VIVACE: A New Concept to Harness Energy from Ocean/River Currents

(**V**ortex **I**nduced **V**ibration **A**quatic **C**lean **E**nergy)

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CEO and CTO, **Vortex Hydro Energy**

Emerging Technology Investment Opportunity:
Clean Tech at UofM
14 September 2007

University of Michigan
N.A. & M.E. and
Office of Tech Transfer

VORTEX HYDRO ENERGY

Overview

Energy | VIVACE | Market | Competition | Business

- **The Problem:** Energy sustainability
- **Part of the Solution:** Marine renewable energy
  - VIVACE: Taps into an untapped energy source: $V_{current}$ < 3 knots*
- **First Market:** River/Coastal Energy Production (USA)
  - Alpha Customer: Detroit Wayne County Port Authority
- **Competition:** VIVACE is cost competitive
- **Business:**
  - First Model: sell devices, service contracts
  - Funding round: $3M in 2 years

*1 knot = 1.15 mph = .514 m/s

VIVACE taps into a vast, untapped energy source

Marine Renewable Energy

- **Water:** The largest medium for storing energy
- **0.1% of the ocean energy:**
  - Would cover the energy needs of 15 billion people
  - Clean, renewable, abundant, world-wide available
- **Marine energy:**
  - **Currents**, waves, tides, thermal, salinity
- **Marine currents:**
  - Most currents flow at $V_{current} < 3$ knots
  - Challenge: Turbines, water-mills need $V_{current} > 6$ knots

Currents < 3 knots are a vast, untapped energy source

The VIVACE Concept

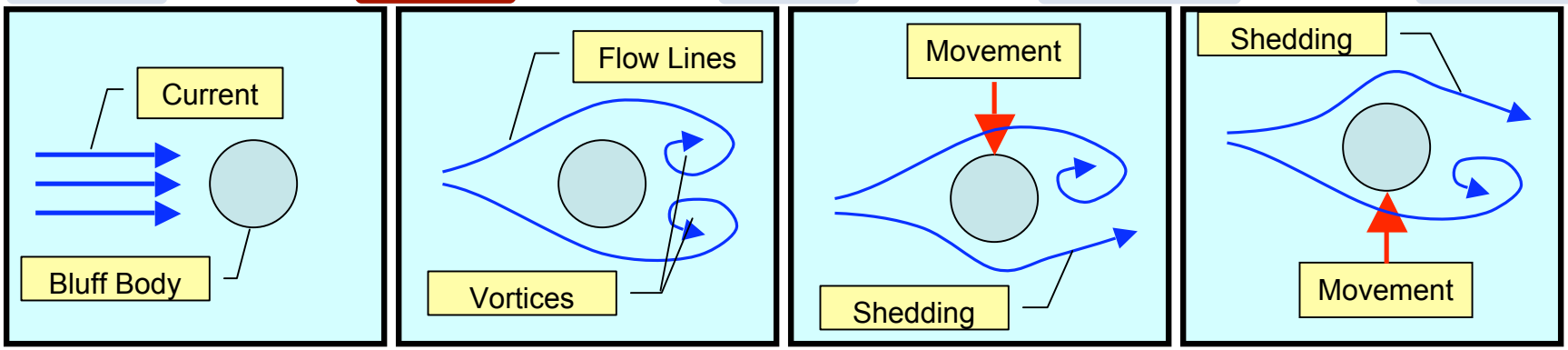
1940: Tacoma Narrows bridge

1965: Ferrybridge England

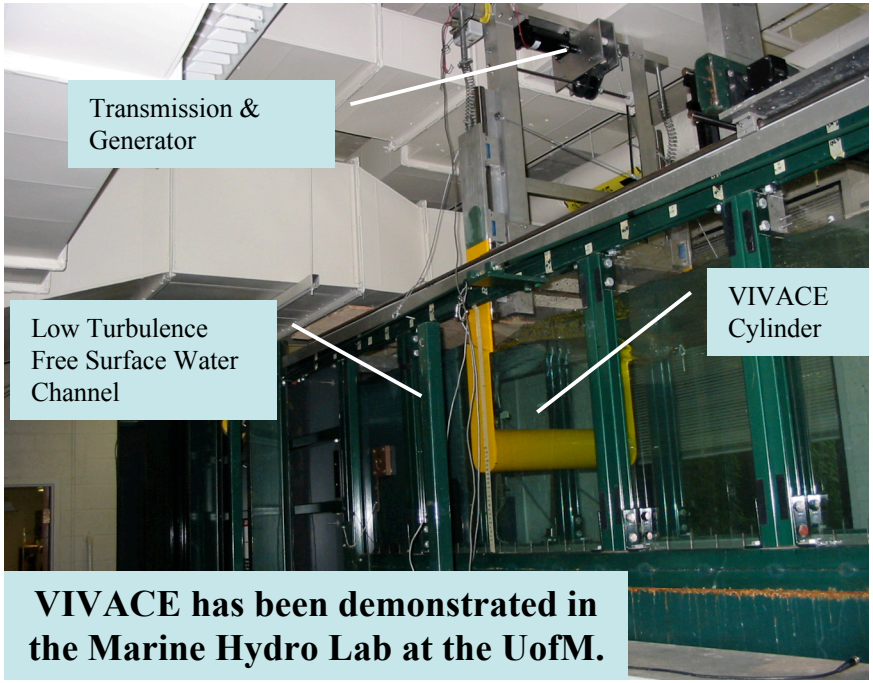
VIVACE can control VIV to ***generate energy***!

