
Offshore wave energy converters
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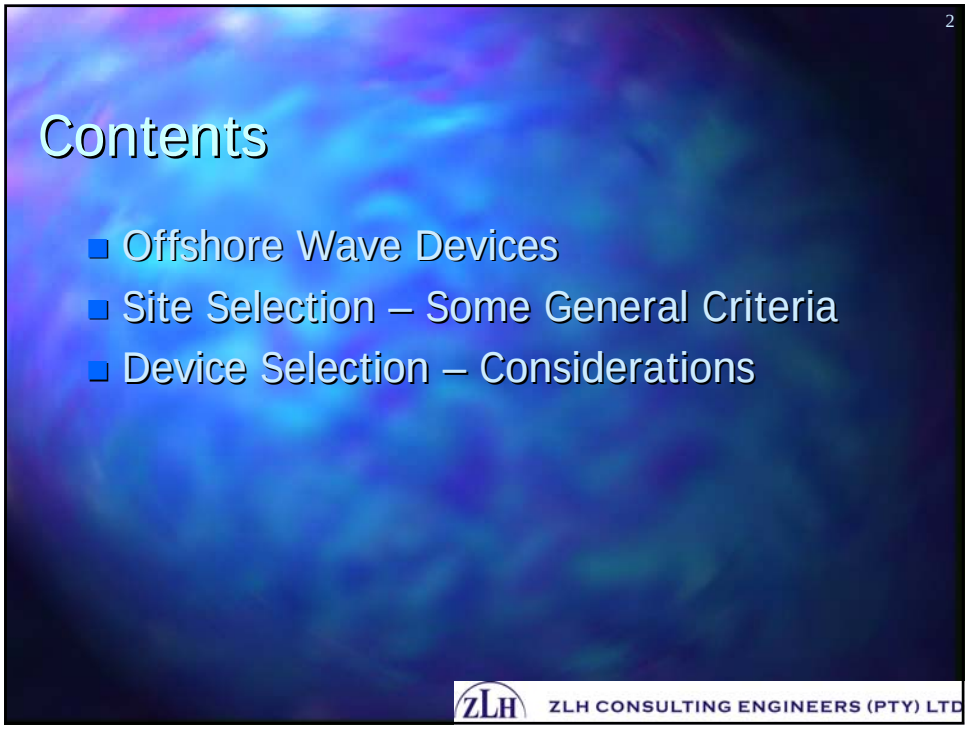
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Offshore Wave Devices

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Why go offshore?

- Higher wave power potential
- Less visual impact (semi- & submerged devices)
- Avoid sensitive coastal areas
- Smaller impact on coastal processes compared to shore based terminator devices

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Aspects to consider when going offshore

- Transmission of energy to shore or storage thereof close to device
- Survivability important, because of limited accessibility and more extreme storm loading
- Location relative to main shipping lanes and commercial ports
- Impacts on marine processes

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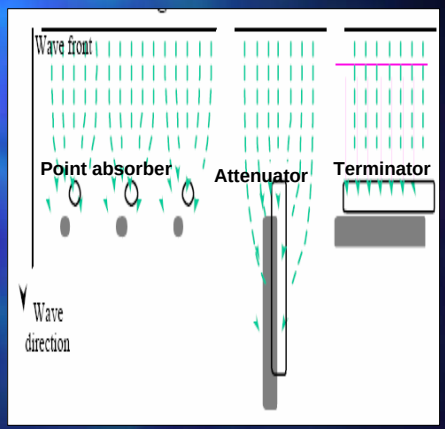
Device classification

- Point absorber
  - Unidirectional
  - Displacer/reactor
- Attenuator
  - Perpendicular to wave front
- Terminator
  - Parallel to wave front



Falnes, 2005

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Point absorbers: AquaBuoy

- Originally AquaEnergy Group now Finavera renewables
- Based on IPS buoy - Swedish hose pump
- Projects: US, Portugal, Canada & South Africa

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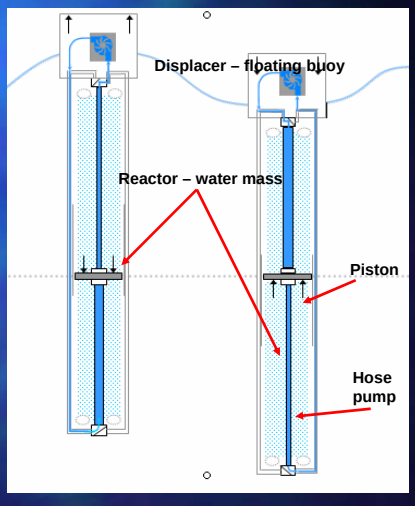
AquaBuoy: How does it work?

