

Pelamis - current status and prospects



4th International seminar on marine energy

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Pelamis Wave Power

- 12 years experience and track record
- 65 highly skilled & experienced staff
- Strong expertise in mechanical, electrical, structural, hydraulic, offshore, control & systems engineering, and track record in marine operations

First to:

- achieve independent design verification
- generate electricity from offshore wave power (2004)
- secure order for wave farm (2005)
- build and operate a wave farm (2008)
- secure orders from major utilities in UK



- 16 investors with £43m invested
- Orders totalling ~£20m
- ~£10m of direct grant support since 1998
- Total £70m of funding, 6 machines / 4.5MW built **plus** 12 years R&D and company operation



Technological development & feedback cycle

1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011

Concept development

Primary R&D & modelling



1/7th-Scale prototype

Full-scale R&D & design

Full-scale joint test



Production prototype



Cost reduction & performance enhancement

First commercial sale

'Hands free' mooring system

P-2 Development

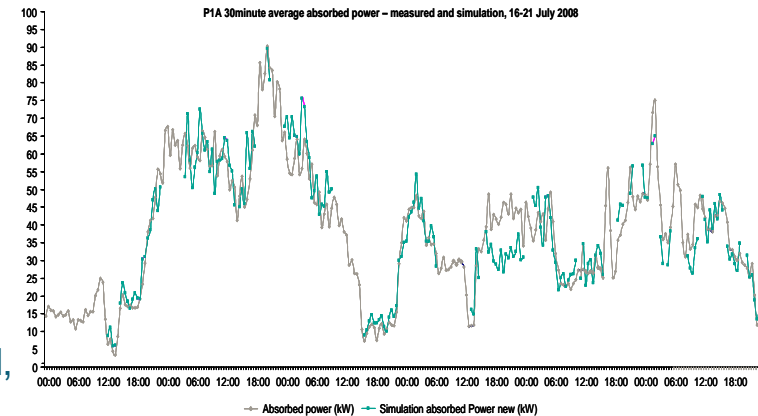


2nd commercial sale

3rd commercial sale

P1 – ‘first-generation’ machines

- 4 off P1 machines built 2004-2007
- String of world-firsts for the sector
- First commercial order in sector
- Key development milestones passed:
 - ‘Proof of Concept’ for the technology
 - Total ~2,700 grid connected testing hours, seas up to 4m Hs
 - Further ~1,250 hours sea trials non grid connected, seas up to 3m Hs
 - Solid body of test data for optimisation and increasing reliability of all elements
 - Full remote operation proven, comprehensive suite of instrumentation & diagnostics
 - Numerical models validated ‘wave-to-wire’ to within a few% - *still unique in sector...*
 - Development and demonstration of remotely operated ‘hands-free’ install/remove system
 - Development, demonstration & refinement of robust remote SCADA package
- Solid experience the basis for P2 as the commercial technology platform

