awtec
Asian Wave and Tidal Energy Conference Series
2016 at Marina Bay Sands, Singapore

Full-Scale Artificial Ocean Wave Generation for Wave Energy Converter Performance Testing

Henry L. Han, Lex L. de Rijk

Hann-Ocean Energy Pte Ltd

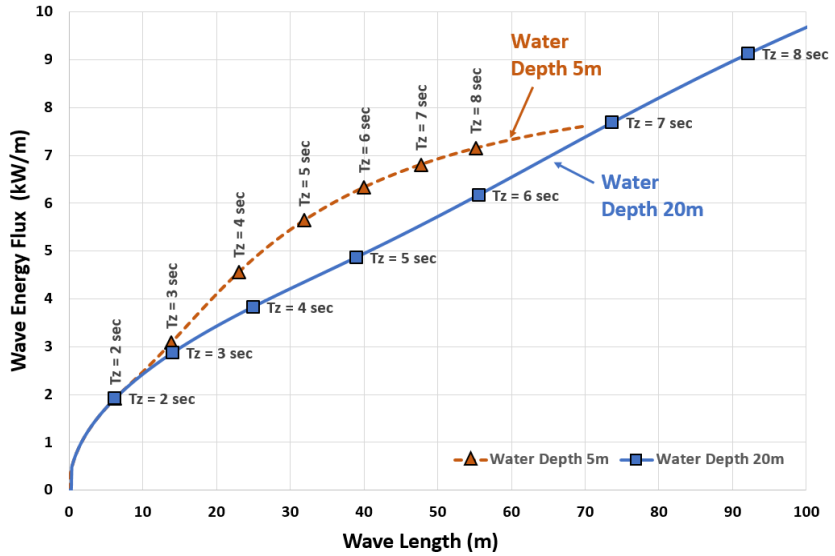
www.hann-ocean.com
cn.hann-ocean.com

Agenda

- Why need a full-scale wave flume?
- Unique design of U-bend Twin Wave Flume
- CFD simulation for the Twin Wave Flume
- Design and testing of a 120kW Flap-type Wave Maker
- Introduction of Drakoo-B WEC 10kW full-scale prototype

Why need a full-scale wave flume?

- To avoid scalability errors in small-scale model tank testing
- To avoid un-scalable factors such as Reynolds in combination with Froude similitude
- To simulate true wave pattern in deep water
- To produce real wave energy flux for prototype testing

