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Harnessing the Power of Wave Energy Converters

An Overview of the West Coast Wave Initiative (WCWI)

Dr. Brad Buckham

WCWI Director

7 November 2013



WCWI

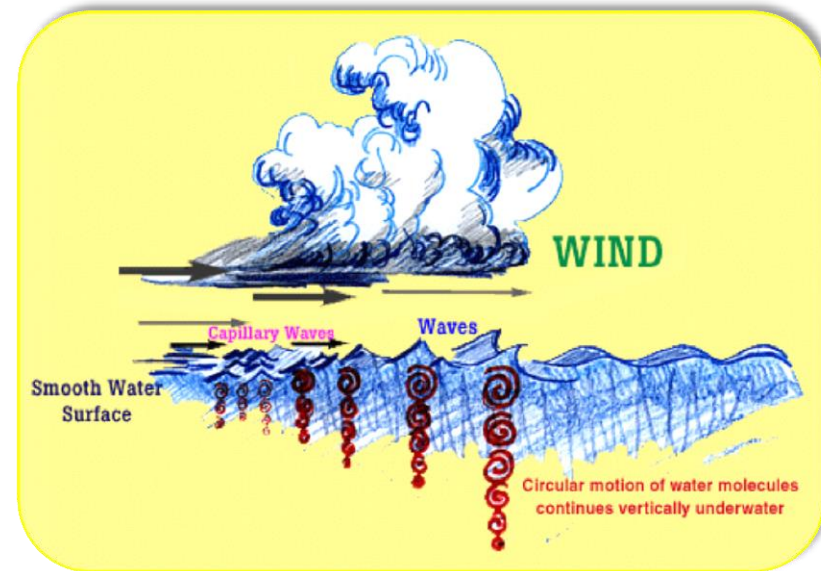
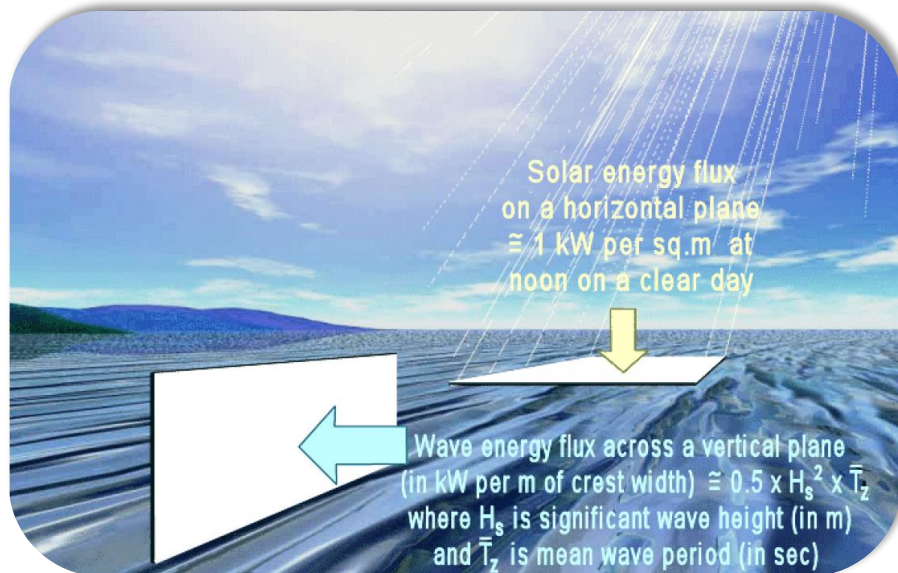
WEST COAST WAVE INITIATIVE

What is wave energy?

Wave energy | Motivation & objectives | People | Gross resource | Net resource | Usable resource

Wave Energy

- Wave energy converters work with long period water waves referred to as *swell*.
- Wave energy is sometimes described as a concentration of solar energy.
- Differential Heating \Rightarrow Winds \Rightarrow Swell



- The magnitude of the power transport in ocean waves has inspired a variety of WEC concepts
- Each class of WEC technology is distinguished by the water wave phenomena that drives it.



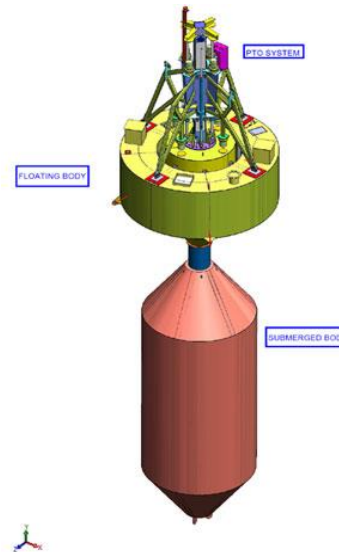
Why was the WCWI proposal approved?

Wave energy | **Motivation & objectives** | People | Gross resource | Net resource | Usable resource

WEC Demonstrations are necessary but not sufficient

WaveBob (Ireland):

- Founded in 2001.
- Sea trials in 2006 & 2007.
- Selected for deployment on the Cornwall Wave Hub.
- “Innovation Company of the Year” – Engineers Ireland, 2006.
- Lockheed Martin Agreement, 2009.
- \$2.4M US Department of Energy Grant, 2010.



WaveBob Shuts Down After Failing to Raise Funds, Find Partner

(Bloomberg.com, 3 April 2013)

“Some of the big players in ocean energy are in fact withdrawing from the sector entirely...Finding a strategic partner and a long-term investor has been impossible and we were almost there a couple of times but they haven’t materialized.”



