ENERGYTECH®
MARINE GROUP

Increasing the efficiency of sailing with the Power Core™ Hybrid-ion Energy System Version 1.2 4/26/09

Let us compare the efficiency difference of partially using the sails of a vessel as a large wind generator, in addition to the normal application of using the sails to propel the vessel through the water. The EnergyTech Marine Power Core allows you to use sails in a hybrid regeneration (energy extraction) mode instead of just as wind-foils to blow the vessel around in the water. This allows a vessel to travel amazingly farther and faster on the same amount of wind energy.

The Power Core offers twin encapsulated horizontal-axis hydroelectric reaction turbines that can be engaged or disengaged at the push of a button. When engaged, the turbines can be throttled to collect a little or a lot of kinetic energy from the water flowing beneath the vessel while sailing. The amount of drag applied (which produces the force) when engaging the turbines can be throttled from zero to a lot.

This allows the option of using wind energy to generate large amounts of electricity in addition to propulsion thrust. Because of the unique proprietary design of the Power Core, wind energy can be skimmed off of user-selected peak pulses of wind power during a voyage. It can be stored to be used more efficiently to power the electric propulsion motors at a later time. Allowing the vessel to use the captured energy later when there is less wind, can take you much farther on the same amount of energy.

This process is called speed-shaving™. The Power Core Hybrid-ion Energy System allows the operator to shave off (reduce) any user-selected peak-speed produced by the sails and capture the power, no longer being used to generate that speed, by converting it into stored electrical energy. Because of the unique design of the Power Core, peak energy can be captured without affecting the power required by the vessel to reach the user-selected minimum cruising speed. This means that the operator can choose to shave off, for instance, one knot and extract the energy it took to produce it, or they can choose to shave off more speed, for instance three knots, and extract that even greater amount of energy. The user can throttle the amount of drag and thereby the amount of energy collected when engaging the reaction turbines. This means that the operator decides how much momentary sailing speed is traded for long-term stored electric energy.

EVEN AFTER THE SPEED TRADE-OFF DURING CAPTURE, YOU STILL GO FARTHER AND FASTER OVERALL

An energy-smoothing™ algorithm directs the operator when to use the wind-generated electric energy to propel the vessel via the electric propulsion motors. Using the energy later, in this hybrid

regeneration fashion, can significantly increase the average speed and distance-covered by wind power beyond that of an ordinary sailboat.

With the new Power Core Hybrid-ion Energy System you can now go farther and faster using the wind, by converting most of the power in the sails into electricity before using it. Energy-smoothing™ can, in many cases, increase the average speed and distance covered for a sailing yacht by hundreds of percent through more efficient use of the exact same wind power. See the table on page three.

HOW IT WORKS

The principle is quite simple. The faster a displacement hull vessel (like a sailboat) travels, the more exponential amount of power it needs for any amount of speed gain until it reaches a point at which almost no practical amount of additional power will increase the speed. This occurs at the point at which drag equals thrust. The farther a displacement hull vessel operates below the intersection of these forces, the more efficiently it can be propelled. This is because the drag increase is exponential to the speed. Don't try to compare this to a hybrid car because its power curve is so different than a marine vessel that you could never use the system from one for the other. The principles are very different.

THIS ALL WORKS BECAUSE AT SOME SPEEDS IT CAN TAKE AS MUCH AS 96 TIMES AS MUCH ENERGY TO *ADD* ONE EXTRA MILE TRAVELED TO YOUR TRIP AS IT DOES AT OTHER SPEEDS.

Let us look at a sailing example where we extract energy from the top end of the power curve and then reuse it later at a lower end of the curve. For this example we will compare traveling at a velocity of five knots and twelve knots. The EnergyTech Marine 83 HD-X test vessel requires 12 kW (16 HP) of power to achieve five knots. That is approximately 2.4 kW (3.2 HP) per knot required to move through the water at five knots. The same vessel requires 222 kW (298 HP) to travel at 11 knots but it requires 452 kW (606 HP) to travel at 12 knots. As you can see, the energy cost per knot is exponential. This, by the way, is typical of all displacement hull vessels. These measurements mean that an additional 230 kW (308.4 horsepower) is required to cover an extra mile in one hour (one nautical MPH) once the vessel is already going 11 knots. This is precisely the amount of extra power it is delivering to the water in the form of thrust or it would not achieve the 12 knots.

