

ICOE-OEE 2022



# HARNESSING WAVE ENERGY

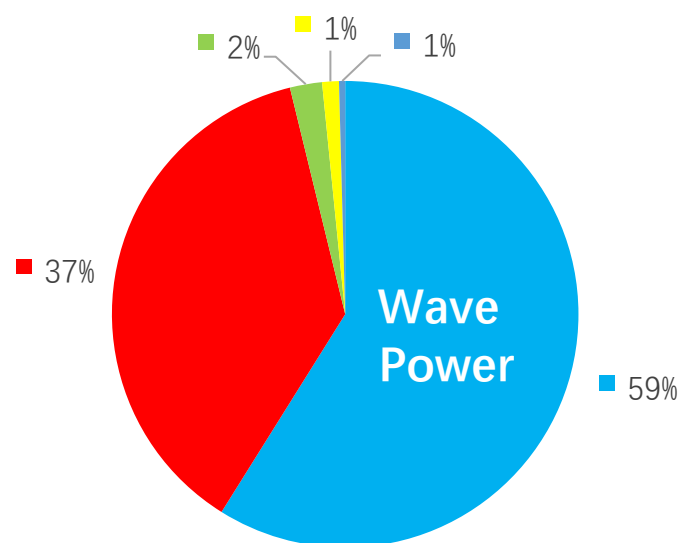
INTRODUCTION OF A NOVEL WAVE ENERGY  
CONVERTER DRAKOO TESTED IN CHINA

by Henry Lei Han, MD, Hann-Ocean Energy



# WAVE ENERGY RESOURCE IN CHINA

## TECHNOLOGICALLY DEVELOPABLE CAPACITY OF OCEAN ENERGY RESOURCE IN CHINA

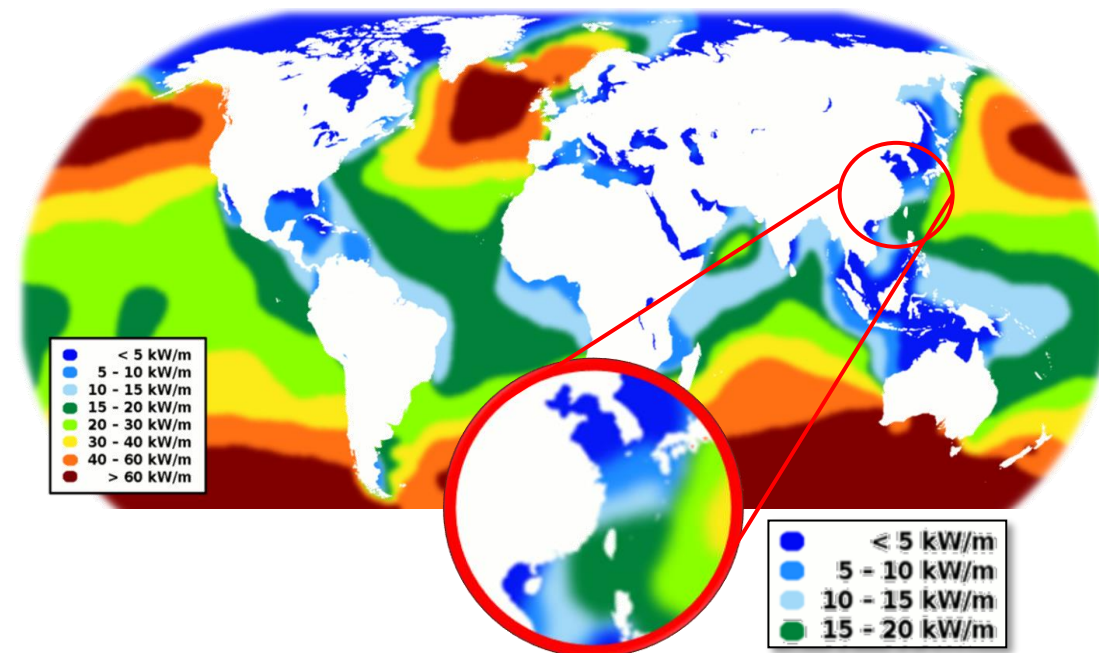


■ Wave Energy  
■ Tidal Energy

■ Ocean Thermal Energy  
■ Salinity Energy

Source: "Coastal Engineering" (2022, Issue 1) in Chinese

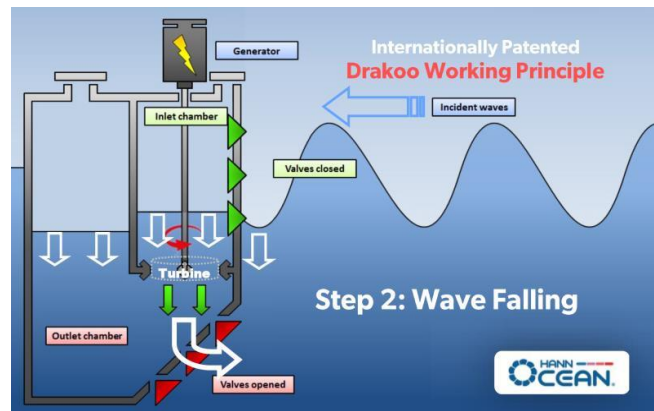
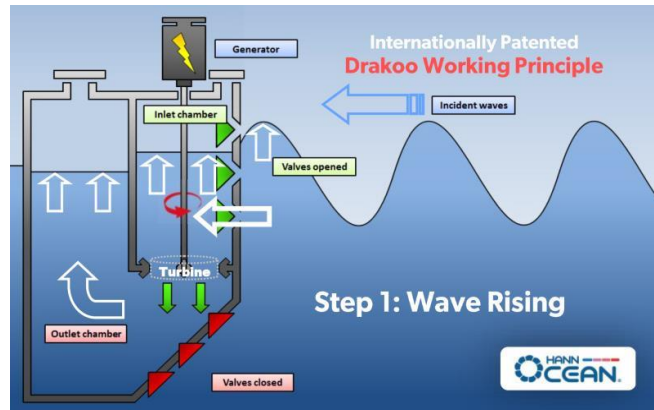
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## WORLD & CHINA WAVE POWER FLEX

## DRAKOO WEC Tech

- ✓ Core Invention patented in 2008
- ✓ Highly efficient hydro turbine converting wave energy to electricity



# Developmental Milestones



- **Verified by Narec:** The first generation Drakoo-1G has a wave-to-hydraulic energy conversion efficiency in excess of 80% at peak and above 50% on average in regular waves verified by NAREC, UK in 2011 (now part of ORE catapult)
- **Sea trials in Singapore:** The second generation Drakoo-2G array (4kWp x 4) was delivered to SembCorp Marine and tested in Singapore in 2013-2014.
- **Verified by DNV-GL:** A series of wave tank tests of the 3<sup>rd</sup> generation Drakoo-3G was witnessed by DNV-GL in 2018. The test protocol and report have been verified by DNV-GL
- **Approved by Atkins:** Hann-Ocean successfully completed a feasibility study for Atkins Global for a hybrid clean energy project for an offshore wellhead platform using Drakoo and Solar PV technologies
- **Continuous R&D:** A Drakoo-4G designed and built for better efficiency and more stable power output. The improvements confirmed and a new patent filled.
- **Ongoing sea trials in China:** A 6-month sea trial completed at Shengsi island on 18 July 2022 , followed by upgrades based on the lesson learnt during the sea trial. A post-upgrade sea trial is ongoing.

## DRAKOO PILOT PROJECT IN CHINA

- A cubic modular Drakoo design of 3.0x 3.5x 5.1m weighs 15 tons and has a peak capacity of 15 kW. It was independently researched and developed by Hann-Ocean Energy
- Completed 6 months sea trial for the 3<sup>rd</sup> generation Drakoo-3G prototype at Shengsi archipelago, Zhejiang, China

# DRAKOO WAVE POWER TESTING

[Click the title to watch the video online]



Our vision transcends turning an innovative concept into a successful business.

