

Catalog of Low Power Hydropower Technologies



U.S. Department of Energy
Energy Efficiency and Renewable Energy
Wind and Hydropower Technologies

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Catalog of Low Power Hydropower Technologies

**Douglas G. Hall, INEEL
Jennifer L. Dalton, INEEL**

IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

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Wind and Hydropower Technologies
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ABSTRACT

This catalog contains listings of low power (less than 1 MW) hydropower power generation equipment and concepts for this equipment. It is a living electric document that is expanded and revised as new or updated information is received, processed, and approved for public release. Technology information supplied by equipment vendors and developers is presented in a standard listing format. Listings contain a basic product or concept description, technical data (if available), company contact information, and a thumbnail company profile. No engineering assessment, verification, or validation of the information supplied has been performed. The information in listings is the sole responsibility of the information providers. The catalog is only accessible via the U.S. Department of Energy Hydropower Program website at <http://hydropower.inel.gov/>. The website allows the reader to view the catalog in its entirety, access specific sections of the catalog, and perform word searches on the catalog using the search utility provided by Acrobat Reader. The website also offers search capability that allows the reader to access technology listings of interest using specified criteria including: product development stage, design working environment, power output range, company name, years in business, and country.

CATALOG CONTACTS

For further information or comments, please contact:

Jennifer L. Dalton, Engineering Editor
Low Power Hydropower Resource Assessment and Technology Development Project
Idaho National Engineering and Environmental Laboratory
P.O. Box 1625, MS 3760
Idaho Falls, ID 83415-3760
Phone: (208) 526-0795
E-mail: daltjl@inel.gov

Douglas G. Hall, Project Manager
Low Power Hydropower Resource Assessment and Technology Development Project
Idaho National Engineering and Environmental Laboratory
P.O. Box 1625, MS 3850
Idaho Falls, ID 83415-3850
Phone: (208) 526-9525
E-mail: dgh@inel.gov

Garold L. Sommers, Program Manager
Hydropower Program
Idaho National Engineering and Environmental Laboratory
P.O. Box 1625, MS 3830
Idaho Falls, ID 83415-3830
Phone: (208) 526-1965
E-mail: sommergl@inel.gov

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ACRONYMS

BNI	Bechtel National, Incorporated
DOE	U.S. Department of Energy
EPRI	Electric Power Research Institute
FERC	Federal Energy Regulatory Commission
INEEL	Idaho National Engineering and Environmental Laboratory
KHPS	Kinetic Hydro Power System (see Verdant Power)
NHA	National Hydropower Association
NYPA	New York Power Authority
NYSERDA	New York Science and Engineering Research and Development Agency
PDF	Portable Document Format
TVA	Tennessee Valley Authority

NOMENCLATURE

Design capacity	The power a system produces when operating at design conditions (kW or HP)
Free-stream power	<p>The power of part or all of a free flowing body of water by virtual of its motion, which can be related to its kinetic or potential energy</p> <p>For kinetic energy systems: $P = k\rho V^3 A$</p> <p>For potential energy systems: $P = kQH$</p> <p>where: P is power k is a proportionality constant ρ is the density of water V is the free stream velocity A is the cross-sectional area of the turbine Q is volumetric flow rate H is hydraulic head</p>
Hydraulic head	The elevation difference over which potential energy is converted to kinetic energy (ft or m)
Power	The rate at which energy is produced or dissipated (kW or HP)
System efficiency	Ratio of system output power to free-stream power; for electricity generation systems, system output power is electrical power supplied to a load or an electrical grid
Turbine efficiency	Ratio of turbine shaft power to free-stream power

Catalog of Low Power Hydropower Technologies

INTRODUCTION

The U.S. Department of Energy (DOE) sponsored an assessment of the water energy resources of the United States performed by the Idaho National Engineering and Environmental Laboratory (INEEL). The assessment has been published in the report *Water Energy Resources of the United States with Emphasis on Low Head/Low Power Resources* (Hall et al 2004), available at <http://hydropower.inel.gov/resourceassessment/>.

The assessment estimated the annual mean power of all undeveloped water energy resources in the country not excluded from development by federal statutes and policies to be approximately 170,000 MW. Of this total, some 50,000 MW of potential power was attributable to resources having less than 1 MW of power potential. Partial use of the 120,000 MW of high power (1 MW or greater) resources could be developed using low power hydropower technologies. The study only addressed natural streams; therefore, the total water energy resources of the country are much larger if the flows in tidal waters, constructed water transmission systems, effluent streams, and ocean currents are included.

Given the large estimated power potential of untapped, natural water energy resources, the DOE Hydropower Program is interested to learn what technologies and concepts for new technology are currently available to capture resources having a potential power less than 1 MW. The DOE is committed to facilitating increased hydropower generation with low environmental impact through the use of damless hydropower technologies.

This catalog showcases low power hydropower technologies from around the world in order to provide those considering installations of green, renewable energy technologies with a comprehensive, easy to use reference presenting technologies existing that make low power hydropower a viable option. The collection of technologies in this catalog will also assist the DOE in identifying promising technologies and concepts that may merit financial assistance to

further their development. It may also highlight technology gaps and thus help to direct the DOE in its research and development efforts.

The technology and concept listing information contained in this report is provided by vendors and inventors filling out a web-based information form accessible at <http://hydropower.inel.gov/techcatalog/>. The information provided is formatted into a standard catalog listing to provide all contributors an equal opportunity to profile their technology or concept and their company. Only information provided by the contributors is included in the listings. Not all contributors chose to or were able to provide all of the information requested in the information form. No attempt is made to supplement information provided with information from contributors' websites. Contributed information is not verified or validated. The contributors bear sole responsibility for protection of their intellectual property. Each technology listing is approved for public release by the contributor before appearing in the catalog. Submittals are not included if the technology is questionable beyond a liberal allowance; the technology submitted is not a low power, hydropower, energy producing system; or the submitter has not provided the minimum required information.

This catalog is a living, electronic document that will be expanded as additional technology listings are received. It is displayed via the U.S. DOE Hydropower Program website at <http://hydropower.inel.gov/>, which allows the reader to view the catalog in its entirety, access specific sections of the catalog, and perform word searches on the catalog using the search utility provided by Acrobat Reader. The website also offers search capability that allows the reader to access technology listings of interest using specified criteria including:

- Development stage
- Working environment
- Power output range

- Company name
- Years in business
- Country

All information is in PDF format and printable. However, the reader must be aware that the contributor may update information at any time and thus listing information may change. Each technology listing is date stamped with its release date to assist the reader in determining whether an update has occurred since last access.

At present, the catalog has three sections of principal interest to the reader. The first section

contains listings of low power hydropower systems that are in the spectrum of development stages from completed conceptual design to commercially available equipment. The next section is devoted to low power hydropower technology concepts that may range from a bright idea to concepts backed by extensive engineering analysis. The last section is a directory of all the companies that have listings in the catalog. It contains contact information for each company and is organized alphabetically by company name.

TECHNOLOGY LISTINGS

The low power hydropower technology listings in this section cover a spectrum of development stages from conceptual design to commercially available equipment. They were produced using vendor or developer supplied information. Although a standard listing format was used, the information in the listings varies depending upon the completeness of the information supplied. The listings all contain the following four principal sections:

- **Production description-** gives an overview of the technology
- **Product specification/details-** provides detailed technical data
- **Company contact information-** includes company address, contact name, telephone and fax numbers, email address, and website URL
- **Company profile-** provides a thumbnail image of the company based on years in business, number of employees, annual sales of low power hydropower equipment, and any affiliations, alliances, credentials, references and/or publications.

The reader should be aware that the catalog authors made no attempt to verify or validate information that appears in the technology listings. Information is included only with the approval of the information supplier, who is solely responsible for the contents of the listing. If the reader requires additional information, it should be requested from the listed technology contact. Technology listings in this catalog may be updated at any time without notice. Each listing contains a date stamp to identify when the information was updated.

Canyon Hydroelectric Turbines

*Development Stage:
Commercially available*



Canyon Hydro Pelton Type Turbine

Product Description

Canyon Hydro is a manufacturer of hydroelectric turbines, using Francis, Pelton, and Crossflow designs. Canyon offers complete turbines or hydroelectric systems in sizes ranging from 4 kW to 15 MW.

Product Highlights		
Standard Unit Design Capacity	5 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input checked="" type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	-	
Rotational Axis Orientation	Horizontal, perpendicular to flow	

Product Specifications/Details (Standard Unit)

- **Performance Category Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	0.5	500	ft ³ /sec
Hydraulic head range	20	2500	ft
Power output range	4	15,000	kW
Waterway depth	-	-	ft
Waterway width	-	-	ft

- **Deployment Locations:** Worldwide

Company Contact Information

Company Name	Canyon Industries, Inc.
Mailing Address	5500 Blue Heron Lane Deming, WA 98244 US
Website URL	www.canyonhydro.com
Contact's Name	Dan New
Contact's Title	President
Contact's Telephone	360-592-5552
Contact's Email	citurbine@aol.com

Company Profile

Years in Business	20-30 years
Number of Employees	21-50 employees
Annual Equipment Sales	greater than \$1,000,000

Cargo & Kraft Turbines

*Development Stage:
Commercially available*



Turbine

Product Description

Full automatic vertical and horizontal full kaplan and semi-kaplan.

Product Highlights		
Standard Unit Design Capacity	4,000 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	0.5 m	
Rotational Axis Orientation	Vertical	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Flow range	0.1	10	m^3/sec
Hydraulic head range	1	30	<i>m</i>
Power output range	5	4,000	<i>kW</i>
Waterway depth	—	—	<i>m</i>
Waterway width	—	—	<i>m</i>

- **Efficiency:** Turbine: 93% Total System: 85%
- **Deployment Locations:** Various sites in Sweden and Estonia
- **Operating History:** 45 units operate from 1 to 6 years
- **System Dimensions (meters):** 4 (L) × 2 (W) × 4 (D)
- **Unit Price (U.S. dollars):** \$625,000

Company Contact Information

Company Name	Cargo & Kraft Turbin Sverige AB
Mailing Address	Kedjebohammar S-739 92 Skinnskatteberg Sweden
Website URL	www.cargo-kraft.se
Contact's Name	Peter Ruyter
Contact's Title	Manager
Contact's Telephone	+46 222 280 80
Contact's Fax	+46 222 280 20
Contact's Email	turbin@cargo-kraft.se

Company Profile

Years in Business	6-10 years
Number of Employees	6-20 employees
Annual Equipment Sales	greater than \$1,000,000

Darrieus Water Current Turbines

*Development Stage:
Commercially available*



Darrieus Water Current Turbine

Product Description

Alternative Hydro Solutions Ltd. believes that the Darrieus turbine is the best choice for small and medium river sites. The advantages that Darrieus turbines have over propeller type turbines

(continued on next page)

Product Highlights		
Standard Unit Design Capacity	0.5 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input checked="" type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	3.75 ft	
Rotational Axis Orientation	Vertical	

Product Description continued

include: i) their ability to have a greater diameter than depth which enables more area to be swept in a shallow stream and therefore more power production per turbine, ii) the vertical shaft provides easy maintenance as the electrical components and bearings are above water, and iii) increased efficiency over propeller turbines not specifically designed as water current turbines.

