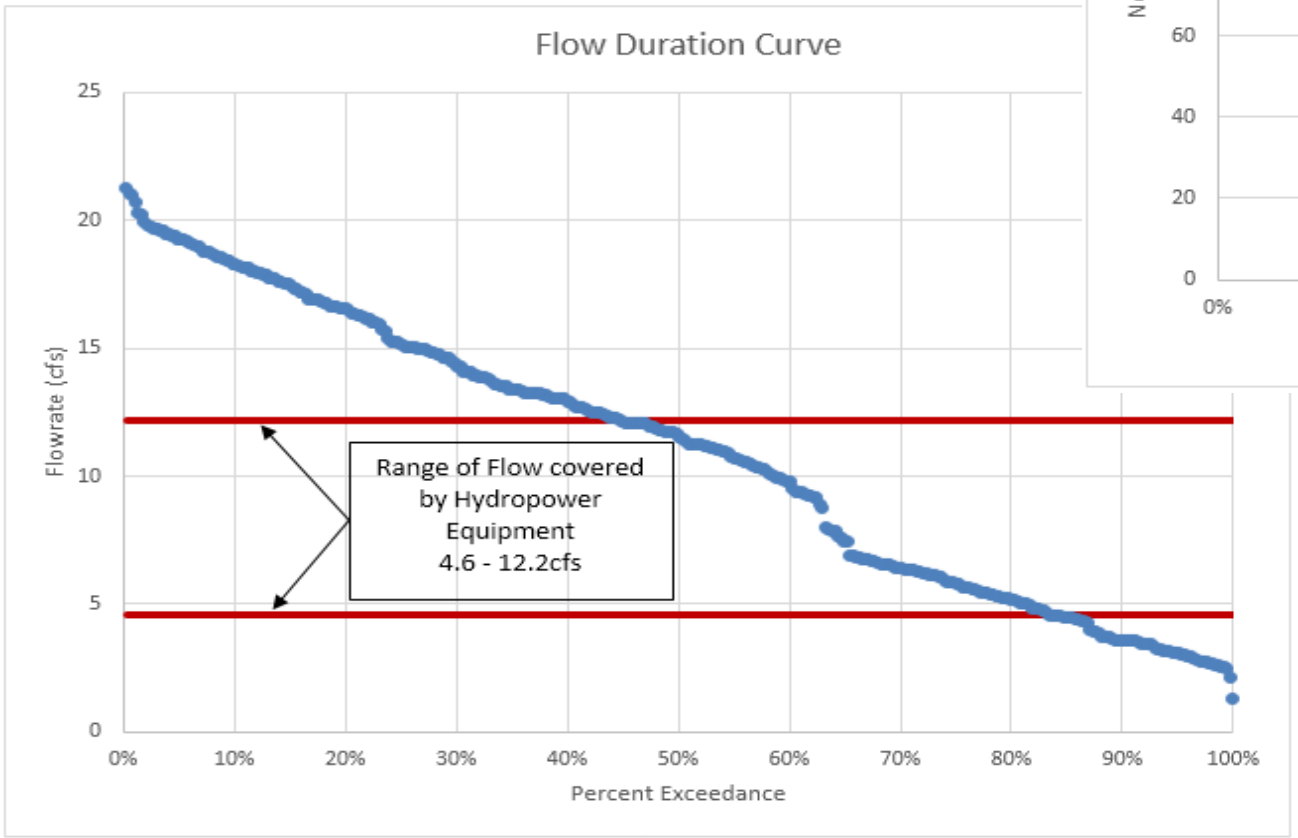
Data Analysis: Equipment Selection





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Example Results

Item	Site 1A (Refurbish)	Site 1B (Replace)	Site 2	Site 3
Capacity	1,300 kW	1,300 kW	1,000 kW	117 kW
Head	154 ft	154 ft	53 ft	140 ft
Flow	120 cfs	120 cfs	260 cfs	12.2 cfs
Annual Energy Generation	7,200,000 kWh	7,200,000 kWh	6,500,000 kWh	530,000 kW
Total Present Value of Costs	$5,800,000	$10,200,000	$12,400,000	$2,200,000
Total Present Value of Revenue/Benefit	$15,500,000	$15,500,000	$12,000,000	$1,100,000
Net Present Value*	$9,700,000	$5,300,000	-$400,000	$1,100,000
Overall Present Value B/C Ratio	**2.68**	**1.52**	**0.97**	**0.51**