Harness a powerful & destructive phenomenon in nature

How it works



- High energy density
- Environmentally compatible
- Scalable
- Robust to environmental changes
- Unobtrussive



VIVACE has been demonstrated in the Marine Hydro Lab at the UofM.

Utilizes VIV to extract energy from marine currents

Proof of Concept

Flow Velocity
U=1.6knots
(0.8m/s)

Lab model

Patent-pending Technology

Patents pending:

1st on the VIVACE concept

U.S. on Nov 10, 2005

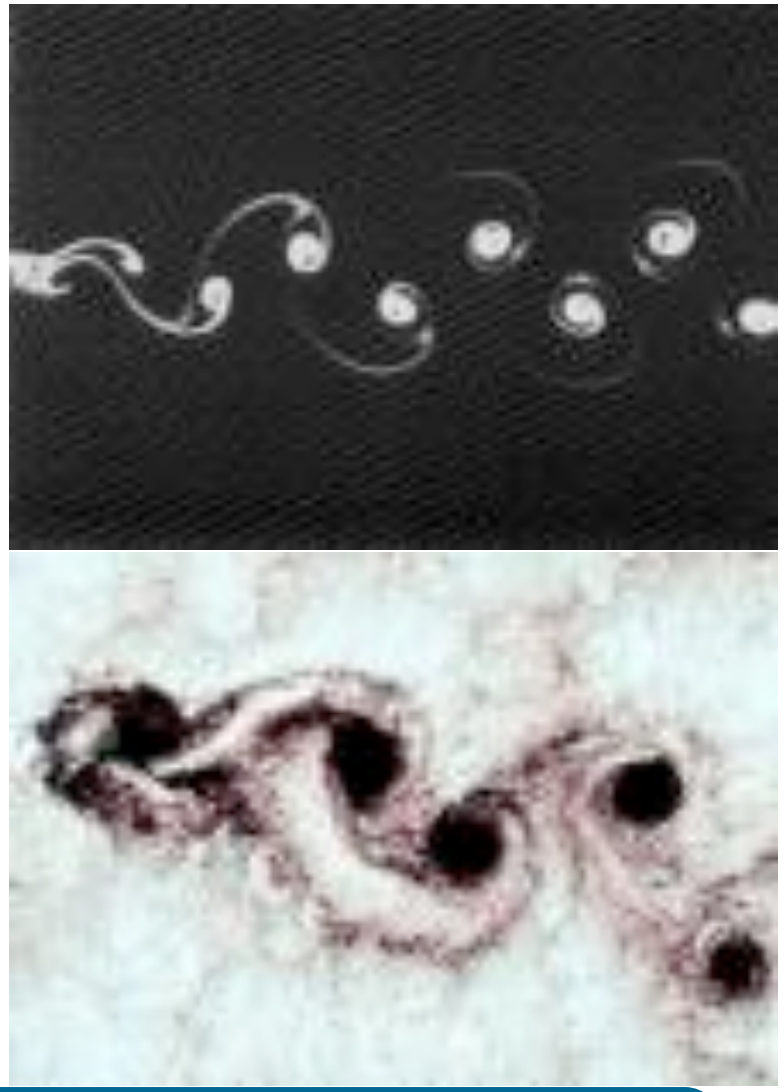
International on Nov 11, 2005

2nd on turbulence enhancement

U.S. on May 28, 2007

3rd on shape enhancement

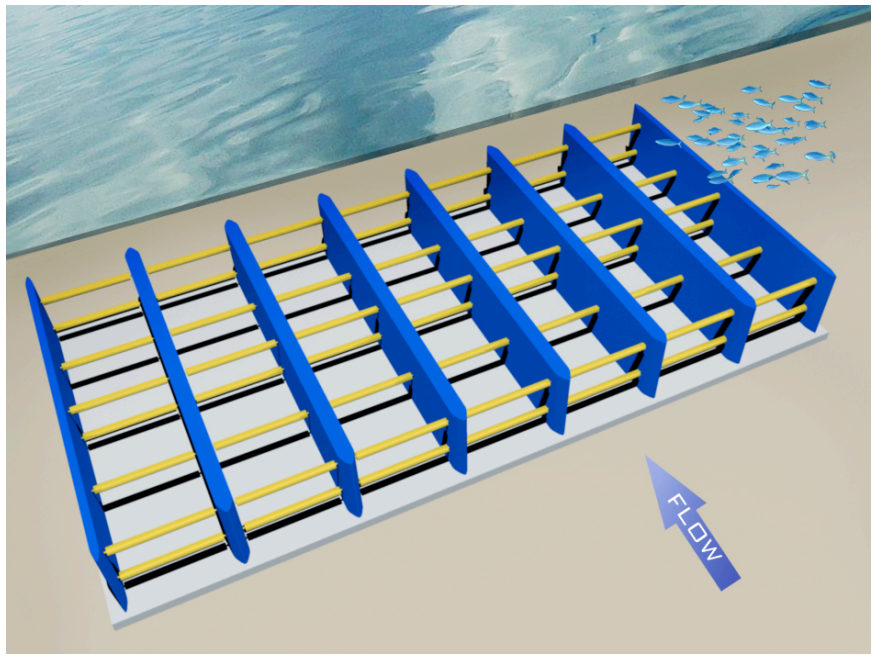
Provisional in Sept, 2007

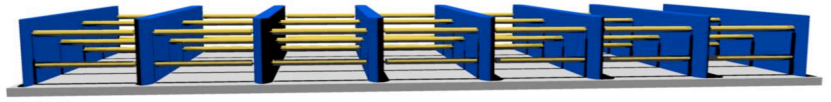


Patent of a scalable concept not just a device

VIVACE Advantage

- **Untapped energy source**
- **Grid-compatible**
- **Modular, reconfigurable, scalable** (1kW - 1GW)
- **Cost competitive**
- **Unobtrusive**



