Evaluation of various WEC devices in the Romanian near shore

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Abstract: The present work presents a study related to the evaluation of the performance provided by various technologies for wave energy conversion that would operate on the western side of the Black Sea. This side is usually considered as being the most energetic part of the sea. An overview of the wave climate in the target area has been first carried out considering data coming from the Gloria drilling platform. Based on these data, diagrams for distributions of the sea states occurrences, defined by the significant wave height and the energy period, were designed separately for total and winter time. Considering the above scatter diagrams and the power matrices of various devices for the wave energy conversion the electric power expected was evaluated. The devices considered in this evaluation are: Wave Dragon,Pelamis,Aqua Buoy,Archimedes Wave Swing, Langlee, Oceantec,OE Buoy,Pontoon,Seabased ABand Wavebob.

The results of the present work show that, although not so rich in wave energy as the oceanic coastal environment, the western side of the Black Sea may present interest in the future for the marine energy extraction most probable in hybrid wind-wave projects.

Key-Words: Black Sea, wave power, WEC, renewable energy, electric power, wave height.

1 Introduction

In recent years the extraction of energy from the marine environment, and particularly from surface waves, has become an increasingly favorable alternative, being at the same time one of the most challenging technologies of the beginning of this century. This form ofenergy is abundant and is more predictable than wind or solar energy and it has also a higher energy density allowing an extraction of more energy in smaller areas than wind and solar energy.

Shoreline energy converters have been tested for some years and several successful devices have been installed. Within this category of alternative energy resources, generally, there are four classifications of conversion methods: the point absorber (using the wave-excited resonant, periodic motion of a device), an attenuator (using the differential motion of a wave surface) and the terminator (using oscillation of a water column). Several types of devices as well as an overview on the WEC evolution are given in Babarit et al, [1].

Despite a degree of uncertainty related to the variability in the wave climate, improvements of evaluating the environmental data in the marine areas would enhance also the accuracy of the predictions that future energy convertors yield. Until now, more evaluations of the wave conditions and of the wave energy resources in the Black Sea have been performed. Probably one of the most relevant can be the work of Rusu [2] where it has been proved that the western side of the sea is its most energetic part.

When harvesting the wave energy in a certain area, selecting the most appropriate device for this area is a very important issue. Depending of the bathymetric features, or some other particularities, the wave energy can be higher than in some other neighboring marine sectors. Also, other important issues are designing diagrams for the bivariate distributions of the sea occurrences, which correspond to the sea states defined by significant wave height and energy period. These diagrams can provide fundamental information concerning the performance of various wave energy converters (WEC) operating in a specific location.

The objective of the present work is to perform evaluations of the performance of ten different technologies for the wave energy extraction in the Romanian nearshore.

2 Wave climate in the western Black Sea

To assess the energy performance of WEC systems in the Black Sea area have been used a similar methodology to the one described by Rusu and Guedes Soares [3].

Wave measurements were considered from the Gloria drilling platform, the data covering the period: January 2003-December 2009.

In Fig. 1 is presented the area from where the wave data have been collected.

Fig. 1: Position of Gloria drill platform on the map.

In the month December it is the highest probability of occurrence of waves with heights greater than 7m.

Waves between 2–3 and 3–4m are present throughout the year with a frequency fairly equilibrated between summertime (60%) and wintertime (60.79%) and regarding wave periods, values greater than 9s were encountered only in January, while periods greater than 7s are characteristic only to wintertime.

In December, a significant enhancement occurs of periods from the class 5–7 s (61.01%), while the periods from the class 3–5 s represent only a 34.69%.

The dominant wave direction is from the northern sector (NW, N, NE) both for winter (51.71%) and summer (50.18%). In the southern sector (SE, S, SW), the percentages are 37.04% for winter and 32.12% for summer.

3 Conversion of the Wave Energy into Electrical Energy

In order to evaluate the energetic potential based on energy characteristics of the considered zone, scatter diagrams of the *Hs*-*Te* distributions were generated using significant wave heights (*Hs*) and wave energy period (*Te*) for the total period and for the winter season (October to March).

