SAND2011-5383C

Sandia Water Power Program Update

Rich Jepsen,

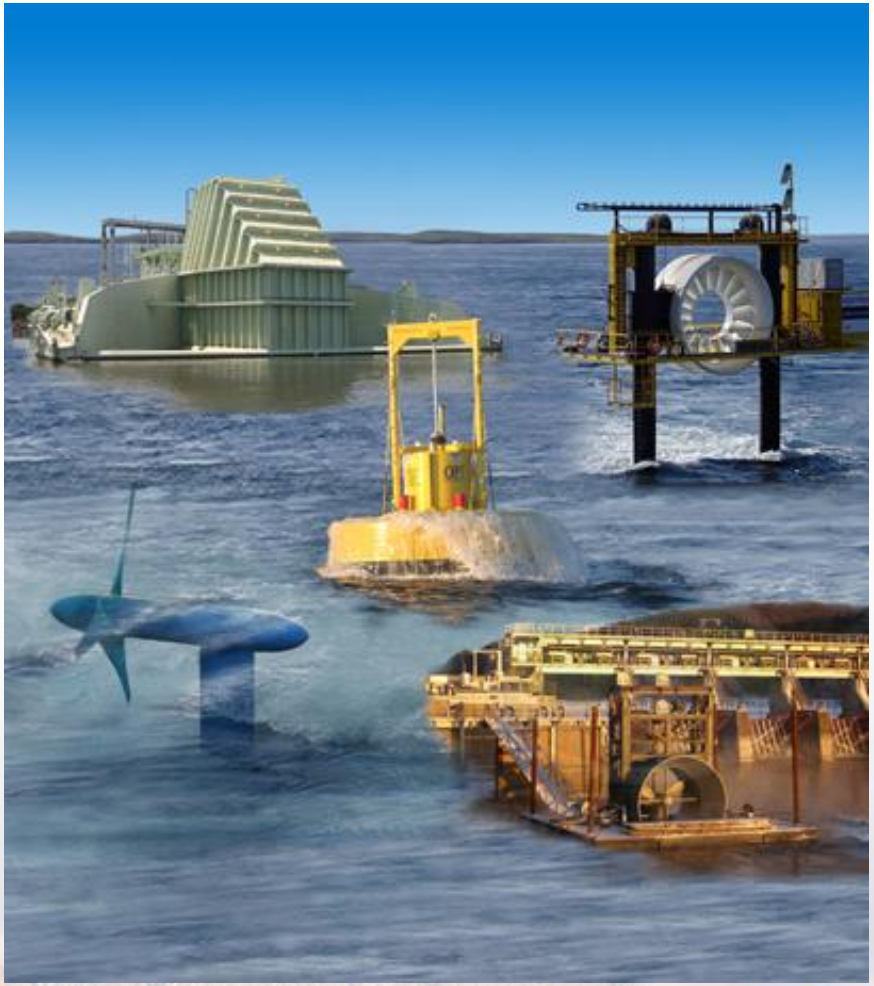
August 8, 2011

GovEnergy

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

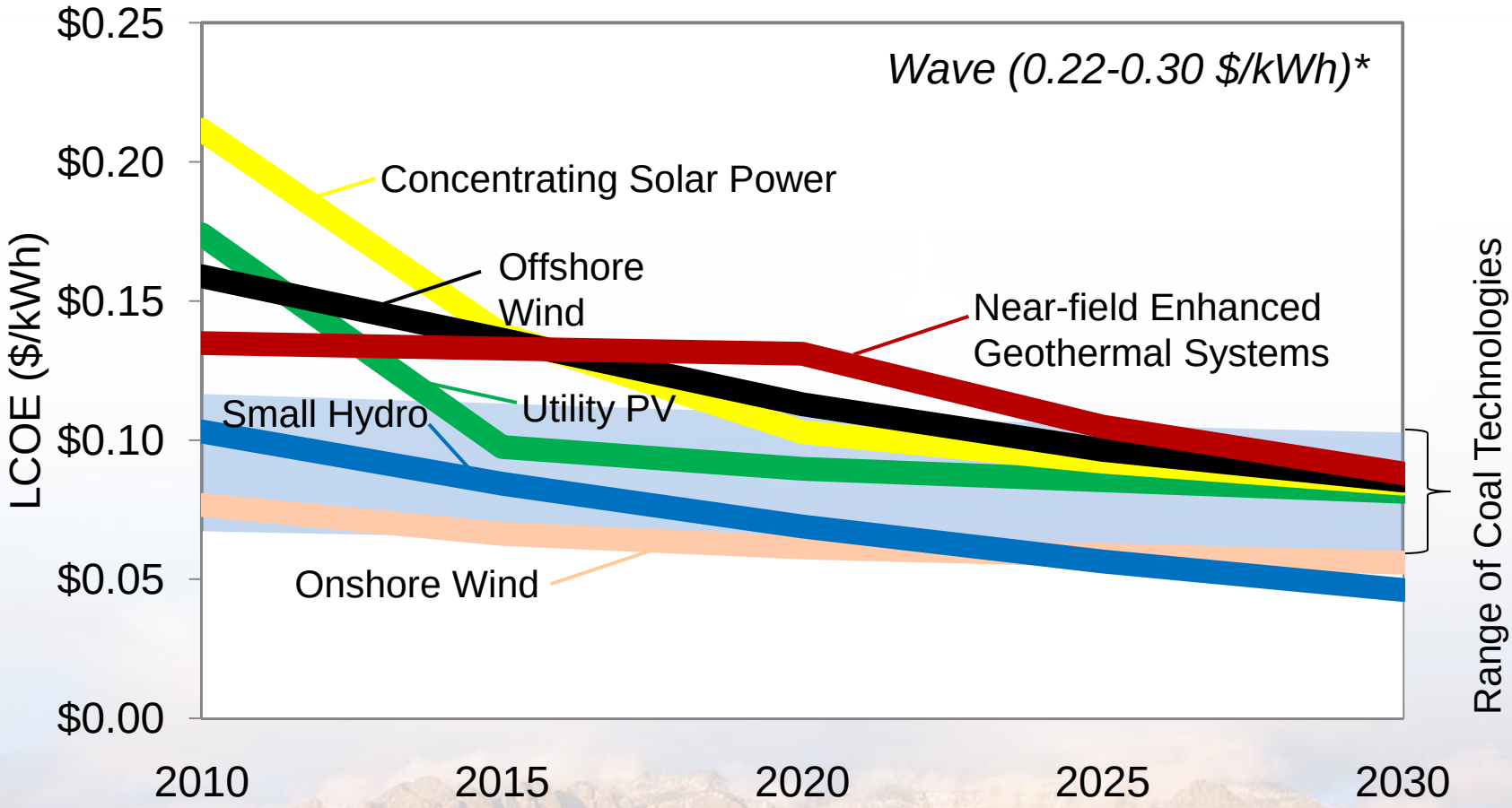
Background

- **State of the Marine HydroKinetic (MHK) "Industry"**
  - **Wave: >100 Devices***
    - Attenuator
    - Pitching/Surging/Heaving/Sway (PSHS)
    - Oscillation Water Column
    - Overtopping Device
    - Submerged Pressure Differential
  - **Current/Tidal: >60 Devices***
    - Horizontal Axis Turbine
    - Vertical Axis Turbine
    - Oscillating Hydrofoil
    - Venturi



***Includes conceptual ideas, prototypes and demonstration projects. There are no commercial units on the grid.**

Renewable Electricity Cost Scenarios



