ROARING RUN AMD TREATMENT SYSTEM WITH MICROHYDRO TURBINE POWER GENERATION PLANT

Presented by:
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&
- **LTC(R) JAMES H. BOSCHMA, BOSCHMA RESEARCH, INC.**

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Cyclo-Turbine Power Generation

Kiskiminetas River Project

Project Goals

1) Demonstrate a Venturi to treat AMD to remove iron and increase pH while reducing or eliminating the need for chemicals.

2) Demonstrate a submerged Cycloidal turbine and generator effectiveness in shallow, low head flow by driving a pollution treatment plant requiring 20 kW at an abandoned mine "off-the-grid."

Kiskiminetas Research Team

Roaring Run Watershed Association, Grantee and overall management

Marmo Consultant, Inc., Program Manager and construction coordinator with additional responsibilities for Permitting and License support

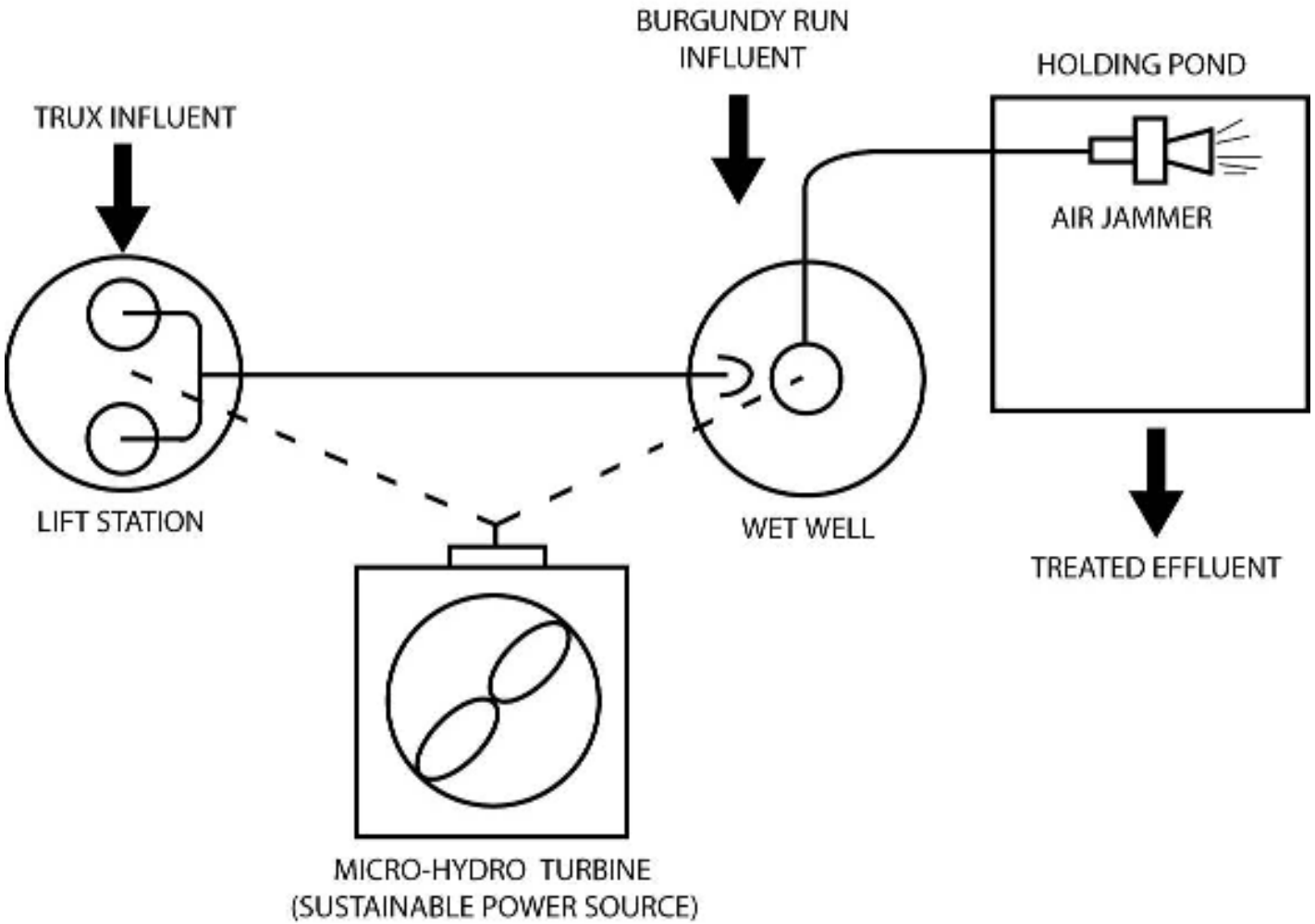
Boschma Research, Inc., Turbine and power generation design and fabrication with additional responsibilities for operational assessment and system upgrades for performance, maintenance, and operations

Oak Ridge National Laboratories, Technical supportin permitting & science

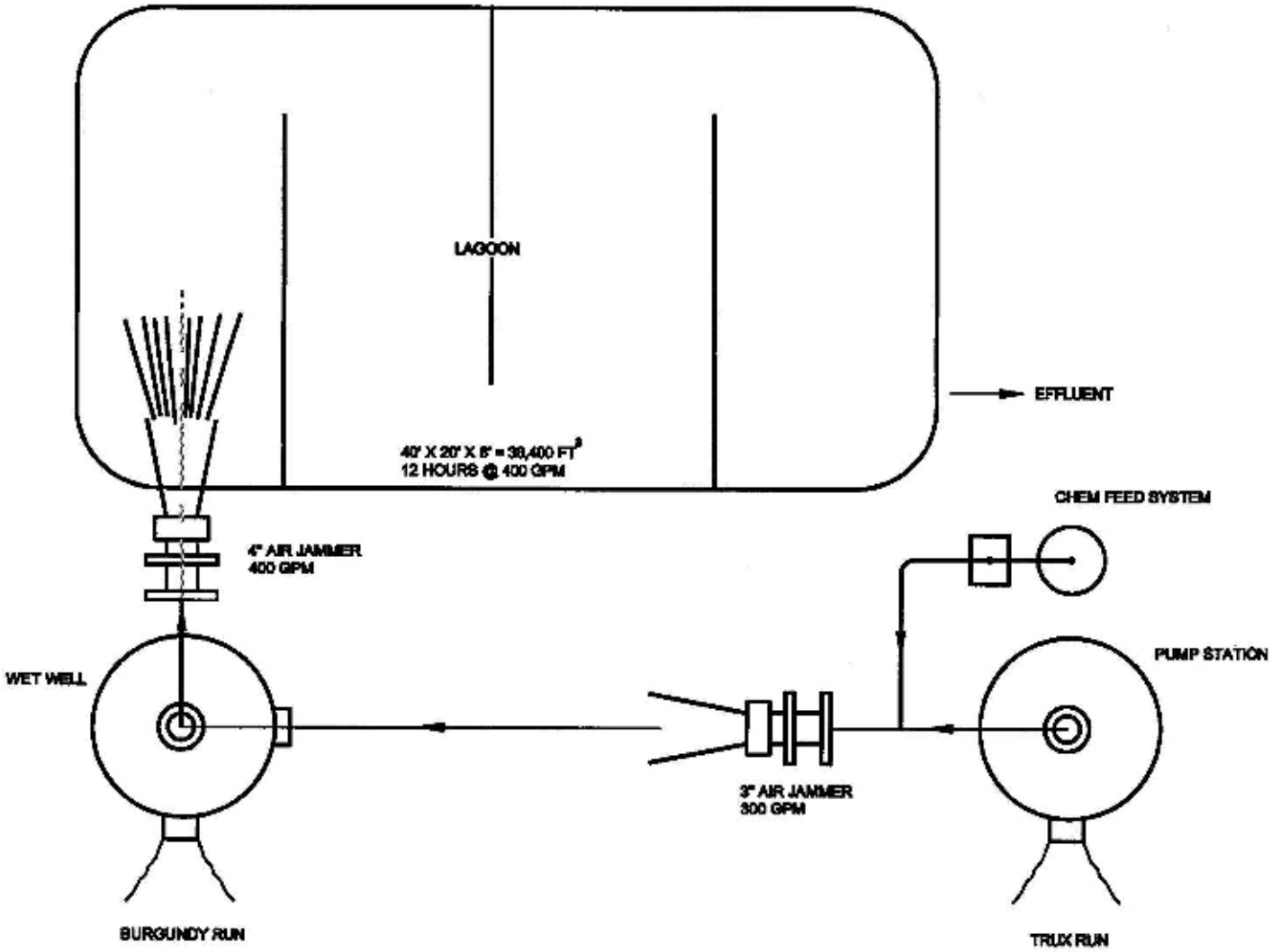
Allegheny Power, Utility (tech support in renewables)