Such diagrams are presented also by [4] that made an analysis of the wave conditions of the Galician coast.

In general, the instrumentation does not provide the wave features with the form parameters *Te* and *Hs*, but they can be obtained indirectly through the relationships 1 and 2 [5, 6]:

$$Te = 0.9Tp = 1.269Tz \qquad (1)$$

$$H_s = \frac{H_m}{0.64} \qquad (2)$$

where: *Tp* and *Tz* represents maximum and mean wave period and *Hm* is the mean height of the wave.

Such a diagram shows the probability of various sea states occurrence expressed in percentages of the total number of observations. They are made of cells with size 0.5s×0.5m ($\Delta Te \times \Delta Hs$) and the color of each cell represents the percentage that it occupies reported to the figure legend.

In addition to these data in diagrams are represented also the isolines of wave power, which for large water depths are calculated with the equation [7]:

$$P_W = \frac{\rho g^2}{64\pi} TeHs^2 \qquad (3)$$

where P_W is the energy flux in watts per meter (length of wave crest), $\rho = 1025 kg/m^3$ is the water density and $g = m/s^2$ is the gravitational acceleration.

For the platform Gloria, these distributions are shown in Fig. 2 and they are valid for the period: January 2003 - December 2009. The most common sea states are in the range 3-9s (*Te*) and 0-2.5m (*Hs*) and are located in isoline of 25kW/m. It also can be observed the cells between the isolines 25kW/m and 100kW/m but for which the percentage values do not exceed 0.5%.

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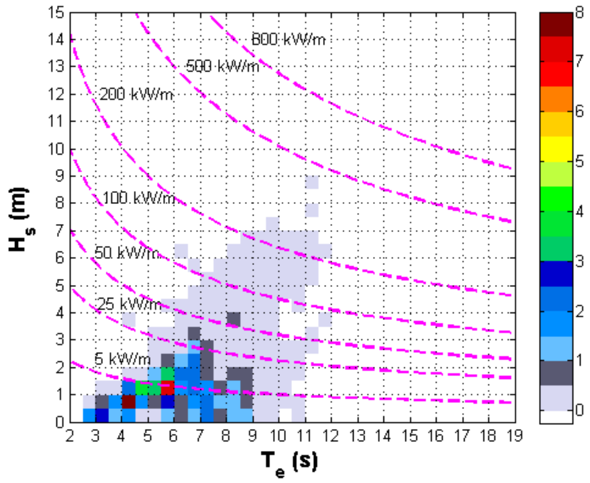

Fig. 2: *Hs-Te* diagram corresponding to Gloria station reported to the total period for the time interval: January 2003-December 2011. Colored squares are representing the number of occurrences expressed in percentage of all observations, which have a length of 0.5s in direction x and a length of 0.5m in direction y. Also in the figure are represented the isolines of wave power.

In Fig. 3 the diagram *Hs-Te* for the Gloria station reported for the winter period is presented. Most values obtained are also grouped in intervals *Te* and *Hs* given in the total period, except that in this case they are concentrated more diagonally, occurring a significant distribution between the isolines 5kW/m and 50kW/m.

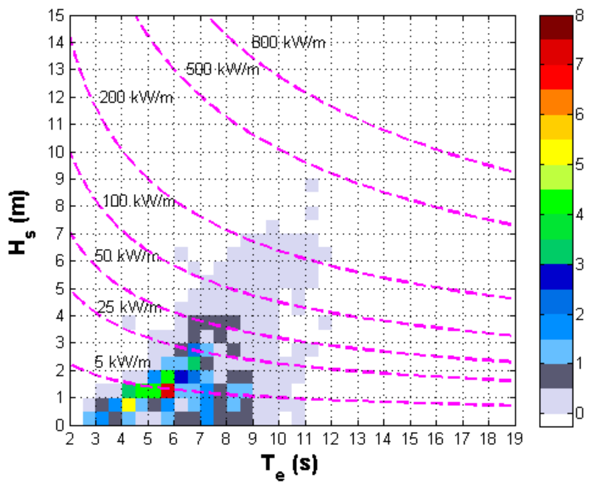

Fig. 3: *Hs-Te* diagram corresponding to Gloria station reported to the winter season for the interval time: January 2003 - December 2011.

