marinerenewables.ca

Creating an industry out of another Canadian resource!

Chris M Campbell Ph.D
Executive Director

marine renewables canada

The power to think bigger.

- We are a national association
  - Membership includes governments, utilities, project and technology developers and suppliers
  - We have been an influence on policies and strategies to build an industry at home and abroad
- Nova Scotia's tidal strategy has the attention of the world
- We are hosting the world's industry developer conference for its first time outside Europe in 2014

Ocean Energy – Marine Energy

- Obviously wave and tidal current
- But need to focus on river current as well
- There are also interests in offshore wind, and,
- Maybe in osmotic gradients in estuaries

- The real focus is river and tidal currents, followed by wave opportunities
- It is in creating an industry to deliver power from these resources

Why marine renewable energy?

(image: www.opportunityenergy.org)

Market Opportunity

•~10-15% world electricity consumption (IEA, 2008)

•Estimate of $1.2 billion spent over 2011-2015 (Douglas Westwood)

•Canadian Roadmap estimates $2 billion by 2030

State of the sector

•Hundreds of patents & designs

•Growing number of demonstration projects

•Handful at full-scale testing

Canada - Ocean Energy leader

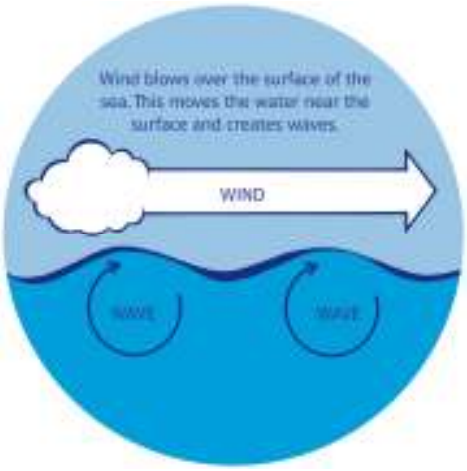
- 20 MW$_{(5,000\ homes)}$ - Nova Scotia since 1980's

Kinetic vs potential energy

- Original approaches were tidal barrages and hydro - height difference = power
- Tidal Stream - capture the energy in ebb and flood currents as tide changes
  - Favourable sites are passes and headlands
  - Most will be less than 30m deep
- Wave – nearshore areas on exposed west coasts
- River – uses the energy in river flows

Strengths of marine energy

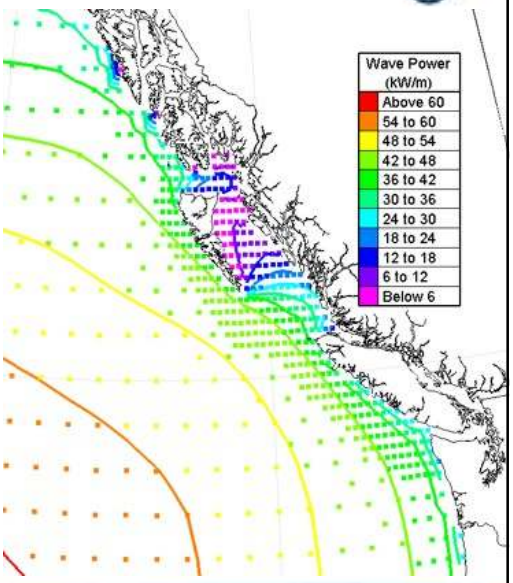
- Energy density up to 50 times that of wind, and 100 times solar PV
- 2 knot tidal stream - 500 W/m^2
  - Flow and timing predictable
- NW Pacific - 20-50 KW/m wave front
  - Forecastable 5+ days
  - Endures longer than wind events
- Rivers
  - 24 hr, 365 day flow
  - Forecastable seasonality