Alden Laboratories: Site specific Venturi design, construction requirements, and performance evaluation, CFD and physical modeling

Roaring Run
AMD Treatment System



RRWA AMD Treatment



Features

- **Air Jammer Venturi Aerator/Mixer**
  - Flow rates from 50 GPM to 5000 GPM
  - Aerator and Mixer in one machine
  - Compact – 1200 GPM is 6” diameter x 52” long
- **Air Jammer Venturi Aerator**
  - Advantages Include
    - Supersaturated Iron Oxidation
    - Reduce or eliminate chemicals
    - CO_2 stripping to raise pH
    - Reduced power consumption
    - Reliable – no moving parts

Problem

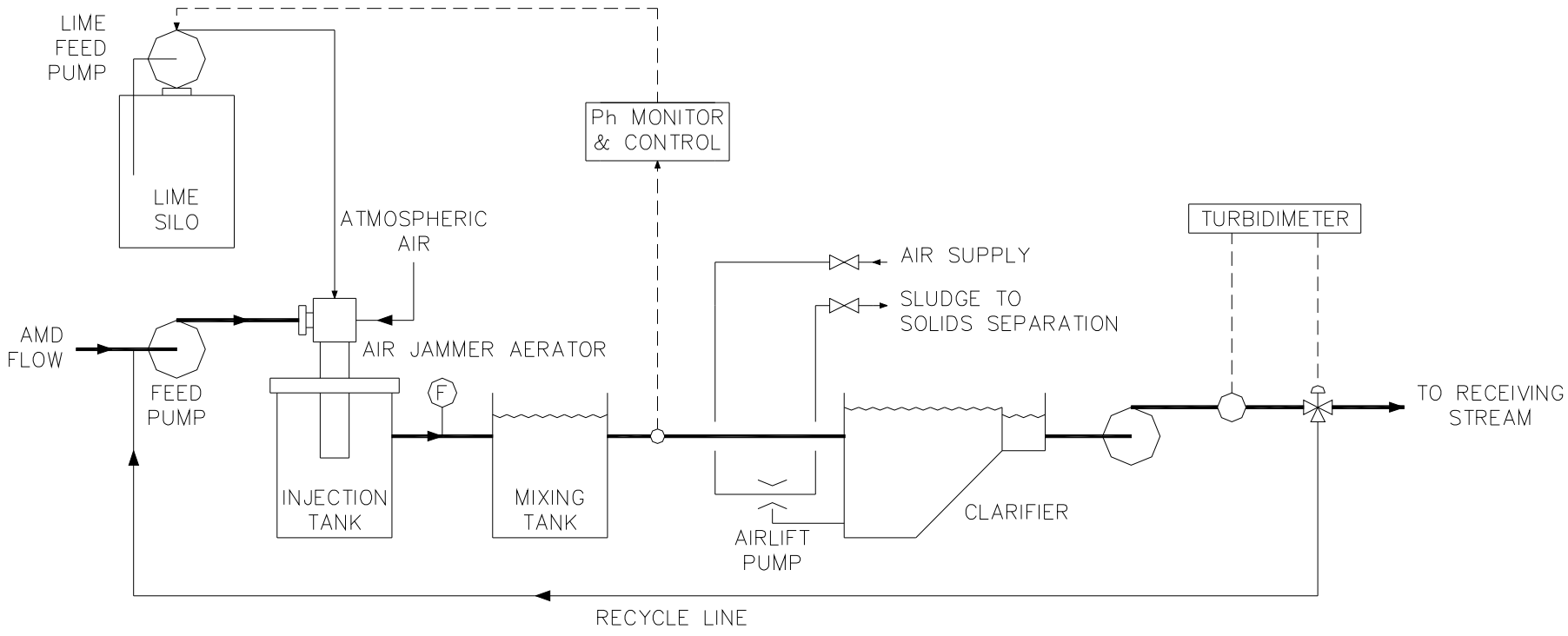
❑ Case #1: Abandoned Lion Mine Site

- AMD Flow Rate 725 GPM
- Ferrous Iron Content 90 PPM
- Influent pH 5.8
- Iron Content Final 5 PPM
- pH Final 6.8

❑ Case #2: Abandoned Rosebud Mine Site

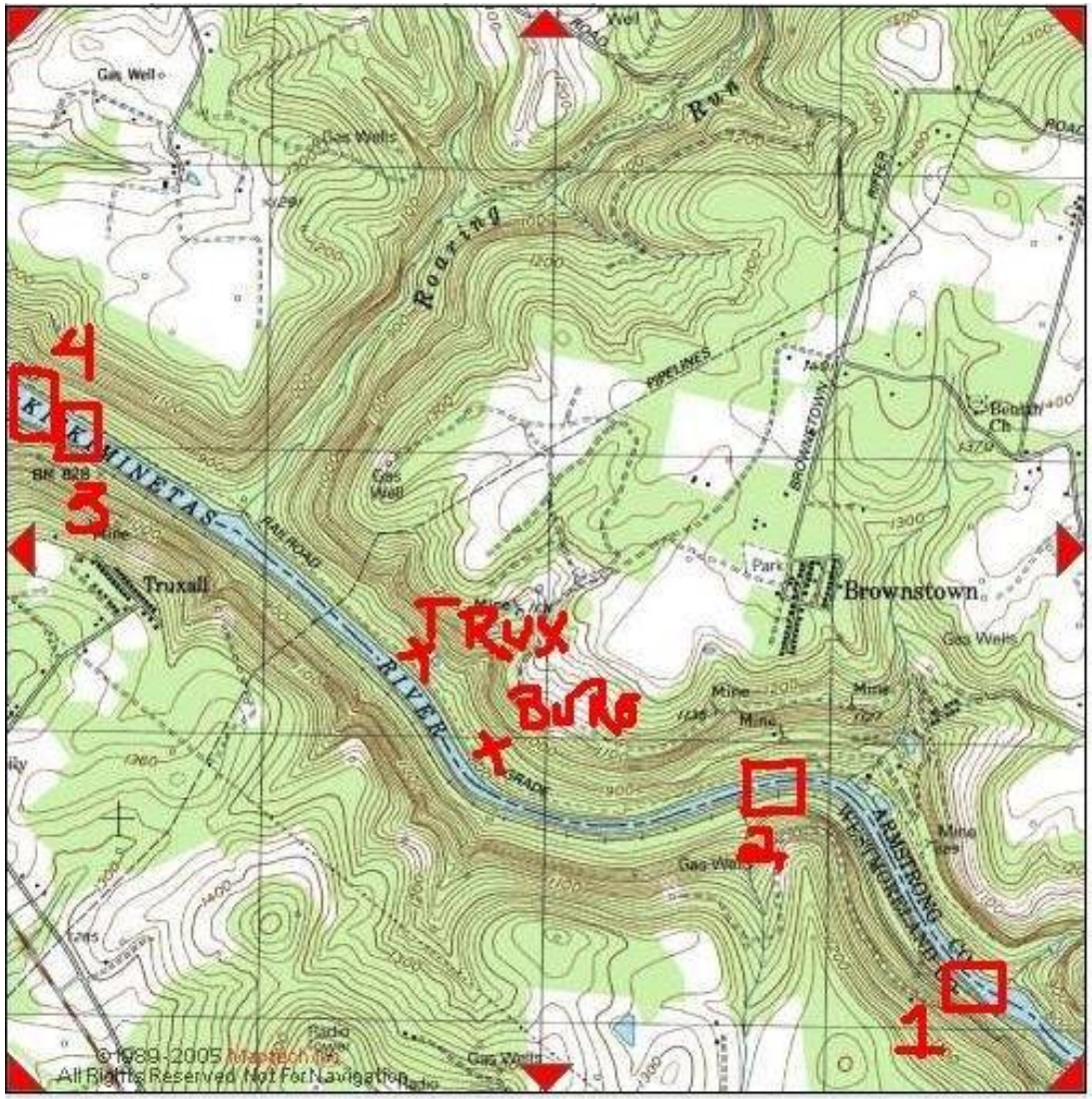
- AMD Flow Rate 600 GPM
- Ferrous Iron Content 30 PPM
- Influent pH 5.8
- Iron Content Final 0.5 PPM
- pH Final 6.9

