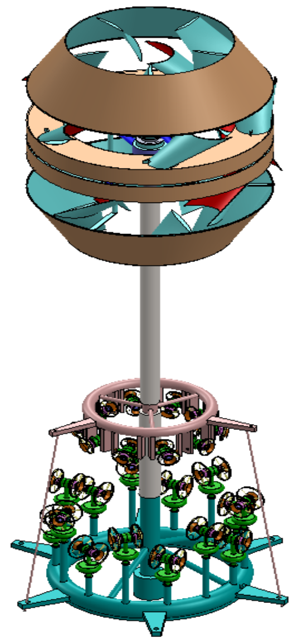
KING OF ALL RENEWABLE ENERGY MACHINES



A quintessentially American renewable energy machine

US Patent # 11441540, 9/13/2022

US Patent #11428211 8/30/2022

White paper

Fluid Dynamics System LLC

10/23/2022

Table of Content

1. Introduction

The purpose of this proposal is to present a king of all renewable, reliable energy machines producing electricity 24/7- an all-depth offshore electrical generation system based on a quintessentially American secret weapon - disruptive methodology and innovative technology, and the spirits of the never-end quest for excellence. This system has capacities from 1 Kilowatt to 400 Megawatts. Why it is so unique because there is no such machine which been defined with all renewable power sources before. The goal is to develop decentralized renewable power systems in 5 years to deliver electricity where the customers consume unlike the inefficient centralized fossil power systems and mega wind turbines. The machine includes top wind turbine subsystems, middle wave turbine subsystems, and bottom tidal turbine subsystems and solar panels to harness all ocean energy, this system has all-season safety features for birds, marine life, humans, and itself and is modularized and scalable for low Levelized cost of energy <$0.10 kWh. If the steam engine brought us the industrial revolution, then this quintessentially American secret weapon would bring the USA to the top of the world for the 21 first century energy revolution and be the ultimate fossil energy alternative.

2. Global challenges

The U.S has vast untapped offshore energy resources; the forms of energy include wave energy, tidal energy, and wind energy and solar energy. The offshore regime includes the great lakes, the east coasts, the west coasts, and the Gulf of Mexico and is provided with great opportunities as well as great challenges, but the US wind turbine industry is way behind other countries. (https://blog.bizvibe.com/blog/energy-and-fuels/top-10-wind-turbine-manufacturers-world) Out of the top 10 Wind Turbine Manufacturers in the World 2022 , GE is the only US company which is listed as number 4 behind Vestas, Siemens Gamesa, Goldwind (China), How can the US play catch up in this renewable energy game? Here is the good news so far there is no single turbine manufacturer or country which can harness all forms of energy in the world, especially for the hurricane-prone states, the offshore turbines are faced with great challenges from wind, wave, and tidal destructive forces during the hurricane season or regular season. So far there are no good solutions even with the millions spent on land-based or shallow offshore wind turbines or European or China companies have installed. All wind turbine technologies developed in European cannot provide a solution when hurricanes are a factor. As far as the wave and tidal turbines are concerned, so far there has been no single commercialized product for the last 35 years that solve those technical challenges. It goes to the heart of this proposal, should we take the solution European companies provided for example to build bigger and bigger wind turbines? Or have a quintessentially American solution to disrupt the renewable energy market? The answers would be provided at the end of this proposal.

3. Performances and issue

3.1 Low Efficiency. In 1919, German physicist Albert Betz declared that the limit for the theoretical maximum efficiency of a wind turbine is 59 % or a factor of 0.59. Today in 2022, more than 100 years later, we still cannot even reach the efficiency of 50%, even with all the powerful computation resources and sophisticated CFD models, and millions spent on building turbines. Most engineering books still tell us that 0.40 is the practical efficiency of wind turbines, with the same limit being used for tidal or wave turbines. If we continue to do the same thing over the next 100 years, Mr. Betz would come out of the grave and laugh at us. Maybe the limit is not right, but if we cannot even reach at least 50% efficiency, or figure out what is wrong, the rest of the effort would be futile. Do we really have no other way to increase efficiency other than increasing rotor diameter? Or the bigger, the better? In fact, the bigger, the worse, because it would have more energy consumption, more carbon emissions! Why they would fail? Because they just replicate fossil power systems, a few larger power plants near rivers or water resources get all fuels and resources from everywhere to produce max electricity, then deliver it as far as they can reach, but for the centralized power systems are outdated in the digital age, there are huge transportation and transmission costs that never create value, operations are very inefficient, in fact, the rich source locations unfortunately barely match with the rich customer base, just check the fossil power plants locations against the populated areas.

3.2 Low power density. All existing turbines are an area-based power system with ever larger diameter blades occupying larger and larger footholds; as a result, they generate very low-density power. The area-based turbines not only have low performance (Power/M^2), but also have a high cost due to the lack of economics of scale, and difficulty of production, assembly, transportation, installation, and repair. As far as tidal or wave farms are concerned, those costs would be higher than that of wind turbines. Finally, they occupy large areas in the ocean or rivers and affect large numbers of marine life, so it is impossible to deploy them in rivers or coastal areas. Let us take a look at GE's Haliade-X wind turbine with a 220-meter rotor diameter, 12 MW, the price tag is $13 million, first, if we use Power = ½ p (A) CpV^3, for comparison purposes , given for the river water or seawater, density p is 1000 kg/m^3 and velocity V = 10 m/s, for the air, density p=1.23 kg/m^3 and velocity V= 23 m/s, assuming the same efficiency, the rotor diameter would reduce to 44 meters if the turbines are powered with river water or seawater, the price would reduce less than $ 6.5 million, second if we can increase the power density only by 25 % through increasing swept area efficiency, Cp = efficiency and improving structure optimization, the price would reduce to less than $10 million, clearly the future of low-density power systems looks very dark .

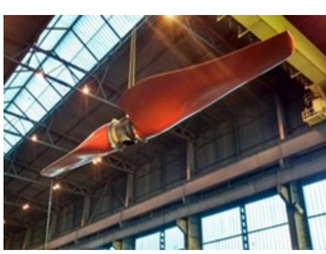
Safety issues

Safety issues related to the turbines in the market include injected broken blades, electrical fire, rotor blades killing birds, and noise. Those issues cause public fear and even legal actions and disproval of turbine projects. The Injected blades can hurt marine life or humans nearby and damage boats and float structures. Electrical fires are caused by overheating generators or short circuits, and this electrical fire can damage the turbines and can electrocute animals or humans, the noise is the biggest negative effect on humans, marine life, and animals in the long run. As we know from Navy sonar studies, it would hurt marine life and their reproductive abilities, and so far there are no solutions. According to the Natural Resources Defense Council, powerful underwater sounds produced by sonar can output sounds of more than 200 decibels, a level that spreads sound across the ocean and severely harms sound-sensitive marine life like whales.