This is a perfect scenario for engaging speed-shaving™ while sailing. The difference in the amount of isolated energy to add one MPH when the vessel is already traveling at 11 knots compared to what the same energy would accomplish in speed and distance at five knots is astronomical. It literally consumes 96 times more energy to add a mile to your voyage at the upper speed as compared to the lower speed. You are still just adding the same mile either way. One way just consumes 96 times more energy to deliver the same mile of distance traveled.

Let us simplify the above example. The same power expended over an hour to add one knot to reach 12 knots could propel the vessel with its electric motors for 19.2 hours at five knots for a total

of 95.8 miles instead of only one mile. The Power Core can shave-off that one knot of extra speed when sailing at 12 knots, and convert some (not all) of the energy required to produce it, into electricity. A conservative efficiency estimate of 33.3% for the hydroelectric turbines means that 66.6% of the energy might be lost in the process of extracting the kinetic energy from the water to store it in the battery. This would still mean that after losses, energy-smoothing could provide the power to motor 31.9 miles at five knots instead of only one mile at one knot. It is simply a better use of the same energy.

Let us compare the efficiency of using energy-smoothing in the above example. Using the energy differently moves the vessel 3,191% as far at 500% the velocity. This is even after huge conversion losses. The percentage gains from shaving are less, as the vessel sails more slowly but are still more efficient than just using-up the wind energy by sailing.

The following table shows that implementing energy-smoothing is more efficient all the way down to five knots. It is more efficient to employ some amount of speed-shaving until your velocity drops below six knots.

There are different efficiency gains at different speeds by employing energy-smoothing. What is the trade-off? What did you give-up and when? What did you get in return and when? You went farther and faster on the same energy. This table shows the distance you got in return for your trade-off as a percent, from the same energy, even after losses of two thirds.

How many miles of distance did you give-up at what sailing speed vs. distance gained in trade at the electric motoring speed of five knots, expressed as a percent?

	While traveling at 12 knots	*While traveling at 11 knots*	*While traveling at 10 knots*	*While traveling at 9 knots*	*While traveling at 8 knots*	*While traveling at 7 knots*	*While traveling at 6 knots*	*While traveling at 5 knots*
Distance % gain giving-up 1 mi. @ 1 knot	3,191%	1,304%	805%	291%	222%	180%	111%	—
Distance % gain giving-up 2 mi. @ 2 knots	4,496%	2,109%	1,1096%	513%	402%	291%	—	—
Distance % gain giving-up 3 mi. @ 3 knots	5,300%	2,400%	1,318%	694%	513%	—	—	—

Read the above table as follows: The figure of 1,304% in the third column, second row means that in exchange for giving up one mile at a speed of one knot, while traveling at a speed of 11 knots (which means you are now reduced to only 10 knots as a result) the vessel went 1,304% as far on the same energy at a speed of five knots. That means it went 13.04 times as far. That means that instead of traveling the one-mile, for which the system gave up its energy, it traveled 13.04 miles instead. That means it went a net 12.04 miles farther, at a four-knot gain in average speed, as a result of the trade.

You actually gave up nothing by using the same energy more efficiently. Just like converting diesel to electricity before using it, converting wind to electricity first, also offers greater efficiency. You get more miles on the same energy. You can use the stored energy to propel with electric motors or to motor assist while sailing. The distance gained is the same.

Using up all of your wind-power when it isn't getting you very far isn't as efficient as using the same power later, when it might get you dozens of times farther. The Power Core allows you to make that choice at a broad range of speeds down to five knots.

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ENERGYTECH®
MARINE GROUP
SAN DIEGO BAY
POST OFFICE BOX 6368
CHULA VISTA, CALIFORNIA 91909

WWW.ENERGYTECHMARINE.COM