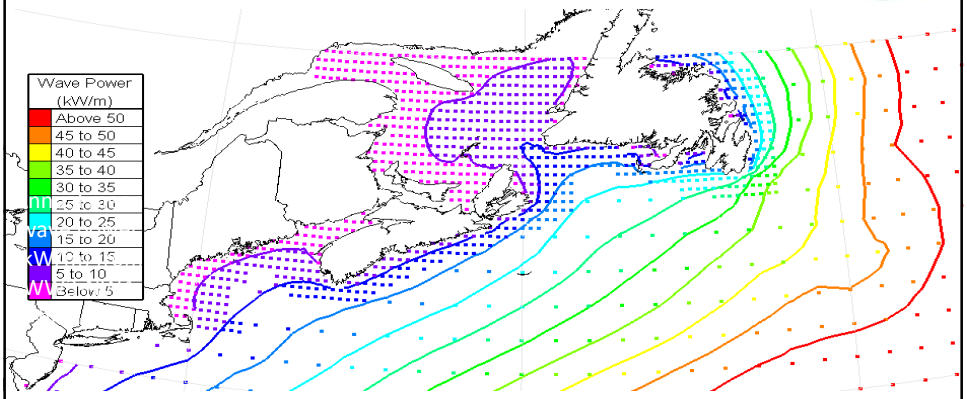


Wave energy comes from wind

Wave

- 10,000MW – Haida Gwaii
- 10,000MW – Vancouver Island

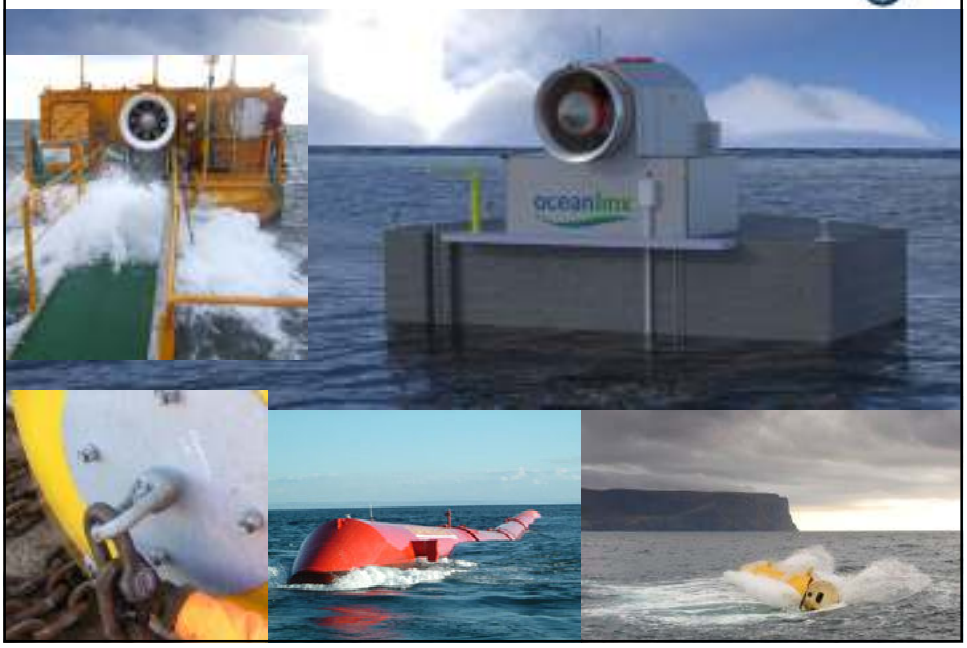




- 0.25° by 0.25° resolution
- 54,000 grid points
- NW Atlantic up to 60°N
- 3 hour time interval
- 5+ year simulation
- Considers ice cover
- Approximation of shallow water effects
- Extensive validation
- Data courtesy NOAA-MMAB