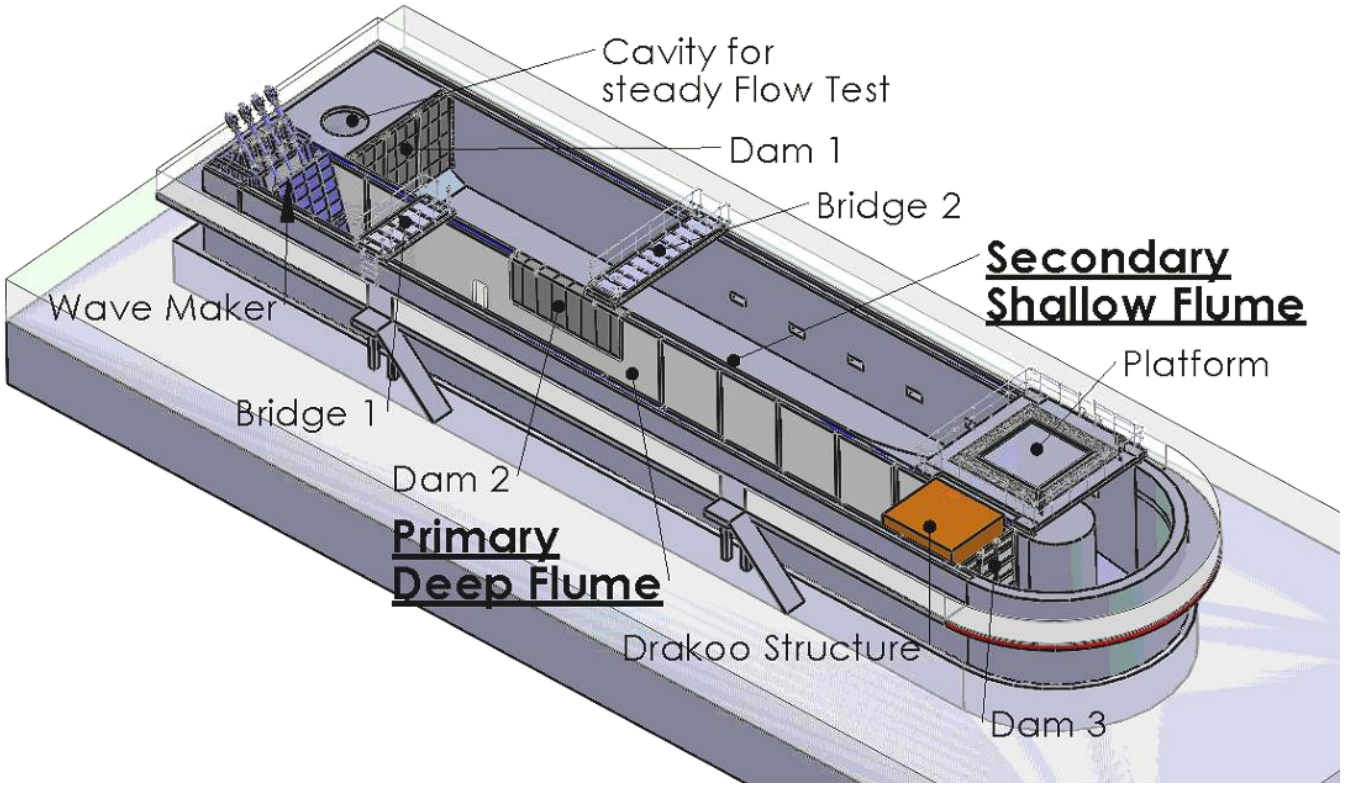


- To improve prediction of mechanical and hydraulic losses in real scale
- To avoid limitations of empirical formulas for PTO performance in scaling

So as to improve accuracy of total energy conversion efficiency of a full-scale WEC prototype

