DRAKOO

Technical Specifications

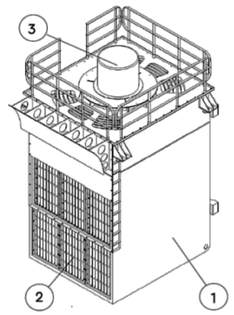
Model No.: B0015	Version: 092018
Length (L)	3.0 m
Width (B)	3.5 m
Height (H)	5.1 m
Weight (W)	12 ton
Peak Output Wave Height (H_{wp})	1.7 m
Optimal Wave Period (T_z)	5 sec
Electricity Generator	Permanent Magnetic AC Generator
Peak Power Output (p_p)	15 kWp
Peak Efficiency (η_p)	Up to 50%
Average Active 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

Design Configuration:

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

The modular system offers quick assembly, easy transportation, simple maintenance and higher load factor.

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.



Peak Power Output Scatter Diagram

Generator Output Peak [kWp]		Wave Period, Tz (sec)											Ver. 092018
		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
	0.5	0.4	0.8	1.1	1.3	1.5	1.5	1.2	1.4	1.5	1.5	1.5	1.8
	0.7	1.0	1.4	2.0	2.3	2.4	2.9	2.9	3.4	3.7	3.8	4.0	4.1
	0.9	1.9	2.4	3.4	3.6	4.1	4.6	4.7	5.0	5.4	5.7	5.9	6.2
	1.1	3.1	3.8	4.4	5.0	5.6	6.1	6.6	7.1	7.5	7.9	8.3	8.7
	1.3	4.8	5.6	6.4	7.1	7.8	8.5	9.1	9.7	10.3	10.8	11.3	11.8
	1.5	6.7	7.6	8.5	9.3	10.1	10.9	11.7	12.4	13.1	13.8	14.4	15.0
	1.7	8.8	9.9	10.9	11.8	12.8	13.7	14.5	15.0	15.0	15.0	15.0	15.0

Note: 1. Data in red have been witnessed by DNV GL; Data in black are extrapolated using dual parameter curve fitting.
2. The root-mean-square (RMS) values are about 64% of the peak values indicated in the table above.

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DRAKOO™

Energize the Future with Ocean Waves

Durable·Efficient·Simple·Economical

Reliable·Versatile·Eco-friendly·Scalable

Drakoo is the most efficient and diversified wave energy converter technology to date. It will provide a new technical solution that allows wave energy to meet growing global demand for sustainable energy.

- Henry L Han, Inventor of Drakoo

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Drakoo Peak Power Record

14/03/2018

10kW

17/11/2017

21/10/2017

8kW

26/09/2017

25/09/2017

6kW

4kW

01/09/2017

2kW

20/06/2017

20/03/2017

23/12/2016

0kW

DRAKOO

Why Wave Energy?

Wave energy is a vast, untapped resource that could help reduce our reliance on fossil fuels. Like solar and wind power, wave power harnesses energy that comes ultimately from the sun. However, it is more than ten times denser than wind and solar energy. Furthermore, waves are easier to forecast when compared to solar and wind they can be harnessed 24/7!

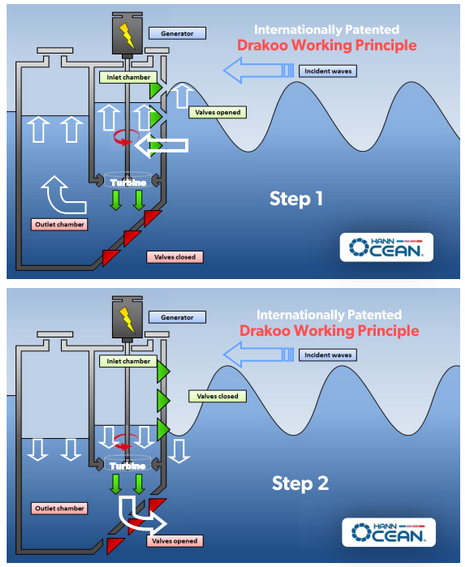
Drakoo Working Principle

Drakoo works by transforming ocean waves into a steam of continuous water which drives a hydro turbine generator. This is accomplished in two steps.

