Marine Renewable Energy

Clean Power from Free-flowing Water

New York

Commercial Standard System

Vietnam

US-Vietnam Energy Trade Conference
November 3, 2015
Marine Renewable/Ocean Energy In Vietnam

Turning the Lights On Sustainable Energy and Development in Vietnam Case Study 9/2014

Table 4 – Renewable Energy Potential in Vietnam

Ocean Energy (tidal/wave) 100-200MW

Marine Renewable Energy Near Term - Rivers

- IPCC*, 2011: Special Report on Renewable Energy Sources and Climate Change Mitigation states: "it is believed that its most practical application in the near term is likely to be in rivers."

- Rivers more predictable and reliable than wind or solar with capacity factors ranging from 60% to 70% or more

* - Intergovernmental Panel on Climate Change
Verdant is a project developer of integrated marine renewable energy systems, using its proprietary fifth generation (Gen5) turbine system.

- Marine renewable energy from water currents of rivers, tides & oceans
- Water currents are predictable & reliable
- No dams or impoundments required
- Add capacity as "incremental power" at existing hydroelectric facilities
- Create capacity at non-hydropower dams
- Base load & distributed generation as utility-scale or village-scale power
- Replace diesel generators in remote communities
The Company
Milestones to Date & Planned

• 2002, deployed first working system prototype to validate concept

• 2005, FERC issued a precedent order allowing delivery of energy, during testing

• 2007, installed world’s first & only, grid-connected array of marine energy systems

• 2012, granted first-ever U.S. marine energy project commercial license by FERC

• 2015, issued USTDA feasibility study grant for Turkey & closing Series B funding round

• 2016, third-party validation & certification of Gen5 System system
Gen5 System key advancements are as follows:

- Composite Blades - NREL tested
- Ductile Iron Hub Casting
- Casting for pylon / nacelle connection
- Integrated gearbox unit incorporating shaft housing / bearings / seals
- Failsafe brake (rotation at 1 m/s)
- Redundant dynamic (shaft) & static sealing to retain lubricant & exclude seawater
- Non-toxic fouling-release coating system

The Gen5 system was designed for simplicity in order to make it robust and reliable, as well as to minimize assembly and maintenance costs.
Kinetic Hydropower System (KHPS)

System Performance

• Gen 3-4 KHPS – Full-Scale (5m) Demonstration (2007-09)
  o World’s first grid-connected array (2007)
  o Multi-turbine field installed, reinstalled & operated
  o Ten (10) deployments for on-water work metrics
  o Fully bidirectional tidal operation
  o Fully continuous, automatic, unattended generation
  o Operation over 9,000 turbine hours
  o Full system performance – 30-45% water-to-wire efficiency
  o Generated Power 77% of the time
  o Average Power 14.5 kW (35 kW peak rated)
  o Capacity Factor > 30%
  o Generated over 80 MWh into the NYC Grid
  o Environmental monitoring, compatibility & hydrodynamic analysis
Technology
Commercial Standard System, Tailored to Sites

• State of the art rotor sizes being extended for higher water speeds and deeper waters

• New triframe anchoring system, firmly affixes 3 turbines at once onto seabed in an efficient & cost-effective manner

• Benefits of the new anchoring system:
  – Provides for utility-scale systems ranging from 300 kW to nearly 1.5 MW on each triframe
  – Allows greater adaptation for utility & village-scale systems in more common water conditions
  – Lowers O&M costs due to easier deployment & retrieval

<table>
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<th>Machine Class</th>
<th>Rotor size (m)</th>
<th>2 m/s</th>
<th>3 m/s</th>
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<td>10m Class</td>
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New York’s East River
Roosevelt Island Tidal Energy (RITE) Project
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Roosevelt Island Tidal Energy (RITE) Project

[Logos of NYserda, Cornell University, Oak Ridge National Laboratory, KeySpan, United States Navy, IBM, ConEdison, Inc., New York Power Authority, Sandia National Laboratories, and NREL]

Leading clean energy innovation
Market Overview
Renewable Energy Generation to Double

