DRAKOO

- Energizing the Future with Ocean Waves

awtec
Asian Wave and Tidal Energy Conference Series

Presented by Hann-Ocean Energy

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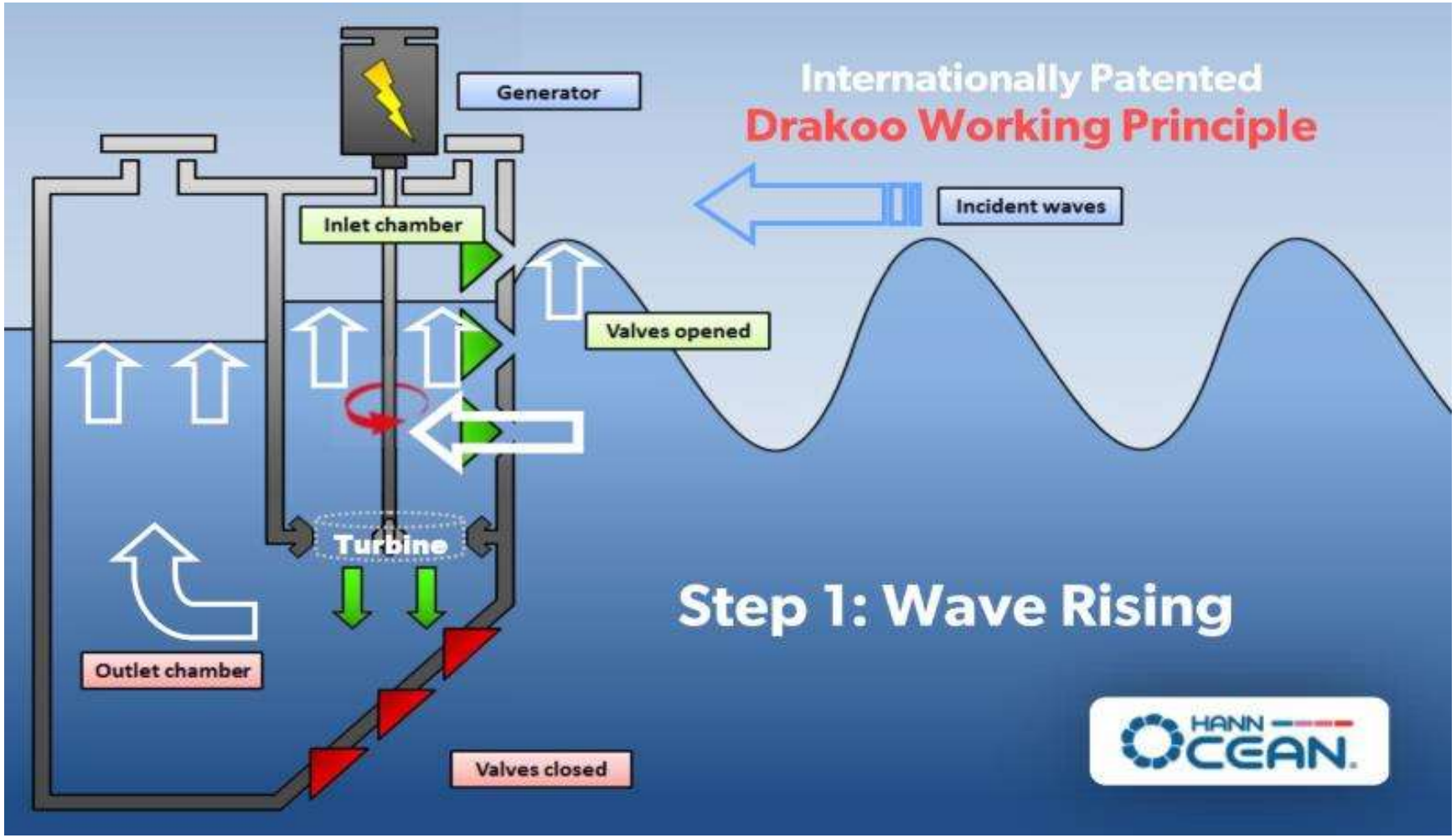
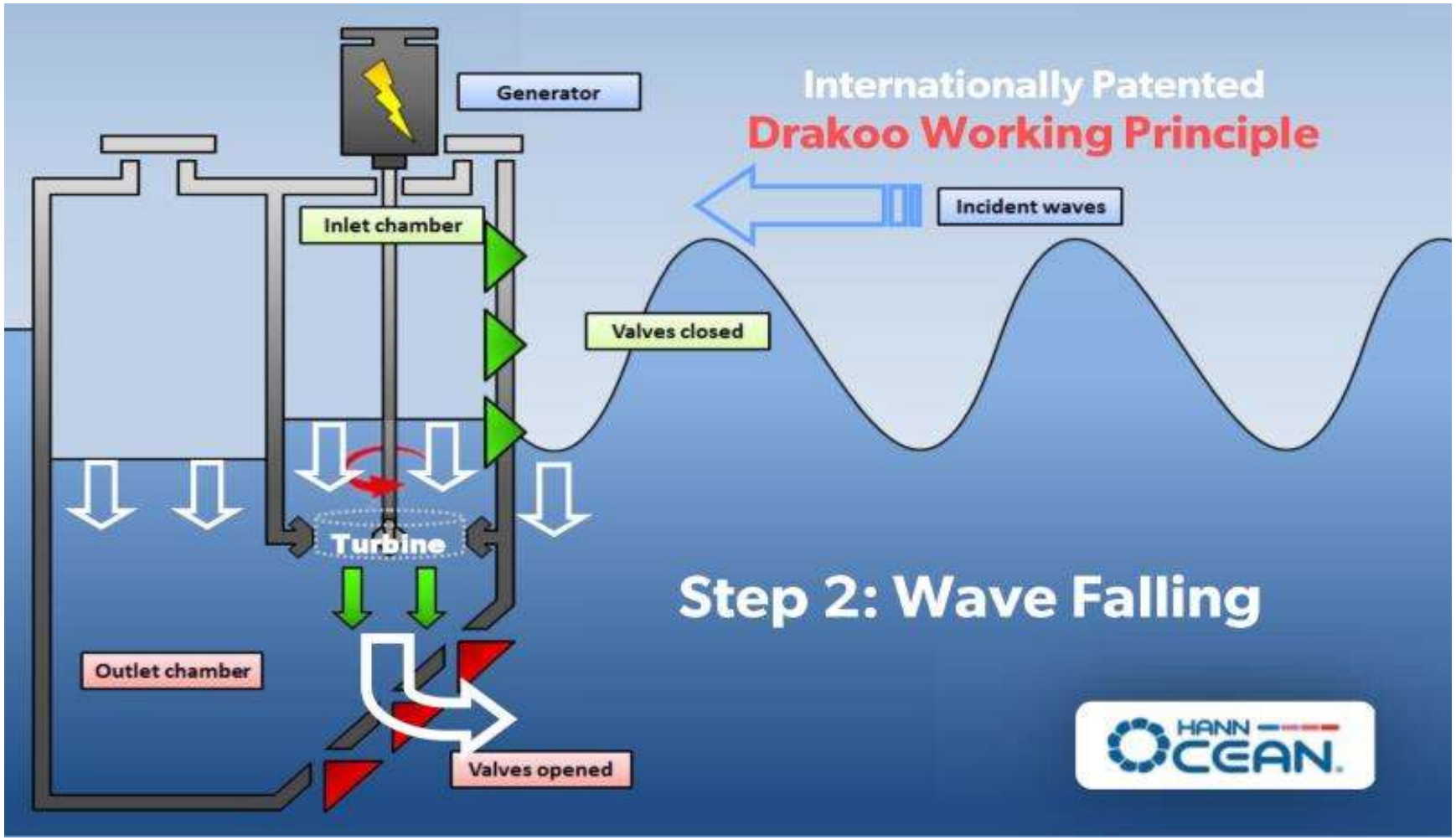
Drakoo Working Principle



