

*MAVEL*

Mavel Hydro Turbines



Mavel designs, engineers, and manufactures hydro turbines and related equipment for projects ranging from 30 kW to 30+ MW. The company focuses on the global small hydro market and offers a complete line of Pelton, Francis, Kaplan, and TM Micro turbines.

### **Kaplan**

The majority of Mavel's projects over the past 20 years have been Kaplan turbines. These turbines come in a variety of configurations and are best suited for low head, high flow sites.

### **Francis**

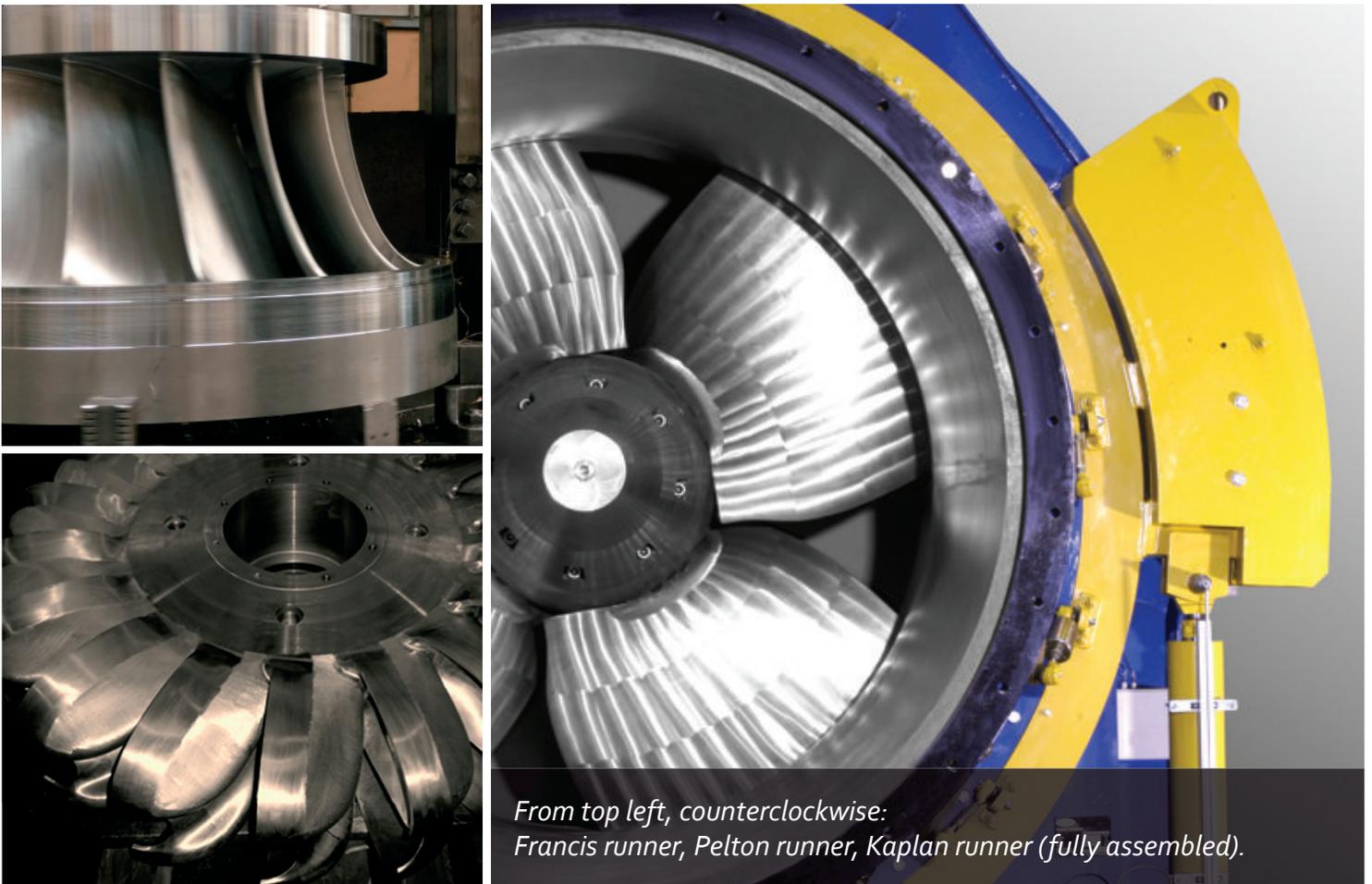
The Francis turbine is the most commonly used turbine in the world today. Mavel's Francis runners are milled from a single block of forged steel to ensure high runner quality. Francis turbines have a wide application range for medium heads.

