Background:

The most *significant force* acting against an efficient high speed water propulsor is friction. Water is extremely dense and it takes enormous energy to drive (pump), or alternatively to drive through (propel). A British Scientist called Reynolds defined the phenomenon. Reynolds number is used to calculate energy absorbed by a fluid's motion relative to a surface. The viscous nature of water is the source of the problem. A water molecule adheres to the surface of any object with which it comes in contact, causing it to lag behind the flow of the main body of water. Each molecule interacts in turn with the adjacent water molecules, thereby transmitting some of this lag. The molecules with the least lag are furthest from the source of the friction and therefore travel faster. The higher the velocity the greater the relative lag until finally the flow starts to tumble. The effect is called "turbulent flow." Reynolds states that once turbulent flow is reached, energy usage will increase exponentially in relation to the water-speed and whetted surface area. This represents a huge barrier for high speed water propulsion, pumping and hydro-electric production. At speed, propellers, boat hulls, rudders, support structures and water-jets are all subject to extremely large losses. Because of the cubic rate of increase in energy usage with velocity, this is where the potential for greatest savings reside. This is as true for the Contrapel system as it is for any propeller or water-jet propulsor.

In these other propulsion systems, the development of specialized propellers with complex shapes, reduced diameters and whetted surfaces has helped mitigate the losses associated with friction and enabled relatively high propulsive speeds. Within the water-jet range of units specifically, one variety called a "mixed-flow pump" is utilized to achieve greater top speeds, as these are able to produce very high head-pressure. The cost for high speeds however, is poor low-speed propulsive efficiency.

Attempts to reduce the effects of friction, started with the obvious, such as streamlined shapes and smooth surfaces. The less obvious solutions included constructing large bulges on the nose of displacement vessels. Recently swim suits developed to reduce friction have been banned from competition because of the competitive advantage they apparently gave. Unfortunately once each small advance is optimised and the velocity gains realised, the frictional losses resume their cubic rate of climb and the only way to push the envelope further is to pour in more energy. Once again, modest increases in velocity come at a ridiculous increase in energy input. Other issues, such as cavitation damage also start to impact the equation, as well as loss of low speed propulsive efficiency. In this sense it could be claimed that these measures are mitigating the effects of friction but not confronting the issue.

One technology that could claim to tackle the problem has been developed in Russia, where they've been leading the way in high-speed torpedo development. The maximum speed able to be reached by a conventional underwater torpedo is about 150 km per hour whereupon practical power and conventional propulsion is overcome by friction. The Russians have been working on reducing friction on torpedoes by cocooning them in gas. A rocket propels the torpedo while some of the gas is diverted and expelled at the nose. Completely encapsulated in a shroud, the missile is able to achieve outstanding speeds of many hundreds of kilometres per hour. This example is relevant to the following discussion since it clearly demonstrates that breaking direct contact with the water can result in huge energy savings and unparalleled gains in speed.

Other "contact breaking" efforts include a lot of work on larger surface planning boats to try to reduce the hull's contact with the water. Entrained air under specially designed shapes within the hull have led to some gains, however they have mostly been offset by the energy required to maintain the air supply. The principle of reducing friction as a way to make speed and efficiency gains, has been well established. Unfortunately the applications have been limited, or resulted in less welcomed side-effects. The Contrapel Hybrid system has taken this previously described design consideration and applied it in a new and unexpected way, resulting in outstanding propulsive gains with none of the unwanted consequences.

"*Beat friction ... and rule the waves*"

There are several pre-existing elements inherent to the Contrapel Hybrid system which have enabled the development of the world's first *super efficient propulsor*. While development is still in its infancy, the gains witnessed in tests are massive and the consequential performance improvements are stunning. This impacts propulsion, pumping and hydro-electric low-head power generation in a very profound way.

A normal submerged propeller will reach the point where it is simply unable to be rotated at a higher speed without "skidding" (loss of propulsive thrust) which can incur significant blade damage. This is a very limiting and potentially destructive effect called cavitation. There are propellers that have been designed called super-cavitation propellers. These propellers are specially shaped so that the cavitation forms over the low pressure side of the blade thus reducing the wetted surface and friction. Special designs cause the collapse of the bubbles to occur once the propeller has passed by, thus avoiding material damage to the blades. Surface piercing propellers are also able to defeat the damage by momentarily equalizing the pressure and reducing the wetted surface area. At speed, these propellers rotate partially out of the water. However in the critical low speed range the shape of blade required to achieve these feats, reduces the propulsive efficiency for both super-cavitating and surface piercing propellers.