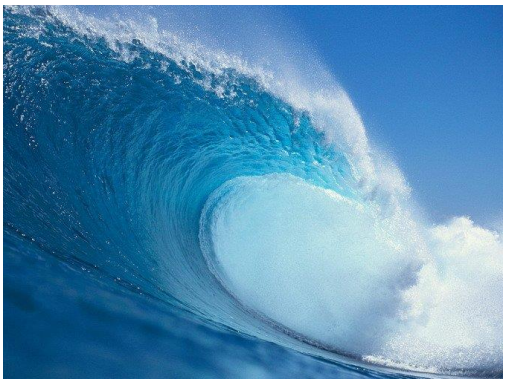
GIAR

Reaction Turbine



GIAR Energy presents The Universal Turbine

14/02/2023

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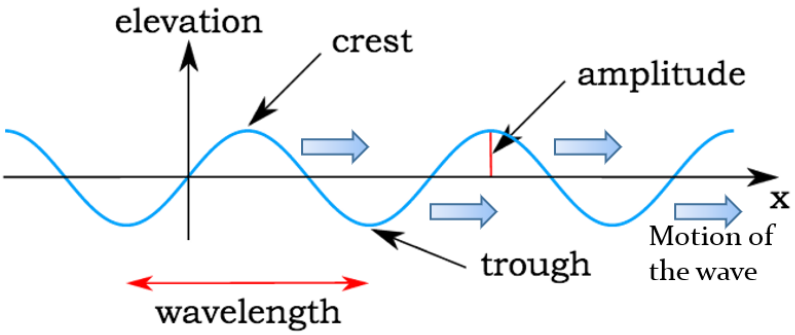
INNOVATIVE TECHNOLOGY TO PRODUCE 100% GREEN ENERGY FOR THE GENERATION OF HYDROGEN BY MEANS OF ELECTROLYSIS

1. Background

The ever-increasing demand for energy availability by the industry requires the production of more and more energy, with serious consequences for the Environment since it is mainly produced with fuels that consume atmospheric oxygen and release a large amount of carbon dioxide and pollutant dusts.

1.1. Energy from wave motion (OWC)



The sea constitutes an inexhaustible and largely unused reserve of renewable energy, with a potential electricity production estimated up to 90.000 TWh/y.

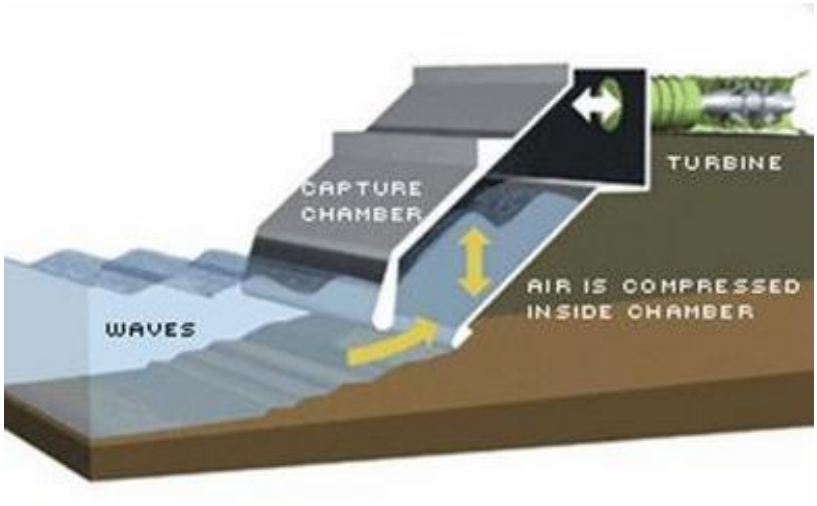
From now on up to 2030, it is expected that wave energy production will have a growth greater than all other renewable sources, with a potential market estimated in the order of 100 billion dollars.

Technologies aimed at the exploitation of wave motion have always been the subject of serious interest in the renewable sources scenario.

However – although the energy from wave motion is the one studied for the longest time and therefore the one that has seen the largest number of experiments, solutions and plant prototypes – it is not yet very widespread due to the specific complexities it presents.

Among the main technologies aimed at producing energy from wave motion, the one exploiting the principle of the Oscillating Water Column (OWC) is the subject of research and growing consideration both in Italy and in other countries.

Fig. I: Operation schematics of OWC technologies

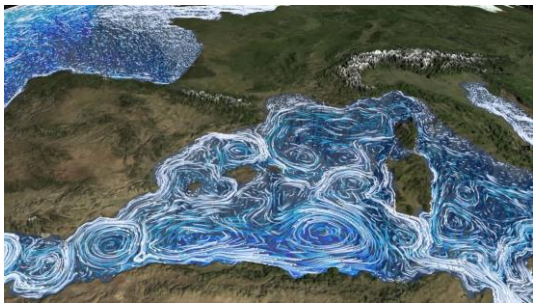
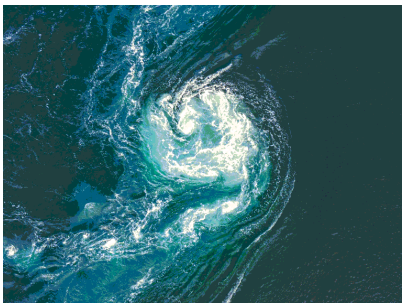


OWC plants can be:

- Offshore (marine) → having the advantage of operating at high levels of wave height and, therefore, of being able to produce large amounts of energy;
- Onshore (terrestrial) → having the advantage of entailing low construction and power grid connection costs.

