WIND | WAVE | TIDAL | CURRENT | HYBRID

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Technological Cost Reduction Opportunities for Oscillating Water Column Devices

- Diana Bull – Sandia National Laboratories
- Presented by: Bill Staby – Resolute Marine Energy

Overview

Whitepaper's Goal

- Offer concrete research paths in key development areas producing evidence that the LCOE of current devices have a technologically sound pathway for reduction.

Methodology

- Research specific MHK device types to understand the key cost drivers and determine cost reduction pathways.
  - Research composed of independent data, literature surveys, and interviews with industry.

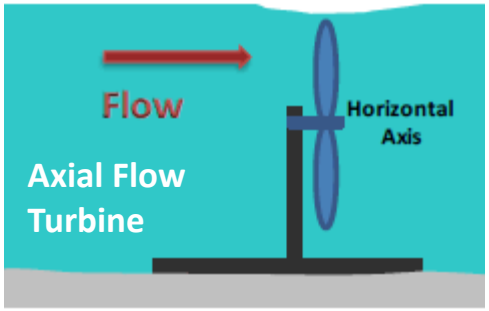
Impact

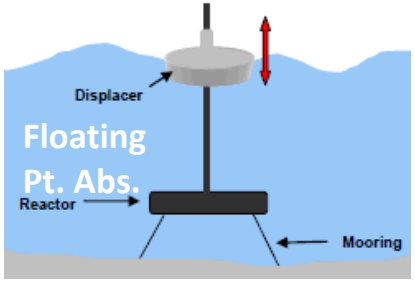
- These results will be integrated into the MHK Techno-Economic Assessment (TEA) due to Congress at the end of FY13.

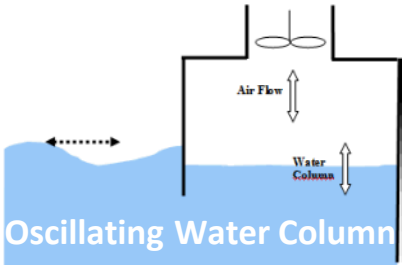
Presentation Focus

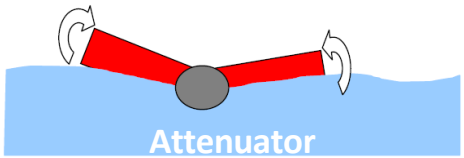
- Highlight methodology and results for one of the devices studied in support of the TEA for Congress:

  The Oscillating Water Column Device







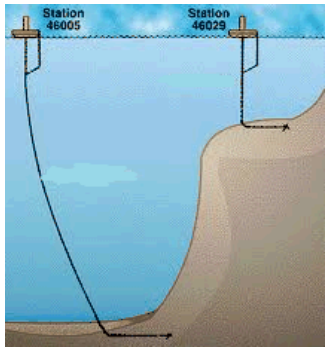


Pictures: [1]

WEC Types [2]

Water Depth

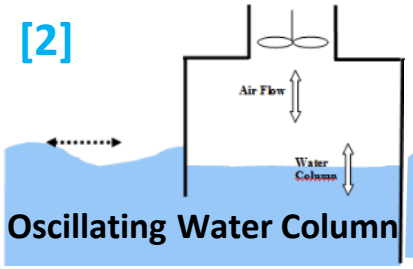
- Shore-Mounted—depth ~0-5m
- Near-Shore—depth ~5-50m
- Offshore—depth ~50^{+}m

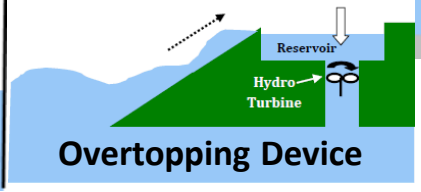


Conversion mechanism

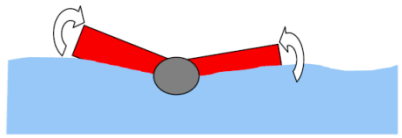
- Oscillating Water Column (OWC)
- Overtopping Device (OTD)
- Wave Activated Body (WAB)