The Darrieus turbine typically rotates at 45 to 90 rpm, the most efficient range being 55 to 70 rpm. At higher rotational speeds the turbine blades reach their stall point and therefore the turbines overspeed is naturally limited, at this point power production also starts to taper off. The water flow speed that is generally accepted as the minimum for power production is 0.8 m/s (2.6 ft/s). Every increase in velocity over this minimum provides a dramatic increase in power production.

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Velocity range	0.5	1.7	<i>m/sec</i>
Hydraulic head range	—	—	<i>m</i>
Power output range	0.1	0.2	<i>kW</i>
Waterway depth	0.75	5	<i>m</i>
Waterway width	2	100	<i>m</i>

- **Efficiency:** Turbine: 40% Total System: 35%

- **System Dimensions (meters):** 1.35 (L) × 1.35 (W) × 0.75 (D)

- **Unit Price (U.S. dollars):** \$4,800

Company Contact Information

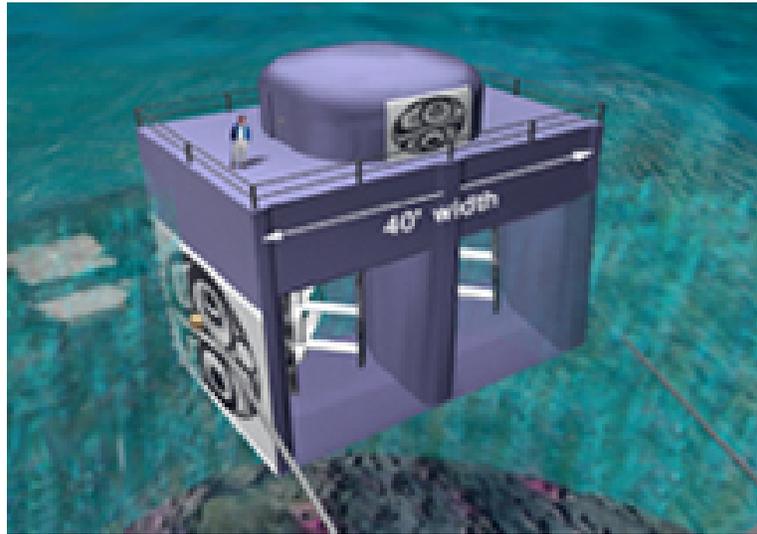
Company Name	Alternative Hydro Solutions Ltd.
Mailing Address	323 Richmond St. E. Suite 421 Toronto, ON M5A 4S7 Canada
Website URL	www.althydro.com
Contact's Name	Steve Gregory
Contact's Title	President
Contact's Telephone	416-368-5813
Contact's Fax	416-368-5813
Contact's Email	sdgregory@althydro.com

Company Profile

Years in Business	3-5 years
Number of Employees	less than 5 employees
Annual Equipment Sales	\$1000 - \$10,000

Davis Hydro Turbine

Development Stage: Demonstration



Two Linked Davis Hydro Turbines, Suitable for Remote Energy

Product Description

Blue Energy Canada, with assistance from the Canadian National Research Council, has successfully developed and tested 6 prototypes of its proprietary Davis Hydro Turbine, which generates renewable, non-polluting energy from moving water. The company is now working to develop a commercial-scale demonstration project in Canada, or abroad. Following successful demonstration, we anticipate licensing 250-kW units (mid-range scale) and 2-10 MW units (ocean class; can be joined in series) and deploying worldwide. Many locations worldwide have the appropriate conditions to deploy the Davis Hydro Turbine and it has been approved by the David Suzuki Foundation, Greenpeace, the Sierra Club and Friends of the Earth. For more product information, please see www.bluenergy.com.

Product Highlights		
Standard Unit Design Capacity	250 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input checked="" type="checkbox"/> Tidal estuaries <input checked="" type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input checked="" type="checkbox"/> Other (spillways, tailraces)
Other sizes currently available	No	
Characteristic Dimension	4 m	
Rotational Axis Orientation	Vertical	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	2.5	8	<i>m³/sec</i>
Hydraulic head range	—	—	<i>m</i>
Power output range	0	250	<i>kW</i>
Waterway depth	8.5	75	<i>m</i>
Waterway width	5	—	<i>m</i>

- **Efficiency:** Turbine: 50% Total System: 50%
- **Deployment Locations:**
 - commercial-scale demonstration project anticipated soon in Canada and/or US
- **Operating History:**
 - successful prototype development: 5 funded by Canadian National Research Council, 1 privately
 - commercial-scale demonstration project: in-process
- **System Dimensions (meters):** 5 (L) × 4 (W) × 6 (D)

Company Contact Information

Company Name	Blue Energy Canada, Inc.
Mailing Address	PO Box 29005 1950 West Broadway Vancouver, BC V6J 5C2 Canada
Website URL	www.bluenergy.com
Contact's Name	Michael Maser
Contact's Title	Communications
Contact's Telephone	604-886-8783
Contact's Email	maser@uniserve.com

Company Profile

Years in Business	6-10 years
Number of Employees	less than 5 employees
Annual Equipment Sales	less than \$1000

Affiliations/Alliances/Credentials/References/Publications

- Ocean Renewable Energy Group (OREG) - newly-formed national industry association, Canadian chapter (anticipate expanding into US in 2005)

EOS 1100 Turbine

*Development Stage:
Commercially available*



EOS Standard Hydropower Unit

Product Description

The EOS are axial (propeller) type with a horizontal shaft, S shaped duct, 4 fixed blade runner, 12 vane cylindrical regulated wicket gate, 2 or 3 profiled column distributor and radial-axial ball bearing.

The EOS family of turbines includes five sizes of axial propeller turbines: EOS 350, EOS 500, EOS 700, EOS 900 and EOS 1100. The symbol means: E - propeller, O - horizontal shaft, S - S duct turbine type, and the runner diameter in mm.

The hydropower units with EOS turbine, assembly turbine – generator, is settled on four bearings, with one of the turbine bearings also acting as a thrust bearing. A particular general arrangement includes a speed multiplier between the turbine and the generator.

Product Highlights		
Standard Unit Design Capacity	587 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	1.1 m	
Rotational Axis Orientation	Horizontal, parallel to flow	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	4.4	9	<i>m³/sec</i>
Hydraulic head range	2.5	20	<i>m</i>
Power output range	45	1200	<i>kW</i>
Waterway depth	-	-	<i>m</i>
Waterway width	-	-	<i>m</i>

- **Deployment Locations:** The following sites in Romania:

- Arinis - Suceava
- Tei - Bucuresti
- Talmaciu - Sibiu
- Dridu - Slobozia
- Galanesti I - Suceava
- Galanesti II - Suceava
- OGREZENI - Giurgiu
- HERASTRAU - Bucuresti
- BARAJ CET - Oradea
- Valenii de Munte - Ploiesti
- Galanesti III - Suceava
- Berzovia - Resita

- **Operating History:**

- Number of sites where turbine model is in commercial operation: 15
- Years turbine model has been commercially available: 22

Company Contact Information

Company Name	UCM Resita SA
Mailing Address	1 Golului Street 320053 Resita Romania
Website URL	www.ucmr.ro
Contact's Name	Dan Petrescu
Contact's Title	Commercial Director
Contact's Telephone	+40-255-217111
Contact's Fax	+40-255-223082
Contact's Email	contact@ucmr.ro , dpetrescu@ucmr.ro

Company Profile

Years in Business	30 or more years
Number of Employees	51 or more employees
Annual Equipment Sales	\$100,000 - \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- Caras Severin Chamber of Commerce, Industry & Agriculture
- International Association for Small Hydro (IASH)
- References: SC Hidroelectrica SA, Romanian Commercial Bank - Resita Branch

FO 230/720 Turbine

*Development Stage:
Commercially available*



FO Standard Hydropower Unit

Product Description

The FO Series are Francis turbines with a horizontal shaft, metallic spiral case, regulated wicket gate, runner of stainless steel, sealing system, self opening depression valve, radial-thrust slide bearing, bent draft tube at 45° or 90°, flywheel, and a hydraulic brake.

The FO family consists of 5 sizes of Francis turbines: FO 90/390, FO 90/570, FO 125/640, FO 190/720, FO 230/720. The symbol means: F - Francis turbine type, O - horizontal shaft and the specific speed (m-kW) of the turbine model/runner diameter in mm.

The assembly of turbine – flywheel – generator of a hydropower unit with FO turbine is settled on four bearings, with one of the turbine bearings also acting as a thrust bearing. A particular general arrangement is without a flywheel, with assembly on two bearings, of the generators.