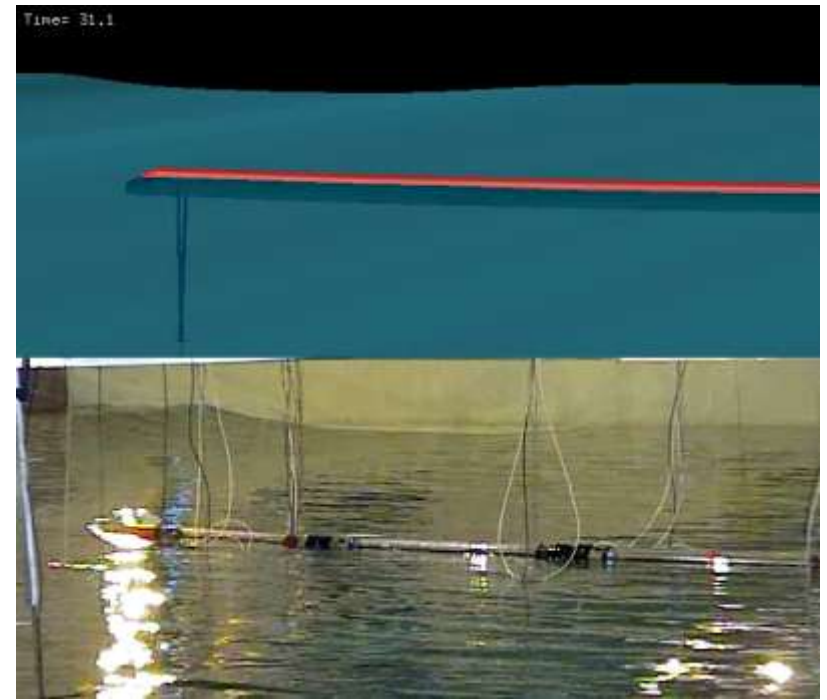


Fundamentals

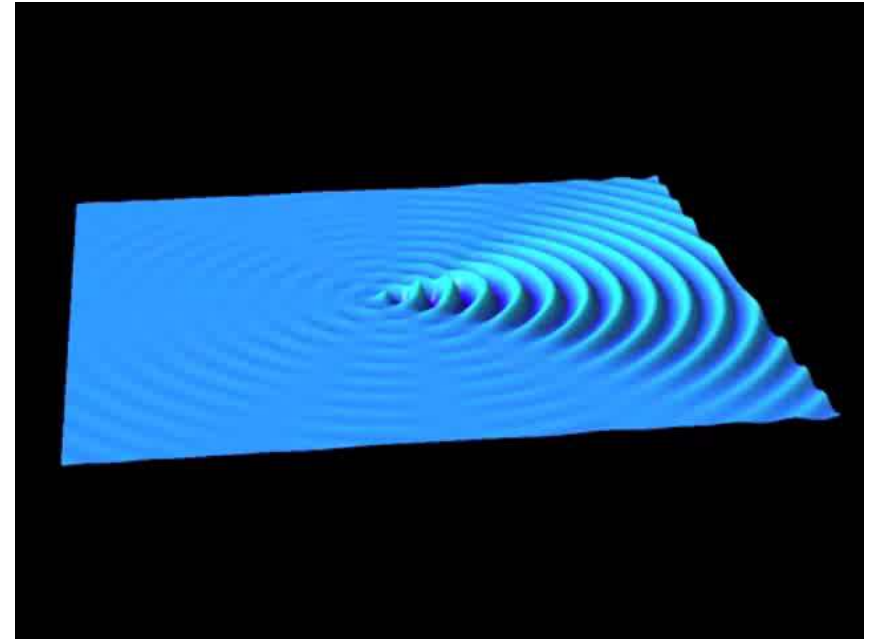
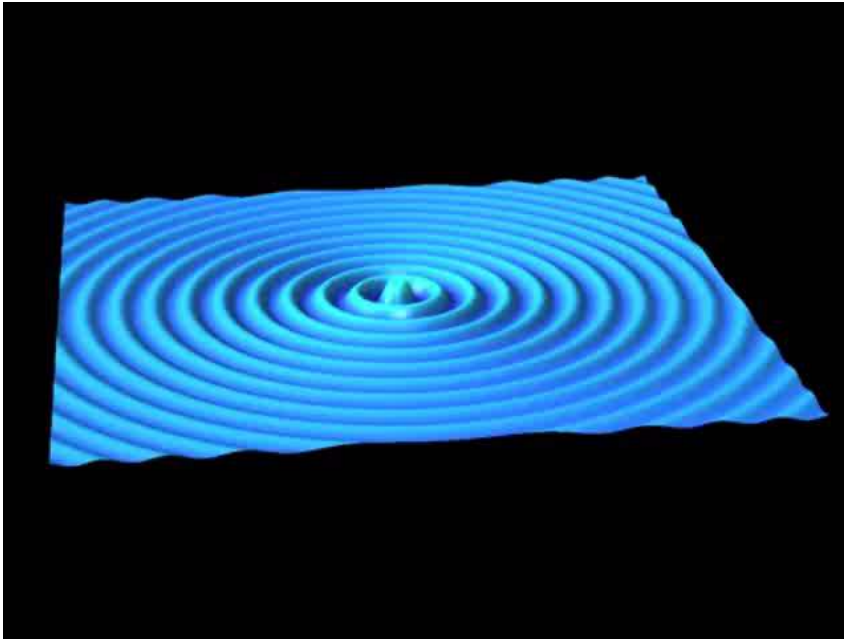
- Survivability
- Power capture efficiency
- Material and manufacturing costs
- Reliability and availability
- Maintainability