Source: DOE and NREL
http://www.nrel.gov/analysis/tech_costs.html

*Estimates from Renewable Energy Cost of Generation Update, CEC Report (2009)

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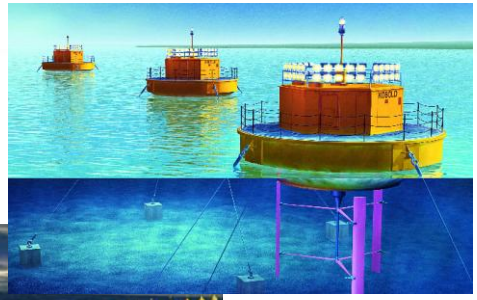
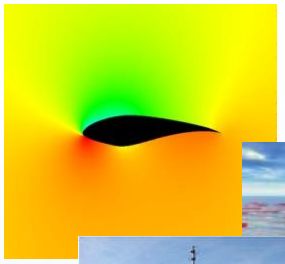
MHK Industry COE Strategy

MHK COE Reduction Pathway

- Large manufacturing product lines
- Large system arrays
- Easy maintenance
- High reliability





- Component evaluation
- Prototype testing
- Component/System analysis
- Material characterization

Cost

Today!

Time

Cost-Competitiveness

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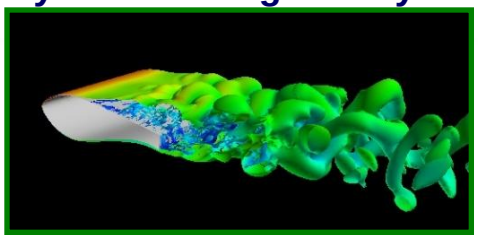
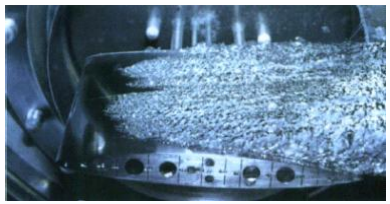
Technology Readiness