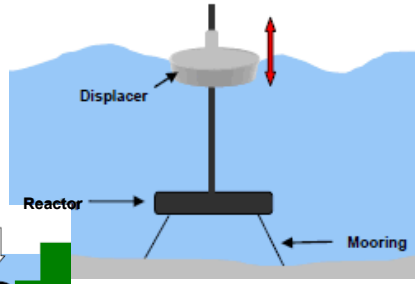
[2]

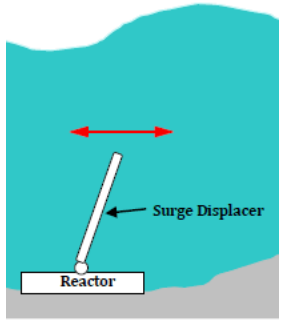


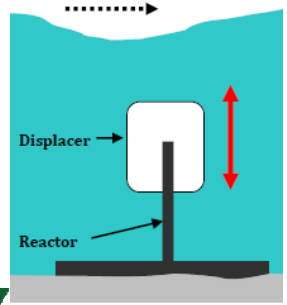


Wave Activated Bodies





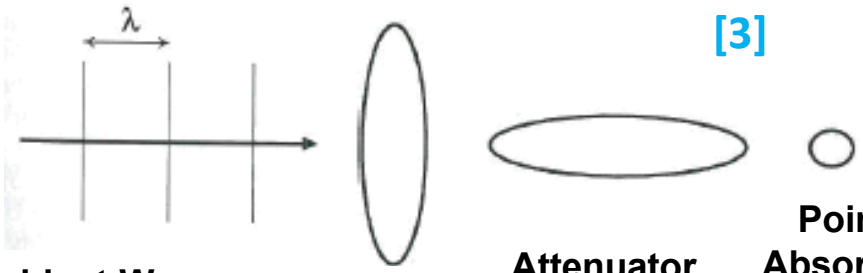




Directional dependence

- Point Absorber
- Terminator
- Attenuator

[3]



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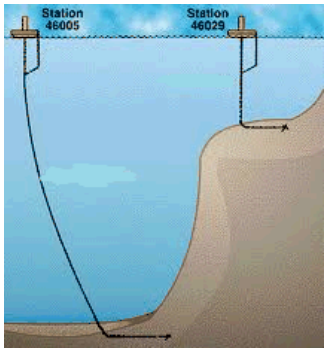

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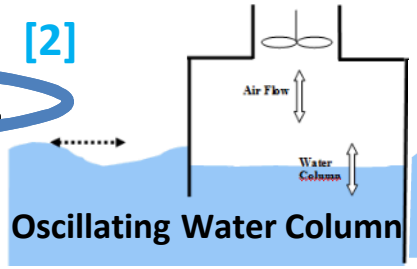

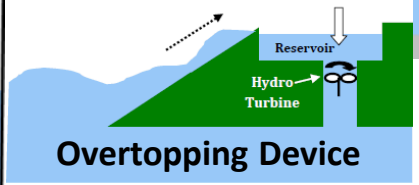

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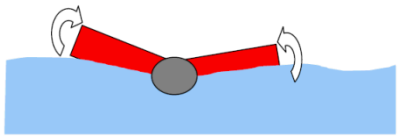