Drakoo Working Principle



Development Milestones

Drakoo 1kWp


Drakoo 4kWp


Drakoo 16kWp

Drakoo 15kWp

Aug. 2008	International patent of the Drakoo WEC concept filed
Sep. 2010	1:5 scale Drakoo model tested in Nanyang Technological University (NTU), achieving a peak Capture Wave Ratio (CWR) of up to 66%
Jul.2011	1kWp Drakoo prototype tested at National Renewable Energy Centre UK (Narec), achieving a peak CWR beyond 80%
Jun. 2012	1st commercial order from Sembcorp Marine secured
Oct. 2012	4 units of Drakoo 4kWp delivered to Sembcorp Marine
Nov. 2012	Drakoo 4kWp sea trial conducted
Aug. 2013	Drakoo 16kWp array deployed in Tuas View Sea
Feb. 2015	Hann-Ocean Energy's subsidiary in China registered
Nov. 2015	"Hann-Ocean 01" ocean wave tank construction completed
Jul. 2016	"Hann-Ocean 01" wavemaker (120kWp) installed and tested
Dec. 2016	Drakoo 10 kWp full-system assembled and started generating electricity
Nov. 2017	Drakoo 10kWp reached its peak electric capacity
Oct. 2017	Sales enquiries from the Persian Gulf for wellhead platforms and South Africa
Mar. 2018	Further upgraded to 15kWp

Narec UK Verification

- Full-system prototype Drakoo-III tested in July 2011
- Wave energy capturing efficiency beyond 80% at peak and average 50% for regular waves.





