Asia Pacific Clean Energy Summit

Ocean Energy Panel

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LOCKHEED MARTIN

Lockheed Martin

- **A Global Security Company**
  - **Focus on research, design, development, manufacture, integration and sustainment of advanced technology systems, products and services**
- **126,000 Employees**
- **63,000 Scientists, Engineers and IT Professionals**
- **Operations in 1,000 Facilities, 500 Cities, 50 States and 75 Countries**
  - **More than 300 Partnerships Across the Globe**

We Do What Hasn't Been Done… A Passion for Innovation

Lockheed Martin Ocean Energy

Ocean Thermal Energy Conversion

Exploits existing ocean thermal gradients to drive a heat engine to produce electricity

- **Long-Term Focus**
- **OTEC Plant Designs**
- **Discriminating Technology**
  - **Heat Exchangers**
  - **Coldwater Pipe**
- **Significant Technology Investments with Broader Commercialization Potential**

Tidal Energy

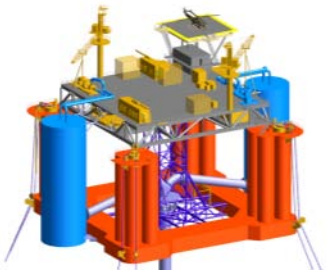
Captures energy from tidal flows to rotate submerged turbine-generators to produce electricity

- **Atlantis Resources Relationship**
- **Yaw Drive Development**
- **ETI and Turbine Engineering Programs**
- **Canada Bay of Fundy Project**
- **Supply and Support of Tidal Turbine Systems**

Wave Energy

Transforms wave motion to electricity from device arrays near the coasts

- **Ocean Power Technologies (OPT) Relationship**
- **Product Design Support**
- **DOE contract**
- **Supply and Support of Wave Energy Converters (WEC)**
  - **Victoria, Australia & Reedsport, OR projects**



Operating Across the Ocean Energy Sector

Why Lockheed Martin in Ocean Energy?

Experience & Innovation

- Proven Marine Design Expertise
- Advanced Modeling and Simulation
- Research & Development
- Technology Innovations
- Design for Manufacturing

Marine Engineering Domains: 10,000+ SMEs

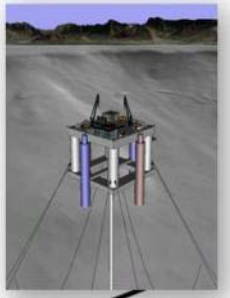
Proven Performance

- Large Scale, Complex Systems Integration
- Ocean Based Products with Proven System Performance
- Experienced Program Management
- Global Footprint and Ability to Achieve Scale
- Design - Production - Operations and Support

Bringing Experience to Deliver Ocean Energy Solutions

LM OTEC Progression

LM Investment



NAVFAC CRAD

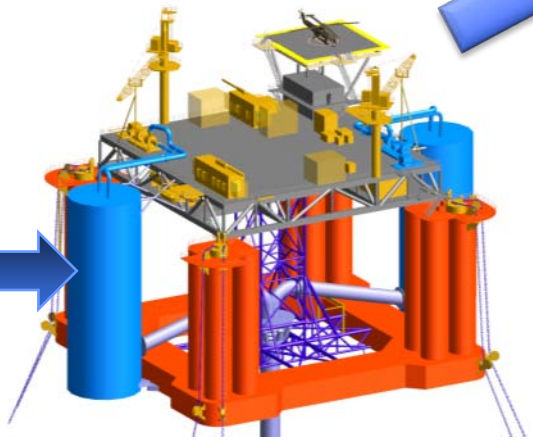
2007 | 2008 | 2009 | 2010 | 2011

DOE AWPP CWP Grant

ONR HX Program

DOE OTEC Model Basin Test

10MW Offshore Pilot Plant



- *Deploy and Prove Technology at Relevant Scale in Relevant Environment*
- *Stepping Stone Testbed for Commercialization*