Unique design of U-bend Twin Wave Flume

Main Parameters of the U-bend Twin Wave Flume



Primary Deep Flume

- Length 42m
- Beam 3m
- Depth 5.5m

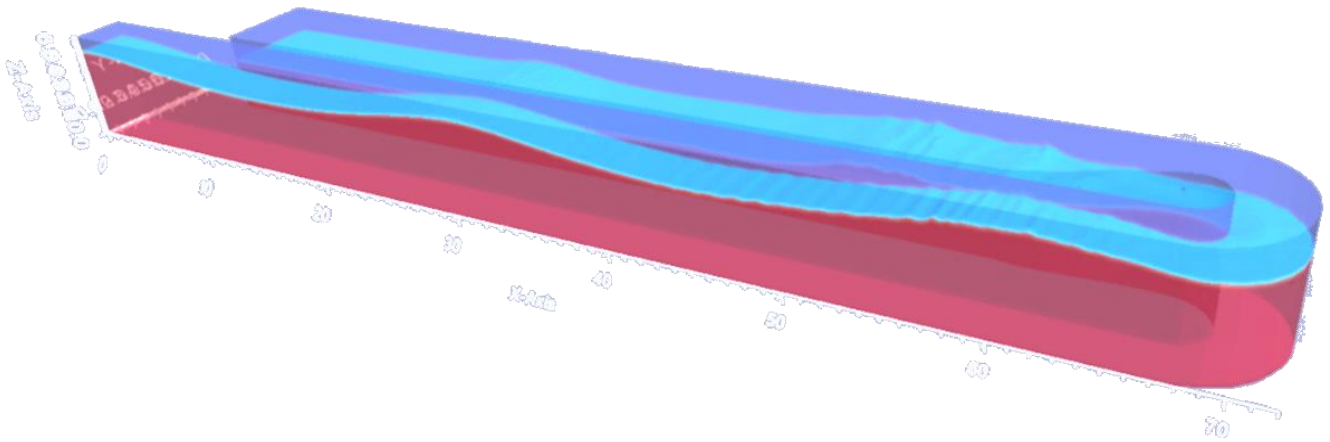
Secondary Shallow Flume

- Length 42m
- Beam 5.5m
- Depth 4.0m

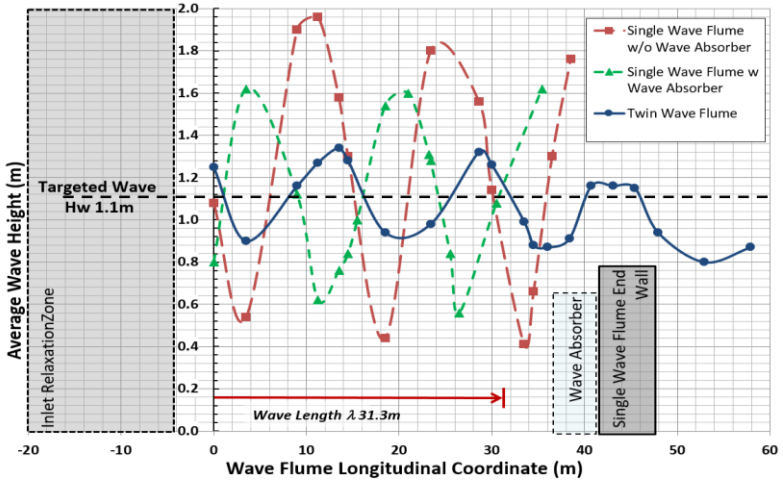
U-bend Circular Flow Flume

© Hann-Ocean

CFD simulation for the Twin Wave Flume



- Using customized OpenFoam code with WaveFoam solver
- Series of studies conducted for optimization of the U-bend shape design
- Numerous configurations simulated with various dimensional boundaries of the flume.

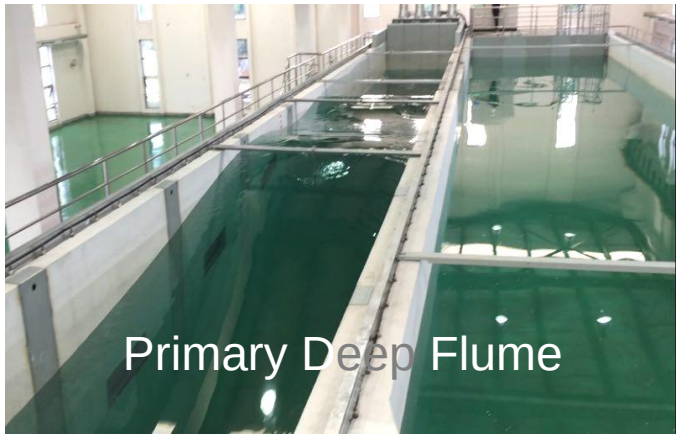


Comparison of fully developed waves of:

1. A single wave flume with rigid and fixed end-wall
2. A single wave flume with wave absorber and end-wall
3. The final design double-wave flume with U-bend