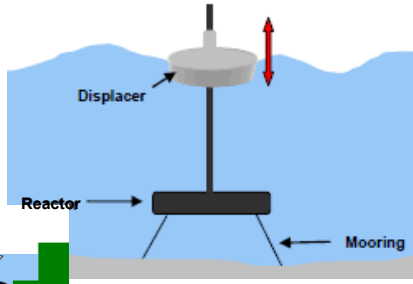

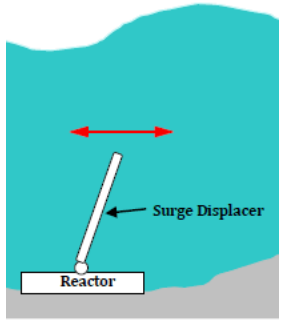

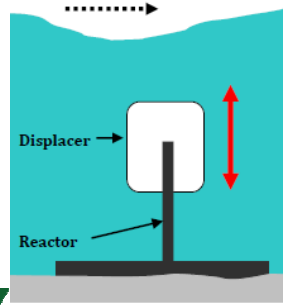

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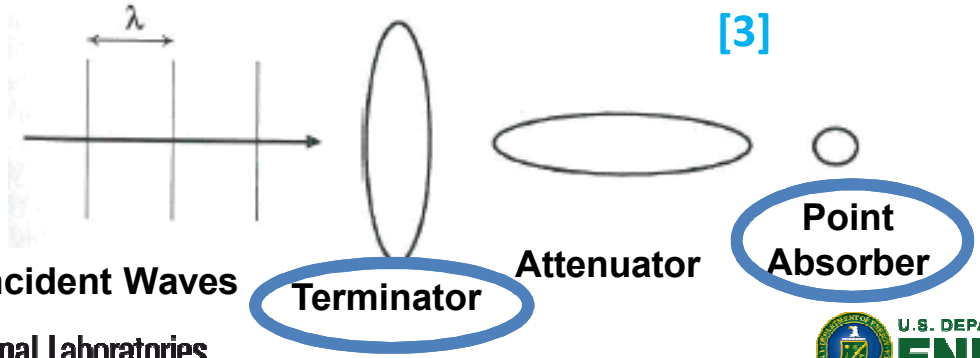

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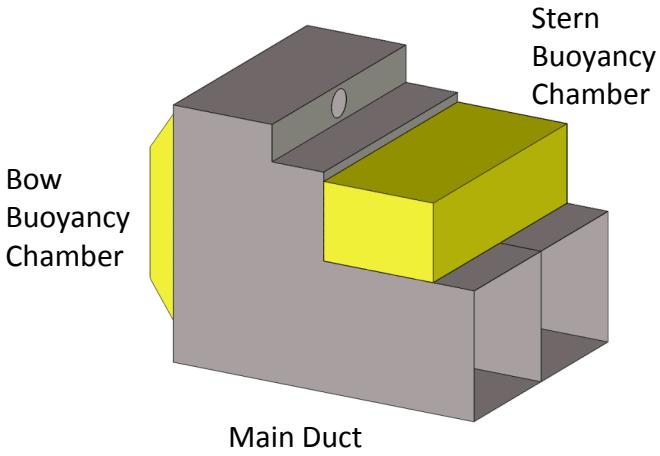
Whitepaper Data Sources

Reference Device

- Independent research to obtain impartial understanding of device type.
- Data compiled from literature used to supplement independent research when necessary.

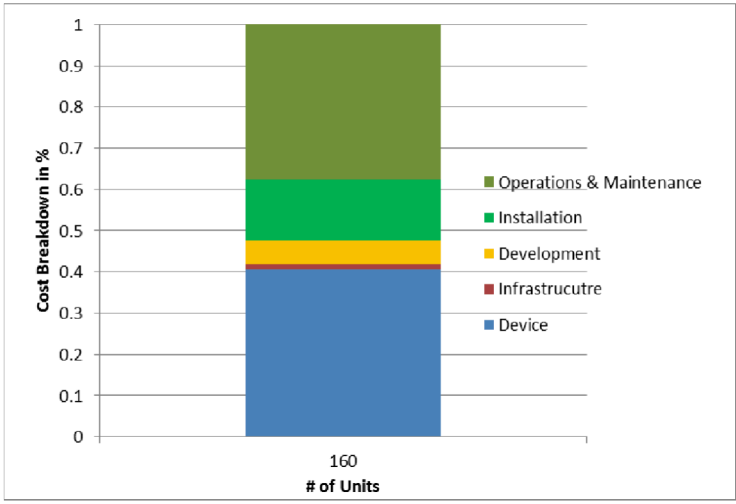


Literature Survey

- Investigate current research efforts being performed both nationally and internationally on device type.
- Data used to identify device hurdles prior to industry interviews and aid in determination of cost reduction pathways.

