Jun 22nd, 4:30 PM - 4:45 PM

Session B3: Alden Fish-Friendly Hydropower Turbine: Potential Application, Performance and Economics

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Presenter Information
Greg Allen, Steve Amaral, George Hecker, Doug Dixon, Brian Murtha, and Jeremy Smith

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Alden Fish Friendly Turbine
Potential Application, Performance & Costs

Greg Allen, Steve Amaral and George Hecker
Doug Dixon
Brian Murtha and Jeremy Smith

Environmentally-enhanced Turbines and Turbine Passage Survival
Alden Fish Friendly Turbine

Presentation Outline

- Turbine characteristics
- Performance & fish survival
- Example Applications
- Costs
Mechanical design review indicates it is readily implementable for a range of applications

Performance exceeded expectations (~94% efficient at BEP)

Thrust, runaway speed, and pressure pulsations were within anticipated ranges

No cavitation for the operating conditions corresponding to design point
Biological Criteria

Hydraulic Design Objectives

- Minimize pressure change rates
- Minimize velocity shear rate
- Maximize absolute minimum pressure
- Minimize strike probability and strike survival
- Maximize strike survival

(EPRI 2008, 2011)
### Biological Performance

#### Prototype Survival

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Alden Turbine</th>
<th>Kaplan MGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runner Diameter (m)</td>
<td>4 m</td>
<td>2.4 m</td>
</tr>
<tr>
<td>Number of Blades</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Rotational Speed (RPM)</td>
<td>120 rpm</td>
<td>300 rpm</td>
</tr>
<tr>
<td>Inflow Angle</td>
<td>21°</td>
<td>44°</td>
</tr>
<tr>
<td>Radial Velocity (m/s)</td>
<td>3.9 m/s</td>
<td>11.0 m/s</td>
</tr>
<tr>
<td>Strike Velocity (m/s)</td>
<td>12.7 m/s</td>
<td>17.7 m/s</td>
</tr>
<tr>
<td>Fish Survival</td>
<td>98.4%</td>
<td>83.5%</td>
</tr>
</tbody>
</table>

*Image of Alden Turbine and Kaplan MGR shown.*
Fish Friendly Turbine Application Ranges

Turbine Application

Alden Turbine

Minimum Gap Kaplan > 95% Survival

Alden Turbine > 99% Survival

Alden Turbine > 98% Survival or Kaplan MGR > 85%

Alden Turbine > 95% Survival or Kaplan MGR > 80%
POTENTIAL APPLICATION

Pébernat Hydroelectric Project

Head: 20 m
Flow: 35.9 cms
Diameter: 3.2 m
Speed: 101 rpm
POTENTIAL APPLICATION
Pébernat Hydroelectric Project

Head: 20 m
Flow: 35.9 cms
Diameter: 3.2 m
Speed: 101 rpm

Turbine Passage Survival (%) vs. Fish Length (mm)

98.1%
Project Info

- USACE Project
- ~30 m head
- 9,118 cms capacity
- 16 units @ 135 MW
- Nameplate – 2160 MW
Vacant turbine bay is approx. 9 m dia.

### John Day Dam Application

#### Potential Turbine Options

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Turbine dia. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.5</td>
</tr>
<tr>
<td>BEP Flow (cms)</td>
<td>215</td>
</tr>
<tr>
<td>L.E. Blade Thickness (mm)</td>
<td>455</td>
</tr>
<tr>
<td>Speed (RPM)</td>
<td>56.7</td>
</tr>
<tr>
<td>Power (MW)</td>
<td>60</td>
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<tr>
<td>Blade Spacing (m)</td>
<td>8.8</td>
</tr>
</tbody>
</table>
John Day Application

Alden Turbine Predicted Fish Survival - John Day Dam

~99.9% for 200 mm smolts

~96% for 700 mm kelts
Turbine Application

Modernization

VOITH

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Solving flow problems since 1894
Turbine

Turbine Equipment Cost Data

![Graph showing the relationship between Turbine Price and Runner Diameter.](image-url)
## Relative Costs

### SIZING

<table>
<thead>
<tr>
<th></th>
<th>Alden Turbine</th>
<th>Conventional Francis</th>
<th>Conventional Kaplan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (mm)</td>
<td>3900</td>
<td>2510</td>
<td>2650</td>
</tr>
<tr>
<td>Power (MW)</td>
<td>11</td>
<td>11</td>
<td>11</td>
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</table>

### COSTING

<table>
<thead>
<tr>
<th></th>
<th>Alden Turbine</th>
<th>Conventional Francis</th>
<th>Conventional Kaplan</th>
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</thead>
<tbody>
<tr>
<td>Turbine</td>
<td>1</td>
<td>0.5</td>
<td>0.55</td>
</tr>
<tr>
<td>Generator</td>
<td>0.8</td>
<td>0.65</td>
<td>0.65</td>
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<tr>
<td>Installation and Comm.</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
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<tr>
<td>Automation/ BoP</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
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<tr>
<td>Relative Costs</td>
<td>2.3</td>
<td>1.65</td>
<td>1.7</td>
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</table>

*Premium for Alden*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>39%</th>
<th>35%</th>
</tr>
</thead>
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Questions?

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