

VIVACE: A NEW CONCEPT FOR HARNESING HYDROKINETIC ENERGY



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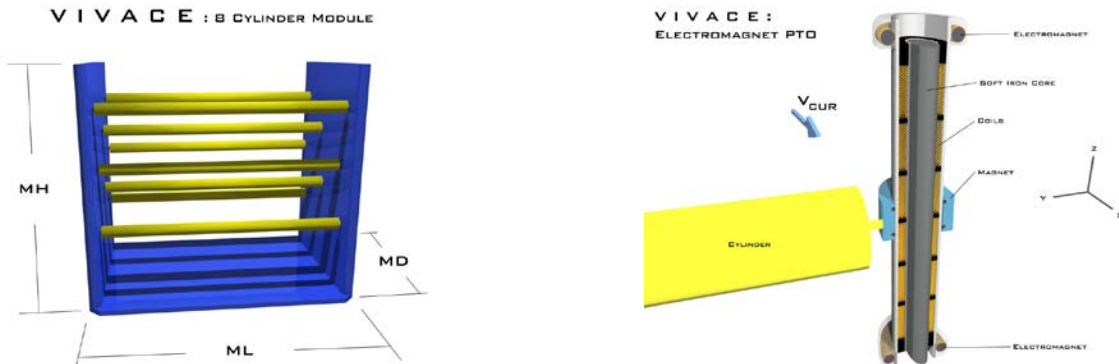


SUMMARY: VIVACE (*Vortex Induced Vibration for Aquatic Clean Energy*) is a breakthrough technology, which emulates the natural and destructive phenomenon of vortex induced vibration (VIV) and enhances it by borrowing from fish-biomimetics to harness the hydrokinetic energy of even slow water currents. VIVACE greatly expands our ability to harness the energy of river /ocean currents. Importantly, hydrokinetic energy is clean, renewable, and available worldwide.

THE PROBLEM AND THE CHALLENGE: According to the United Nations the most challenging problem that the World faces today is low-cost sustainable energy generation. The second is clean water supply, which can be solved with adequate renewable energy. Solving the energy challenge requires that we tap into every available source of energy and develop every technology that can generate energy at a competitive cost. It is expected that renewable energy generated in environmentally compatible ways will contribute more and more towards solving the energy challenge.

Hydrokinetic energy from currents can be harnessed using turbines or watermills. Typical water currents flow at speeds of less than 3 knots. According to EPRI, turbines require an average speed of 5-7 knots to be financially viable. For marine renewable energy – and particularly hydrokinetic – a viable technology must be simple, environmentally compatible, cost competitive, unobtrusive to people, have high energy density, be scalable, manufacturable, robust to loads, and generate grid-dispatchable electricity.

THE INNOVATION: VIVACE (3 patents pending) is a novel, lab-demonstrated approach to harness hydrokinetic energy from water currents even as slow as 1-2 knots. It is designed to: (a) enhance rather than spoil vortex shedding; (b) maximize rather than suppress VIV; (c) harness rather than mitigate VIV energy. It further enhances VIV using fish-biomimetics in the form of passive turbulence control and passive fishtail. VIVACE takes this destructive phenomenon and, for the first time, successfully transforms it into a valuable resource for mankind.



Vorticity/circulation/lift generated by circular cylinders with roughness and tails may appear exotic to people because we live in air and see only lifting surfaces (bird/airplane wings, sails, propellers, paddle wheels, etc). In reality, however, most objects moving in fluid have a bluff body with some surface roughness and a tail; from tiny (sperm) to gigantic (whale) objects.

THE PRODUCT: A VIVACE Converter module consists of an array of cylinders excited in VIV by a water current. It operates under high damping needed for energy extraction. The energy density achieved in the University of Michigan's Marine Renewable Energy Lab is 51 W/m³ at 3 knots. VIVACE is simple, modular, reconfigurable, and scalable from 1kW - 1GW. It is robust to environmental changes due to the nonlinear nature of VIV, which makes VIV persist over broad ranges of current speeds.

VIVACE ADVANTAGE: VIVACE harnesses hydrokinetic energy of water currents at any speed with energy density 2-10 times higher than other marine energy converters. Most important, it taps into a virtually untapped energy source, the hydrokinetic energy of currents with $V_{\text{current}} < 3$ knots. Unlike wave, wind and solar energy, currents are predictable, making electricity generated by VIVACE dispatchable to the grid. VIVACE is unobtrusive to people as it remains submerged at all times, and to fish as they also generate alternating vortices to harness hydrokinetic energy. At maturity, 10MW, and speed of 3knots it will generate electricity at $\phi 5.5/\text{kWh}$ making it competitive to conventional and alternative energy sources.

CURRENT R&D: Improving the hydrodynamic design using fish-biomimetics, increasing energy density, matching the power take-off system to the specific VIVACE scale, and developing a simple integrated design for manufacturability will set this revolutionary technology on a path to commercial viability.

CURRENT FUNDING: The University of Michigan has received funding in recent years from the DOD, DOE and others to address basic research aspects of VIVACE. In addition, the Detroit Wayne County Port Authority has funded Vortex Hydro Energy to do an assessment of using the system in the Detroit River. The time is right to accelerate VIVACE's development to a real-world commercial level. NIST-TIP funding is critical to carrying this out.

WHY NIST-TIP: Marine renewable energy in oceans and rivers is a large-scale initiative that can revolutionize energy generation and requires a major and aggressive effort that only NIST-TIP has the vision to accomplish. Industry can only follow such large-scale efforts. Three years ago, when we invented VIVACE, all funding agencies had explicitly excluded hydroelectric power because nothing new has been invented for about 200 years and dams and turbines have created environmental concerns. VIVACE has revived the field but is still in the development stage. NIST-TIP provides the type of enabling funding that can accelerate a breakthrough technology through the "valley of death" to the market by bringing together academe, government labs, industry, and consumers to the table with a focus. Current funding of VIVACE supports concept proof, model development, and testing. DOE anticipated funds will support development and prototype testing, with the objective of having industry take over. NIST funding will enable this exciting but embryonic concept to take root and flourish.