Components

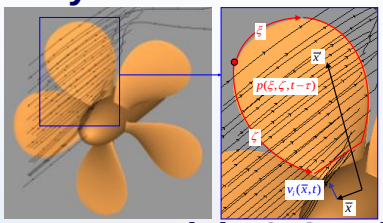
Hydrofoil Design/Analysis



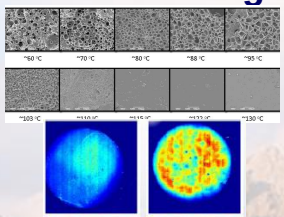
Cavitation



Hydro-Acoustics

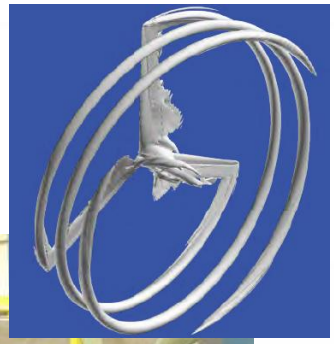


Materials & Coatings



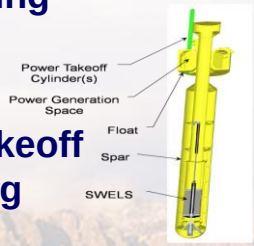
Sub-systems

Performance Modeling



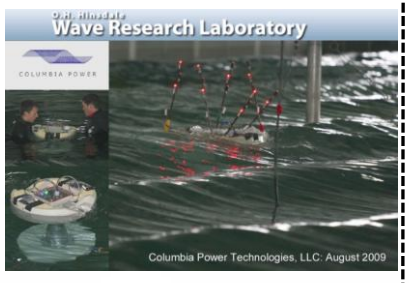
Rotor Design & Testing

Power Takeoff Testing



System Testing

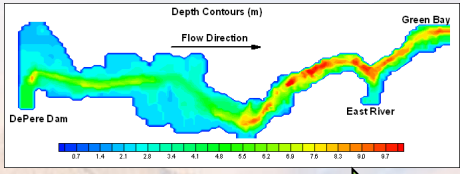
Columbia Power 1/15th Scale Test (OSU)



Water Tunnel (PSU/ARL)

Deployment

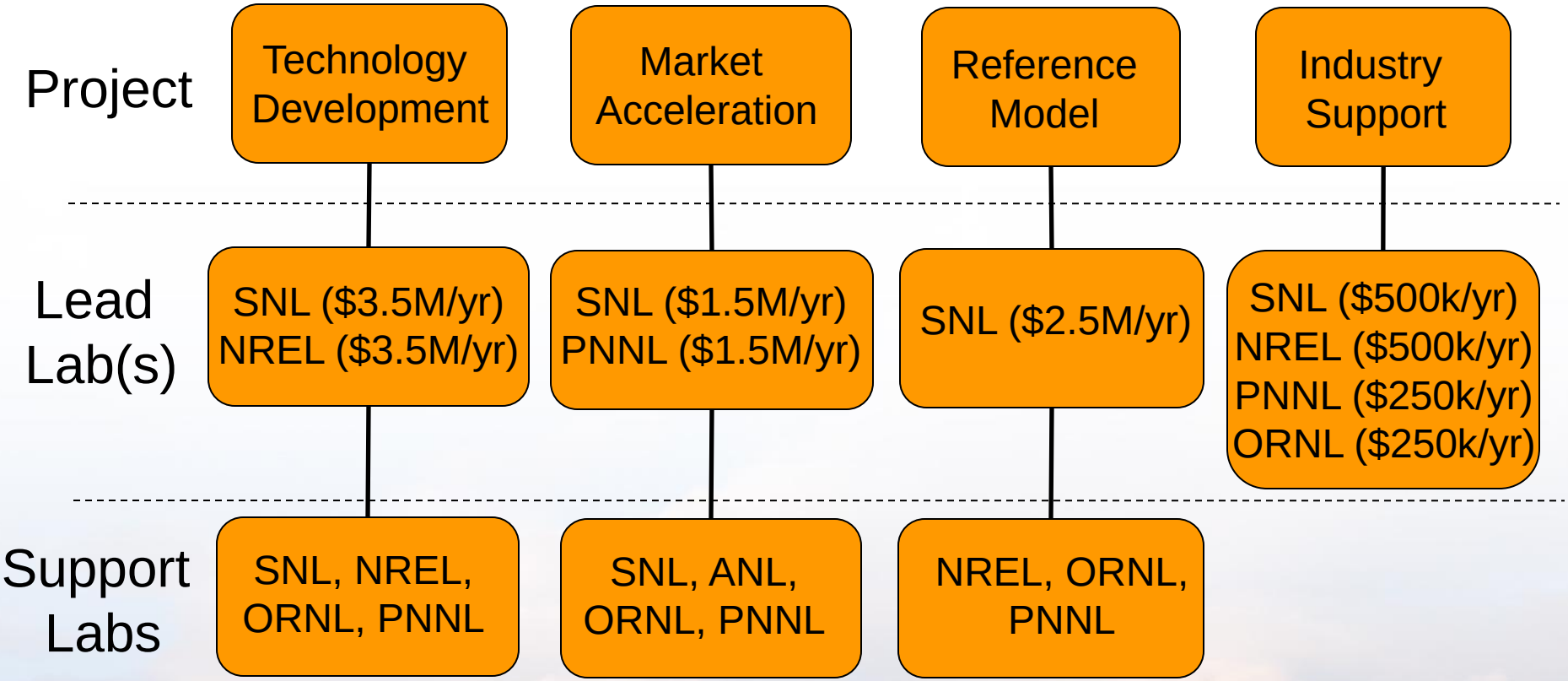
Coupled Device Array and Environmental Analysis



