pelamis
wave power

750kW

PELAMIS

P-750
WAVE ENERGY CONVERTER

The Pelamis P-750 Wave Energy Converter is the result of extensive testing, modelling and development by Pelamis Wave Power, formerly known as Ocean Power Delivery.

The machine is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure oil through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity. Power from all the joints is fed down a single umbilical cable to a junction on the sea bed. Several devices can be connected together and linked to shore through a single seabed cable.

A novel joint configuration is used to induce a tuneable, cross-coupled resonant response, which greatly increases power capture in small seas. Control of the restraint applied to the joints allows this resonant response to be 'turned-up' in small seas where capture efficiency must be maximised or 'turned-down' to limit loads and motions in survival conditions. The machine is held in position by a mooring system, comprising of a combination of floats and weights which prevent the mooring cables becoming taut. It maintains enough restraint to keep the Pelamis positioned but allows the machine to swing head on to oncoming waves. Reference is achieved by spanning successive wave crests.

The Pelamis is designed to be moored in waters approximately 50-70m in depth (typically 5-10km from the shore) where the high energy levels found in deep swell waves can be accessed.

The design of the Pelamis has been independently verified by WS Atkins according to (DNV) offshore codes and standards.

KEY FEATURES

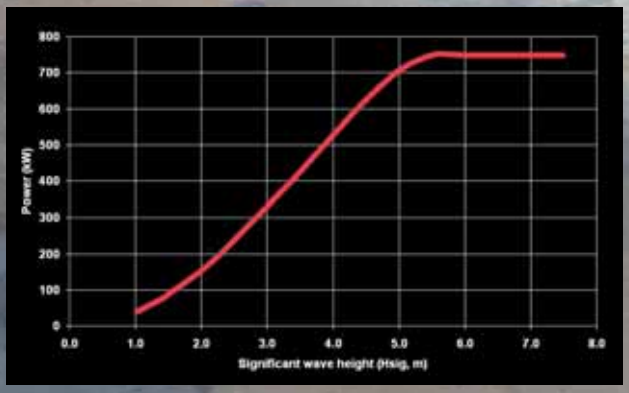
- **SURVIVABILITY**
  The core theme of the Pelamis WEC concept is survivability. All Wave Energy Converters absorb power in small waves through HYDROSTATIC forces – that is buoyancy versus weight or hydrostatic pressure. However extreme loads in waves arise from the HYDRODYNAMIC forces, namely inertia, drag and slamming. The Pelamis is very strongly coupled hydrostatically but is almost invisible to large hydrodynamic effects.
- **100% AVAILABLE TECHNOLOGY**
  The Pelamis is an assembly of proven technology from the offshore oil and gas sector.
- **NON SITE SPECIFIC**
  The Pelamis is designed for offshore locations with water depths of 50 – 70m, giving maximum flexibility and scalability.
- **MINIMUM ON-SITE WORK**
  The Pelamis is constructed, tested and maintained off-site with a minimum of installation work required on-site.
- **POWER CAPTURE EFFICIENCY**
  The Pelamis can be tuned to match conditions and optimise energy extraction.
- **DESIGN INDEPENDENTLY VERIFIED**

PELAMIS

P-750 WAVE ENERGY CONVERTER

These are internal views of the Power Conversion Module.

Power Limiting



Example of Pelamis hydrodynamic power limiting for a representative wave period (Tpow) of 8 seconds. Above a certain wave height absorbed power is limited through the Pelamis inherent design characteristics.

Power Matrix

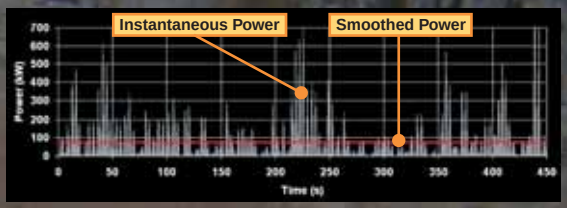
Significant wave height (H_{sig}, m) \ Power period (T_{pow}, s)	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
0.5	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle
1.0	idle	22	29	34	37	38	38	37	35	32	29	26	23	21	idle	idle	idle
1.5	32	50	65	76	83	86	86	83	78	72	65	59	53	47	42	37	33
2.0	57	88	115	136	148	153	152	147	138	127	116	104	93	83	74	66	59
2.5	89	138	180	212	231	239	238	230	216	199	181	163	146	130	116	103	92
3.0	129	199	260	305	332	340	332	315	292	266	240	219	210	188	167	149	132
3.5	-	270	354	415	438	440	424	404	377	342	328	292	260	230	215	202	180
4.0	-	-	462	502	540	546	530	490	475	429	384	366	339	301	267	237	213
4.5	-	-	544	635	642	648	628	590	562	528	473	432	382	356	338	300	269
5.0	-	-	-	739	726	731	707	667	670	607	557	521	472	417	369	348	328
5.5	-	-	-	783	792	788	764	768	737	667	658	586	530	496	446	395	355
6.0	-	-	-	-	792	792	758	768	769	760	711	633	619	558	512	470	415
6.5	-	-	-	-	792	792	792	768	769	760	759	743	658	621	579	512	481
7.0	-	-	-	-	-	792	792	768	769	760	759	759	755	678	633	594	525
7.5	-	-	-	-	-	-	792	768	769	760	759	759	759	700	686	622	593
8.0	-	-	-	-	-	-	-	792	769	760	759	759	759	759	759	690	625

