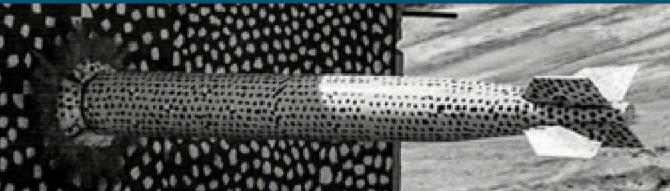


Overview of the Marine & Hydrokinetic Advanced Materials Program



PRESENTED BY

Bernadette A. Hernandez-Sanchez*, Budi Gunawan,
George Bonheyo, David Miller, Scott Hughes, Francisco
Presuel-Moreno

Water Power Technologies Office within the U.S. Department of Energy's Office of Energy
Efficiency and Renewable Energy (EERE)"



FAU FLORIDA ATLANTIC
UNIVERSITY

M MONTANA
STATE UNIVERSITY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY


Pacific Northwest
NATIONAL LABORATORY




SANDIA NATIONAL LABORATORIES

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SAND2018-7478PE

Thank You for submitting samples (FY17-18) program!

**Listed in alphabetical order*

Composite Coupons & Coatings Provided by:

Composites Engineering Research Laboratory

Composites Technology Development, Inc.

Hygrateck

Janicki Industries

Ocean Renewable Power Company

Polyone

Verdant Power

We have a multidisciplinary team dedicated to addressing material & coatings needs.

Sandia National Laboratories

- Bernadette A. Hernandez-Sanchez: (PI) Materials Chemistry
- Budi Gunawan: Loads & FBG Sensors



Pacific Northwest National Laboratory

- George Bonhoyo (WSU): Biofouling



National Renewable Energy Laboratory

- Scott Hughes: Substructure Testing



Montana State University

- David Miller: Composite Performance



Florida Atlantic University

- Francisco Presuel-Moreno: Corrosion



Webinar Agenda (Times listed in EDT)

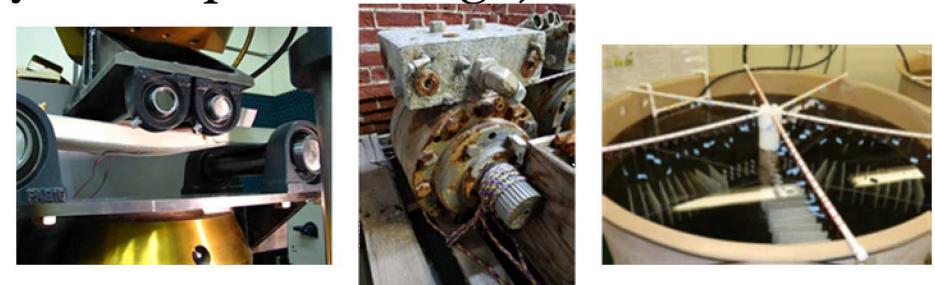
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10:10 am	Overview of the MHK Materials Program (Bernadette Hernandez-Sanchez)	
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12:50 pm	Wrap Up (B. Hernandez-Sanchez)	

Program Overview

Marine and Hydrokinetics Advanced Materials Program: support the MHK industry through applied research and guidance on Materials & Coatings to enable viability, lower the cost of energy (COE), and accelerate commercialization.

The Challenge: Proper structural/component materials and coatings are critical to reducing engineering barriers, COE, and commercialization time