### **Pelton**

This impulse turbine is designed for sites with high head and lower flow rates. Like the Francis turbine runners, Mavel's Pelton runners are milled from a single block of steel for superior quality.

### **TM Micro**

Mavel's TM Micro turbines come as complete packages, including all electrical, mechanical, and control components needed for turnkey operation. These turbines are designed for sites with heads up to 6 meters.



*From top left, counterclockwise:  
Francis runner, Pelton runner, Kaplan runner (fully assembled).*



# The Kaplan Turbine

Invented in 1912 by Victor Kaplan in Brno, the second largest Czech city, the Kaplan turbine gained widespread popularity due to its high efficiency over a wide range of site conditions. In the 100 years since its creation, a variety of turbine configurations have been developed.

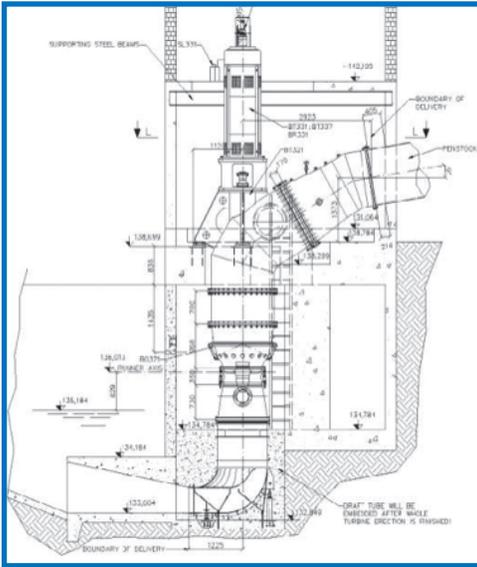
The Kaplan turbine automatically adjusts its runner blades and wicket gates to suit changing water conditions. This unique adaptability allows for consistently high efficiency over a range of flow and head conditions.

Mavel's Kaplan turbines are designed for power plants with heads up to 35 meters. A number of turbine configurations (Z, Pit, S, Vertical, and Bulb) ensure an effective solution for specific site conditions. Mavel's Kaplan turbines have three to six runner blades and can be single or double regulated. Mavel has over 250 Kaplan turbines installed at sites around the world.

## Kaplan Turbine Range

<b>Turbine Configuration</b>	Z, Pit, S, Vertical, Bulb
<b>Runner Diameter</b>	550 mm to 5500 mm
<b>Number of Runner Blades</b>	3, 4, 5 or 6
<b>Head</b>	1.5 to 35 meters [4.9 to 115 ft]
<b>Flow</b>	0.9 to 100 m <sup>3</sup> /s [31 to 3531 cfs]
<b>Power Output</b>	30 to 20,000 kW

Mavel produces five different configurations of the Kaplan turbine: Z, Pit, S, Vertical, and Bulb. The ideal configuration for a system is dependant upon head and flow conditions.

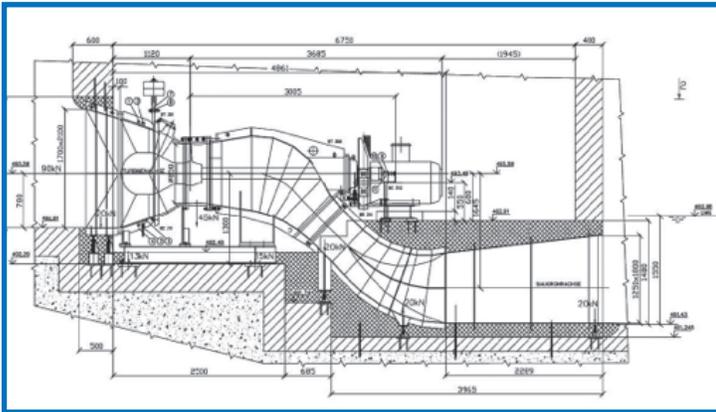
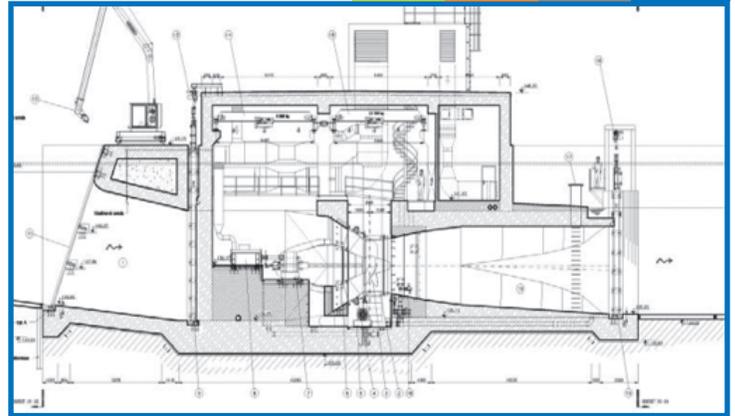