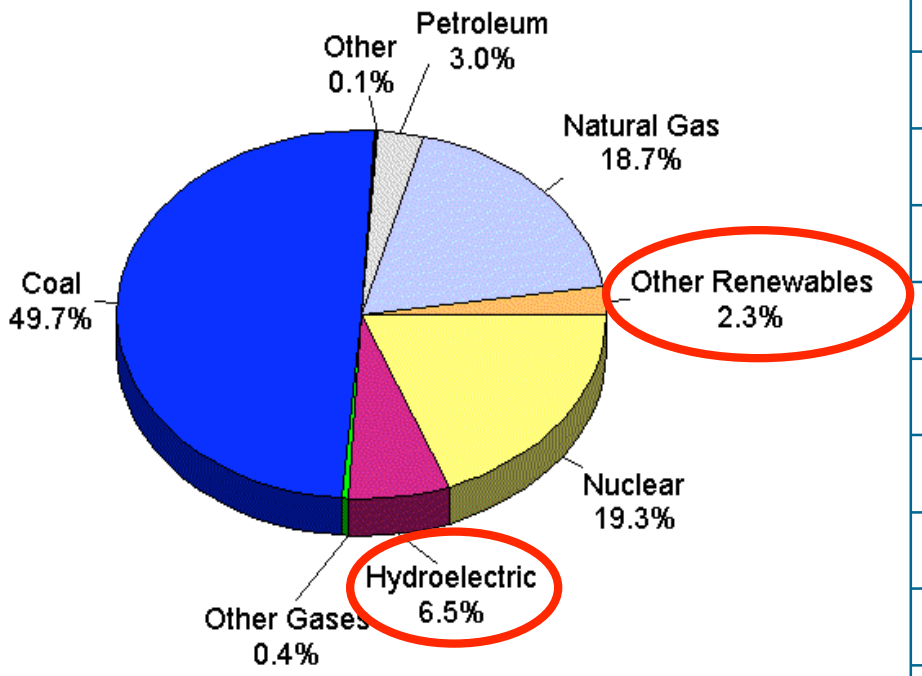


VIVACE is modular and manufacturable

Market Size and Growth

U.S. Power Generation

8.8% → Renewable



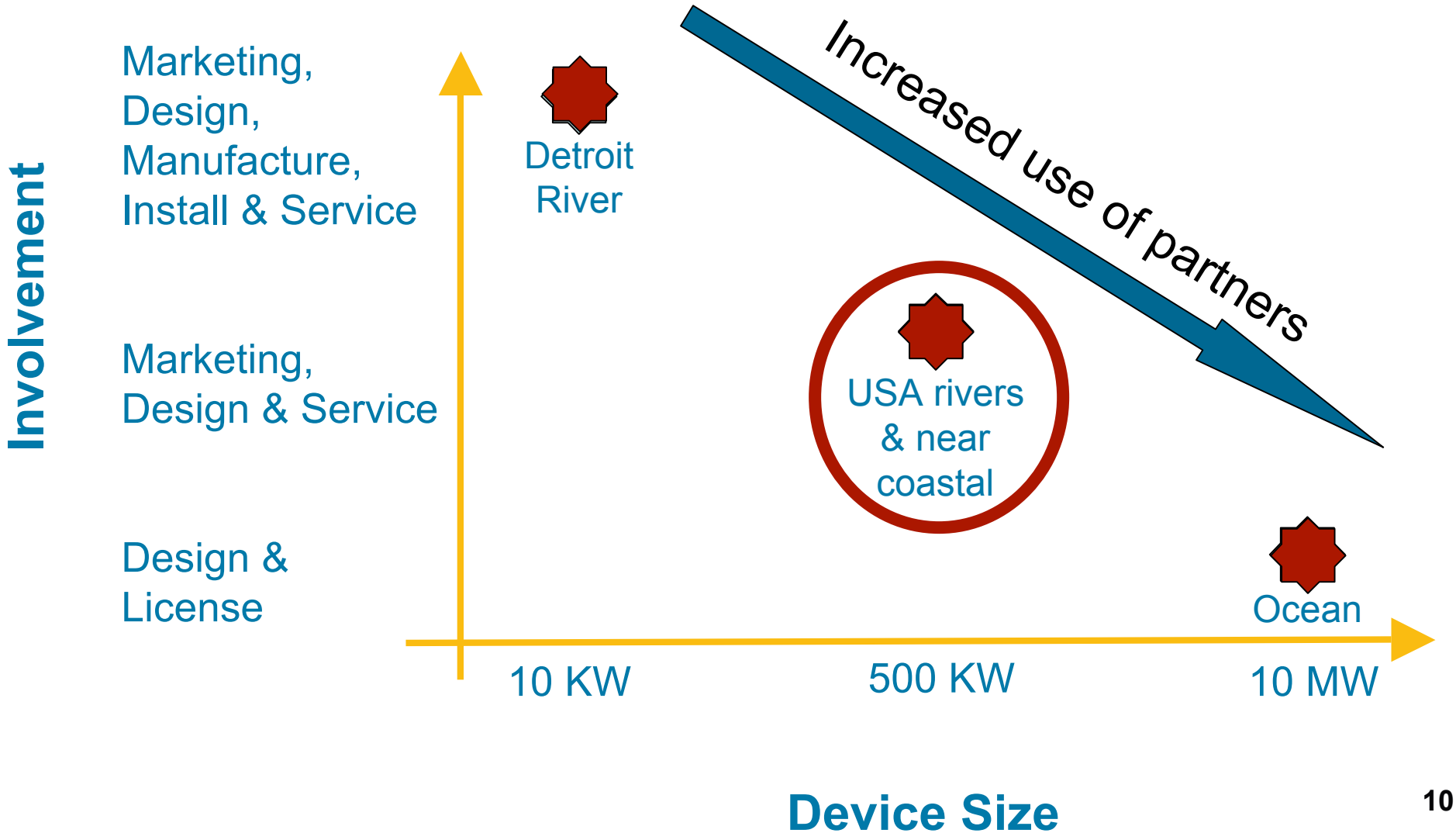
Energy Information Administration, Form EIA-860, "Annual Electric Generator Report."

Renewable Portfolio Standards

State	Amount	Year
Arizona	15%	2025
California	33%	2020
Colorado	10%	2015
Connecticut	10%	2010
DC	11%	2022
Hawaii	20%	2020
