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Asian Wave and Tidal
Energy Conference Series

HANN-OCEAN

Wave Energy Resource Evaluation and Drakoo WEC Array Application for Yushan Island, China

Henry L. Han, Lex L. de Rijk

Hann-Ocean Energy Pte Ltd
www.hann-ocean.com

3RD awtec 2016
ASIAN WAVE AND TIDAL ENERGY CONFERENCE

Agenda

- Electricity Demand, Yushan Island

- Wave Energy Resources @ Site

- Drakoo WEC Working Principle

- WEC Array Solution Proposal
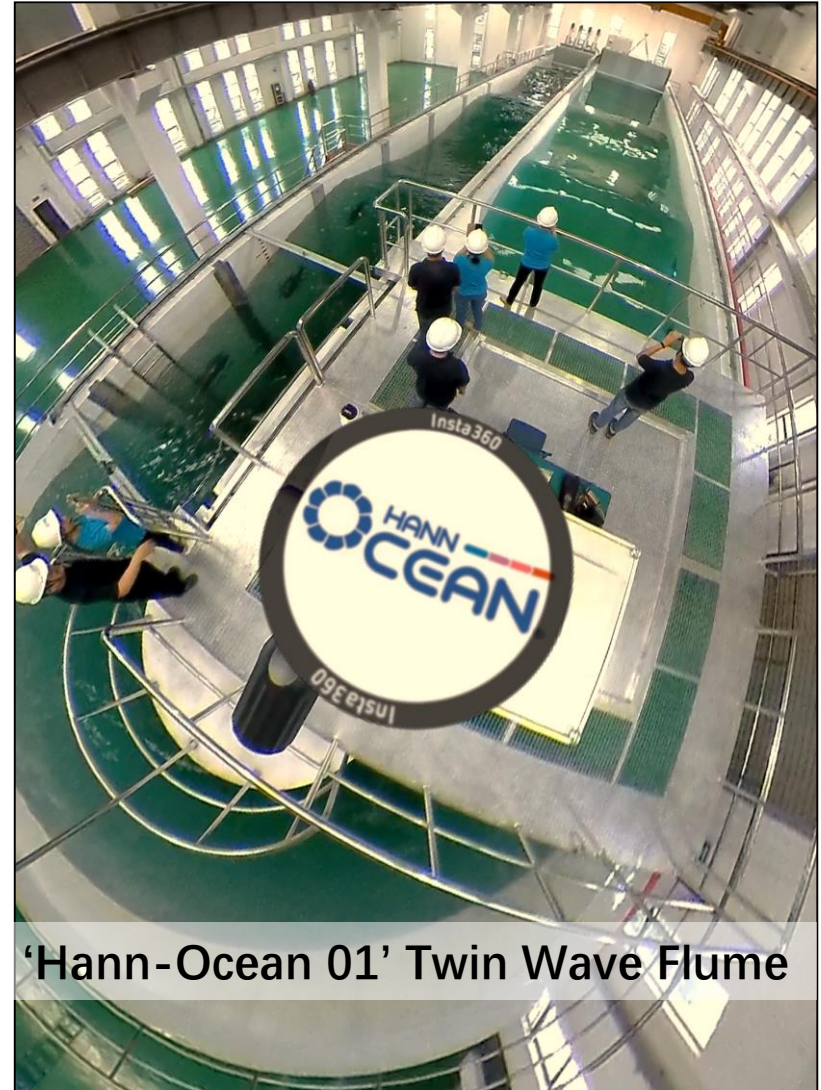
'Hann-Ocean 01' Twin Wave Flume

WEC Array Application at Yushan Island, P.R. China

- Energy Supply Target:

    6000 MWh per Year

- Power Capacity at least:
    2 MW

- For 60% of time (219 days per year):
   400 kW

Wave Energy Resources

- **Annual Energy Flux Scatter Diagram**

Location Coordinate: Yushan Island, China; 29° 00'N, 122° 30'E

[kWh/m]*		Zero-Crossing Wave Period* (sec)								
	From	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
From	**To**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
0	0.5	0	2	9	13	10	3	3	0	0
0.5	1	0	248	2,195	2,024	725	223	56	31	0
1	1.5	0	41	6,948	6,378	1,588	343	77	0	0
1.5	2	0	0	4,724	11,230	2,154	673	152	171	0
2	2.5	0	0	459	14,361	2,572	668	250	0	0
2.5	3	0	0	0	8,110	5,320	665	374	0	0
3	3.5	0	0	0	1,096	7,843	928	523	0	0
3.5	4	0	0	0	0	3,847	1,236	0	0	0
4	4.5	0	0	0	0	1,412	2,382	894	0	0
4.5	5	0	0	0	0	0	1,983	0	0	0
5	5.5	0	0	0	0	0	1,211	1,364	0	0
5.5	6	0	0	0	0	0	0	1,636	0	0
6	6.5	0	0	0	0	0	0	1,933	0	0
6.5	7	0	0	0	0	0	0	2,254	0	0

(Wave Height (meter) — row axis label)

- **How to Harvest?**

- **How to Deal with Typhoon Environment?**

Mean wave energy density (KW/m)
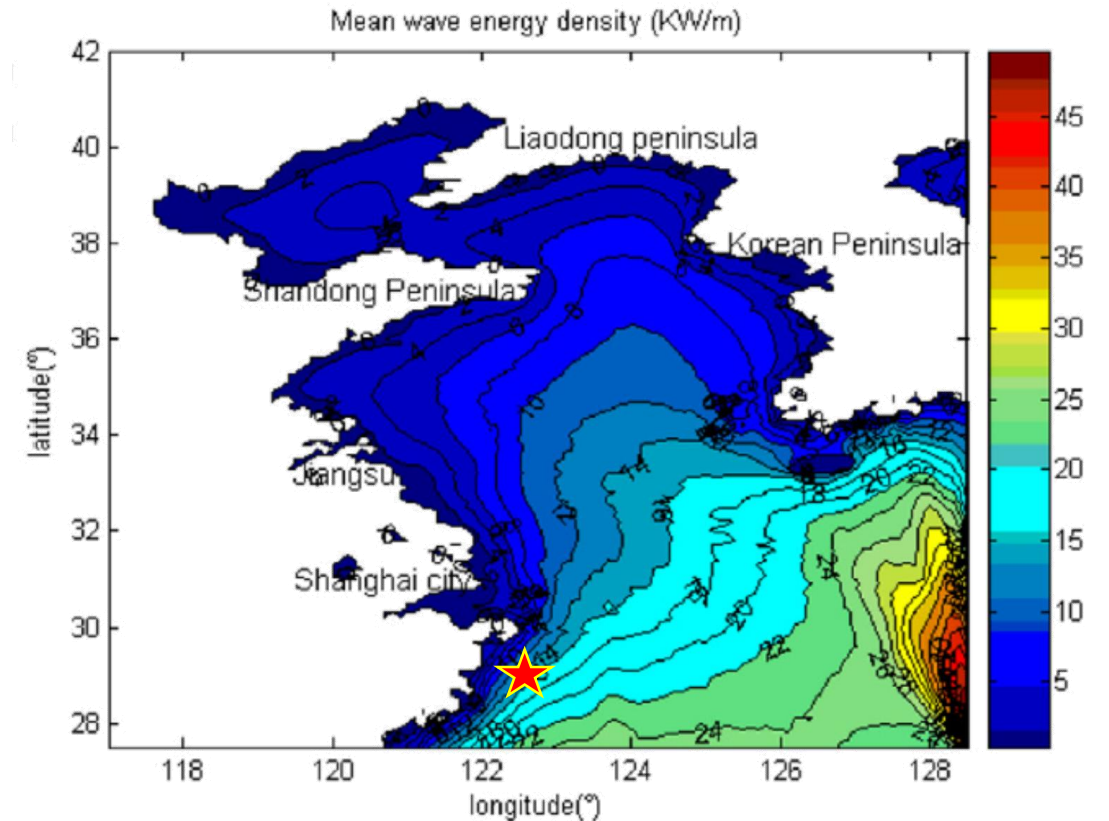
Data bank