Firstly, an incoming wave increases the inlet chamber's water level. Simultaneously, water is partly directed from the inlet to the outlet chamber through the hydro turbine.

As the wave passes inward and the water level outside falls with the incoming trough, so do the levels in both the chambers, leading to a flow from the inlet chamber to the outlet chamber via the turbine, followed by flow from the outlet chamber to the outside environment.

Drakoo is able to synchronize this two-step action of its water columns continuously with waves by using passive, one-way checkerboard valves to regulate the flow which is kept constant and unidirectional, enabling a smooth operation of the hydro turbine. These mechanisms make Drakoo an incredibly potent wave energy converter.



Development Milestones

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 prototype reached its peak power output.
Mar. 2018	Peak power output of the Drakoo prototype upgraded to 15kWp.

Key Elements

Drakoo WEC consists of following elements:

1. Twin-chamber hull
2. Checkerboard valves
3. Power take-off system

Hann-Ocean has devised a unique method of integrating these three factors, allowing the system to be customized for different Drakoo models which use various wave conditions. The system employs a specially designed composite material for the checkerboard valves, a proven permanent magnetic generator, mature technology for the hydro turbine and cost effective materials in the overall design. When taken in conjunction with its highly efficient working principle, Drakoo's modular configuration and simplicity give it an unassailable edge over its competitors.

Performance

Verified by National Renewable Energy Centre (Narec, UK), Drakoo has consistently achieved a wave to hydro power conversion efficiency (a.k.a. Capture Width Ratio or CWR), of over 80% at peak and 50% on average in regular waves over broad wave spectrums. The latest Drakoo WEC technology has achieved a peak conversion efficiency (waves to electricity) of beyond 50% and an average Active Power Output Efficiency (average RMS) of 22%. The performance and load tests of Drakoo WEC (15kWp) have been witnessed by DNV GL and participated by China Ship Scientific Research Centre (CSSRC).

Benefits

The internationally patented technology proven in labs and seas provides a cost-effective solution to replace diesel generators. We believe that the Drakoo is the most efficient and diversified WEC technology to date. It will set a brand-new technology standard that allows wave energy to meet growing global demand for clean energy, especially in island communities and remote offshore operations.

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

Advantages

Durable
Self-pressure relieving feature in extreme waves.

Efficient
Up to 22% average active power output efficiency and 50% peak power efficiency.

Simple
Plug & Run power take-off in modular configuration.

Economical
Low material and life cycle-costs, reasonable cost of electricity.

Reliable
Uses parts from the wind power industry, key components customized.

Versatile
Deployable nearshore or offshore, in fixed or floating modes.

Eco-friendly
Harmless to marine life, minimal impact on sea environment.

Scalable
Installation capacity variable, from kW unit to MW array.

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DRAKOO

技术规格

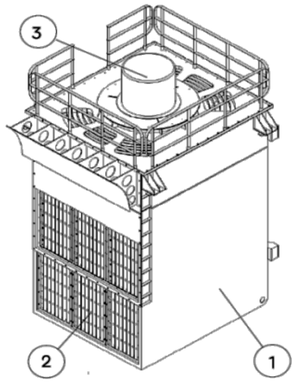
型号： B0015	版本： 092018
长 (L)	3.0 米
宽 (B)	3.5 米
高 (H)	5.1 米
重量 (W)	12 吨
峰值波高 (H_{wp})	1.7米
最优浪周期 (T_z)	5 秒
发电机	永磁同步交流发电机
峰值功率 (P_p)	15 千瓦
峰值效率 (η_p)	高达 50%
有用功均值输出效率 (平均 RMS) (η_{RMS})	22%
波能吸收 (CWR)	高达 80%
安放位置	依附或连接在浮动平台或固定结构上

设计构造:

1) 双腔体
2) 单向导流格栅
3) 动力输出系统

这种拥有国际专利的模块化设计能够通过螺栓、焊接或者韩洋的"坚浮"浮动平台连接器，扩展为更大规模的波浪能发电矩阵结构。

该“绝酷”15千瓦波浪发电机的性能及载荷试验由DNV GL见证，中国船舶科学研究中心（中船重工702研究所）参与。确认了其输出功率及对支撑结构的载荷数据。



峰值输出功率频谱

峰值输出 [kWp]		浪周期 Tz (sec)											Ver. 092018
		2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
浪高 (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
	0.5	0.4	0.8	1.1	1.3	1.5	1.5	1.2	1.4	1.5	1.5	1.5	1.8
	0.7	1.0	1.4	2.0	2.3	2.4	2.9	2.9	3.4	3.7	3.8	4.0	4.1
	0.9	1.9	2.4	3.4	3.6	4.1	4.6	4.7	5.0	5.4	5.7	5.9	6.2
	1.1	3.1	3.8	4.4	5.0	5.6	6.1	6.6	7.1	7.5	7.9	8.3	8.7
	1.3	4.8	5.6	6.4	7.1	7.8	8.5	9.1	9.7	10.3	10.8	11.3	11.8
	1.5	6.7	7.6	8.5	9.3	10.1	10.9	11.7	12.4	13.1	13.8	14.4	15.0
	1.7	8.8	9.9	10.9	11.8	12.8	13.7	14.5	15.0	15.0	15.0	15.0	15.0

注意：1）上述峰值功率基于“绝酷”B0015样机规则波测试的数值呈现，并通过DNV GL审核及见证。
2）有用功均值输出（RMS）大约是上述的峰值输出的64%。

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波浪点亮未来

高效 • 可靠 • 简洁 • 持久 • 高性价比 • 绿色环保
多功能 • 可扩展

“绝酷”波浪能转换器是迄今为止最高效、最多样化的设备。它将为波浪能满足全球对清洁能源的日益增长的需求提供一个崭新的技术解决方案。

- 韩磊，“绝酷”发明者

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测试峰值
功率记录

14/03/2018
10kW
17/11/2017
21/10/2017
8kW
26/09/2017
25/09/2017
6kW
4kW
01/09/2017
2kW
20/06/2017
20/03/2017
23/12/2016
0kW

DRAKOO

为什么选择波浪能?

波浪能是一种分布范围广、密度高、开发潜力巨大的能源，利用波浪能可以减少对传统化石燃料的依赖。波浪能与太阳能和风能一样，其本源还是太阳能，但是波浪能的密度较风能与太阳能相比，超出10倍以上。波浪能更容易预测，并且与太阳能不同，波浪能可以全天候不间断地获取。

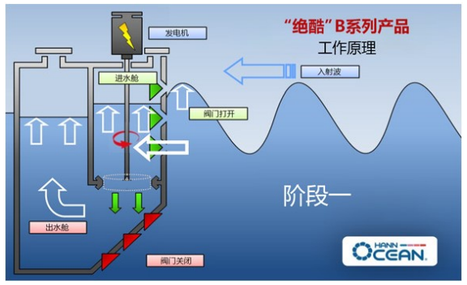
“绝酷”工作原理

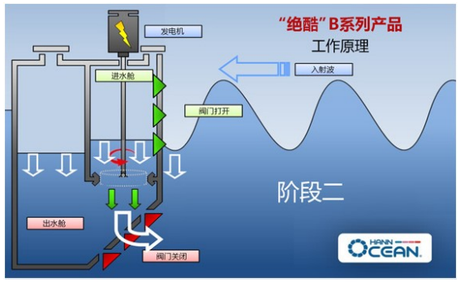
“绝酷”波浪发电机作为一个双腔振荡水柱水轮发电系统，其工作原理是将海浪转变为连续的水流，从而驱动水轮机发电。

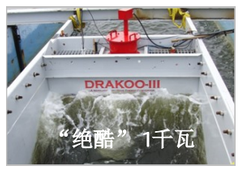
阶段一：当外在的水面向上从波谷升到波峰，入射波浪将外在的水推入进水舱，使得进水舱的水位升高，同时，进水舱的水又通过进水舱和出水舱之间的水涡轮机进入出水舱。

阶段二：当外在的水面向下从波峰跌倒波谷，出水舱的水位将跟着进水舱的水位同时下降，而引起另一轮来自进水舱到出水舱的水流。

在这两阶段中，水柱不断的在波浪运动中循环振荡。在此过程中，通过两组单向导流格栅控制水流的流动方向，从而产生稳定、单向的水流，推动水涡轮机顺利的运转，并产生稳定有效的电力。