Illinois	25%	2017
New York	24%	2013
Pennsylvania	18%	2020
Texas	5,880 MW	2015

Demand for renewable power is rising

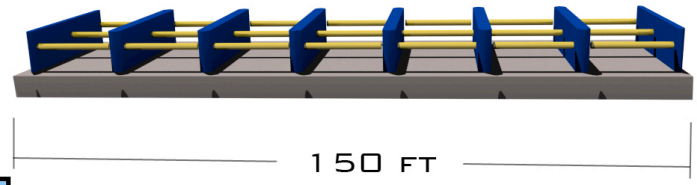
Value Chain

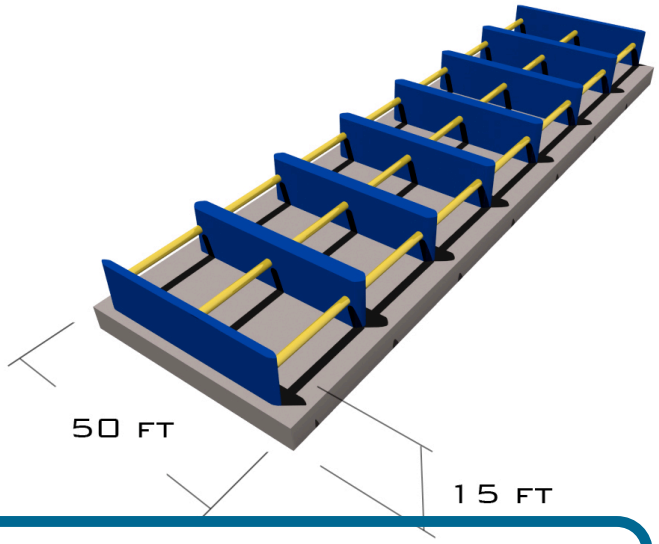

Involvement
Marketing, Design, Manufacture, Install & Service
Marketing, Design & Service
Design & License
Detroit River
USA rivers & near coastal
Ocean
Increased use of partners
10 KW
500 KW
10 MW
Device Size