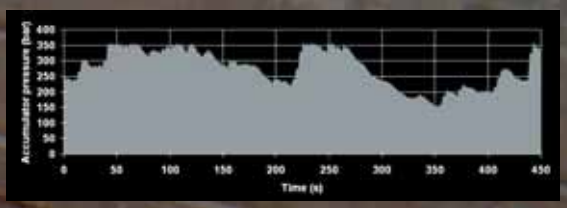
The Power Matrix shows the power generated by the Pelamis in a range of sea spectra defined by significant wave height (Hsig) and power period (Tpow). It was derived using an experimentally verified numerical model assuming a two parameter Pierson-Moskowitz spectra as input and taking account of design constraints and machine efficiency.

Power Prediction

Like the Power Curve of a wind turbine the Power Matrix can be used in conjunction with site specific resource data to predict the machine's annual energy yield. The graphs above show wave buoy data for a particular site (top) with the Pelamis' predicted power output (bottom). Due to the Pelamis' optimisation of power capture for small sea states, power output is flatter during the year compared to incident power levels.

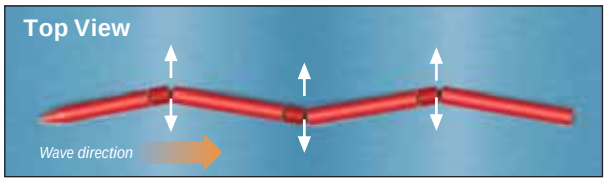
Smooth Power



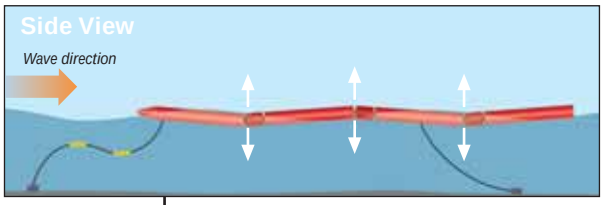


Waves produce a widely variable power input as illustrated above for a single hinged joint. The Pelamis stores energy in hydraulic accumulators to even out this unsteady input and provide a smooth flow of fluid to the variable displacement drive motor, and a steady power output from the machine's generators.

The Pelamis Wave Energy Converter is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints.

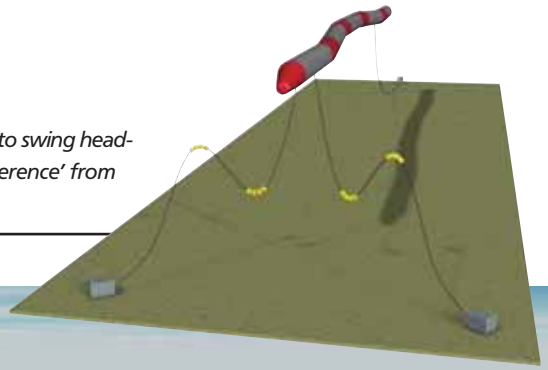


The wave-induced motion of these joints is resisted by hydraulic rams which pump high pressure fluid through hydraulic motors via smoothing accumulators.

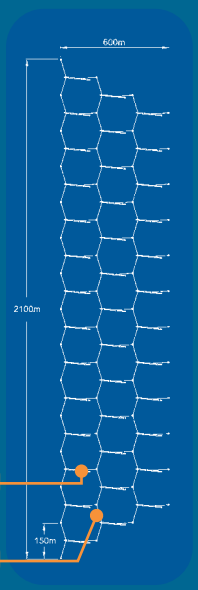


The hydraulic motors drive electrical generators to produce electricity. Power is fed to the seabed via a single dynamic umbilical connected to a transformer in the machine's nose.