- Displacer
  - Above water surface
  - Typical diameter = 6m
- Reactor
  - Water mass drives piston
- Water gets pressurised inside hose pump



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AquaBuoy: Specifications

- Power rating = 250kW
- Required water depth = 50m
- Draught = 30m
- Steel structure
- Mooring important and biggest cost component

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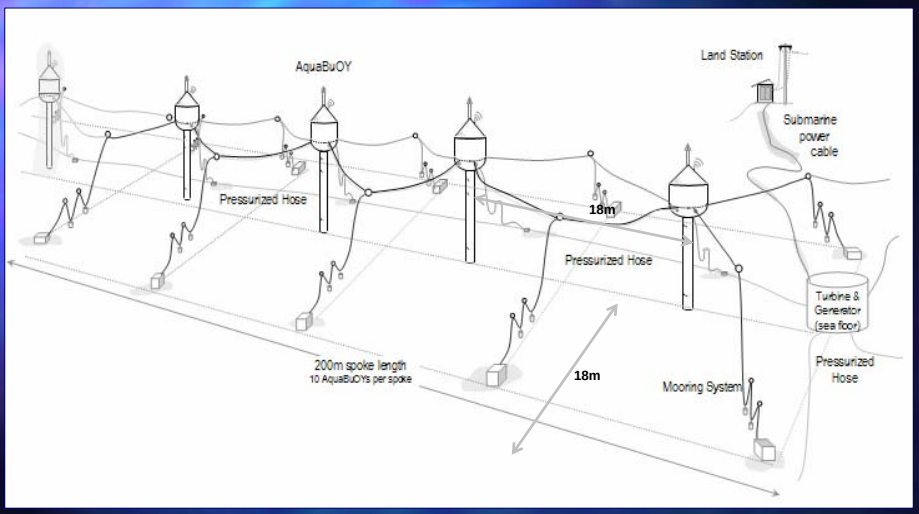
AquaBuoy: Wave park



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AquaBuoy: Conclusions

- Buoy technology (wave measuring buoys) mature and tested
- Modular units – easy to transport and repair
- Site specific
  - Steep bathymetry gradient required to reduce transmission costs (max distance 4km)
  - Deployment near port
- Cannot be rapidly tuned
- High mooring & transmission costs

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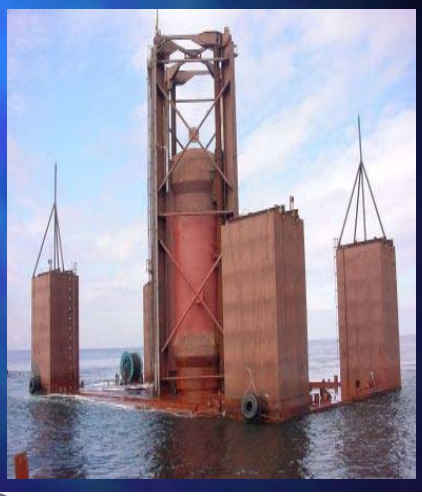
Point absorber: Archimedes wave swing

- AWS Ocean Energy
- Fully submerged system (6m below water surface)
- Increased survivability
- Sea trials – Portugal
- Project: Scotland



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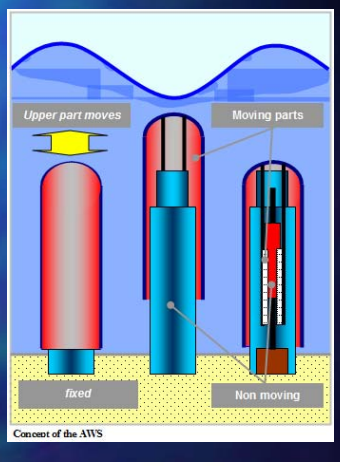
Archimedes wave swing: How does it work?