4. Technical barriers and design difficulty

4.1 Turbine. Turbine designs have not changed over time, with most of the knowledge coming from the aerospace industry. There have been no breakthroughs or big leaps since the first patent for gas turbines was filed in 1791 by John Barber. We see the solid shaft in every turbine around the world, from steam turbines to wind turbines. The inherent flaw in this design is that the central passage is blocked and restricts the flow. The same shaft unfortunately has also blocked our imagination for the past 250 years. All wind, wave, and tidal turbines are not about wind, wave, and tide but turbines, because a turbine is a final machine before all kinetic energies like wind, wave, and tide is converted to electrical energy regardless how many conversion the machine has. If turbomachinery is the soul of all turbines, then the blade is the heart of the turbines, if the blades do not work properly, any effort on the rest of the components would be futile. The blades of tidal turbines are largely based on airplane blade design or propellers, while the wind turbine blades are inspired by bird wings. Even with advanced simulations utilizing DEM method with advanced CFD, there have been no significant improvements, so what is wrong? The reason is that the efforts are based on the wing and lift or thrust theory of moving objects, and not based on the torque and rotation theory of stationary objects.



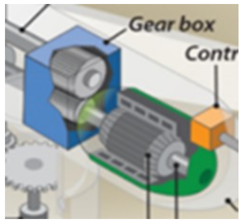


4.2 Horizontal wind turbine blades

We have not seen much change to wind turbine blade optimization for the last 40 years except for the size of the blades, the blades get ever bigger blade diameters, and even with the best CFD optimization, the shape of the blade is much like early -day propeller on the piston engines, the eddy flow and wake are still with us and damage the blades and cause noise far from the wind turbine farms with horizontal sound waves, three blades wind turbines still seem everywhere and kind of boring and inefficient, finally the hollow blades are easy to be damaged due to bigger pressure difference between the lowest point and the highest point of large rotor rotation in the air.

4.3 Vertical wind turbine . The conventional vertical wind turbines are drag based machine and has two types , Darriesus and Savonius , since Darriesus patented the first aerodynamic wind turbine in 1927 , almost 100 year last , not too much has been changed. It still inherently has a very low efficiency of 7 to 30% . There are three inherant disadvangtes in vertical turbines , first the vertical wind turbines are they only works with half of the effected area , no matter how the blades are strusted , secondly a low efficiency area structure with a small diameter and a longer height, finally the rotor speed limit would never surpass the wind speed .

4.4 Drive train. First, the current drive train has too many mechanic conversions, on average four to six conversions to reach a desirable speed. These conversions not only reduce the efficiency but also weaken the structural integrity of turbines by adding more moving parts and increasing cost and complexity, secondly the most problematic component is the gearbox, which accounts for 60 % of the failures in wind turbines. The repair costs of wind turbine gearboxes are the main issue for the users and greatly increase LCOE. Finally, the bearing is another issue for all turbine drive trains, besides the bearings in the gearbox, the relatively small bearing is subject to high loads from the heavy rotor and large blades, because wind speed changes constantly, and the gearbox is placed between two high inertial blades and generator shaft, and subject to high twist, even roller bearings cannot sustain the loads and suffer premature damages.



4.5 Scalability. Scalability starts with a product design, without a good product design, the product would not be scalable, Scalability is also related to product manufacturing, product marketing, and product cost, at this point, the scalable may not even be a subject, If a product is not scalable, the cost of the products would never reduce, so it would never enter the market at an affordable price no matter how good it is. So far all wind turbines are not scalable, each blade should be made for each different size of a wind turbine, and so are all existing tidal turbines or wave turbines, all existing tidal turbines or wave turbines never entered the commercial market due to high cost and lack of scalability along with other barriers.

4.6 Synergy. Synergy is a very important performance requirement for any modern energy system, it not only reduces cost but also increases system reliability and versatility, among the wind turbines, tidal turbines, and wind turbines, wind turbines are the most mature products; the other two are still struggling to stay alive, even though there is not any combination between a wind turbine and wave turbines, or combination between wind turbines and tidal turbines. At best, offshore solar panels combine with a few wind turbines, but in terms of structures, there is not much synergy.

4.7 To be floating or not to be floating. One is one of the important questions for offshore renewable energy systems is whether to be floating or not to be floating, most European offshore turbines are located in shallow waters, but in the US there are few offshore fixed bottom projects, and not many floating offshore turbines and just start to develop offshore wind turbines, most windy offshore is much deep, the most knowledge or knowhow are based on offshore oil and gas industries, so the current offshore wind turbines are classified as fixed bottom and floating, the fixed bottom design is used for the depth < 60 m, float design is used for the depth >80 m, the question is that the classification is optimized?

How about structures on the river or great lake regions for floating or fixed bottom, the depth is less than 60 m, what if we can find a kind structure for all depths regardless of being floating or not being floating, can we challenge ourselves? Or just disrupt the whole industry.

4.8 Pitch control. Pitch controls are used in almost all commercial wind turbines around the world, and they became so " important " that cause lawsuits, the case in point is Siemens Gamesa Renewable Energy A/S v. General Electric Co, U.S. District Court for the District of Massachusetts, No. 1:21-cv-10216, the main disputes are about pitch control and bearing, but two giants in the wind turbine filed are fighting for it, those issues are so old, and not belong to 21 first century wind turbine, what we expect any innovation from big companies? But it posed the question of whether it is necessary for wind turbines. Because we can see the root of pitch control from jet engines and marine propellers which are used for moving vehicles, but wind turbines are stationary, do we really care about stalling, the wind turbine cannot generate more power, can we remove it? Because it consumes energy and adds more cost and structural complication. (https://www.govinfo.gov/app/details/USCOURTS-mad-1_21-cv-10216/USCOURTS-mad-1_21-cv-10216-1)

4.9 Yaw control. Yaw control is another early designed feature, it is used in almost all commercial wind turbines around the world, and the question is everyone does it, do we really need it? Because it consumes energy and adds more cost and structural complication.

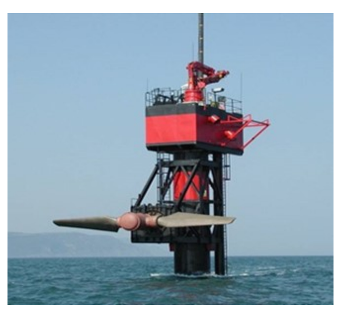
4.10 Survivability It is a deal breaker, almost 99 % of turbine failures are due to survivability issues, especially for the wave turbines and wind turbines in hurricane-prone states; they cannot sustain severe ocean or river conditions or need constant repair due to part damages or wear. In fact, most wave turbines have too many moving parts and cannot sustain violent waves. While tidal turbines are subjected to less violent waves, they are subjected to high tidal impact in the seafloor or riverbed. Many tidal turbines' base structures are not suitable or robust enough for the seafloor or river flood terrain under tidal pulling forces. Finally, the horizontal wind turbines would have blades too large to withstand scale 1 or 2 hurricanes due to the nature of the rotor and blade designs even with the brake system.