The highest percentage of all observations (7%) occurs around the combination 5.5s-1m where a wave power of 5KW/m is recorded. This distribution of data leads to a frequent occurrence of some wave powers in the range of 25 - 50kW/m, an aspect that is not reflected by the Gloria station.
For the winter period (Figure 2) it is observed that the waves high smaller than 0.5m have a reduced contribution to the overall condition of the sea, also registering the wave height appearance between the interval 3.5-4m, which are leading to obtain a wave maximum power of 75kW/m.

Gloria station shows wave conditions that include also waves that exceed 8m (0.5%), in this situation the majority of WEC systems must be turned off to avoid damage.

From the analysis of wave measurements can be identified theoretical energy for various periods of time, but electricity that can be obtained depends on the individual characteristics of each WEC system. The same like in the case of the wind turbines, where manufacturers describe their performance through a power curve, the performances of the WEC systems are obtained with the help of a power matrix.

To each bivariate diagram, a table was associated, showing the wave activity in the time interval 2003–2009 for the total and winter time, respectively. These tables indicate the number of occurrences, in percentage from the total.

Of course, the electric power yield, depend on the WEC characteristics. Because each technology has different efficiency under various sea states and have their own operating principles. the most appropriate WECs for a specific area are those that have the maximum efficiency in the ranges of *Hs* and *Te* that provide the bulk of occurrences. Regarding these issues of various WEC devices is given by Dunnett [8].

The performance data of any product is distributed by the WEC manufacturers as a function of *Hs* and of a wave period. This performance is provided in tables, showing the expected power output and a distinct pair of significant wave height and wave period is presented to as an amount of energy.

Ten wave energy converters are considered in the present work. These are Wave Dragon [9], Pelamis [10], Aqua Buoy [11], Archimedes Wave Swing [12], Langlee [1], Oceantec [13], OE Buoy [1], Pontoon [1], Seabased AB [1], Wavebob [1]. This system was chosen because each is representative for the class of devices in which are included: point absorber, attenuator and terminator. All ten devices are designed to operate in offshore areas. Moreover, the ten considered devices also cover a wide range of dimensions and of their power capacities that can produce. For example, Wave Dragon is characterized by a large size while Aqua Buoy is of smaller size (the bins for these cases are defined in terms *Hs* and *Tp* and the bin resolutions are 1 s × 0.5 m and 1 s × 1 m) and Pelamis have average dimensions (the bins are defined in terms of *Hs* and *Te with the* bin resolution 0.5 s × 0.5 m).

To estimate the energy produced by a WEC system in a certain period of time, the most common method is to associate the power matrix of the of the WEC system to the environmental matrix from the considered area in the determined time interval. This can be done using the equation:

$$P_E = \frac{1}{100} \cdot \sum^{n_T} \sum^{n_H} p_{ij} \cdot P_{ij} \qquad (4)$$

where P_{ij} is the energy percentage corresponding to the cell defined by line *i* and column *j* in the environmental matrix (as given by the tables associated with the diagrams presented in Figures 1 and 2), while *Pij* is the electric power reported by the WEC system in the same cell (as given by the tables given in Appendix).

Following this approach, the results of the average electric power that is probable to be delivered by each of the ten converters considered is given in Table 1.

Mean Power		
Period → / WEC Systems ↓	Total	Winter Season
Wave Dragon	391.79	579.23
Pelamis	59.84	89.23
Aqua Buoy	15.92	24.00
Archimedes Wave Swing	59.85	95.01
Langlee	66.29	93.48
Oceantec	96.03	131.75
OE Buoy	96.73	148.13
Pontoon	164.41	234.14
Seabased AB	1.42	1.97
Wavebob	55.42	83.96

Table 1: Mean power (kW) per day provided by ten systems in the Gloria station area. Reported results for the total and winter period.