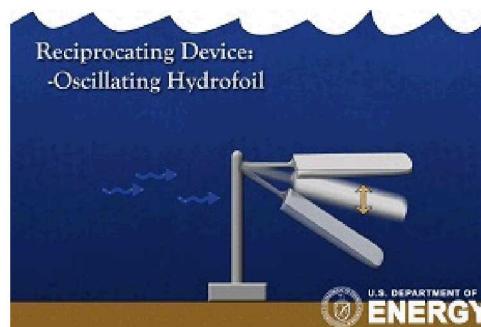
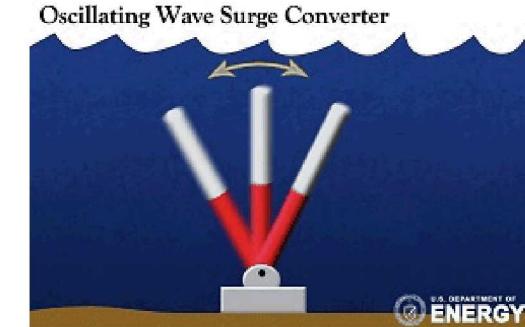
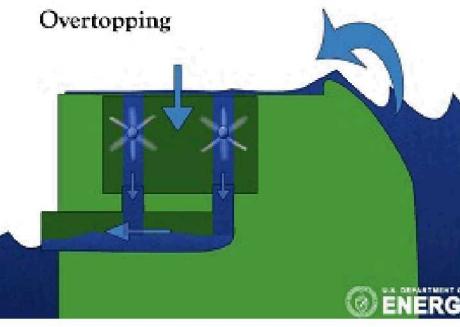
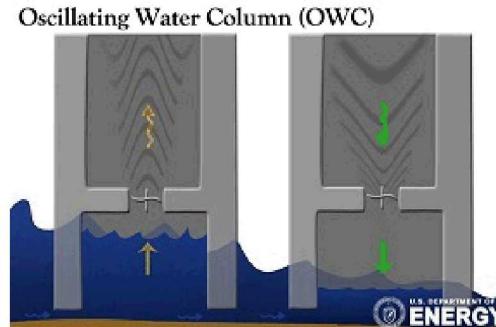
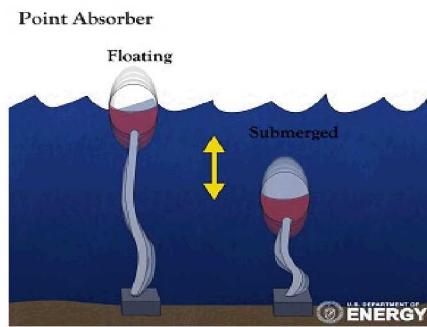
- **Structure Design & Component:** (LOADS! uncertainty in composite/design)
- **Environmental Exposure Issues**
- **Cost (Manufacture, O&M, Reliability)**
- **Safety & Certification**



Current Program Objective: **Helping MHK industry reduce uncertainty in using composites in their designs.**

- Direction taken from 2015 Workshop on Composite Needs for MHK.
- Past efforts involved determining materials needs for industry, examining coatings for biofouling, and examining marine effects on wind based composites.

Why investigate fiber reinforced composites?



- **Areas of concern vary by design:** metals, hydraulic fluids, polymers, cement, magnetic, coatings, composites
- **Composites Include:** Reinforced rubbers, reinforced concrete, fiber reinforced plastics
- **Studies indicate impact to cost:** Reference Models (SNL, NREL); Wave Energy Scotland Structural Loads and Materials Landscape Study; and 2011 Carbon Trust report indicate the structure costs can be impacted by using light weight and non-corroding materials.

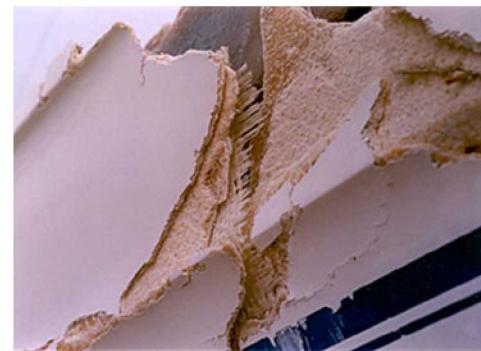
Materials can impact areas that affect commercialization.

- Structure costs
- Design & manufacture
- Accelerate manufacturing or direct advanced manufacturing strategies
 - We are working to reduce risk through testing of novel materials and materials validate for other marine-based industries under MHK conditions.
 - Future testing on materials under deployed conditions are needed for validation.
- Reliability & Survival
- Operation & Maintenance
- Certification & Safety

Helping the MHK industry with materials & protective coatings challenges



Courtesy of Resolute Marine Energy



<http://www.yachtsurvey.com/glassboats-1.jpg>



<http://www.racerocks.ca/>



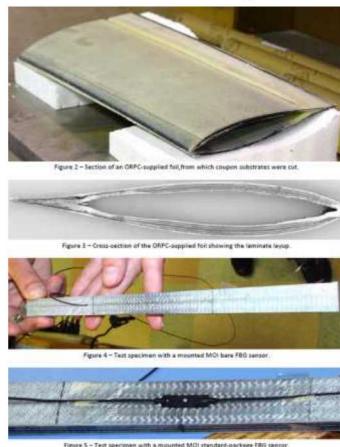
ICIT & EMEC
<http://tidalenergytoday.com/2016/01/12/icit-emec-study-biofouling-of-marine-energy-technologies/>