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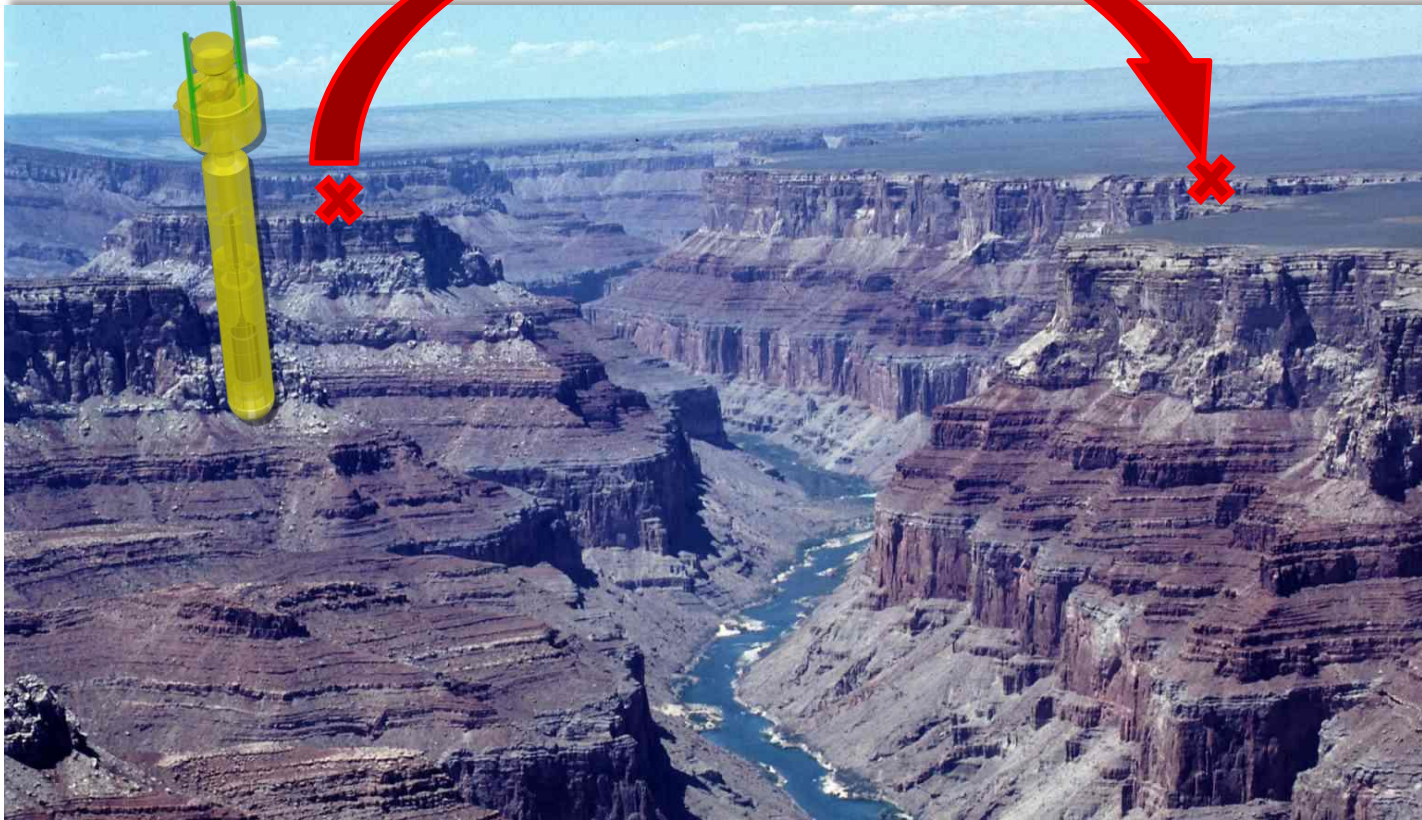


Why was the WCWI proposal approved?

Wave energy | **Motivation & objectives** | People | Gross resource | Net resource | Usable resource

Pre-commercial demo

Commercial operations



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Why was the WCWI proposal approved?

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Pre-commercial demo

Commercial

Detailed study of WEC integration is a necessary complement to WEC demos.

- Technical management (energy production & storage).
- Consider future scenarios along with present-day conditions.
 - Technology (WEC control).
 - Pricing (62 ¢/kWh, 50 ¢/kWh, 15 ¢/kWh, ...?).
 - Public demand / GHG reduction targets.
 - Reduced risk for WEC demos
 - What will a present-day demo demonstrate?

Integration studies require detailed knowledge of the resource and the converter performance.



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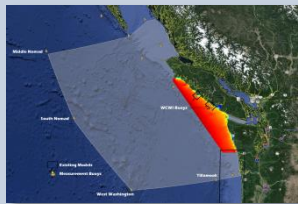
West Coast Wave Initiative at the University of Victoria

Wave energy | **Motivation & objectives** | People | Gross resource | Net resource | Usable resource

WCWI

Resource Assessment

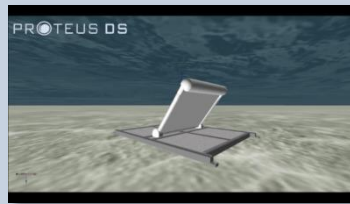
- Nearshore & Offshore SWAN/ SWASH Wave Model
- Fully Directional Model
- 3 Measurement Buoys
- WEC Site Investigations



GROSS RESOURCE

Technology Modeling

- Complete Spatial Motion
- Flexible Time Domain Model
- Fully Coupled PTO, Mooring and Device Model
- Hydrodynamic Drag



NET RESOURCE

Grid Integration

- KW: Hot Springs Cove
- MW: Vancouver Island
- GW: BC / Alberta



USABLE RESOURCE



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WCWI – external partners and service providers

Wave energy | Motivation & objectives | **People** | Gross resource | Net resource | Usable resource

WCWI – Institute for Integrated Energy Systems

Program Director & Project Manager

2 Senior Research Engineers

5 Faculty (Mech Eng)

6 PhD, 3 MASc students

Grid Integration

WEC Modeling
&
Resource
Assessment

External Partners – WEC Developers

Carnegie Wave Energy
Seawood Designs Inc.
Resolute Marine Energy
Ocean Energy
Triple X Energy