1st 100MW Plant

- *Pilot Plant Scale-Up*
- *Reference Plant*

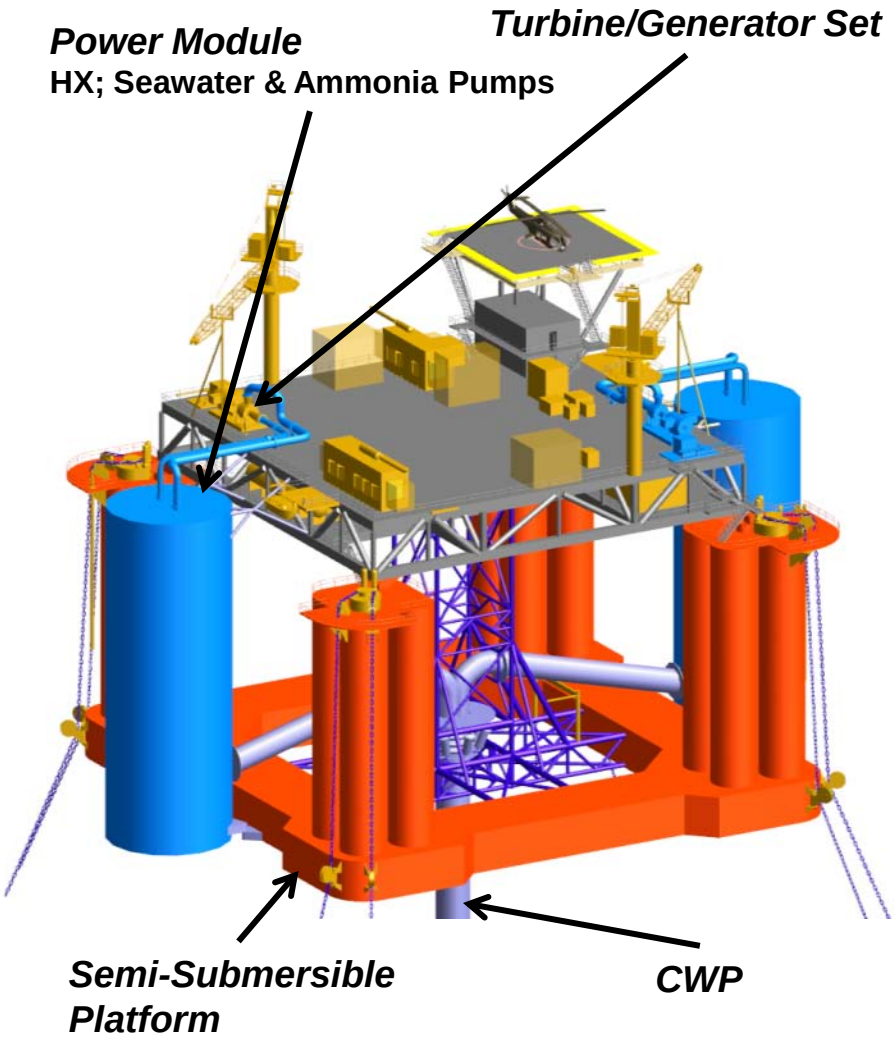
100MW+ Plants

- *Commercial Operations*

Many Years of Research… 5+ Years Focused Development Ready for Transition to Deployment

OTEC Offshore Pilot Plant

Major Component	Pilot Plant Approach
Platform	Modified Standard Offshore Config
Turbine/ Generator	Non-Developmental
Pumps	Non-Developmental
Power Cable	Non-Developmental
Instrumentation & Control (I&C)	Modified Commercial
Heat Exchangers (HX)	Technology Scale-Up
Composite Cold Water Pipe (CWP)	Finalize Development and Deployment
CWP System Elements	Detailed Design & Technology Scale-Up

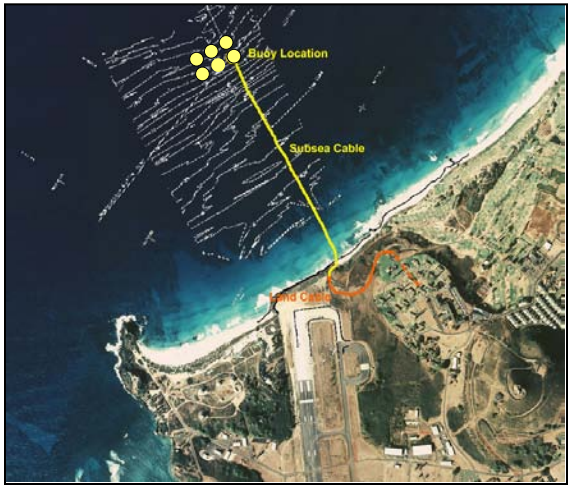


R&D Focused on HX and CWP … Pilot Plant Build is Next Step

Wave Energy Program in Hawaii

- PB-40 early prototype installed off Marine Corps Base Hawaii (MCBH)
  - First grid-connected wave energy system in the U.S.
  - Survived severe storms & confirmed models
  - Validated design for scale-up to higher power buoys

