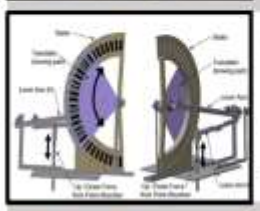
Neptune Wave Engine **Wave Energy Testing Station**

NeptuneWave.ca is a privately funded R & D corporation. It has developed the Neptune Wave Engine, which:

- **uses multiple Point Absorbers constrained to reciprocate up and down from wave energy along vertical piles embedded in the sea floor;**
- **operates in shallow water, less than 30 m deep, usually near shore, allowing overhead power transmission lines;**
- **uses common low height waves from .25 m to 4.5 m high;**
- **produces continuous power more than 8,000 hours per year (1 yr = 8,760 hrs);**
- **is economically viable.**

2010 Linear Generator
Generator above point absorber out of water, direct drive, makes electricity but slow stop & go motion needs to be speeded up.



2011 Compound Levers
Lever arms speed up motion but forces at stop points need capturing (by spring or hydraulics), rotation more technically feasible for us.

2012 Custom PM Generator
1.2 m diameter generator (ref. Hugh Piggott) enables electricity generation from relatively slow (< 200 rpm) rotation speeds.

2013 Direct Drive PTO
Patented method to convert reciprocating motion to one way rotation motion with power input from both up and down strokes.

2014 Full Size Floating Unit
Complete electricity producing full sized unit with direct drive PTO and generator. It produced 460 Volts, no load 3 phase power from 0.5 m waves.

2015 Tidal Compensator
PCT Patented maintains the floating "registered vessel" complete power producing unit in the waves during 6 m high tides.

2016 Disharmony of Floats
We hypothesized that a 10:1 weighted floating "vessel" would ensure that it moved in disharmony with the point absorber motive float.

2017 Test Lever Arm PA
Point Absorber tested under 4 conditions with 3 tests each for 3 wave sizes (36 tests) proved concept would be economically viable and scalable.

2018 Multi Point Absorbers
Test of 4 PAs on lever arms required mitigation due to high 2.6 m/s (5 knot) currents and 6 m/s horizontal wave transfer forces at test location.

2019 Point Absorber on Pile
Test proves unit is stable in wave & current conditions. Vancouver Wave Test Station added for 3rd party verification of power output.