Service Providers

Axys Technologies
Cascadia Coastal Research
Dynamic Systems Analysis



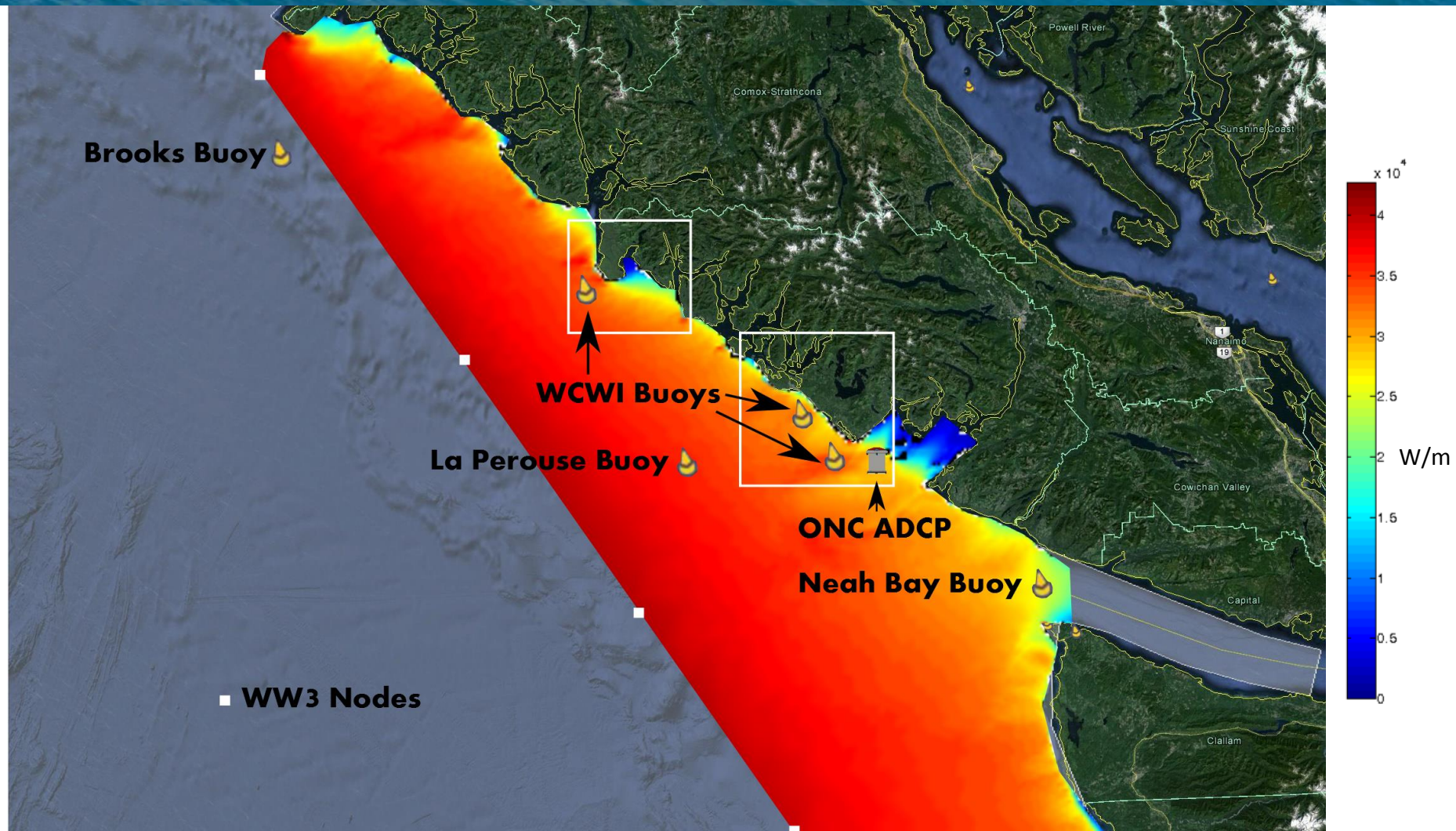
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West Coast Wave Initiative – SWAN & Measurement Buoys

Wave energy | Motivation & objectives | People | **Gross resource** | Net resource | Usable resource



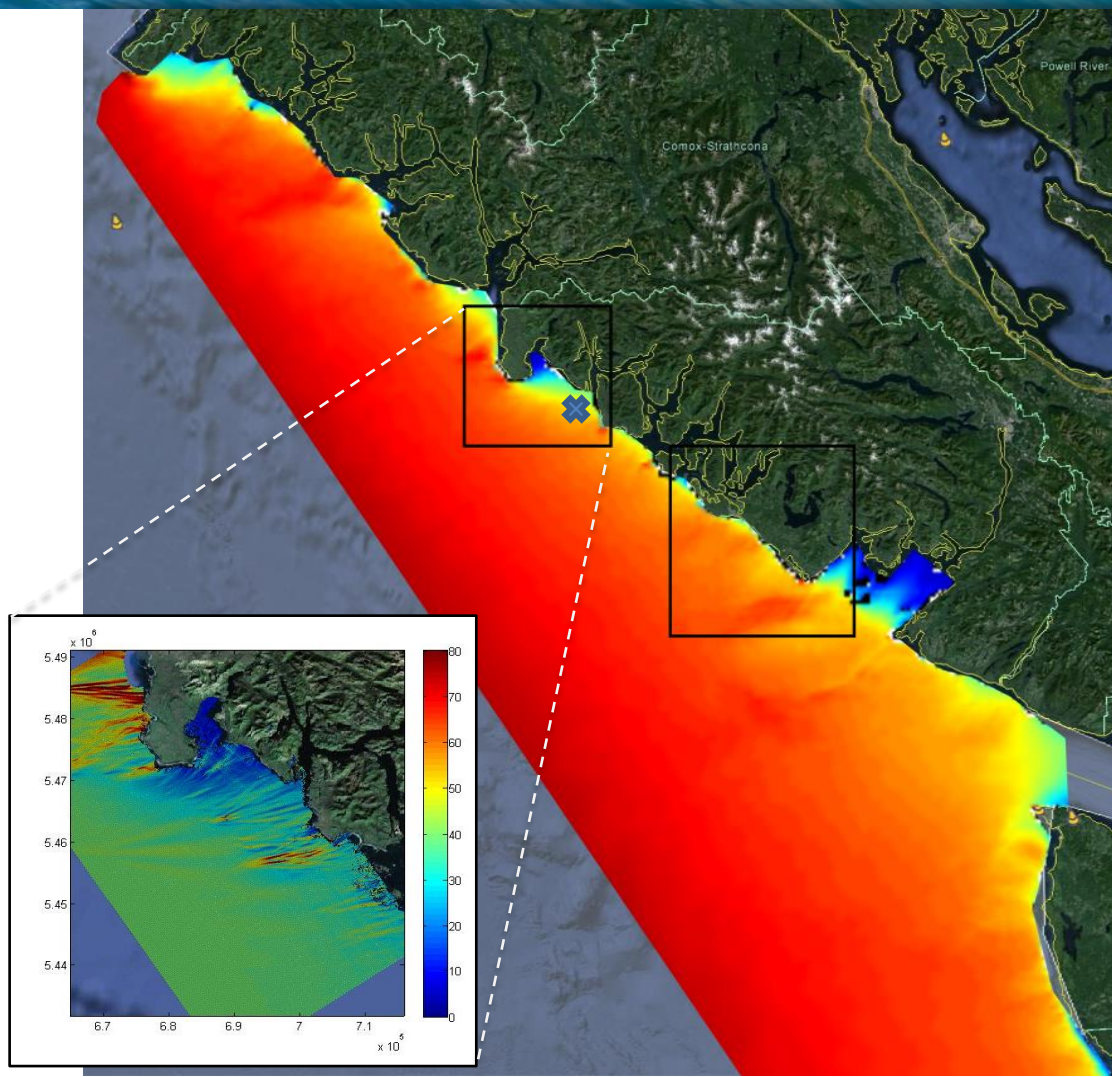
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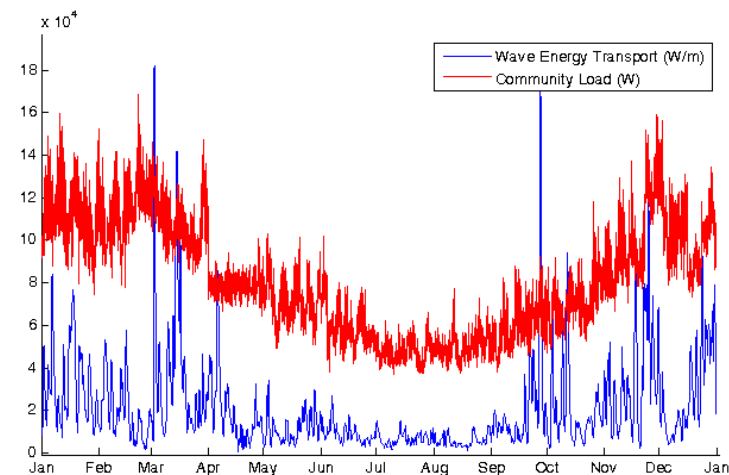
Gross Wave Resource Assessment – Hot Springs Cove