Air Jammer Aerator System
Acid Mine Drainage Treatment



FEED PUMP – 4000 GPM @ 90 FT TDH

Map


Gas Well
Gas Wells
Roaring
Run
ROAD
PIPELINES
BROWNSTOWN
Beech Ch
Truxall
Brownstown
Park
Mine
Gas Wells
RIVER
RAILROAD
ARMSTRONG
WESTMORELAND
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Burg
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Lion Pond East

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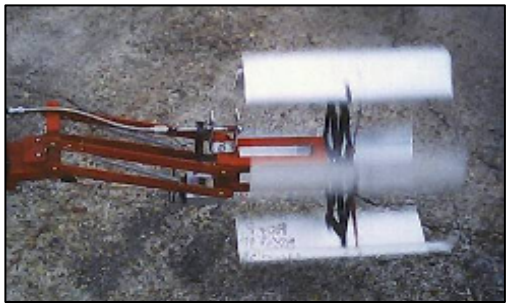
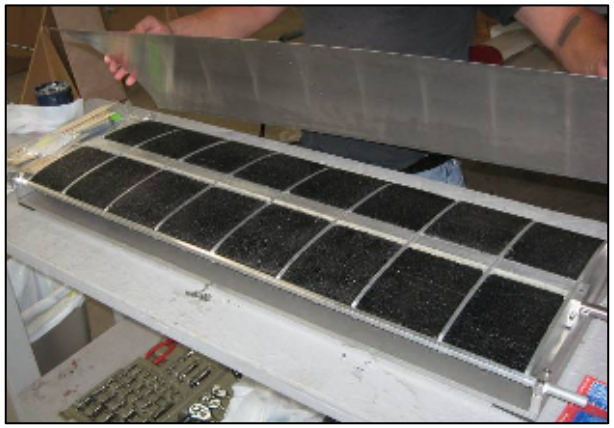
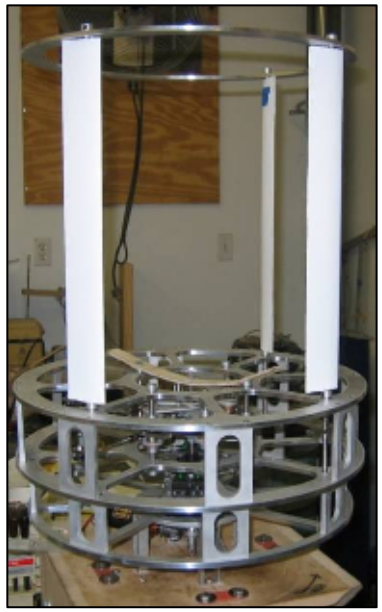
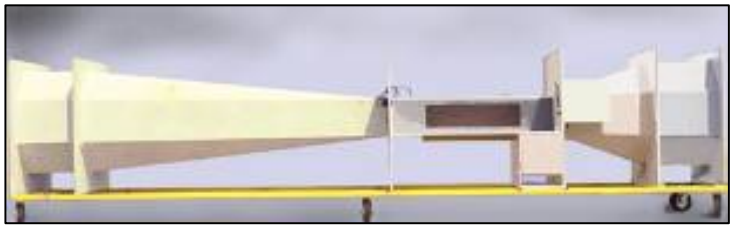
Cycloidal Activities









Cyclo-Turbine Generator Applications

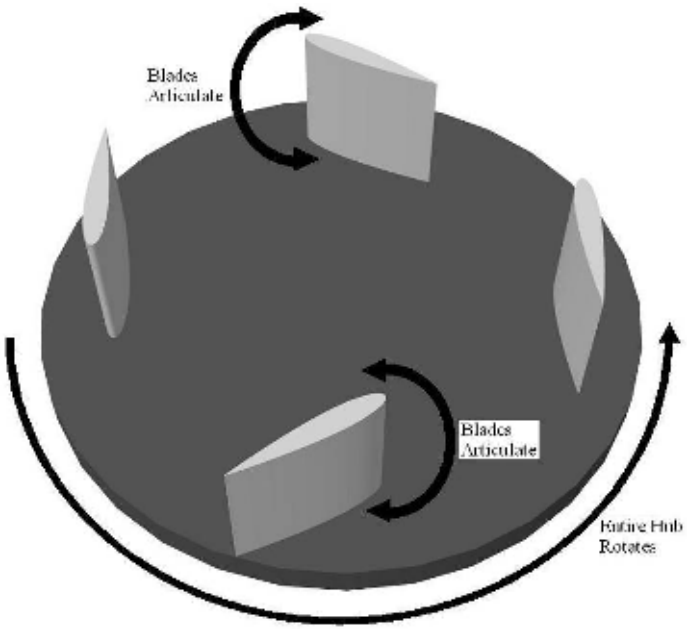
Free-stream Cyclo-Turbines operating in rivers, canals, and tidal areas can generate power at levels rivaling output from large dams on major rivers.

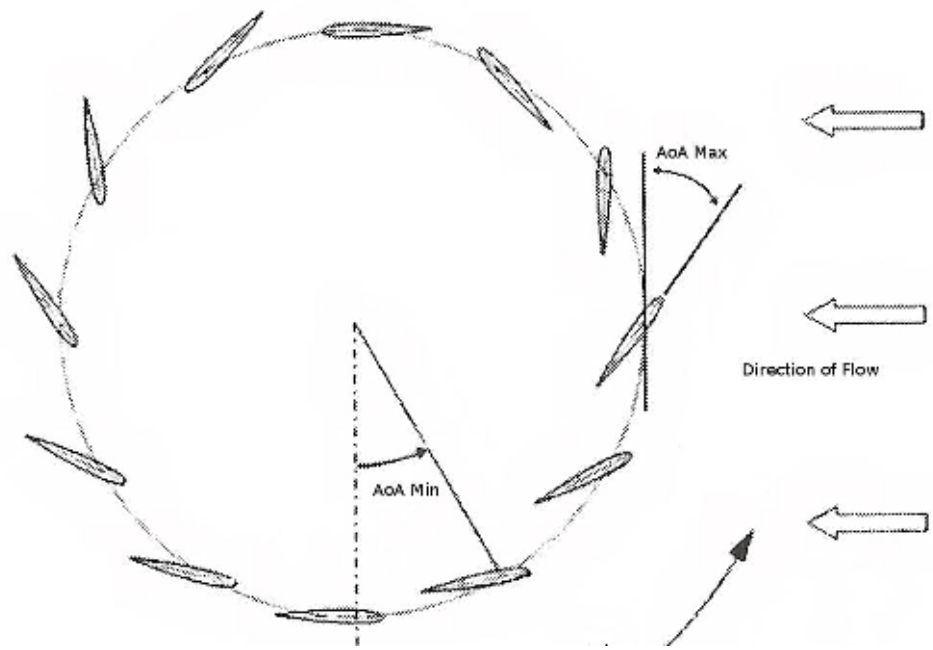
The Cyclo-Turbine overcomes many environmental concerns, eliminating the need for new dams, river locks, and fish ladders.

But, perhaps more significant is its ability to operate efficiently in hundreds of thousands of miles of shallow rivers and minor tidal flows found around the world.

What is a Cycloidal Turbine?

Visually similar to a common paddlewheel; however, functionally the Cycloidal Turbine is able to vary individual blade angle-of-attack (AoA) during rotation to optimize lift and torque extraction from flowing water.