Core concept – survivability

- Small cross-section, finite length, streamlined form, compliant moorings
- Self-limiting '*hydrostatic loading*' => limits absorbed power in large waves
- Almost invisible to '*hydrodynamic loading*' in large seas
- Too short to react against extreme storm waves



Power capture efficiency



WAVE CAPTURE WIDTH



WAVE CAPTURE WIDTH

- All wave energy converters bound by well documented fundamental absorption principles
- Theoretical absolute absorption limits usually expressed as fraction of wavelength ' λ '
- Pelamis – is in effect a *phased array* wave energy converter, a '*line absorber*'
- Theoretical maximum absorption 0.75λ for 200m long machine (~5x heave only, ~2.5x surge only)
- High waterplane-area:volume ratio – Pelamis can get closer to its limit for realisable machines
- Limits effectively extend to individual machine rated power

Manufacturing costs



P1 design feedback

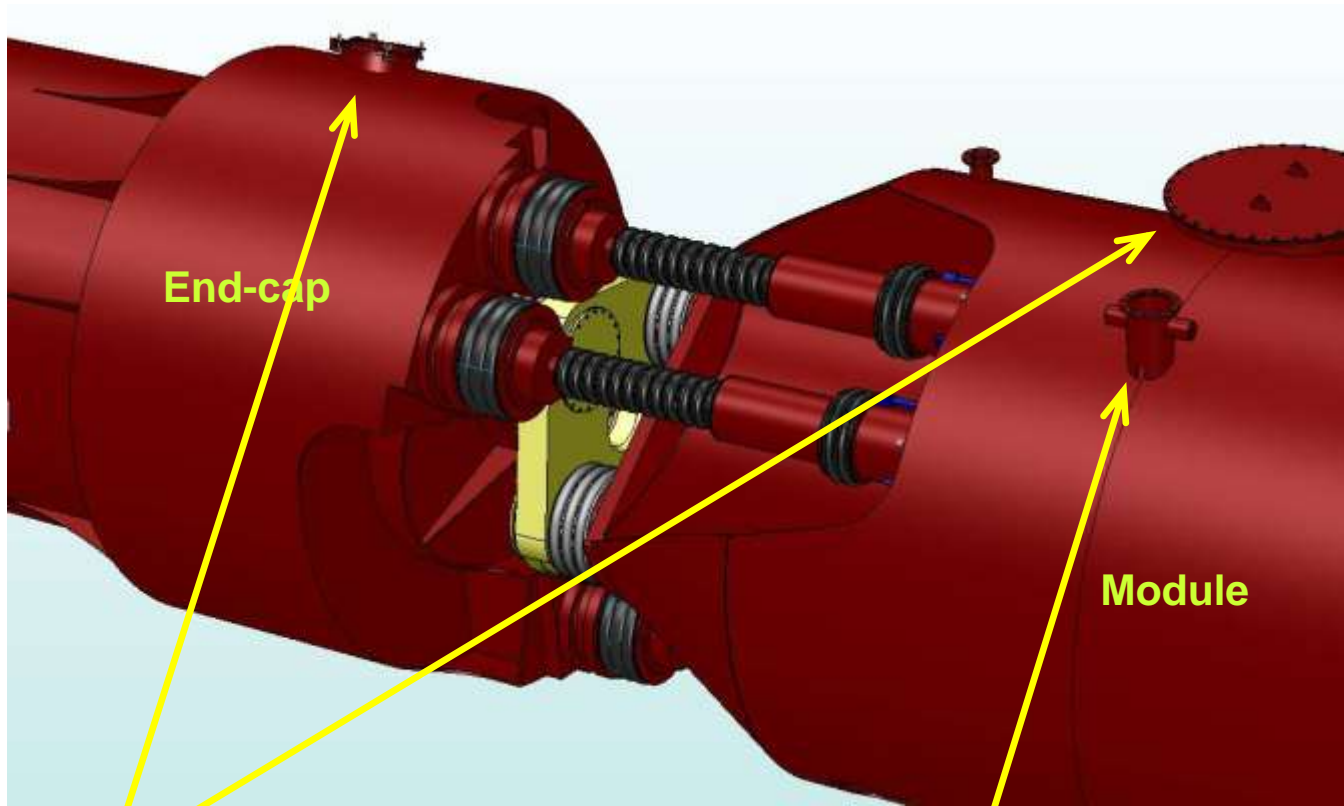
- Confined space assembly time consuming
- Structural end caps expensive
- Restricted control resolution
- Lower performance potential