Wave energy | Motivation & objectives | People | **Gross resource** | Net resource | Usable resource



	Energy Transport (kW/m)	Wave Height (m)	Energy Period (sec)	Wave Direction (degrees)
Winter				
Mean Value	34.1	2.38	9.77	240
Mean 10 th %	8.4	3.56	11.9	215
Mean 90 th %	69	1.36	7.69	255

Summer				
Mean Value	10.1	1.35	9.4	238
Mean 10 th %	19.8	1.93	12.7	215
Mean 90 th %	3.5	0.91	6.71	257



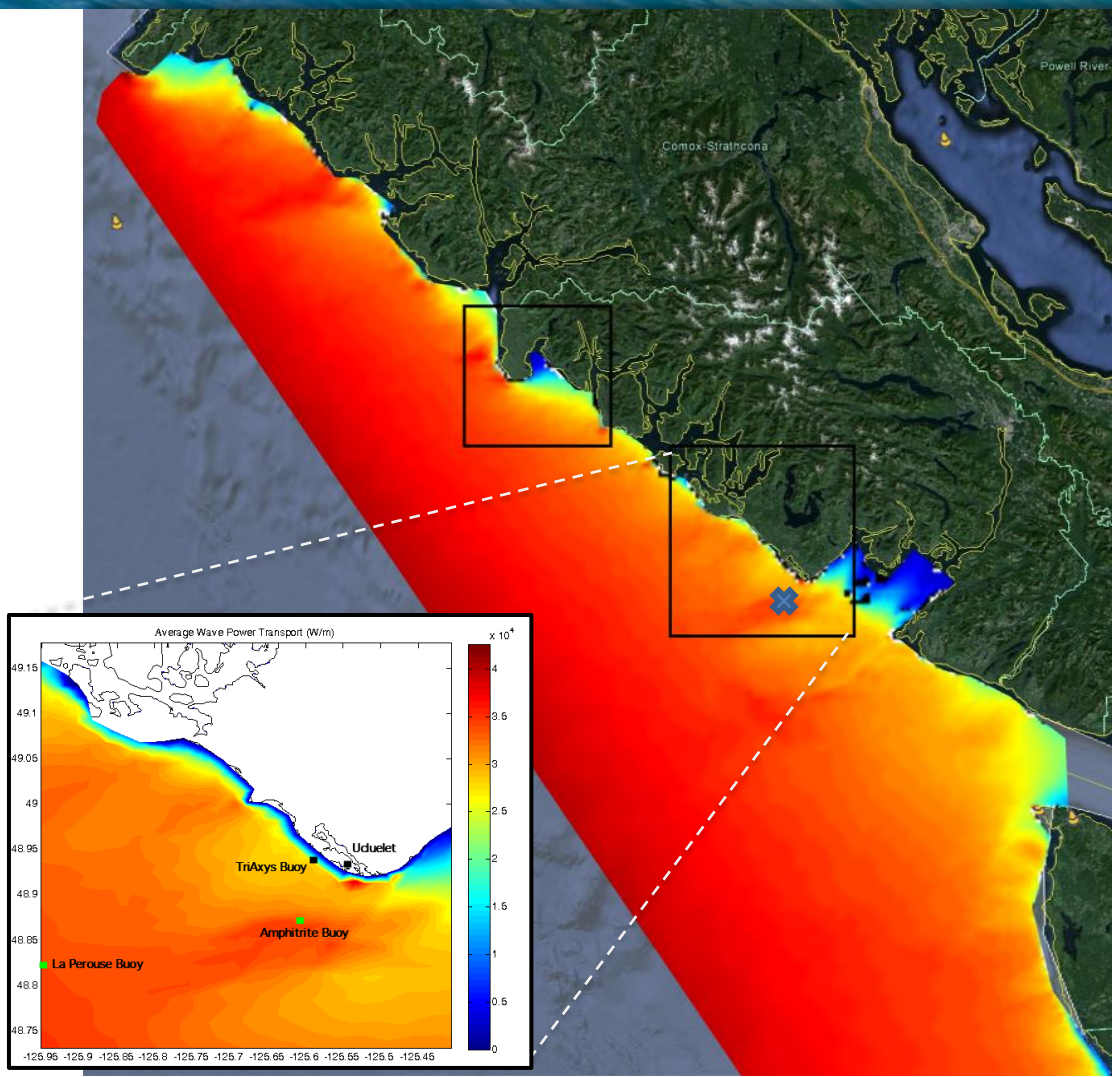
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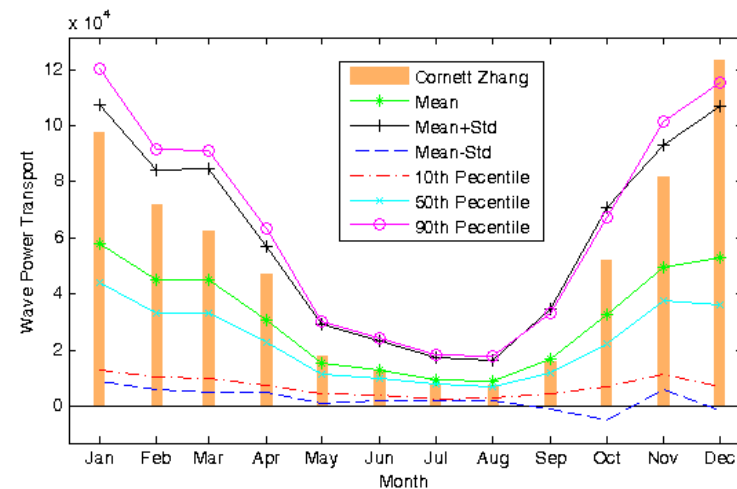


