



**Neptune Wave Engine** 

**Wave Energy Testing Station** 

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

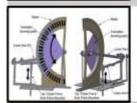
- uses multiple Point Absorbers constrained to reciprocate up and down from wave energy along vertical piles embedded in the sea floor;
- operates in shallow water, less than
   30 m deep, usually near shore, allowing overhead power transmission lines;
- uses common low height waves from.25 m to 4.5 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.



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



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.



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.



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



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.



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



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.



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.



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

10 Years of Wave Engine Development the Vancouver Wave Energy Test Station has been deployed.

### **The Test Station allows:**

- interested 3<sup>rd</sup> 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.

### **Brief Summary of 10 years of Wave Energy Development**





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

## PAMEC 2020 SESSION II. c.1 WAVES 14:00 - 16:00 Monday January 27:

NAV	VE HEIGHT & PERIOD V	ALUES FR	- ALEXANDER OF THE PARTY OF THE			N DATA F	OR 2016		Conversi	on Formu		Havg = Hs	*.7017			SUM	SUM %	SUM	SUM %
	Avg Period [s]	2.22	2.74	7.95	3.24	3.33	3.74	4.1	4.27	4.79	5.33	5.89	6.4	6.92	7.41	Hrs / yr	T. Hrs/ yr	kWh/yr	kWh/yr
1	Avg W. Height [m]															/WH Row	/WH Row	/WH Row	/WH Ro
(a)	0.1 Hrs / yr.	212	146		94		24	667	86	24	12	108	177			1550	18%	1.111	
(6)	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	6	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	1	-		100000														
(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																		
(8)	0.4 Hrs / yr.	27	496	187	509		89		11	15	4		2			1340	15%	2007000	
<b>(b)</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	11	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%		
[6]	0.62 Proj. kWh/hr		7.8	ii.	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%		
[6]	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)	0.64 Actual kWh/hr																		
(a)	1.1 Hrs / yr.			-		_	10		73	24	1	1				109	2%		
(b)	1.1 Proj. kWh/hr	Note:	(at tes	t locati	on)		10.1		8.8	7.9	7.1	6.4						949	3%
(c)	1.1 Actual kWh/hr	Nep Te	st Engine	w/1 st	nall pisto	n		1											
(a)	1.2 Hrs / yr.		(Wh per )				5		50	26	1	1				83	1%		
(b)	1.2 Proj. kWh/hr	Commercial Model w/ 1 larger piston				11.0		9.6	8.6	7.7	7.0						776	2%	
[c]	1.2 Actual kWh/hr	= 121 A	AWh per	yr		CALL I													
(a)	1.6 Hrs / yr.	Commercial Model w/ 24 large pistons = 3,000 MWh / yr				istons	1		14	47	25	12	2			101	1%	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					_													
	ALIEN AND STREET							101011		94500		1045.0				8721	100%	34 MWh/yr	100.00%
	SUM of Hours	529	1607	506	1993	922	1079	685	556	194	76	209	251	11	3	8721			

## **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.

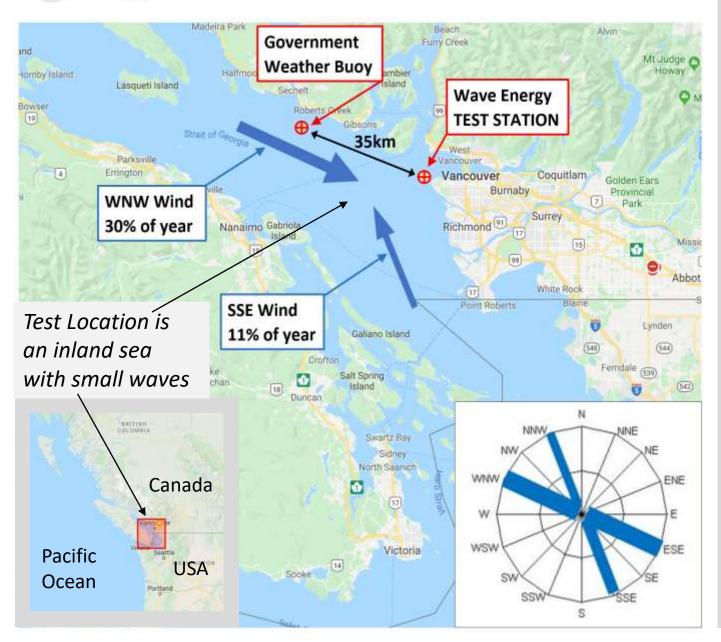
Test 1 will also determine the minimum continuous 'firm' electricity that this wave engine will generate per year in the test wave regime.