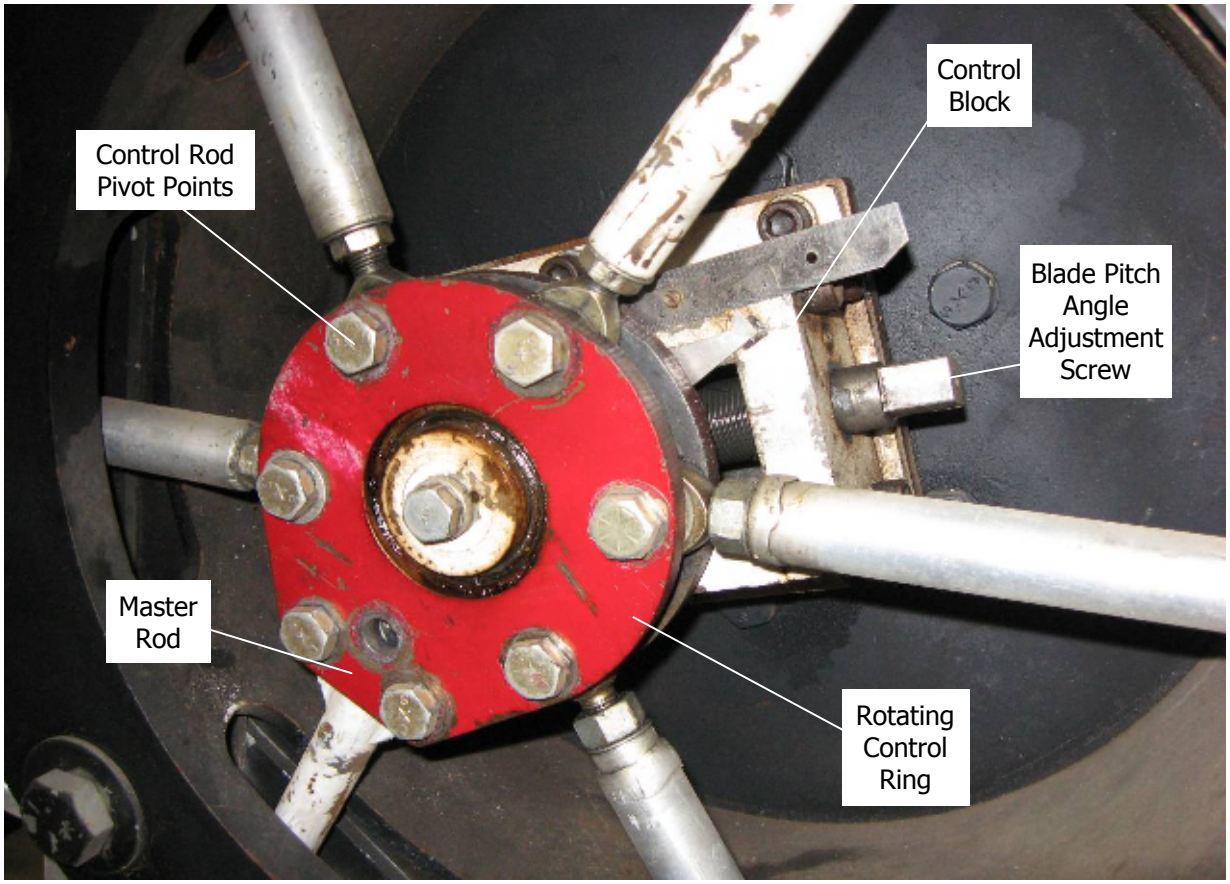




Eccentricity for Control

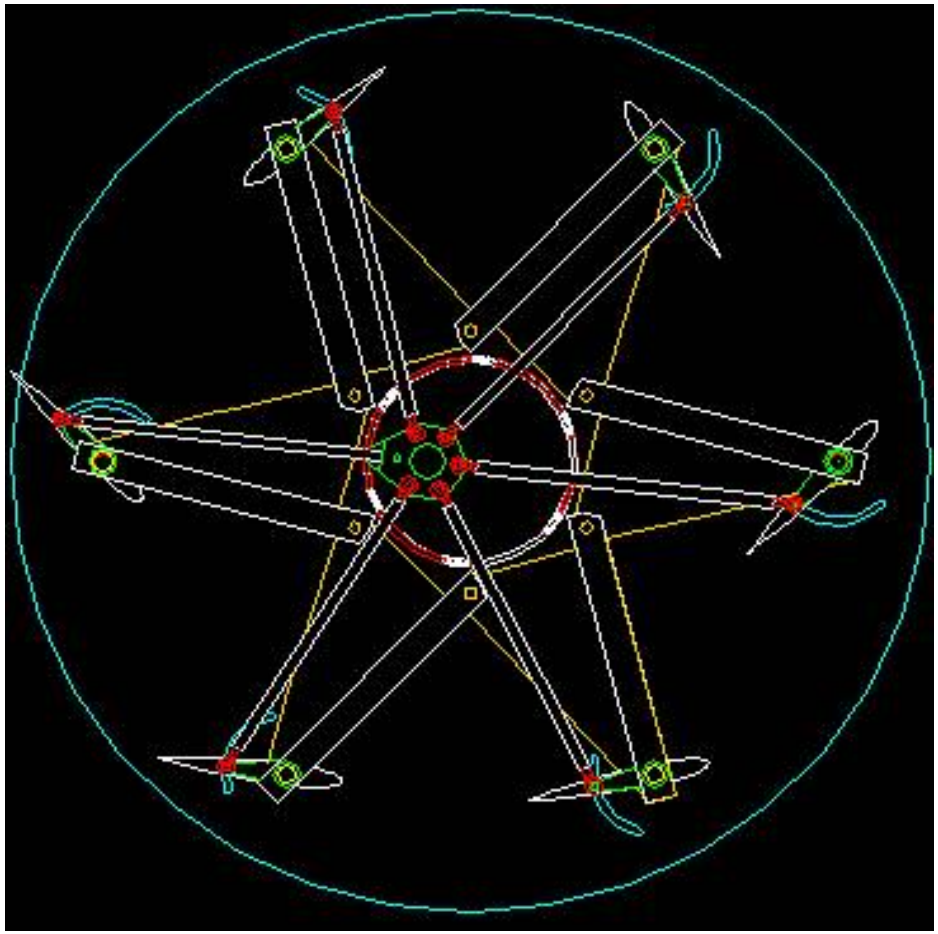
- AoA is achieved by the eccentricity between the rotor axis and the center of the of the rotating control ring.
- The control ring is mounted on a non-rotating control block and the eccentricity of the control ring can be varied by the pitch angle adjustment screw.
- Phase angle (point of Max AoA) can be adjusted via a worm and ring gear arrangement.
- The blades are connected to the Control Ring by push/pull tubes.

Cyclo-Turbine AoA Control



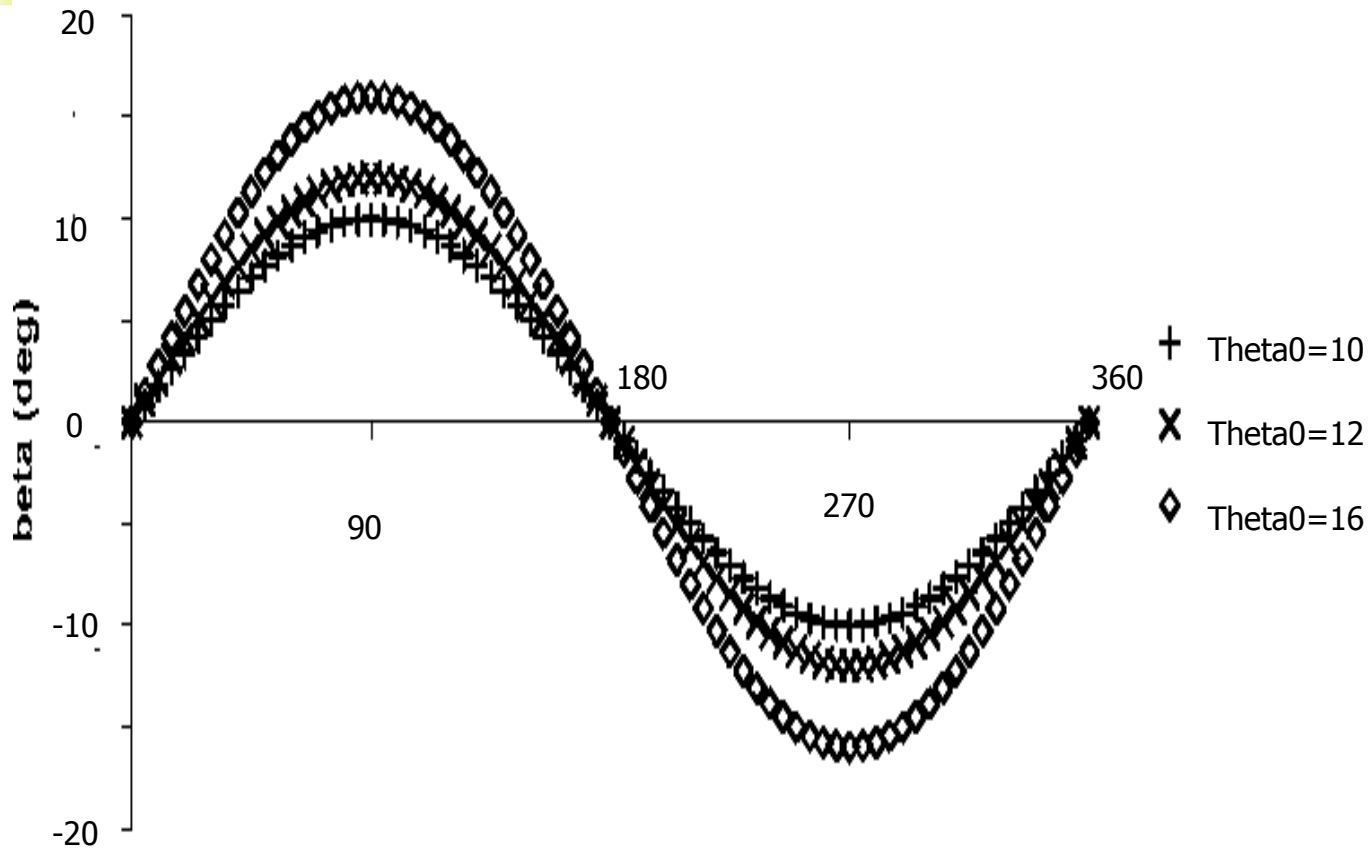
Configuration of the Blade Control Mechanisms
(Control Block is white; Control Ring is red)
The Phase adjustment is accomplished by a worm and ring-gear not shown.