Gross Wave Resource Assessment - Ucluelet

Wave energy | Motivation & objectives | People | **Gross resource** | Net resource | Usable resource



	Energy Transport (kW/m)	Wave Height (m)	Energy Period (sec)	Wave Direction (degrees)
Winter				
Mean Value	41.9	2.70	9.84	250
Mean 10 th %	8.70	1.50	7.56	215
Mean 90 th %	87.0	4.07	12.1	275
Summer				
Mean Value	10.8	1.51	8.78	246
Mean 10 th %	2.10	0.98	6.21	201
Mean 90 th %	28.0	2.14	12.1	275



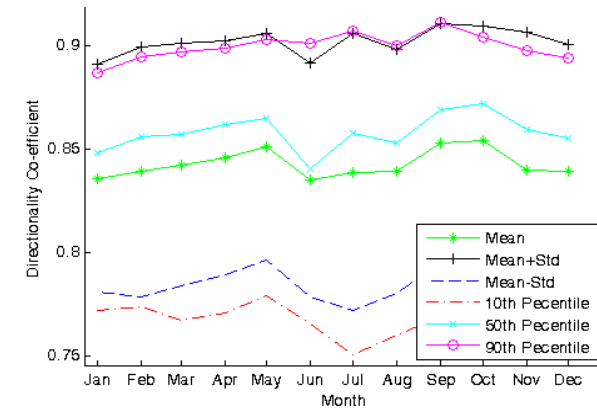
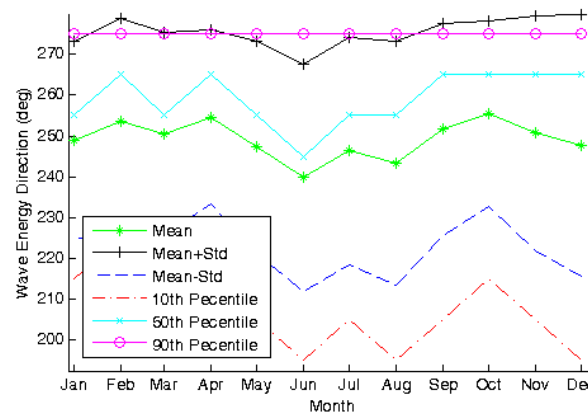
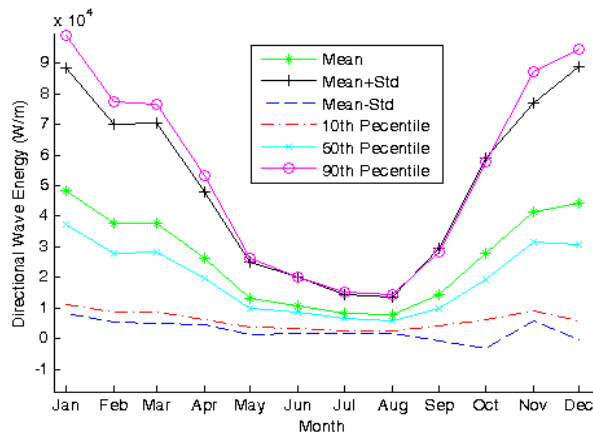
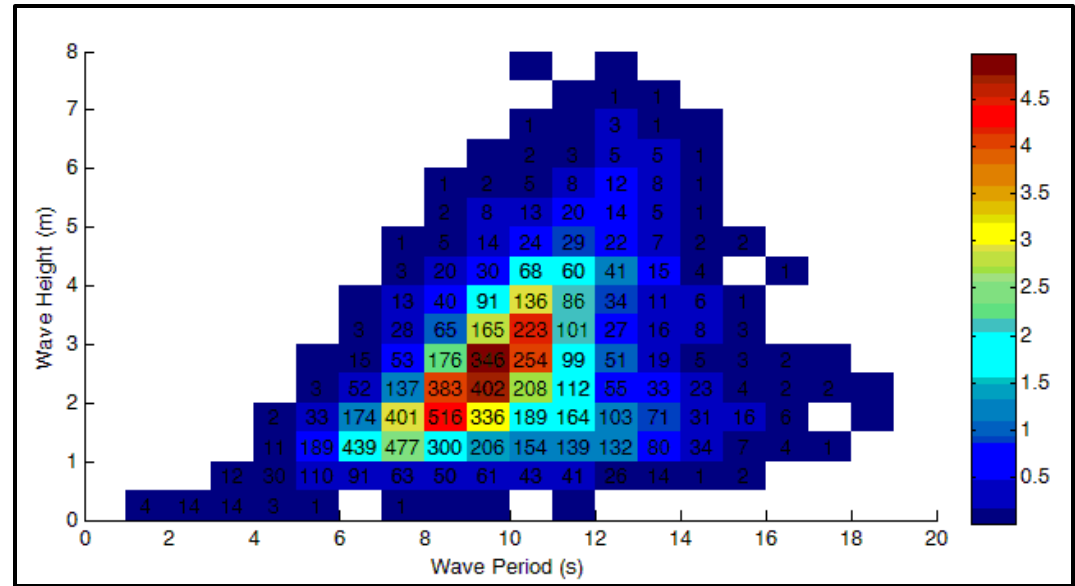
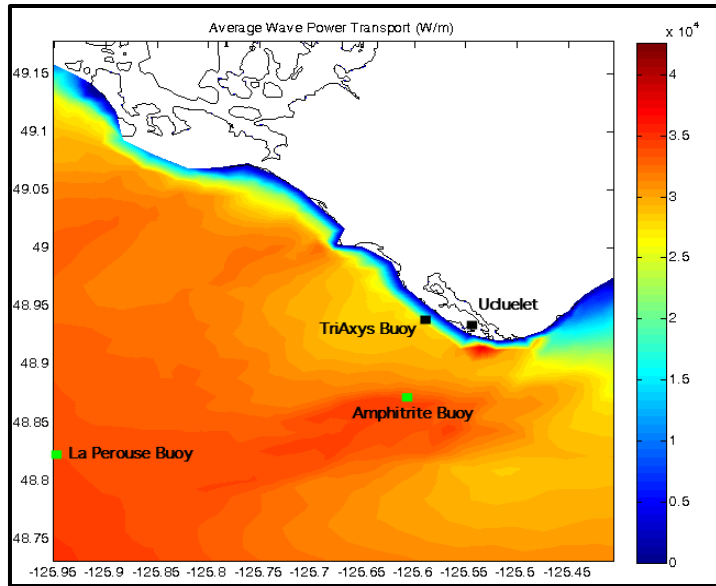
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Gross Wave Resource Assessment - Ucluelet