Alpha Customer

VIVACE: 21 Cylinder Array
Detroit River Project

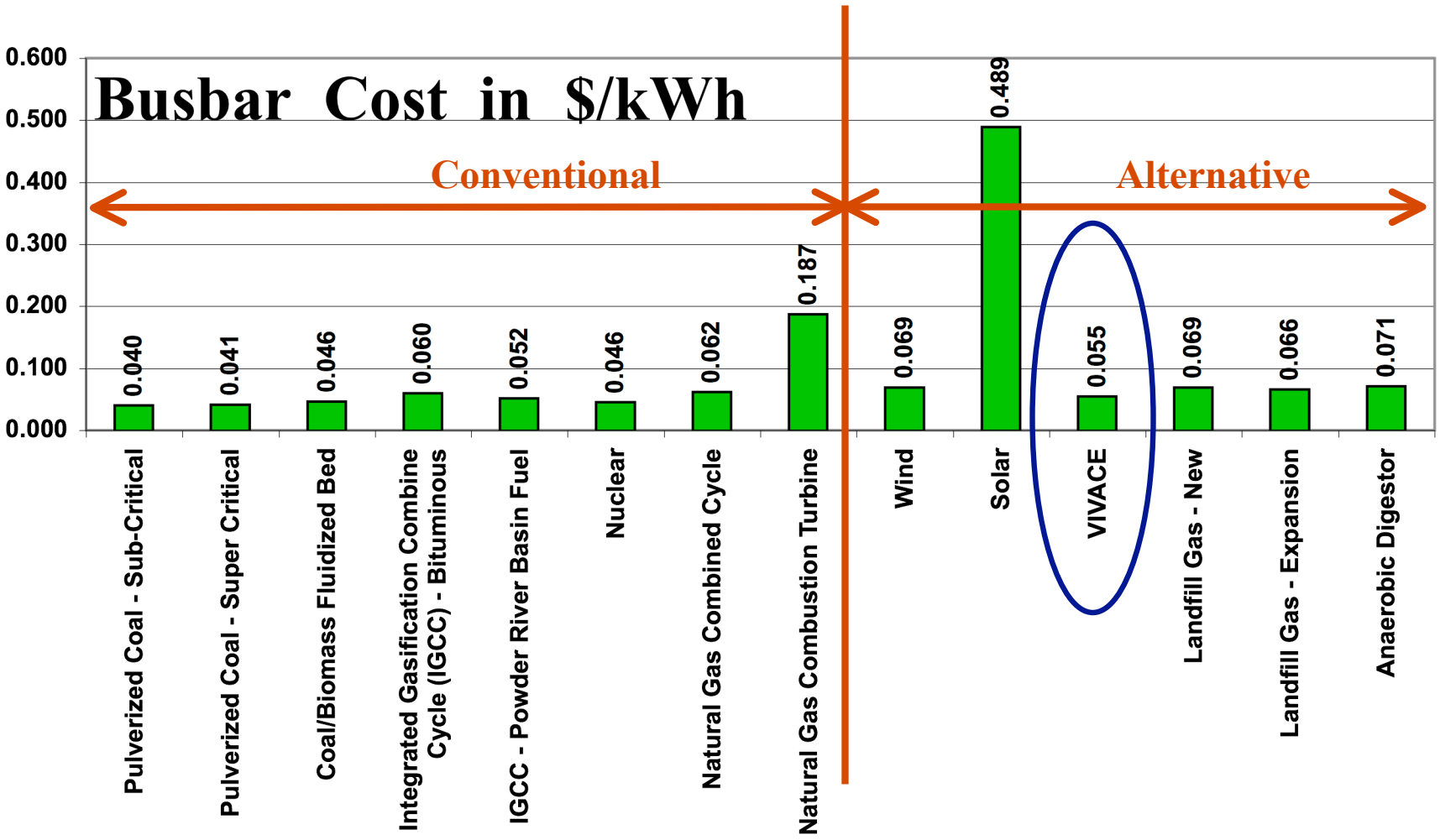
- Detroit Wayne County Port Authority
  - Power a new wharf/building on the Detroit River
- Beta Customer
  - In talks with Ambassador Bridge (Detroit River) and others
- Next: Ocean Prototype
  - Off-shore Florida with FAU





Vortex Hydro Energy already has a customer

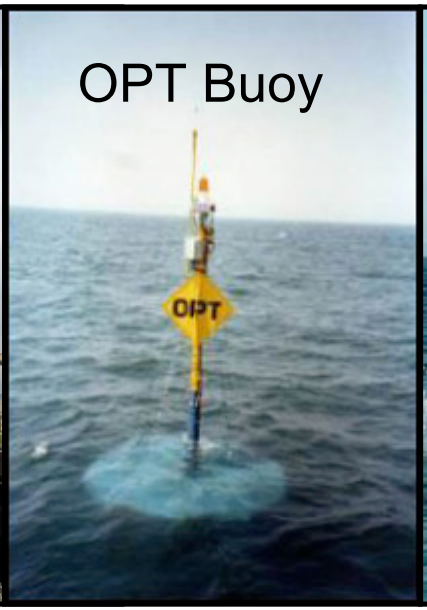
Comparison: Energy Cost ($/KWh)