Cyclo-Turbine AoA Control



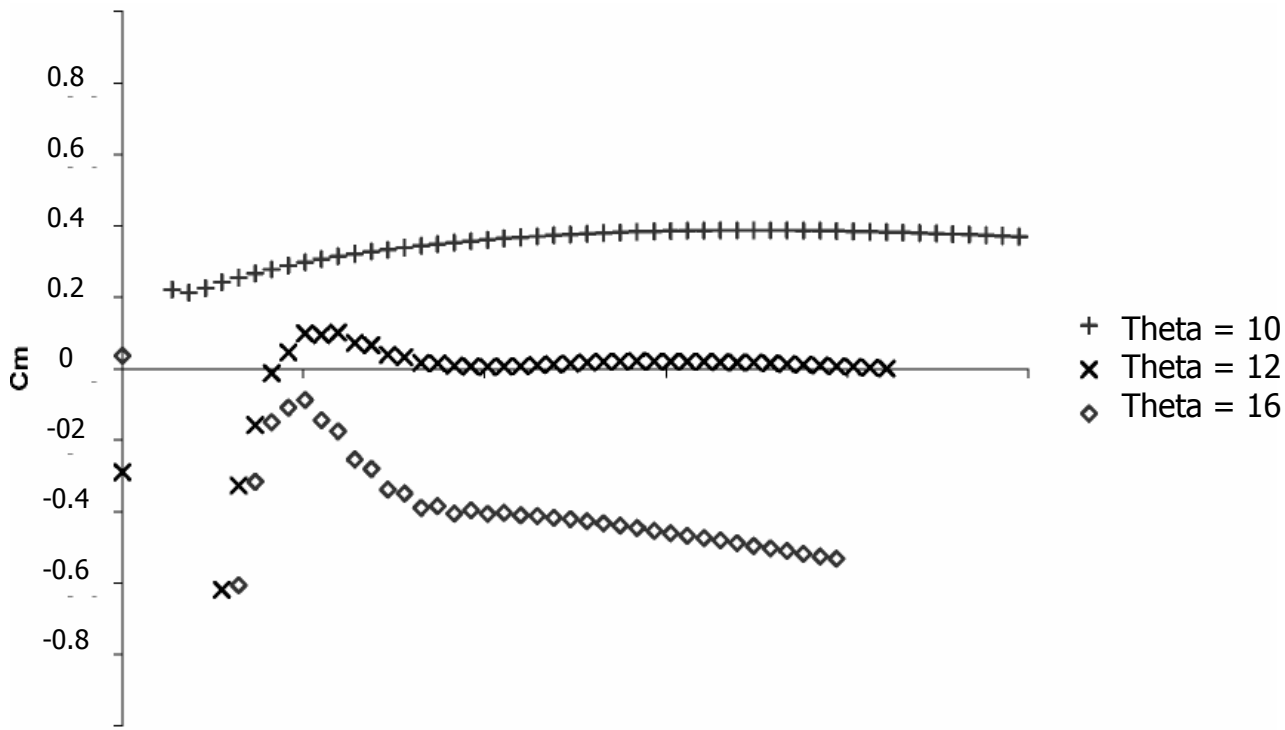
Eccentricity/AoA Control Graphic

Single Blade AoA vs. Orbit Position



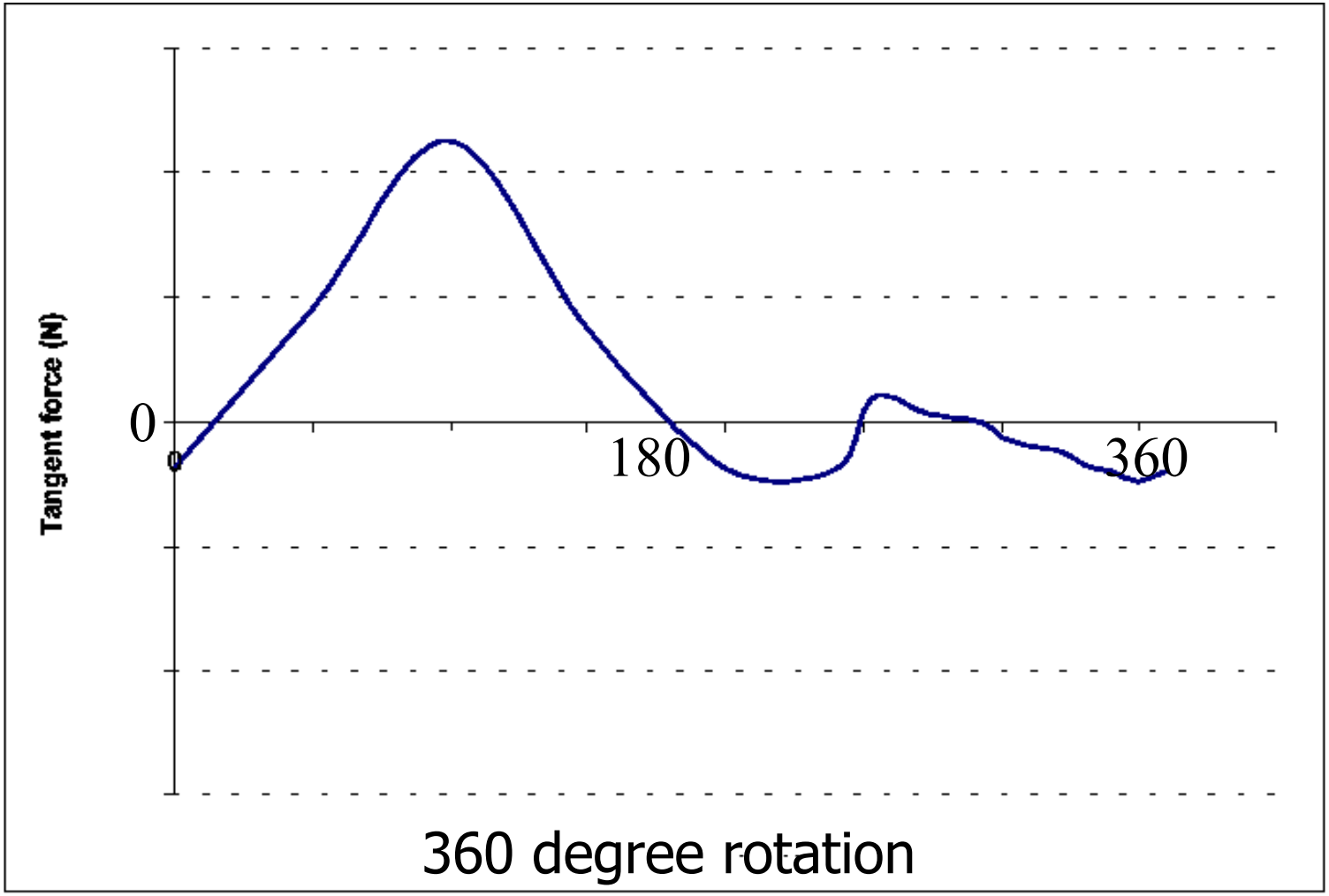
Angle of vane to tangent, Theta, as a function of orbital angle, beta. Three angles examined. Note: Sinusoidal Curve

Cyclo-Turbine Concept



Moment coefficient for the turbine for three vane tangent angles.