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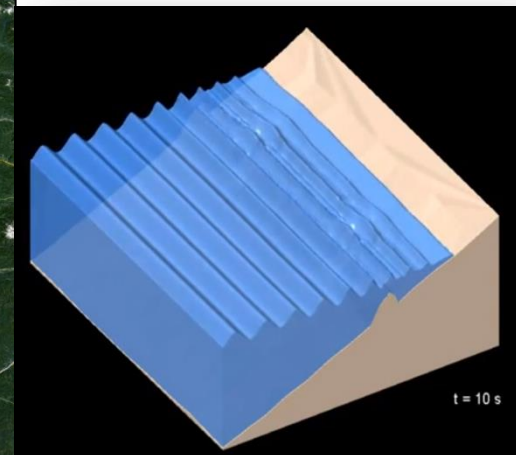
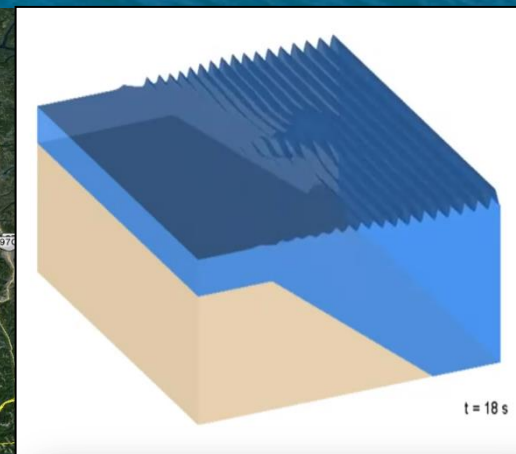
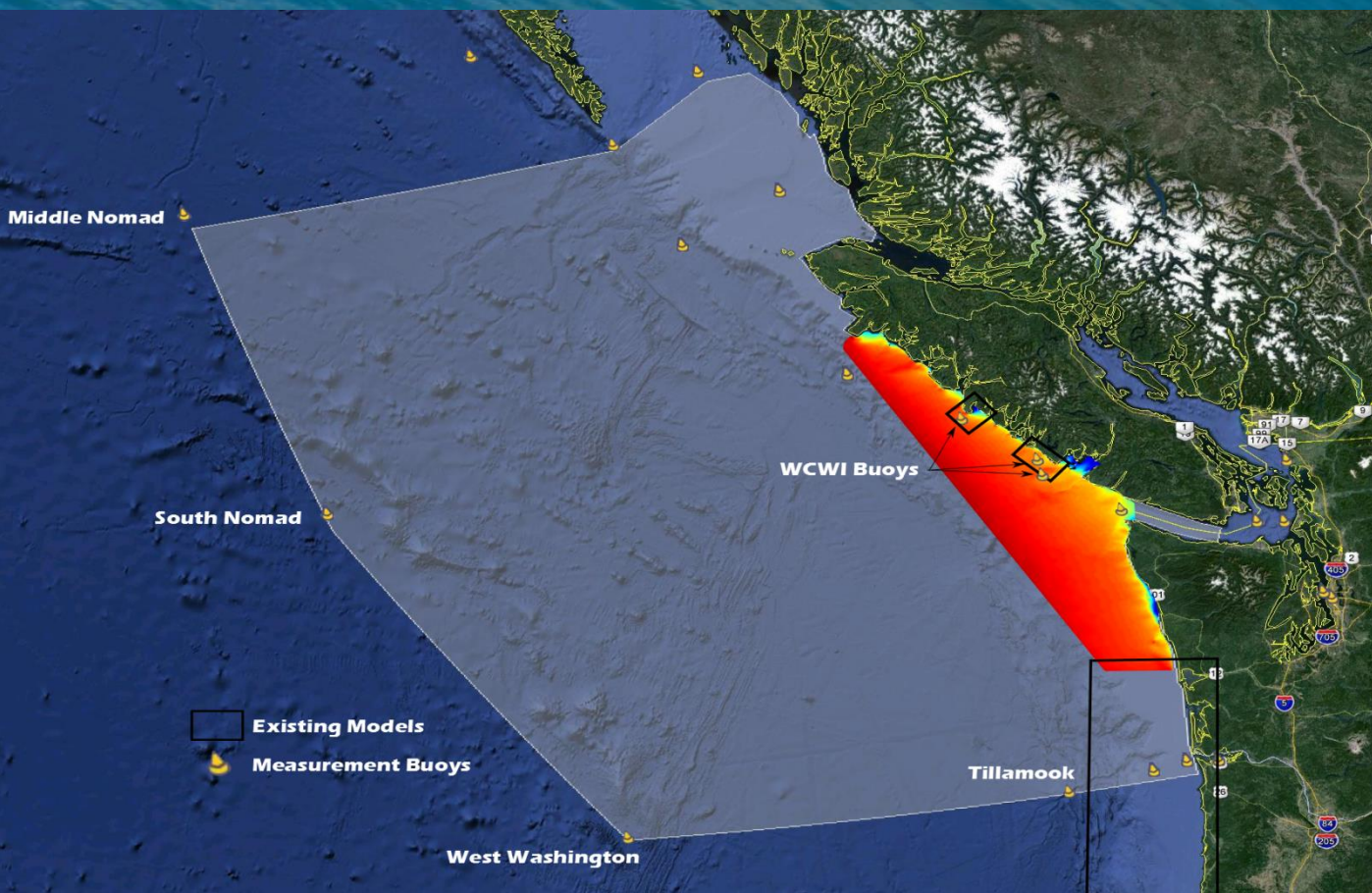
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West Coast Wave Initiative – Next Steps

Wave energy | Motivation & objectives | People | **Gross resource** | Net resource | Usable resource



- Larger SWAN Model: Directional Spectrum, North Island, Central Coast
- SWASH Model: Resolve non-linear near shore processes



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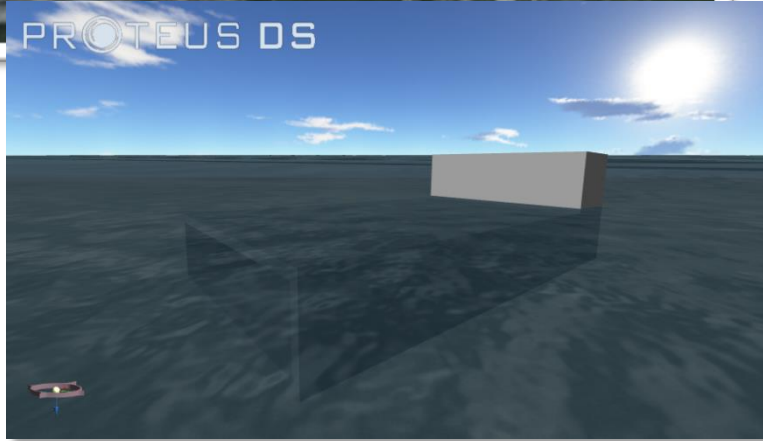