P2 improvements

- Half number of complex & expensive 'end' fabrications per joint
- Half the number of flexible unions
- 4 cylinders acting around single 'universal' joint improves control resolution & performance
- 'Manufacturability' greatly simplified & improved
- Significantly greater energy yield

P2 joint



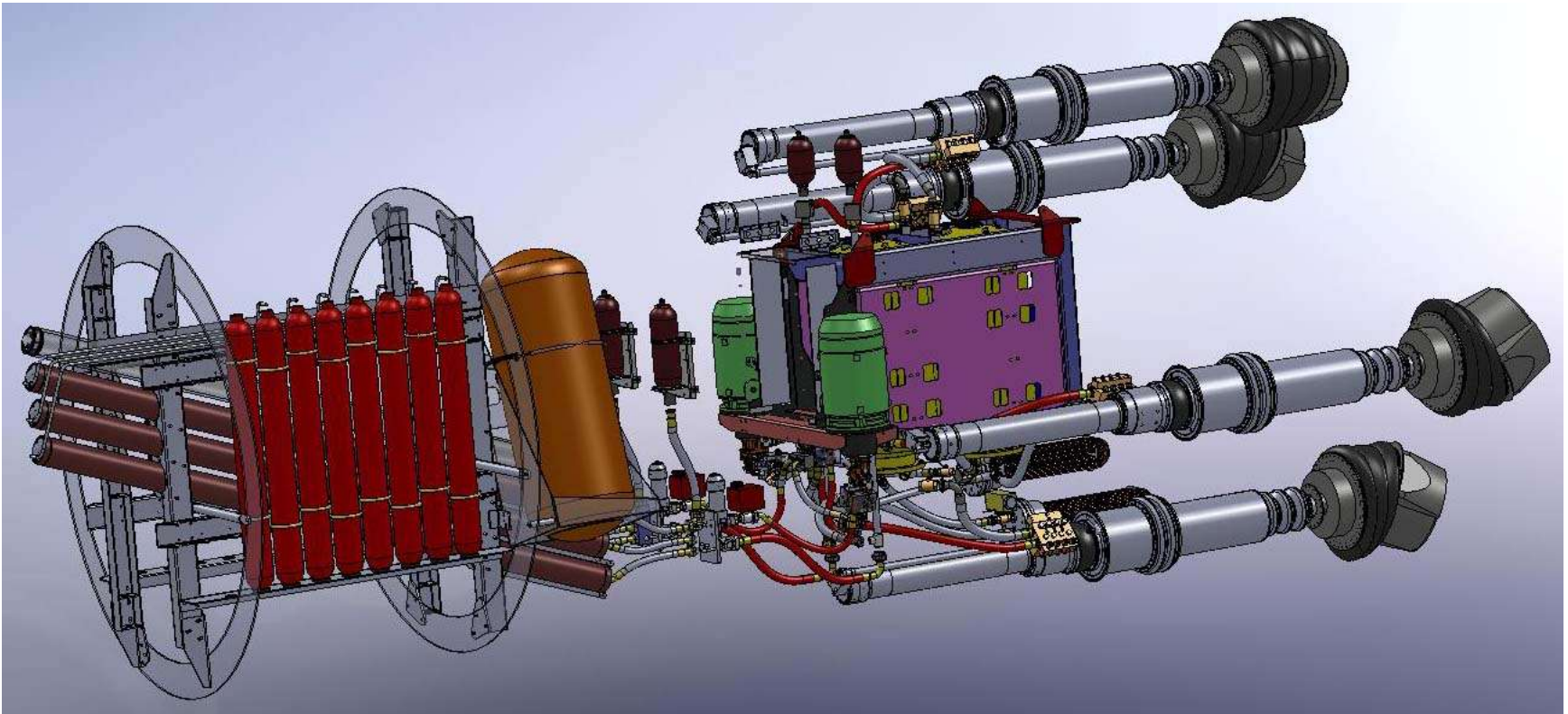
Access hatches

- Man and equipment access hatches as required
- For safety have manually operated hatches at each end of each tube, plus in each bulkhead (bolted in P1A & PRT)
- Circular bolted main equipment hatch on each module

Mooring & towing attachments