SNL EFDC

Technology Development Cycle

Primary DOE/National Lab MHK Projects



Sandia National Labs (SNL), National Renewable Energy Lab (NREL), Pacific Northwest National Lab (PNNL), Oak Ridge National Lab (ORNL), Argonne National Lab (ANL)

MHK Technology Research Portfolio & Partnerships

Lead Lab

Sandia National Laboratories

Org. 6362

Wave Energy Technologies

Sandia National Laboratories

(6362)

NREL

Ocean & River Current/Tidal Technologies

Sandia National Laboratories

(6362 and 1534)

NREL

Pacific Northwest NATIONAL LABORATORY

UCDAVIS

Instrumentation & Testing

Sandia National Laboratories

(6362, 1534)

OAK RIDGE National Laboratory

NREL

PENNSTATE ARL

Bucknell UNIVERSITY

System Reliability & Evaluation

Sandia National Laboratories

(6362)

NREL

Materials & Manufacturing

Sandia National Laboratories

(6362, 1800)

Pacific Northwest NATIONAL LABORATORY

BYU

NDSU

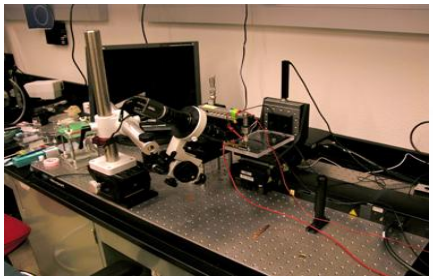
MONTANA STATE UNIVERSITY

Sandia National Laboratories

MHK Technology: Materials and Manufacturing

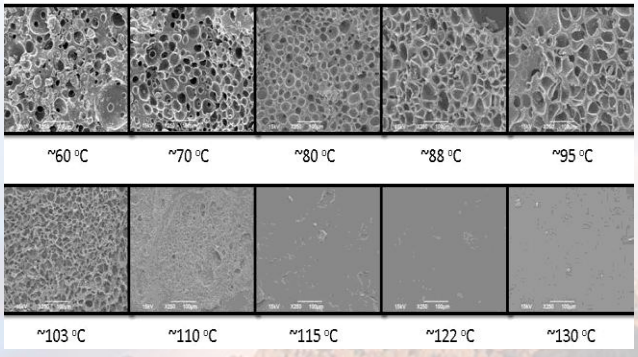
Problems: corrosion, sediment and biological fouling, erosion, fatigue, cost, manufacturing

Corrosion & Reliability

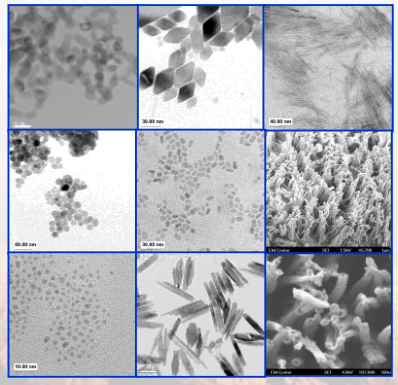


Biofouling Mitigation

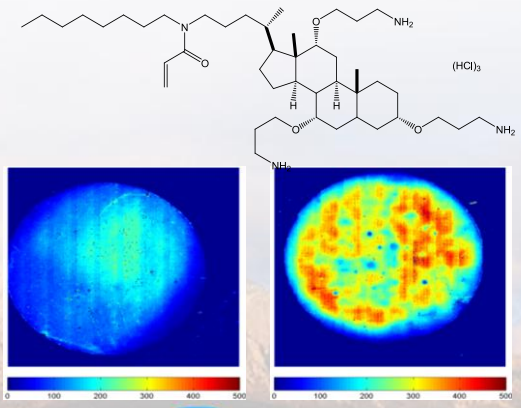
Organic Thin Film Synthesis



Nanoparticle, Thin Film & Powder Synthesis



Antimicrobial Coatings Synthesis



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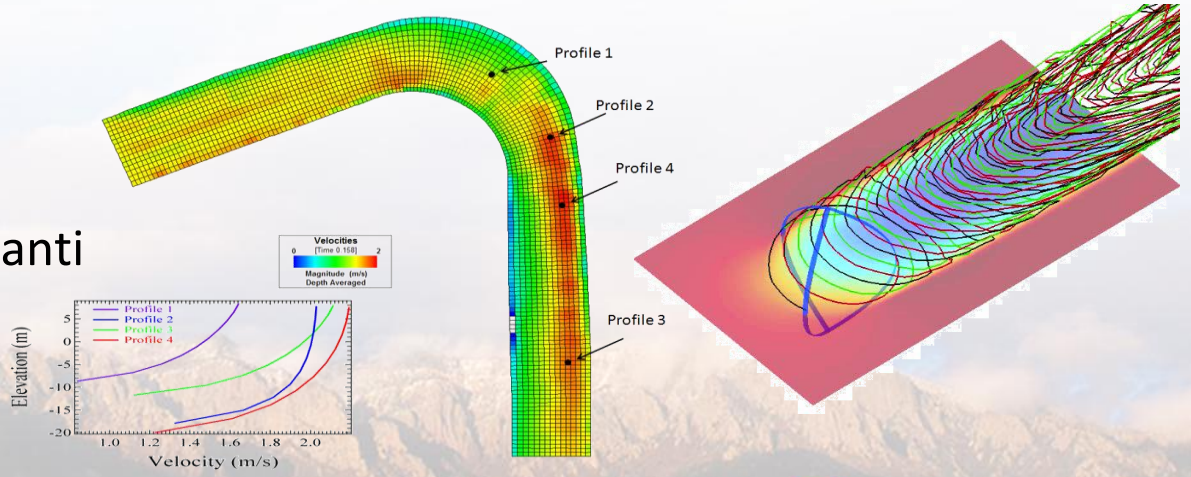
Other Capabilities being Leveraged for MHK Research