Product Highlights		
Standard Unit Design Capacity	675 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	0.72 m	
Rotational Axis Orientation	Horizontal, perpendicular to flow	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	0.85	4	<i>m³/sec</i>
Hydraulic head range	10	89.2	<i>m</i>
Power output range	50	1200	<i>kW</i>
Waterway depth	-	-	<i>m</i>
Waterway width	-	-	<i>m</i>

- **Deployment Locations:** The following sites in Romania:

- Tesila I - Ploiesti
- Tesila II - Ploiesti
- Surduc - Timisoara
- Cepari - Pitesti
- Bistra Noua - Resita
- Tohan I - Brasov
- Sadu I - Sibiu
- Olteti II - Targu Jiu
- Gura Haiti I - Suceava
- Novaci II - Targu Jiu
- Novaci III - Targu Jiu
- Novaci IV - Targu Jiu
- Novaci V - Targu Jiu

- **Operating History:**

- Number of sites where turbine model is in commercial operation: 21
- Years turbine model has been commercially available: 19

Company Contact Information

Company Name	UCM Resita SA
Mailing Address	1 Golului Street 320053 Resita Romania
Website URL	www.ucmr.ro
Contact's Name	Dan Petrescu
Contact's Title	Commercial Director
Contact's Telephone	+40-255-217111
Contact's Fax	+40-255-223082
Contact's Email	contact@ucmr.ro ; dpetrescu@ucmr.ro

Company Profile

Years in Business	30 or more years
Number of Employees	51 or more employees
Annual Equipment Sales	\$100,000 - \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- Caras Severin Chamber of Commerce, Industry & Agriculture
- International Association for Small Hydro (IASH)
- References: SC Hidroelectrica SA, Romanian Commercial Bank - Resita Branch

Hydro Turbines

*Development Stage:
Commercially available*



900 mm Kaplan - 300 kW

Product Description

Hydroelectric turbines from 50 kW to 15 MW. Kaplan, Propeller and Francis turbines of 500 mm to 2.5 m diameter. Complete water-to-wire packages or replacement runners. Engineering, design, manufacture and assembly all done in-house. We have standard size axial flow turbines in inventory for quick delivery. For more information and photos of our equipment, please visit www.canadianhydro.com/products.htm

Product Highlights		
Standard Unit Design Capacity	1000 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	1.7 m	
Rotational Axis Orientation	-	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	-	-	<i>m³/sec</i>
Hydraulic head range	2	150	<i>m</i>
Power output range	50	15,000	<i>kW</i>
Waterway depth	-	-	<i>m</i>
Waterway width	-	-	<i>m</i>

- **Deployment Locations:** Canada, United States, Dominican Republic, Poland, Papua New Guinea, Australia. Project details are at www.canadianhydro.com/projects.htm

- **Operating History:**

- Since 1987, Canadian Hydro Components has supplied equipment to over 100 projects worldwide. From a 500 mm, 150 kW turbine for the Nazarene Hospital in Papua New Guinea to 4 X 1500 mm turbines for a 6 MW Hydro Project for Reliant Energy in New York State.

Company Contact Information

Company Name	Canadian Hydro Components Ltd.
Mailing Address	P.O. Box 640 16 Main Street Almonte, Ontario K0A 1A0 Canada
Website URL	www.canadianhydro.com
Contact's Name	Mike Dupuis
Contact's Title	President
Contact's Telephone	613-256-1983
Contact's Fax	613-256-4235
Contact's Email	inquiries@canadianhydro.com

Company Profile

Years in Business	15-20 years
Number of Employees	6-20 employees
Annual Equipment Sales	greater than \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- Export Development Canada, Canadian Hydropower Association, Ontario Waterpower Association, Association of Power Producers of Ontario

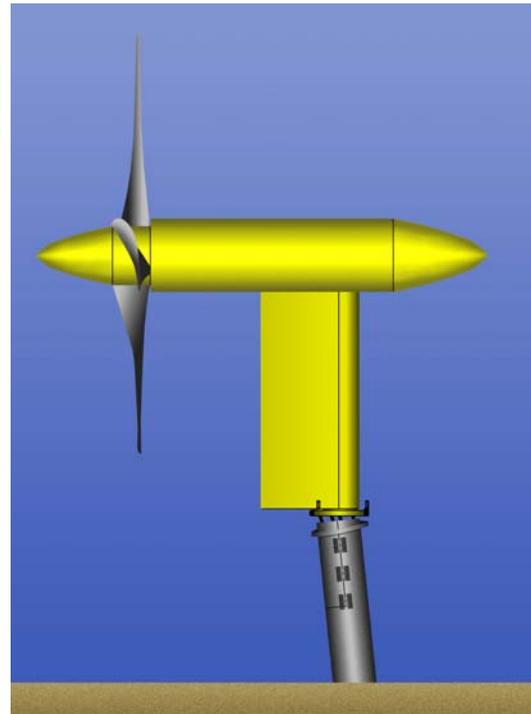
Kinetic Hydro Power System (KHPS)

an Axial Flow Turbine

Development Stage: Demonstration

Product Description

The KHPS is a 5-m diameter 3-bladed axial flow turbine rated at 35 kW, which incorporates a patented blade design having a high efficiency over a large range of speeds. The turbine rotor drives a speed increaser, which drives a grid-connected, three-phase, induction generator. The gearbox and generator are in a waterproof streamlined nacelle, which is mounted on a streamlined pylon. The pylon assembly has internal yaw bearings allowing it to pivot the turbine with the direction of the tidal current, ebb or flood. The pylon is bolted via an adjustable adapter to a pile fixed to the river bottom. Underwater cables carry the AC power to shore where they are connected to the power grid using standard distributed generation switchgear.



KHPS Turbine Using Piling-mounted River Bottom Deployment Method

Product Highlights	
Standard Unit Design Capacity	35.9 kW
Other sizes currently available	Yes
Characteristic Dimension	5.0 m
Rotational Axis Orientation	Horizontal, parallel to flow
Design Working Environment	
<ul style="list-style-type: none"> <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input checked="" type="checkbox"/> Effluent streams <input checked="" type="checkbox"/> Tidal estuaries <input checked="" type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input checked="" type="checkbox"/> Other (dam outflows, aqueducts) 	

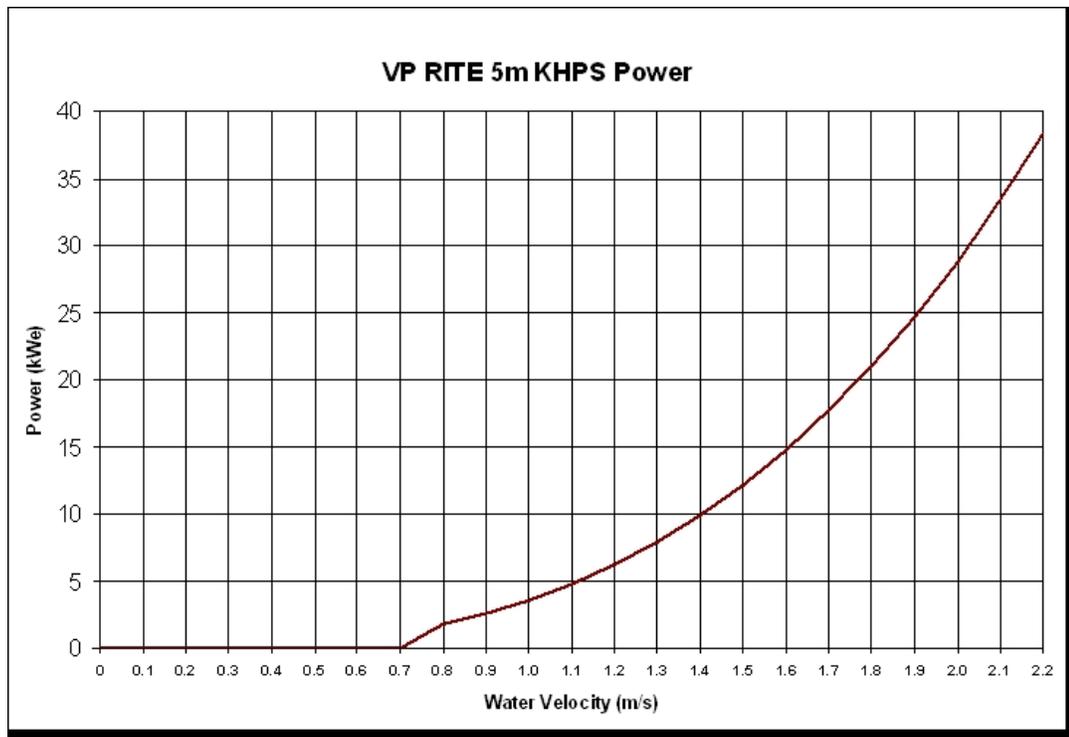
Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Velocity range	1.0	2.1	m/sec
Hydraulic head range	—	—	m
Power output range	4.2	35.9	kW
Waterway depth	6.0	20.0	m
Waterway width	6.0		m

- **Efficiency:** Turbine: 45.0% Total System: 38.5%

- **Operating Curve/Envelope:**



Design Capacity Tested:	25 kW
Test Date:	January 2003
Test Location:	East River, NY

Product Specifications/Details (Standard Unit) continued

- **Deployment Locations:** East River, New York City, NY
- **Operating History:**
 - **Blade Development & Testing:** NY University; sponsored by U.S. DOE, NYPA including use of David Taylor Model Basin: 1983–1986
 - **Initial Deployment:** Bong Canal, Mangla, Pakistan 1989
 - **Third Generation Model:** 3-Meter Diameter: Winter 2002–2003 field tested in Chesapeake Bay, MD and East River, NY
 - **Pilot 6-Unit Integrated Study System in East River, NYC:** deployment pending final regulatory approvals, Fall 2004–intended to operate up to 18 months delivering grid connected power, and providing environmental study platform
- **System Dimensions (meters):** 4.8 (L) × 5.0 (W) × 6.0 (D)
- **Unit Price (U.S. dollars):** \$90,000

Company Contact Information

Company Name	Verdant Power LLC
Mailing Address	4640 N. 13th St. Arlington, VA 22207-2102
Website URL	www.verdantpower.com
Contact's Name	Trey Taylor
Contact's Title	President and Chief Marketing Officer
Contact's Telephone	703-528-6445
Contact's Fax	703-812-8157
Contact's Email	ttaylor@verdantpower.com

Company Profile

Years in Business	3–5 years
Number of Employees	6–20 employees
Annual Equipment Sales	less than \$1,000

Affiliations/Alliances/Credentials/References/Publications

- NYSERDA, Massachusetts Technology Collaborative, DOE @ Oak Ridge & Idaho Falls, TVA, EPRI, NHA, Hydro Research Foundation
- Cooper Union School of Engineering, Columbia U, Amherst, U. of South Carolina
- Environmental Resources Trust, American Council on Renewable Energy, the Natural Step, Metropolitan Waterfront Alliance (NY)
- Authored EPRI Tech Assessment Guides for 2002, 2003, and 2004 Instream Energy Generation Technologies; Articles in Boston Globe, Environmental Science & Technology, Energy Prospects, City Limits, The New York Times, etc.

Microhydropower Unit MLU / Propeller Turbine

*Development Stage:
Commercially available*

Product Description

Microhydropower unit MLU is a unit of large range utilization, having a compact monoblock vertical shaft construction in variant with an axial/propeller turbine and a Francis turbine. The unit can be connected to an energy system or operate alone in an isolated network.

