FUTURE APPLICATION OF THE ALDEN FISH-FRIENDLY HYDRO TURBINE

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ALDEN
Solving flow problems since 1894

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VOITH HYDRO
POWER GENERATION
ALDEN TURBINE DEVELOPMENT

Conceptual Design - Biocriteria

- 40 ft/s peripheral runner speed
- 69 kPa minimum pressure
- 552 kPa/s maximum pressure change
- 4.6 m/s/cm maximum shear
- Minimize number of blades and length of leading edges
- Maximize distance between runner and wicket gates and minimize clearance between other components
- Maximize size of flow passages
ALDEN TURBINE DEVELOPMENT
Pilot-Scale Biological Evaluation

**SPECIES TESTED**

- American eel
- White sturgeon
- Coho salmon
- Rainbow trout
- Smallmouth bass
- Alewife

**PREDICTED SURVIVAL**

97 – 100%
ALDEN TURBINE DEVELOPMENT

Final Development and Model Testing

U.S. Department of Energy awarded grant to EPRI team to conduct final development and model testing

Objective: Develop a robust design for commercial application

- Turbine runner refinement
- Stay ring and stay vanes
- Wicket gates
- Head cover
- Shafting, bearings, and seals
- Model construction and testing
- Ready for fabrication and installation at selected site
ALDEN TURBINE DEVELOPMENT
Considerations for Future Application

- Increase capacity at existing hydro projects
- Non-powered existing dams
- New Development
- Fish bypass systems
- Minimum flow releases

Head range: 20 to 120 ft (or higher?)
Flow range: 500 to 2,000 cfs (or more?)
New powerhouse with Alden turbine.

Angled bar rack upstream of existing powerhouse leading to Alden turbine.

Blueback herring and American eel.

First time U.S. resource agencies have accepted a turbine for passing fish downstream.

**Brookfield Renewable Power’s School Street Project**
- Operating Head: 92 ft
- Turbine Flow: 1,500 cfs
- Power Capacity: 11 MW

*American eel*  
*blueback herring*
### FUTURE APPLICATION

**School Street Hydroelectric Project**

<table>
<thead>
<tr>
<th></th>
<th><strong>Alden Turbine</strong></th>
<th><strong>Kaplan MGR</strong></th>
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<tbody>
<tr>
<td>Runner Diameter (m)</td>
<td>12 ft</td>
<td>8 ft</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>13 ft/s</td>
<td>36 ft/s</td>
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<tr>
<td>Relative Velocity (m/s)</td>
<td>42 ft/s</td>
<td>58 ft/s</td>
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<tr>
<td>Fish Survival</td>
<td>96.7%</td>
<td>83.5%</td>
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<tr>
<td>(fish length = 100 mm)</td>
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*Fish survival is expected to exceed 98% for Alden Turbine with thicker blade leading edges*
FUTURE APPLICATION

Hadley Falls Analysis

- Head: 35 ft
- Flow: 1,200 cfs
- Runner diameter: 13 ft
- RPM: 72 rpm
- Leading edge thickness: 6 inches
- Distance between blades: 13 ft
- Strike velocity: 25 ft/s

[Image of Hadley Falls analysis]
FUTURE APPLICATION

Hadley Falls Analysis

### Fish Length (mm) (inches)

0 100 200 300 400 500 600

#### Turbine Passage Survival (%)

- 80.0
- 82.5
- 85.0
- 87.5
- 90.0
- 92.5
- 95.0
- 97.5
- 100.0

- Atlantic salmon
- Shortnose sturgeon

### Fish Length (mm) (inches)

- (4)
- (8)
- (12)
- (16)
- (20)
- (24)
EPRI has completed an industry solicitation for potential additional demonstration sites for the fish-friendly Alden turbine.

Proposed sites have been evaluated using specified engineering, operational, and biological criteria, including:

- 40 to 80 ft head
- 1,000 – 2,000 cfs turbine flow
- Added capacity at existing dam or new development
- Presence of important species (eel, salmon, sturgeon, shad, herring)

Based on the initial screening process, three projects have been selected for a detailed feasibility assessment and preliminary design and cost estimates.

Site selection process will be completed by the end of 2010.