West Coast Wave Initiative – partner technologies

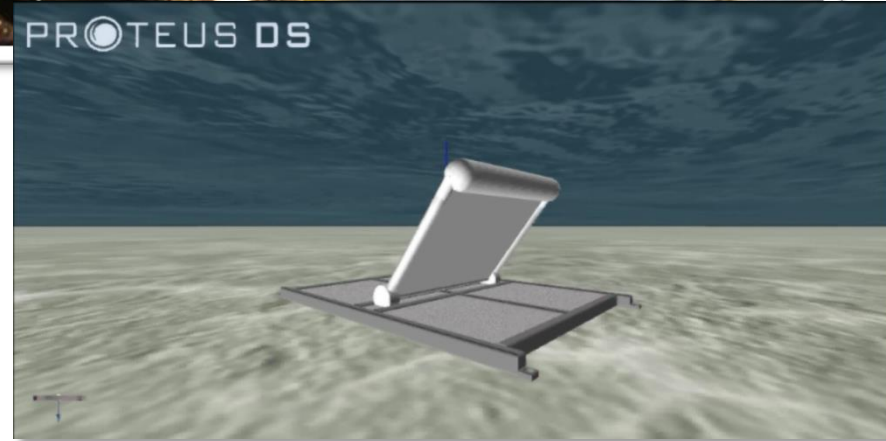
Wave energy | Motivation & objectives | People | Gross resource | **Net resource** | Usable resource



PROTEUS DS



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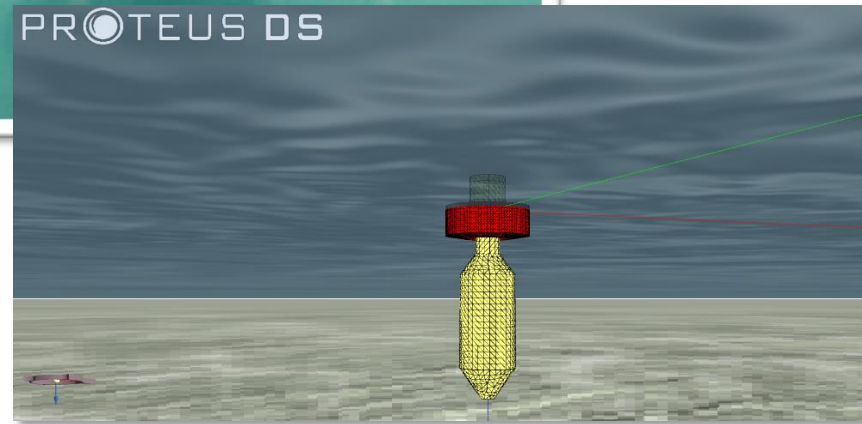
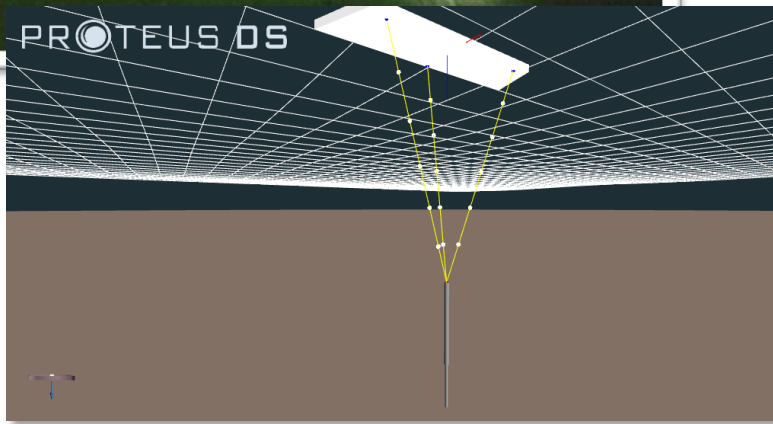
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West Coast Wave Initiative – partner technologies

Wave energy | Motivation & objectives | People | Gross resource | **Net resource** | Usable resource



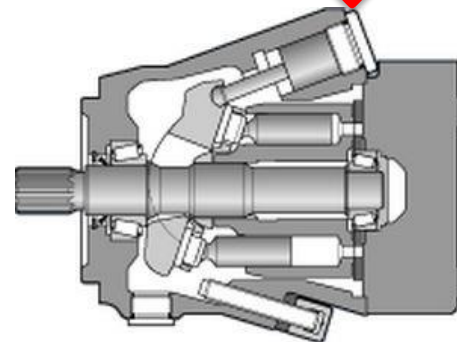
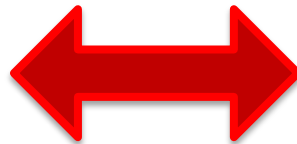
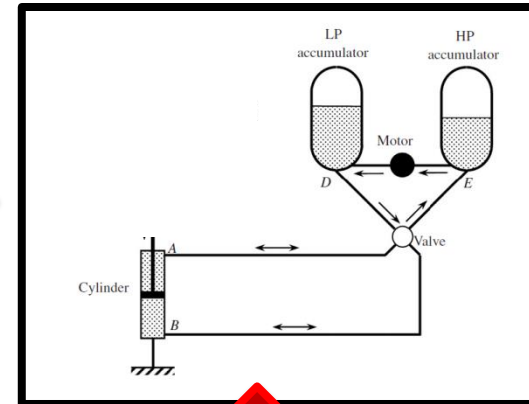
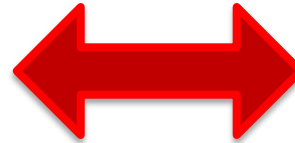
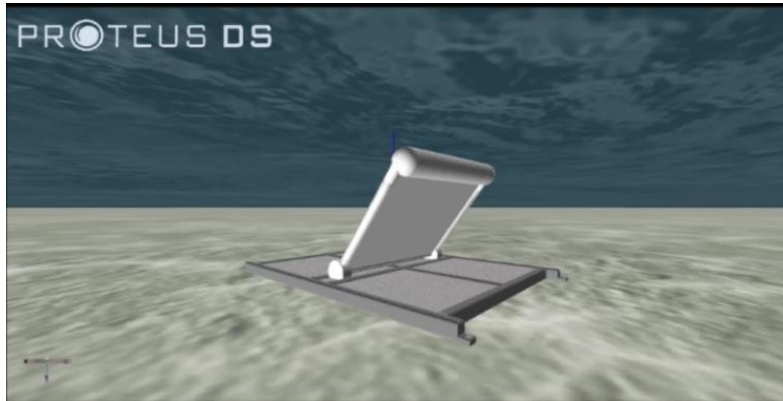
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Technology Simulations – power take off dynamics