The micro hydro unit consists of: turbine, induction generator with scroll cage rotor with a power suitable to turbine and hydroelectric plant data, actuating mechanism for turbine wicket gate, and inlet valve. Separately it consists of the automation and control panel with thermal and electromagnetic protection device, gauges, signaling, control keys, and buttons.

In order to operate on an isolated network, the induction generator is provided with condenser batteries that provide the self excitation, and the control panel is provided with speed/frequency control system. Such micro hydro units are used near to isolated chalets, fish culture farms, forest exploitation etc.



MLU Axial Turbine, Draft Tube and Automation and Control Panel

Product Highlights		
Standard Unit Design Capacity	14 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	0.25 m	
Rotational Axis Orientation	Vertical	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow Range	0.11	0.33	m^3/sec
Hydraulic head range	4.5	14.5	<i>m</i>
Power output range	4	30	<i>kW</i>
Waterway depth	-	-	<i>m</i>
Waterway width	-	-	<i>m</i>

- **Deployment Locations:** The following sites in Romania:

- Azuga - ISJ Ploiesti
- Sibiu - IFET Sibiu
- Rasinari - RENEL Sibiu
- Stana de Vale - UM 01334 Beius
- Valea Bistrei - IJGCL Alba
- Cavnic - CPJ Baia Mare
- Huza - CONEL Cluj
- Bocsig - OGA Arad
- Fagaras - ISJ Brasov
- Arad - CPJ Arad
- Rasinari - CONEL Sibiu
- Globul Craiovei - OGA Resita

- **Operating History:**

- Number of sites where turbine model is in commercial operation: 46
- Years turbine model has been commercially available: 23

Company Contact Information

Company Name	UCM Resita SA
Mailing Address	1 Golului Street 320053 Resita Romania
Website URL	www.ucmr.ro
Contact's Name	Dan Petrescu
Contact's Title	Commercial Director
Contact's Telephone	+40-255-217111
Contact's Fax	+40-255-223082
Contact's Email	contact@ucmr.ro , dpetrescu@ucmr.ro

Company Profile

Years in Business	30 or more years
Number of Employees	51 or more employees
Annual Equipment Sales	\$100,000 - \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- Caras Severin Chamber of Commerce, Industry & Agriculture
- International Association for Small Hydro (IASH)
- References: SC Hidroelectrica SA, Romanian Commercial Bank - Resita Branch

Micro-turbine Reiffenstein

*Development Stage:
Commercially available*



Micro-turbine Reiffenstein for Small Water Power Plants

Product Description

The unit representing a compatible ecological solution is a horizontal arrangement. It is supplied in assembled state. The unit is provided with common frame for the turbine and the generator. The turbine runner is overhang seated on the generator shaft. The turbine is equipped with welded steel spiral case of a square profile and a regulating blade of welded construction. Stainless steel runner is of welded construction. The regulating blade is controlled by means of an electric servomotor. Emergency closing the regulating blade is ensured by means of weight on servomotor lever and electric shifted claw clutch. The platform of the unit is 2550 x 1300 mm and the unit height is 1150 mm. Weight of the unit without the generator is 1500 kg. The generator shaft is adapted for turbine runner overhang seating as well as for turbine guide bearing and shaft seal. The rotor is provided with speed sensor.

Product Highlights		
Standard Unit Design Capacity	75 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	0.35 m	
Rotational Axis Orientation	Horizontal, perpendicular to flow	

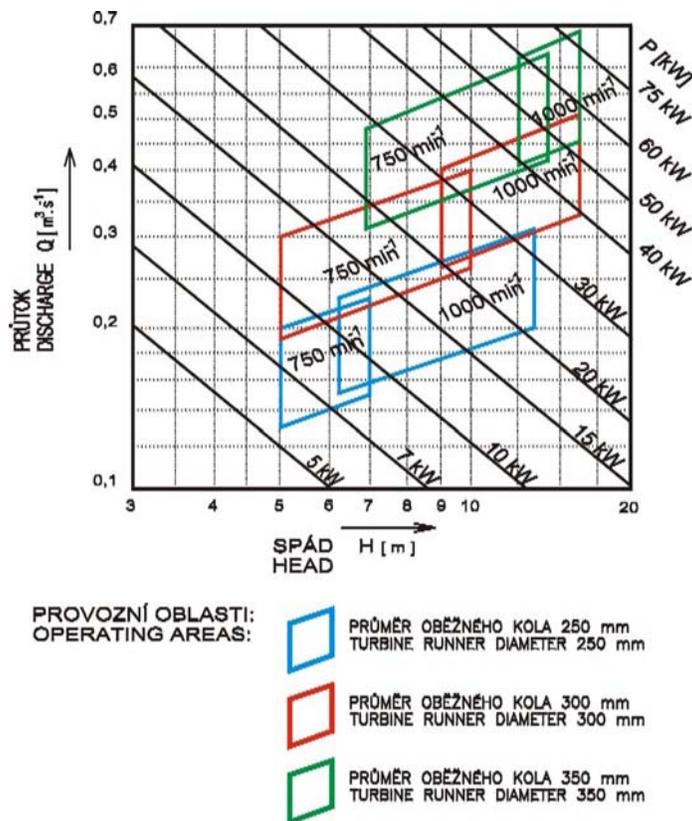
Product Specifications/Details (Standard Unit)

- Performance Specifications:

Category	Minimum	Maximum	Units
Flow range	0.31	0.68	m ³ /sec
Hydraulic head range	6.9	15	m
Power output range	16	75	kW
Waterway depth	—	—	m
Waterway width	—	—	m

- Efficiency: Turbine: — Total System: 90%

- Operating Curve/Envelope:



Test Date:	February 2001
Test Location:	Mech. & Hydro Laboratory, Blansko, Czech Republic

- **Deployment Locations:** Nemilka Project, Zabreh, Czech Republic
- **System Dimensions (meters):** 2.55 (L) × 1.3 (W) × 1.15 (D)

Company Contact Information

Company Name	CKD Blansko Engineering, a.s.
Mailing Address	Gellhornova 2235/8 67801 Blansko Czech Republic
Website URL	www.cbeas.com
Contact's Name	Adolf Svoboda
Contact's Title	Commercial Director
Contact's Telephone	00420-533 309 802
Contact's Fax	00420-533 309 588
Contact's Email	or@cbeng.cz

Company Profile

Years in Business	6-10 years
Number of Employees	51 or more employees
Annual Equipment Sales	greater than \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- Technical Academy of BRNO
- Memberships: IAHR, Europump, IEC, Czech Calibration Association

Open Center Turbine

Development Stage: Demonstration



Turbine One at Palatka Facility

Product Description

Our open center turbine is in and of itself a generator. Its blade is the rotor and its housing is the stator. When the water rotates the blade, 3 phase electricity is produced directly from its housing.

Product Highlights		
Standard Unit Design Capacity	500 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input checked="" type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input checked="" type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input checked="" type="checkbox"/> Other ocean current (Gulf Stream)
Other sizes currently available	Yes	
Characteristic Dimension	28 ft	
Rotational Axis Orientation	Horizontal, parallel to flow	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Flow range	6.5	25	ft ³ /sec
Hydraulic head range	3	200	ft
Power output range	10	5,000	kW
Waterway depth	36	1,000	ft
Waterway width	50	100,000	ft

- **Efficiency:** Turbine: 59% Total System: 50%

- **Deployment Locations:**

- Saint John's River, Palatka, FL
- Florida Gulf Stream (Palm Beach)

- **Operating History:**

- Prototype 1 (10 ft dia.) was towed (tested) in the Saint John's River, Palatka, FL in 1995
- Prototype 2 (10 ft dia.) was tested in the Florida Gulf Stream (Palm Beach)
- Turbine one (production 10 ft dia.) is currently being tested and should be ready for commercial production in October 2004

- **System Dimensions (feet):** 50 (L) × 12 (W) × 35 (D)

- **Unit Price (U.S. dollars):** \$208,000

Company Contact Information

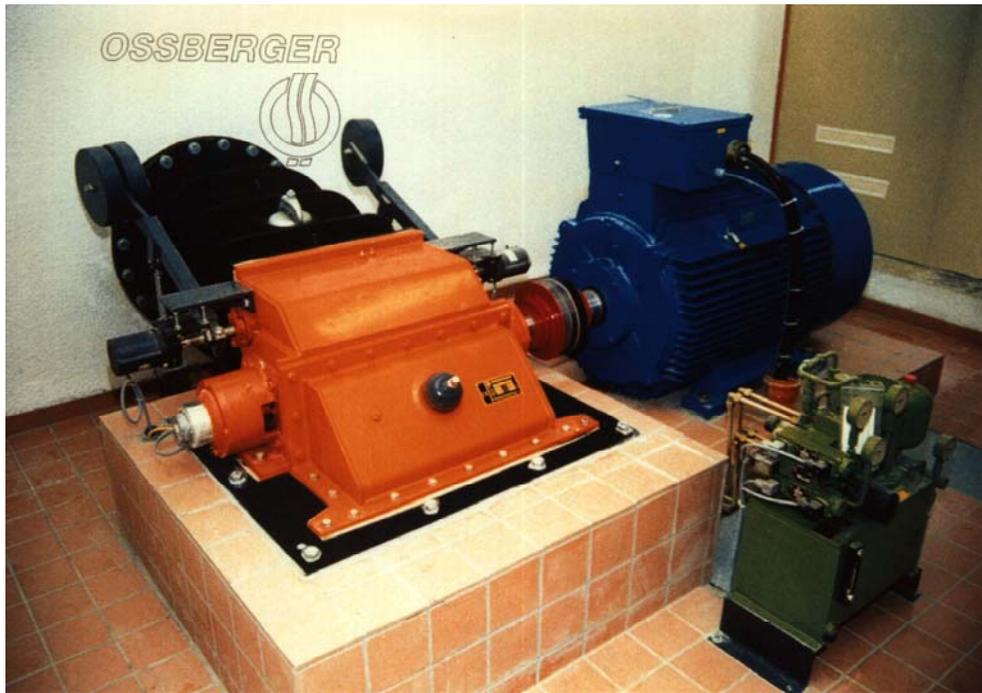
Company Name	Florida Hydro, Inc.
Mailing Address	171 Comfort Rd. Palatka, FL 32177 US
Website URL	http://floridahydro.com/
Contact's Name	Herbert Williams
Contact's Title	President
Contact's Telephone	386-328-2470
Contact's Fax	386-328-2558
Contact's Email	floridahydro@msn.com

Company Profile

Years in Business	6-10 years
Number of Employees	6-20 employees
Annual Equipment Sales	less than \$1000

Ossberger Cross-Flow Turbines

*Development Stage:
Commercially available*



Typical OSSBERGER Turbine Installation

Product Description

The OSSBERGER Turbine is a radial impulse-type turbine with partial admission. Its specific speed makes it a low-speed turbine. The jet of water which is given a rectangular cross-section by the guide vanes, flows through the ring of blades on the barrel-shaped rotor, first from outside to inside and then, after crossing the interior of the runner, from inside to outside again.