Efficiency		
Period → / WEC Systems ↓	Total	Winter Season
Wave Dragon	5.60	8.27
Pelamis	7.98	11.90
Aqua Buoy	6.37	9.60
Archimedes Wave Swing	2.42	3.85
Langlee	3.98	5.61
Oceantec	19.21	26.35
OE Buoy	3.36	5.14
Pontoon	4.54	6.47
Seabased AB	10.52	14.59
Wavebob	5.54	8.40

Table 2: Efficiency index provided by ten systems in the Gloria station area.

4 Discussions

As expected, the results presented in Table 1 show that the winter time provides higher estimations for the average electric power than the total time and the highest amount of energy is produced by Wave Dragon which is the biggest of all devices and the lowest by Seabased AB which is the smallest device.

Related to the maximum production capacity,an efficiency index (%)can be calculated by dividing the obtained power to the maximum value. The maximum production capacity is presented in tables 3-12. For example the most significative value is presented at Wave Dragon and the lowest value at Seabased AB.

The efficiency of each device is presented in Table 2. So the best results have Oceantec with 26.35% (winter season), followed by Seabased AB with 14.59% (winter season) while the lowest values are recorded by Archimedes Wave Swing with 3.85% (total).

Also, regarding their efficiency, we can specify that the biggest differences between the two cases (total and winter season) appears at Oceantec, with a difference of 7.14% and the most constant is Archimedes Wave Swing with 1.44%, followed by Langlee with 1.63%.

5 Conclusions

The evaluation of the wave conditions in the western side of the Black Sea (corresponding to the time interval 2003–2009) was performed in the present work.

On this basis, the efficiency of ten different wave energy converters, was evaluated in the Romanian offshore region. The estimations were made by designing diagrams for the bivariate distributions of the occurrences corresponding to the wave data defined by significant wave height and period.

The results demonstrate that although a correct identification of the hot energy spots is an issue of highest importance, also a crucial role has an adequate estimation of the wave energy distribution along the sea states reflected by the scatter diagrams. The value of the wave energy expected for a certain geographical location is an important indicator, but only the analysis of its value can mislead in the identification of the most appropriate devices for extracting the wave energy.

The estimations of the expected electrical power can provide fundamental information concerning the performance of various wave energy converters operating in a specific offshore location. In this connection, it would be also relevant to observe that various technologies for wave energy extraction can have different efficiencies in the same marine environment and, on the other hand, that not always the device with the highest average wave energy represents the best solution for the wave energy conversion.

According to the present analysis we can consider that the most recommended device for the area targeted might be Oceantec, despite the fact that in the Table 1, Wave Dragon device produce more energy. But, of course for an accurate assessment, both production costs and the surface that each device is covering must be taken into account.

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Appendix

Wave Dragon													
	Te (s)												
Hs (m)	5	6	7	8	9	10	11	12	13	14	15	16	17
1	160	250	360	360	360	360	360	360	320	280	250	220	180
2	640	700	840	900	1190	1190	1190	1190	1070	950	830	710	590
3	0	1450	1610	1750	2000	2620	2620	2620	2360	2100	1840	1570	1310
4	0	0	2840	3220	3710	4200	5320	5320	4430	3930	3440	2950	2460
5	0	0	0	4610	5320	6020	7000	7000	6790	6090	5250	3950	3300
6	0	0	0	0	6720	7000	7000	7000	7000	7000	6860	5110	4200
7	0	0	0	0	0	7000	7000	7000	7000	7000	7000	6650	5740

Table A1: Power matrix – Wave Dragon [9]

Table A2: Power matrix – Pelamis [10]