The Mediterranean Sea presents peculiar conditions, hence the need for further research and experimentation aiming to extract energy even from low waves.

1.2. Energy from river, sea and tidal currents

The electrical energy obtained from the exploitation of kinetic energy from river, sea and tidal currents has an extraordinary potential in the future scenario of electricity generation from renewable sources. Moreover – since river, sea and tidal currents are more predictable than wind and solar energy – they are certainly suitable for the use of devices for the production of energy.

River currents were the first renewable energy source to be used, since the times of the Greeks and Romans, who used the energy from the moving water to run the mills for grinding grain, up to modern hydroelectric technologies. However, much can still be done to increase energy yields.

All scientists agree that the sea will become the largest source of renewable energy in the world, not only thanks to the exploitation of its waves but also thanks to the exploitation of its currents.

Sea and tidal currents have immense potential for electricity generation: a 2006 report from United States Department of the Interior estimates that capturing just 0,1% of the available energy from the Gulf Stream would supply Florida with 35,0% of its electrical needs.

1.3. Wind energy

Unlike the energy coming from the combustion of fossil fuels, wind energy is renewable, abundant, widely distributed, clean; it produces no greenhouse gas emissions during operation and it consumes no water. The effects it produces on the Environment are far less deleterious than those produced by non-renewable energy sources.

Onshore wind is a cheaper source of electricity than coal or gas-fired power plants; offshore wind is steadier and stronger than on land and offshore farms have less visual impact, but their construction and maintenance costs are considerably higher.

Wind is a variable energy source, that is characterized by quite stable average annual values but also by significant variations over shorter time scales. Therefore, in order to obtain a more stable electrical supply, it is exploited in conjunction with other energy sources.

2. The GIAR Patent

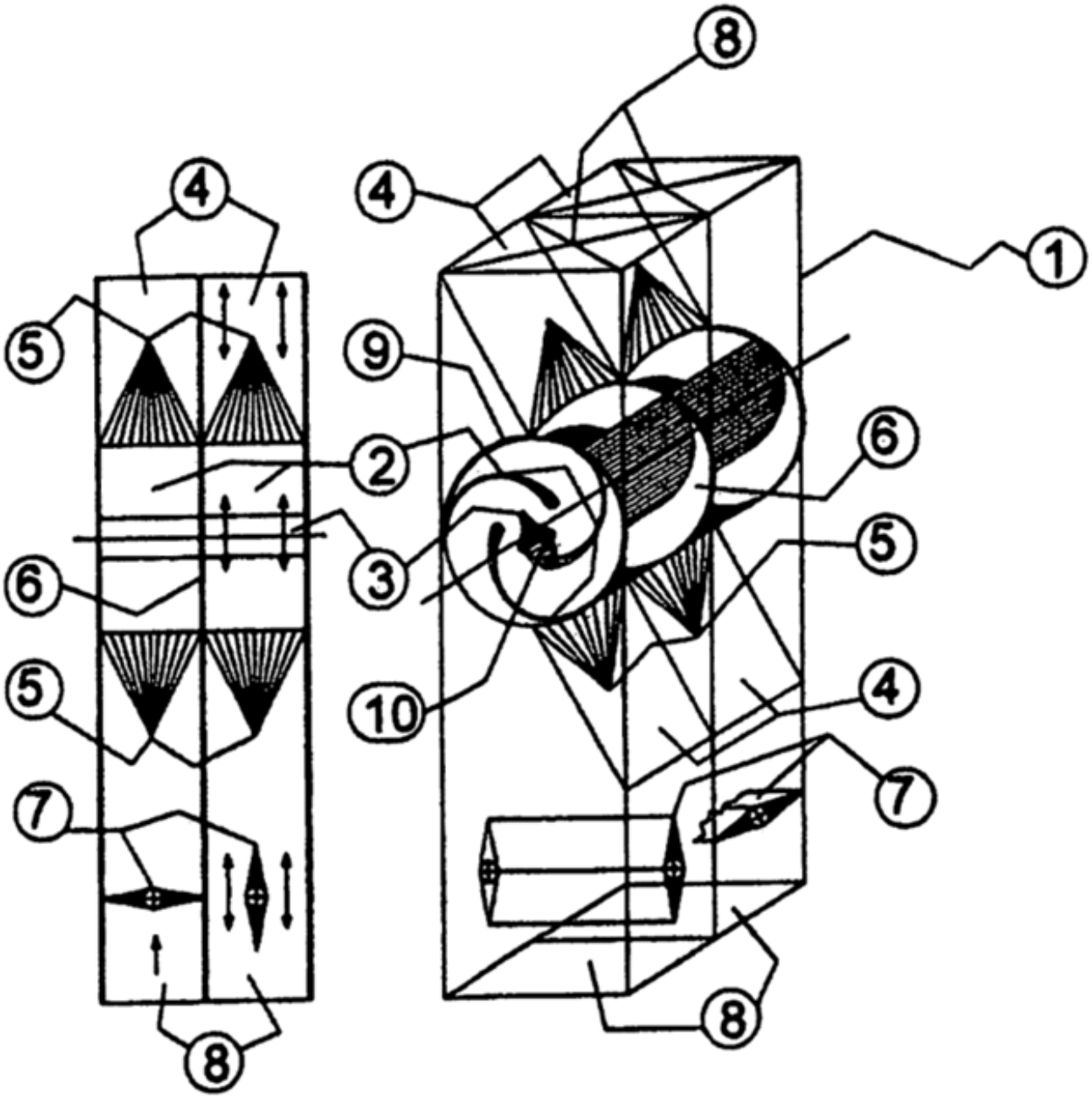
GIAR is the Universal Turbine that exploits the properties of fluids – ***air and water*** – to extract energy from multiple renewable sources in efficient way, with Patent for Industrial Innovation valid in 23 European countries and provided with the average mechanical Efficiency Certification released by the Department of Physics of Camerino University: **94%**. Obtained following tests conducted in a fluvial environment at Pievebovigliana site by means of a 1:1 scale prototype, this Certification places the GIAR Patent at grade "**TRL 7**" of the Technology Readiness Levels scale defined by the ISO 16290:2013 standard.