22-Year wave energy hindcast for the China East Adjacent Seas

Bingchen Liang [a, b], Fei Fan [b], Fushun Liu [a, b, *], Shanhong Gao [c], Hongyan Zuo [b]

[a] Shandong Province Key Laboratory of Ocean Engineering, Ocean University of China, 238, Songling Road, Qingdao 266100, China
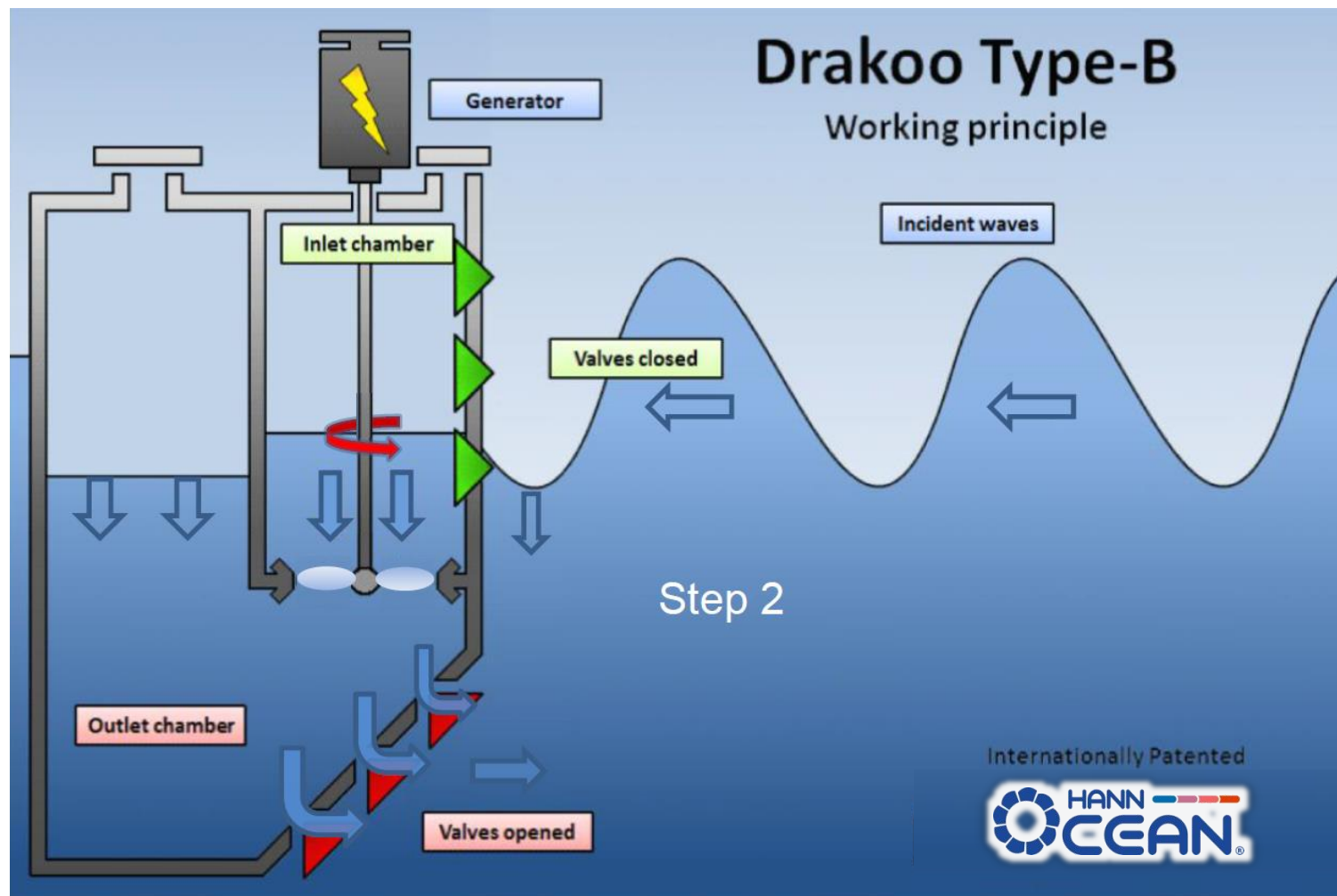[b] College of Engineering, Ocean University of China, China
[c] Marine Environment College, China
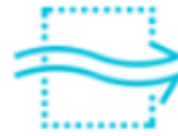
Drakoo Working Principle
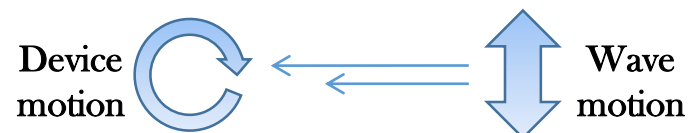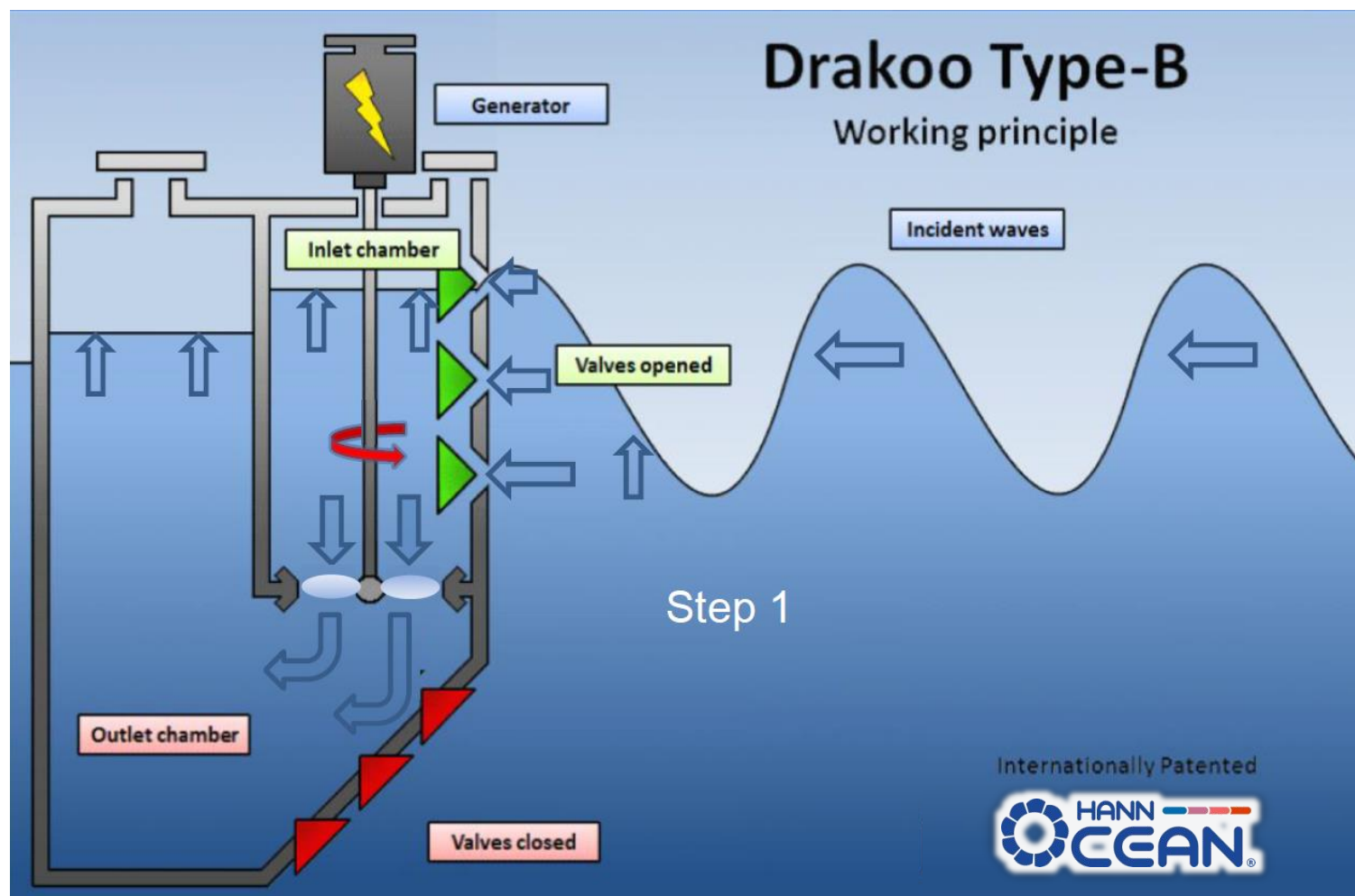
Drakoo Working Principle