Hs (m)	Te (s)																
	5	5,5	6	6,5	7	7,5	8	8,5	9	9,5	10	10,5	11	11,5	12	12,5	13
0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	22	29	34	37	38	38	37	35	32	29	26	23	21	0	0	0
1,5	32	50	65	76	83	86	86	83	78	72	65	59	53	47	42	37	33
2	57	88	115	136	148	153	152	147	138	127	116	104	93	83	74	66	59
2,5	89	138	180	212	231	238	238	230	216	199	181	163	146	130	116	103	92
3	129	198	260	305	332	340	332	315	292	266	240	219	210	188	167	149	132
3,5	0	270	354	415	438	440	424	404	377	362	326	292	260	230	215	202	180
4	0	0	462	502	540	546	530	499	475	429	384	366	339	301	267	237	213
4,5	0	0	544	635	642	648	628	590	562	528	473	432	382	356	338	300	266
5	0	0	0	739	726	731	707	687	670	607	557	521	472	417	369	348	328
5,5	0	0	0	750	750	750	750	750	737	667	658	586	530	496	446	395	355
6	0	0	0	0	750	750	750	750	750	750	711	633	619	558	512	470	415
6,5	0	0	0	0	750	750	750	750	750	750	750	743	658	621	579	512	481
7	0	0	0	0	0	750	750	750	750	750	750	750	750	676	613	584	525
7,5	0	0	0	0	0	0	750	750	750	750	750	750	750	750	686	622	593
8	0	0	0	0	0	0	0	750	750	750	750	750	750	750	750	690	625

Table A3: Power matrix – Aqua Buoy [11]

Hs (m)	Tp (s)												
	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	8	11	12	11	10	8	7	0	0	0	0
1,5	0	13	17	25	27	26	23	19	15	12	12	12	7
2	0	24	30	44	49	47	41	34	28	23	23	23	12
2,5	0	37	47	69	77	73	64	54	43	36	36	36	19
3	0	54	68	99	111	106	92	77	63	51	51	51	27
3,5	0	0	93	135	152	144	126	105	86	70	70	70	38
4	0	0	0	122	176	198	188	164	137	112	91	91	49
4,5	0	0	0	223	250	239	208	173	142	115	115	115	62
5	0	0	0	250	250	250	250	214	175	142	142	142	77
5,5	0	0	0	250	250	250	250	250	211	172	172	172	92

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Hs (m)	Te (s)																										
	5	5,5	6	6,5	7	7,5	8	8,5	9	9,5	10	10,5	11	11,5	12	12,5	13	13,5	14	14,5	15	15,5	16	16,5	17	17,5	18
0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	7	13	19	26	34	41	48	58	68	81	93	105	118	131	144	153	163	183	203	213	223	223	223	223	225	227
1,5	4	15	28	41	56	72	85	99	121	143	173	203	226	248	266	285	309	334	357	380	389	398	398	398	398	403	409
2	8	26	49	73	100	127	150	172	210	247	292	337	366	395	418	442	482	523	543	563	579	596	596	596	596	597	598
2,5	15	43	78	113	159	205	234	263	320	376	438	499	531	563	603	643	675	708	741	774	785	797	797	797	797	800	804
3	25	61	111	161	227	293	339	386	453	521	600	680	722	765	827	888	897	906	945	984	996	1009	1009	1009	1009	1003	998
3,5	35	92	155	218	305	391	454	517	605	694	772	851	913	975	1036	1096	1119	1141	1163	1185	1198	1211	1211	1211	1211	1208	1206
4	35	114	194	273	380	486	572	659	776	894	961	1027	1103	1179	1227	1275	1316	1357	1365	1374	1394	1414	1414	1414	1414	1415	1416
4,5	0	0	235	332	479	626	722	819	957	1096	1168	1240	1320	1401	1449	1497	1547	1598	1590	1583	1610	1637	1637	1637	1637	1616	1595
5	0	0	280	400	592	784	899	1014	1144	1274	1380	1487	1569	1651	1691	1731	1785	1838	1807	1777	1806	1836	1836	1836	1836	1806	1777
5,5	0	0	320	432	641	849	1033	1216	1331	1446	1568	1690	1778	1867	1919	1970	1977	1984	1994	2005	2017	2030	2030	2030	2030	1990	1951
6	0	0	0	0	680	944	1155	1367	1495	1623	1759	1895	1983	2072	2137	2202	2205	2207	2226	2246	2240	2234	2234	2234	2234	2194	2154
6,5	0	0	0	0	720	1123	1335	1547	1678	1809	1963	2116	2200	2284	2332	2380	2425	2470	2452	2434	2403	2373	2373	2373	2373	2354	2336