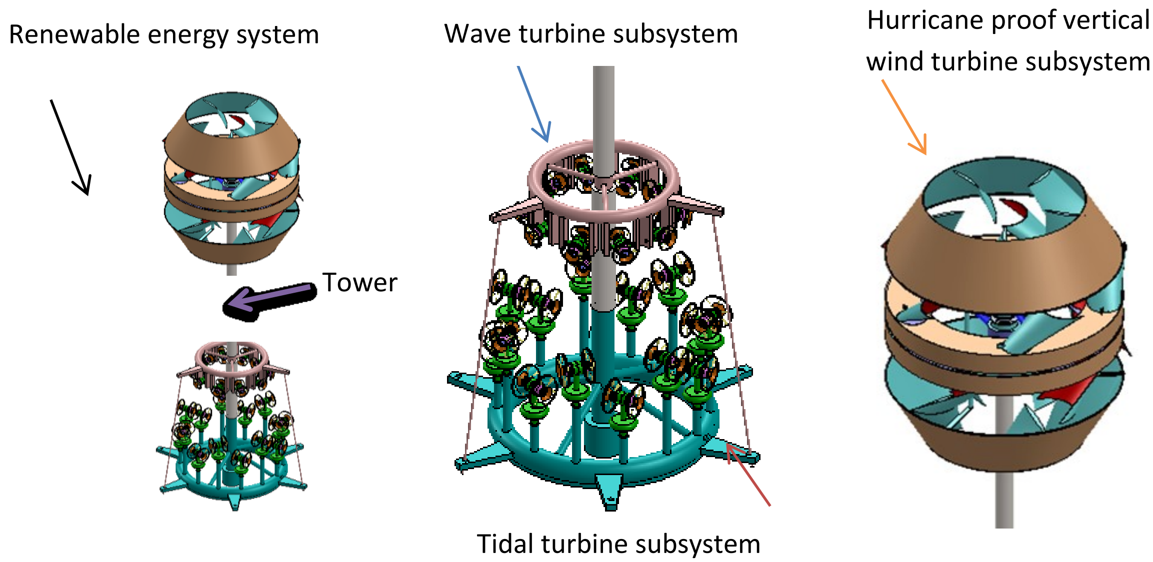
4.11 Sealabilty. As the turbines are deployed in oceans or rivers, the turbines become pressure vessels. As the tidal turbines are deployed deeper, the external pressure becomes higher, and sealabilty/leakage becomes a big issue for turbines, (especially tidal turbines) which can cause short circuits and damage to the turbines. The hot spots for leaks are between the heavy rotor shafts and bearing bores (called 12 and 6 o'clock leaks), due to the dynamic seal under heavy weights. Moreover, if the blades are hit by foreign objects, the leakage could become even worse.

4.12 Accessibility. The accessibility is another deal breaker for most tidal turbines even with mature technologies from other land based turbines, because even today, most tidal turbines are not ready for prime time. They have lots of issues, so the accessibility becomes a key issue, even in the mature subsea oil/gas industry like the Deepwater Horizon oil spill. The cost of access to tidal turbines would become more expensive with a lift tower, which is about 20 times or even higher than the cost of tidal turbines, or with divers the cost of access to tidal turbines would increase the repair and maintenance cost in the long run, so both would increase LCOE.





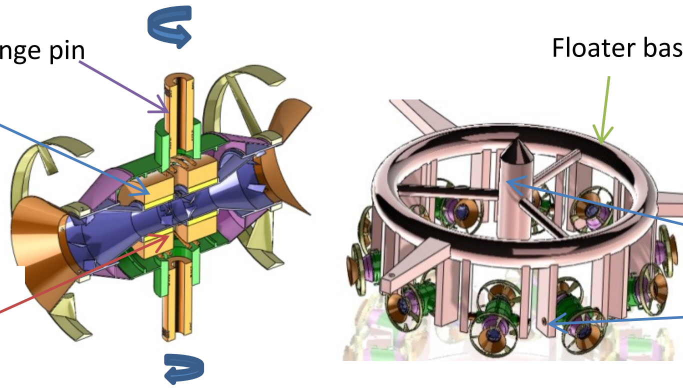

6. Our solutions (US patents 11441540, 11428211)



6.1 Descriptions of the system

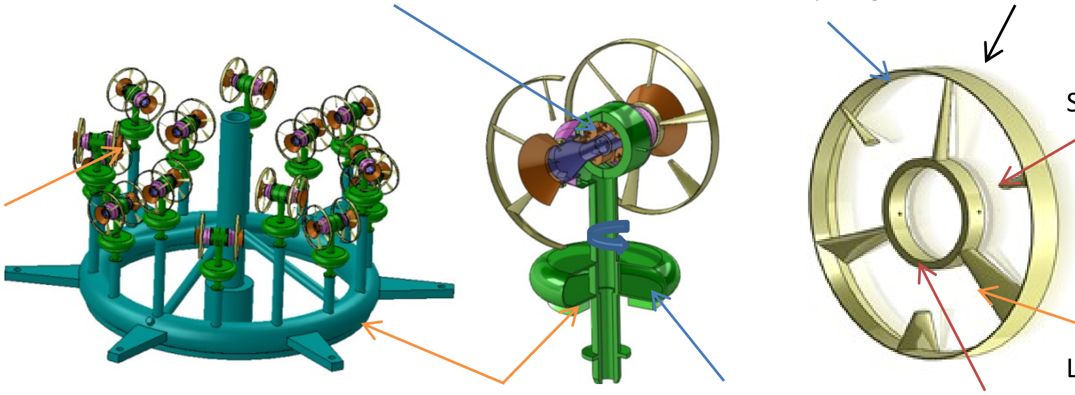
The intent of this system is to develop a decentralized power system unlike the fossil power system, The high density offshore wind turbine system is a volume-based power system(Kw/ m^3) instead of the current area base power system (Kw/m^2) and includes a top layer of a wind turbine subsystem, a middle layer of a wave turbine subsystem and at least one bottom layer of a tidal turbine system. The wind turbine subsystem has a vertical turbine type for prone hurricane offshore states and a horizontal type for the rest of the offshore states, with high density power output and modular capacities from 1 Kilowatt to 500 Megawatt. It produces electricity 24/7 in a synergic manner by sharing the output power cable, the control box, electrical equipment, access, and tower, additional three sets of wave and tidal subsystems with three solar panels to establish a stable triangle structure.

6.1.1 Wave turbine subsystem



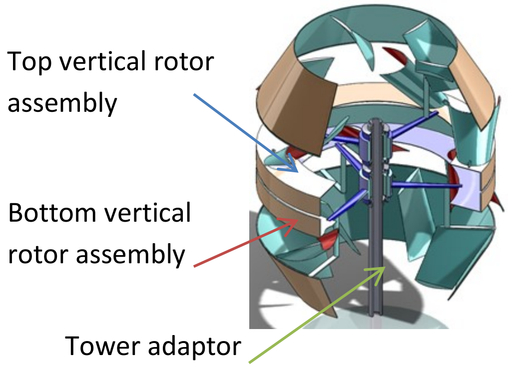
The wave turbine subsystem has a floater base assembly and multiple wave turbines engaged with the floater base assembly rotating freely around 360 degree by hinges of the floater base assembly and hinge pins of wave turbines, so each wave turbine produce electricity with an one-conversion generator between the electrical stator and the electrical/magnetic rotor. The wave turbines can produce electricity constantly with the wave, because it is based on the length of the wave and not the height of the wave.