Drakoo-B0004 in Singapore Sea Trial and Demo, Nov 2012

Drakoo Wave Energy Converter Pilot Array 16kW, Singapore

Presentation for:

Drakoo Wave Energy Converter Pilot Array 16kW, Singapore

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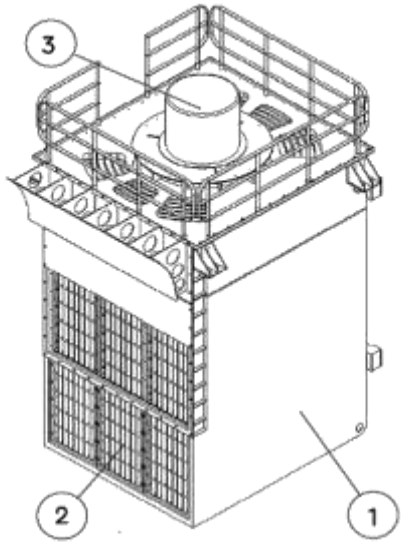
- The 15kWp WEC

Technical Specifications

Model No.: B0015	Version: 092018
Length (L)	3.0 m
Width (B)	3.5 m
Height (H)	5.1 m
Weight (W)	12 ton
Peak Output Wave Height (H_{wp})	1.7 m
Optimal Wave Period (T_z)	5 sec
Electricity Generator	Permanent Magnetic AC Generator
Peak Power Output (p_p)	15 kWp
Peak Efficiency (η_p)	Up to 50%
Average Active Power Output Efficiency (Average RMS) (η_{RMS})	22%
Wave Absorption (Capture Width Ratio) (CWR)	Up to 80%
Position Keeping	Attached or integrated into floating platforms or fixed structures

Key Features and Advantages



Design Configuration:

1) Twin-chamber Hull
2) Checkerboard Valves
3) Power Take-off System

The Internationally patented modular design enables constructions of large-scale wave power arrays by connecting multiple units using bolting, welding or Hann-Ocean's Rigid Pontoon Connectors.

Simplicity	Plug & Run power take-off; In modular configuration
Efficiency	High Efficiency, up to 50% overall energy conversion
Reliability	Use of commercially available parts for key components
Durability	Self-pressure relieving feature in stormy seas
Eco-friendliness	Harmless to marine life, minimal impact on sea environment
Cost-effectiveness	Low material costs and economically justifiable pricing
Versatility	Applicable at shoreline or far offshore, in fixed or floating mode
Scalability	Installation capacity variable from kW unit to MW array

Drakoo-B0015 Generator Output Scatter Diagram

Peak Power

Generator Electric Power Output [kW] PEAK		Wave Period, Tz (sec)											
		2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
Wave Height (m)	0.3	0.0	0.2	0.3	0.5	0.5	0.6	0.7	0.7	0.7	1.0	0.9	1.0
	0.4	0.2	0.5	0.6	0.9	0.9	1.3	1.2	1.4	1.5	1.5	1.5	1.8
	0.5	0.4	0.8	1.1	1.3	1.5	1.5	1.8	2.1	2.0	2.1	2.2	2.6
	0.6	0.7	1.0	1.5	1.8	2.0	2.1	2.5	2.9	3.0	2.8		
	0.7	1.0	1.4	2.0	2.3	2.4	2.9	2.9	3.4				
	0.8	1.4	1.8	2.6	3.2	3.1	3.7	3.7					
	0.9	1.9	2.4	3.4	3.6	4.1	4.6						

Note: 1. Data above have been witnessed by DNV GL

2. The root-mean-square (RMS) values are about 64% of the peak values indicated above.

Drakoo-B0015 MPPT Output Scatter Diagram

Root-mean-squared Averaged Power

MPPT Electric Power Output [kW] RMS		Wave Period, Tz (sec)											
		2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
Wave Height (m)	0.3	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4
	0.4	0.0	0.1	0.3	0.5	0.5	0.7	0.6	0.7	0.7	0.7	0.7	0.8
	0.5	0.0	0.3	0.5	0.7	0.8	1.0	1.1	1.2	1.1	1.1	1.2	1.3
	0.6	0.2	0.4	0.8	1.0	1.1	1.3	1.6	1.6	1.6	1.6		
	0.7	0.3	0.6	1.1	1.5	1.5	1.9	2.0	2.1				
	0.8	0.5	0.9	1.4	2.0	2.0	2.5	2.6					
	0.9	0.7	1.2	1.8	2.6	2.6	3.0						

