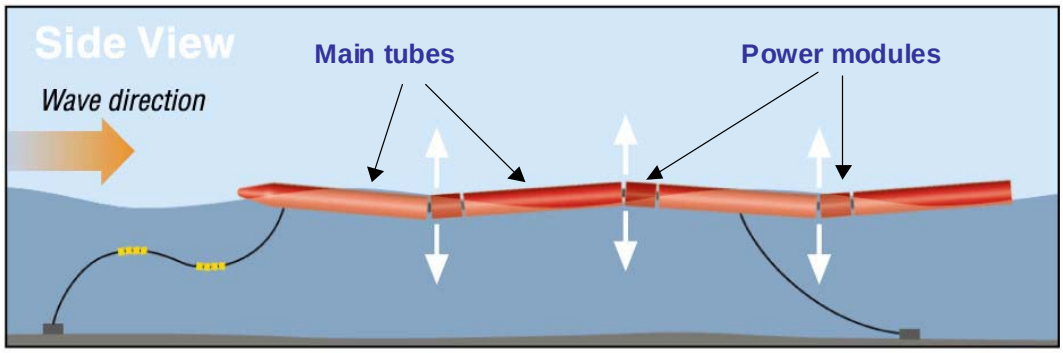
WAVE ENERGY PROJECT BASED ON PELAMIS TECHNOLOGY
IN NEW CALEDONIA

PELAMIS OVERVIEW

The Pelamis is a wave energy device developed and manufacture by Pelamis Wave Power (formerly called OP Ocean Power Delivery) a Scottish based company. For further information on the company please contact www.pelamiswave.com

The Pelamis is a semi-submerged wave energy converter with a simple geometry configuration based on individual cylindrical segments linked linearly by hinged joints. As waves pass down the length of the machine, the induced motions of the separate segments relative to one another are resisted by hydraulic rams.



Main tube cylinders are separated at each joint by shorter Power Conversion Module's (PCM's), each housing an independent power generation system consisting of two separate hydraulic circuits. Located at either end of the PCM's are pairs of hydraulic rams; one pair resisting a sway joint and the other end-pair resisting a heave joint. The hydraulic rams drive pressurised fluid into power smoothing, high pressure accumulators which then direct the fluid through variable displacement motors and back to low pressure fluid reservoirs. The variable displacement motor is directly linked to an asynchronous generator producing a 3-phase voltage. The maximum overall generating capacity of a single Pelamis machine is 750kW. The motor generator sets in each PCM feed the produced electricity onto a high voltage bus-line which runs the length of the device and feeds into a nose-mounted transformer. The transformer output is fed down to the seafloor via a flexible umbilical connector which is subsequently joined to a static high voltage cable on the sea bed taking the generated power to the shore and a suitable grid connection. The device is moored in offshore depths >50m by a

unique mooring spread which enables it to self-reference itself and maintain a directional heading perpendicular to the predominant wave direction.

Current production machines (Pelamis - P1A) have a geometry consisting of four main tube sections and three PCM's. However the next generation of production machines (Pelamis - P1B) consist of an additional main tube section and PCM. Both P1A's and P1B's have the same rated capacity (750kW).

The Pelamis WEC concept is unique among systems under development. It embodies a number of sophisticated hydrodynamic and engineering principles that give it a decisive competitive advantage over all other WEC concepts. The key principles, characteristics, differentiators, and unique selling points of the system are summarised below:

A. *Survivability & power capture, each achieved with no compromise to the other.*

Pelamis effectively balances the conflicting requirements of survivability in the harsh marine environment, and power capture efficacy in small seas.