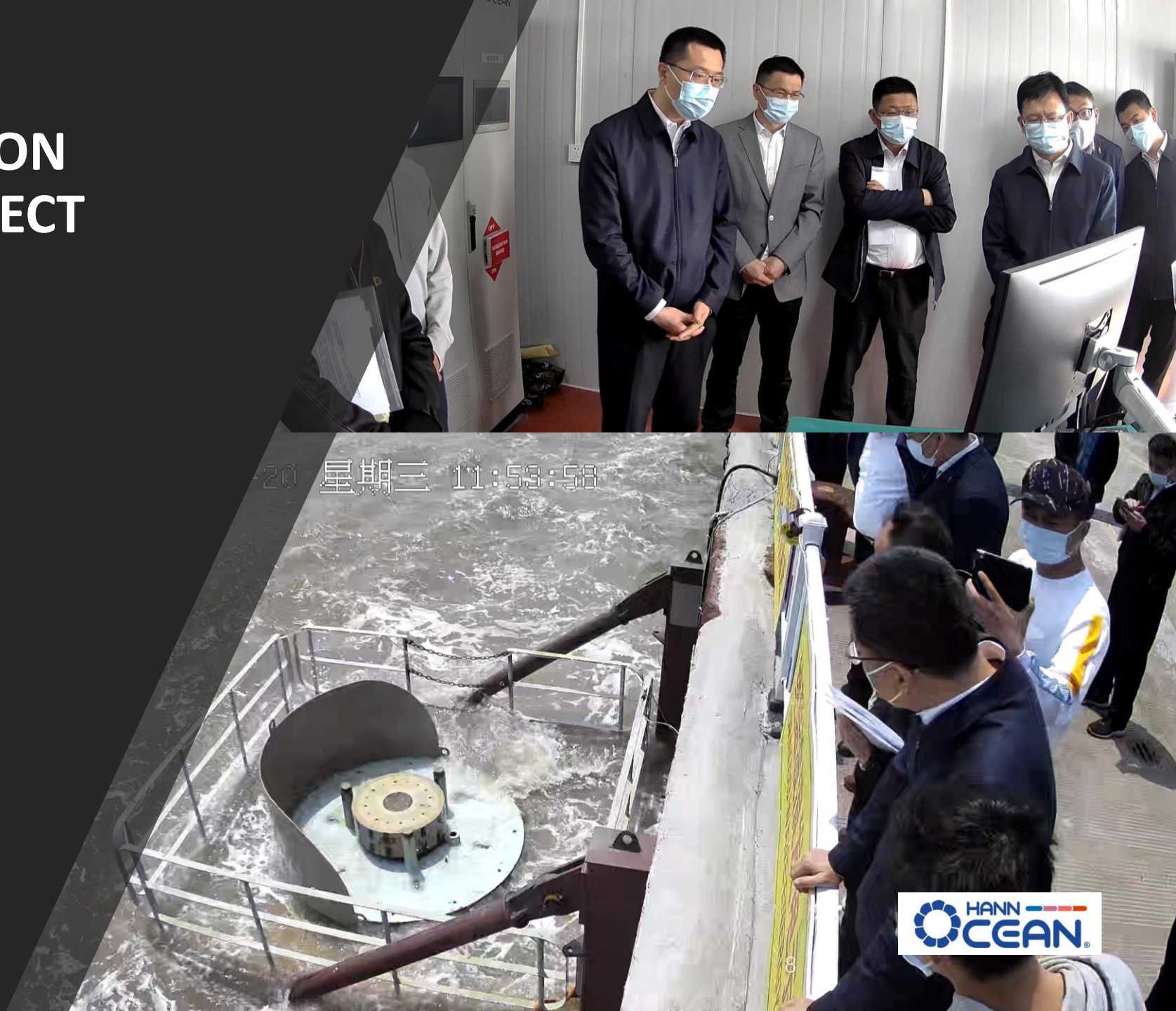
# 6-MONTH DRAKOO-3G SEA TRIAL COMPLETED AT SHENGSI, CHINA



- The average energy conversion efficiency from waves to electricity of the 3<sup>rd</sup> gen Drakoo can reach up to 30%, with the peak efficiency nearing 45%, verified by DNV
- Valuable real sea test data were collected during the 6-month sea trial
- Wave height of starting power generation found as low as 0.2m
- Solutions addressing the design problems found during the sea trial have been formulated
- Realistic issues such as marine growth, seawater corrosion and typhoon weather were recorded and taken into consideration for the next upgrade.