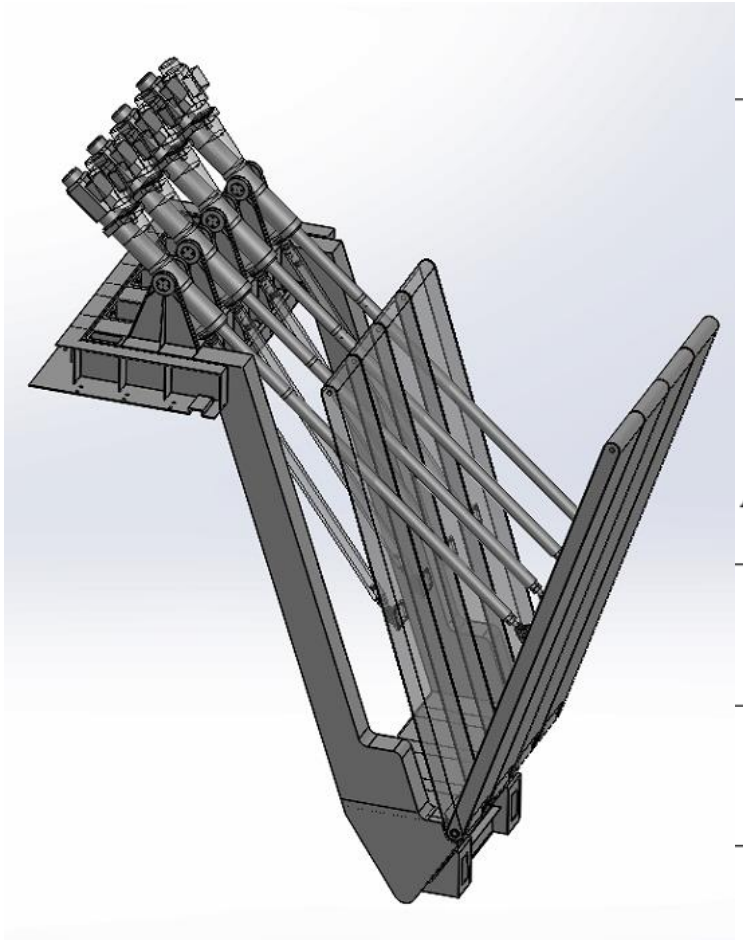
Unique design of U-bend Twin Wave Flume

360º Twin Wave Flume


Primary Deep Flume


Secondary Shallow Flume

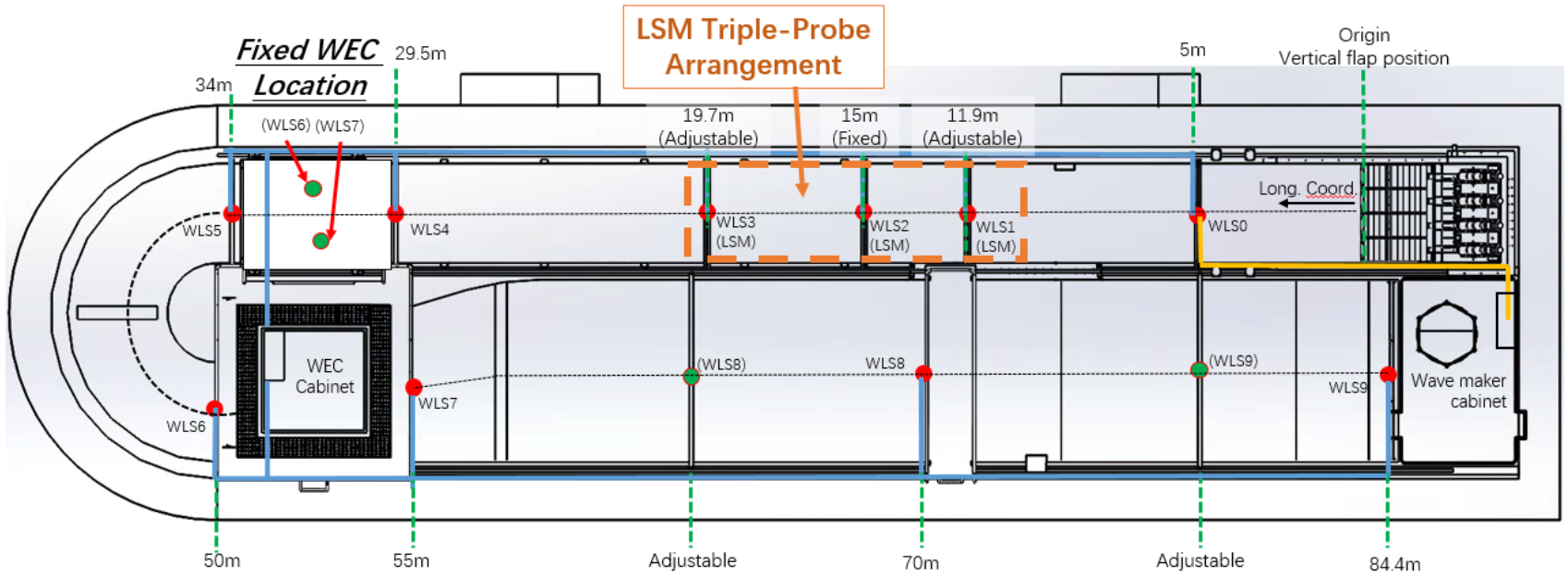
Design of the 120kW Flap-type Wave Maker

