A New Low Head Turbine

Northwest Hydroelectric Association: Low Impact Hydropower Workshop

September 22-23, 2010
The Riverhouse, Bend, Oregon
Why low head hydropower?

1,200 cfs through 10 feet is 1 MW
Why low head hydropower in canals / conduits?

Minimal environmental impacts

Multiple benefits
Significant conduit potential compared to in-stream low head

California Navigant study concluded **255 MW** of in-conduit potential in CA that is not reflected in any of the DOE resource assessments.
However:

Scant development of 100’s of GW potential
Why?

Cost.
Conventional hydro technology:
high cost at low head
SLH: Simple, Low cost, Highly scaleable

- Water intake
- SLH cassette
- Housing
- Idler shaft
- Lid (removable to lift out cassette)
- Output shaft (drives generator)
- Outlet to draft tube
Filling a competitive void

<table>
<thead>
<tr>
<th>head</th>
<th>turbine type</th>
<th>efficiency</th>
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</thead>
<tbody>
<tr>
<td>low</td>
<td>impulse</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>SLH</td>
<td>50%</td>
</tr>
<tr>
<td>medium</td>
<td>crossflow, Turgo</td>
<td>60%</td>
</tr>
<tr>
<td>high</td>
<td>Pelton</td>
<td>80%</td>
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<tr>
<td></td>
<td>reaction</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Kaplan, propeller</td>
<td></td>
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<td></td>
<td>Kaplan, Francis</td>
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better for low-head
Strong performance over wide range of flows…

…without blade or wicket gate servos

…at fixed shaft speed
No cavitation
(reduce excavation cost & uncertainty)

Scenario:
SLH-50, 4 m head
106 kW, 129 cfs
Example bypass or run of river layout
Buckeye South Extension Project
from an old irrigation drop...
...to a grid-connected pilot plant

Old irrigation drop  Construction completed winter 2009  Grid-connected April 2010
Pilot Plant: Buckeye, AZ

Irrigation drop owned by Buckeye Water Conservation & Drainage District. Power sold to Arizona Public Service. Project uses an SLH-10 unit, with a rating of 25 kW at 4 m head.

From left, Abe Schneider, Ed Gerak (District General Manager), Joe Blankenship and Ken Saline standing downstream of site

The old South Extension drop structure
Pilot Plant: Buckeye, AZ, continued

December 2008: Buckeye completed work on drop and canal. Project required an “exemption from licensing” from FERC before it can connect to the grid.

April 19, 2009: Public comment period closed with no comments raised.

September 2, 2009: Letter granting FERC Exemption issued

December 2009: SLH engine installed
View looking along intake out towards draft tube

Dan Schneider and Ed Gerak

Switchgear

SLH

Generator

View looking down on the SLH from above
Water back on: December 12, 2009
Running in off-grid mode prior to grid-connection
Security fence installed around powerhouse

Installation of the pole and transformer
Grid-connected April 23, 2010
Commissioning event held on May 4, 2010
## Buckeye South Extension Recap

<table>
<thead>
<tr>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
</tr>
<tr>
<td>Draft application filed with FERC</td>
<td>Supplemental information (publication of public notice) filed with FERC</td>
<td>Final application filed with FERC containing results of first consultation process and waivers of second consultation process</td>
</tr>
<tr>
<td>Final application accepted for filing by FERC starting 45 day comment period</td>
<td>45 day comment period closes; no comments; application moved to FERC internal review process</td>
<td>Exemption granted</td>
</tr>
<tr>
<td>All drawings approved</td>
<td>Final site drawings filed with regional FERC office</td>
<td>Installation of SLH</td>
</tr>
<tr>
<td>Interconnect application filed with APS</td>
<td>Off-grid operation of SLH</td>
<td>Interconnect Commission event</td>
</tr>
</tbody>
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Experience at Buckeye

FERC Exemption
Integrated Civil – Machine Design
Programming for PLC and SCADA
Construction and Installation
Interconnection
Operating Data
Natel Pilot Program

Canal Diversion

5 – 20 Ft Drop

Variable Flow is Acceptable

Potential for cost participation on project
Summary Points

• Primary barriers to new low-head hydro development are 1) cost and 2) environmental, particularly fish passage

• Our product cuts the cost of the water-to-wire package by as much as 50% over competing technology for low-head applications

• Our product is fish friendly (downstream passage)

• Product line will have 5 unit sizes → 20 kW, 100 kW, 200 kW, 400 kW and 1 MW targeting sites with heads (dam height) between 5 and 30 feet and per-unit flows ranging from 20 to 1,500 cfs

• Demonstrated technology → tested in lab and field settings; 10,000 hours of field test operation; pilot commercial project installed in December 2009
Thank You

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