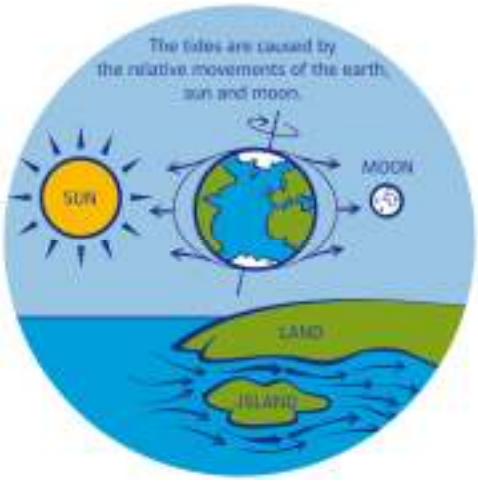
Wave resource summary

- Wave energy resources are spatially and temporally variable (greatest in deep water during winter)
- Potential Offshore resource:
  - 37,000MW in the Pacific and
  - 145,000MW in the Atlantic (annual mean values)
- Potential Nearshore resource (annual mean values):
  - 35kW/m near the Queen Charlotte Islands (~9,600MW)
  - 25kW/m near Vancouver Island (~9,400 MW)
  - 25kW/m near Sable Island (~1,000 MW)
  - 25kW/m near SE Nfld (~9,000 MW)



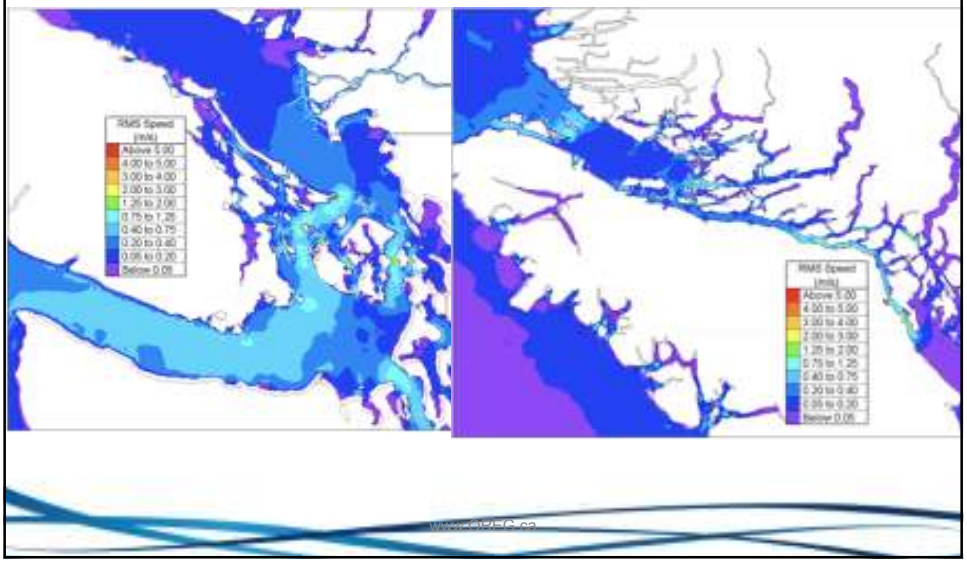
Wave Energy Experience

- Great west coast and offshore Atlantic resource
- Several Canadian energy capture innovations (sidelined by investment challenges)
- International proposals waiting for market driver - FIT
- The West Coast Wave Initiative- industry/academic research collaborative pushing resource assessment approach