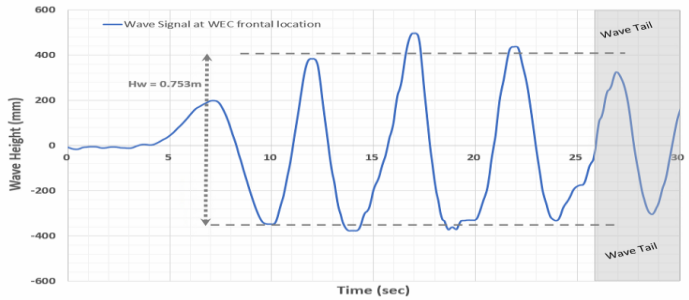


WAVE MAKER SPECIFICATIONS	
Height x Width x Depth	7.9 x 3.8 x 6.2 m
Weight	11.8 ton
Wave board type	Hinged flap type, wetback
Flap Length	5.2 m
Total flap width	3.0 m
Drive System	Servo Motor (120kW)
Flap max. Angular Displacement	±18°
Wave Direction	Straight | Oblique
Active Wave Absorption (built-in)	<Being Calibrated>
Regular Wave	
Wave Period	2.00 ~ 8.00 sec
Wave Height	0.10 ~ 1.00 m
Irregular Wave	
Peak Wave Period	2.0, 2.5, …, 6 sec
Significant Wave Height	0.1, 0.2, …, 0.8m
Spectral Distribution	Jonswap, Pierson-Moskowitz