Product Highlights		
Standard Unit Design Capacity	1500 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input checked="" type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	1.25 m	
Rotational Axis Orientation	Horizontal, perpendicular to flow	

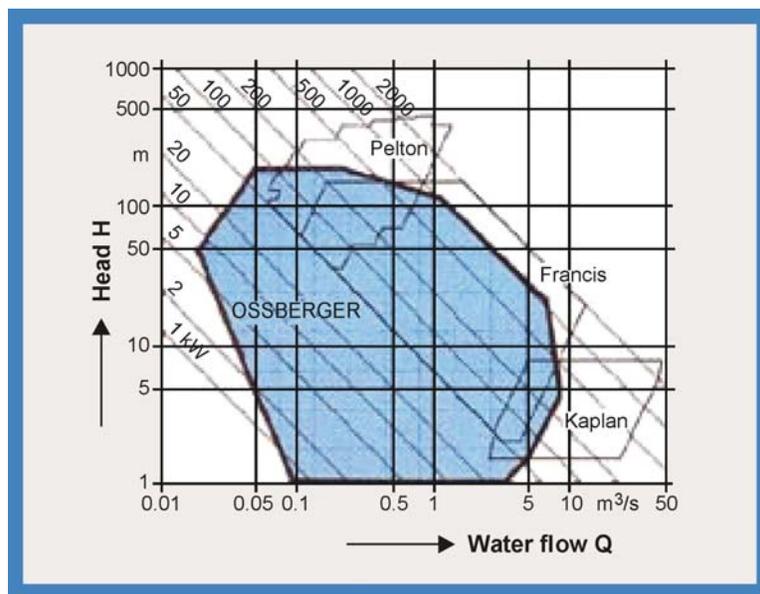
Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Flow range	1	450	ft ³ /sec
Hydraulic head range	3	650	ft
Power output range	1	1500	kW
Waterway depth	—	—	ft
Waterway width	—	—	ft

- **Efficiency:** Turbine: 87% Total System: 83%

- **Operating Curve/Envelope:**



Design Capacity Tested:	1500 kW
Test Date:	continuous
Test Location:	OSSBERGER Plant

- **Deployment Locations:** More than 8000 OSSBERGER turbines are operating in 80 countries around the globe.

Company Contact Information

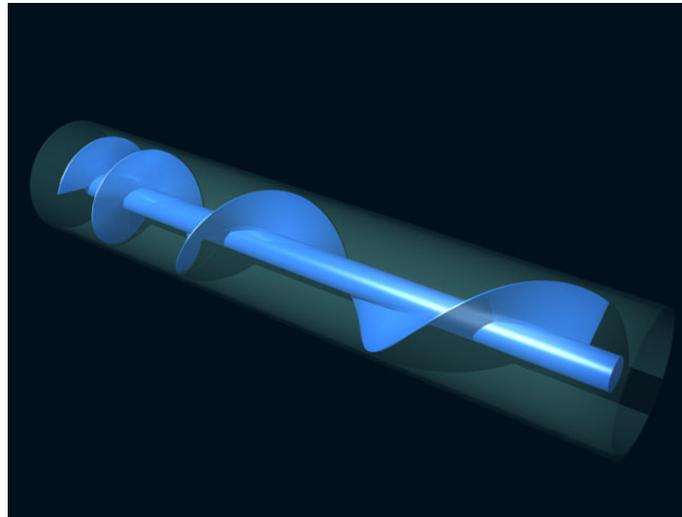
Company Name	Ossberger Turbines, Inc.
Mailing Address	P.O. Box 736 Hayes, VA 23072 US
Website URL	www.ossberger.de , www.hts-inc.com
Contact's Name	Alfred Patzig
Contact's Title	Vice-President
Contact's Telephone	804-360-7992
Contact's Fax	804-360-7993
Contact's Email	patzig@hts-inc.com

Company Profile

Years in Business	20-30 years
Number of Employees	less than 5 employees
Annual Equipment Sales	\$100,000 - \$1,000,000

Ribbon Drive Power Generation Apparatus

Development Stage: Engineering scale



Ribbon Drive Power Generation Apparatus

Product Description

Ribbon Drive Power Generation Design Advantages:

- Simple design of reverse pitch helical coils
- Scalable for different applications, including portable
- Large supplies of high velocity water not required
- Horizontal OR vertical Installation
- Economical to manufacture—can build with relatively low cost, light weight polymer or composite

(continued on next page)

Product Highlights		
Standard Unit Design Capacity	100 kW	Design Working Environment <ul style="list-style-type: none"> ■ Natural waterways ■ Water transmission systems ■ Effluent streams ■ Tidal estuaries ■ Near shore ocean ■ Off-shore ocean ■ Deep ocean ■ Other (high rise buildings)
Other sizes currently available	Yes	
Characteristic Dimension	3 ft	
Rotational Axis Orientation	Horizontal, parallel to flow	

Product Description continued

Ribbon Drive Power Generation Design Advantages: *(continued)*

- Staged startup, operates in varying flow conditions
- Self-orienting to ambient water current
- Ease of maintenance and helical vane/shaft replacement
- Faster rotation than other experimental turbines, slower than industrial power turbines
- No energy loss to sideways ambient current transients as in other experimental systems
- Turn an external electrical generator, OR induce an electrical current via Ribbon Drive unit design incorporating magnets and external wiring
- Entering water is in constant contact with a gradual, increasingly angled surface—not just one plane in a traditional turbine; it incrementally captures most of the axial component of the water's kinetic energy

Features:

- a) Squeezed helical coils of a ribbon-like band spin inside a containment cylinder.
- b) One moving part achieves a high capture rate in converting linear to rotational energy without requiring high r.p.m., fast incoming flow or large water volume without complex, expensive multi-bladed turbines; while helping prevent cavitation and decrease surface erosion.

A New Sequence for Rotation

- Water entry initiates shaft rotation

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	15	20	<i>gpm</i>
Hydraulic head range	4.5	6	<i>ft</i>
Power output range	0.5	100	<i>kW</i>
Waterway depth	0.75	—	<i>ft</i>
Waterway width	0.75	--	<i>ft</i>

- **System Dimensions (feet):** 9 (L) × 3 (W) × 3 (D)

Company Contact Information

Company Name	Fluidmotive, Inc.
Mailing Address	251 W. Montgomery Ave. Suite #2 Haverford, PA 19041 US
Website URL	http://www.fluidmotive.com
Contact's Name	Dr. Jonathan B. Rosefsky
Contact's Title	President
Contact's Telephone	610-745-1990
Contact's Fax	610-896-3919
Contact's Email	fluidmotive.inc@att.net

Company Profile

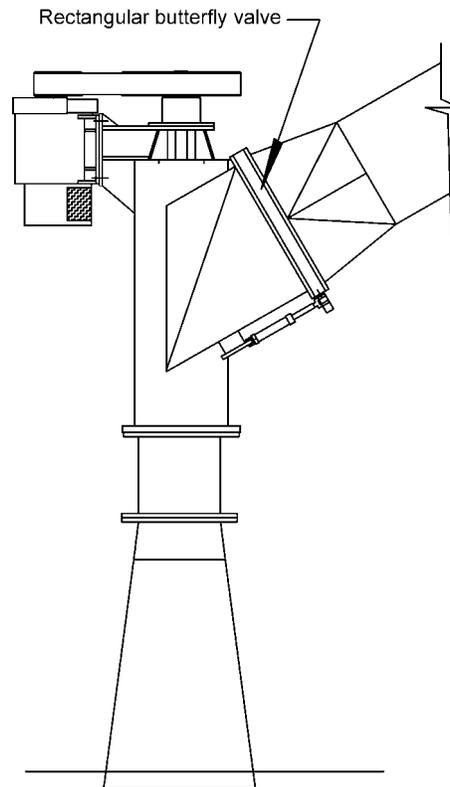
Years in Business	3-5 years
Number of Employees	less than 5 employees
Annual Equipment Sales	less than \$1000

Affiliations/Alliances/Credentials/References/Publications

- Grant from Ben Franklin Technology Partners of SE Penna. to Dept. of Engineering, Villanova U., Villanova, PA
- Business plan award from Baiada Center for Entrepreneurship, Drexel U.
- Consultants: Professors Young I. Cho, V.K. Narayanan, Chris Rorres (Drexel U), Professors Kenneth Kroos, James O'Brien (Villanova U)
- Publications: *Popular Mechanics*, June 2003 issue, "TechWatch", p.24; *Kijk (Look) Magazine*, Sept. 2003 issue, (Netherlands science journal), translated at www.fluidmotive.com

SBR Water Turbine

*Development Stage:
Commercially available*



SBR Water Turbine, Typical Arrangement

Product Description

The SBR turbine is a family of low speed, low power density turbines that do not use guide vanes to force a circumferential component of flow on the water approaching the turbine runner. The flow in the guide case has little shear and near constant axial velocity. The turbine is very adaptable to most sites and has in its simplest form an overall efficiency of 90 to 92 percent.