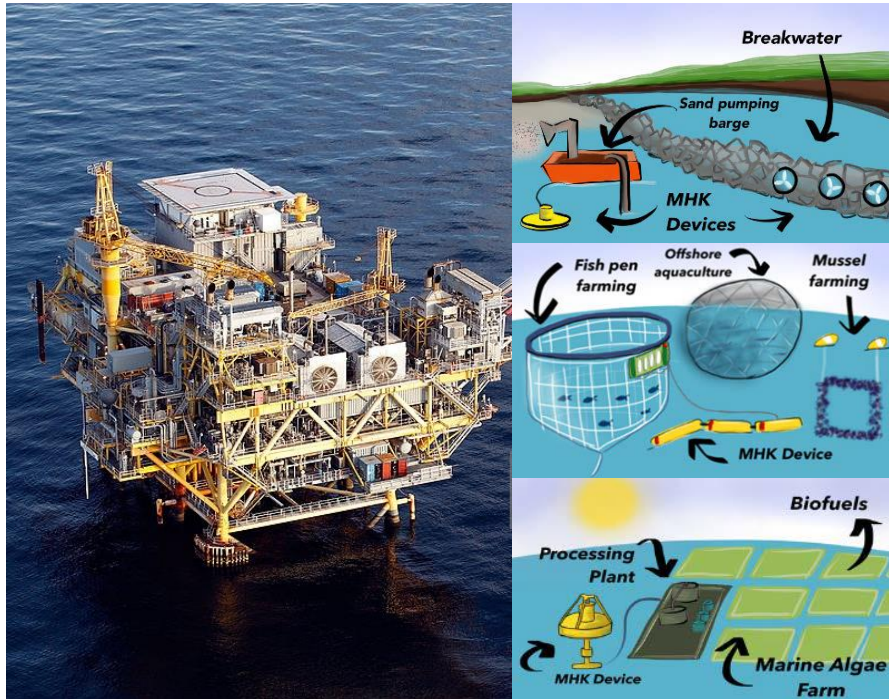
# SUPPORT RECEIVED ON DRAKOO PILOT PROJECT IN CHINA

- In November 2021, the Shengsi government gave permission to Hann-Ocean to commence the Drakoo pilot project
- In April 2022, the vice governor of Zhejiang province, Mr Lu Shan visited the Drakoo site
- In June 2022, Zhejiang Daily newspaper published a special report - "Ocean Energy: How we can harness it", that introduces the Drakoo WEC from Hann-Ocean, among the other latest breakthroughs in Ocean Energy in Zhejiang, China.