- Main towing points are on end of yoke & rear of machine
- Mooring points / pedestal crane bases on each module
- Secondary control line attachments at various points
- Casualty evacuation using davit (system proven on P1A)

P2 joint system – module end



- All module systems on 'PTO Sub-frame' – fully assembled & commissioned prior to insertion in structure
- Four cylinders arranged around 'PTO Sub-frame' – optimised flow paths
- Accumulators in adjacent compartment – 6m length => lower cost energy storage

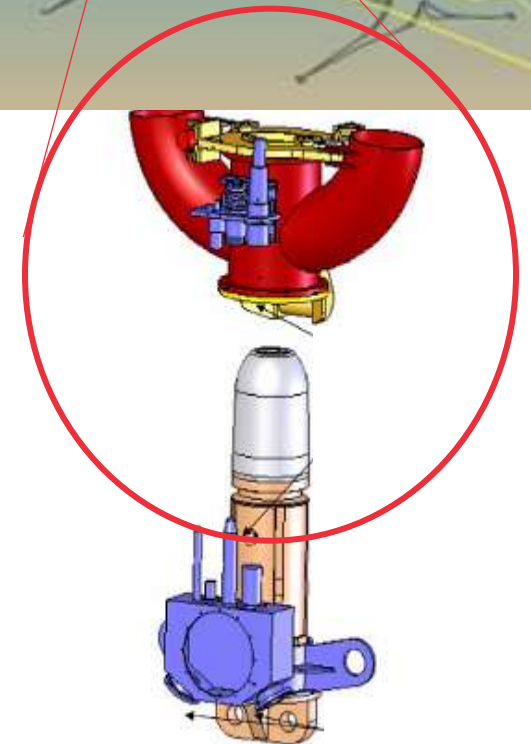
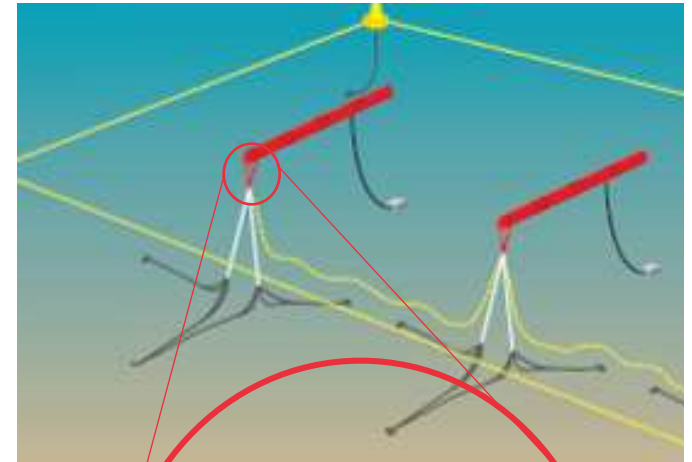
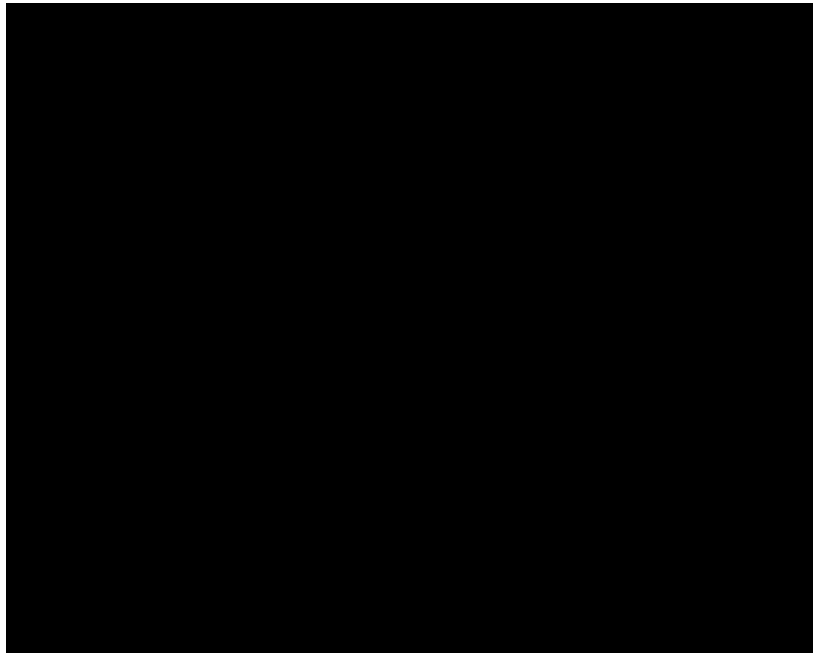