Product Highlights		
Standard Unit Design Capacity	1,000 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input checked="" type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	5 ft	
Rotational Axis Orientation	Horizontal, parallel to flow	

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Flow range	—	—	ft ³ /sec
Hydraulic head range	4	150	ft
Power output range	10	1,000	kW
Waterway depth	—	—	ft
Waterway width	—	—	ft

- **Efficiency:** Turbine: 92% Total System: 86%

- **Deployment Locations:**

- Laurentian Lodge near Elliot Lake, Ontario Canada
- City of Brantford Water Treatment Plant at Brantford, Ontario
- Three of the Grand River Conservation Authorities storage dams
- On the Magnetawan River at Burk's Falls, Ontario

- **Operating History:**

- In commercial operation for 22 years

Company Contact Information

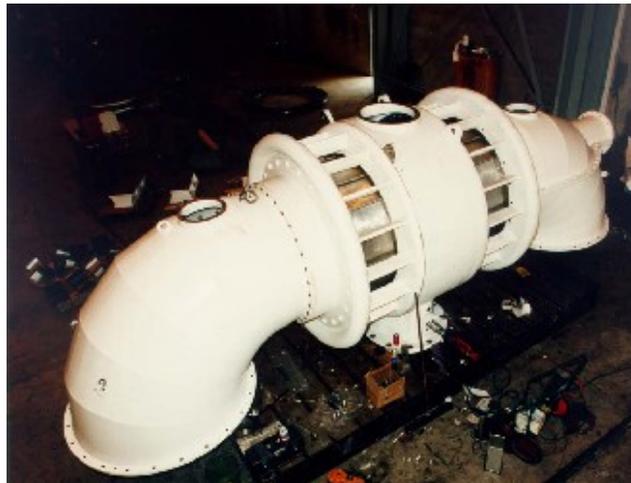
Company Name	Rapid-Eau Technologies, Inc.
Mailing Address	P.O. Box 1113 Cambridge, ON N1R7G8 Canada
Website URL	www.rapid-eau.com
Contact's Name	Dave de Montmorency
Contact's Title	President
Contact's Telephone	519-740-8786
Contact's Fax	519-740-0422
Contact's Email	dave@rapid-eau.com

Company Profile

Years in Business	20-30 years
Number of Employees	less than 5 employees
Annual Equipment Sales	\$100,000 - \$1,000,000

Seagull Hydroturbine

*Development Stage:
Commercially available*



American Hydro

Product Description

The American Hydro "Seagull" is a modern duplex runner hydroelectric turbine designed for high efficiency and power in an open-flume setting. Originally designed to upgrade existing antiquated quad-runner units, it also replaces "camel-back" units and is a compact, powerful unit for new low head open flume applications. Successfully operating units have been in service since 1990. The proven rugged design is self supporting on a central pedestal with a patented dry pit arrangement allowing bearing and gate mechanism service without dewatering the turbine flume. Modern hydraulic performance characteristics are guaranteed and verified ahead of time through advanced proprietary CFD design codes. The custom designed runners (Francis or propeller) as well as stay vanes, wicket gates and draft tube configuration assure optimum performance for each individual site. Mechanical designs meet ASME and company standards based on state-of-the-art stress, deformation, vibration and life analysis technology. Each runner is fabricated from fully CNC machined blade surfaces.

Product Highlights		
Standard Unit Design Capacity	1,000 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	5 ft	
Rotational Axis Orientation	Horizontal	

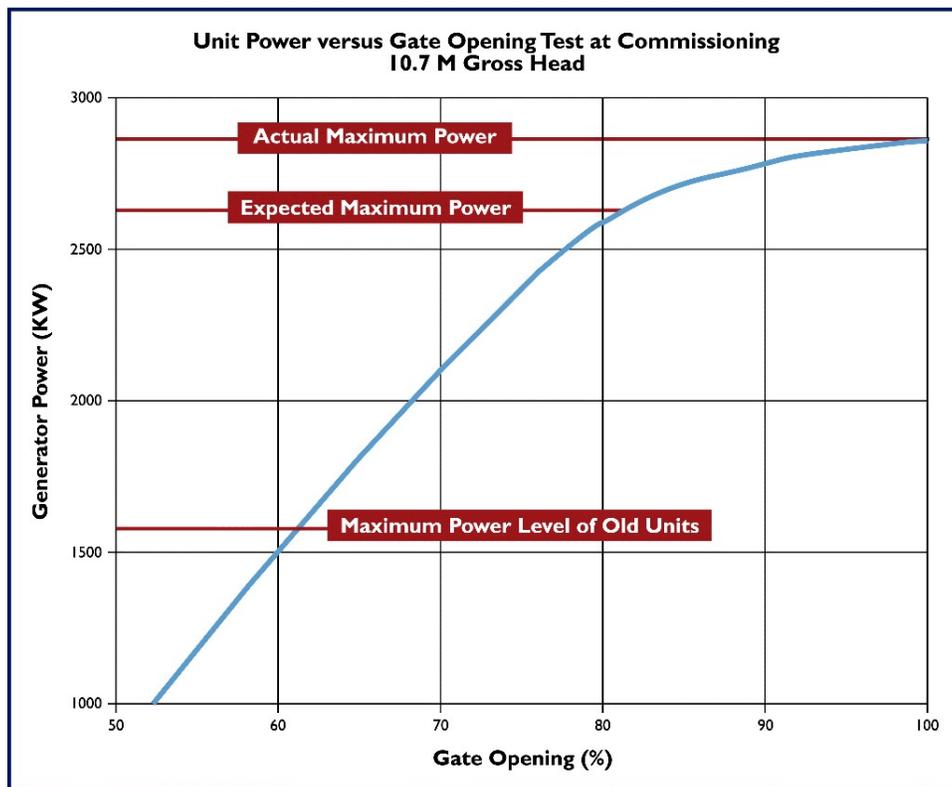
Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Flow range	400	2,000	ft ³ /sec
Hydraulic head range	15	60	ft
Power output range	500	5,000	kW
Waterway depth	—	—	ft
Waterway width	—	—	ft

- **Efficiency:** Turbine: 90% Total System: 87%

- **Operating Curve/Envelope:**



Design Capacity Tested:	2,800 kW
Test Date:	2002
Test Location:	Bishop's Falls Hydro Project

Product Specifications/Details (Standard Unit) continued

- **Deployment Locations:**
 - Gaston Shoals, SC: Duke Power
 - Cross Power, NH: James River Paper
 - Glen Falls, NY: Finch, Pruyn
 - Bishops Falls, Newfoundland: Exploits River Co.
- **Operating History:**
 - 10 units in commercial operation
 - Cross: (1) 450 kW propeller type unit @ 19 ft head operating since 1990
 - Gaston Shoals: (2) 2,100 kW Francis type units @ 47 ft head operating since 1992
 - Glens Falls: (1) Francis type 3,000 kW type unit @ 46 ft head operating since 1995
 - Bishops Falls: (6) Francis type 2,800 kW type unit @ 35 ft head operating since 2002/2003
- **System Dimensions (feet):** 20 (L) × 8 (W) × 10 (D)

Company Contact Information

Company Name	American Hydro Corporation
Mailing Address	PO Box 3628 York, PA 17402 US
Website URL	www.ahydro.com
Contact's Name	Gerry Russell
Contact's Title	Marketing Manager
Contact's Telephone	717-755-5300
Contact's Fax	717-755-5522
Contact's Email	grussell@ahydro.com

Company Profile

Years in Business	15-20 years
Number of Employees	51 or more employees
Annual Equipment Sales	greater than \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- References available upon request from owners and operators familiar with one or more of the more than 375 hydroturbine units built or upgraded by American Hydro.

Stream Engine, Water Baby and LH1000

*Development Stage:
Commercially available*



Stream Engine

Product Description

Presently we manufacture three hydroelectric generators: the Stream Engine, the Water Baby, and the LH1000. We make a machine using a four inch pitch diameter turgo runner and an adjustable permanent magnet generator. Up to four, 1 inch diameter nozzles can be used. Voltages of 12, 24, 48 and higher can be generated at most heads- from five to hundreds of feet. These are used to charge batteries and then power inverters.

We make a Water Baby which uses a hybrid runner that is 2 inches in diameter and can also use as many as four nozzles up to 1/4 inch in diameter. This can operate at heads of 20 feet to hundreds of feet, and it uses a permanent magnet generator that can be adjusted while operating. *(continued on next page)*

Product Highlights		
Standard Unit Design Capacity	2 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input checked="" type="checkbox"/> Effluent streams <input checked="" type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	Yes	
Characteristic Dimension	0.33 ft	
Rotational Axis Orientation	Vertical	

Product Description continued

The third machine we make is a 5 inch diameter propeller turbine. This machine can operate at heads of 2 to 10 feet and uses the same generator as the Stream Engine. It can produce a maximum of 1 kW at a 10 foot head.

Product Specifications/Details (Standard Stream Engine Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Flow range	10	200	<i>gpm</i>
Hydraulic head range	5	400	<i>ft</i>
Power output range	0	2	<i>kW</i>
Waterway depth	-	-	<i>ft</i>
Waterway width	-	-	<i>ft</i>

- **Efficiency:** Turbine: 80% Total System: 60%
- **Deployment Locations:** Worldwide
- **Operating History:**
 - Started in 1984 selling complete machines. To date over 2,000 machines sold.
- **System Dimensions (feet):** 1 (L) × 1 (W) × 0.8 (D)
- **Unit Price (U.S. dollars):** \$1895

Company Contact Information

Company Name	Energy Systems & Design
Mailing Address	P.O. Box 4557 Sussex, NB E4E 5L7 Canada
Website URL	www.microhydropower.com
Contact's Name	Paul Cunningham
Contact's Title	CEO
Contact's Telephone	506-433-3151
Contact's Fax	506-433-6151
Contact's Email	hydropow@nbnet.nb.ca

Company Profile

Years in Business	20-30 years
Number of Employees	less than 5 employees
Annual Equipment Sales	\$100,000 - \$1,000,000

Affiliations/Alliances/Credentials/References/Publications

- Home Power Magazine

T15 Cross Flow Turbine with DTC-Vario Control System

*Development Stage:
Commercially available*



Cross flow turbine on test bench

Product Description

Our high-efficiency cross-flow turbines (Former SKAT) have been steadily optimized over the last years. entec has established itself as the leader for locally manufactured cross-flow turbines in development cooperation.

The latest research resulted in a further increase in efficiency and drastically improved part load characteristic of our latest turbine generation.

(continued on next page)

Product Highlights		
Standard Unit Design Capacity	75 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other
Other sizes currently available	-	
Characteristic Dimension	0.30 m	
Rotational Axis Orientation	-	

Product Description continued

Key Benefits of the Entec Crossflow Turbine T14:

- High part-load efficiency
- Reaches 80% peak efficiency (more for larger units)
- Optimised guide vane for minimal operating forces

The DTC-Vario is our latest generation of digital control systems for decentralized power generation. It is successfully implemented in small hydropower plants, but the DTC-Vario is much more than a simple turbine controller. Developed originally for cogeneration plants, the hardware is highly versatile and can be adapted to almost any type of plant.

Compared to conventional systems, significant cost and complexity reduction can be achieved by combining three basic functions using the same hardware: control, protection and metering. Reducing the number of components also means increasing the reliability. Beyond that, it allows for advanced remote control and data tracking features, up to complete network integration of small units in the sense of a virtual production park.