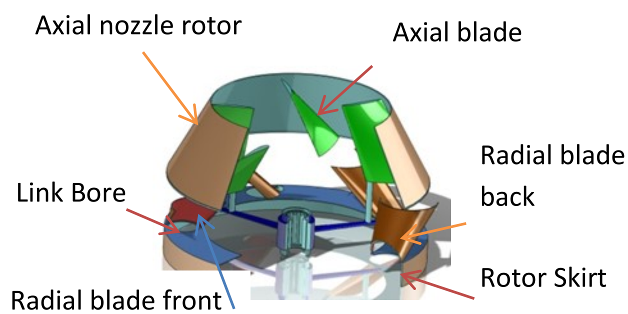
6.1.2 Tidal turbine subsystem

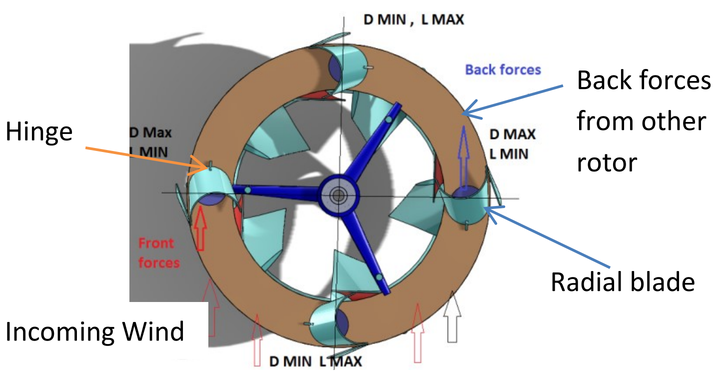


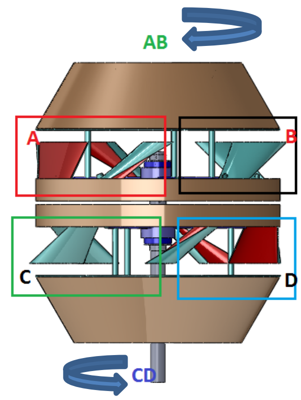
h n oat base th an air bag fixed in a riverbed or seabed or a float at a some level by filling water into the float base assembly, and multiple tidal turbines respectively engaged with the floater base assembly by adapters and rotate freely with tides around 360 degree with maximum outputs instead of current fixed turbines.

6.1.3 Vertical /horizontal wind turbine subsystem









The vertical/horizontal wind turbine for hurricane prone states has a pair of top and bottom vertical rotor assembly, and rotates clockwise and anticlockwise and is connected with a tower adaptor. Each vertical rotor assembly has a self-starting radial skirt rotor with a skirt, four link bores and four airfoil blades tilted to the radial skirt, a non-self-starting axial nozzle rotor with internal four blades. Incoming wind is divided into four streams inlets A, B,C,D and two outlets AB and CD. The stream in section A hits the radial blade front and generates full clockwise rotations without back fluid force or a back wind and goes into the bottom vertical rotor assembly through the link bore in section C. According to Newton's third law, the reaction forces hit the front of blade and rotate it anticlockwise and goes to the bottom conical nozzle and the stream from section A flows out from CD outlet and rotates the bottom vertical rotor assembly further due to Bernoulli's equation. The stream in section D does the same thing and goes out from AB outlet. The stream in section B hit the radial blade back against the reaction forces from section D and the airfoil lift , the stream flows with the blades and move up into the top axial conical nozzle rotor and further rotates the top vertical rotor assembly further due to Bernoulli's equation and the stream flows out from AB outlet , the streams in section C does the same thing as the stream in section B. The rotations or torsion are based on the lift = L and drag = D change as the turbine rotates according to a sine function. As the rotor speeds up, the vertical wind turbine would suck more air than the face areas cover, while the hinge and a joint between the skirt and blade act as the primary and secondary safety barrier. As loads reach the limit of the joint, the blades would flip over, then both sides, section A and B or sections C and D would be balanced and stop rotating. Since the axial nozzle rotor is not self-starting, it would stop too. Finally the joint can be glued, spot welded, or pinned, and can be reestablished soon after high wind or hurricane.

6.2 Analysis

6.2.1 Horizontal Blade design

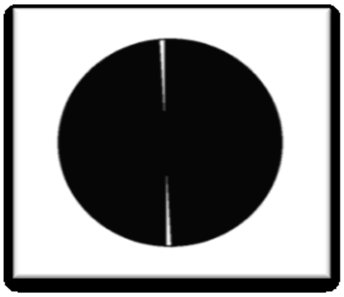
(A) Harness most of the fluid energy

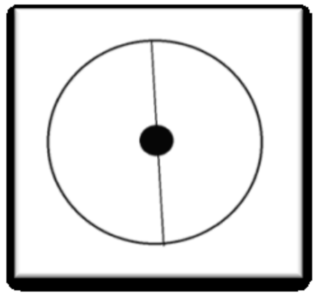
According to the conservation of mass and the energy conservation, an incoming fluid mass = an outgoing fluid mass, the incoming fluid energy = rotor energy + outgoing fluid energy. Our tests indicate there is a peak point efficiency, a test with a 4" rotor with 8 to 16 blades, and another test with a 4" rotor with 2 to 8 blades. Increasing rotor speeds at each given number of blades concludes that the Betz analysis shows U2 = (1-a)U1, where a is the axial induction factor, U1 is an incoming fluid speed, U2 is a speed of a front of a disc speed, if a is closed to 1, it means that too many blades, or too high speed (then the incoming fluid becomes a turbulent fluid , then the Betz limit is no longer valid) then U2 acts as a gate to shelter off any further incoming fluid through the disc, so most turbines would easily pass the peak of efficiency with many blades or high speed.