The Invention can be classified as a vertical axis turbine, free or ducted.

It is an aeraulic Reaction Turbine. It is able to efficiently convert renewable energies – coming from wave motion, from river, sea and tidal currents and from wind – into mechanical energy available at the axis of the device itself, that can be transformed into electrical energy for the widest uses.

The GIAR Turbine has the characteristic that the reversal of the fluid flow does not imply the reversal of the direction of rotation of the turbine's blades, thus offering considerable advantages in practical applications.

Fig. II: Structure of the GIAR Turbine



When the fluid gets in contact with the blades of the turbine's rotor, it transfers to them the most part of its kinetic and pressure energy, which is transformed into mechanical energy available directly at the axis of the turbine for further applications.

The GIAR Turbine presents a central rotating core with polygonal cross-section performing the function of dividing and orienting the fluid that flows through the turbine's rotor, so that it increases the overall Efficiency. The surfaces of the central core, which can be flat, concave or convex, together with the blades form a reduced passage section for the fluid (Venturi tube like): during the crossing, the fluid converts the pressure energy that it still possesses into kinetic energy, and that is then recovered by the blades when the fluid leaves the body of the rotor.

Since the GIAR Turbine is symmetrical, it guarantees the same levels of Efficiency also when the direction of the fluid flow is reversed.

3. The reasons why the GIAR Turbine is more efficient than the others

In 2013 the GIAR Patent was originally developed to address the particular challenges of wave motion in OWC systems, anyway – since it extracts energy from fluids (air and water) by exploiting their properties – it can also be applied for generating electrical energy from river, sea and tidal currents and from wind.

During the period between the granting of the European Patent (09/11/2016) and nowadays, further studies have been carried out for the application of the GIAR Turbine in river, sea and tidal currents through using floating modules.

In 2019 tests in fluvial application were carried out by means of a 1:1 scale model for the performance Certification of the GIAR Turbine – drawn up by the Department of Physics of Camerino University – which confirmed the very high average mechanical Efficiency of the Invention: 94%.

By ensuring the normal flow of water, the GIAR Turbine does not cause any damage to the fauna; being silent, in the multiplicity of its applications the GIAR Turbine does not cause any damage to the Environment.

The following paragraphs describe the advantages of GIAR technology in relation to each of its various applications.

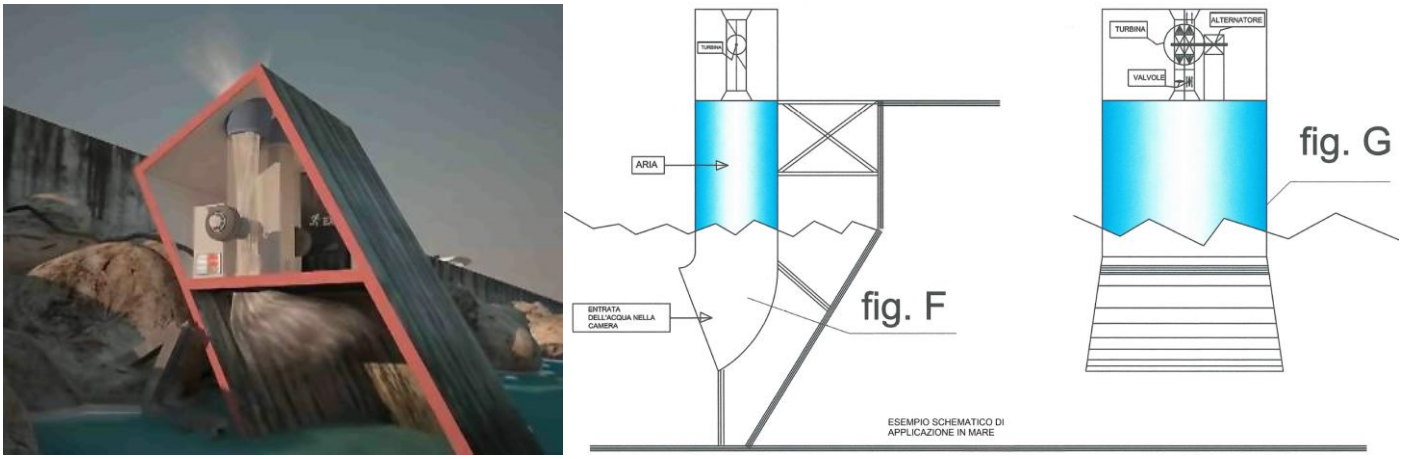
3.1. Energy from wave motion (OWC)

GIAR technology can be applied to OWC plants both inshore (breakwaters in harbors: for connection to power grid) and offshore (platforms: for connection to power grid or self-consumption). It is aimed at institutional subjects, electricity companies and private investors.