© Hann-Ocean

Testing of the 120kW Flap-type Wave Maker





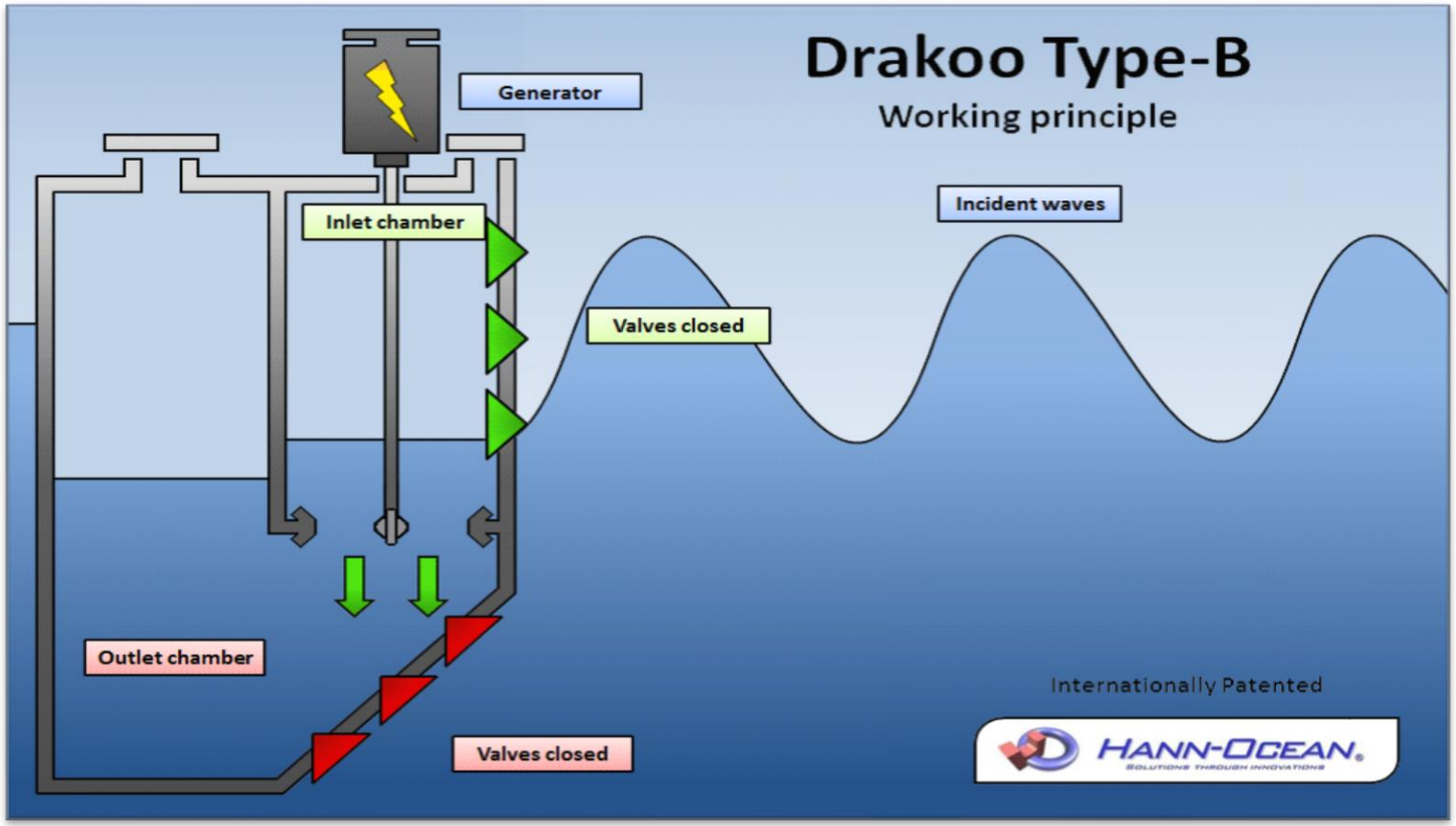
@ WLS4 in front of the testing WEC

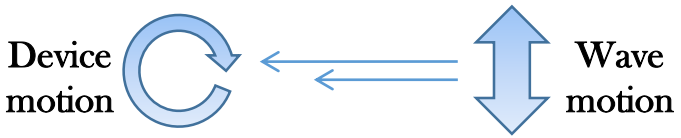
Set H = 0.8m vs 0.786m measured

Set Tz = 5.0s vs 4.97s measured

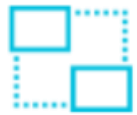
© Hann-Ocean

How does Drakoo WEC work?





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).

BENEFITS

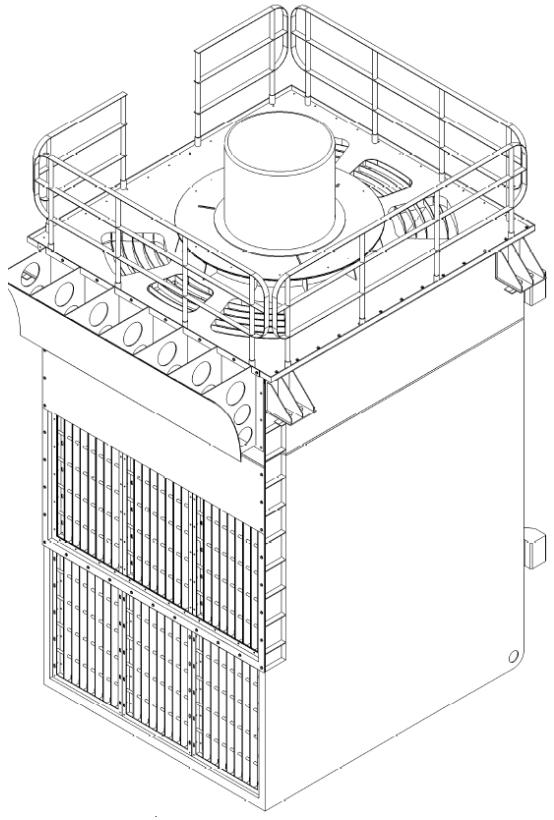
Efficiency	Reliability	Cost-effective	Simplicity	Durability	Eco friendliness
Up to 50% overall energy conversion factor	Use of commercially available key components increase reliability	Low material costs and economically justifiable price	Plug' n' Run power take-off; modular pontoon structure design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

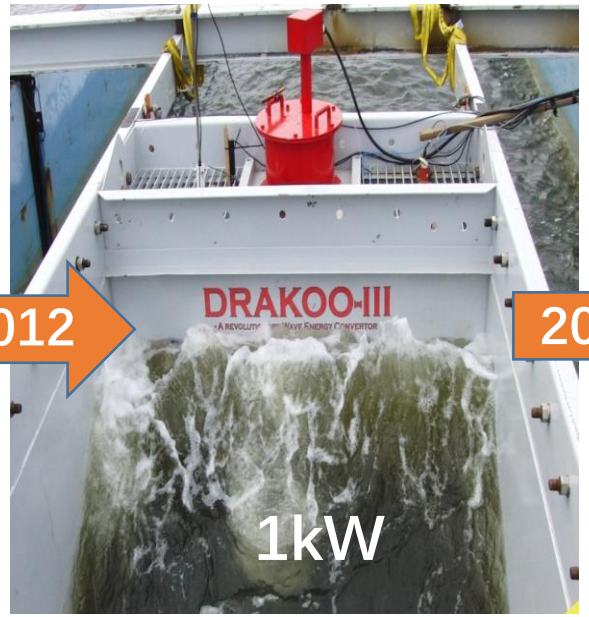
Drakoo-B WEC 10kW Full-scale Prototype

Type: B0010SP

Version: 2016-10

PTO Driver	Kaplan Turbine		
PTO Generator	Permanent Magnet Synchronous Generator (PMSG)		
Peak Wave Height	1.25	m	
Peak Output	10	kWp	
Norminal Wave Height	1	m	
Norminal Power Output	8	kW	
Optimal Peak Wave Period	7.2	sec	
Optimal Zero-cross Wave Period	5.2	sec	
Generator Voltage Output	54-200	VAC (3-Phase)	
Total Wave-electricity Efficiency	50%		