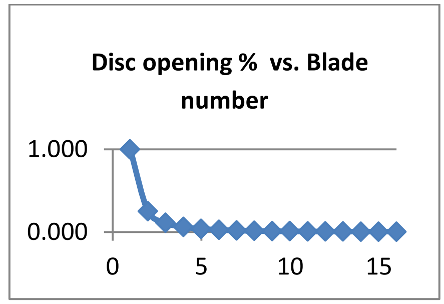
a near 1

a near 0

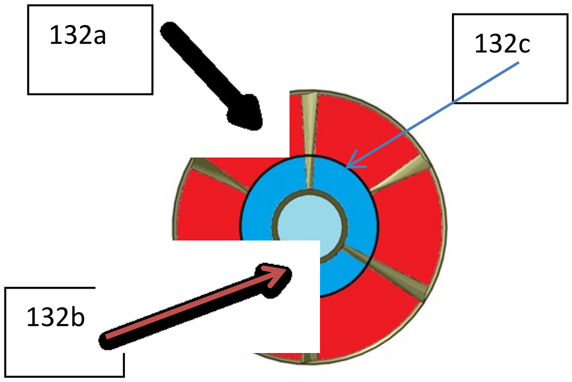
Area % v number of blade or similar speed

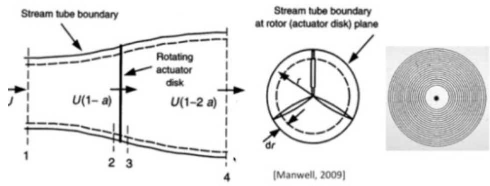






Since number of the conventional blade is angularly arranged, it become obvious that it is impossible to increase the efficiency by adding more blades or speeding up along with track record of last 100 years, but according to Newton second law in the rotary motion , $dq= p U1(1-a) 2 \omega \pi r^3 dr$, so what if the root of the blade is opened up for releasing fluid and more blades are added or area of the tip of blade is increased to harness more fluid energy , as a result the bladed ring is divided radially by the circle 132c into the high energy zone 132a and low energy zone 132b instead of angularly to reach the peak plateau which is not a point , so in the high energy zone 132a , there are three long blades , three short blades with a large mass tip ring and larger radius of bladed ring with centrifugal forces, so the rotor assembly can generate more power in the high energy zone 132a than that of energy in the low energy zone 132b, where there are only three blades 138 with much smaller cross section areas , even though area of low energy zone 132b may be equal to the area of high energy zone 132a, the amount of energy generation in each section is not equal, the angular division of the current blade design has a very short period for the peak value and indiscriminately cuts off areas of high energy fluid and low energy fluid , while radial division method converts the incoming high fluid energy to rotary energy of the rotor assembly in the high energy zone 132a it also releases the fluid at the low energy zone 132b due to conservation of mass as an outgoing fluid.





Rotor Speed: Ω

Wake Speed: $\Omega + \omega$

Torque on one annulus:

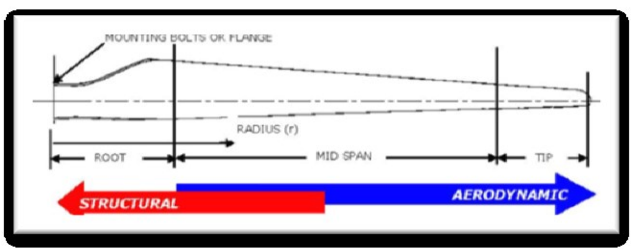
$$dQ = d\dot{m} \cdot \omega \cdot r^2 = \rho U_2 dA \cdot \omega \cdot r^2$$
$$U_2 = U_1(1-a)$$
$$dA = 2\pi r dr$$
$$dQ = \rho U_1 (1-a) 2\pi\omega r^3 dr$$

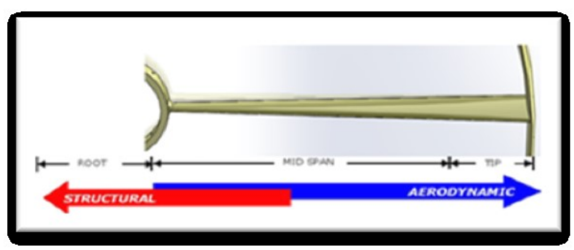
(B) Comparison between conventional blade and bladed ring

(1) Conventional blades are based on airplane and windmill or propeller designs. (1.1) at the root, there is a large area, where the blade produces no torque but block flow passage. (1.2) at the tip, the area is the smallest, as a result this area X largest radius^ 3, generates the smallest torque. (1.3) at the mid span, it produces the most.

Conventional blade

Bladed ring



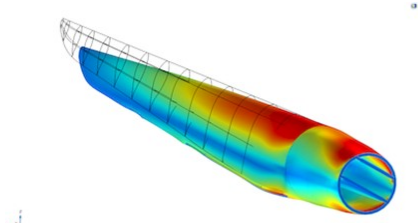


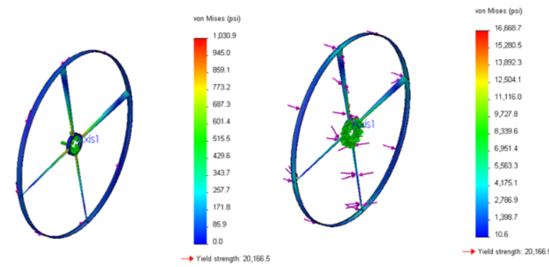
(1’) Bladed ring is based on the dual energy zone technology with symmetrical airfoil cross-sections. (1.1) At the root , there are no blades to cover (1.2) At the mid span , it has the smallest area closest to the root and the strongest strength supporting bending and torsion. (1.3) At the tip, it has the larger twist area X largest radius^ 3 and more number of blades, so together it generates the largest torque over all existing wind blades, moreover the bladed ring not only eliminates the tip eddy flow and flow leak but also increase the efficiency.

(C) Maximize the blade strength with less material and optimized shade

(1) Conventional blades are individually designed, so each blade cannot share loading with each other, therefore each blade must be designed with maximum strength, so there is no

synergy, because each blade is subject to the different water stream speed /pressure gradient due to the increased blade diameter. About 60% of blade failure happened on a single blade (2) most blades are provided with no unsymmetrical airfoil sections and twist angle between the tip and root , those structures inherently become very weak at the root section, so the root section must be designed with a big section, and a tip section must be designed so small, as a result , those structures defeat the purpose of airfoil. It is said that the blade is based on an oval wing or humming bird wing , if so the design is foundationally wrong, because bird wings are used to fly with lift forces while turbine blades are used to rotate and generate torque , many turbine designs are wrongly based on wind theory and lift , a bad aerodynamic design. (3) As the blades get so bigger, the problems get worse, hollow blade becomes the only choice. There is also the subject of thermal stress failure due to the thermal gradient between external and internal temperature, which would not happened for the solid blades.



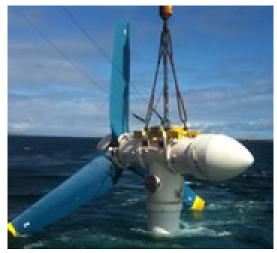


(1’) the bladed ring design is to share loading among blades. The blade is solid with NACA 0012 cross section. It is an optimized aerodynamic design with very thin cross sections that limits the bending and torsion stresses on the blades during the operation as shown in the simulation above. The material for this study is nylon 6/10 , wind load at the bladed ring is 500 lbs , toque is 1000 inch-lbs, so the combined stress is below 20,116.5 psi, weight is 96 lbs , Diameter is 3 M, so the highest stress point is at the blade root , the airfoil is modified per NACA 0012 .