Note: 1. Data above have been witnessed by DNV GL

2. The root-mean-square (RMS) values are about 64% of the peak values indicated above.

Drakoo Wave-to-Electricty Output Efficiency Matrix

Root-mean-squared Averaged

Wave-to-Generator A/C Efficiency (%) RMS		Wave Period, Tz (sec)												
		2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	AVE
Wave Height (m)	0.3	0%	6%	13%	10%	21%	26%	23%	20%	19%	20%	24%	28%	18%
	0.4	1%	12%	17%	27%	23%	30%	25%	25%	25%	24%	26%	30%	22%
	0.5	4%	14%	19%	24%	23%	27%	27%	27%	24%	24%	27%	30%	23%
	0.6	8%	15%	23%	26%	23%	26%	27%	27%	24%	24%			22%
	0.7	10%	16%	22%	27%	23%	26%	25%	26%					22%
	0.8	12%	17%	21%	27%	23%	26%	25%						22%
	0.9	13%	18%	22%	28%	24%	25%							22%
	Average	7%	14%	20%	24%	23%	27%	25%	25%	23%	23%	26%	29%	22%

Note: 1. Data above have been witnessed by DNV GL

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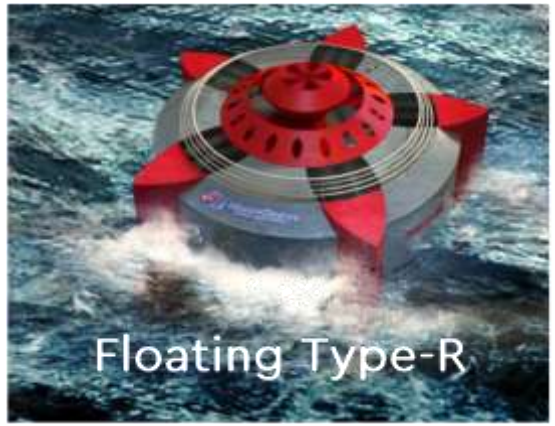
Drakoo WEC Potential Applications

- **Fixed or Floating modular** linear arrays, e.g. Breakwaters / Type-X
- **Floating Stand-alone point absorbers**, e.g. Drakoo Type-R
- **Integrated with** on-shore or offshore structures, e.g. floating sports hubs, oil and gas production platforms, fish farms and offshore wind turbines



Projects in Pipeline

A detailed design study for the application of wave energy for wellhead platforms in the Middle East, for a Offshore Oil & Gas Company is in progress.

Projects in Pipeline

Italian Wave Breakwater Project Feasibility Study

Harmonious design with the surroundings is being investigated

Performance and Benefits

- Internationally patented
- Proven in labs and seas
- Cost-effective solution to replace diesel generators
- Brand-new technology for wave energy to meet growing global demand for clean energy
- Especially in island communities and remote offshore operations.

Replacement of Diesel Generators

Wave Flux	Drakoo Flux	Annu.A. Power	Unit Capacity	Cost of Electricity
kW/m	kW/m	kW	kWp	USD/kWh
12.5	2.6	7.8	15	0.16
17.5	3.6	10.8	15	0.12
25	5.2	15.6	20	0.096
35	7.3	21.9	25	0.077
50	10.4	31.2	35	0.068

Cost of electricity produced by Drakoo based on installation capacity of 15MWp

Cost of Electricity using Diesel Generators on islands: **USD 0.50/kWh**

Indonesian West Coast + **Drakoo WEC** = **Return on Investment (ROI) in 4.5 years**

Our Resources and Partners

- **Hann-Ocean's HQ** in Singapore supports global sales and marketing;
- **Hann-Ocean Energy (Nantong)** in China offered large-scale testing facility and system assembly;
- **Nanyang Technological University (NTU)** Singapore offered wave flume test facility for small-scale tests;
- **SembCorp Marine** offered the first sea trial site and participated in NAREC (UK) tank test;
- **Institute of High Performance Computing (IHPC)** developed CFD software for Drakoo**;**
- **DNV GL Maritime advisory** enforced the testing methodology and witnessed Drakoo's performance;
- **China Ship Scientific Research Centre (CSSRC)** participated in Drakoo's wave load tests;
- **OEMs** in **Nantong**, **China** have long-term partnership established;
- Highly efficient PM generators and MPPT charge controllers supplied by **Korean and American companies**

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Redefining Sustainable Technologies

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Live Demo from our ocean tank

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Redefining Sustainable Technologies

DRAKOO - Energizing the Future with Ocean Waves

THANK YOU!

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- Email us at enquiry@hann-ocean.com
- PPT download site: http://www.hann-ocean.com/index.php/publications/presentations.html