The DTC-Vario is a modular system made of several units. The modern, layered architecture makes a clear distinction between power unit and data processing. Units are also available separately. We also offer oil-hydraulic actuators which perfectly fit our turbines and control system. Turn-key systems (water to wire) in standardized or customized configuration are available.

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Flow range	100	1,200	m^3/sec
Hydraulic head range	4	70	<i>m</i>
Power output range	10	300	<i>kW</i>
Waterway depth	-	-	<i>m</i>
Waterway width	-	-	<i>m</i>

- **Efficiency:** Turbine: 80% Total System: 74%

- **Deployment Locations:** Worldwide, mostly in Asia.

*Product Specifications/Details (Standard Unit) continued***• Operating History:**

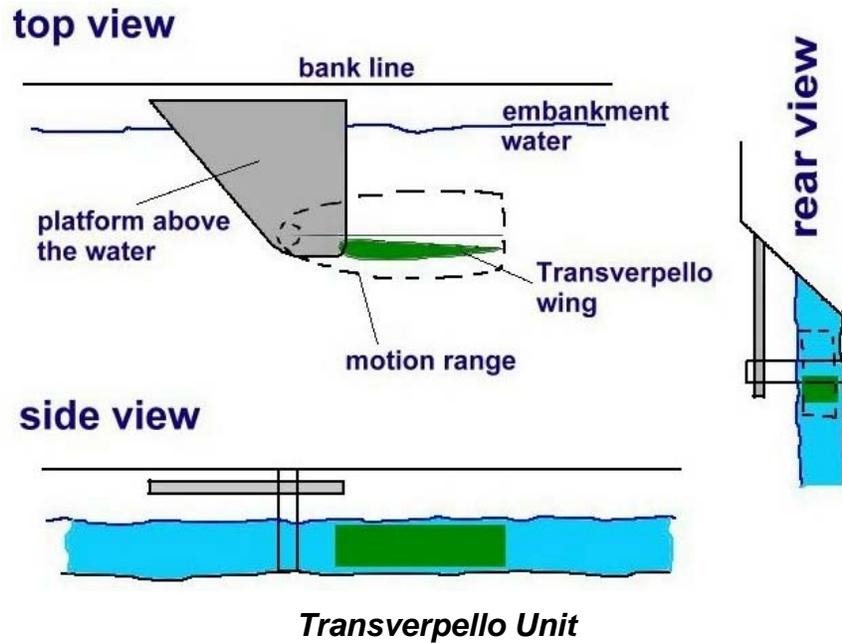
- 1976: The prototype of the T1 turbine is developed for local manufacturing in Nepal. Turbines are successfully used for mill operation and village electrification.
- 1980 - 1996: The T1 is followed by the T3, T7, T8, T12, T13.
- 1998: Complete re-engineering, based on elaborate testing and improved design of components, results in a new design, the T14 Cross Flow Turbine.
- 2002: The DTC-Vario control system is developed and the first two units are commissioned in the same year.

Company Contact Information

Company Name	entec Consulting & Engineering
Mailing Address	Bahnhofstrasse 4 St. Gallen CH-9000 Switzerland
Website URL	www.entec.ch
Contact's Name	Manuel Buser
Contact's Telephone	+41 71 228 10 20
Contact's Email	info@entec.ch

Transverpello

Development Stage: Engineering scale



Product Description

To harness the immense energy of the rivers in lowlands would be to get hold of far and away the biggest, cheapest and most neutral environmental source of energy on planet Earth. It wasn't feasible so far, due to geometrically caused economic reasons: with the circular face of the turbine rotation the very narrow cross-section of a river can't be viably held, it requires a head of water, and for it valley slopes. It will become completely different if the converter is not a rotator and its motion doesn't slip over a circular face but over a narrow rectangle. To visualize, it means the technical transformation of something of aquatic plants waving in the current to and fro. A pendulum wing like a flag on the staff.

(continued on next page)

Product Highlights	
Standard Unit Design Capacity	25 kW
Other sizes currently available	Yes
Characteristic Dimension	25 m
Rotational Axis Orientation	Vertical
Design Working Environment	
<input checked="" type="checkbox"/> Natural waterways <input type="checkbox"/> Water transmission systems <input type="checkbox"/> Effluent streams <input type="checkbox"/> Tidal estuaries <input checked="" type="checkbox"/> Near shore ocean <input type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input type="checkbox"/> Other	

Product Description continued

Such a machine has been built and tested at the Institute of Water Resources of the University of the German Federal Armed Forces, Munich, and the measuring results for checking the calculation hypothesis were greater than the expectations. The measuring report can be found at www.transverpello.de.

The cost degression which is usual with the increase in engine size is far more significant with this application, the constellation is unique. The wing should be trimmed as weightless, it is carried by the water. The single wing modules of a complete plant should be installed into line only in an area near the bank, not in the shipping lane; the shipping will be unimpeded. And in winter the constant motion with its big force, equivalent to draw-loads of many tons, will prevent ice from forming. Down days because of high water will be less than with the turbine plant because here no relative rise of the tailwater level is of importance, nor the smaller driftwood; for bigger things the rough type of rake is possible.

Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

<i>Category</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Units</i>
Velocity range	1.5	—	<i>m/sec</i>
Hydraulic head range	—	—	<i>m</i>
Power output range	—	—	<i>kW</i>
Waterway depth	2.5	—	<i>m</i>
Waterway width	20	—	<i>m</i>

- **Efficiency:** Turbine: — Total System: 50%

- **Deployment Locations:**

- The pilot plant will probably start this year in the Rhine near Koblenz, river kilometer 602.

- **System Dimensions (meters):** 30 (L) × 20 (W) × 2.5 (D)

- **Unit Price (U.S. dollars):** \$180,000

Company Contact Information

Company Name	Muehlhaus + Partner Tragwerksplanung
Mailing Address	Donnersbergerstr. 22 80634 Muenchen Germany
Website URL	www.transverpello.de
Contact's Name	Martin Muehlhaus
Contact's Telephone	+49 89 167023
Contact's Email	info@mup-ing.de

Company Profile

Years in Business	30 or more years
Number of Employees	6-20 employees
Annual Equipment Sales	less than \$1000

Underwater Electric Kite

Development Stage: Demonstration



Lowering the Twin Turbines into the Water for Testing

Product Description

The basic principle of the UEK® System is a shrouded horizontal axial turbine converter.

To take advantage of the fastest water flow velocity, the device is built with two counter rotating turbines, side by side, to cancel the torque exerted on the housing and therefore permit the unit to be free of civil support work such as a tower, bridges, platform or other permanent structures. (Patent No. 6,139,255 – October 31, 2000 and US 6,168,373 B1 – January 2, 2001)

The “Augmentor ring” feature, an integral part of the housing, permits energy extraction from a larger surface cross section than the device which results in a considerably increased availability of kinetic resource.

(continued on next page)

Product Highlights		
Standard Unit Design Capacity	400 kW	Design Working Environment <input checked="" type="checkbox"/> Natural waterways <input checked="" type="checkbox"/> Water transmission systems <input checked="" type="checkbox"/> Effluent streams <input checked="" type="checkbox"/> Tidal estuaries <input checked="" type="checkbox"/> Near shore ocean <input checked="" type="checkbox"/> Off-shore ocean <input type="checkbox"/> Deep ocean <input checked="" type="checkbox"/> Other Instream Energy Recovery System
Other sizes currently available	Yes	
Characteristic Dimension	8 ft	
Rotational Axis Orientation	Horizontal, parallel to flow	

Product Description continued

Present designs, prototypes and tooling encompass river, tidal, amphibious, ocean and instream recovery systems. Sizes available are from 3 to 22 feet in diameter, single or twin runners.

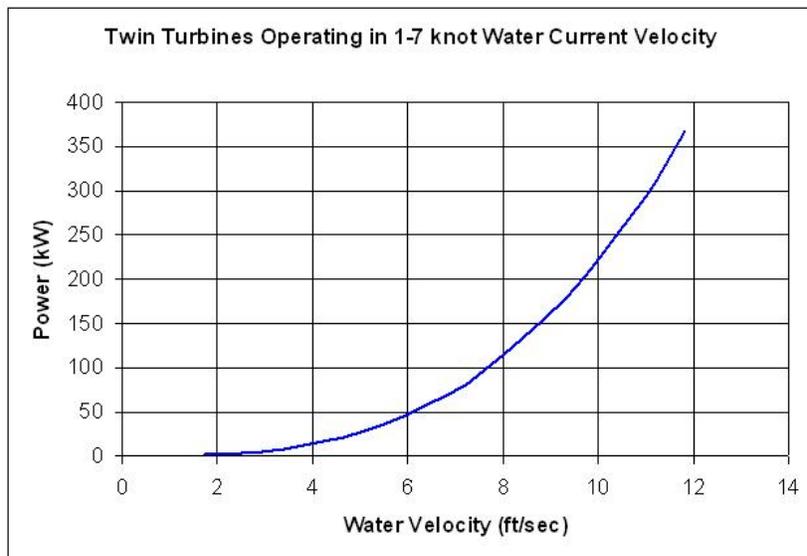
Product Specifications/Details (Standard Unit)

- **Performance Specifications:**

Category	Minimum	Maximum	Units
Velocity range	6.8	11.8	ft/sec
Hydraulic head range	-	-	ft
Power output range	69.1	370.5	kW
Waterway depth	12	-	ft
Waterway width	30	-	ft

- **Efficiency:** Turbine: 65.8% Total System: 57.1%

- **Operating Curve/Envelope:**



Design Capacity Tested:	90 kW
Test Date:	June 12, 2000
Test Location:	DeQew Hydropower Plant, St.Catharines, Ontario

Product Specifications/Details (Standard Unit) continued

- **Deployment Locations:** DeQew Hydroelectric Power Facility, St Catharines, Ontario
- **Operating History:**
 - Demonstrated “Water to Wire” of the UEK® System at the DeQew Hydroelectric power Facility, St Catharines, Ontario, to Ontario Power Generation, May 2000
 - 36 day duration of the test/demonstration took place in the discharge flume of the Power Plant
 - demonstration was 95% successful according to the principal research engineer, Mr. David Young
- **System Dimensions (feet):** 16 (L) × 20 (W) × 10 (D)

Company Contact Information

Company Name	UEK Corporation
Mailing Address	P.O. Box 3124 Annapolis, MD 21403 U.S.
Website URL	http://uekus.com/
Contact's Name	Philippe Vauthier
Contact's Title	President and Chief Marketing Officer
Contact's Telephone	410-267-6507
Contact's Fax	410-280-3717
Contact's Email	ph.vauthier@uekus.com