Extensive experience with range of vessel types



Operations and maintenance

- PWP philosophy and experience – offsite maintenance essential and beneficial
- Key principle: No manned access offshore
- Avoid use of costly specialist vessels
- Development of key enabling technology: rapid attachment/ detachment system
- PWP system now well proven



P2 – ‘second-generation’ machines

- Build directly on experience with P1’s - not back to square one!
- Driven by core R&D 2004-2008
- Step change in performance, manufacturability, cost
- Move supported by Utility Due Diligence and subsequently orders
- Key P2 ‘USPs’:
 - 4 x joints instead of 3 gives extra length
 - Twice joint angle range giving increased margin for survivability
 - Increase tube diameter from 3.5m to 4.0m
 - Better system integration gives higher conversion efficiency
 - New configuration, geometry & refined PTO => over twice expected annual energy yield of P1A
 - Simplified structure will reduce cost of series units
 - All system components pre-assembled & commissioned prior to insertion tubes
- Visible track through cost engineering to £3-4m/MW – convergence with offshore wind

=> More powerful, more reliable, more efficient, cheaper, easier to manufacture



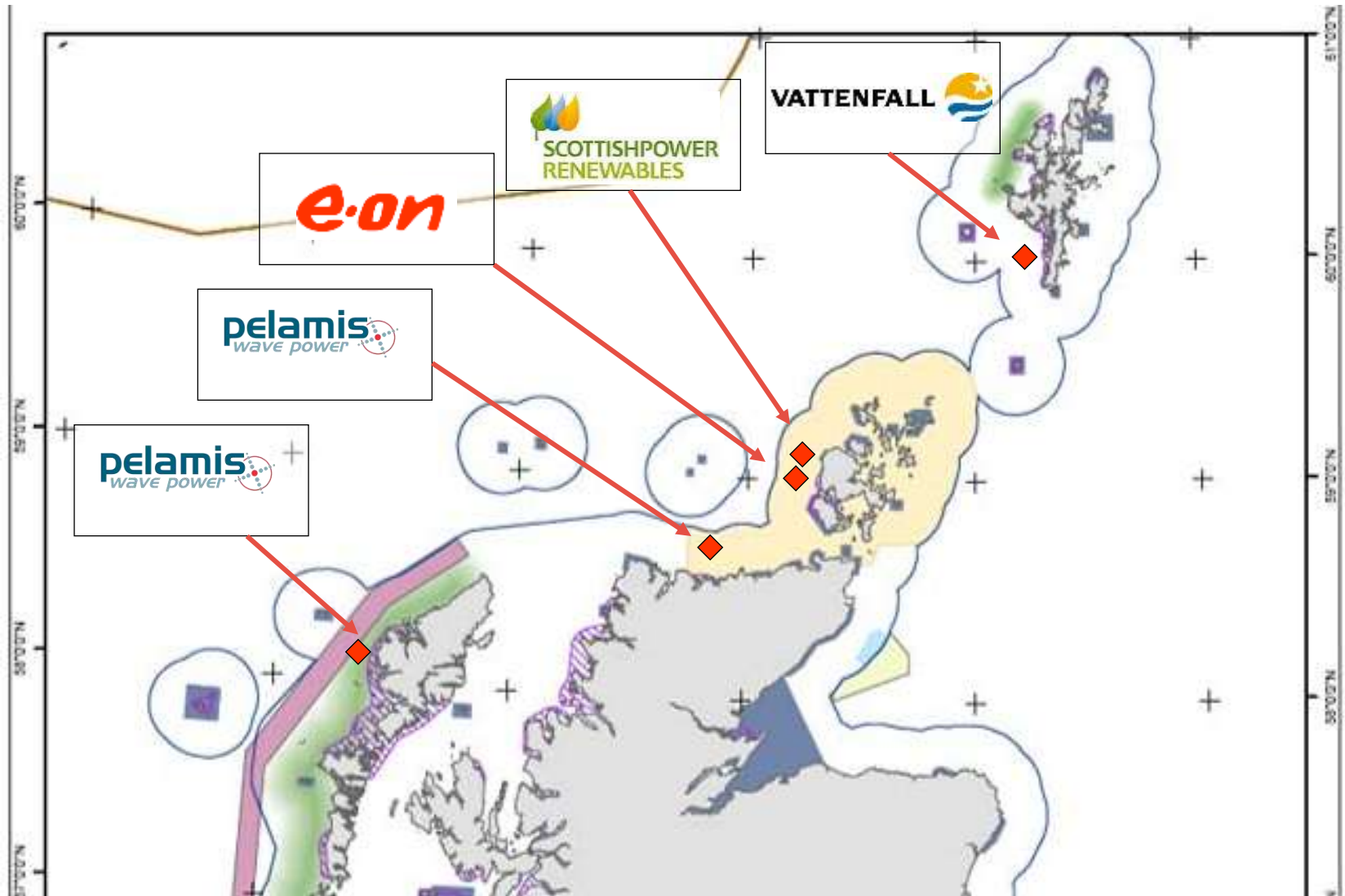
P2 – current status

- E.ON P2 manufacture & commissioning complete, initial operations underway
- New machine type requires staged ‘work-up programme’ to full operations (c.f. new aircraft)
- ‘Work-up’ comprises progressive increase in hours in progressively more arduous conditions or ‘Weather States’, with intensive inspection & data analysis between – NOT deploy & hope!
- First grid installation in October 2010
- All systems working as expected
- Machine taken over by E.ON – another world first in the sector
- Objective to achieve unrestricted operation through work up plan
- SPR P2 nearing completion for ~15% less cost than E.ON machine with only modest changes
- Planned to enter operation this summer, first phase of work-up similar, accelerated thereafter

=> Good progress with initial operations, all indications good



TCE1 and other Pelamis projects in Scotland



Launch of P2 nose tube (this Tuesday)