DRAKOO CONSISTS OF THREE TYPICAL FEATURES:

Twin-chamber body

Checkerboard valves

Power take-off system

These three features have been developed by Hann-Ocean Energy and can be customized for different wave conditions for different Drakoo models. With the use of a matured permanent magnetic generator, existing hydro turbine technologies, and of economical materials, the Drakoo is simple, efficient, of modular design and gives a strong competitive edge over other Wave Energy Converters (WEC).

Efficiency	Reliability	Cost-effective	Simplicity	Durability	Eco friendliness
Up to 50% overall energy conversion factor	Use of commercially available key components increase reliability	Low material costs and economically justifiable price	Plug´n´Run power take-off; modular pontoon structure design	Stress relieving feature in storm sea	Does not harm marine life and has a minimal impact on underwater current and seabed

WEC Array Solution Proposal

- Floating linear array of Drakoo WEC

- 22 x Container length modules

- Each module: 4 x 3m-wide Drakoo cells

- Anchor-line regulation to head wave

- Shut-down wave height of 3m

- Capable to tow away

>> 20.8 GWh Annual Energy to harvest

>> 15 GWh for wave Hw < 3m

Drakoo-B0010SP Prototype - Hull

Drakoo WEC Design Wave Length Optimization

- Optimal design wave length of 44m

- Site water depth 20m

- Design Tz = 5.25 sec

- Design Tp = 7.4 sec

Yushan Island, China; 29° 00'N, 122° 30'E
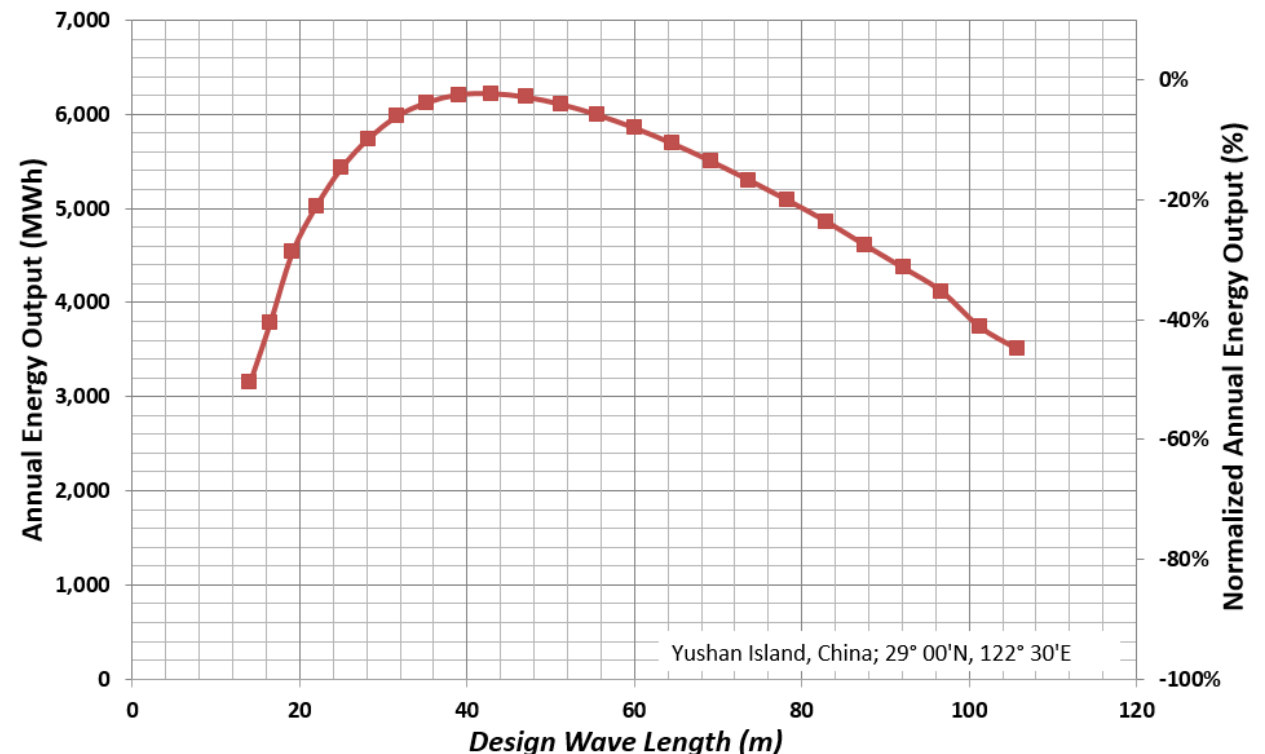
Drakoo WEC Height