Previous work conducted by program (FY12-16)

Biofouling & Marine coatings assessment



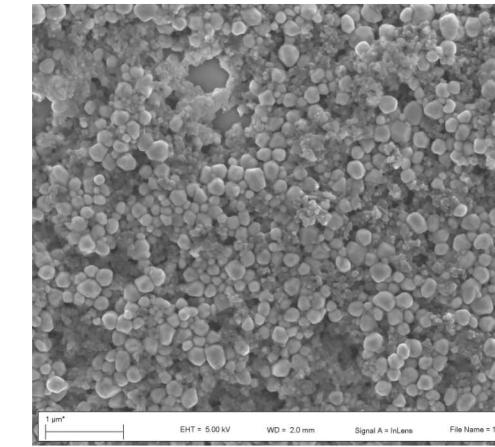
Structural Health Monitoring



MHK Environmental Effects on Composites



Nanomaterials Development



Biofouling Protection

GARD 2014 - 10-032C

Proceedings of the 2nd Marine Energy Technology Symposium
April 15-16, 2014, Seattle, WA

**EXTERNALLY BONDED FBG STRAIN SENSORS FOR STRUCTURAL
HEALTH MONITORING OF MARINE HYDROKINETIC STRUCTURES**

Michael Schuster
Montana State University
Bozeman, MT

Travis Givens
Micro Optics Inc.
Albuquerque, NM

David Miller
Montana State University
Bozeman, MT

Ruthann Errett
Montana State University
Bozeman, MT

Mark Rausch
Sandia National Laboratories
Albuquerque, NM

Eric Johnson
Montana State University
Bozeman, MT

Jarrett McNamee
Ocean Renewable Power Company
Wellesley, MA

Bernardette Schuster
Sandia National Laboratories
Albuquerque, NM

Structural Protection

2012 AIAA SDM Wind Energy Session

Performance of Composite Materials Subjected to Salt Water Environment:
David Miller,¹ John F. Mandel,² David D. Sandusky,³ Berndtse A. Hernandez-Sanchez,⁴
Domenic J. DiPietro,⁵ and Michael J. Koenig⁶

*¹Department of Mechanical and Industrial Engineering,
University of Colorado Colorado Springs, Colorado, 80933, USA*
²Department of Mechanical Engineering, Montana State University, Bozeman, MT, 59722, USA
*³Advanced Materials Laboratory
Sandia National Laboratories, Albuquerque, NM, 87185, USA*

Abstract

This paper presents the recent trends in the mechanical characterization of

Composite Performance

Polymer and poly(ether-based) α -trifluoromethyl coatings for the prevention and easy removal of marine biofouling

Michael R. Höhne,¹ Yves Berthelot,¹ Alonso Hernández,¹ Juaní Rodríguez,¹ and Óscar J. Sastre²

¹*Universidad, Depart. de Física Aplicada, Avda. Universidad 3104, 31004 Almería, Spain* and ²*Universidad, Depart. de Física Aplicada, Avda. Universidad 3104, 31004 Almería, Spain* and ³*Universidad, Depart. de Física Aplicada, Avda. Universidad 3104, 31004 Almería, Spain*

(Received 20 August 2013; revised 26 August 2013)

A series of poly(ether and poly(ether-based) trifluoromethyl coatings were prepared on epoxy-coated aluminum substrates and characterized for their antifouling (AF) and biofouling-release (BR) properties towards marine bacteria, microalgae, and benthic invertebrates. The coatings were based on a poly(ether-based) trifluoromethyl (PTM) polymer and a poly(ether-based) trifluoromethyl silane (PTS). The PTM polymer was synthesized by the ring-opening polymerization of a trifluoromethyl substituted poly(ether sulfone) (TPEPS), the most promising poly(ether-based) trifluoromethyl polymer identified from microbial evaluation, methyl (2-cyano-N,N-dimethyl)-N-[2-(methacryloyloxyethyl)allyl]carbamate (CDMAC) and a poly(ether-based) trifluoromethyl silane (PTS) and characterized (class of AF 2010 structure methods).

Biofouling Protection



Pacific Northwest
NATIONAL LABORATORY



BYU



Our current program's goal is to address barriers & uncertainty in using composite materials for MHK.