Industry Interviews

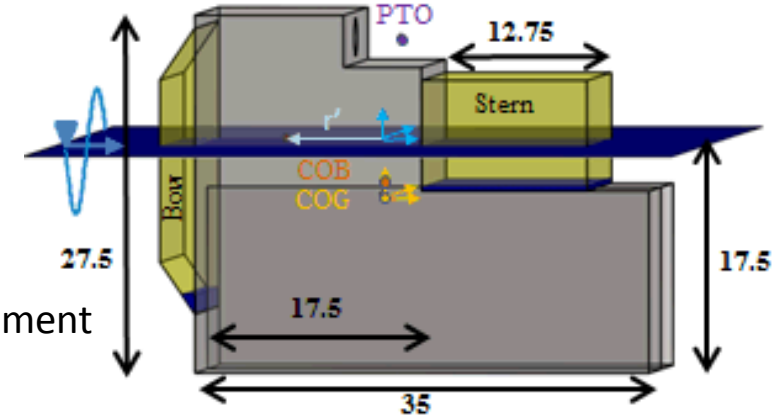
- Prior to interviews:
  - Obtain percentage estimates of CapEx and OpEx costs.
  - Obtain a ranking for the potential for cost reduction of each cost item as well as additional items that influence AEP
- During interviews:
  - Target question based on developer responses.

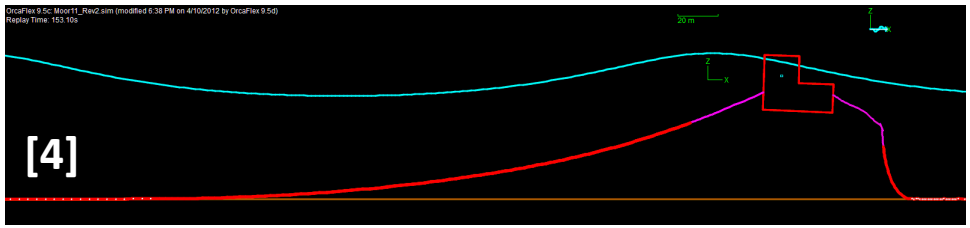


Reference Device

DOE Sponsored Reference Model

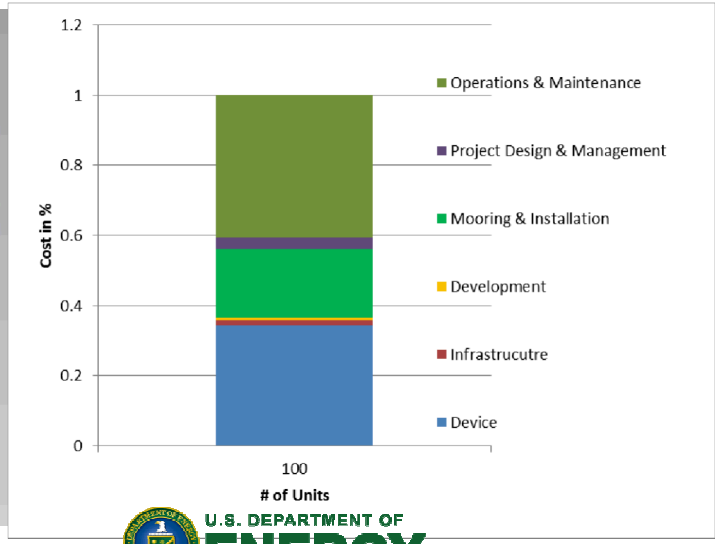
- Generic Backward Bent Duct Buoy (BBDB)
- Developed to WEC TRL 4 considering:
  - Annual Energy Production
  - Power Conversion Chain
  - Anchor & Mooring Design
  - O&M / Installation
  - Permitting & Environment
- Economic analysis to be complete in FY14.





Reference Device From Literature

- UK Department of Trade and Industry [10]
- Axisymmetric point absorber design
- Developed to WEC TRL 4 considering:
  - Annual Energy Production
  - Power Conversion Chain
  - Anchor & Mooring Design



Reference Device--Total

- Impartial cost and cost reduction data

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OWC Developers

Embley Energy [6]

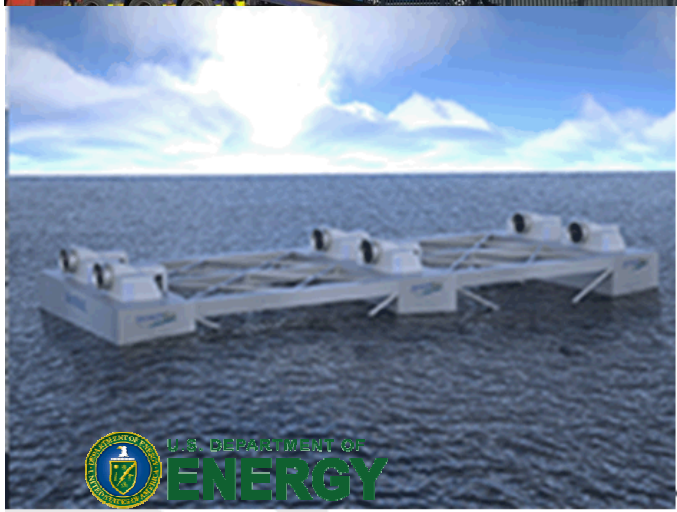
- UK company developing SPERBOY
  - Offshore OWC point absorber
- Pursuing composite concrete for the structure fabrication
- High WEC TRL5 / low WEC TRL 6: 1/5th scale deployment