**Kaplan Z Turbine**

The Z configuration is best suited for turbine replacement or installations where space is limited.

**Kaplan Pit Turbine**

This configuration works best under low head and high flow conditions.

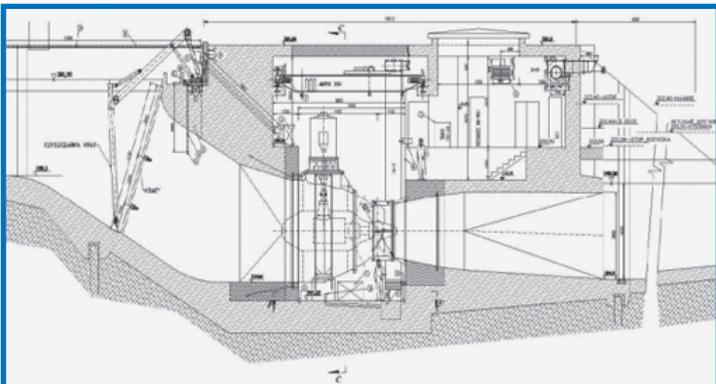
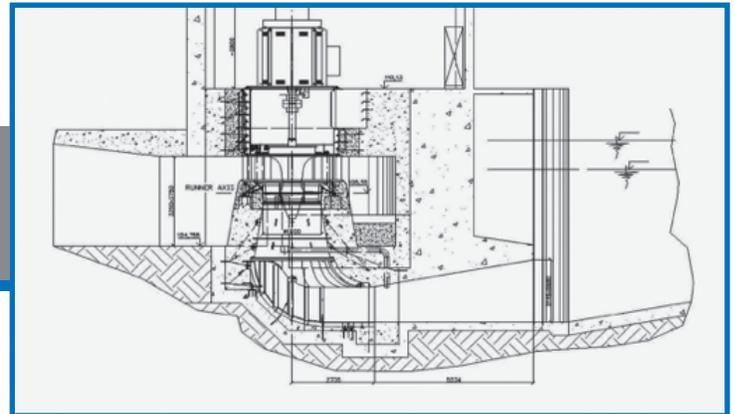


**Kaplan S Turbine**

The S design is best suited for turbine replacement and flows up to 210 cfs.

**Kaplan Vertical Turbine**

The vertical Kaplan turbine is highly versatile and works with a range of site conditions.



**Kaplan Bulb Turbine**

This turbine configuration is best suited for low head and moderate flow, and can be attached to the generator via either belt drive or a gearbox.



# The Francis Turbine

Invented by James Francis in Massachusetts in 1848, the Francis turbine is the most widely used turbine in the world today.

The Francis turbine is designed for medium heads and medium flow rates. Its high efficiency and possible use for wide range of heads from 10 m to 400 m have made it the most widely used turbine in the world.

Mavel's Francis runners are milled from a single block of forged steel using either a 5-axis or 6-axis CNC milling machine. These turbines are customized for each site and can be configured either vertically or horizontally. Over the past 20 years, Mavel has installed over 60 Francis turbines around the world.