Table A4: Power matrix – Archimedes Wave Swing [12]

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Table A5: Power matrix – Langlee [1]

	Tp (s)												
Hs (m)	4	5	6	7	8	9	10	11	12	13	14	15	16
1	19	29	47	57	52	37	29	20	17	13	9	7	7
1,5	42	63	92	111	109	65	56	38	29	22	19	13	11
2	66	99	151	201	165	105	85	59	52	41	23	24	19
2,5	0	160	242	262	226	166	118	83	70	57	39	29	26
3	0	213	319	372	327	211	152	116	94	75	66	45	42
3,5	0	0	436	503	408	293	203	148	115	93	75	58	44
4	0	0	554	540	521	355	261	192	144	123	84	81	56
4,5	0	0	645	746	587	379	302	236	190	154	106	90	74
5	0	0	796	926	695	486	341	287	211	168	136	111	94
5,5	0	0	0	955	808	603	430	343	231	201	150	120	97
6	0	0	0	1161	957	642	481	329	289	212	172	146	111
6,5	0	0	0	1476	1039	702	488	397	312	237	204	153	120
7	0	0	0	1665	1197	821	612	466	385	252	223	181	146

Table A6: Power matrix – Oceantec [13]

	Tp (s)												
Hs (m)	6	7	8	9	10	11	12	13	14	15	16	17	18
1	85	87	59	39	25	16	10	7	5	3	2	2	1
1,5	191	196	133	89	57	36	23	15	10	7	5	3	3
2	339	348	234	158	101	64	41	27	18	12	9	6	4
2,5	500	500	364	245	158	101	65	42	28	19	13	10	7
3	500	500	500	337	228	145	93	61	41	28	19	14	10
3,5	500	500	500	420	309	196	127	83	55	38	26	19	13
4	500	500	500	500	401	258	166	109	72	49	34	24	18
4,5	500	500	500	500	500	326	210	138	92	62	43	31	22
5	500	500	500	500	500	383	259	170	113	77	54	38	27
5,5	500	500	500	500	500	389	308	205	137	93	65	46	33

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Table A7: Power matrix – OE Buoy [1]

		Tp (s)												
		4	5	6	7	8	9	10	11	12	13	14	15	16
Hs (m)	1	8	17	27	42	56	59	52	44	40	38	40	38	30
	1,5	17	39	61	96	126	132	117	99	89	87	89	85	66
	2	30	69	108	170	224	235	208	177	159	154	159	151	118
	2,5	47	108	169	266	350	368	324	276	249	241	248	236	185
	3	68	155	244	383	504	530	467	398	358	347	357	340	266
	3,5	93	212	332	521	686	721	636	542	487	472	486	463	362
	4	121	276	433	680	896	942	831	708	636	616	634	605	473
	4,5	154	350	548	861	1130	1190	1050	896	805	780	803	765	599
	5	190	432	677	1060	1400	1470	1300	1110	994	963	991	945	739
	5,5	0	523	819	1290	1690	1780	1570	1340	1200	1170	1200	1140	894
	6	0	622	975	1530	2020	2120	1870	1590	1430	1390	1430	1360	1060
	6,5	0	730	1140	1800	2370	2490	2190	1870	1680	1630	1670	1600	1250
	7	0	847	1330	2080	2750	2880	2540	2170	1950	1890	1940	1850	1450

Table A8: Power matrix – Pontoon [1]