The GIAR Turbine demonstrates greater Efficiency than competing turbines with any wave height, placing itself as the best solution for use in the oscillating chambers of the OWC systems of the EcoPorts.

Being able to operate at a wave height of 20 cm – when competing turbines struggle even to activate – the GIAR Turbine has what it takes to represent the best clean source to produce energy to be used for generating Hydrogen in port's cold ironing.

Fig. III: Application of the GIAR Turbine for the production of energy from wave motion



► Compared to already existing OWC technologies, GIAR technology brings important technical advantages by presenting the following features.

A. It is composed of a single turbine body that can be divided by means of bulkheads and dividing plates, which create compartments increasing in percentage respect to the entire turbine body, in order to always guarantee the maximum Efficiency.

B. It is capable of developing high torques available to the axis of the turbine even with low rpm.

C. It is capable of delivering a high specific power.

D. It has low noise and low vibrations.

E. It ensures easy access to the maintenance of electrical components and it has low risks of corrosion, due to the fact that the alternator is located outside the duct.

F. It is provided with the Variable Displacement feature, which allows the oscillating chambers (EcoPorts OWC) to get into resonance with the frequency of wave motion, as it is necessary in OWC plants, in order to increase the overall Efficiency and to always obtain very high energy yields.

G. Again thanks to the Variable Displacement feature, it is active with both low and high waves, thus solving both the problem of turbine activation with low pressures and the problem of turbine stall (power loss) with high pressures, which commonly occurs in OWC plants.

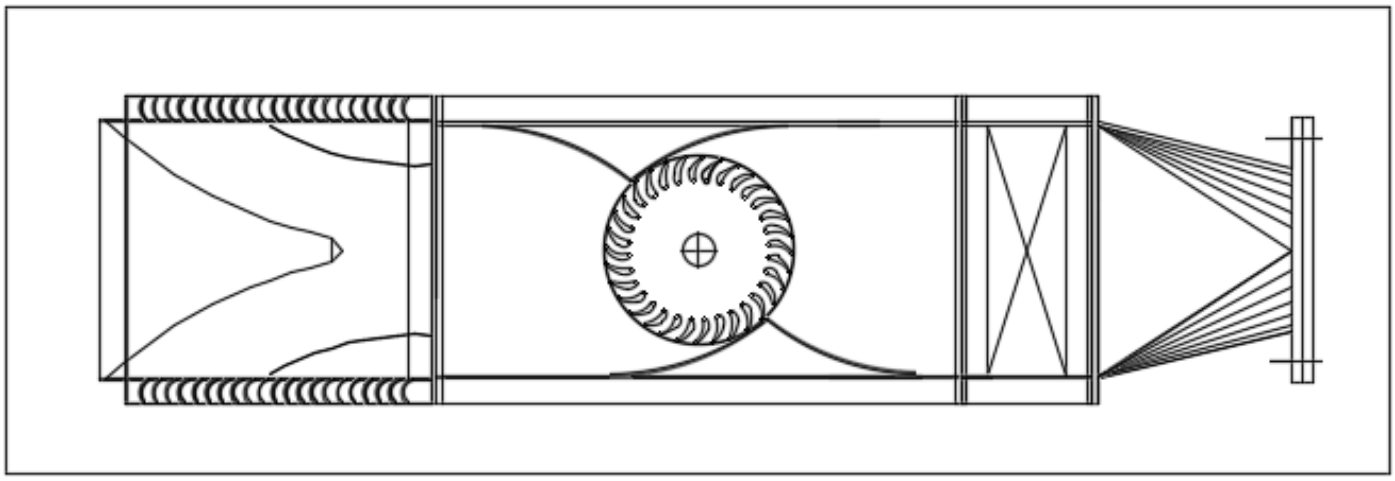
H. Being a Reaction Turbine, it determines that the inlet speed and the outlet speed of the fluid – ***air*** – are very low, hence very low noise levels.

I. It is compact in size and overall dimensions (reduced diameter translates into lower peripheric speeds).

L. Being symmetrical, it is able to guarantee the same very high energy yields also when the fluid flow is reversed.

M. Perfectly suitable for being employed in OWC systems, it represents the best alternative to the problematic and less performing Wells Turbine with horizontal axis.