Material Design Tools for Marine and Hydrokinetic Composite Structures

Objective: Helping MHK industry reduce uncertainty in using composites in their designs

- Providing an *industry approved* U.S. DOE MHK Composite Materials & Structures Database (*open resource*): <http://energy.sandia.gov/energy/renewable-energy/water-power/technology-development/advanced-materials/mhk-materials-database/>
- Mitigating composite biofouling/environmental effects & metal-carbon fiber interconnect corrosion in saltwater
- Examining MHK load challenges on composite material & substructure performance to improve design

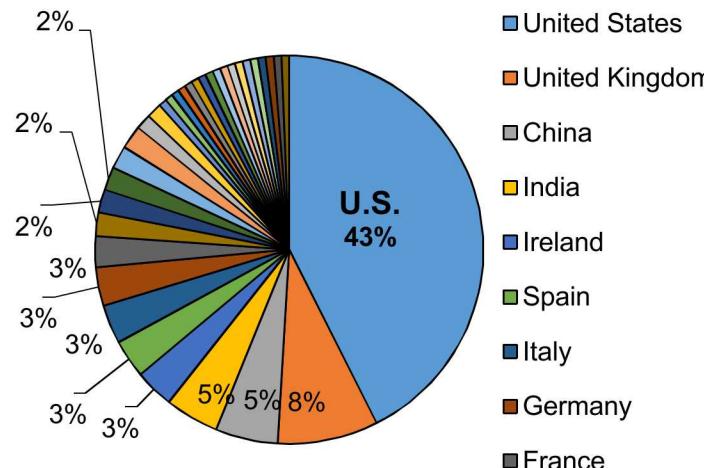


The MHK Composite Materials & Structures Database was born from materials discovery in wind energy.

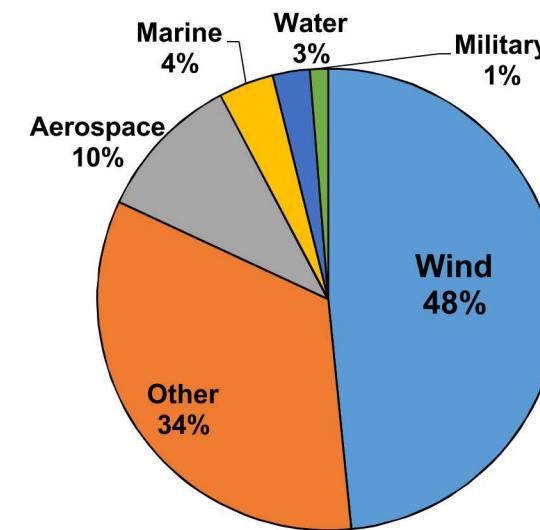
U.S. DOE MHK Composite Materials & Structures Database:

Benefits: Open Source, Industry Advised, Backed with Publications.