B. *Highest 'specific power rating', maximal utilisation of all main elements.*

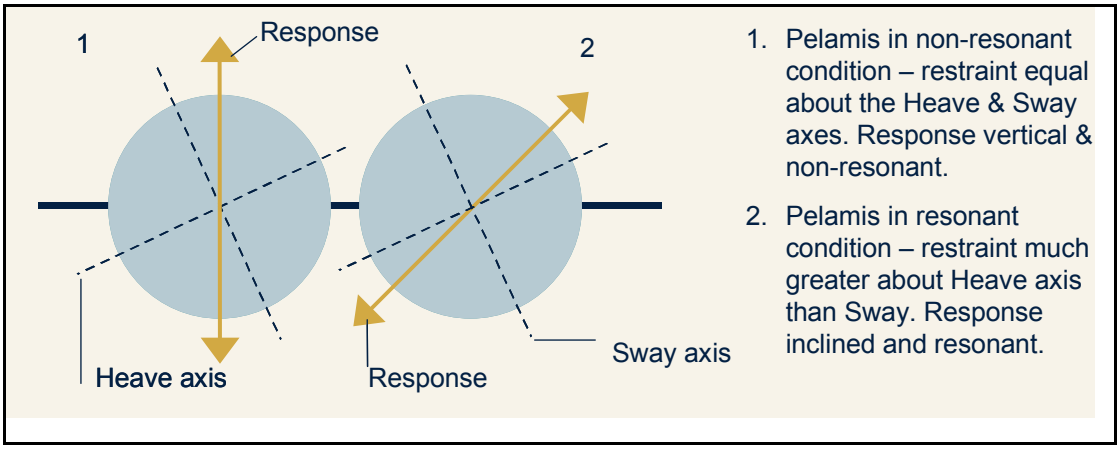
The long thin form of Pelamis gives it the highest water-plane area to volume ratio of any WEC system under development. Water-plane area is the primary driver for power capture in small seas (similar in concept to the swept area of a wind turbine) and volume is a basic indicator of weight and cost.

C. *Self-referencing, no expensive external reaction frames or systems.*

All WECs require a source of reaction against which to push and pull to absorb power. Pelamis is the only WEC system that reacts against its own body, rather than against a separate external reaction frame such as the seabed or a large internal or external weight. This has the double advantage of readily allowing loads to be limited in extreme conditions, and the removal of significant costs associated with the provision of an external source of reaction.

D. *Selectable resonant response, tuneable to the incoming waves.*

Pelamis introduces the concept of 'tuneable resonant response' to its performance – the joints are controlled to induce an artificial, cross-coupled resonant response only when desired, the default or natural condition is a benign, non-resonant response capable of dealing with extreme conditions.



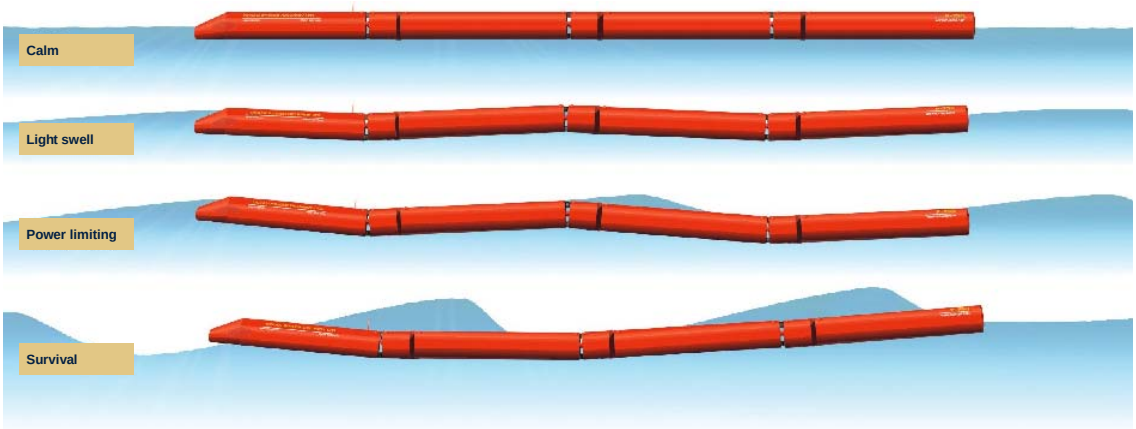
E. *Highest ultimate power capture potential, the key to low cost generation.*

Pelamis is the only system under development that works on the 'line-absorber' principle, where waves are attenuated as they run down the length of the machine. This makes use of sophisticated hydrodynamic properties to dramatically increase power capture from a given volume of machine.

The 'line-absorber' configuration gives Pelamis up to three times the power capture potential per cubic metre of machine volume than any conventional 'point-absorber'.