Wave energy | Motivation & objectives | People | Gross resource | **Net resource** | Usable resource



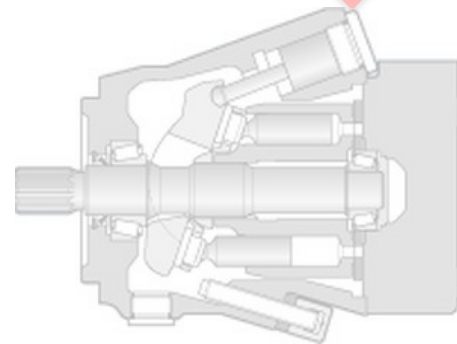
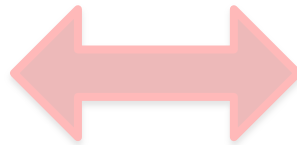
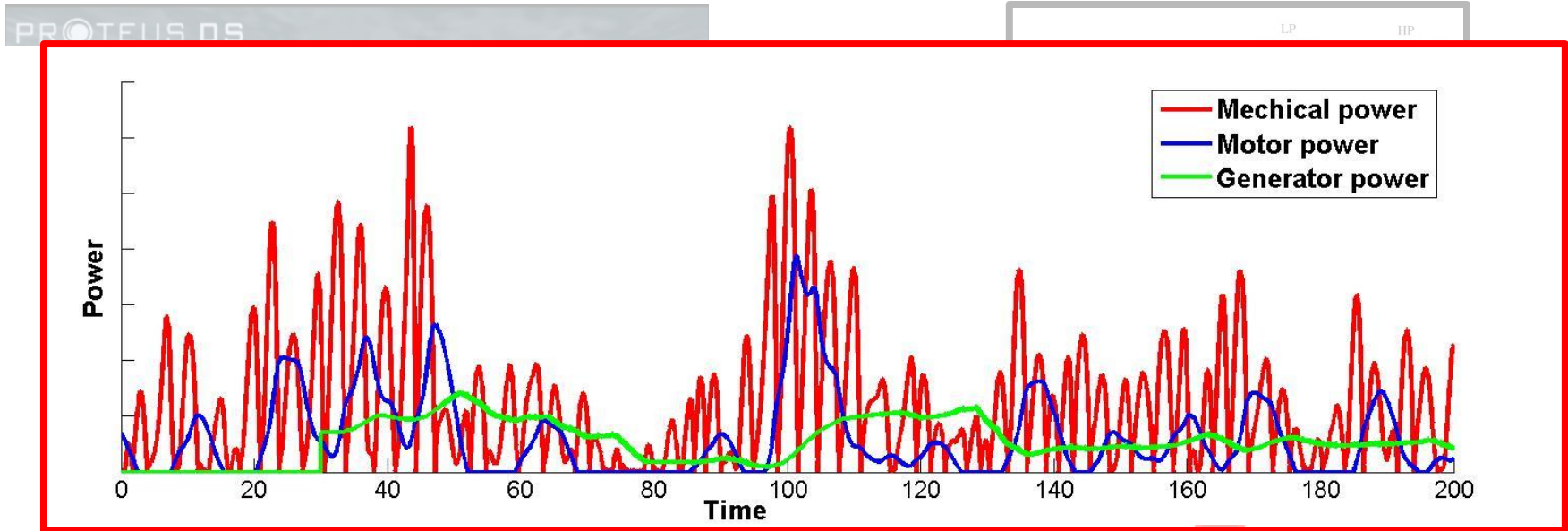
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Technology Simulations – power take off dynamics

Motivation & objectives | Gross resource | **Net resource** | Usable resource



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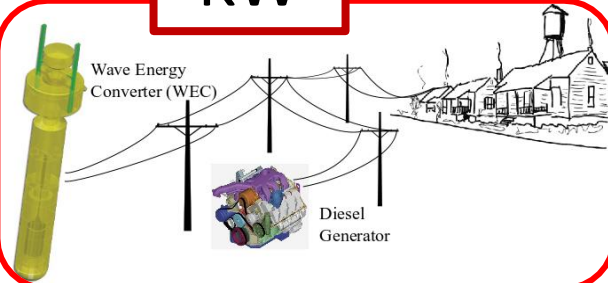
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Grid Integration – Useable Resource

Wave energy | Motivation & objectives | People | Gross resource | Net resource | **Usable resource**

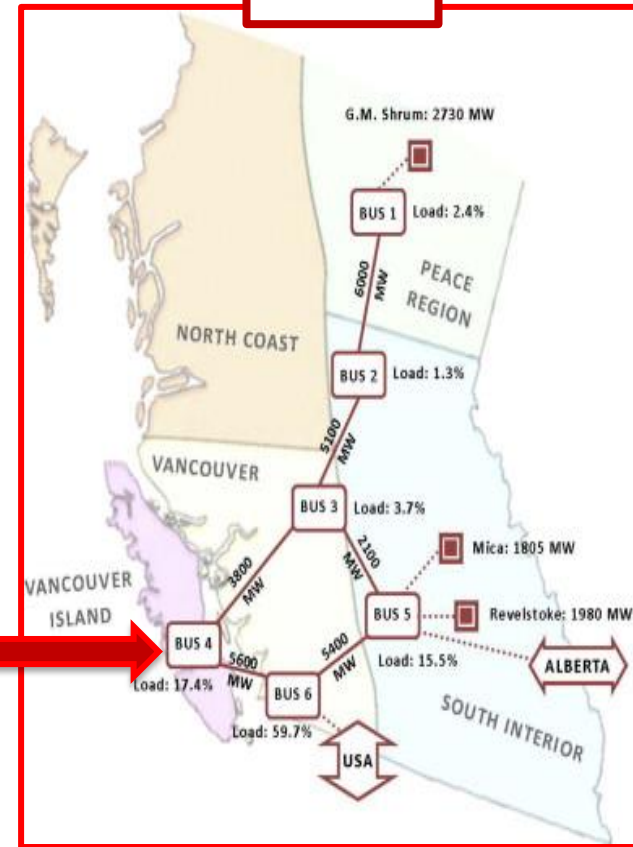
KW



Hesquiaht



GW



MW



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