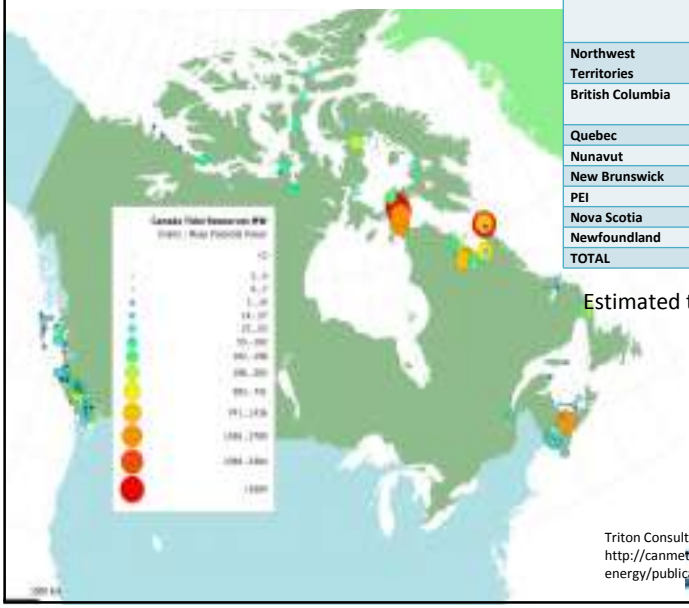


The moon raises the tide - this creates currents

Vancouver Island hotspots



Canada's Tidal Resource



Province	Potential Tidal Current Energy (MW)	Number of Sites (-)	Average Size (MW)
Northwest Territories	35	4	9
British Columbia	4,015	98	45
Quebec	4,288	16	268
Nunavut	30,567	34	899
New Brunswick	63	14	45
PEI	33	4	8
Nova Scotia	2,122	15	141
Newfoundland	544	15	36
TOTAL	42,240	191	221

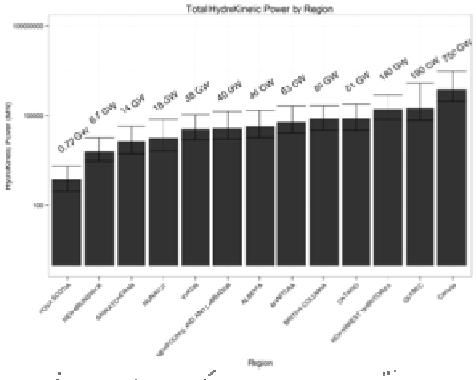
Estimated tidal resource: 370 TWh/yr

Triton Consultants, NRC, A.Cornett 2006, http://canmetenergy.nrcan.gc.ca/renewables/marine-energy/publications/2888

Tidal Current Experience

- Fundy Ocean Research Centre for Energy (FORCE) – demonstration site to pre-commercial (64 MW)
  - Not-for-profit NS company
  - 4 world-leading technologies
  - Strategic research on for environmental considerations
- Emera moving forward based on experience gained from 1 MW deployment in 2009/2010
- Community-scale tidal –
  - Five <<1 MW projects supported by Feed-in-Tariffs in NS
  - Canoe Pass project in BC (500kw)
- Next steps will be array-scale and first commercial-scale in planning
  - Array-scale FIT in development in NS
- Strategy emerging for a tidal industry in Atlantic Canada

River currents - Just the biggest rivers!



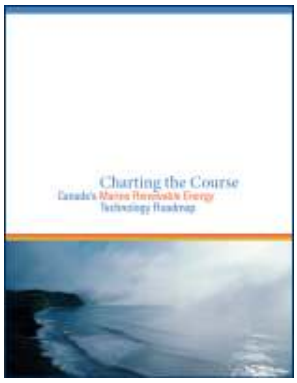
- **Conservative 300 GW**
  - **Twice Canada's generation capacity**
  - **Twice the development potential of hydro**

River Current Experience

- At least four Canadian generator technologies available – technologies tested in current environment
- Reach beyond coastlines – Quebec, Ontario, Manitoba, NWT and British Columbia
- Good connection to traditional hydro and similar technology tidal current
- Manitoba Hydro/U Manitoba lead the Canadian Hydrokinetic Turbine Testing Centre
- A solid leadership opportunity for Canada based on having a strong hydropower community

Potential to Reality: Canada's MRE Roadmap

- National vision and strategy to enable utility-scale commercialization of MRE
  - 100+ sector experts contributed: Technology developers, IPPs, utilities, service providers, academia, government, supply chain companies
  - Sponsored by Natural Resources Canada
- Charts course to accelerate the industry by reducing cost and risk



Roadmap: Enabling Activities

Fundamental activities across all pathways to achieve success.