Ocean Energy [7]

- Irish company developing OE Buoy
  - Offshore OWC terminator (BBDB)
- Tested multiple drivetrain types: Wells & Impulse.
- WEC TRL 6: Tested in Galway Bay for 3^{+} years at ¼ scale

Oceanlinx [8]

- Australian company developing blueWAVE
  - Offshore OWC terminator
- Cluster of six OWCs
- WEC TRL 7: Grid connected test in Port Kembla



White Paper Analysis Process

Cost Data

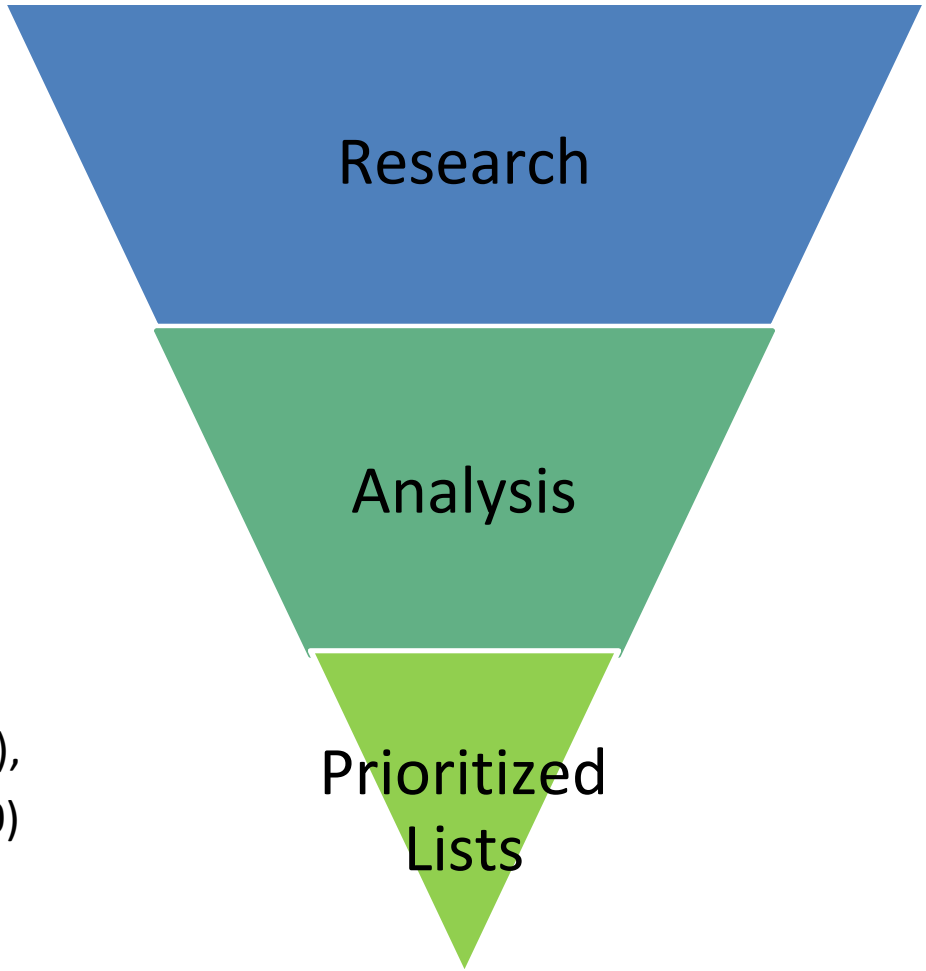
- Industry and reference device data averaged into a single metric.
  - Averages weighted based on devices WEC TRL

Potential for Cost Reduction Data

- Industry and reference device data averaged into a single metric.
  - Averages weighted based on devices WEC TRL

Prioritized Ranking Criteria

- Impact on LCOE (scale: 1-10),
- Potential for progress in the area (scale: 1-4),
- Potential for success in the timeframe (2030) considered (scale: 1-4)
- Confidence in success (scale: 1-4).