**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.

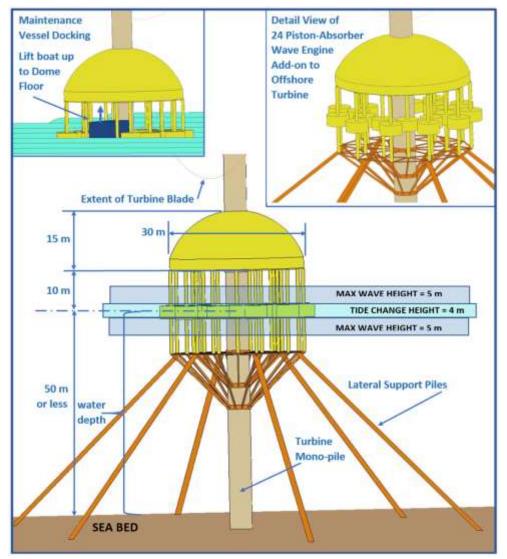
#### These values will be compared with:

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

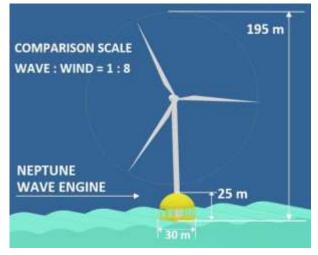
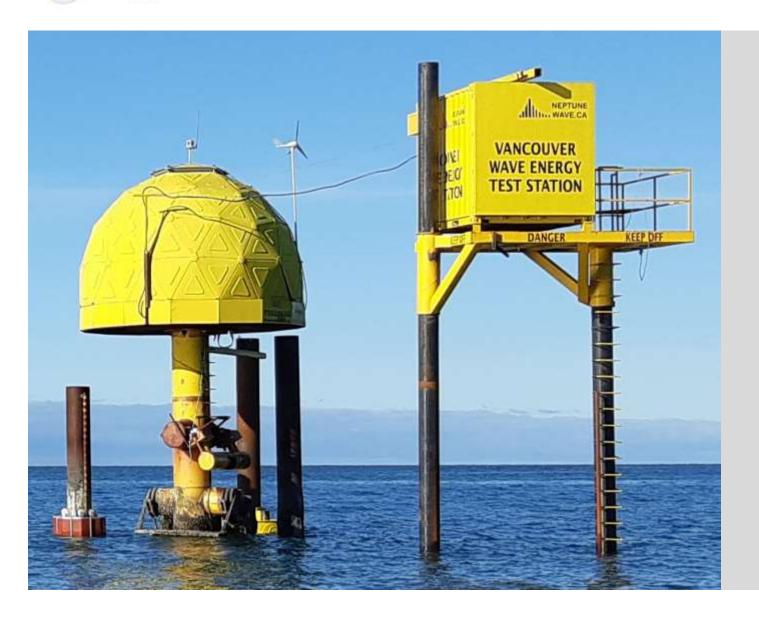


Chart I	Hours &	EWN / Year	NEPTLA	ME WAVE ENG	JOOM 345	OT-327018	NPRV: A to	o 4 MW - CF	v: .72*	Actual Health	8.766
Wave 10	(m) stgir	W. P. Time [4]	0.75	25-25	25-42	4.5-5.5	55-65	65-75	75 83	Sen-Hry/ree	History N. J. ye.
HE 70	W. H. frig.	W. Period Avg.	2.25		100	1000		The second		Services/now	What /m
	0.09	House Money	Cambany.	5.3	36.1	38.4	2.8			015	6.896
r.3077.+		ARRY Green	enhalation*	kulstion*** 935		2,682	215			SAULE	
4.25	10 da	Hours	4.4	391.0	1,024.7	338.4	46.5	518	0.9	1,001.3	21%
		600%	5,108	189,838	373,186	98,580	11,280	1,095	160	679.246	265
2.75	3.51	Makey	8.9	596.5	1,797.9	734.6	11867.4	26.3	8.3	3,203,7	30%
		1000	3,065	781,487	1,964,238	842,045	121,948	36,418	958	8,549,175	1,081
2.25	222	Hours		25,4	991.8	787.2	160.4	23.7	5.8	1,990.3	32%
		\$160m		61,719	1,696,734	1,146,692	194,733	24,627	1.594	5.126.302	3,99
1.75	134	Hours	W. Her Stand	Toront Manager	165.7	566.3	177.1	23.7	0.9	983.6	304
		100%	Swift.	No. of Lot	622,348.	1,554,865	300,932	34,477	1,117	1.811.700	2,018
235	138	Haytt	W. H 97 (c)		3.5	234.1	175.3	36.8	0.9	590.6	5.2%
		kown.	M.F.:Wee	Period:	31,492	613,698	585,082	66,555	1,437	3.076,003	2,394
20	3.94	Hours	Lincolne de	glish Channel		30.0	352.6	43.8	1.8	150.1	2.35%
	330	kWh:	off Weathing			160.128	273,904	105,331	3,512	587,875	2.715
225		Hours.		STATE OF THE PARTY		3.5	40.3	32.8	3.5	70.1	2.87%
		\$18% P	Turn-Durin	VHS.W. Person:	Steb Co	13,280	127,268	61,658	8,300	216,367	1,002
2.29	2.83	Heart	Water Drings 6	resource to the fo	tor the head		7.9	8.5	4.6	10.4	0.21%
		6000		Delete Holder Her Montey of Transa			26,721	19,154	11,971	93,451	8,252
425	20.6	Heart			11		1.8	2.6	1.8	8.5	8479
		630%	Sales Produces	oddon see the	*****	this .	7,296	9,303	5,627	131,966	3,580
ATE	3.36	House	physica receipt	of Neutral We	ve Engine day 7	estitation 0.9			8.8	891%	
		6000						1,406		13,466	1,054
168	13.5	Sumbs./W.P.	5	958	3,980	2,712	1001	192	8.0	8,766	200%
		Sum WWW / W.P.	8,172	1.083.045	4,468,014	3,829,289	1,449,114	339,484	34,477	11,162	MWE / 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

please contact:

**Charles Haynes CEO at:** 

https://www.NeptuneWave.ca