Force vs. Angular Blade Position



Horizontal Installation

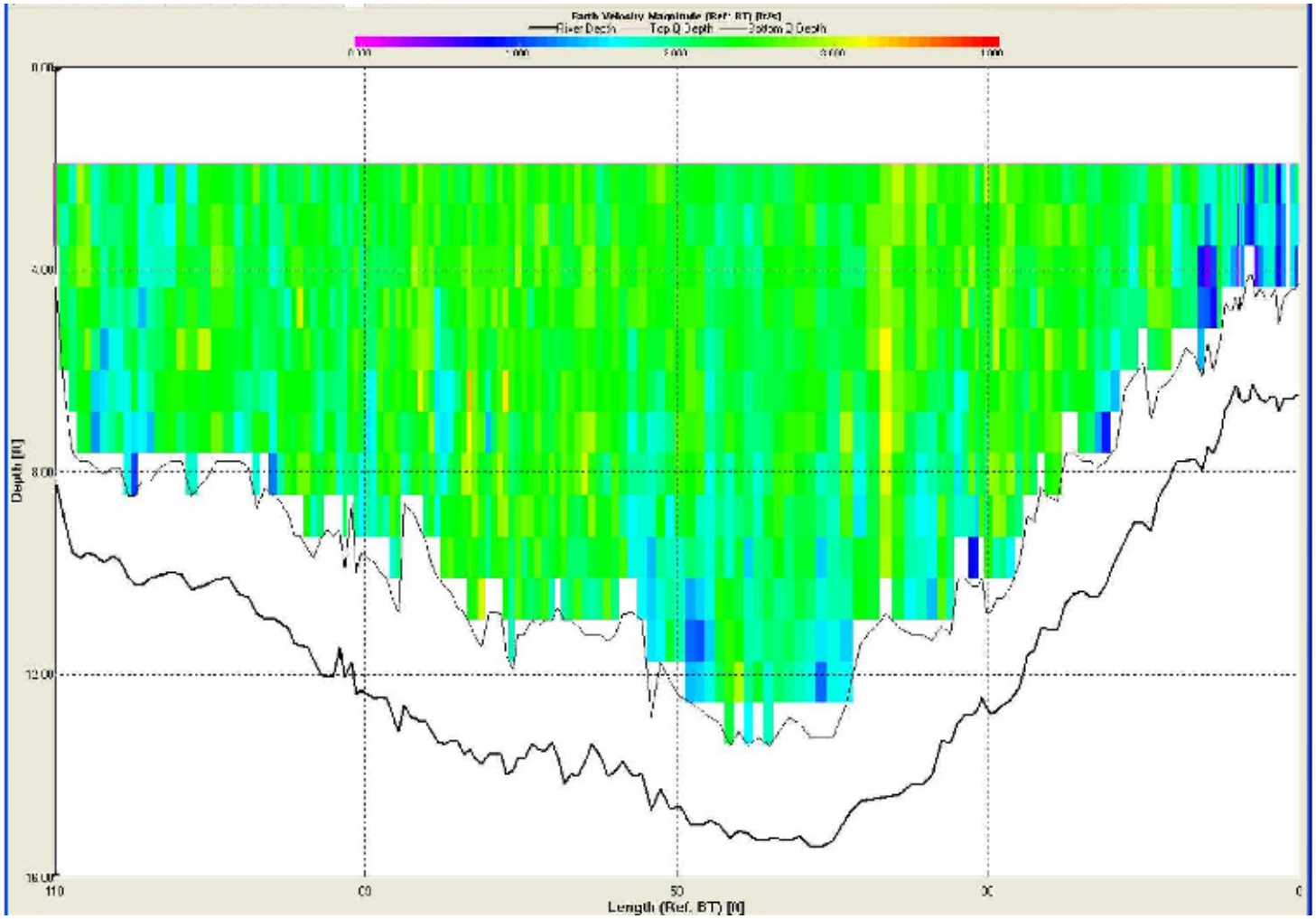
Horizontal Installation: The axis of rotation is parallel to the rivers surface, and the blades are mounted in a cross flow direction to span the flow.

There are four ways to increase torque output:

- **Increase the diameter of the turbine**
- **Increase the velocity of the flow**
- **Increase the span of the blades**
- **Mix any or all of the above**

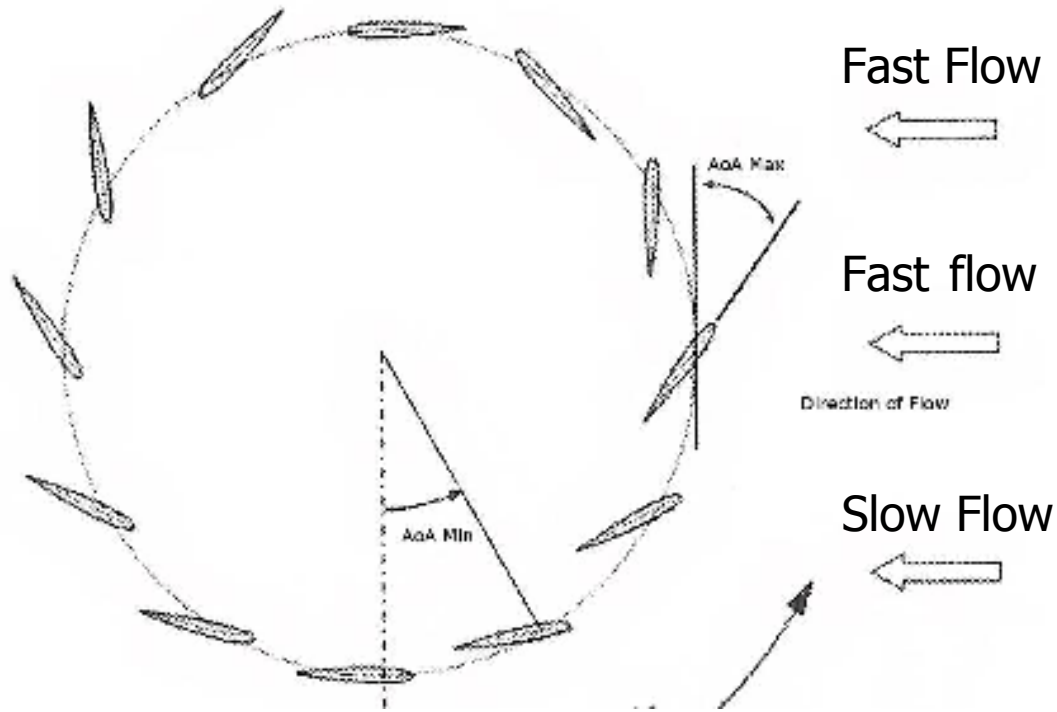
For shallow-river applications, the horizontal Cycloidal Turbine facilitates extraction of energy from the span of the river. Performance can also be enhanced by flow acceleration techniques, such as Venturi installation.

River Flow Characteristics



Flow near bottom and sides is slowest

Horizontal Installation Advantage

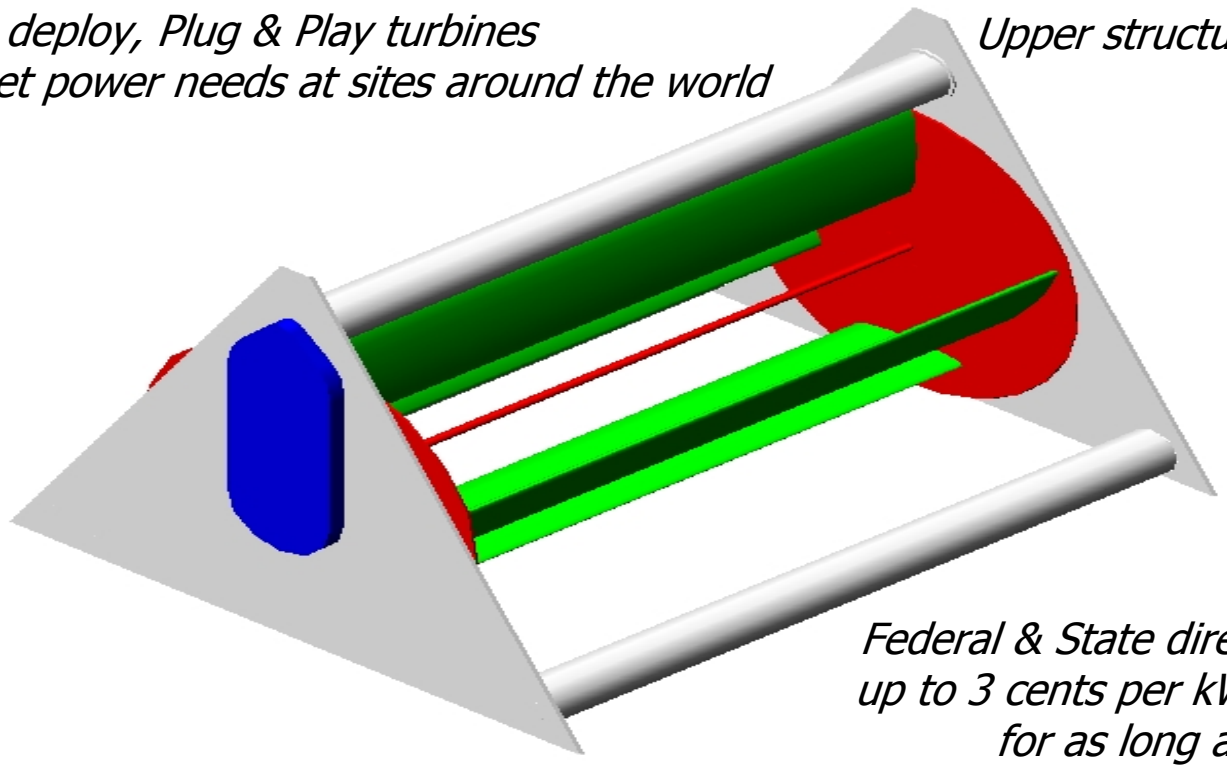


Slow Flow near bottom
minimizes drag on advancing blades

Plug-and-Play Cyclo-Turbine Concept

Easy to deploy, Plug & Play turbines can meet power needs at sites around the world