Brief Summary of 10 years of Wave Energy Development

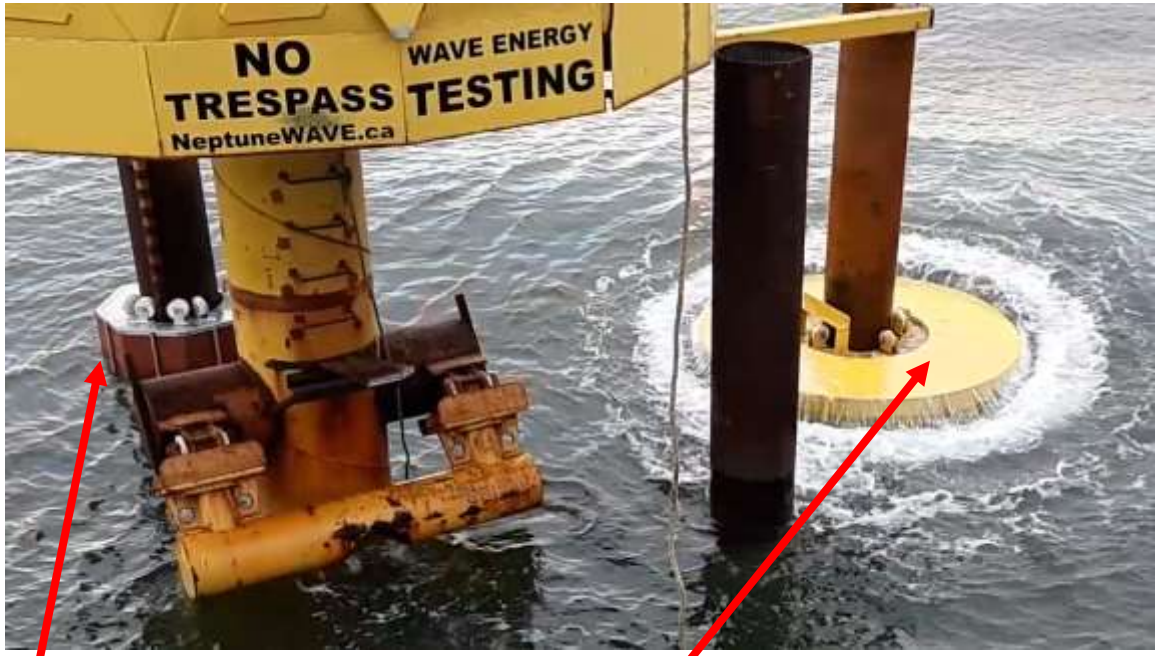
10 Years of Wave Engine Development

the Vancouver Wave Energy Test Station has been deployed.

The Test Station allows:

- **interested 3rd parties**
- **to verify with their own people and their own instruments,**
- **that the continuous electrical outputs claimed,**
- **from the various small waves available in the test location,**
- **are true.**

Test location is 800 m off Point Grey, in Vancouver Harbour, Strait of Georgia.



1. This Float is used for Wave Height Measurements at 100 ms data pulse

2. Single Piston Point Absorber (3 m dia.) is used for energy input from waves of various heights

3. Interior of test station

4. Testing Work Bench instruments & hook ups for verifier's instruments

5. Mobile App for real time display

Neptune Test Scatter Chart 1 Shows: (a) hours / year for Avg. Period & Avg. Height cell; (b) Projected kWh/h; (c) Actual kWh/h — NeptuneWave Engine Model: T-11019

WAVE HEIGHT & PERIOD VALUES FROM HALIBUT BANK STATION DATA FOR 2016 — Conversion Formula used: Havg = Hs*.7017

Avg Period [s]	2.22	2.74	2.95	3.24	3.33	3.74	4.1	4.27	4.79	5.33	5.89	6.4	6.92	7.42	SUM Hrs / yr /WH Row	SUM % T. Hrs/ yr /WH Row	SUM kWh / yr /WH Row	SUM % kWh / yr /WH Row
Avg W. Height [m]																		
(a) 0.1 Hrs / yr.	212	146		94		24	667	86	24	12	108	177			1550	18%		
(b) 0.1 Proj. kWh/hr	1.5	1.3		1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5					1,443	4%
(c) 0.1 Actual kWh/hr																		
(a) 0.2 Hrs / yr.	296	401		159	789	36		60	13	8	82	67	7	3	1921	22%		
(b) 0.2 Proj. kWh/hr	3.1	2.5		2.1	2.1	1.8		1.6	1.4	1.3	1.2	1.1	1.0	0.9			4,253	13%
(c) 0.2 Actual kWh/hr																		
(a) 0.3 Hrs / yr.	94	510	319	215		48		19	8	3	2	3	3		1224	14%		
(b) 0.3 Proj. kWh/hr	4.6	3.8	3.5	3.2		2.8		2.4	2.2	1.9	1.7	1.6	1.5				4,365	13%
(c) 0.3 Actual kWh/hr																		
(a) 0.4 Hrs / yr.	27	496	187	509		89		11	15	4		2			1340	15%		
(b) 0.4 Proj. kWh/hr	6.2	5.0	4.7	4.2		3.7		3.2	2.9	2.6		2.1					6,101	18%
(c) 0.4 Actual kWh/hr																		
(a) 0.5 Hrs / yr.		26		389	60	94		11	7	4					591	7%		
(b) 0.5 Proj. kWh/hr		6.3		5.3	5.2	4.6		4.0	3.6	3.2							3,047	9%
(c) 0.5 Actual kWh/hr																		
(a) 0.62 Hrs / yr.		28		559	73	419		64	9	8					1160	13%		
(b) 0.62 Proj. kWh/hr		7.8		6.6	6.4	5.7		5.0	4.4	4.0							7,133	21%
(c) 0.62 Actual kWh/hr																		
(a) 0.84 Hrs / yr.				68		353	18	168	21	10	3		1		642	7%		
(b) 0.84 Proj. kWh/hr				8.9		7.7	7.0	6.8	6.0	5.4	4.9		4.2				4,788	14%
(c) 0.84 Actual kWh/hr																		
(a) 1.1 Hrs / yr.						10		73	24	1	1				109	1%		
(b) 1.1 Proj. kWh/hr						10.1		8.8	7.9	7.1	6.4						949	3%
(c) 1.1 Actual kWh/hr																		
(a) 1.2 Hrs / yr.						5		50	26	1	1				83	1%		
(b) 1.2 Proj. kWh/hr						11.0		9.6	8.6	7.7	7.0						776	2%
(c) 1.2 Actual kWh/hr																		
(a) 1.6 Hrs / yr.						1		14	47	25	12	2			101	1%		
(b) 1.6 Proj. kWh/hr						14.7		12.9	11.5	10.3	9.3	8.6					1,121	3%
(c) 1.6 Actual kWh/hr																		
															8721	100%	34 MWh/yr	100.00%
SUM of Hours	629	1607	506	1993	922	1079	685	556	194	76	209	251	11	3	8721			