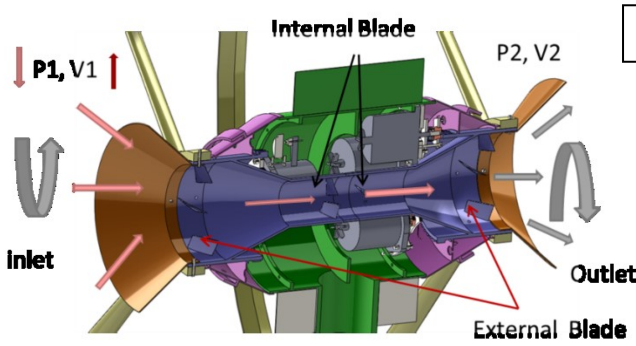
6.2.2 Horizontal Rotor design

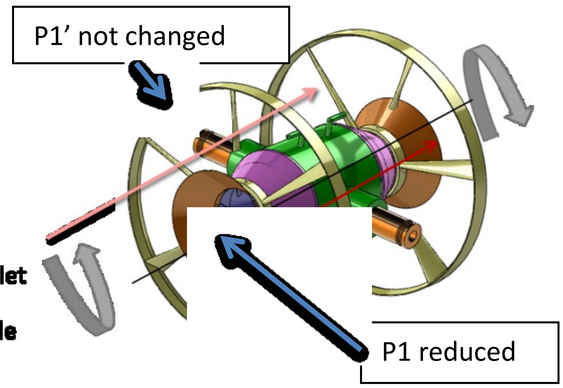
(1) **Conventional turbine Efficiency** (a) Cp , the efficiency for a wind turbine or other turbines, according to the Betz limit is 59% or .59 factor. The conventional turbine has a

single blade rotor inherently with a large central shaft , it blocks the larger central area A1, so the formula should be P = ½ p (A -A1) CpV^3, by now you know why the conventional turbine never reach even 50%. (b) The swept area would not increase without physical change. (c) Wind speed or the stream speed of river or ocean is given by Mother Nature and cannot be increased by the turbines.

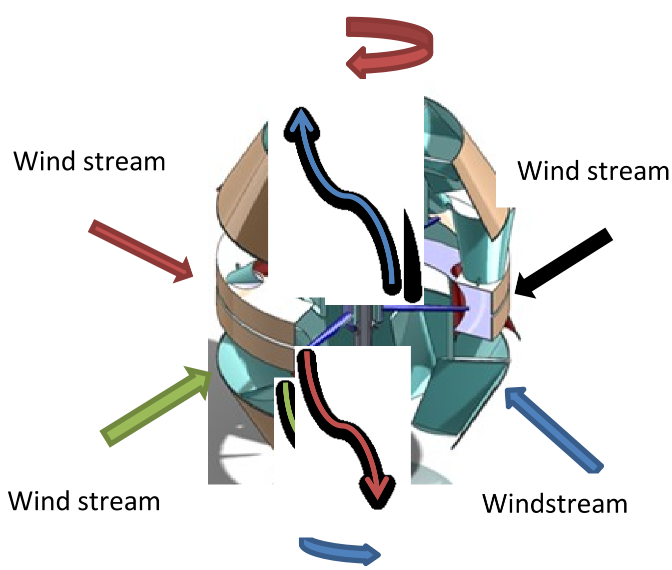


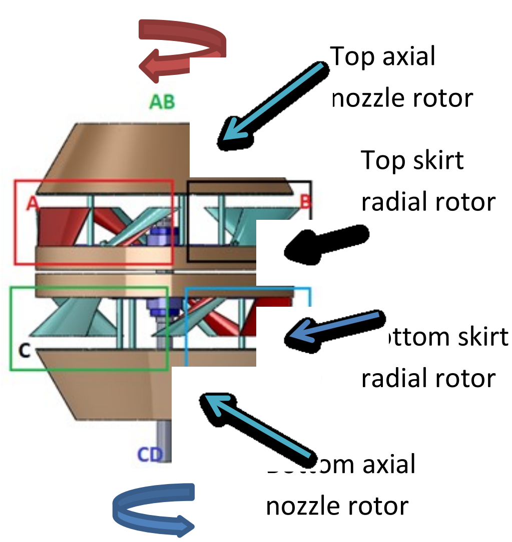

(1') **Twin rotor turbine Efficiency** Twin rotor design is a volume-base power generation and based on a shaft-less turbomachinery and the vortical mechanism with the central passage and a large bladed fan stream like a high bypass turbofan jet engine (a) Area = 2*A with two rotors , breaking the Betz limit (a2) full area with a center open area (a3) the vortical mechanism not only increase the effective swept area about 10% more (b) but also increase flow stream speed and reduce the central flow pressure, so the incoming flow P1 at inlet would decreases, while P1' at the tip ring has no change, so the pressure radiant causes the inlet nozzle to sucks more flow than that the swept area covers, and speed up rotors with two blades (c) Two rotors are concentric and rotated clockwise and counterclockwise and generate some vibrations, but the two vibrations would cancel out each other. (d) Two bladed rings eliminate the tip eddy, canceling out two wake rotations, those improvements greatly reduce the noise, as a result , the protective area of river or ocean can be reduced as well as the cost , risk of hurting ocean life or river life can be reduced as well. (e) The two bladed rings generate three dynamics streams like three dynamic wind tunnels. Due to Newton's third law, they become rigid and eliminate the yaw control system and increase the density





6.2.3 Vertical twin wind turbine breaks three barriers that no existing technologies can. First for the Betz limit, this turbine generates more power than all existing horizontal turbines doubling the top and bottom areas 2*A , creating both a top and bottom vortical mechanism. Each stream in Sections A,B,C,D counterbalances each other , and work together to increase efficiency and strengthen two vortical counterbalanced outlet streams, increasing the density of air for the first time. The streams in Sections A (red) , D (black) generate two starting rotations with the top and bottom radial skirt rotor , then flow into the top non self-starting axial nozzle rotor and the top non self-starting axial nozzle rotor, speeding up the rotation with the vertical blades, while the streams in Sections B (red) , C (black) flow into the top and bottom radial skirt rotor without producing rotations , then flow into the top and bottom non self-starting axial nozzle rotors and speed up the rotations. The left streams from section A and C flow downwards, and the right streams from section B and D





flow uppwards, and is compliant with the conservation of mass. Finally this vertical twin wind turbine is the quietest among all wind turbines. The wind streams flow in front of this turbine and flow out vertically by design , so it can be installed in city streets, while conventional turbines wind streams flow in the front and back, propergating noises horizontally.

6.2.4 Drive train and power generator design

(a) Length of the drive train for wave and tidal turbines

The conventional wave turbine drive trains have **5 conversions** (1) electrical rotor to electrical stator in a power generator (2) the electrical rotor shaft to the electrical rotor (3) a gear box output shaft to the electrical rotor shaft (4) a rotatory shaft to the gear box input shaft (5) a linear shaft to the rotatory shaft ,

The twin rotor wave turbine 110a has only **one conversion** ; an electrical/ turbine rotor to an electrical stator in a power generator, so the shorter the drive train is , the more efficient and the more robust the drive train would become. This is the reason that twin rotor wave turbines succeed while conventional wave turbines fail. The conventional wave turbines have been not commercialized for more 25 years, because they have too many conversions and moving parts to sustain severe waves of rivers or oceans.