F. *Inherent power-limiting, no over-rated components.*

WECs must cope with a much larger range of input power than any other energy technology. Peak energy levels in storm conditions are typically 100 times that encountered in normal operation – it is essential that a WEC concept incorporate inherent hydrodynamic power-limiting above normal operating conditions. Failure to do this will mean that power take-off systems will have to be rated for much higher levels, increasing cost and rendering them inefficient at normal operating levels. Pelamis achieves power limiting as wave height increases by smoothly and progressively locally submerging and emerging locally down the length of the machine as depicted by 'survival' in figure below. This self-limits the load, motions and therefore absorbed power, as wave height increases further.



Source: Adapted from **Aquatera** (www.aquatera.co.uk)

G. *Extreme load-limiting, inherently survivable form.*

The effects described in the previous point also give rise to desirable survivability characteristics in the case of much-publicised freak, or rogue, waves. However, most extreme loads in the marine environment arise from drag and slamming loads due to the high water velocities experienced in such conditions. Pelamis is almost invisible to such hydrodynamic loading due to its sleek, streamlined form, presenting the minimum cross sectional area to oncoming waves. This process is similar to a surfer diving under the wave crests when swimming from the beach.

H. *Hydraulic power take-off system - powerful, efficient & controllable.*

Waves are characterised by very high forces in conjunction with low velocities. Efficient energy extraction from waves relies on precise control of loads and motions. In industry and engineering, high-pressure fluid hydraulics are invariably specified for this challenging mix of requirements. In addition, as individual waves and wave groups pass a Pelamis the input power to the individual joints is highly variable in nature. Standard high-pressure accumulators smooth the input power, and therefore output while coping efficiently with the high instantaneous power levels required in individual waves.

I. *Robustness & redundancy, fault tolerance.*

All critical elements within the power take-off and conversion incorporate an appropriate degree of redundancy and fault tolerance to allow continued safe operation in the event of partial failure, and to minimise the number and severity of single point failures should they occur. This is the key to achieving reliable operation and high levels of availability for power production in the hostile marine environment.

J. *Control system with capacity to optimise.*

The importance of advanced control techniques for optimising power capture cannot be over-emphasised. PWP has therefore implemented a state-of-the-art integrated control and data acquisition system to allow rapid and flexible optimisation as the understanding of optimal control strategies develops with time. The control system also incorporates a high level of redundancy and fault tolerance. In the event of a complete failure of the on board computer systems, a worst case scenario, a mechanical failsafe control system takes over.

K. *Available technology, no prototypes within prototypes.*

The central rule of avoiding the use of prototypes-within-prototypes has been learnt the hard way repeatedly in the world of engineering. Obeying this principle is central to PWP's development approach. All systems within Pelamis are built up from proven components with a track record in a range of applications.

L. *Rapid, flexible deployment, removal & maintenance - minimising on-site work.*

The mooring system, the machine installation and removal systems and the maintenance strategy and techniques have been carefully designed to minimise on-site work, and thereby cost. PWP has pioneered the approach of off-site maintenance – taking the machine to the equipment, rather than the equipment to the machine. Rapid deployment and removal of the system is central to achieving low operating costs, a high system availability and a high degree of operational safety. The shallow depth or draft of the system (less than 3m) means that a wide range of maintenance facilities will be accessible.

M. *Minimal visual & environmental impact, small surface and seabed footprint.*

Minimising visual and environmental impact are key considerations with regard to installation of large projects. Concerns over these have dogged the development of wind power projects, on and offshore. Pelamis has what is anticipated to be the lowest environmental and visual impact of all renewable technologies. The seabed footprint is limited to small fixed anchor points and the system itself is practically invisible from the shore. All systems are contained within the machine body, with at least two independent seal barriers to the outside world. No environmental harmful substances are used - the hydraulic fluid specified is biodegradable and certified as non-toxic to marine organisms.

N. *Scalable, non-capital intensive production process, flexible low cost production.*

All elements of the machine lend themselves to volume production using modest facilities and equipment. All components can be manufactured by a wide range of subcontractors to allow rapid establishment of a flexible, responsive and competitive supply chain. The system is highly modular and the production, assembly and commissioning processes are readily scalable to allow a rapid, flexible expansion of production to meet demand, with minimal investment.