Note: *(at test location)*
Nep Test Engine w/ 1 small piston = 34 MWh per yr
Commercial Model w/ 1 larger piston = 121 MWh per yr
Commercial Model w/ 24 large pistons = 3,000 MWh / yr

Test Station Record Scatter Chart
Shows projected power & measured power outputs

TEST 1 – verification of projected power

The scatter chart shows the power projections to be verified from the single piston-absorber wave engine at the Test Station.

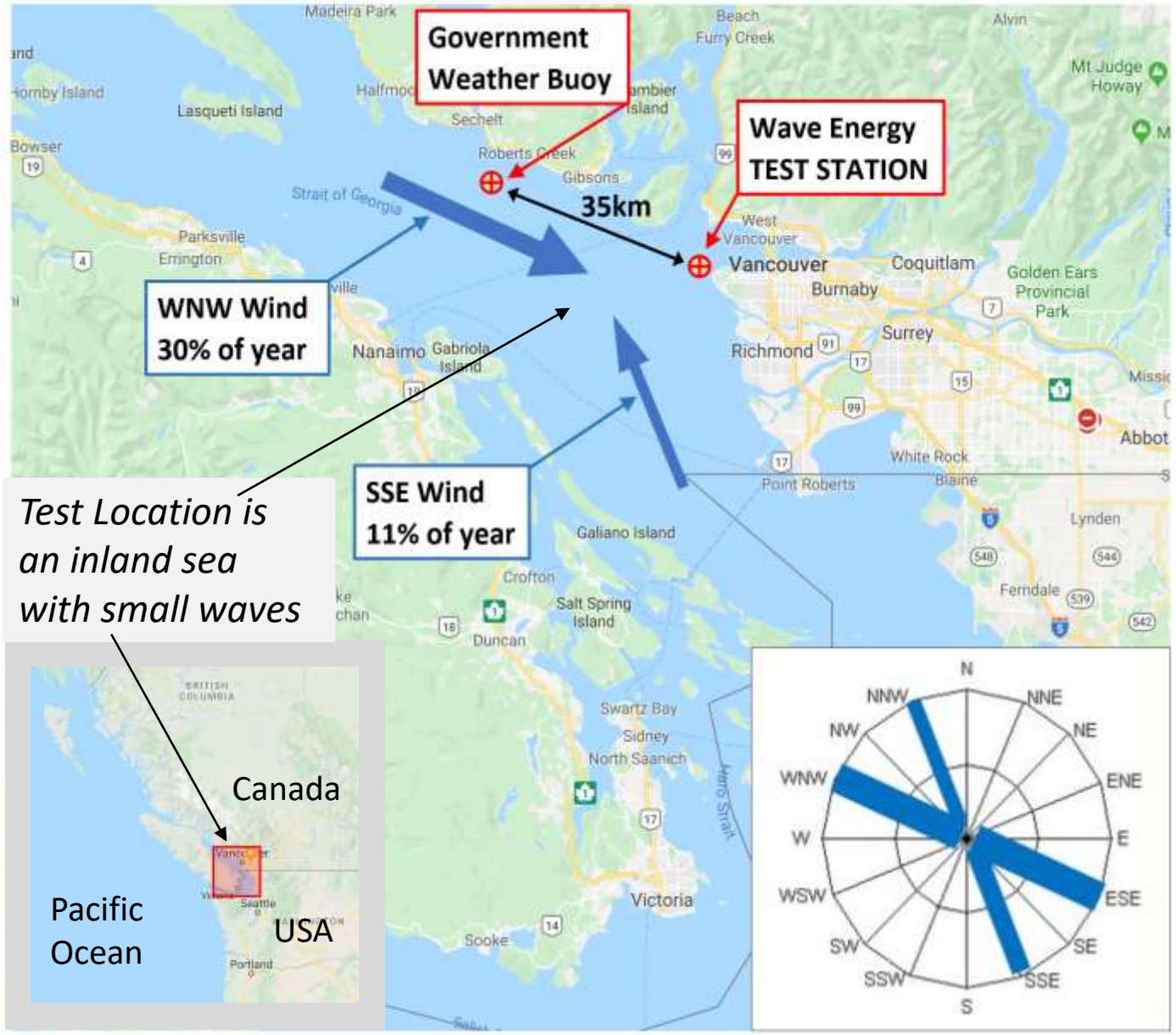
These projections result from full size tank and shop tests which have confirmed the calculations from the physics model of the entire system – from prime mover wave to continuous 3 phase AC output from the generator.