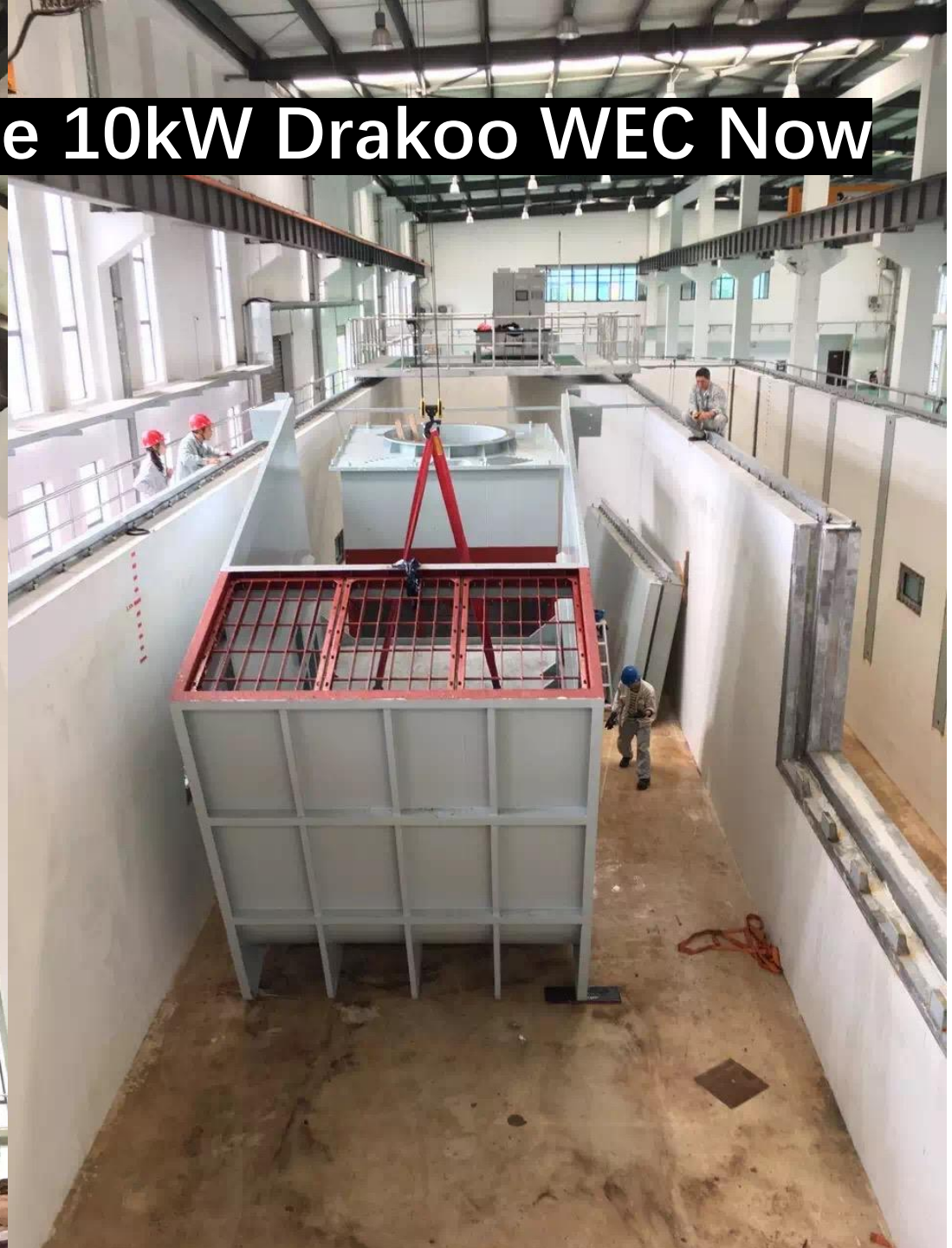


2012

2013

2016

Preparing for Testing of the 10kW Drakoo WEC Now



Preparing for Testing of the 10kW Drakoo WEC Now