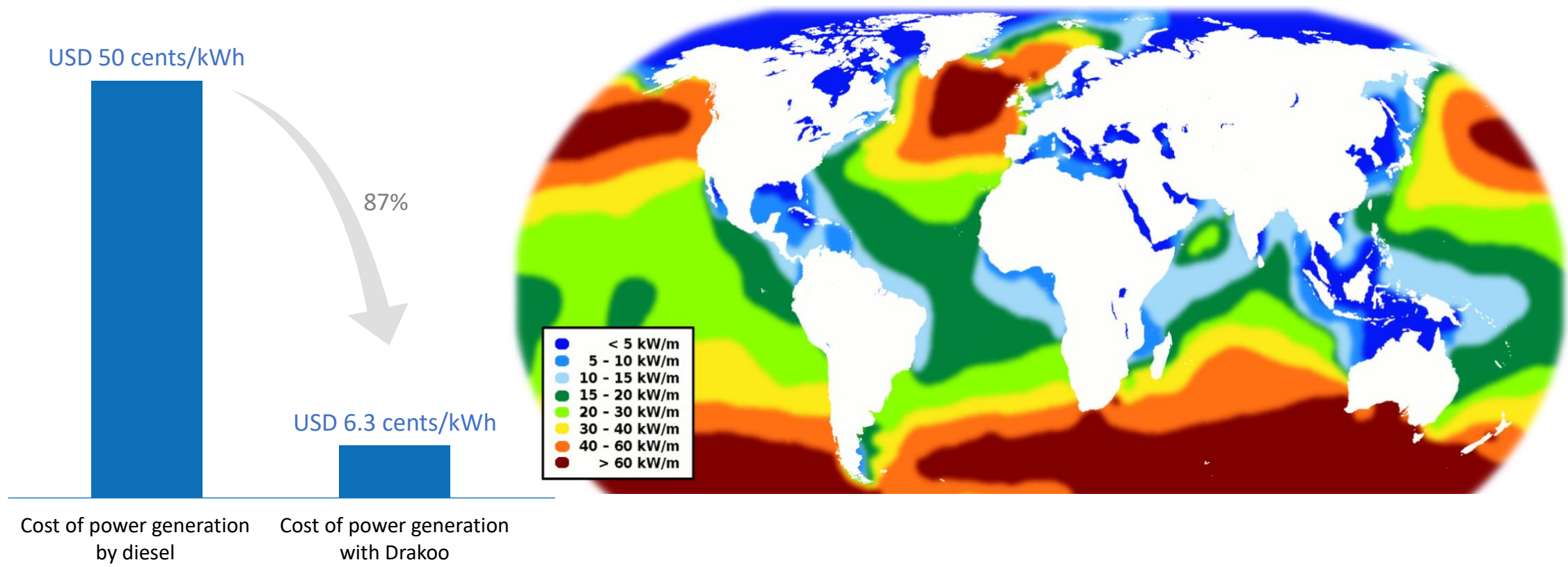
# Drakoo Wave Energy Series Products For Broad Applications

- Drakoo products are mainly designed for **small and medium ocean waves** and **where photovoltaic and wind power applications are not feasible**.
- Drakoo is **simple, modular and expandable**, and is an ideal replacement to diesel generators



Images from U.S. DOE 2018

Target Market Segments					
Drakoo Array Config.	Oil & Gas Platforms	Island Communities	Offshore Wind Farms	Aquaculture	Shoreline Protection / Breakwater
Drakoo-B	✓	—	—	—	✓
Drakoo-V	—	✓	—	—	—
Drakoo-X	—	✓	✓	—	—
Drakoo-W	—	✓	✓	—	—
Drakoo-R1	—	—	—	✓	—
Drakoo-R2	—	✓	—	—	—
Drakoo-B-FRC	—	—	—	—	✓