- Floater – air filled cylinder shaped buoy
- Floater oscillates due to pressure differences
- Electricity generated by linear direct induction generator



my.fit.edu/~swood/OE_topic.html 23/03/2017

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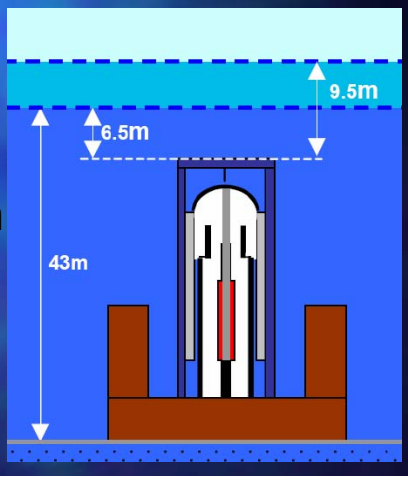
Archimedes wave swing: Specifications

- Rated capacity = 4MW (depending on wave climate)
- Floater diameter = 9.5m
- Water depth 40 – 100m
- Steel structure



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Archimedes wave swing: Conclusions

- Power takeoff require less O&M
- High repair costs for sub-sea system (ROV's used)
- No visual impact
- No output smoothing, because direct generator
- Bottom standing device – foundation preparation important

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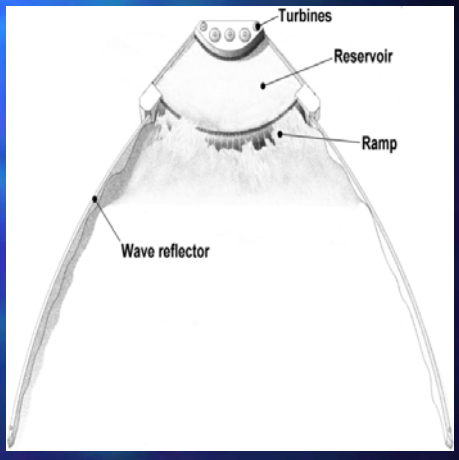
Terminators: Wave Dragon

- Wave dragon Ltd (Denmark)
- Low-head hydro power plant
- Overtopping device
- Floating, slack moored (swivel to face dominant wave direction)
- Largest WEC (capacity and size)



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Wave Dragon: How does it work?

- Reflector arms focus waves onto double curved ramp and into storage reservoir
- Water runs from reservoir through simplified Kaplan turbines

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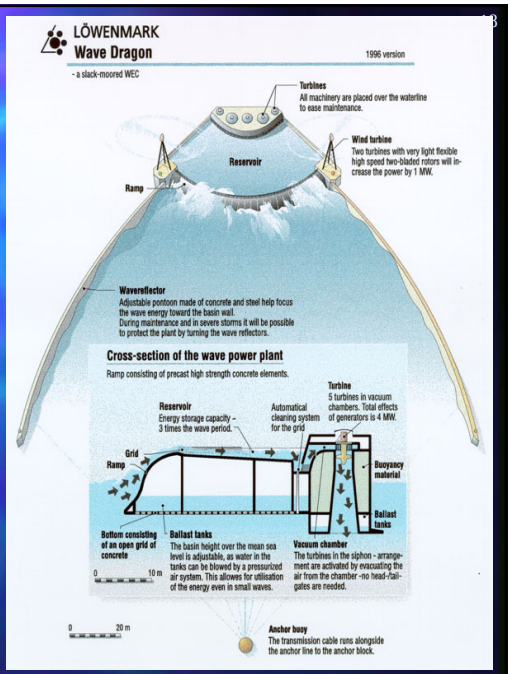
Wave Dragon: Specifications

- Capacity = 4-7MW
- Width = 260-300m
- Length = 170m
- Water depth = >25m
- Steel & reinforced concrete structure



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Wave Dragon: Conclusions

- Power storage and smoothing output possible due to reservoir
- Efficiency of hydro power as high as 80%
- Broad bandwidth ~ tune-ability not as important as for point absorbers
- Physically large device (total weight up to 54000t)

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Attenuators: Pelamis

- Ocean Power Delivery Ltd (Scotland)
- Pelamis = latin for sea snake
- Full scale sea trials in Scotland
- 3MW wave park planned at EMEC in Orkney
- Project: Portugal

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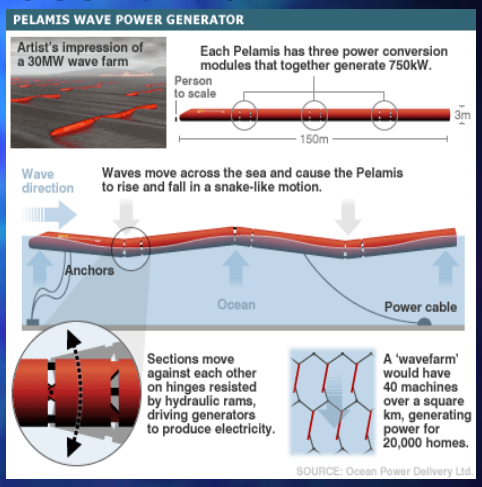
Pelamis: How does it work?