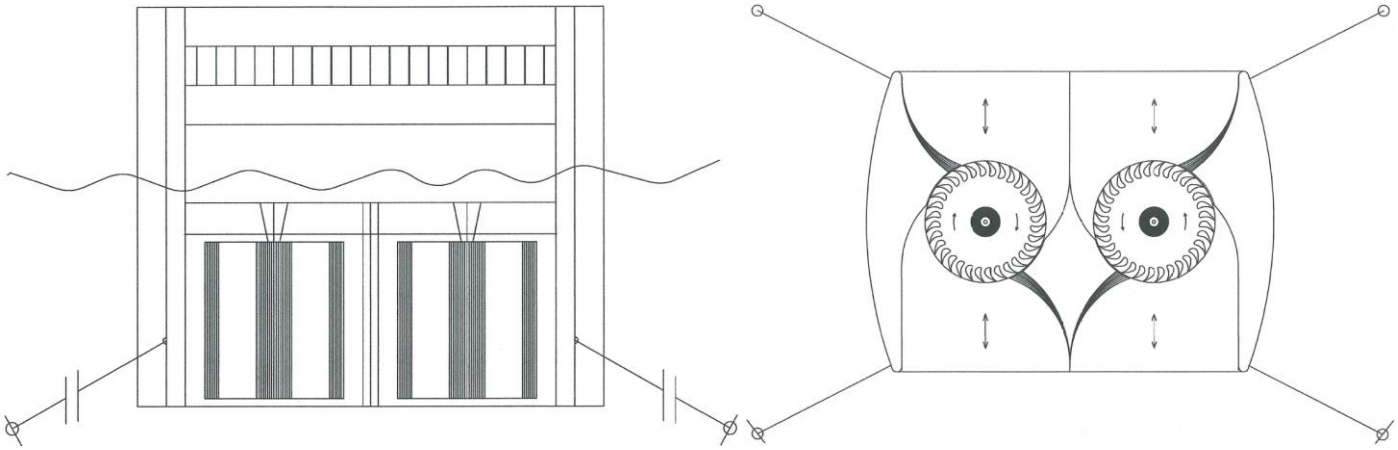
Fig. IV: Application of the GIAR Turbine for the production of energy from wave motion



3.2. Energy from river, sea and tidal currents

Many of the advantages described in the applications in OWC systems characterize the GIAR technology also in applications for the exploitation of river, sea and tidal currents.

Fig. V: Application of the GIAR Turbine for the production of energy from river, sea or tidal currents



► Especially in river applications, GIAR technology brings great technical advantages by virtue of the following characteristics.

A. It is composed of a single turbine body that can be divided by means of bulkheads and dividing plates, which create compartments increasing in percentage respect to the entire turbine body, in order to always guarantee the maximum Efficiency.

B. It is capable of developing high torques available to the axis of the turbine even with low rpm.

C. It is capable of delivering a high specific power.

D. It has low noise and low vibrations.

E. It ensures easy access to the maintenance of electrical components and it has low risks of corrosion, due to the fact that the alternator is located outside the duct.

F. It is provided with the Variable Displacement feature, which allows it to obtain very high and constant energy yields regardless of the water flow rates.

G. Again thanks to the Variable Displacement features, it can operate where other turbines cannot operate, that is to say even with low pressures.

H. Being a Reaction Turbine, it determines that the inlet speed and the outlet speed of the fluid – ***water*** – are very low.
This involves a reduced passage speed of the sediments that are suspended in the fluid crossing the system, which leads to minimum wear of the components of the system itself, both in its fix parts and in its moving parts (rotor).

I. Again, by being a Reaction Turbine, in the river environment it guarantees greater efficiency than the Banki turbine (cross-flow turbine), whose Efficiency in river applications varies between 40% and 86% depending on the water flow rates.

L. Due to its design characteristics, it is the GIAR Turbine itself that "creates" the river jump.

The positioning of the GIAR Turbine determines the elevation of the fluid vein and therefore an altitude difference (Δ h), a difference in height between the fluid vein entering and the fluid vein exiting the system, leaving the fluid vein downstream of the system itself completely unaltered, just as if the system was not there.
Precisely thanks to this peculiarity, in river applications the GIAR Turbine can bring specific complementary advantages, which are truly valuable in terms of environmental sustainability.

a. By virtue of the Δ h resulting from the positioning of the system, it allows to take full advantage of the height of the incoming fluid vein, always keeping it below the level of the existing containment embankments.
This way, it allows to take full advantage of the height of the river banks, without the need to carry out additional preparation works for the construction of the system, so as to combine low construction costs and environmental protection.
Therefore, for river systems with GIAR technology, the heights of the water jumps are proportional to the heights of the river banks: the higher the river banks are, the higher the exploitable water jumps are, with consequent greater production of electrical energy.

b. It can allow the navigability of previously non-navigable waterways.

c. It can improve the navigability of waterways which are already navigable.

d. It can significantly contribute to the reduction of the phenomenon of marine intrusion ("saline wedge") connected to the lowering of the fluid vein near the maritime river mouths, caused by climatic variations, which has the consequence of making vast land surfaces unproductive in proximity to such areas.
In correspondence with the river mouths, in fact, the further rise of the saline wedge due to the lack of pressure causes the unusability of the pumped water which rises upwards, as it is saline, therefore the pumping of water suitable for irrigation takes place at ever greater depths with ever greater costs.
The rise in the level of rivers determined by the positioning of the GIAR Turbine has the effect of easing water withdrawals for irrigation canals, so as to replenish the aquifers too.

e. It can perform a relevant function from an urban perspective: the realization of sequenced installations gives life to the virtuous combination of renewable electricity generation and river crossing.