*20 year economic analysis

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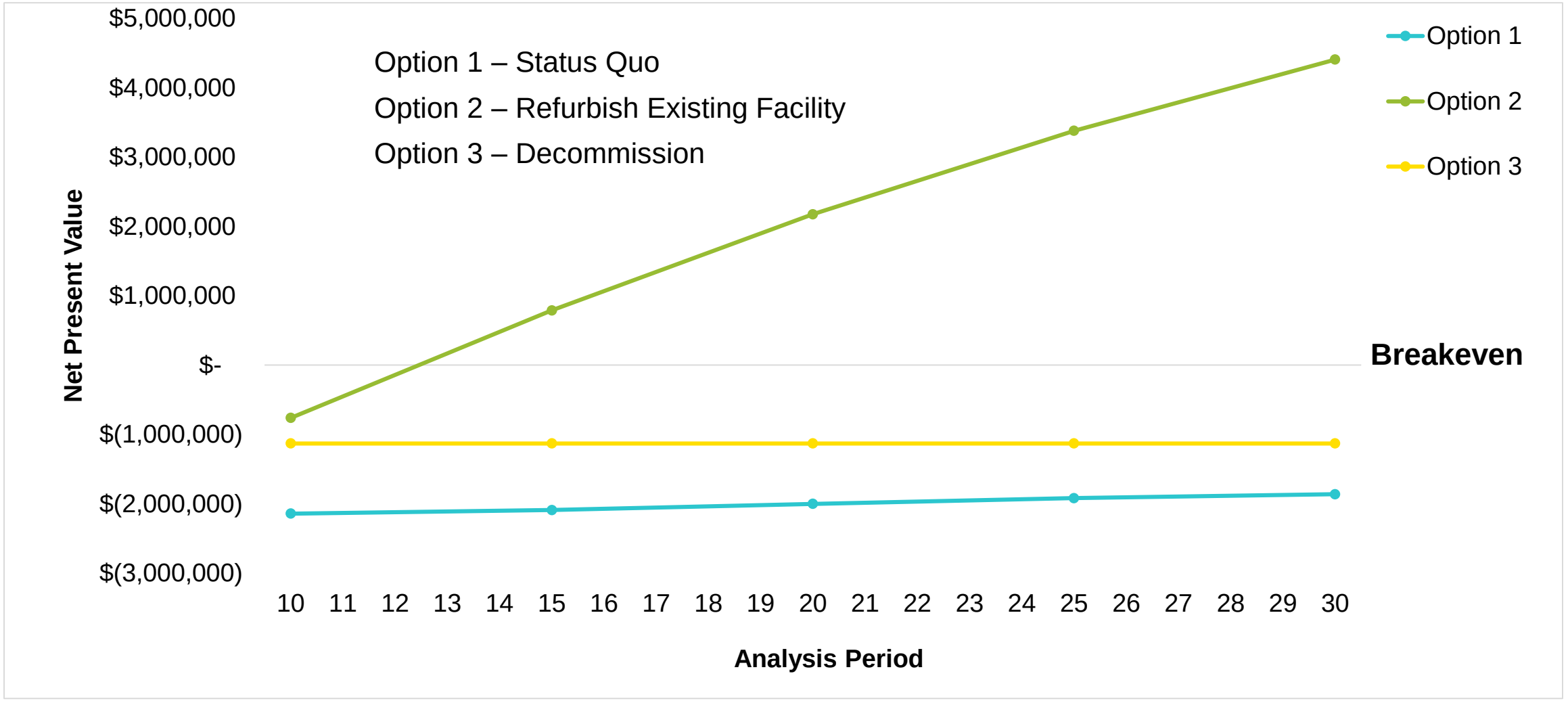
Example Results



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Community Benefits of Hydropower Generation

- Renewable Energy / Carbon Offset
- Efficient Energy
- Positive Public Perception
- Financial Incentives
- Economic Payback
- Local employment / Common Skillset

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Considerations

Conveyance System	Dam/Reservoir	Run of River	Pumped Storage
Minimal regulatory requirements	Moderate to Maximum regulatory requirements	Minimal to Moderate regulatory requirements	Maximum regulatory requirements
Generally little to no environmental permitting	Moderate to Maximum environmental permitting	Moderate to Maximum environmental permitting	Maximum environmental permitting
Existing or greenfield	Existing or greenfield	Existing or greenfield	Generally greenfield
$/kWh or Net-meter	$/kWh and/or Capacity payments	$/kWh and/or Capacity payments	$/kWh and/or Capacity payments
Operations based on other priorities	Operations based on other priorities	Operations based on other priorities	**Operations optimized for generation**
Low capital cost for existing sites	Moderate to High capital cost	Moderate to High capital cost	High capital cost
Minimal generation potential	Minimal to maximum generation capacity	Minimal to Moderate generation capacity	**Maximum generation potential**

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