Prioritized List

Top Tier

- Advanced Controls
- Improved Power Conversion
- Optimized Structural Design
- Array Optimization

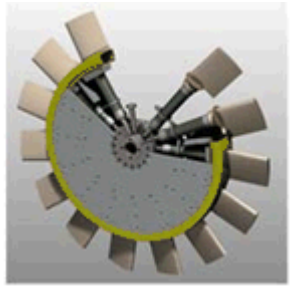
Second Tier

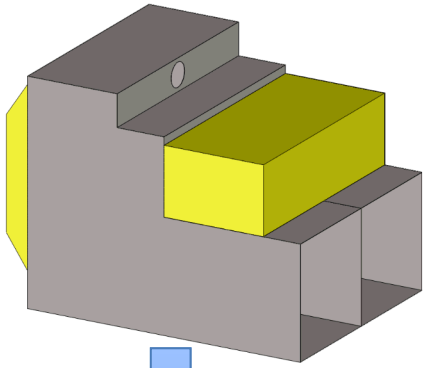
- Improved Mooring Design
- Optimized Device Profile
- Increased System Reliability
- Planned Maintenance

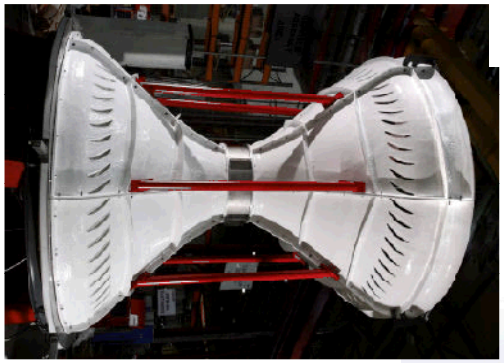
Third Tier

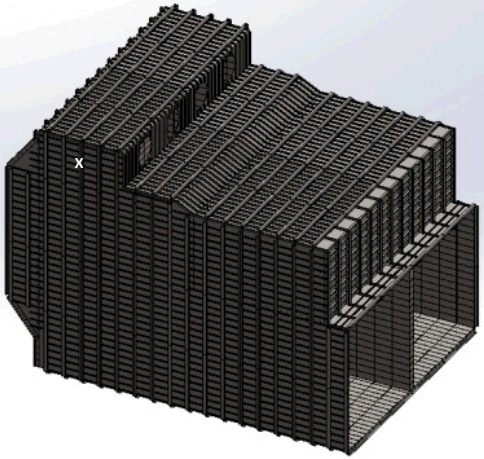
- Infrastructure Improvements
- Installation Procedures
- Unplanned Maintenance
- Subsystem Integration

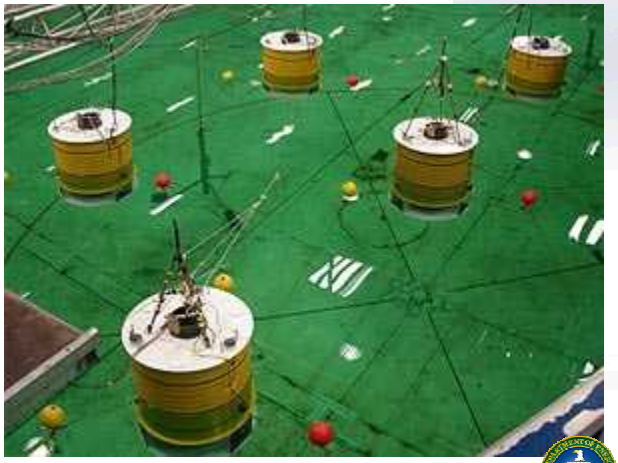
Air Turbines











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Sampling of Top Tier Research Paths

Advanced Controls

- Structural Control
- Wave Prediction
- PCC Control

Array Optimization

- Performance Modeling
- Shared Mooring Modeling
- Performance Optimization through Controls
- Environmental Modeling
- Infrastructure Case Studies
- Installation and Maintenance Case Studies
- Grid Integration Case Studies