Company Profile

Years in Business	20-30 years
Number of Employees	less than 5 employees
Annual Equipment Sales	\$10,000 - \$100,000

Affiliations/Alliances/Credentials/References/Publications

- Acquire Ltda, Alaska Power & Telephone, University of Alaska, University of Manitoba, Manitoba Hydro, Kraft Fluid Systems Inc., RSW Inc., Ontario Power Generation, NRG, MTS, Natsource
- DOE, GRE, PCG
- US Navy
- See web page “ links” for more detail of publications

TECHNOLOGY CONCEPT LISTINGS

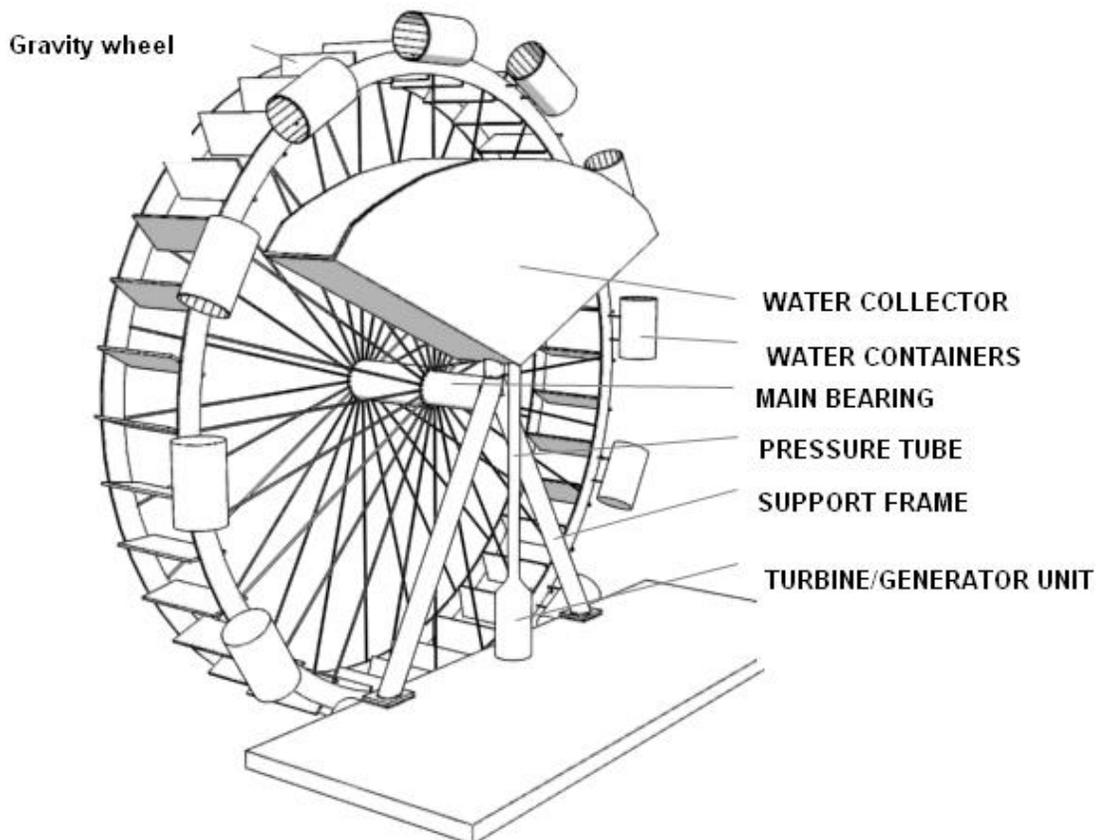
The low power hydropower technology concept listings in this section are for technologies at the pre-conceptual design stage of development. They may range from a bright idea to concepts supported by extensive engineering analysis. Each listing was produced using developer-supplied information. Although a standard listing format was used, the information in the listings varies depending upon the completeness of the information supplied. The listings all contain the following four principal sections:

- **Production description-** gives an overview of the technology
- **Company contact information-** includes company address, contact name, telephone and fax numbers, email address, and website URL
- **Company profile-** provides a thumbnail image of the company based on years in business, number of employees, annual sales of low power hydropower equipment, and any affiliations, alliances, credentials, references and/or publications.

The reader should be aware that the catalog authors make no attempt to verify or validate information that appears in the technology concept listings or to assess the viability of the concept based on basic physical principles or engineering practicality. Information is included only with the approval of the information supplier, who is solely responsible for the contents of the listing. If the reader requires additional information, it should be requested from the listed technology concept contact. Technology concept listings in this catalog may be updated at any time without notice. Each listing contains a date stamp to identify when the information was updated.

Gravity Wheel

Development Stage: Concept



Gravity Wheel- The Future of Hydroelectric Power

Product Description

The Gravity Wheel is actually an ancient design. It is known as a Persian waterwheel. These are still in use around the world. The difference in these two models is the Gravity Wheel raises water to produce electricity by way of a turbine; a Persian waterwheel raises water for irrigation and drinking water. The problem with waterpower today is it builds water pressure with a dam, which is environmentally impactful. The Gravity Wheel does not use a dam. It floats so there are no structures driven into the bed of the river. It is held in place with cables.

Many people have tried to design machines that would harness the power of a river. They all have failed due to the gearing problem. To change the slow (but powerful) movement of a river into electricity, one must multiply the RPM by the hundreds. My design avoids all of that. It acts like a huge transformer. It turns high volume-low pressure into low volume-high pressure water, which can be used to run a turbine.

Company Contact Information

Company Name	Dennis Buller
Mailing Address	114 Fifth Ave Milford, CT 06066 US
Contact's Name	Dennis
Contact's Telephone	860-212-6367
Contact's Email	WildWaterPower@msn.com

Company Profile

Years in Business	less than 1 year
Number of Employees	less than 5 employees
Annual Equipment Sales	less than \$1000

Company Directory

Alternative Hydro Solutions Ltd.

323 Richmond St. E.
Suite 421
Toronto, ON M5A 4S7
Canada

Tel: 416-368-5813
Fax: 416-368-5813
www.althydro.com

Contact: Steve Gregory, President
sdgregory@althydro.com

American Hydro Corporation

PO Box 3628
York, PA 17402
United States

Tel: 717-755-5300
Fax: 717-755-5522
www.ahydro.com

Contact: Gerry Russell, Marketing Manager
grussell@ahydro.com

Blue Energy Canada, Inc.

PO Box 29005
1950 West Broadway
Vancouver, BC V6J 5C2
Canada

Tel: 604-886-8783
www.bluenergy.com

Contact: Michael Maser, Communications
maser@uniserve.com

Canyon Industries, Inc.

5500 Blue Heron Lane
Deming, WA 98244
United States

Tel: 360-592-5552
www.canyonhydro.com

Contact: Dan New, President
citurbine@aol.com

Canadian Hydro Components Ltd.

P.O. Box 640
16 Main Street
Almonte, Ontario
K0A 1A0
Canada

Tel: 613-256-1983
Fax: 613-256-4235
www.canadianhydro.com

Contact: Mike Dupuis, President
inquiries@canadianhydro.com

Cargo & Kraft Turbin Sverige AB

Kedjebohammar
S-739 92 Skinnskatteberg
Sweden

Tel: +46 222 280 80
Fax: +46 222 280 20
www.cargo-kraft.se

Contact: Peter Ruyter, Manager
turbin@cargo-kraft.se

CKD Blansko Engineering, a.s.

Gellhornova 2235/8
67801 Blansko
Czech Republic

Tel: 00420-533 309 802
Fax: 00420-533 309 588
www.cbeas.com

Contact: Adolf Svoboda, Commercial Director
or@cbeng.cz

Dennis Buller

114 Fifth Ave
Milford, CT 06066
United States

Tel: 860-212-6367

Contact: Dennis
WildWaterPower@msn.com

Company Directory

Energy Systems & Design

P.O. Box 4557
Sussex, NB
E4E 5L7
Canada

Tel: 506-433-3151
Fax: 506-433-6151
www.microhydropower.com

Contact: Paul Cunningham, CEO
hydropow@nbn.net.ca

entec Consulting & Engineering

Bahnhofstrasse 4
St. Gallen
CH-9000
Switzerland

Tel: +41 71 228 10 20
www.entec.ch

Contact: Manuel Buser
info@entec.ch

Florida Hydro, Inc.

171 Comfort Rd.
Palatka, FL 32177
United States

Tel: 386-328-2470
Fax: 386-328-2558
<http://floridahydro.com/>

Contact: Herbert Williams, President
floridahydro@msn.com

Fluidmotive, Inc.

251 W. Montgomery Ave.
Suite #2
Haverford, PA 19041
United States

Tel: 610-745-1990
Fax: 610-896-3919
www.fluidmotive.com

Contact: Dr. Jonathan B. Rosefsky, President
fluidmotive.inc@att.net

Muehlhaus + Partner Tragwerksplanung

Donnersbergerstr. 22
80634 Muenchen
Germany

Tel: +49 89 167023
www.transverpello.de

Contact: Martin Muehlhaus
info@mup-ing.de

Ossberger Turbines, Inc.

P.O. Box 736
Hayes, VA 23072
United States

Tel: 804-360-7992
Fax: 804-360-7993
www.ossberger.de, www.hts-inc.com

Contact: Alfred Patzig, Vice-President
patzig@hts-inc.com

Rapid-Eau Technologies, Inc.

P.O. Box 1113
Cambridge, ON N1R7G8
Canada

Tel: 1-519-740-8786
Fax: 1-519-740-0422
www.rapid-eau.com

Contact: Dave de Montmorency, President
dave@rapid-eau.com

UCM Resita SA

1 Golului Street
320053 Resita
Romania

Tel: +40-255-217111
Fax: +40-255-223082
www.ucmr.ro/

Contact: Dan Petrescu, Commercial Director
contact@ucmr.ro, dpetrescu@ucmr.ro

Company Directory

UEK Corporation

P.O. Box 3124
Annapolis, MD
21403
United States

Tel: 410-267-6507
Fax: 410-280-3717
<http://uekus.com/>

Contact: Philippe Vauthier, President and Chief Marketing
Officer
ph.vauthier@uekus.com

Verdant Power LLC

4640 N. 13th St.
Arlington, VA 22207-2102
United States

Tel: 703-528-6445
Fax: 703-812-8157
www.verdantpower.com

Contact: Trey Taylor, President and Chief Marketing
Officer
ttaylor@verdantpower.com