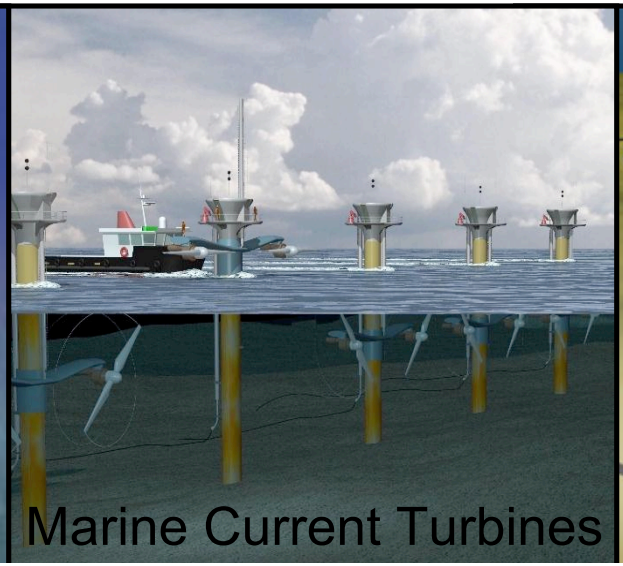


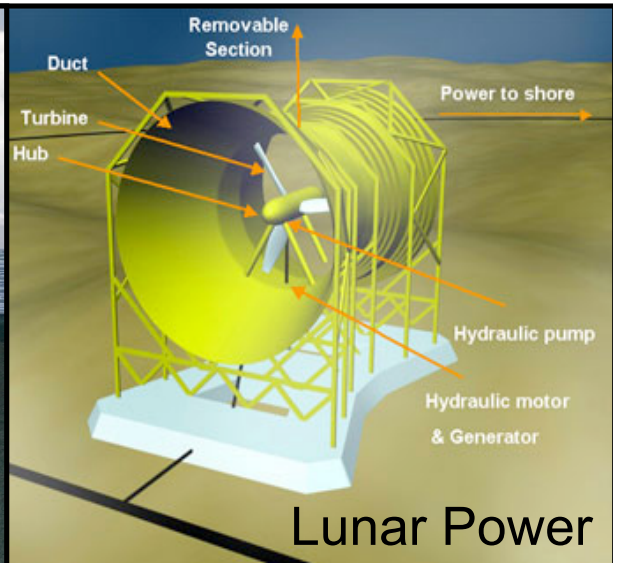
(1) Oil at $70/barrel is $0.041/kWh (thermal values only)

