Irving Shipbuilding Inc. Institute for OCEAN RESEARCH Enterprise OTCNS Ocean Technology Council of Nova Scotia

Marine Renewable Energy

Instructor:

1. Dr. Sue Malloy, Dalhousie University

The Marine Renewable Energy Workshop will give a quick introduction to energy, and the traditional ways of producing energy. As the workshop moves on, you will discuss the motivation behind exploring more non-traditional ways of producing energy and the social, economic and ecological impacts of these "greener" energy sources.

As marine renewable energy relied heavily on understanding tides, activities in this workshop will introduce relevant concepts and factors around tides. You will build your own mini turbine and test it out and calculate the power that it can create. As you complete these activities you will learn about the importance of design, materials and placement of turbines within the ocean.

All of these activities are easily replicable for your class, and require minimal, easy to find, low-cost materials. This is an 80-minute workshop, but can be expanded to a whole module when teaching within the school.

Key Outcomes

- Develop an understanding of how light behaves in water
- Explore optics and acoustics technologies such as hydrophones and spectrograms
- Investigate how sound propagates in water
- Gain insight into how information can be transmitted and captured in water using the science of optics and acoustics

Key vocabulary

Optics, acoustics, sound propagation, refraction, Snell's Law, total internal reflection, hydrophone, spectrogram

Curriculum Integration Document

Topic	**Description of discussion or exploration**	**questions and probes**	**resources**
Intro Activity: What is Energy	What is Energy? How is energy measured? How is energy transferred? How is energy captured, stored, and distributed? (bottle demo)	What evidence of Energy do we see in the room right now? What are the traditional ways in which Energy is produced?	
Activity 1 Energy Use in our Daily Lives	Use a killawatt measure to determine the energy used by typical household appliances (have participants measure energy usage for 2-3 different applicances; i.e. kettle, toaster, coffee maker) **Alternate activity:** Calculate your household use Compare with averages around the world	What have you learnt about your energy use? What would happen if your access to available energy was disrupted? What aspects of our daily lives would be disrupted?	NS Power Energy Calculator http://www.nspower.ca/en/home/for-my-home/save-energy/energy-calculator.aspx
Large Group Discussion: The importance of reliable, affordable Energy	What is our motivation to shift away form traditional approaches to producing E? What is renewable Energy? Is renewable Energy necessarily 'green'? What types of marine renewable Energy are there? What can impact our access to cheap, reliable E? (political, natural disaster, overuse of old grid) Why are many types of renewable energy more expensive that traditional polluting forms?	Why is this an important issue? (need for cheap affordable E, and energy security). Is our reliance on Energy increasing or declining? Who has access to affordable E? (compare with other countries) How can we use energy in the most efficient way? (SMART grid). Deferred loads	Household power (high use periods) https://www.smartgrid.gov/the_smart_grid/

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	What careers do this type of work?	What are the potential economic benefits to our region?	
Activity 2 From Energy to Tides	**Understanding Tides** What are tides? (gravitational force) What are the benefits of tidal energy over solar and wind? (reliable, predictable and consistent, tides don't rest at night, more sustained) How can we leverage the Energy from tides? (turbines) What factors are relevant to this (density, swept area, efficiency, velocity of the water, how much power you want to produce, friction, ice flow and residue in the water) – analogous to wind tubrines. Why can't we just take wind turbines and put them under the water? **The Power Equation** How much energy is in the tides? Calculate Power Equation – P=1/2 cp(density)(area)(velocity)^3 How do you decide where to put a tide turbine? Use tide tables to calculate where the good places are for a turbine (5 groups with 5 different tables). What makes this site ideal?	How can tidal energy be captured, stored, and transferred/used? Why is the Bay of Fundy an ideal place for harnessing tidal Energy? What is resonance? (extra big tides) What is the energy potential of the Bay of Fundy comparable to? What are the social, ecological and economic impacts of this type of Energy? What regional technologies have been developed to harness this energy?	Video of how tides work. What causes tides https://www.youtube.com/watch?v=QcbN9SVkqYU Tide tables Fast rising tides in NS https://www.youtube.com/watch?v=OP0cpXpw8yk View images of tidal flow' https://www.youtube.com/watch?v=qfhNjpu_IU4

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Activity 3 Design a tidal turbine	**Turbine Design** Activity 1: Materials and Design Examine images and animations for different types of turbines. Using the materials available (plasticine, blade materials, exacto knives), build prototype of a turbine that focuses on materials and design. Discuss why groups chose the materials and design that they did. What is unique to the marine environment that needs to be considered when designing an aquatic turbine vs a wind turbine (i.e. marine life, ice flows, turbulence and the force of the flow, how to get the turbines out and positioned, how to lay the cable) Estimate the power that would come from this prototype using equations and chart. What are the social and ecological issues associated with tidal energy? (expensive start-up costs, but eventually inexpensive E source, possible ecological issues relating to marine life colliding with turbines, can individuals harness their own tidal energy?)	What are the key parts of a turbine and what is their function? (tower/foundation, rotor and rotor blades, Nacelle and drive train, generator) How do these other considerations influence the design of the turbine? What features do you want to keep/discard from other examples	Fundy Force video http://fundyforce.ca/ Cape Sharp tidal http://tidalenergytoday.com/2016/06/09/video-openhydro-tidal-turbine-vs-fish/ Launching a Giant Turbine https://www.youtube.com/watch?v=R9_8c7d-cIM Triton platform http://tidalenergytoday.com/2015/01/07/video-triton-platform-with-stg-tidal-turbines/ Images of different types of turbines
Activity 4 Engineering: build a marine turbine	Using available materials, construct a marine turbine that can light an LED bulb. Test under running water	How does your prototype account for stability, durability, maximizing energy capture, minimizing ecological impact?	Recyclable materials
Discussion			

Instructor Bios

Dr. Sue Molloy

Sue Molloy, PhD, PEng, MEng, BEng, BSc, based in Halifax, Nova Scotia, Canada, is a consulting engineer, researcher and adjunct professor in Ocean Engineering, specializing in Electric Boats & Ships, Marine Renewable Energy, Eco-Ships and sustainable engineering. Sue is currently working on a range of projects for groups such as the Canadian Space Agency and Transport Canada. Sue's doctoral work focused on ship propulsion and diesel electric propulsion. Sue is regularly invited to speak to engineering organizations and institutions around the country. She is the international chair for the International Electrotechnical Committee River Turbines Project Team, a Canadian delegate on the Design PT of IEC TC114 Marine Energy and is a board member of Marine Renewables Canada. Sue has taught sustainable engineering and turbomachines for Dalhousie University, Faculty of Engineering and has taught sustainable industrial design and renewable energy at OCAD University in Toronto. Sue is an adjunct professor in the Faculty of Engineering at Dalhousie working on a range of tidal turbine research projects. Sue's consulting clients include ocean related SMEs, tidal power project developers, non profits, academia and government.