- **Large Scale Field Testing**
  - Sandia Lake test facility
  - Instrumentation in marine environments
- **Model Development and Research**
  - Device performance and design
  - Array performance and environmental impact
- **Materials Research**
  - Marine anti-fouling and anti corrosion coatings
  - Marine composites



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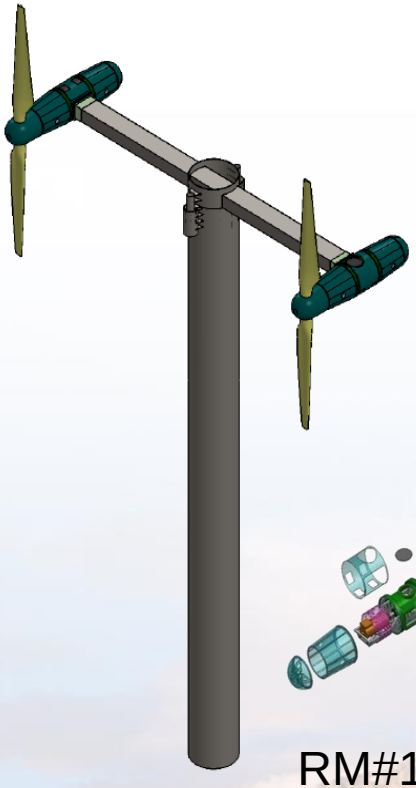
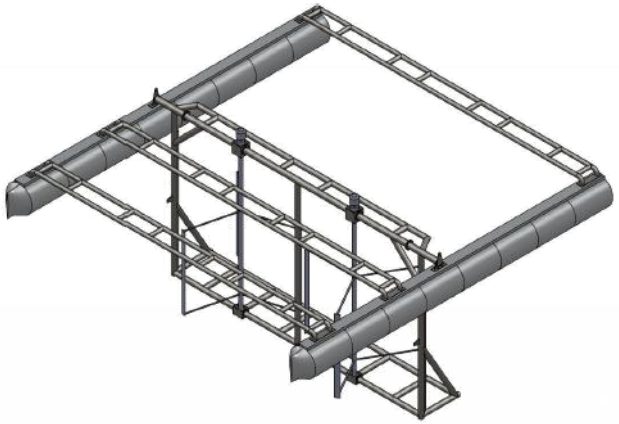
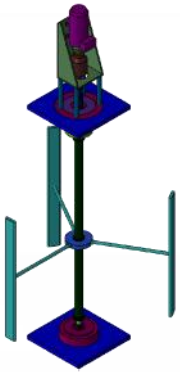
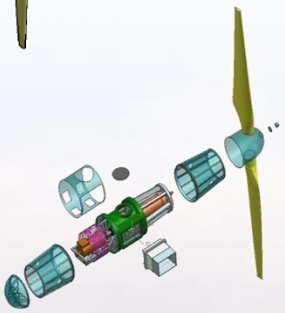
Reference Models