## Francis Turbine Range

<b>Turbine Configuration</b>	Horizontal or Vertical
<b>Runner Diameter</b>	400 mm to 2500 mm
<b>Head</b>	15 to 300 meters [49 to 985 ft]
<b>Flow</b>	0.5 to 35 m <sup>3</sup> /s [17.5 to 1236 cfs]
<b>Power Output</b>	Up to 30,000 kW



# The Pelton Turbine

Lester Pelton invented the Pelton turbine in 1878, following the California Gold Rush. Having witnessed miners using inefficient water wheels for energy, Lester Pelton was inspired to design a better turbine.

The Pelton turbine is designed for high heads and lower flow rates. A number of jets (1-6) direct water at extremely high velocity at the turbine buckets, which cause the turbine to spin.

Mavel's Pelton turbines are designed for hydroelectric plants with heads ranging between 50 and 1000 meters. Each Pelton runner is customized and can be configured either vertically or horizontally. The runners are milled from a single block of steel. Mavel's Pelton turbines are installed at projects in Europe, Asia, and North America.

## Pelton Turbine Range

<b>Turbine Configuration</b>	Horizontal or Vertical
<b>Runner Diameter</b>	Up to 2500 mm
<b>Number of Jets</b>	Horizontal: 1 or 2 Vertical: 3, 4, 5 or 6
<b>Head</b>	50 to 1000 meters [164 to 3280 ft]
<b>Flow</b>	0.1 to 10 m <sup>3</sup> /s [4 to 353 cfs]
<b>Power Output</b>	Up to 30,000 kW



## The TM Micro Turbine

Mavel's line of TM Micro turbines are designed for sites with low flow and head conditions. Easily installed, the TM Micro turbines utilize siphon technology to generate electricity.

Mavel's TM Micro turbines are sold as complete units for turnkey installation. With three different sizes (300 mm, 500 mm, and 1000 mm runner diameter) the TM Micro turbines are suitable for most low head sites.

This line of TM Micro turbines are designed for installation with minimum construction demands for sites with low head and flow conditions. With no powerhouse necessary, these turbines are easy to install and come fully equipped with turbine, generator, inlet, draft tube, and electric and control systems. Mavel has installed over 50 TM Micro turbines globally.

### TM Micro Turbine Range

<b>Runner Diameter</b>	300 mm to 1000 mm
<b>Head</b>	1.5 to 6 meters [4.9 to 19.7 feet]
<b>Flow</b>	0.15 to 4.5 m <sup>3</sup> /s [5.3 to 159 cfs]
<b>Power Output</b>	3 to 180 kW

Mavel is the only company that combines a complete range of Pelton, Francis, Kaplan, and TM Micro turbines, a global marketing reach, and a sole focus on small hydropower.

#### Engineering

Each hydroelectric project begins with design. Mavel's team of civil, mechanical, hydraulic and electrical engineers begin working on a project during the preparation of the sales proposal. Their work, using 3D software, continues through design, to final manufacturing and installation documentation.

#### Welding and Coatings

Mavel employs experienced welders and is certified as CSN EN 287-1. The company also has 2,400 square feet of specialized work areas and trained technicians to oversee all special coatings and painting operations.

#### Assembly

Mavel's headquarters in Benesov has a 26,900 square foot hall with 60 ton crane capacity for assembly operations. Each turbine is fully assembled, fitted and tested prior to preparation for transport.

#### Quality Control

Mavel is an ISO 9001:2008 and ISO 14001:2004 certified company and has quality control procedures in accordance with recognized international standards. Mavel's QC certified personnel perform most testing. External specialists complete certain specialized tests, such as x-ray, chemical composition, and metallography.