Alternators contained in the Upper structural support tube



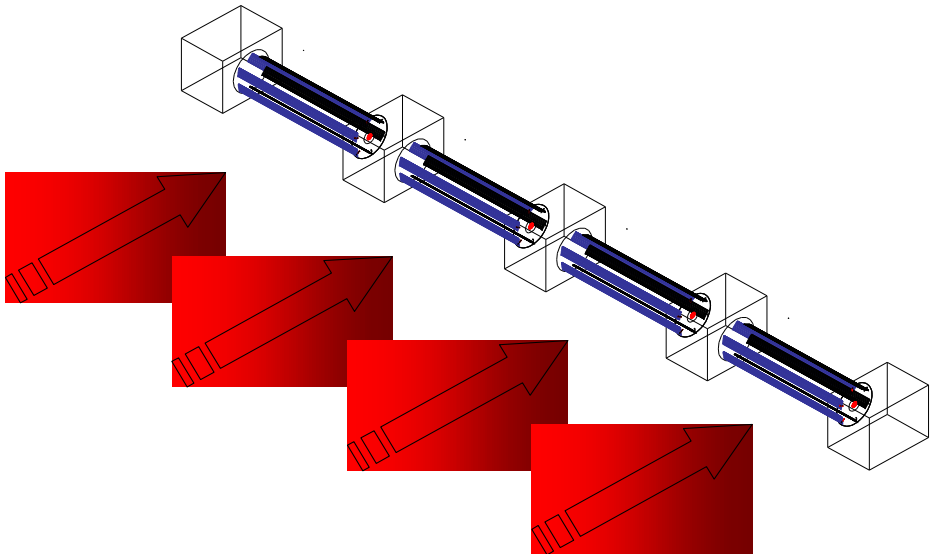
Federal & State direct pay benefits of up to 3 cents per kW hour can gained for as long as 10 years

Easily deployed, turbine provides direct interface to Controller/inverters via marine electric cable

Linking Cycloidal Generators

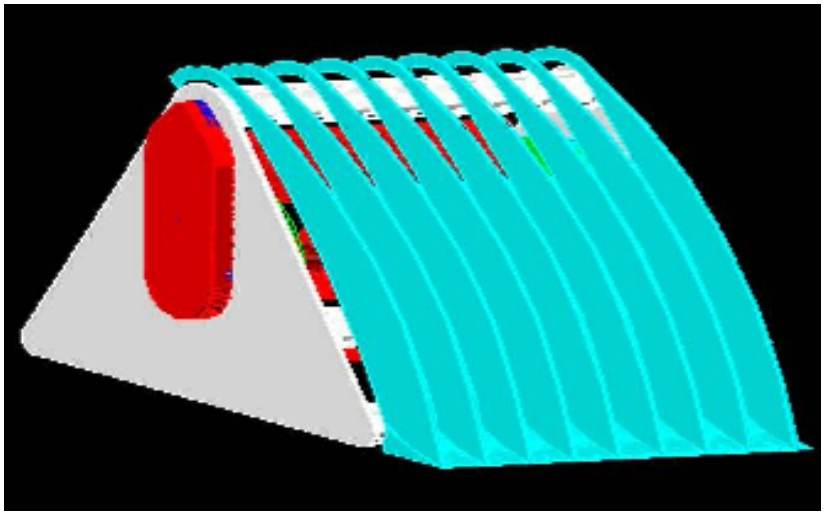
Cyclo-Turbines can be mounted horizontally for shallow-water installation to efficiently extract torque from flow across the entire blade span.

Turbine sections can be linked to span flow and maximize efficiency, reduce construction and lower maintenance costs. Proprietary flow director may increase performance > 5%.

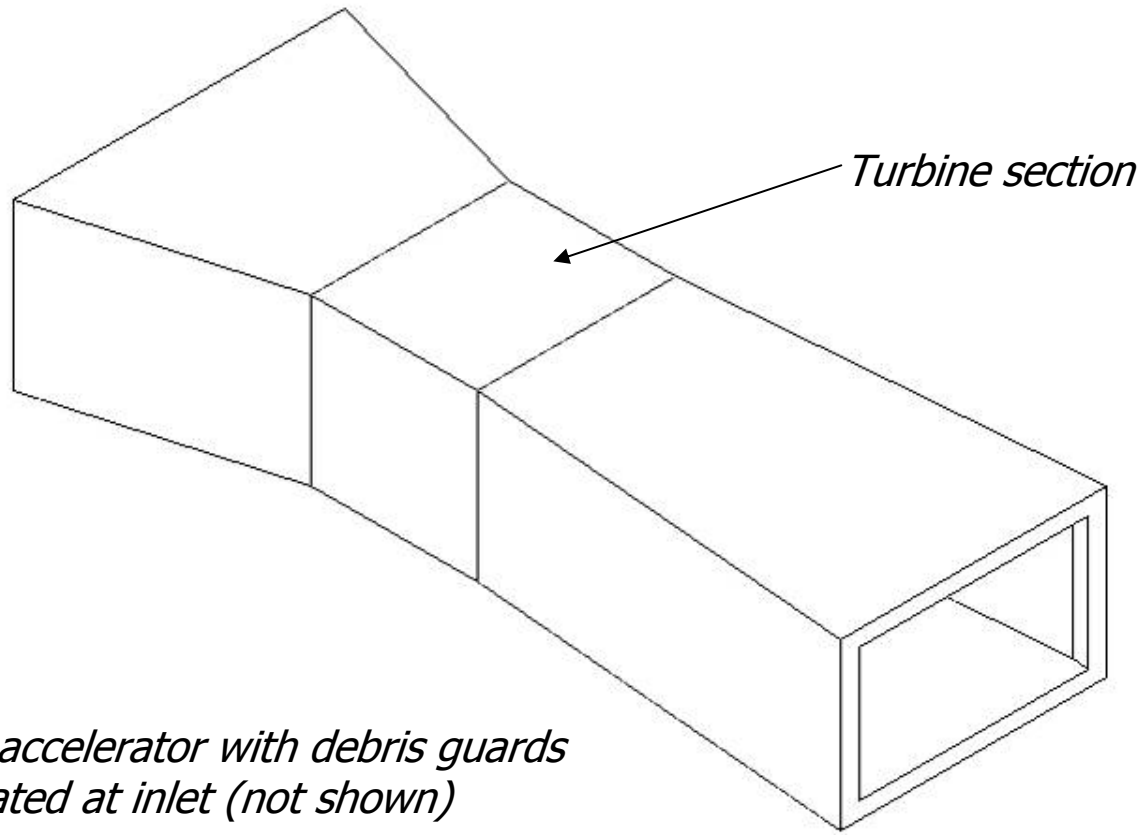


What About FOD Control?

- A reinforced 'cow-catcher-like' debris guard is placed up stream to filter out Foreign Objects: fish, wildlife, and personnel are protected.
- Debris guard is robust, low-maintenance, and damage tolerant. Debris is forced over the top of the turbine.
- The guard can be removed for maintenance or access.
- A similar guard can be applied at mouth of Venturi flow accelerator.