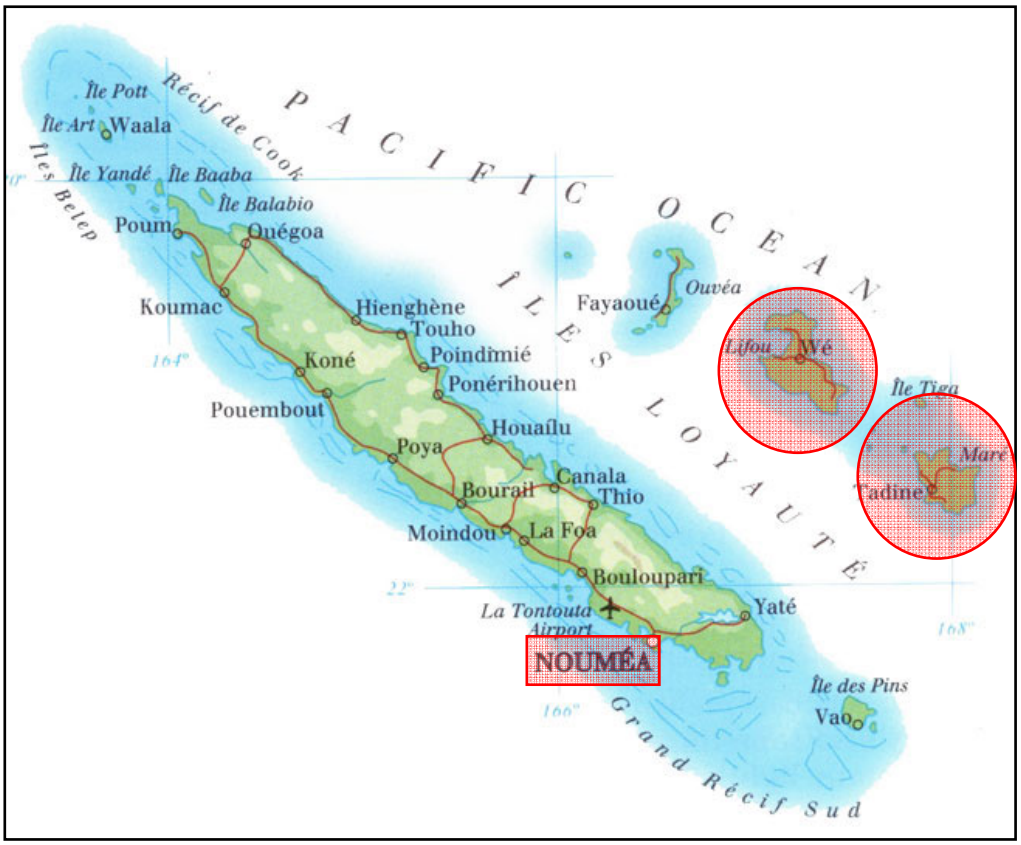
O. *Non site specific.*

The Pelamis can be installed in a range of water depths and seabed conditions.

All of the key characteristics described above are the result of extensive work undertaken during the R,D&D programme. PWP intends to continue R,D&D work such that the cost of producing Pelamis machines is reduced and that the machine's performance is continually improved, maintaining the existing competitive advantage.

NEW CALEDONIAN PROJECT OUTLINE.

SRP have identified a number of potential project installation sites, of which the New Caledonian islands of Lifou and Maré (in the Loyalty Islands) to the north east of the mainland capital, Nouméa, were investigated further. See map below.