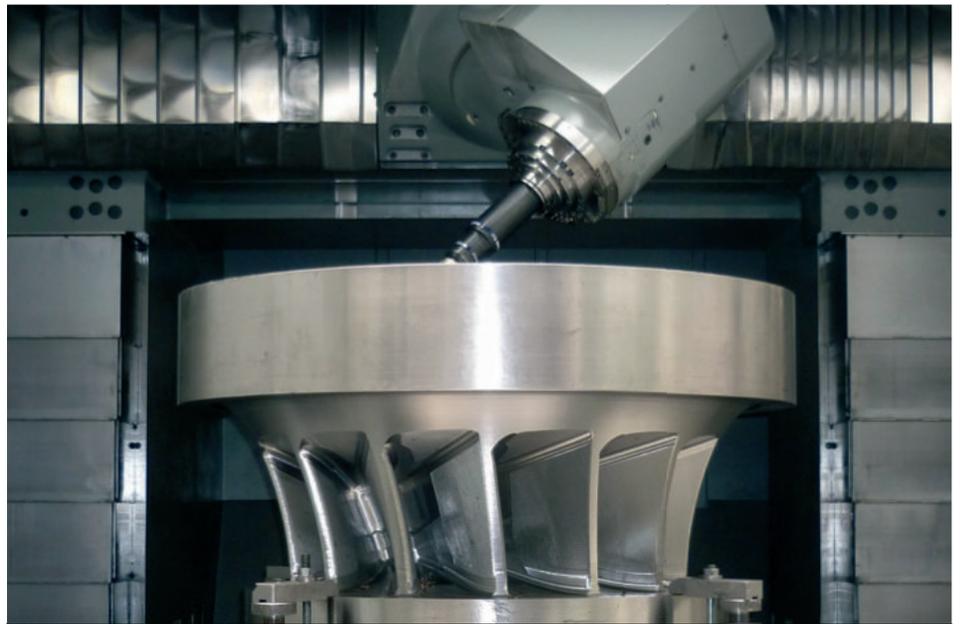
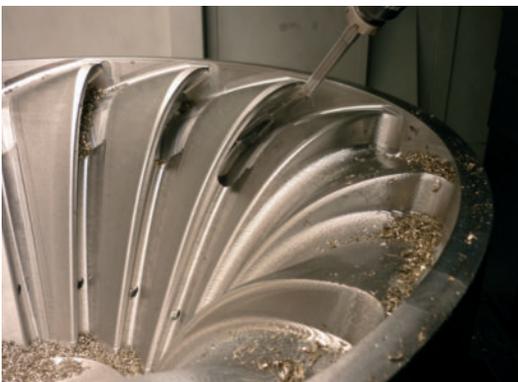
#### Machining

Mavel manufactures its turbines and related equipment at one of its two Czech Republic facilities, which are equipped with both traditional production technology and state-of-the-art customized machine tools. These include a 6-axis milling machine put into operation in 2013 and a 5-axis milling machine installed in 2010. In addition, Mavel's approximately 50 machines have the following capabilities:

- milling of small and large parts
- horizontal boring
- drilling and pressing
- grinding and sawing
- metal rolling and cutting

#### Purchasing

Mavel has an office of strategic purchasing, which sources castings, raw material and large subcomponents (such as generators) from suppliers across Europe and the Americas. Each supplier is researched for quality assurance and each subcontracted item meets the same quality standards as ISO 9001:2008 certification.



*From top left, counterclockwise:  
Partially machined solid steel block before milling; Francis turbine partway through milling process; 5-axis CNC mill in the finishing stages of manufacturing.  
All photos from the Benesov, Czech Republic facility.*



Mavel's experienced teams of engineers, designers, and production experts work together to produce a cost-effective, customized solution.

#### **Complete "water-to-wire" Solution**

Mavel provides customers with a complete solution. A team of dedicated engineers will evaluate each site and, based on the requirements of the location, recommend a complete solution from civil design to turbine type and configuration to control systems. Once an overall design is selected, Mavel will provide all the needed hydro equipment.

#### **Penstocks, Draft Tubes and Outlets**

Mavel has the capability to design and provide all water handling equipment including penstocks, draft tubes, outlets, associated valves and other ancillary equipment.

#### **Weir Gates, Trash Racks and Cleaning Machines**

Mavel manufactures automated and hydraulically controlled gates and other steel structures for the weir. The company also produces its own line of customized trash racks, screens and cleaning machines.

#### **Electrical Equipment**

Mavel supplies customers with a complete hydroelectric power system including generator, hydraulics, governor, transformer as well as control and electrical systems for onsite or remote operation. This equipment is designed and provided in-house or in coordination with an experience supplier.

#### **Installation, Testing, and Commissioning**

Mavel's installation team has supervised the installation, testing, and commissioning of more than 400 turbines globally in the past 20 years.

#### **Refurbishment and Repair**

Mavel has a qualified after sales service department which is able to devote the same engineering and technical expertise to customers for the maintenance, refurbishment and/or repair of existing facilities.