发展里程碑

2008.08	“绝酷”波浪能转化器概念设计国际专利申请。
2010.09	1:5 比例的“绝酷”模型在南洋理工大学测试，捕获波浪率（峰值）高达66%。
2011.07	1千瓦“绝酷”样机在英国国际可再生能源中心通过测试，捕获波浪率（峰值）超过80%。
2012.06	从胜科海事获得第一个商业订单。
2012.10	4台“绝酷”4千瓦波浪能转换器交付胜科海事。
2012.11	“绝酷”4千瓦波浪能转化器进行海试。
2013.08	“绝酷”16千瓦阵列投放至大士景海域。
2015.02	韩洋能源在华子公司注册成立。
2015.11	“韩洋一号”造波水池建造完成。
2016.07	“韩洋一号”造波机（120千瓦）安装完成并通过测试。
2016.12	“绝酷”10千瓦全尺寸样机组装完成并开始发电。
2017.11	“绝酷”10千瓦样机实现峰值发电。
2018.03	“绝酷”10千瓦样机峰值发电升至15千瓦。

关键要素

“绝酷”由三个关键要素组成：

1. 双腔体
2. 单向导流格栅
3. 动力输出系统

以上三项要素的独特结合设计均由韩洋独立研发。可以根据波浪条件的不同，定制不同型号的”绝酷”波能转换器。通过采用成熟的永磁发电机、水涡轮技术以及经济的材料，加上简单、高效、模块化的设计使得”绝酷”对比其他波能转换器具有更强的竞争优势。

性能

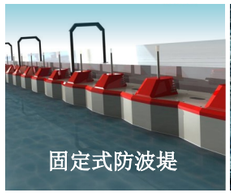
通过英国国际再生能源中心（Narec）的验证，在规则波情况下”绝酷”已经持续实现了最大波能-液压能转换效率/捕获波浪率（CWR）超过80%，而平均CWR为50%。商用型”绝酷”总体转换（波能-电能）峰值效率超过50%，有用功（RMS）平均效率为22%。关于“绝酷”-B型在各种波浪条件下的电力输出，请参考技术参数中的功率输出频谱。

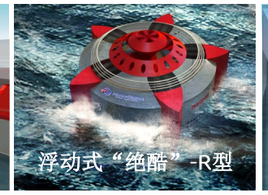
效益

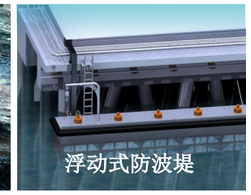
这项拥有国际专利的技术已经在实验室及真实海况中得到证明，是替代柴油发电机的高效的技术解决方案。我们坚信“绝酷”波浪能转换器是迄今为止最高效、最多样化的波浪能转换器。“绝酷”将为波浪能发电提供了一个崭新的概念和专业规范，为满足全球对清洁能源的日益增长的，尤其是对于岛屿及偏远离岸区域的需求作贡献。

应用

- 与防波堤相结合的浮动或固定式波浪能转换器。
- 与海上建筑相结合的浮动或固定式波浪能转换器，如油气平台、渔场养殖和海上风力发电。
- 固定式模块化波浪能转换器阵列，如固定式防波堤。
- 浮动式模块化波浪能转换器阵列，如”绝酷”-X型。
- 浮动独立式波浪能转换器，如”绝酷”-R型。


固定式防波堤


浮动式“绝酷”-R型


浮动式防波堤

优势

效率
波浪至电力转换效率，高达22%（平均有用功率）和50%（峰值功率）。

可靠
部分部件采用风力发电电力系统组件，关键部件通过定制。

高性价比
低生命周期成本及经济实惠的电力价格。

简洁
即插即用的动力输出装置，模块化结构设计。

持久
具有在极限海浪中自我释放内部压力的装置。

绿色环保
不伤害海洋生物，对海域和海床影响甚小。

多功能性
可沿海岸线或离岸，以固定或浮动模式安置。

可扩展性
装机容量可从千瓦级扩展至兆瓦级。

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