• Renewables double from 2010 to 2040, accounting for nearly 25% of world electricity at that time - U.S. Energy Information Administration*

• Hydropower largest source of renewable energy; second only to wind power for newly-built capacity between 2005 & 2010

• Hydropower could produce 6,000 TWh in 2050, nearly 2X current installed capacity - International Energy Agency

*INTERNATIONAL ENERGY OUTLOOK 2013; Release Date: July 25, 2013
Market Overview
Marine Renewable/Ocean Energy Increasing Sevenfold

Total Addressable Market - 250 GW
- River - 140 GW (World Energy Council)
- Tidal - 60 GW (Ocean Energy Council)
- Canal - 50 GW (U.S. FERC)

Serviceable Available Market - 23 GW
- Capacity 23 GW by 2025 ($69 billion) – Electric Power Research Institute
- Installed capacity to increase 7X by 2017 – PIKE Research Report (2012)

Share of Market - 1.7 GW
- Projected financials & pipeline by 2025
- Developed Countries - 0.7 GW
- Developing Countries - 1 GW
Competitive Advantages

Verdant Power - Readily Scalable

**Tidal Competitors**
- Atlantis Resources
- Andritz Hydro Hammerfest
- Voith Hydro
- Alstom (GE)
- Open Hydro

**Disadvantages**
- Require depths of 40m ≥
- Highly capital intensive technology
- Complex designs, uncertain reliability

**Verdant Power**
- Operates in depths of < 40m
- Greater application - sited near needs
- Lower O&M - closer to shore
- Uniquely & readily scaled
- Demonstrated higher efficiency
- Third-party verification
Competitive Advantages
Verdant Power - Sited in Core Current

River Competitors
• Scotrenewables
• Tocardo
• New Energy Corp
• RER Trek
• Clean Current

Disadvantages
• On top - debris & slower currents
• On bottom - debris & slower currents
• Ducted systems - higher CAPEX & O&M; fouling & wildlife entrainment
• Complex designs; uncertain reliability

Verdant Power
• In “core” current, not bottom nor top
• Un-ducted - less fouling, lower O&M
• Uniquely & readily scaled
• Demonstrated higher efficiency
• Third-party verification
Siting in Core Currents
Resource Assessment & Feasibility Analysis (RAFA)

• Systems tailored to sites; ADCP-mapped
• GIS & modeling methods evaluating technical & developmental criteria
• Water velocity & bathymetric analyses; environmental compatibility determine rotor & generator sizes and anchoring
Business Development
Market Entry: 5m Class River System

USA - NYC pilot commercial project; New York State & U.S. Department of Energy support

Canada - RAFAs river sites; Ontario Ministry of Research & Innovation; SDTC & OPA support

Turkey - RAFA downstream of dams; Elektrik Uretim AS (EUAS); General Directorate of State Hydraulic Works (DSI) & USTDA support

Ireland - RAFA prep for tidal river sites; SEAI & Ministries of Energy & Environment support

UK - Tidal sites identified; potential being assessed; Crown Estate & Isle of Wight support

Others: Chile, Zambia, Vietnam - Assessing locations; e.g., below dams & large canals
Business Development
Federal Government and Industry Market Support

U.S. Department of Energy
  Office of Policy & International Affairs
  Office of Energy Efficiency & Renewable Energy

U.S. Department of Commerce
  International Trade Administration

U.S. Department of Agriculture
  Rural Development

U.S. Trade & Development Agency

U.S. Trade Representative

National Hydropower Association

American Council on Renewable Energy
Marine/Ocean Energy in Vietnam
Seize the Opportunity

Project Resource Assessment and Feasibility Analysis (RAFA)

Identifies Attractive Ocean/River Project Site and Completes On-Site Analysis Resulting in Project Feasibility and Economic Analysis

(9-15 Month to Complete, $1.25M Cost)

First Marine Sustainable Energy Project (24-42 Months after RAFA)

At Ocean or River Site - 3 - 15MW (3,000 to 30,000 homes)

$15-60M Investment
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Gen5 System
New York's East River