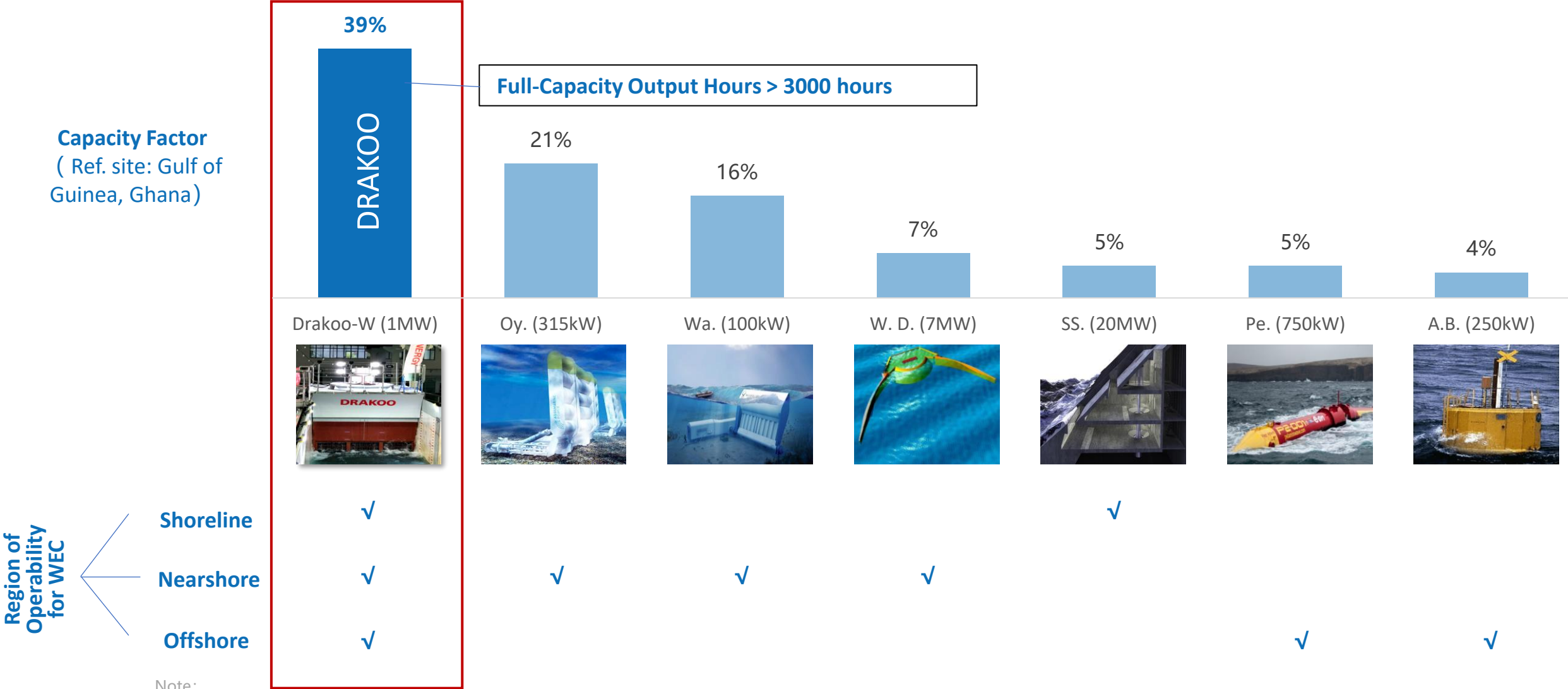
Drakoo Wave Power Plant		Cost of Electricity	
Order quantity (MW)	Operational life(year)	USD/kWh	RMB/kWh
100	20	\$ 0.086	¥ 0.60
100	30	\$ 0.063	¥ 0.44

Ref. site: Gulf of Guinea, Ghana

Integrated power generation of offshore wind and Drakoo wave energy		Cost of Electricity	
Order quantity (MW)	Operational life(year)	USD/kWh	RMB/kWh
20	20	\$ 0.073	¥ 0.51
20	30	\$ 0.057	¥ 0.40

Ref. site: Gulf of Guinea, Ghana

# Comparison with other WECs

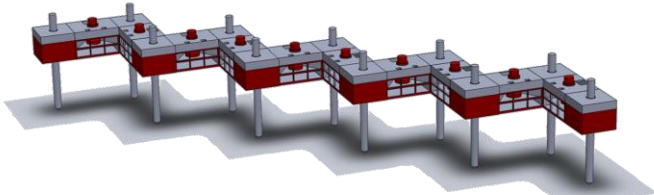


Note:

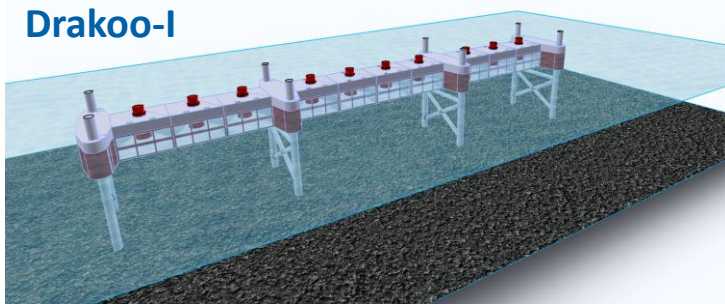
1. Capacity Factor = Actual Annual Electricity Production/Total Array Capacity x 24 x 365; Assumed that wave power is converted per its published Power Matrix, omnidirectional. Drakoo is fixed
2. Power matrices of Pelamis, SSG, Wave Dragon, Aqua Buoy and Oyster obtained from Silva, D.; Rusu, E.; Soares, C.G. Evaluation of Various Technologies for Wave Energy Conversion in the Portuguese Nearshore. Energies 2013, 6, 1344-1364.
3. Waveroller power matrix (normalized) obtained from: <https://www.wavec.org/contents/files/04-aw-energy.pdf>

## MW-scale Floating Drakoo Array

### Drakoo-W

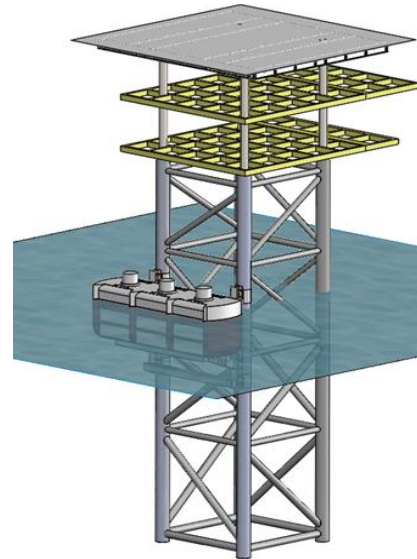


### Drakoo-I



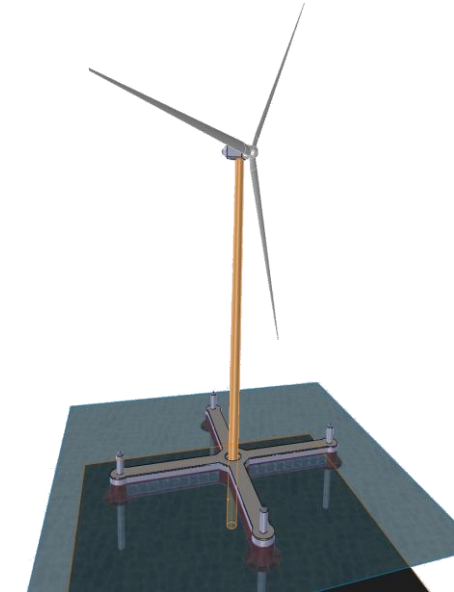
- Hann-Ocean is developing a floating wave power array (**1MWp**) consisting of **ten modules (100 kW each)** to provide sustainable energy to coastal cities

## Oil & Gas Application Feasible



- **An engineering feasibility study** was completed successfully in April 2019 by Hann-Ocean Energy under a consultancy contract with **ATKINS** Global:
  - (a) To provide the annual wave power projections of Drakoo WEC array at the chosen site
  - (b) To design the support structure for integrating the WEC array with the wellhead platform
  - (c) To simulate the 6-DOF dynamic loads acting on the jacket.