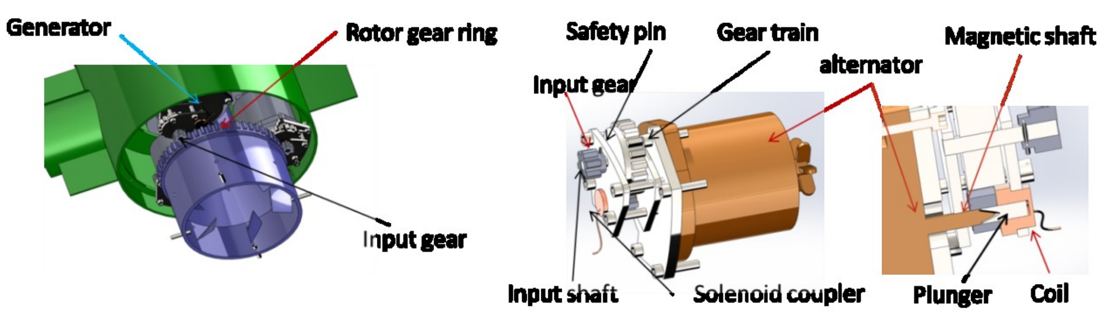
The conventional tidal turbines or wind turbines have **6 power conversions** (1) an electrical rotor to an electrical stator (2) the electrical rotor shaft to the electrical rotor (3) a gear box output shaft to the electrical rotor shaft (4) a link shaft to the gear box output shaft (5) a turbine rotor hub to the link shaft (6) blades to the turbine rotor hub.

The twin tidal turbines or wind turbines have only **3 conversions** (1) an electrical rotor/to an electrical stator (2) a gear train output shaft to the electrical rotor shaft (3) turbine rotor to the gear train input shaft , it is clear that which one is the winner.

(b) Adaptable drive trains and satellite power generator

The conventional tidal turbines or wind turbines has a “one to one ” type of drive train and has no flexibility and adaptable , the gearbox ratio is fixed , so a pitch control system must be added in order to optimize the system performance.

The twin tidal turbine has a “one to many” type of drive train, one rotor to multiple satellite generators. It has great flexibility, first each pair of generators has different gear ratio, second each gear train has a solenoid coupler, and the solenoid coupler has three states. The solenoid coupler has a coil and a plunger, the plunger has a conical hole engaged with a magnetic tip of the alternator shaft, the coil can be: (a) Deactivate - When deactivate, the plunge would engaged with the magnetic shaft, so the generator would generate power (b) Active with a front north polarity - If active with front north polarity, the alternator shaft has the same polarity, they would be disengaged, so at low wind or stream speed, all or some generators can be disengaged, so the rotor can build up speed , as rotor speed up (c) the coil can be switched to south polarity , the alternator shaft has double strong engagement force with the plunger, so with different gear ratios, the drive train acts like a resultant car transmission to optimize the output performances and eliminate the pitch control and the brake system, finally the gear safety pin is the first safety barrier and the joint engagement between solenoid plunger and the alternator is the second safety barrier.

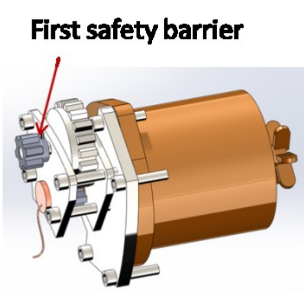


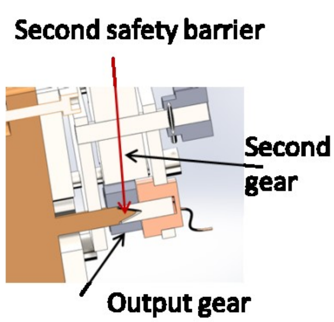
(C) Reliability of drive train

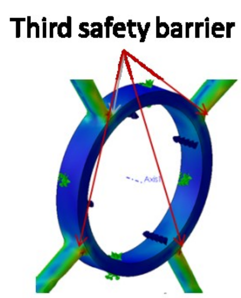
The gearbox is the weakest link in the conventional drive train, the biggest problem for the modern tidal turbines or wind turbines drive trains, and it accounts for 60 % of failure rates. The gear box is designed between a blade rotor and a generator and has a foundational flaw especially for larger size turbines. The blade rotor has the largest rotational inertial, the generator rotor has the second largest rotational inertial, and the gear box has the smallest output rotational inertial. When the rotor change the speed due to the wind or river stream speed change, the gear box output shaft cannot change immediately, because the generator rotor with the second largest rotational inertial is still rotating at the previous speed according to the Newton's first law, so this condition generates a dynamic speed difference or ratio between a low speed shaft and a high speed shaft in the gear box. Although the gear box has a static gear ratio by a design, the static ratio would not match the dynamic speed ratio, as a result, the gear box becomes a cushion between the static ratio and dynamic speed ratio, this is why the gear box has the highest failure rate, and a flywheel function of the rotor would not produce the power to the generator , but rather damages the gearbox , while the twin rotor has the smart drive train , it has the largest, rotational inertial in the rotor , and two similar, much less rotational inertial in the gear train and the alternator, so the rotor can act like a flywheel to store energy and smoothen rotation, while the gear trains and alternators act accordingly, the smart drive train is the most reliable over all drive trains in the world.

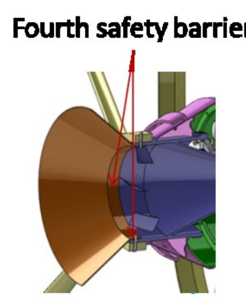
(d) Safety of drive train

(d1) The drive train for horizontal turbine is provided with four safety barrier, each one is designed accordingly with cost vs protective value by an order, from lowest to highest with a goal to minimize loss and save life and assets. It includes (1) the gear pin (2) the engagement between solenoid plunger and alternator shaft (3) joint between the root ring and the blades (4) pins on the rotor joint

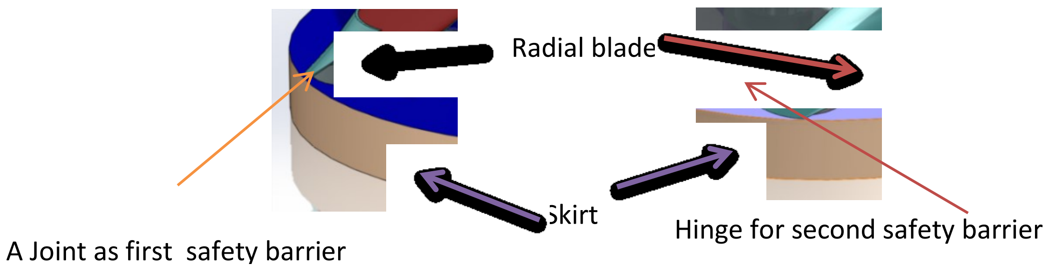








(d2) The drive train for vertical turbine is provided with two safety barriers



7. Conclusion

7.1 Performance and ratification

7.1.1 the highest efficiency > 60% The proposal provides the best performance with high efficiency greater than 59% as a new benchmark and a high density power by disruptive innovation beyond imagination. The age old Power = ½ Cp A*V ^ 3 should become P=½ Cp (A-A1)* V^3, to express true power. With this innovative design, the center area is open to allow more flow, the area doubles $A_{total=}$ Ax2 due to the twin rotors, A and V become even larger due to the vortical mechanism resulting in the highest power. For the conventional turbines, A and V were unchangeable for a given turbines due to the physical size and natural stream velocity , moreover the area-based power generation has low density, wasting a lot of materials and space, while a volume-based power generation has high power density, so Power density = P/A*L L= length , all those innovative features create an efficiency leap.