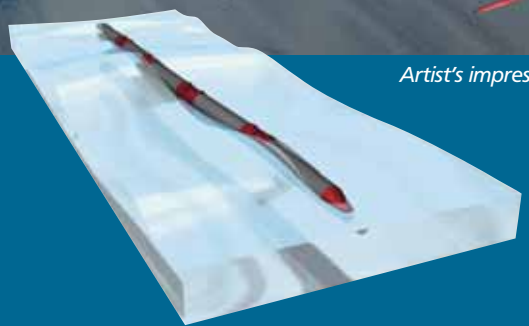
The complete machine is flexibly moored so as to swing head-on to the incoming waves and derives its 'reference' from spanning successive wave crests.



A 30MW offshore 'wave-farm' would consist of 40 machines occupying a square kilometre providing sufficient power for over 20,000 homes.



Artist's impression of a 30 MW wave farm.



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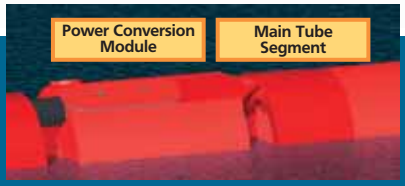
The Pelamis is designed with a rapid attachment/detachment system which allows machines to be towed back to sheltered water for maintenance. The system is designed to avoid the use of specialist equipment, divers or ROVs. All maintenance activities are able to be carried out with the machine afloat at a quayside location.

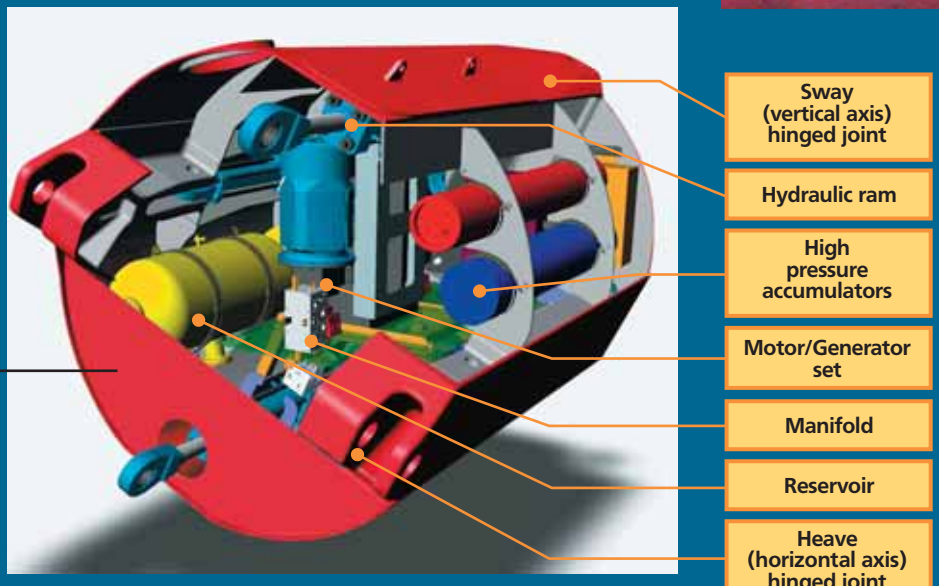
PELAMIS

The Pelamis installed on site at the EMEC test centre, Orkney.

All internal components are modular and can be installed/removed by standard 5T mobile crane.

The Pelamis contains three Power Conversion Modules, each rated at 250kW. Each Power Module contains a complete electro-hydraulic power generation system.





Internal view of a Pelamis Power Conversion Module.

SPECIFICATIONS

STRUCTURE

Overall length	150m
Diameter	3.5m
Displacement	700 tonnes (including ballast)
Nose	5m long, drooped conical
Power take off	3 independent power conversion units

POWER CONVERSION UNIT

Power take off	4 x hydraulic rams (2 heave, 2 sway)
Ram speed	0 – 0.1m/s
Power smoothing/storage	High pressure accumulators
Working pressure	100 – 350 Bar
Power conversion	2 x variable displacement motors
Generator	2 x 157kVA / 125kW
Speed	1500rpm

POWER

Overall power rating	750kW
Annual output	2.7GWh
Nominal wave power	55kW/m

Hydrostatic power limiting	>6 – 7m significant wave height
Generator type	Asynchronous
System voltage	3-phase, 415/690Vac 50/60Hz
Transformer	950kVA step up to typ. 11kV or 33kV

SITE MOORING

Depth	>50m
Current	<1 knot
Mooring system	Compliant, slack moored

COMPARISONS

Equivalent gas turbine – fuel	600 tonnes/year
Equivalent gas turbine – CO_2 emissions	2000 tonnes/year

PWP reserves the right to change specifications without notice.

Patents: US6476511, AU754950, ZA20012008, EP1115976B; other patents pending.

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