Fig. VI: Modules configuration for river, sea or tidal currents

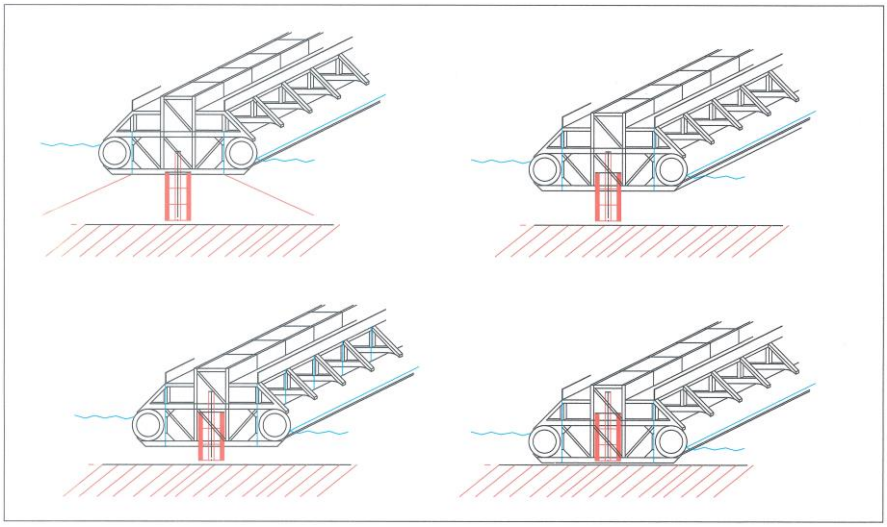
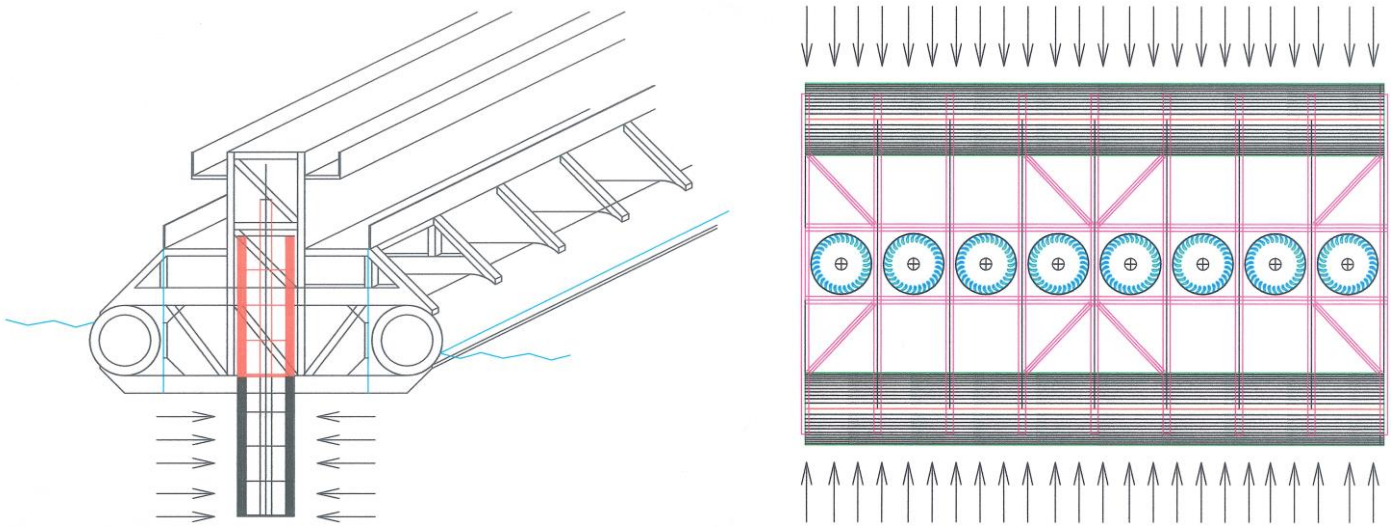


Fig. VII: Floating module



3.3. Wind energy

► The GIAR Turbine can be used in a wide range of sizes and installed capacities in wind applications as well, thanks to the following advantages:

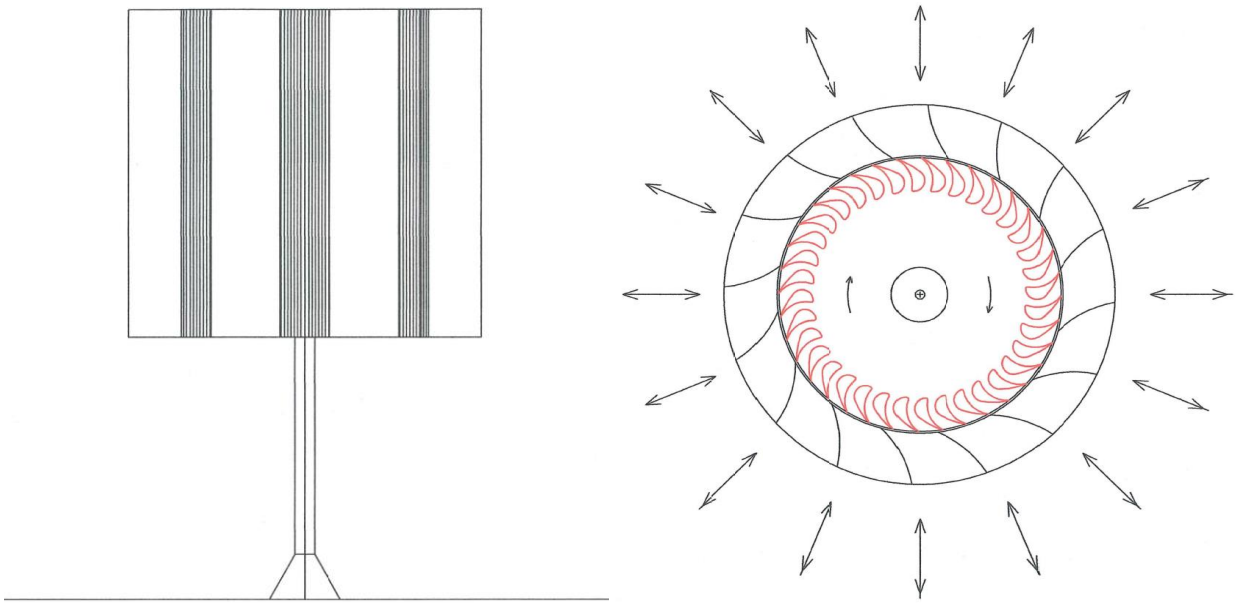
A. It is suitable both for wind farms (for connection to power grid) and isolated locations (for connection to power grid or self-consumption);

B. It has minimum environmental impact (very low visibility impact, very low noise emission);

C. It has minimum maintenance needs, by virtue of its minimum number of components and moving parts;

D. Since it is independent on wind direction, unlike traditional wind blades, it needs no orientation.

Fig. VIII: Application of the GIAR Turbine for the production of energy from wind



4. Comparison with the different types of turbines used for the production of electrical energy

The turbines on the market show numerous critical issues, including low Efficiency, exclusive use in high- or low-power plants, high noise, reverse flow inactivity, complexity of construction and high maintenance costs.

► The following synoptic comparative table shows the features of the main turbines currently in use in comparison with the features of the GIAR Turbine.

TECHNOLOGY	FEATURES						
	Reaction Turbine	Active also with reverse flow (*)	Variable Displa-cement (**)	NACA type blades (***)	Low noise	Active also at very low pressures (****)	Suitable also with variable pressures and flow rates (*****)
GIAR	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Wells	YES	YES	NO	NO	NO	NO	NO
Francis	YES	NO	NO	NO	NO	NO	NO
Kaplan	YES	NO	NO	NO	NO	NO	NO
Banki	NO	NO	NO	NO	NO	NO	NO
Pelton	NO	NO	NO	NO	NO	NO	NO

* The GIAR Turbine produces energy also when the direction of the fluid flow is reversed.

** The Variable Displacement feature ensures the optimization of the resonance parameters of OWC plants, increasing their overall Efficiency.

*** The NACA type blades make the GIAR Turbine a Reaction Turbine.

**** The GIAR Turbine can operate even in the presence of very low jumps.

***** In ensuring maximus Efficiency by optimizing the pressure and the speed of fluids, the Variable Displacement feature makes the GIAR Turbine the most suitable device for producing energy from fluids.

► Below are described the main critical issues the most common turbines show, which are overcome by GIAR technology.

Wells Turbine → main critical issues:

- It is not provided with the Variable Displacement feature, therefore it is not able to increase the overall Efficiency of OWC plants by optimizing the resonance parameters;
- It does not activate operating with low pressures (low jumps);
- It stalls (loss of power) operating with high pressures, that are typical in OWC plants;
- It is highly noisy;
- It has very low Efficiency.

Francis Turbine → main critical issues:

- It is not provided with the Variable Displacement feature, therefore it is not able to increase the overall Efficiency of OWC plants by optimizing the resonance parameters;
- It activates with jumps starting from about 3 meters;

- It does not produce energy when the direction of the fluid flow is reversed. On the contrary, since it acts like a pump, when the direction of the fluid flow is reversed it absorbs energy.

Kaplan Turbine → main critical issues:

- It is not provided with the Variable Displacement feature, therefore it is not able to increase the overall Efficiency of OWC plants by optimizing the resonance parameters;
- Its use is limited to jumps between 2 and 20 meters;
- It is not a reversible flow turbine, therefore it is not suitable for OWC systems.