		Tp (s)												
		4	5	6	7	8	9	10	11	12	13	14	15	16
Hs (m)	1	180	166	153	171	125	87	72	65	85	85	37	29	16
	1,5	223	195	157	148	261	192	223	139	155	155	74	67	46
	2	0	0	214	227	396	335	237	235	172	138	115	104	70
	2,5	0	0	0	440	598	514	379	342	204	169	142	128	95
	3	0	0	0	681	801	735	594	486	199	174	151	134	121
	3,5	0	0	0	904	1035	949	788	617	239	209	183	164	146
	4	0	0	0	1131	1269	1163	982	743	285	248	216	195	175
	4,5	0	0	0	1358	1488	1374	1187	869	330	287	250	225	201
	5	0	0	0	1585	1712	1585	1392	988	380	334	285	263	226
	5,5	0	0	0	1812	1937	1798	2138	1107	429	381	323	301	261
	6	0	0	0	2040	2162	2010	2884	1234	439	416	361	336	295
	6,5	0	0	0	2267	2386	2221	3143	1360	449	450	406	372	329
	7	0	0	0	2494	2611	2433	3619	1483	506	464	451	408	363

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Table A9: Power matrix – Seabased AB [1]

	Tp (s)												
Hs (m)	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1,2	1,3	1,2	1,2	1,1	1	0,9	0,8	0,7	0,7	0,7	0,6	0,7
1,5	2,6	2,5	2,3	2,2	2,3	2	1,9	1,7	1,4	1,5	1,2	1,2	1,2
2	4,4	4	3,7	3,6	3,5	3,1	2,8	2,5	2,3	2,2	2	1,8	1,7
2,5	0	6	5,2	4,5	4,6	4,3	3,9	3,6	3	2,8	2,5	2,7	2,6
3	0	7,4	6,7	6,2	5,7	5,4	4,7	4,1	4,1	3,7	3,3	3,3	3,2
3,5	0	0	8,4	7,3	6,9	5,8	5,4	4,9	4,4	4,2	3,7	3,4	3,6
4	0	0	8,9	8,6	7,6	6,8	6,2	5,6	5	4,6	4,5	4,3	3,6
4,5	0	0	10,6	9,5	8,7	7,6	7	6,1	5,9	5,4	5,1	5	4,7
5	0	0	12,2	10,8	9,8	8,6	7,3	7,2	6,3	5,9	5,7	5,4	5
5,5	0	0	0	11,1	10,1	8,9	8,1	7,5	6,8	6,4	6,1	5,5	5,8
6	0	0	0	13,1	11,3	10,1	9,1	8,3	7,5	6,7	6,9	6,4	5,8
6,5	0	0	0	13,5	11,6	10,4	9,8	9	7,6	7,3	7,5	6,2	6,4
7	0	0	0	15	12,9	10,9	10	8,8	8,6	8,2	7,6	7,3	6,8

Table A10: Power matrix – Wavebob [1]

	Tp (s)												
Hs (m)	4	5	6	7	8	9	10	11	12	13	14	15	16
1	6	11	19	25	30	44	50	53	44	34	22	20	17
1,5	13	25	43	55	68	90	102	92	91	66	65	45	37
2	24	45	65	100	121	153	175	151	122	126	87	61	58
2,5	0	65	104	141	191	179	243	255	190	181	135	99	83
3	0	96	137	205	244	357	293	353	260	248	184	137	120
3,5	0	0	192	254	291	431	385	424	314	285	239	222	172
4	0	0	256	366	403	551	536	531	473	420	289	268	179
4,5	0	0	327	418	574	678	708	665	509	415	386	244	249
5	0	0	358	514	658	824	828	618	638	512	452	384	333
5,5	0	0	0	610	774	880	936	905	805	603	456	397	311
6	0	0	0	711	952	974	1000	838	886	648	501	503	396
6,5	0	0	0	788	1000	1000	1000	979	1000	727	577	435	424
7	0	0	0	871	1000	1000	1000	1000	1000	959	748	574	472

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