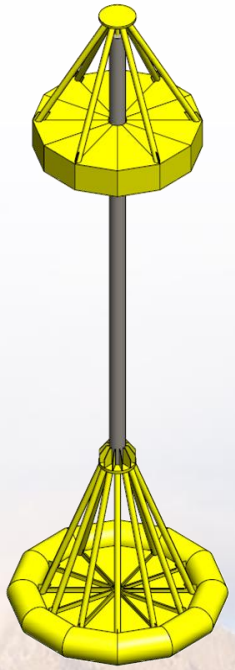


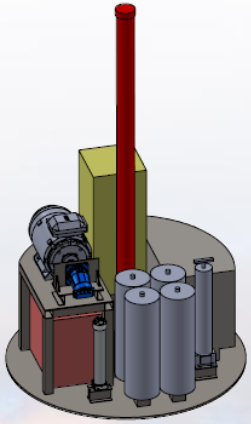


RM#2 River Turbine



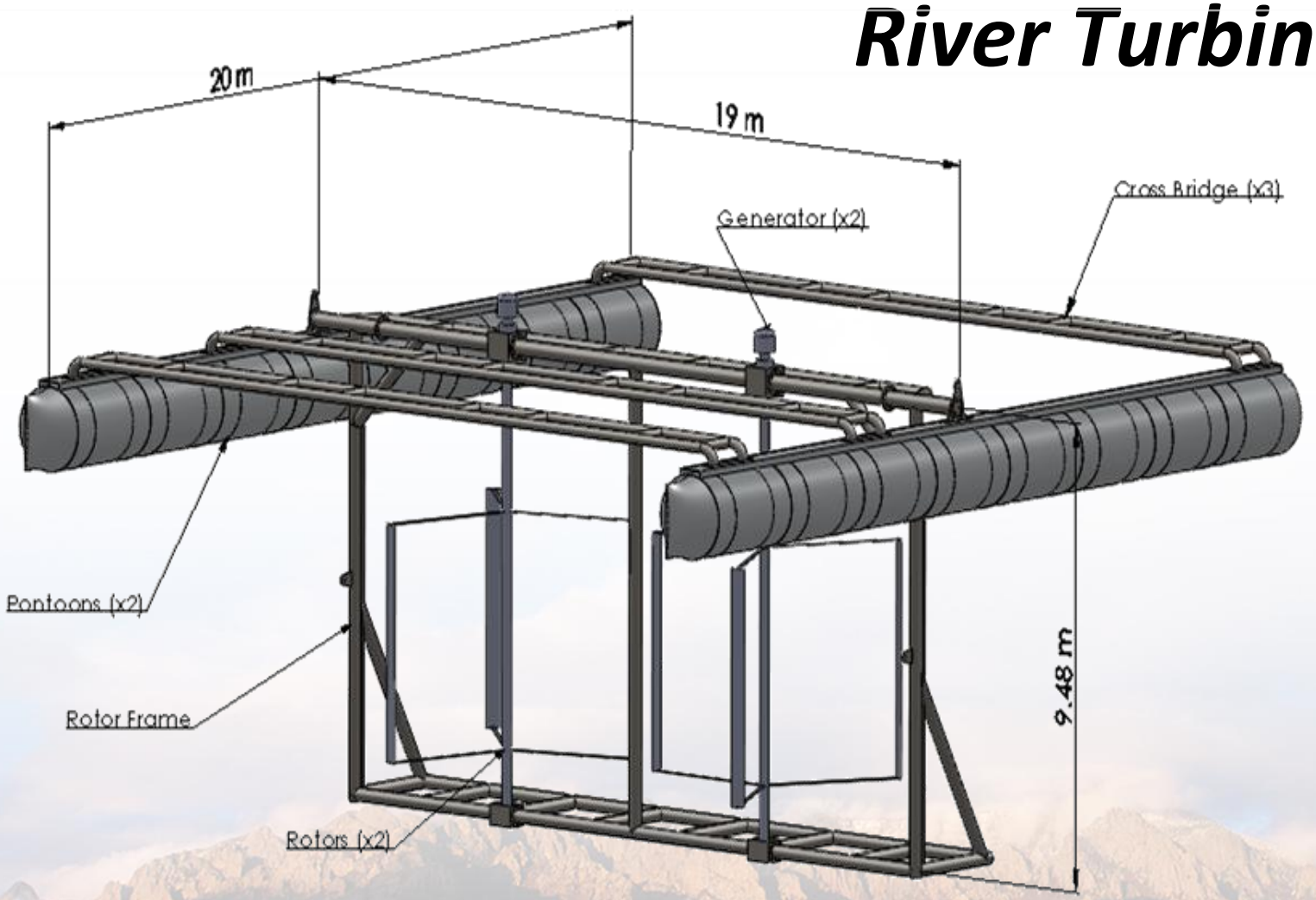
RM#1 Tidal Turbine





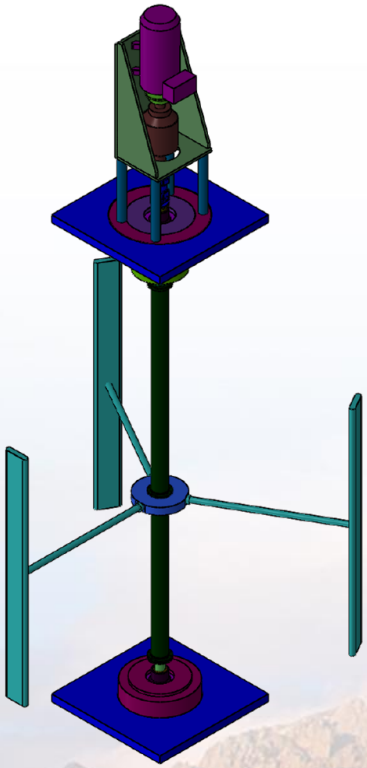
RM#3 WEC Point Absorber

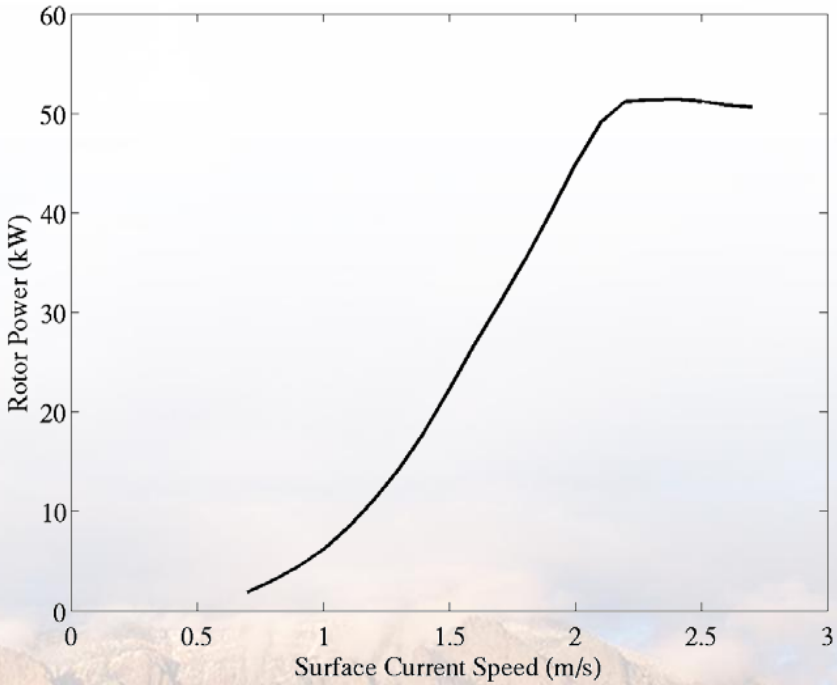
Reference Model 2: River Turbine