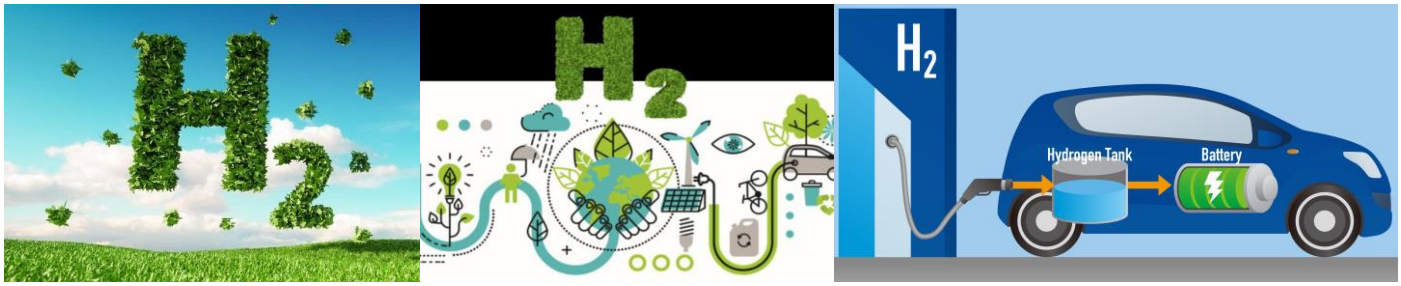
Banki Turbine → main critical issues:

- It is not provided with the Variable Displacement feature, therefore it is not able to increase the overall Efficiency of OWC plants by optimizing the resonance parameters;
- It is not a Reaction Turbine: the push on the blades is due to the centrifugal force exerted by the water flow forced to bend along the profile of the blades themselves, therefore there is no pressure difference in the water between the point of entry and the point of exit from the blades;
- It does not activate with low jumps, it is suitable for water jumps from 5 to 100 meters;
- Its use is limited to low-power plants;
- It is not a reversible flow turbine, therefore it is not suitable for OWC systems.

Pelton Turbine → main critical issues:

- It is not provided with the Variable Displacement feature, therefore it is not able to increase the overall Efficiency of OWC plants by optimizing the resonance parameters;
- It is suitable for high jumps and low flow rates;
- It is not a Reaction Turbine;
- It is not a reversible flow turbine, therefore it is not suitable for OWC systems.

5. Application in projects related to the generation of Hydrogen and positioning in the supply chain



The Maritime Space management Plans (MSP) have as a general purpose the coexistence of different uses in marine waters in ways that guarantee the achievement and the maintenance of the good ecological status of the sea and the preservation of the landscape and of the cultural heritage. The Plans for the three Italian maritime areas are geared towards the growth and development – which must be balanced and projected over the medium to long term – of the maritime sectors, mature or emerging, in ways to enhance the vocations of the territories and the well-being of coastal communities and of the whole national community.

Given the strategic objectives defined on a national scale and the specific objectives set out in the maritime areas, the guidelines provide for the identification of measures and actions aimed at achieving them (D.P.C.M. 1 December 2017, par. 20), to which indicators will be

associated in order to be able to follow up on the monitoring during the implementation phase and to be able to proceed effectively in the event of misalignments between the expected objectives and what is produced.

The specific purpose of the MSP measures and actions is the unitary management of the interactions among the uses and of the interactions between uses and transversal objectives.

The analysis of both current and to-be-developed uses confirmed that the primary need to which the MSP must respond is precisely the unitary management of the interactions among uses, to reduce conflicts, and to strengthen the synergies between uses and transversal objectives.

In fact, there are several combinations of uses in each sub-area and in each Production Unit (PU), which must be regulated directly by the Plans or by the competent administrations following the recommendations and guidelines of the Plans themselves, above all: where multiple priorities have been assigned in the same PU; where other uses compatible with priority or limited use are indicated; where the vocation is for generic use.

In the current context, therefore, **the production of electrical energy from river currents and wave motion can be focused on the generation of Green Hydrogen by means of Electrolysis**.

In the port area, this process – that is notoriously energy-intensive (it takes over 4 kWh of electricity to produce 1 m³ of H2, therefore it takes 48 kWh to produce 1 kg of H2) – can benefit from the interfacing of the energy produced by GIAR technology through a series of turbines that can be installed in the oscillating chambers that can be placed along the breakwaters of the ports.

Indeed the GIAR Turbine has operating characteristics such as to ensure a good constant supply even in the port area – which is the most challenging area – so as to be able to provide the energy necessary for the operation of electrolysers with even medium-high production capacity.

The Hydrogen Valleys that are springing up at some Italian ports are perfect ecosystems for the insertion of GIAR technology, which can be coupled to electrolysers as a source of electrical energy with Guarantee of Origin (GO) for the generation of Hydrogen.

Since river currents and wave motion are completely natural and therefore ecological resources, **the GO of Hydrogen generated from the electricity production of the GIAR Turbine is perfectly in line with the criteria that distinguish the generation of Green Hydrogen**.

6. Video (links)

- GIAR – La Turbina Universale – Video Presentation ITA (2022)
- GIAR – The Universal Turbine – Video Presentation ENG (2022)
- GIAR Turbine – Very first video rendering...4 years before it became a Patent (Oct 2012)
- GIAR Turbine – Very first prototype, First experimental test (Nov 2012)
- GIAR Turbine – Very first prototype, Second experimental test (Dec 2012)
- GIAR Turbine & Wells Turbine – First experimental tests in wind gallery (Jan 2013)
- GIAR Turbine vs Wells Turbine – Comparative experimental tests in wind gallery (Feb 2013)
- GIAR Turbine – TV News TG3 Marche (23/03/2013)
- GIAR Turbine – Experimental test for average mechanical Efficiency Certification (Jun 2019)

GIAR Energy S.r.l. Benefit Company

– Innovative Start-Up –

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