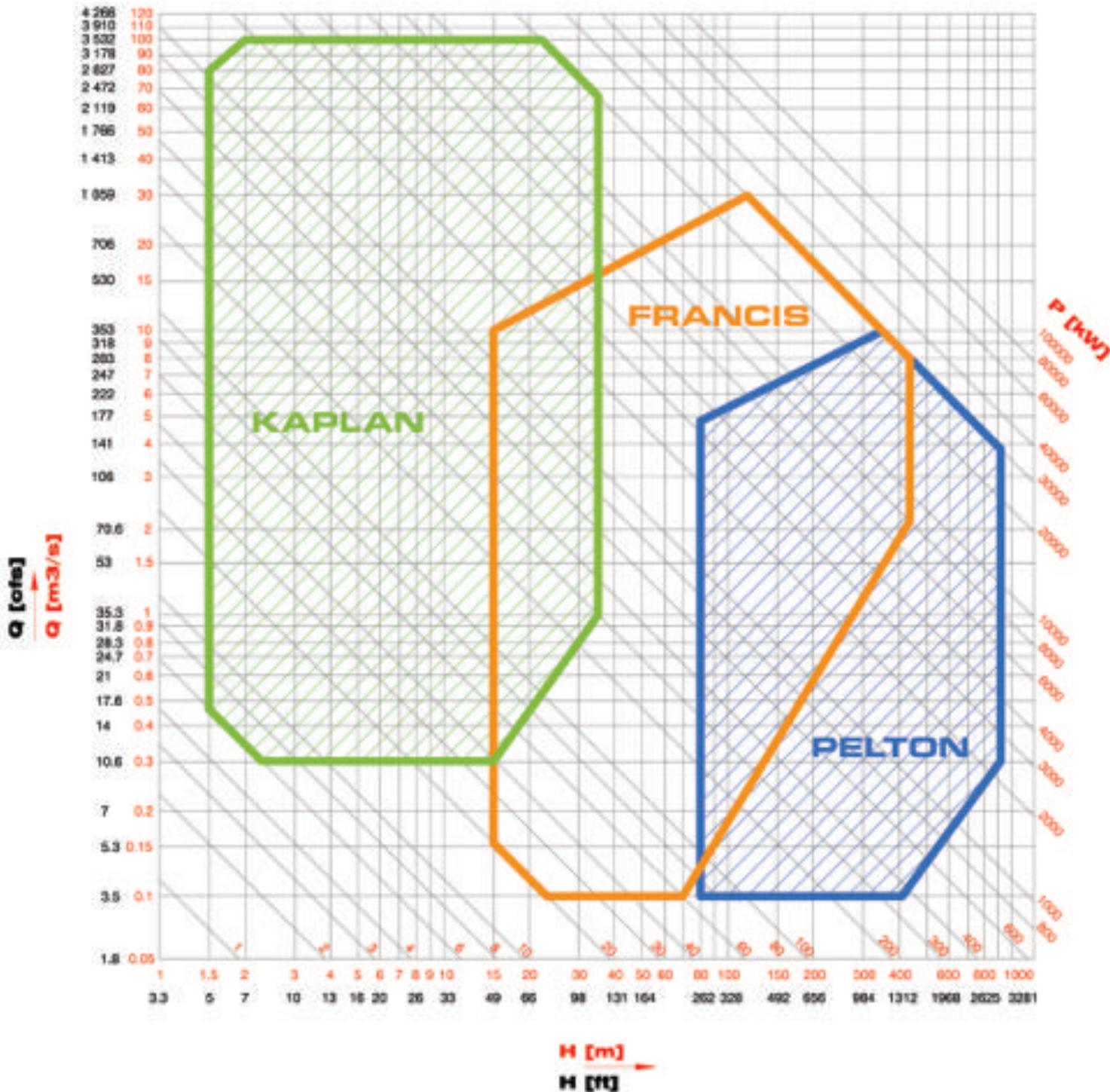
## Production

All of Mavel's turbines are manufactured and assembled in two state-of-the-art production facilities located in the Czech Republic.

*Above: assembled Kaplan Bulb turbine prior to transport.*

# Turbine Application Range

The 3-axis chart below displays the relationship between head, flow, and power output for Kaplan, Francis, and Pelton turbines. TM Micro turbines are specialized for low power output and are not included in this diagram.





Mavel's 6-axis milling machine at Benesov, CZ manufacturing facility

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