Overview of Underwater Energy Systems

People:

- **Arijit Bose**, Distinguished Engineering Professor of Chemical Engineering, URI (Lead)
- **Wilson K. S. Chiu**, Professor, Mechanical Engineering, UConn
- **M. Reza Hashemi**, Assistant Professor, Ocean Engineering, URI
- **Radenka Maric**, Professor, Materials Science and Engineering, and Vice President for Research, UConn
- **Ugur Pasaogullari**, Professor, Mechanical Engineering, Director, Center for Clean Energy Eng. UConn
- **Peng Zhang**, F. L. Castleman Associate Professor, Electrical & Computer Engineering, UConn
- **Yi Zheng**, Assistant Professor, Mechanical, Industrial, and Systems Engineering, URI
Capabilities

- Wireless underwater charging
- High performance lithium ion batteries
- Tidal power generation
- Wave energy conversion
- Air independent power sources
- High energy density fuel cells
- Fuel cells with logistical fuel potential
- Oxygen generating electrolyzers
- Shipboard power systems
- Microgrids, networked microgrids
- Stability and cyber-physical security
- Formal analysis and verification

- URI has unique facilities for testing and calibration of batteries.
- UCONN has wave energy converter prototypes, underwater wireless charging testbed, real-time hardware-in-the-loop testbed for power & energy systems, etc.
High specific energy and cycle stability in lithium ion batteries is critical for underwater vehicles.

Spatially organize SiNP, CB and binder to maximize specific energy and cycle stability.

**Bose group**

Replace CB with RGO to reduce total carbon.

**Maric group:** Reactive spray deposition technology (RSDT)

Improve the performance to cost ratio of fuel cell materials and components; develop low temperature Solid Oxide Fuel Cell (SOFC).
Smart Ocean Energy Systems Research at UConn Power Lab

- Underwater Wireless Power Transfer
- Smart-Wave Energy Conversion
- Power Electronics
- Tidal Energy Generation
- Cyber Security in Smart Ocean Systems
- Microgrids and Networked Microgrids

http://power.engr.uconn.edu

UConn’s underwater wireless charging system (Senior design advisor: P. Zhang)

• **Underwater wireless power transfer**
  – Resilient to highly uncertain marine environment
  – Maintain high power efficiency under dynamically changing loads/coupling coefficients
  – Critically important to reduce power losses and preserve energy for undersea applications

• **MPET:**
  – A novel **Maximum Power Efficiency Tracking (MPET)** method for achieving maximum power efficiency **without communication or feedback** from the transmitting side of the UWPT system

Smart-WEC
• Single body point absorber type wave energy converter oscillating in heave motion
• Air-cored direct-drive linear generator (DDLG)
• Unique features:
  ❏ Underwater WPT
  ❏ Intelligent controls (MPET, MPC, MLCT)
  ❏ Cyber security
  – In the foreseeable future, Smart-WEC can offer power solutions in the ocean space, which could help accelerate sustainable development and deployment of distributed ocean systems that requires electrical power.

Low Temperature Electrochemical Systems: Pasaogullari group

• Focus:
  – Low temperature electrochemical systems
  System/component evaluation, fabrication
  – Hydrogen refueling system components

• Key capabilities:
  – Electrode, MEA fabrication
  – Nanofabrication (e-beam PVD)
  – Electrochemical characterization
  – Material characterization
  – Modeling

Novel gas diffusion media

Engineered Nanostructures with GLAD

Role of environment on degradation

Stabilized carbon support
URI Zheng: Professional in design, theoretical calculation, micro/nano fabrication, and experimental measurement of photonic nanoscale (meta-)materials.

Undersea Energy Applications:
- Fine control of visible, near-/mid-infrared optical/radiative properties of nanomaterials for stealth technology (infrared suppression) of naval vessels, such as submarines and warships.
- Undersea thermo-photovoltaic energy conversion and undersea vehicles waste heat recovery
- Novel Energy Management and Saving Technique: Radiative (photon-based) cooling photonics for naval unmanned vehicles
- Microfluidic devices for undersea bio-sensing, ocean monitoring, and anti-biofouling

URI Zheng’s available facilities, highlighting unique capabilities (Link: http://egr.uri.edu/energylab/facilities/)
Research Capabilities – Wilson K. S. Chiu (UConn)

- High energy density fuel cells
- Air independent power sources
- Fuel cells with logistical fuel potential
- Oxygen generating PEM electrolyzers


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Relevant Research Projects – Wilson K. S. Chiu (UConn)
1. Investigated fuel cells as underwater power sources. Electrochemical Modeling of Advanced Naval Fuel Cell Systems, Office of Naval Research, 6/02-5/05.