(2) Natural Gas at $10/10^6 BTU is $0.034/kWh

Marine Energy Conversion

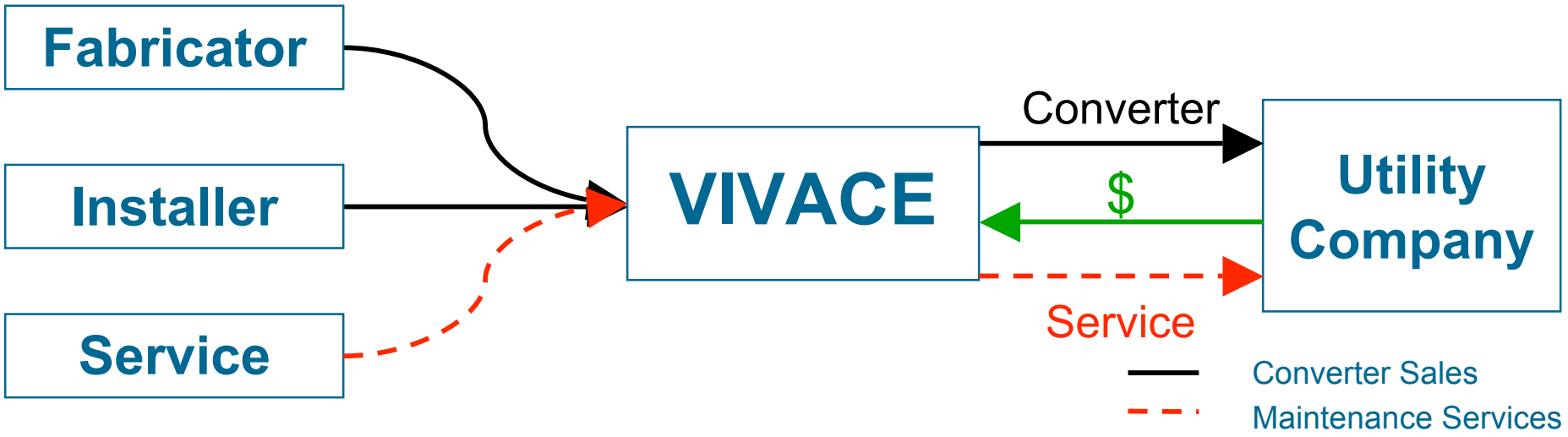






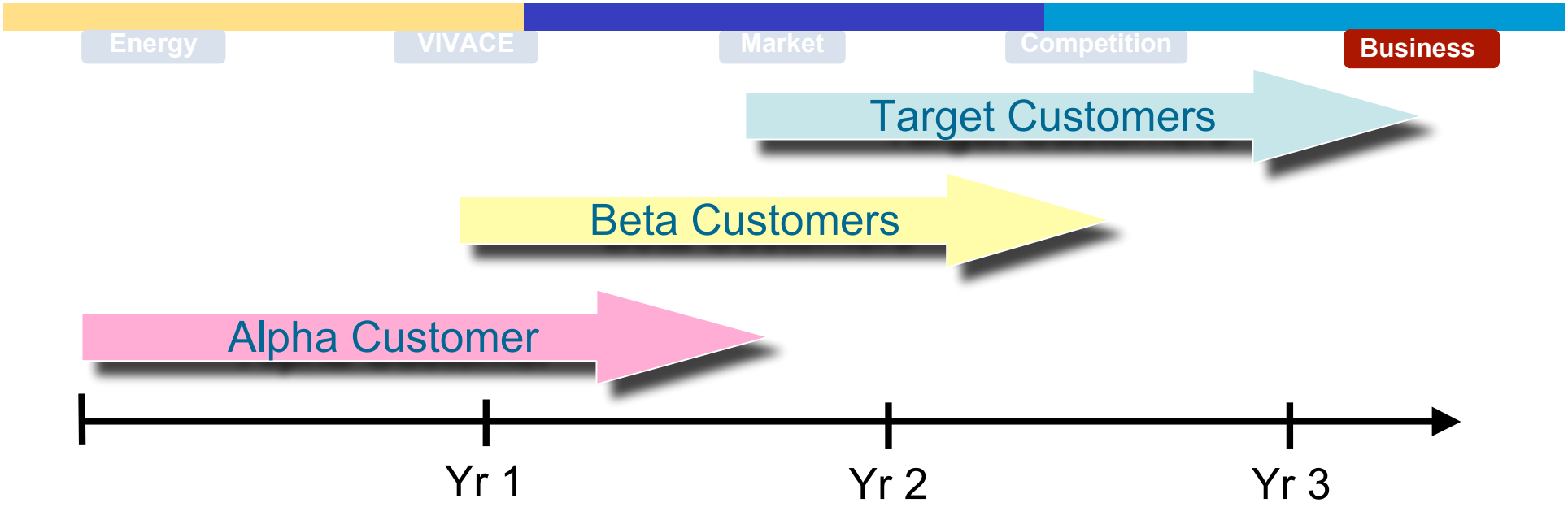
Value Chain

- Business Model: Technology and service provider (GE-Wind)
- Sale of VIVACE: 500 KW units @ $1.5M
- Sale of Services: $250K /device/year



VIVACE will partner with marine engineering companies

Development Plan



	Alpha Customer	Beta Customers	Target Customers
Goal	Prove technology in marine environment	Develop technology of single module	Establish functionality of a modular installation
Power Output	10 KW	50-100 KW	500 - 700 KW
Location	Detroit River, MI	Ocean, FL Detroit River, MI	River/Ocean/Aqueduct
Customer	Detroit WC Port Auth.	Ambassador Bridge	Electric Utility

Development plan reduces technology risk

Funding

Awarded

- DOD: Office of Naval Research
- DOE: Invention & Innovation
- Detroit WC Port Authority with DTE foundation
- Private
- U of Michigan

Total funding to date: $400K

Near Future

- DOD: Office of Naval Research
- DOE: Invention & Innovation Second Phase
- Detroit WC Port Authority (DTE): Second Phase
- DOE: Marine Energy Authoriz.
- DOC: FY08 NIST Tech. Innov.
- Next Energy
- 21st Century Job Fund

VIVACE has been awarded several grants

Risk Mitigation

- **Environment**
  - Study impact of VIVACE on:
    bottom sediments and fish-food film
- **Market**
  - Cost of energy may go down
  - Environmental responsibility (California)
- **Technology**
  - Technology may not scale as expected
  - Development plan designed to mitigate such risk