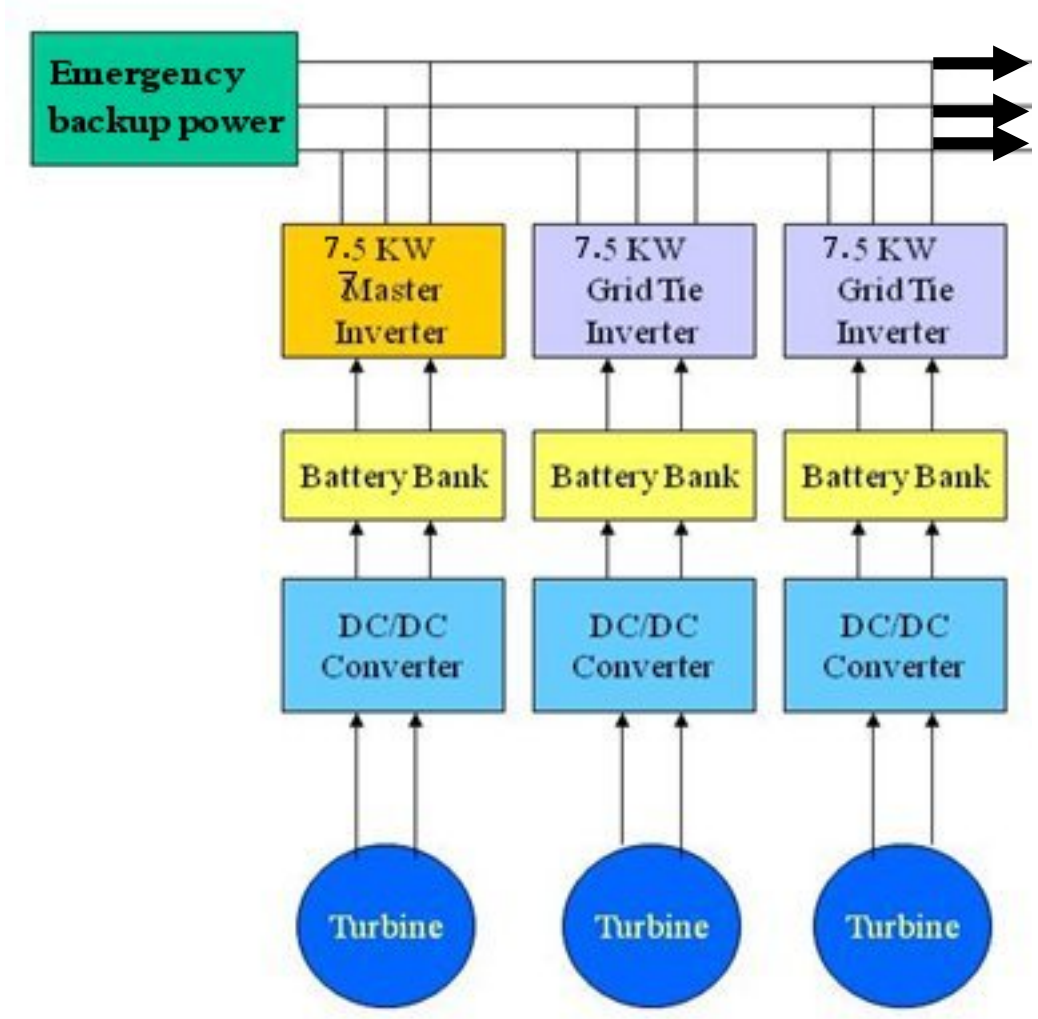
Kiskimenitas Flow Accelerator



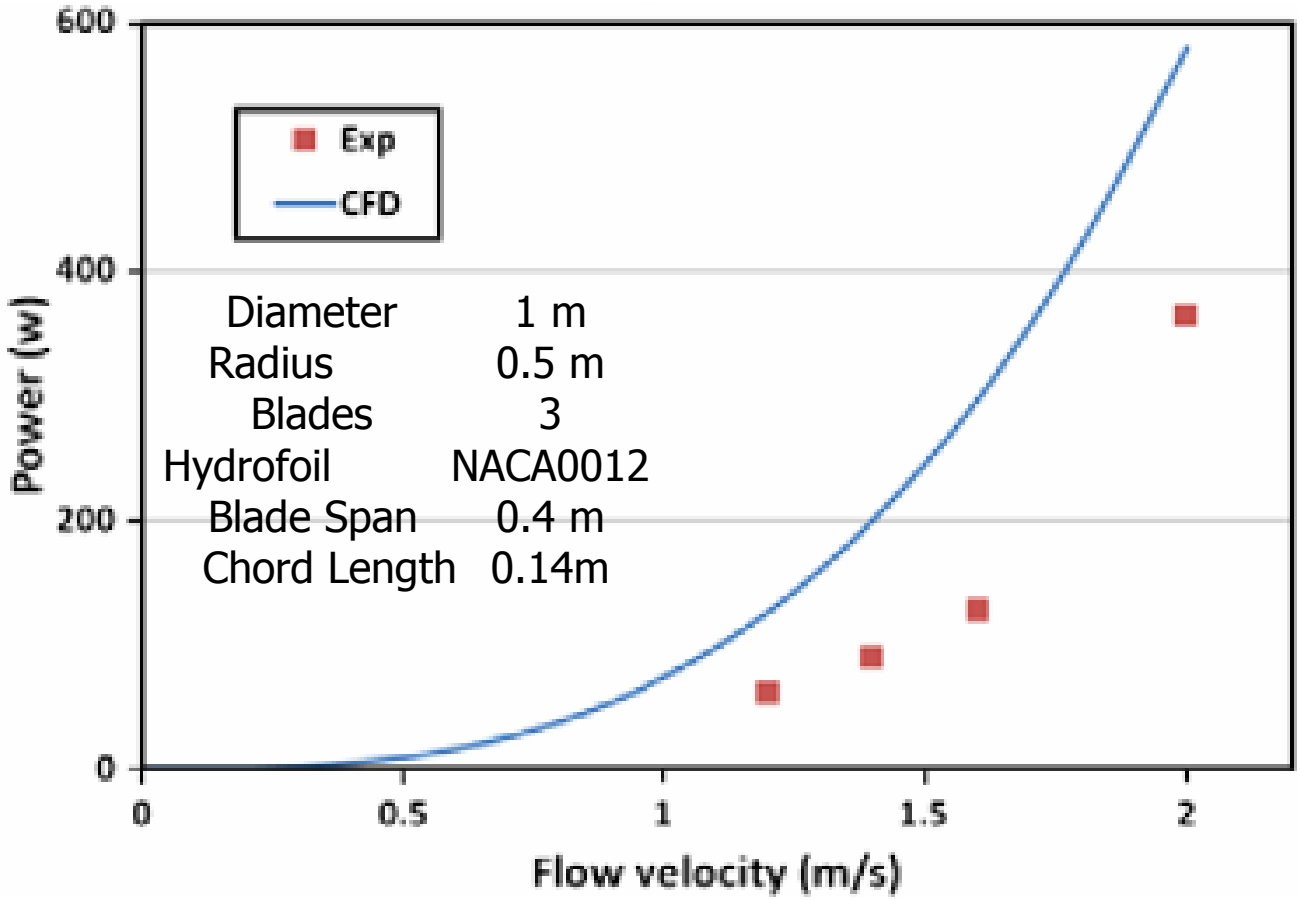
Venturi flow accelerator with debris guards Integrated at inlet (not shown)

Electric Power Production

23 kW system using multiple small Plug and play turbines



In-Water Test Data



These data are extracted from "Optimization of Cycloidal Water Turbine and Performance Improvement by Individual Blade Control" Authors-; In Seong Hwang, Yun Han Lee, Seung Jo Kim, School of mechanical and aerospace engineering, Seoul National University, Republic of Korea, released January 2009.

System Efficiency

- CFD studies show efficiency at Betz Limit, 59.3%
- In-Water testing demonstrated 46% efficiency, considerable higher than competing axial turbines
- BRI proprietary flow control techniques expected to yield >5% efficiency gain
- Substantial growth path for more efficiency gains such as blade MORFING, AoA tweaking, blade camber mods
- Alternative installation orientations (Vertical or horizontal) expand application opportunities to take advantage of most efficient technique for specific sites

Summary

- The project will provide and validate in operations of an advanced mine water pollution cure with international market potential
- Project benefits will include a Plug-and-Play shallow water Hydro-Kinetic power solution with numerous applications in Pennsylvania & elsewhere around the globe
- The combined AirJammer and Cyclo-turbine system provides a pollution free, zero carbon footprint solution in an environmental friendly, cost effective package

Boschma Research, Inc.

Service Disabled Veteran Owned Business (SDVOB)

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Bob Marmo

Curtate Motion

- Curtate Mode: Hydrodynamic forces are optimized by blade AoA control throughout the orbit of rotation
- High torque output and exceptional efficiency proven by IN WATER tests. Rotation 2 – 3 times the flow speed.
- Curtate motion will be used for the Kiskiminetas River project.

BRI 1.2m Curtate Cycloidal Turbine