- Share experience
- Aggregate early activity
- Create the scale & momentum
- Incent the development of technologies & skills transfer

Site Screening & Project Feasibility	
• Desktop modeling tools and analysis expertise (resource assessment) • Research support • Technical and engineering expertise (identification of suitable grid connection, logistics analysis, technology identification)	
Planning	
• Vessel and operator (range of vessels can be used including local fishing crane, 30m long vessels and specialist physical surveying vessels for environmental surveying) • Surveying, trawling, and imaging equipment • Aircraft (helicopter) and operator for aerial survey • Wildlife observation and data collection by marine biologist, ecologist, environmental scientist, and/or local knowledge from fisherman, etc. (should have knowledge of local species)	• Technical/research consultancy: sediment transfer, geotechnical engineering, analysis of survey data, data analysis and resource modeling, device suitability analysis, metocean • Meteorological instruments and packaged instruments • Remotely operated vehicles (ROV) and diver • Electrical expertise • Legal expertise
Project Design & Development	
• Public relations, consultation, First Nations expertise • Meeting/conference space (local community centre or hotel) • Environmental assessment experience • Permitting and approval of marine projects expertise • Power project interconnection studies	• Legal expertise • Health & safety expertise • Engineering consultants (technology and project design) • Marine architect (logistical support) • Procurement & contract management
Project Fabrication	
• Marine architect • Electrical expertise (subsea electrical equipment) • Health and safety expertise • Technical experience in construction for short access windows due to tidal flow • Steel fabrication • Concrete supplier • Expertise in corrosion and marine growth prevention • Local knowledge of marine conditions • Electrical and hydraulic knowledge in marine environment • Subsea connectors from device to inter-array cabling • Specialist sensors and data collection systems. • Experience in design and use of SCADA systems • Hydraulic actuators, valves, or other equipment. • Bearings and actuation components for use in yawing or pitching	• Large-scale and high precision cabling extrusion and assembly equipment • Expertise in the production of insulation for cables to provide thermal and electrical protection • Cable armouring products to protect against extreme forces and ensure life of the conductor • Electrical design knowledge • Mechanical engineer • Expertise in the design of dynamic structures for the marine environment • Corrosion and marine growth prevention products • Cranes • Insurance • Transportation of component parts to site for final assembly

Construction, Installation & Commissioning	
• Marine consultant • Customs broker for importing materials and guidance in obtaining proper permits for temporary use of barge • Heavy lift capacity of up to 1000 tonnes • Large lay-down and storage areas to enable assembly of components and rapid deployment of devices for larger scale developments • Suitable space for final assembly adjacent to quayside • Dry and potentially wet commissioning of electrical parts • Sufficient draft and beam to facilitate movement of vessels and devices at a range of tides. • Electrical Engineer • Mechanical Engineer • System Engineers • Power Engineers	• Certified welders (CWB Class 47.1) • Journeyman machinists • Tugboat and operator • Fishing boats for transporting additional personnel and emergency response • Health and Safety/Emergency Response preparedness • Personal protective and safety equipment • Radios for communication between all parties involved in deployment • Environmental consultant/researcher • Diving services • Instrumentation for communication • Specialist tooling and ROVs • Marker buoys and navigational lighting • Specialist vessels - complex installation procedures. • Drilling and piling operations
Operations & Maintenance	
• Dedicated operations, maintenance staff and control centre • Marine engineer (class 4 or higher) • Power Engineer (Class 1 and Class 4) • Computing systems • Navigation systems and data • GIS services • Subcontractor support services • Vessels • Ecologists and marine biologists	• Port facility • Portside lifting capability to lift the device to shore if needed (crane) • Local workshop facilities • Mechanical technicians • Electrical technicians • Storage for replacement parts/PTO systems • Welding and machining • Health & Safety/Emergency Response • Diving services

marinerenewables.ca

GET IN TOUCH

Chris Campbell, *Executive Director*
Email: chris@marinerenewables.ca
Phone: 250-754-0040

Elisa Obermann , *Atlantic Director*
Email: elisa@marinerenewables.ca
Phone: 902-817-4317

From Prototyping Technology to Prototyping an Industry
November 20-21, 2013 The Westin, Ottawa, Ontario

ICOE 2014 – the world's fifth industry developer conference
First outside Europe

marine renewables canada

The power to think bigger.