Test 1 will also determine the minimum continuous 'firm' electricity that this wave engine will generate per year in the test wave regime.

TEST 2 – optimization from feedback

Test 2 is concerned with testing the real time optimisation controls in the PTO with human feedback adjustments.

Once optimum benchmarks are determined for various wave regimes they will be automated by the PTO.



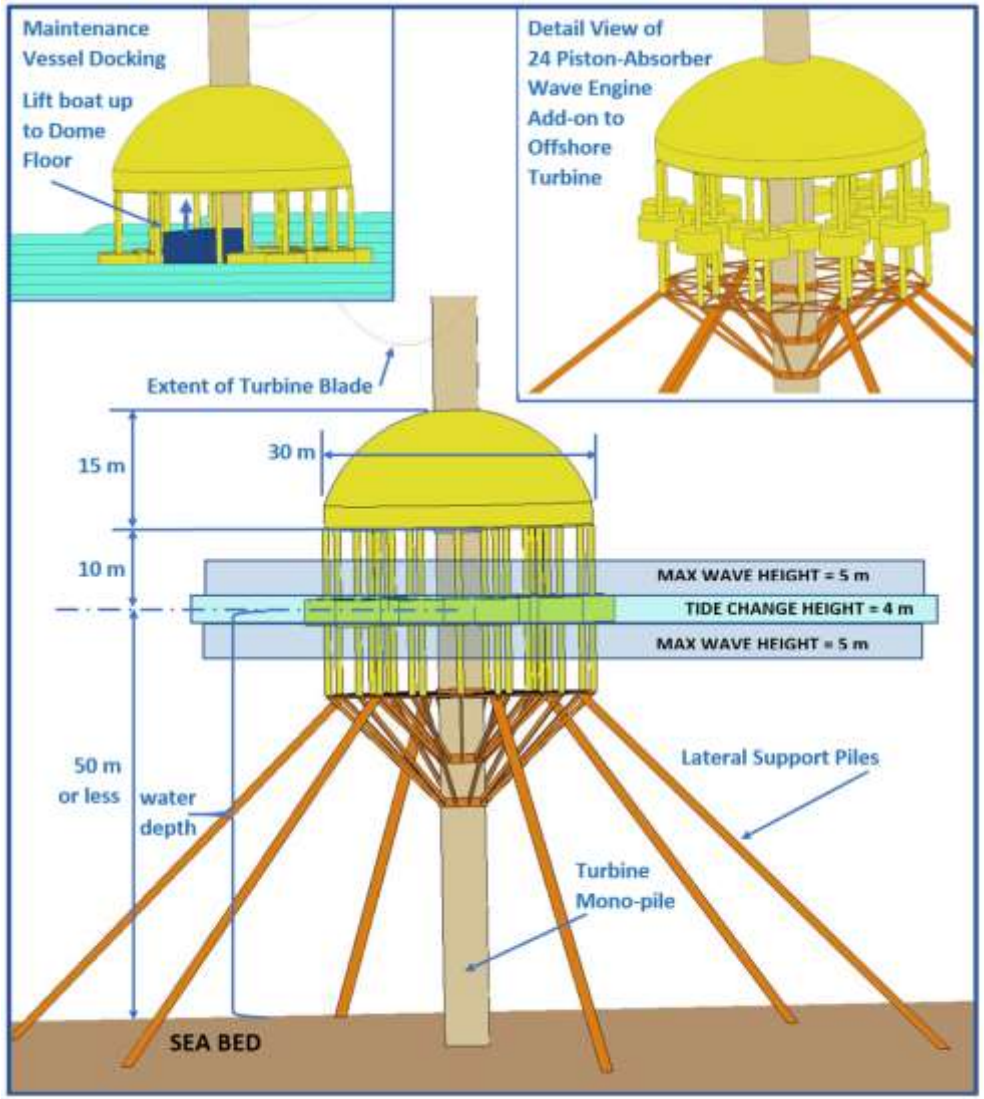
TEST 3

Test 3 uses the wave measurement-float on a pile at test site to record individual wave heights & periods. Averages /hour & significant wave heights [Hs] /hour are calculated.

These values will be compared with:
a. the wave values from a government weather station located 35km to the west, and,
b. the wave values for this area available from NOAA and Copernicus.eu WAVERYS.

It is hoped a reliable verified nexus of this data will result. This will enable predictions of wave engine output throughout the world.