- Draft ⬆ > energy extraction ⬆

- Restriction 6m Drakoo height

- Proposed 4m Drakoo draft

Realistic annual energy output: 6.2 GWh

Max annual energy output: 7.5 GWh

if free Drakoo height

Drakoo-B0010SP Prototype - Hull

Drakoo WEC Capacity Optimization

- PTO Capacity

- Size of Turbine

- Size of Generator

- Best Performance:

  - Array **2.4 MWp (min)**

  - Drakoo-Cell **27.5 kWp (min)**

- Load Factor: 29%

Annual Energy Output

- Case: Best Performance (Realistic)

- Total Annual Energy Output: **6.2 GWh**

- Shut-Down Wave Height 3m

Location Coordinate: Yushan Island, China; 29° 00'N, 122° 30'E

[MWh]*		Zero-Crossing Wave Period (sec)								
	From	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
From	**To**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
0	0.5	0	0	0	1	0	0	0	0	0
0.5	1	0	14	191	198	69	19	4	2	0
1	1.5	0	2	613	627	151	29	5	0	0
1.5	2	0	0	397	1,023	187	52	10	9	0
2	2.5	0	0	36	1,220	208	48	15	0	0
2.5	3	0	0	0	643	384	43	21	0	0
3	3.5	0	0	0	0	0	0	0	0	0

(Wave Height (m) — row axis label)

Drakoo Array Total Efficiency

- Case: Best Performance (Realistic)

- Total Annual Energy Output: **6.2 GWh**

- Shut-Down Wave Height 3m

Best Efficiency 49%

Location Coordinate: Yushan Island, China; 29° 00'N, 122° 30'E

[MWh]*			Zero-Crossing Wave Period (sec)								
	From		**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
From	**To**		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
0	**0.5**		0	12%	22%	26%	25%	22%	18%	0	0
0.5	**1**		0	28%	43%	49%	47%	42%	34%	27%	0
1	**1.5**		0	29%	44%	49%	47%	42%	35%	0	0
1.5	**2**		0	0	42%	45%	43%	38%	32%	26%	0
2	**2.5**		0	0	39%	42%	40%	35%	30%	0	0
2.5	**3**		0	0	0	39%	36%	32%	28%	0	0
3	**3.5**		0	0	0	0	0	0	0	0	0

Wave Height (m) (row axis label)

Annual Energy Output & Performance

Reminder: Requirements

- Energy Supply Target:

   6000 MWh per Year

- Power Capacity at least:

   2 MW

- For <u>60%</u> of time (219 days per year):

   400 kW

	Best Performance	Max. Load Factor*
Available Annual Incident Wave Energy (MWh)	20,802	
Annual Wave Absorption Ratio (%)	30%	29%
Annual Average Power Output (MW)	0.71	0.70
Drakoo-Cell Power Capacity (kWp)	27.5	22.75
Design Array Power Capacity (MWp)	2.42	2.00
Annual Energy Production (MWh)	6,220	6,136
Load Factor (%)	29%	35%
Annual Availability of Array Power – 400kW (Days)	231	
Annual Availability of Array Power – 1000kW (Days)	104	

*For which requirements hold

Thank You for Your Attention

Questions?