7.1.2 Safety system

All safety issues are addressed with solutions, all four safety barriers resolve the drive train under abnormal conditions, two safety barriers are design to protect the vertical turbine from high wind, the joint between radial blades and the skirt would be separated , as a result the blades would flip over and stop to produce torque, and the axial nozzle rotor would stop too due to no-self-starting design, while the risk of electrical fires are minimized by two sealing solution and cooling systems, T seal ring and sealable bearings are designed to provide robust seals to prevent shaft dynamical leaks, while water cooling coils along with alternators fan are provided with the best natural cooling solution. The noise and turbulent wakes are greatly reduced by the twin rotors and bladed rings. Finally the wind turbine with bladed rings as well as the vertical turbines would great reduce the risk of killing birds.

7.2 Innovative technology impact

7.2.1 Turbine design Shaft-less turbine design is based on a breakthrough discover, solid-fluid dynamics which include four laws and would change the course of turbomachinery history forever. it makes every following innovative features possible from high efficiency blade to smart drive train , just think about all turbines around the world from jet engine , stream turbine to submarine , boat propellers, what if the large stream turbine shaft is replaced with a tubing rotor with internal blades and external blades, requiring less material to manufacture and producing more power. What if a jet engine shaft is replaced by a tubing rotor with additional central air stream and fuel, it would become even more efficient and quieter, what if the submarine shaft is replaced by a twin propellers, so powerful even quieter, or a Tesla boat with twin rotor electrical propeller , the air and water would be much cleaner.

7.2.2 Blades design high and low energy zone technology is based on a third law of solid –fluid dynamics which state "in order get the highest efficiency, a solid-fluid system must produce useful work or work in a high power zone and release low energy in a low power zone" , a game changer, it broke all rules based on wing and lift theories with a goal to maximize output torque and minimizing material and drag. So many contrast features between the bladed ring and conventional individual blade from " a central hole v. a center block" , " a root ring v. a large root" , "a large tip mass and area v. small mass and area" and " radical division v angular division". The bottom line is (1) that Bladed ring to maximize output torque from the fluid energy in the high energy zone and release the used fluid in the low energy zone vs Three Blades to minimize torque in high energy zone , maximize torque between high energy zone and low energy zone, and release used fluid at high energy zone (2) the bladed ring against a single blade is designed in a synergic manner, so it greatly reduce materials and increase strength and efficiency (3) the ring structured blades not eliminate tip eddy or leak but also make modular design possible to reduce cost and more blades possible in high energy zone to make it more efficient.

7.2.3 Drive train and power generator Drive trains include first "one to one" type for wave and tidal turbines , it has the simplest conversion with the smart drive train between turbine rotor/electrical rotor to electrical stator, again because of shaft-less turbomachine technology , so twin wave turbine with the shaft-less turbomachine technology become only commercially suitable wave turbine , second one is one to many type for wind turbines and has 3 conversions from the rotor to multiple satellite , so it replaces the troublesome gearbox by multiple gear train with various ratio and solenoid couplers , the drive train can act as a resultant transmission , it not only optimize input with output , eliminate pitch control system ,but also revolve overheat issue with natural water or air cooling system and without the electrical cooling system and the brake system .

7.2.4. Scalability design. It can be a stand-alone system or three separate systems and modular design lays a foundation for scalability of all turbine parts and productions, all rotor and bladed ring sizes, nacelles and drive trains are based on the existing ASME and API pipe schedule, so they have much low cost and high availability with existing supply chains and facilities , we have following Modular unit specifications and the structure materials include cement , steel , aluminum and PVC , there is no yaw control or pitch control , all wave or tidal power generators have no converting gear , just electrical stator vs. electrical rotor , while wind turbine generator system have multiple satellite power generators

Modular unit specification					
Floater base diameter (m)	**2.5**	**5**	**10**	**20**	**30**
Wind rotor diameter (m)	**2.5**	**5**	**10**	**40**	**50**
Wind housing inside diameter (m)	**1.0**	**2**	**4**	**6**	**8**
Wave/tidal rotor diameter (m)	**0.5**	**0.8**	**1.0**	**1.50**	**2**
Wave/tidal housing inside diameter (m)	**0.15**	**0.25**	**0.5**	**0.75**	**1**

7.2.5 Vertical /horizontal twin rotor wind turbine. The vertical twin rotor turbines not only resolves the low efficiency issue with internal horizontal blades , but also provides two additional safety barriers saving lives and assets with minimum cost even in the hurricane seasons and remove final barriers to deploy wind turbines for those hurricane prone states.

7.2.6 Survivability The twin-rotor wave turbine has two key protective features: the single conversion and the hinge joint, those features can make the turbines survivable for severe river or ocean conditions, while the twin-rotor tidal turbine and the joint between the tidal base system and tidal turbine can sustain tidal direction change impact, the tidal base system is provided with a large, stable base support with the buoyant ring and craws secured with seabed or riverbed, so no single tidal turbine base can compare with this.

7.2.7 Sealabilty The sealabilty is provided with T seal ring and the sealable ball bearings, the sealable ball bearings not only resolve dynamic leakage on the rotors but also increase efficiency, while T seal ring solve the leak between two rotors, it is a pressure energized seal as well spring backed seal , the design life is between 5 to 10 years.

7.2.8 Accessibility The system offers the lowest cost for accessibility over existing methods or practices , the wave turbine system is provided with a surface accessibility to check the control box and each turbine performances and a signal of the turbine system for any bypass boat or ship , while each tidal turbines has an airbag lift for on-surface repair or replacement and the tidal turbine base assembly has a decommission airbag lift.

7.2.9 Pitch control –less this system has no pitch control due to the adaptable satellite power generation system and not only reduce cost and control complexity, but also increase efficiency by expanding the wind speed cut-in and cut –out ranges

7.2.10 Yaw control-less this system has no yaw control due to twin rotor self-addable structure **,** so it not only reduce cost and control complexity, but also increase efficiency for all wind turbine, wave turbine and tidal turbines.