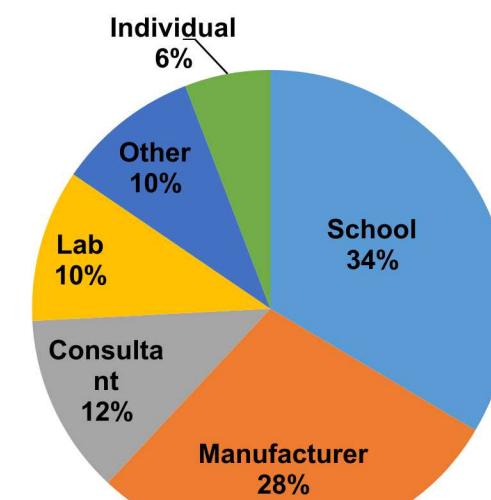
Country



Institution



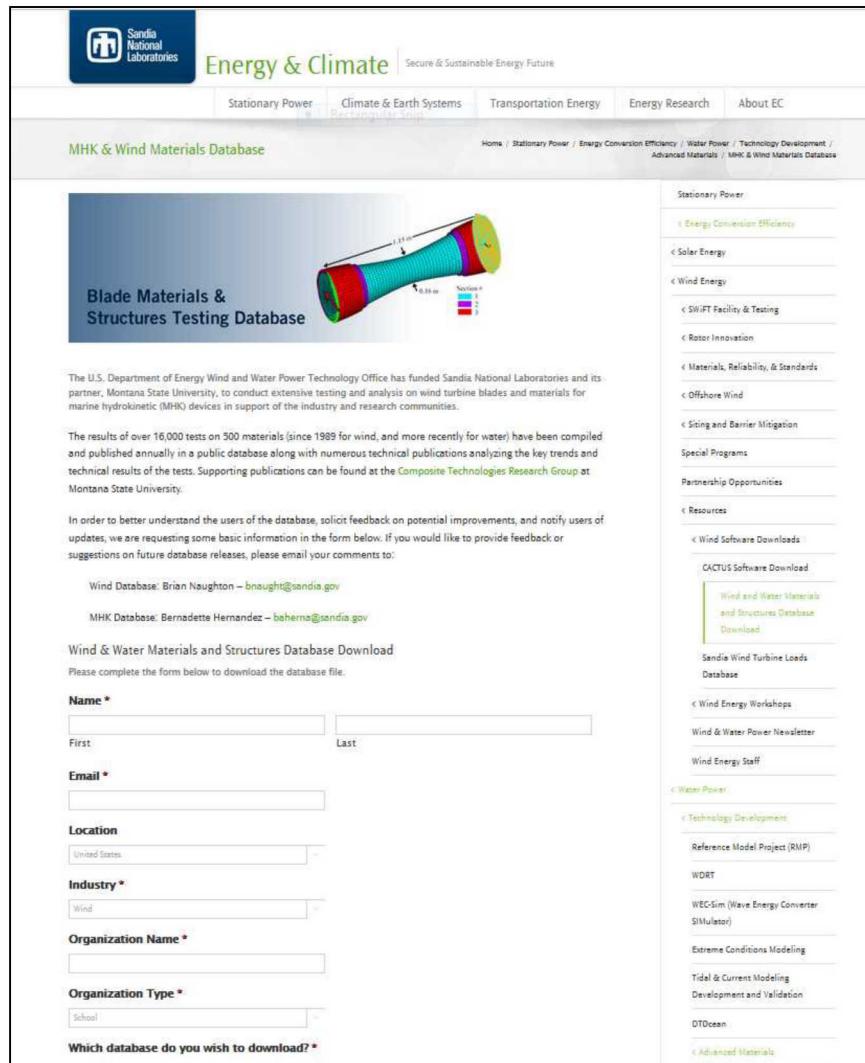
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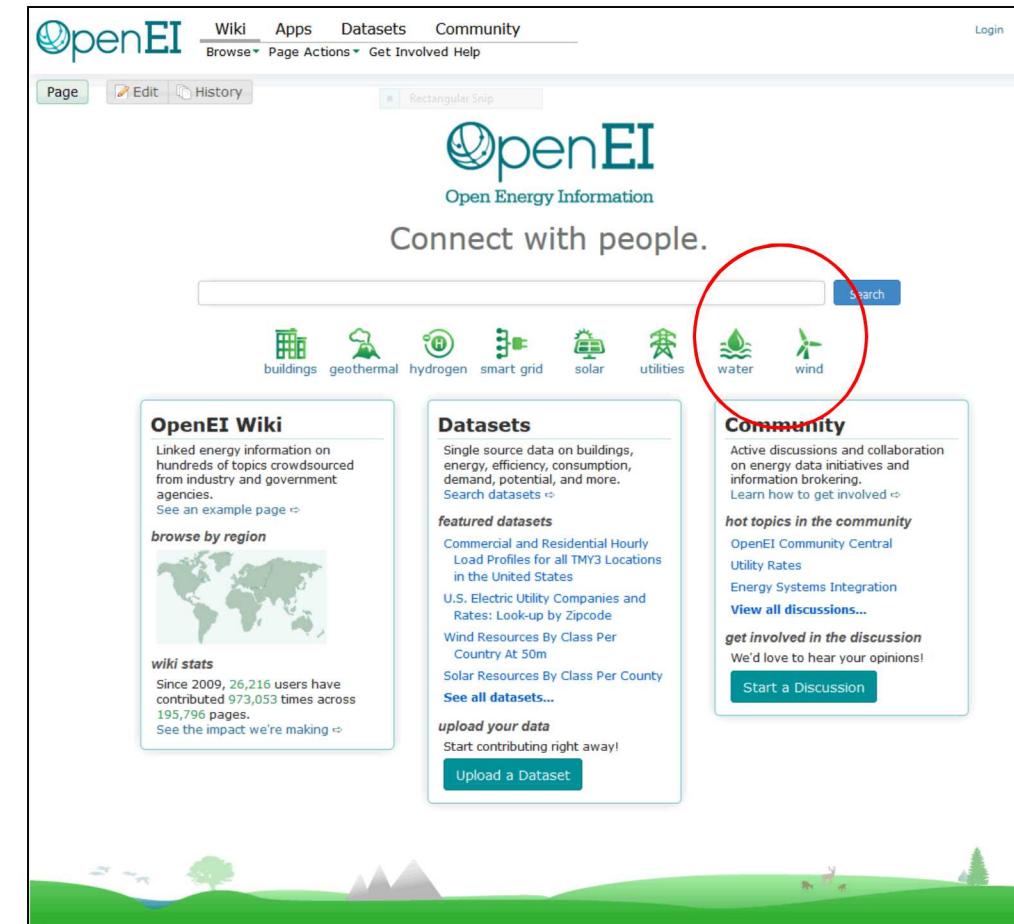
- <http://energy.sandia.gov/energy/renewable-energy/water-power/technology-development/advanced-materials/mhk-materials-database/>