Design and Performance Analysis

- **CACTUS (Code for the Analysis of Cross- and axial-flow TUrbine Simulation) Evaluation for Performance**

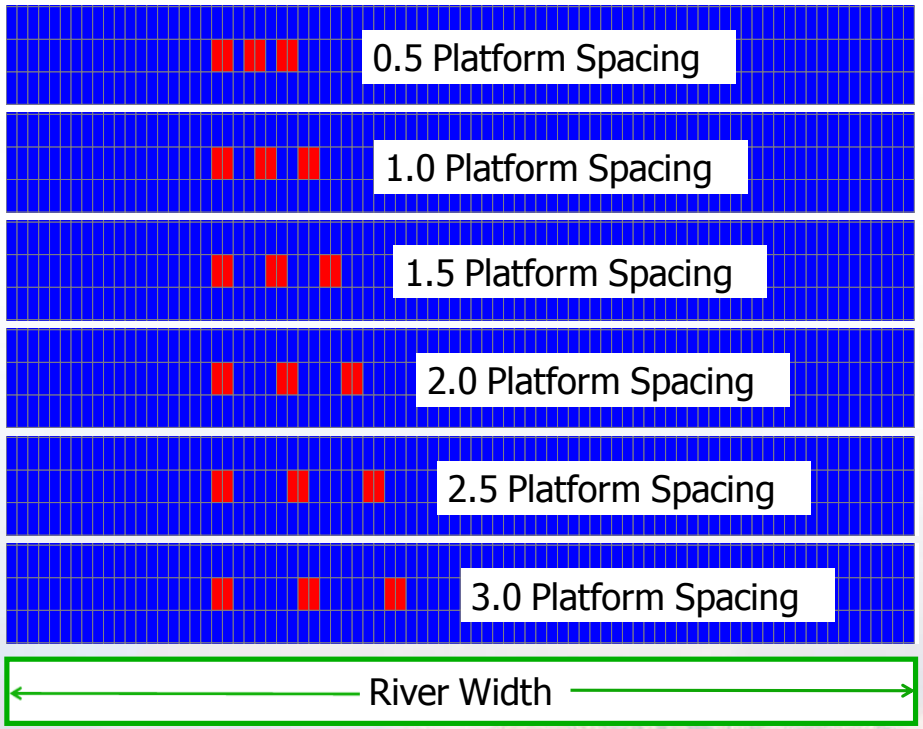


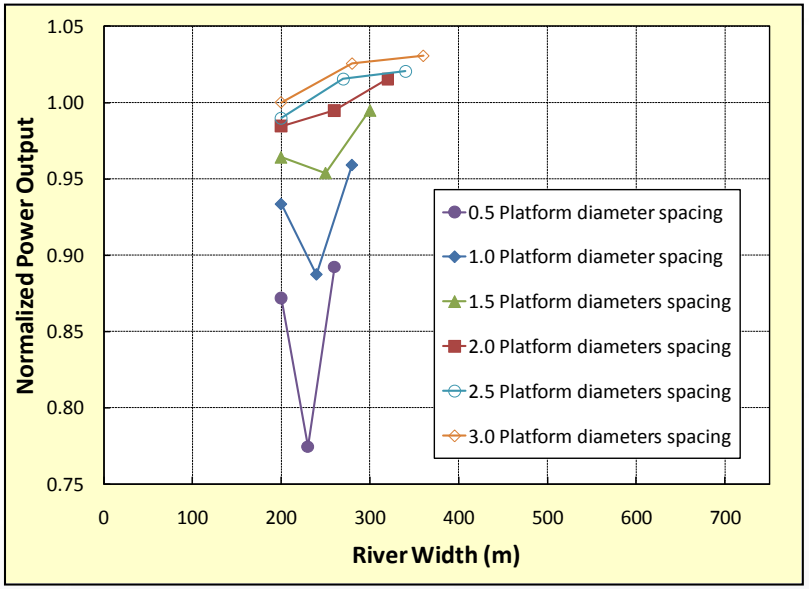


Array Analysis Using SNL-EFDC

Spanwise Array Spacing:

= 1 Platform with 2-Rotors





- Power is **normalized to a single platform** near the middle of the channel
- Effects of spanwise spacing is negligible above 2 platform diameters
- An increase in power above unity at higher spacing is attributed to 'channel focusing'

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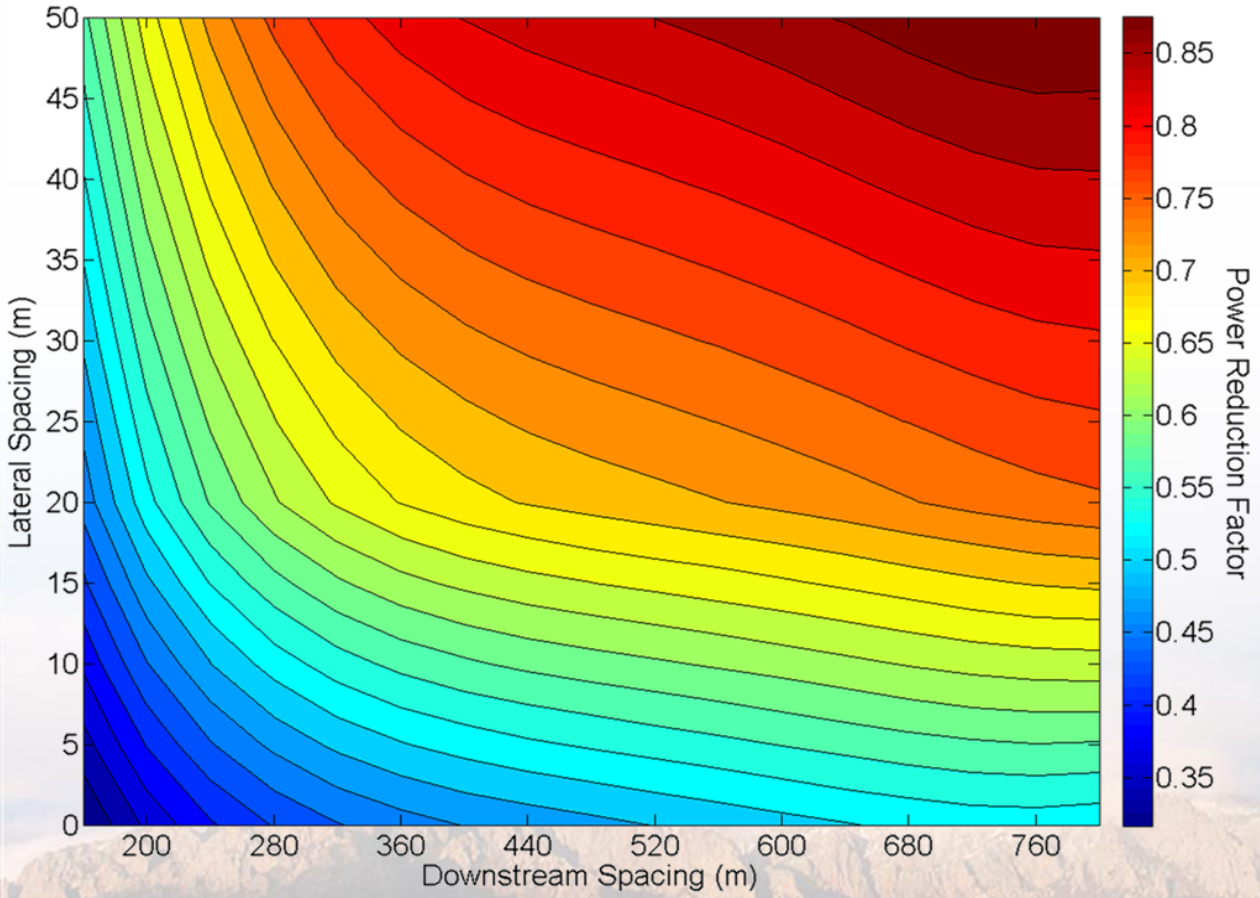
Array Optimization

- 100 Unit Array Spacing Contour of Power Output



Reference Models Moving Forward

- **Complete and Release version 1 of reference models 1 through 3 by fall of 2011**
- **Initiate work on three more reference models**
  - Oscillating water column WEC
  - Surge WEC
  - Shrouded tidal turbine
- **Plan for validation testing on first three reference models for FY12**
- **Eventually complete a total of 8-10 reference models with validation testing by the end of FY13**

Overall MHK Research Progress

- Release SNL-EFDC code this summer with training classes for industry and regulators
- Release CACTUS turbine performance code summer of 2012
- Developing wave energy device performance code
- Material development and testing (Owens Corning, Verdant Power)
- Supporting testing through instrumentation and national test facility assessment (joint work with NREL)

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