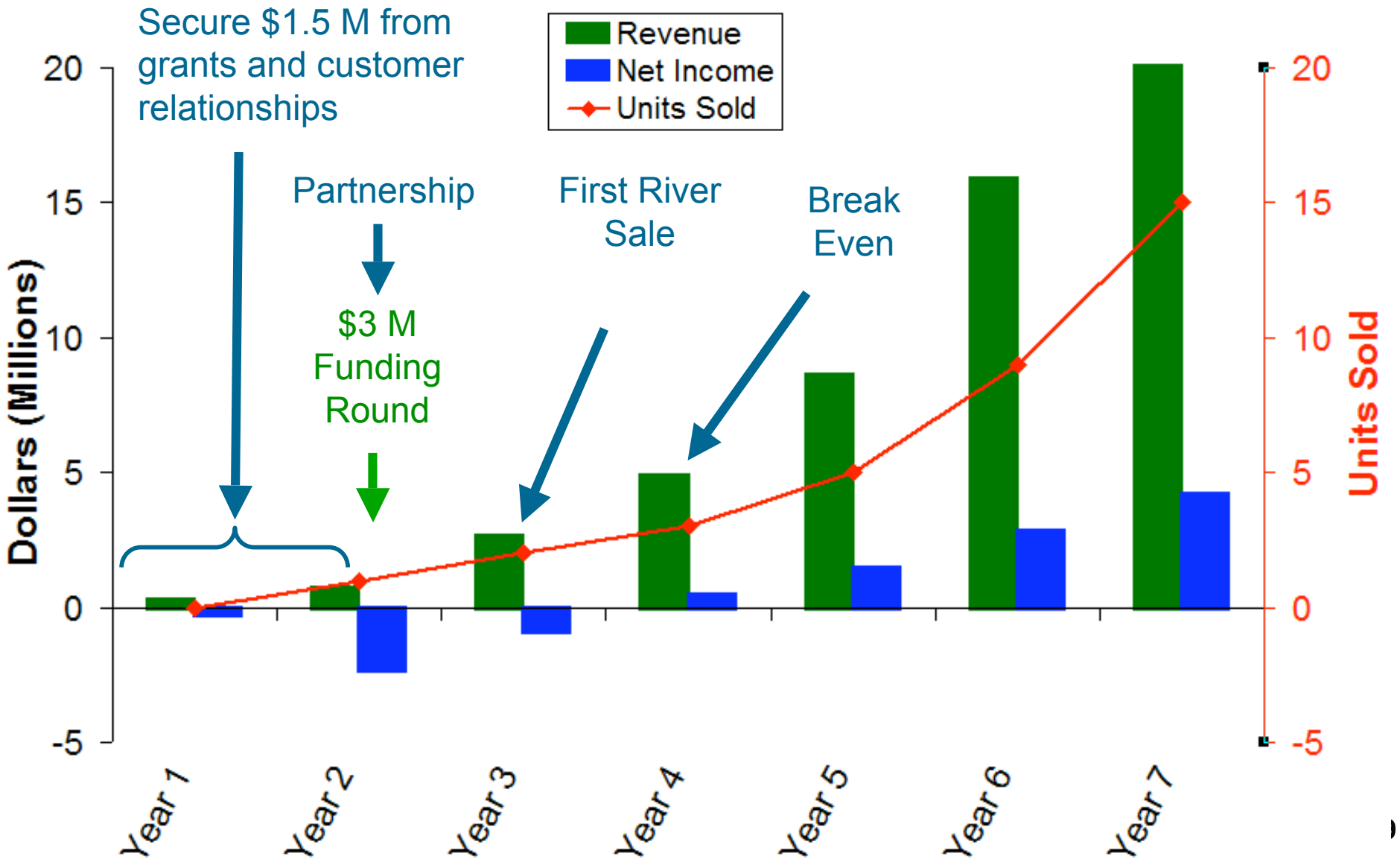
Technology development is VHE's current focus

Regulatory

- **Placing device in river – 1.5 to 3 years**
  - Army Core of Engineers
  - Section 404 Clean Water Act & Section 10 of Rivers / Harbors Act
  - River Banks – Owned by local, municipal and county
  - Expedite: Scientific instrument – 6 months
- **Grid Connection – 2+ Years**
  - Federal Energy Regulatory Commission (FERC)
  - Expedite: “Verdant Exception” - 6 Months
    - Cannot sell electricity
- **Environmental**
  - Department of Environmental Quality (Michigan) – 401 Certification
  - Green Credit Certification – Low Impact Hydroelectric Institute

Although cumbersome, regulation is not a barrier

Financials


Secure $1.5 M from grants and customer relationships
Partnership
$3 M Funding Round
First River Sale
Break Even
Revenue
Net Income
Units Sold
Dollars (Millions)
Units Sold
20
15
10
5
0
-5
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7

Management Team

Current:

- CEO and CTO
  - Dr. Michael M. Bernitsas
- President
  - Dr. James C. MacBain
- VP Business Development
  - Gus Simiao
- Three part-time engineers

Lab Team:

- 6 PhD students
- 3 UG students
- 6 graduated

Searching for:

- CEO
- VP Engineering
- Board Members

Building necessary experience

Summary

Energy | VIVACE | Market | Competition | Business

- **Untapped source of energy**
  - Marine currents
  - World-wide availability
- **Breakthrough technology**
  - Cost competitive
  - Grid compatible
  - Environmentally compatible
  - Scalable and modular
- **Large market**
  - Civilian and military applications
  - Target: 500kW modules
  - Potential for assembly line production

Stay tuned at: vortexhydroenergy.com

Acknowledgements

Energy | VIVACE | Market | Competition | Business

Office of Technology Transfer: Andrew McColm
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Ross School of Business: Gustavo Simiao
Paul Kirsch

Detroit Wayne County Port Authority: John Kerr

Vortex Hydro Energy: Dr. James C. MacBain

Next Energy

DOE

DOD

Shepherd Advisors: Loch McCabe

MMPEI

GESI

Great idea … great team … great support