Current User Community of U.S. DOE Materials & Structures Database

Database can be found in 2 locations online and is free for users to download.



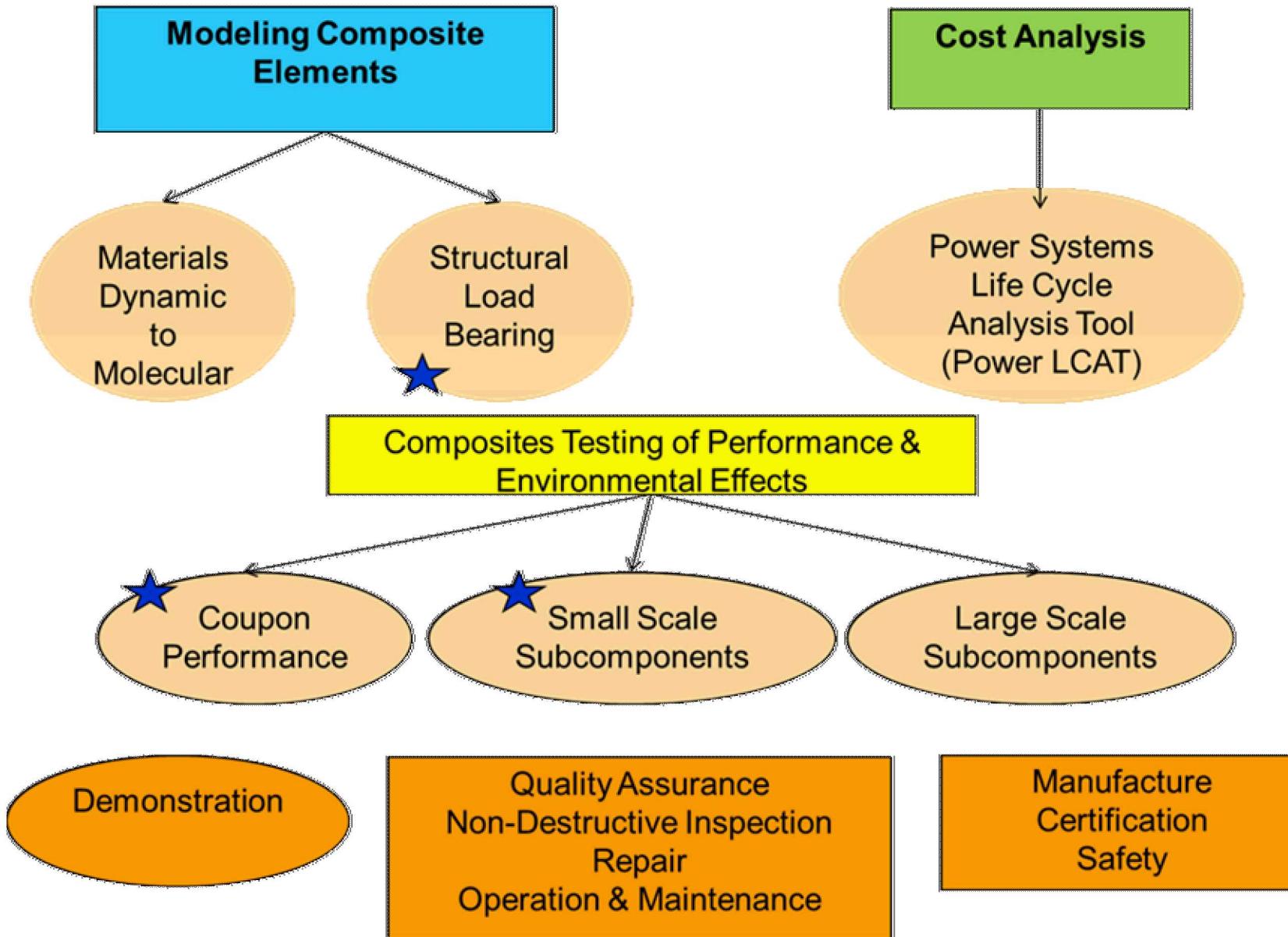
<http://energy.sandia.gov/energy/renewable-energy/water-power/technology-development/advanced-materials/mhk-materials-database/>