This is an essential calculation for the wave energy industry. An opportunity exists for further research in this area such as PhD theses, particularly in open ocean locations.

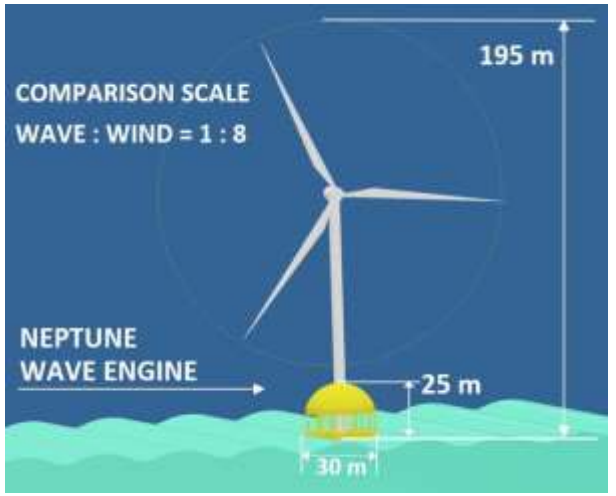


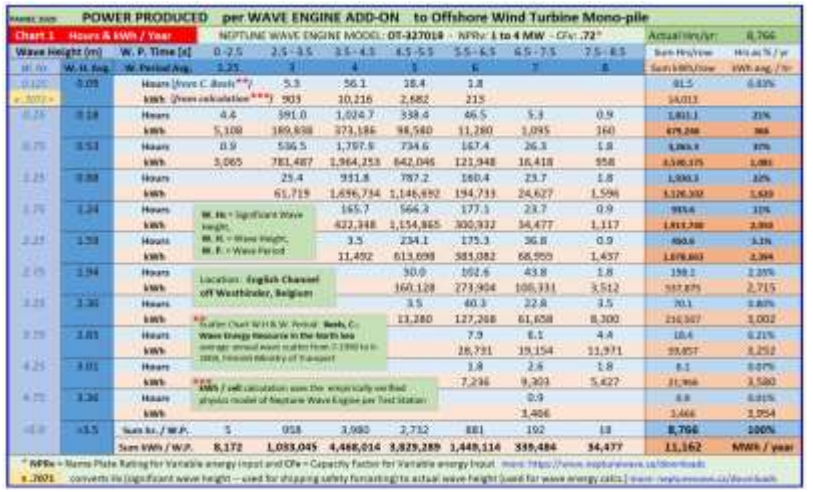
FEASIBILITY STUDY – Future Opportunities

A feasibility study sponsored by Otary (Belgium) for adding-on multi-piston Neptune wave engines to Otary's offshore wind turbine monopiles in the English Channel showed that:

a. relatively small wave engines, approximately 30 m diameter by 25 m high

b. were projected to produce over 7,500 MWh of electricity per year. A portion of this electricity would be output continuously for at least 8,000 hours per year





Wave Engine Add-On to Wind Turbine | **Size Comparison** | **Projected Power Scatter Chart**

Thank you

For more information
or to visit the
Vancouver wave energy test station

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