- 4 tubular sections
- 3 hinges
- Relative motion of sections transmits through hinges which uses digitally controlled hydraulic power conversion system
- Slack moored – able to swivel



http://seaseel.org/Soft/eqwe/images/0315pelamisgenerator.gif, 23/05/07

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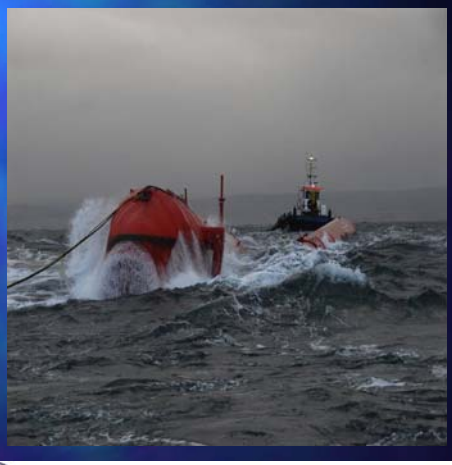
Pelamis: Specifications

- Rating = 750 kW
- Diameter = 4.6m
- Length = 150m
- Water depth > 50m
- Steel structure
- Hydraulics uses bio-degradable fluids



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Pelamis: Conclusions

- Closest to commercialisation (EPRI/E2I report)
- High survivability (design to withstand 1:100yr storm)
- Rapidly tuneable (digital control system)
- Power conversion efficiency = 80%

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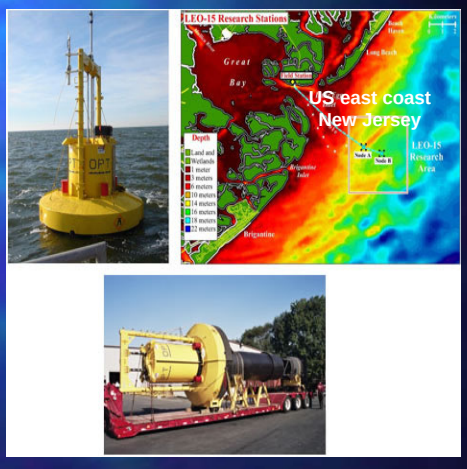
Some more offshore devices: PowerBuoy

- Ocean power technology (OPT)
- Sea trials in Hawaii & New Jersey (40kW)



http://www.oceanpowertechnologies.com/pelamis.htm

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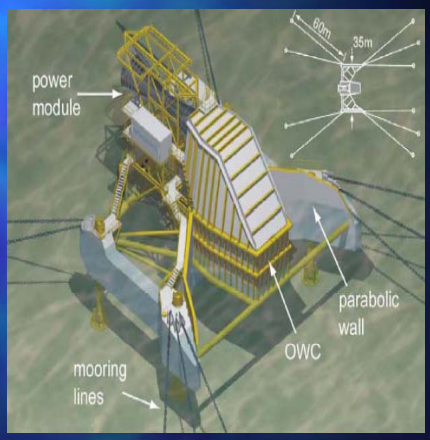
Some more offshore devices: OWC

- Energetech (Australia)
- Rating = 0.5 – 2MW
- Parabolic width = 35m
- Water depth = max 50m



Site Selection: General Criteria

- Available Wave Energy Resource
- Extreme Events
- Sediment Transport Processes
- Distance Offshore to Suitable Water Depth
- Geological/Geotechnical Considerations
- Subsea Transmission Route and Shore Crossing
- Distance to Nearest Grid Integration Substation
- Distance to Costumer and Distribution Route
- Shipping and Other Users in the Area
- Existing Mining/Oil and Gas Concession Blocks
- Distance to Nearest Suitable Port for Maintenance Requirements

Device Selection – SA Context

- Maximize Local Skills for Construction and Maintenance
- Adaptable to Local Wave Climate to Ensure Maximum Energy Conversion
- Scalability/Modularization
- Survival Strategy during Extreme Events
- Accessibility to Maintenance Intensive Components
- Environmental Impacts
  - Coastal Sediment Processes
  - Impact of Catastrophic Failure of Device
  - Impact of Mooring Failure
  - Visual Impacts
  - Risk to Shipping and other users in the area