– Now deploying larger devices to better capture available wave energy resources



OPT
OCEAN POWER TECHNOLOGIES

PB150 Deployment in Scotland

PB150 Float Assembly

PB150 Bridge Assembly

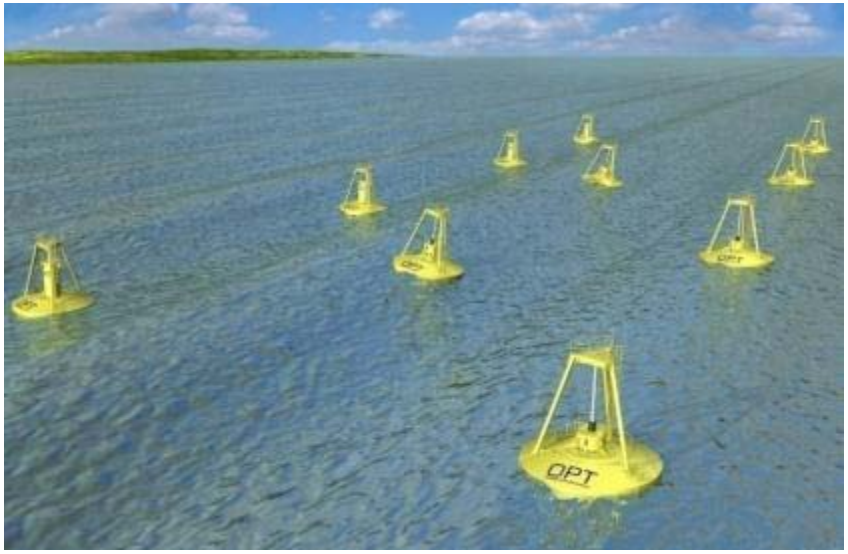
Rated power output: 150 kw
Peak power output: 866 kw

PB150 assembled on wharf

PB150 Unit Deployed in Scotland and 2nd Unit Ready for Deployment in Oregon

Portland, Victoria, Australia
Wave Power Demonstration Project

- Approvals, licences and funding during 2012 / 2013
- 19 MW in 3 development stages
  - Stage 1 – 0.5 MW – 2013 / 2014
  - Stage 2 – 5.0 MW – 2014 / 2015
  - Stage 3 – 13.5 MW – 2016/ 2017
- Supported by Federal grant - $66.5M max
- Grid connected; 25 year operating life
- Located within State waters



- Sufficient power to fulfill energy needs of approximately 10,000 homes
- Project Web Site: http://victorianwaveproject.com.au/

- *Role of OPT:* Power Buoy Design; Provide Power Buoy technology, Provide Power Take-Off (PTO), Underwater Substation
- *Role of LM:* Power Buoy Design Support; Buoy Component Production; System Integration & Test; Program Management

Atlantis – LM Tidal Energy Efforts

Engineering

- Turbine Design and Analysis
- Performance Modeling
- Yaw Drive Development
- UK Energy Technology Institute (ETI) Tidal Energy Converter (TEC) Project

Testbeds

- EMEC, Scotland [AR-1000]
- FORCE, Canada [Test Berth]
- NAREC, UK [AR-1000]

Focus Projects

- **MeyGen,** Scotland**:** 400MW project with 85 MW Stage 1, FEED in Progress, Construction 2014
- **Mundra, India**: 250MW project, FEED in progress
- **Projects in planning** - Canada, Bay of Fundy; others

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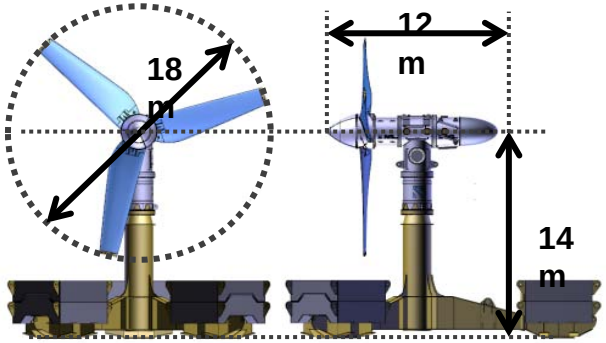
Atlantis Resources 1 MW Horizontal Axis Tidal Turbine



- **Designed for very rough offshore wave exposed locations (high survival state)**
- **ARC/ABB designed power conditions system full UK & European grid compliant**
- **Full onboard health monitoring system with fiber telemetry remote link**

Key Statistics

Water Speed	
Rated operational	2.65 m/s
Maximum operational	3.4 m/s
Output	
Rated output	1,000 kW @ 2.65 m/s
Expected capacity factor range	35-50%
Shaft speed	6-15 rpm
Operating Conditions	
Design depth of operation	25-60m (max)
Minimum clearance from surface (LAT)	7m
Expected life of turbine nacelle Maintenance cycle	20 years (structural) Overhaul every 5 years
Deployment and Support	
Method	Gravity Base (GBS) or mono-pylon

ATLANTIS RESOURCES CORPORATION

Source: Atlantis Resources

Advantages of Ocean Power

- **Close to Population centers on the coast, with minimal land usage and sight impact**
  - Transmission costs and losses minimized
  - Perfect for islands and coastal land

- **Predictable Power**
  - OTEC is baseload, Wave and Tidal are periodic/predictable
    - Not prone to short-term variations like solar/wind
  - Able to predict output with high accuracy, often days in advance

Challenges

- **Transition from Research / Pre-Commercial to Commercialization**
  - Recognizing and leveraging the tipping points
- **Testbeds that Advance Industry toward Commercialization**
- **Support for technology development and initial projects**
  - Incentives and government support
  - Risk sharing