## Integrated Wind and Wave Power Platform



- Hann-Ocean is developing a unique integrated ocean renewable energy platform **comprising a wind turbine and wave power array** to maximize the use of sea surface. (1.5MWp wave array and 1.5MW wind turbine )
- Sharing the subsea cables, transformers, inverters and the mooring foundation, which reduces the capacity cost and the total lifecycle cost of the installation, while allowing for a stable electrical output from the hybrid system

## Easten-China-Sea Bridge – 20MW WEC Array



- The bridge is 32.5 kilometers long and has 500 piers, each of which can be installed with a 40-kilowatt Drakoo. It can constitute a wave power array of 20 MW. It is estimated that the entire bridge can produce 46 million kwh yearly. If calculated at 75 cents per kw/hour, the total annual power generation is equivalent to 34.5 million yuan.

## Hong Kong-Zhuhai-Macao Bridge – 32MW WEC Array

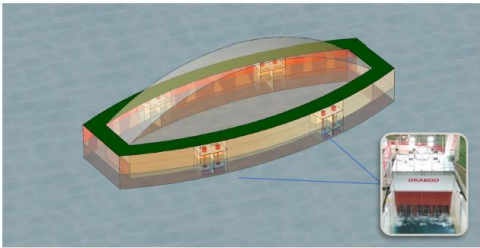


- The bridge is 55 kilometers long and has 800 piers, each of which can be installed with 40-kilowatt Drakoo. It can constitute a wave power array of 32 MW. It is estimated that the entire bridge can produce 74 million kwh yearly. If calculated at 75 cents per kw/hour, the total annual power generation is equivalent to 55 million yuan.

## ZPMC 100 Units of Fishery Floating Farms

“绝酷”波浪发电机集成深海养殖平台

- “百台万吨”生态养殖平台建设(振华重工福州项目)
- “深蓝1号”呈橄榄形，总长60米，至宽30米，养殖水体达13000万立方米
- 建议安装“绝酷”波浪发电机



**DRAKOO**  
www.hann-ocean.com

初步方案：“绝酷”波浪发电机  
- 单机容量为DB-15千瓦 x 8台 = 120 千瓦/艘  
- 同时可以起到主动防摇功能  
- 建议做可行性研究



信息来源：国际船舶网 船舶海工圈  
[https://mp.weixin.qq.com/s/lccS\\_2hPwFk\\_RhNc1oMgw](https://mp.weixin.qq.com/s/lccS_2hPwFk_RhNc1oMgw)

## China Power 2.2km/30MW Breakwater



## Shandong Ocean Modern Fish Farm “耕海1号”



## Proposed WEC Application on Breakwater – 500kW Wave Park



Case Study: Santa Marina Port of Sicily Island, Italy.

Label: 1) WEC; 2) Park; 3) Wave Power Exhibition; 4) Viewing Gallery and 5) Floating Stage and Swimming Pool

## Self-developed Core Technology

- ✓ Internationally Patented > **20 countries**

# DRAKOO

The most commercially viable wave technology to date

## Progressing Steady of Commercialization

- ✓ Projects in Pipeline > **100 MW**

## Effect verified

- ✓ Lab Tests and Sea Trials > **4000 hours**
- ✓ Expected Annual Full-Capacity Output > **3000 hours**
- ✓ **Verified by NAREC, DNV-GL and ATKINS** for Concept, Output & Application

## Low cost and high efficiency

- ✓ Drakoo Wave power costs as little as, **\$0.063/kWh\***
- ✓ Cost of Integrated power generation of offshore wind and Drakoo wave energy **\$0.057/kWh\***
- ✓ Breakeven Period in 3-7 years from diesel power cost saving

## Broad Application Market

- ✓ Offshore Facilities & Remote Islands
- ✓ **Ideal replacement for diesel power**



Note: NAREC – National Renewable Energy Centre UK, DNV-GL – Ship Classification Society from Norway, ATKINS – ATKINS Global Consulting Firm, Dubai

\* Location dependent



With Drakoo<sup>®</sup>, Wave Power will become  
a reliable clean energy source for a  
sustainable future.

Let's do it together!

ICOS-OEE  
2022

Contact: [enquiry@hann-ocean.com](mailto:enquiry@hann-ocean.com)  
Visit: [www.hann-ocean.com](http://www.hann-ocean.com)