Improved Power Conversion Chain

- Drivetrain Design
- Generator Design
- Survivability
- Short Term Storage

Optimized Structural Design

- Survivability Modeling
- Fatigue Modeling
- Material Case Studies
- Manufacturing Case Studies
- Structural Component Testing Facility

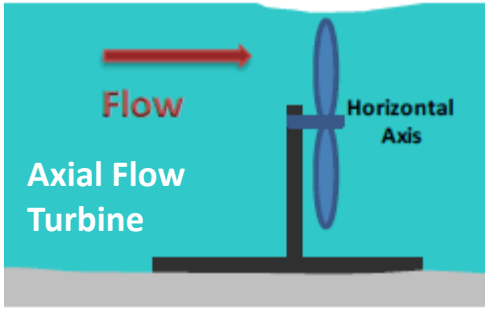
MHK Techno-Economic Assessment

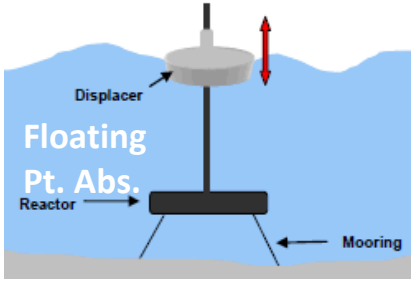
Whitepaper's

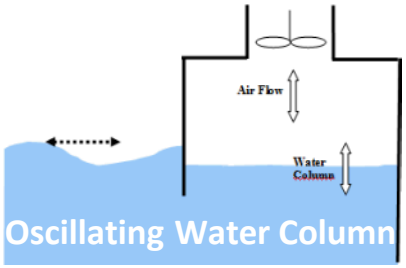
- Analysis considers each aspect of the cost of energy: capital expenditures, operational expenditures, and the amount of energy produced
- Offer concrete research paths in key development areas to alter the current state of the industry
- Four Whitepaper's representing distinct types of MHK devices will be produced
- Data from the four white papers will be coalesced into a single set of device-independent development areas with the capability to reduce LCOE.

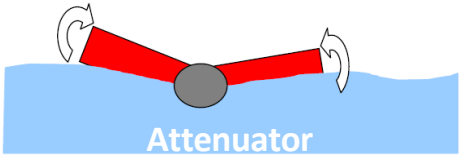
TEA Summary

- MHK Techno-Economic Assessment (TEA) due to Congress at the end of FY13.
- TEA will detail: Resource, Technologies, and Cost.
- TEA goal: generate enthusiasm for MHK industry and produce evidence that the MHK industry can result in strong market penetration.
  - Whitepaper's are an integral part of producing evidence that the LCOE of current devices have a technologically sound pathway for reduction









Pictures: [5]

Acknowledgements

SNL: Margaret Ochs, Todd Heinrichs, and Daniel Laird

DOE: Alison LaBonte Cardinal Engineering: Whitney Blanchard

Presenter: *Bill Staby*—Thank you so much!

Whitepaper Releases

Publically accessible reports on the Sandia National Laboratory Website.
Expected release for all whitepapers is the beginning of August.

References

[1] HMRC-UCC, "Dynamic Characteristics of Wave and Tidal Energy Converters and a Recommended Structure for Development of a Generic Model for Grid Connection," OES-IEA Document No: T0321, Jul. 2010.

[2] Harris, R.E., Johanning, L., and Wolfram, J., "Mooring systems for wave energy converters: A review of design issues and choices," in *Marec2004*, 2004.

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[6] Embley Energy Ltd., "Embley Energy's Sperboy." [Online]. Available: http://www.sperboy.com/index.html?_ret_=return. [Accessed: 19-Apr-2013]

[7] Ocean Energy Ltd., "Ocean Energy OEBuoy: A Backward Bent Duct Design." [Online]. Available: http://www.oceanenergy.ie/. [Accessed: 04-Apr-2013].

[8] Oceanlinx Ltd., "Oceanlins'x blueWAVE (offshore) and greenWAVE (nearshore)." [Online]. Available: http://www.oceanlinx.com/. [Accessed: 19-Apr-2013].

In general all non-referenced pictures not produced by personal or collaborative work were goggled and can be easily found.

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Support

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