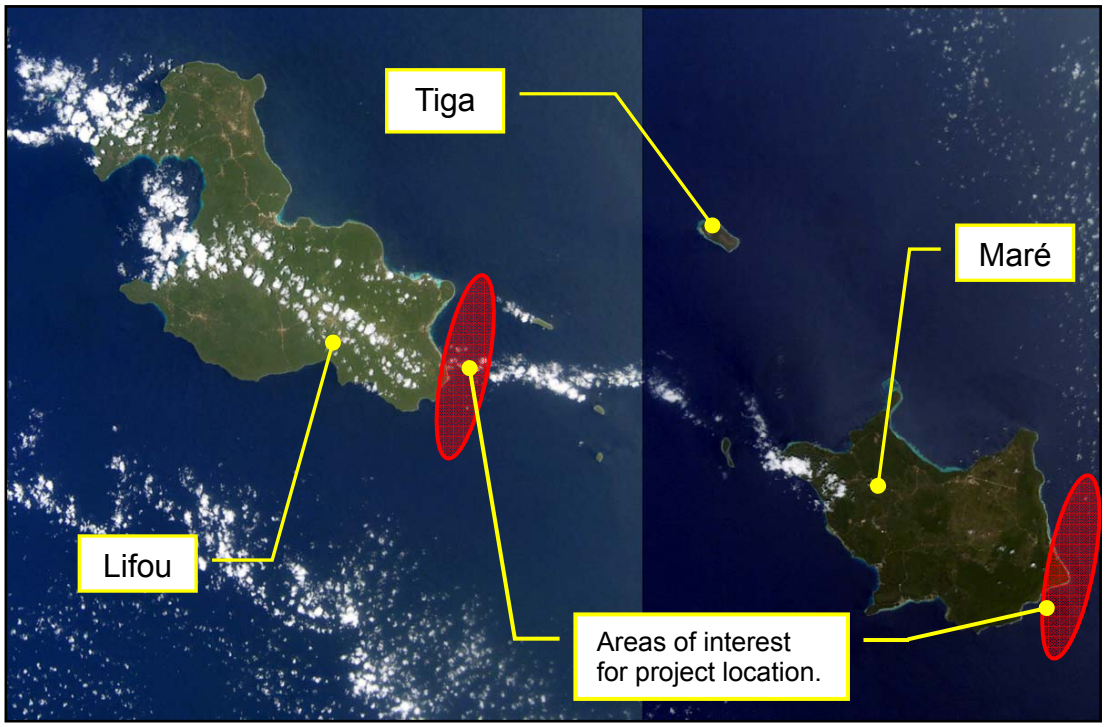


Offshore (deep water), hindcast wave data was obtained for a site within the region and waverider buoys were deployed closer to the shores of Lifou and Maré to verify specific site resource levels. For more information and the results of the resource study please contact SRP direct on www.srp-nc.com

Both islands have small populations (Lifou- 10,320 and Maré- 7,401. Recorded census 2004) and no large heavy industry, therefore their electrical grid generating capacity (predominantly diesel) is small (<2MW). As the project is proposed to connect to the islands grid (and there is no electrical interconnection between Loyalty Islands and the New Caledonian mainland), and the current Pelamis designs have a peak generating capacity of 750kW, projects on either island will be restricted to

small numbers of Pelamis machines due to operating limits of local grid networks (≤3 machines).

The satellite photograph on the following page shows, in more detail, the project areas of interest in the Loyalty Islands; the predominant swell direction experienced through New Caledonia and the surrounding islands is from a south-east direction, therefore projects will be sited off coastlines exposed to this direction.



Loyalty Islands.

Pelamis machines are designed to be moored in >50m depth of water; characteristic to the topography of the region (both islands are former coral atolls that were part of a submerged volcano. Approximately 2 million years ago, the islands were uplifted to their present shape and elevation) the bathymetry surrounding the islands shelves steeply away to allow mooring installation to be ~2km from shore.

Due to the lack of quayside facilities on either Lifou or Maré, operations requiring such facilities are likely to be carried out on the New Caledonian mainland (most likely Noumea) unless a suitable alternative is found or developed.

The installed machine(s) will be held on station by a mooring system, electrical and fibre core connections are carried out via a flexible umbilical connection from the machine to the sea bed and a static sea bed cable. The sea bed cable will follow the cable installation route back to the shoreline where it will be terminated in the project substation. From the substation; power generated by the project will be fed directly onto the local distribution network.

Following wave resource assessment, the only economically viable project at this moment is Maré, where the resource is twice higher than in Lifou.

The complete feasibility study has been undertaken by SRP (Société de Recherche du Pacifique) with PWP's support.
The Maré project, made of one Pelamis machine (750kW) on south east of Maré, will be moored 3km off shore, and will land in Patho, where the substation 6.6kV/15kv will be installed, and the connection to the 15kV grid will take place.

It could generate around 1.7GWh per year, and save 1400t of CO2 emission per year.

This 6 million Euros project, is currently waiting for funds to proceed.

For further information please contact SRP on www.srp-nc.com