- Both the wind & water icons take you to webpages that house the link.
- Under Water Power Database and Tools
- PNNL has environmental effects database



You will see the initiation of research for a larger vision needed to support composite development.



Summary of Current Activities and Future Directions

FY17



Salt Water Effects on
Composite Performance
Testing

Biofouling &
Environmental Effects on
Composites



FY18

Metal – Carbon Fiber
Composite Interconnects
in Seawater



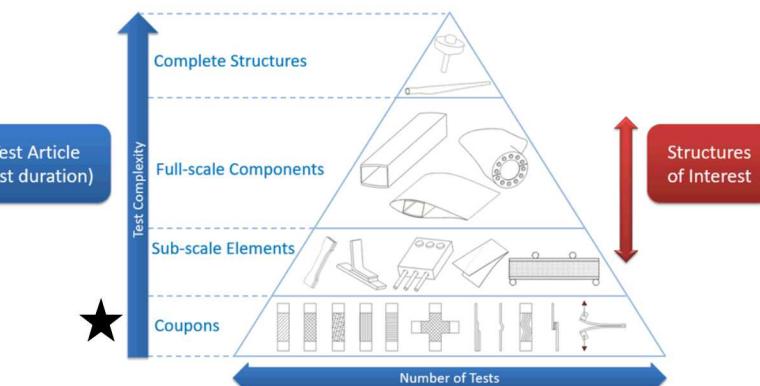
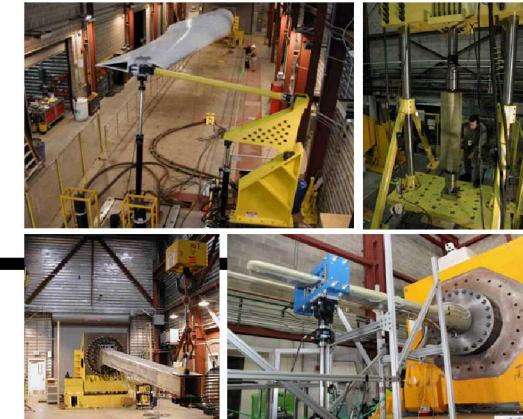
Coupons provided by:
Composites Engineering Research Laboratory, Composites Technology Development, Inc.
Hygrateck
Janicki Industries
Ocean Renewable Power Company
Polyone
Verdant Power

Industry directed sub scale
elements & joined coupon
fabrication/testing
(Artificial & Actual Seawater)



FY19

Industry directed full scale
subcomponent testing
(Artificial & Actual Seawater)



You will hear what we have learned and what else we would like to know.

14

- Water absorption into composites impacts materials properties (composite performance, accelerated corrosion-carbon based)
- Not all antifouling coatings are created equal. MHK has its own conditions.
- What does the MHK industry needs for subcomponent testing?
- Corrosion: anode samples are corroding and calcareous deposits have formed on the interconnected composites.
- Load characterization and measurements testing are being conducted to advance our understanding of MHK conditions on composite materials.
- Results on samples from industry have been explored and will be downloaded to our database.
 - This public information is garnered to support design decisions.
- Future activities



Feedback and recommendations are more than welcome!

Bernadette Hernandez-Sanchez
Sandia National Laboratories
baherna@sandia.gov

or

Lauren Moraski
Water Power Technologies Office
Lauren.Moraski@ee.doe.gov

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12:50 pm	Wrap Up (B. Hernandez-Sanchez)	

Wrap up

- Thank you for listening and participating.
- Additional questions or comments can be sent to Lauren.Moraski@ee.doe.gov
- Link to database: <http://energy.sandia.gov/energy/renewable-energy/water-power/technology-development/advanced-materials/mhk-materials-database/>