Hydropower – Smart Energy
Sonya Reiser, PE

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Agenda

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

Convert kinetic and potential energy of water into electricity

\[ kW = Q \text{ (cfs)} \times H \text{ (ft)} \times e^{11.81} \]

1000kW = 750 to 1000 homes

Requirements:

- Flowing Water (Q)
- Available Net Head (Pressure, H)
Types of Hydropower – Multipurpose Project

Hydroelectric energy generation can be a secondary benefit of a water storage or water delivery project.
Types of Hydropower – Run of River/Canal

Run of River hydropower Diversion structure

Environmental Mitigation Fish Passage

Interconnection and Controls

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

[Image links to energy.gov website for more information]
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
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
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
Data Analysis – Historic Flow and Head

PRS Annual Flow and Net Head

Flowrate (cfs)

Net head (ft)

Date

Flowrate
Net Head
Data Analysis: Equipment Selection

Head Duration Curve

Flow Duration Curve

Range of Flow covered by Hydropower Equipment 4.6 - 12.2 cfs
## Example Results

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

*20 year economic analysis
**Example Results**

Option 1 – Status Quo
Option 2 – Refurbish Existing Facility
Option 3 – Decommission

![Net Present Value Analysis Period Graph](image)

- **Option 1**
- **Option 2**
- **Option 3**

Breakeven

Analysis Period

10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30

Net Present Value

$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
$(1,000,000)
$(2,000,000)
$(3,000,000)
Community Benefits of Hydropower Generation

• Renewable Energy / Carbon Offset
• Efficient Energy
• Positive Public Perception
• Financial Incentives
• Economic Payback
• Local employment / Common Skillset
Hydropower – Smart Energy

Sonya Reiser, PE
Jacobs Energy & Power Solutions
Sonya.Reiser@jacobs.com
## Considerations

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