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Programme Area: Marine

Project: ReDAPT

Title: ReDAPT: Turbine Deployments and Achievements in Operation

Context:

One of the key developments of the marine energy industry in the UK is the demonstration of near commercial scale devices in real sea conditions and the collection of performance and environmental data to inform permitting and licensing processes. The ETI's ReDAPT (Reliable Data Acquisition Platform for Tidal) project saw an innovative 1MW buoyant tidal generator installed at the European Marine Energy Centre (EMEC) in Orkney in January 2013. With an ETI investment of £12.6m, the project involved Alstom, E.ON, EDF, DNV GL, Plymouth Marine Laboratory (PML), EMEC and the University of Edinburgh. The project demonstrated the performance of the tidal generator in different operational conditions, aiming to increase public and industry confidence in tidal turbine technologies by providing a wide range of environmental impact and performance information, as well as demonstrating a new, reliable turbine design.

ReDAPT - MC6 & 7 – Turbine Deployments and Achievements in Operation

Jon Rhymes – Engineering Director

Overview – 1MW DeepGenIV Concept

Turbine

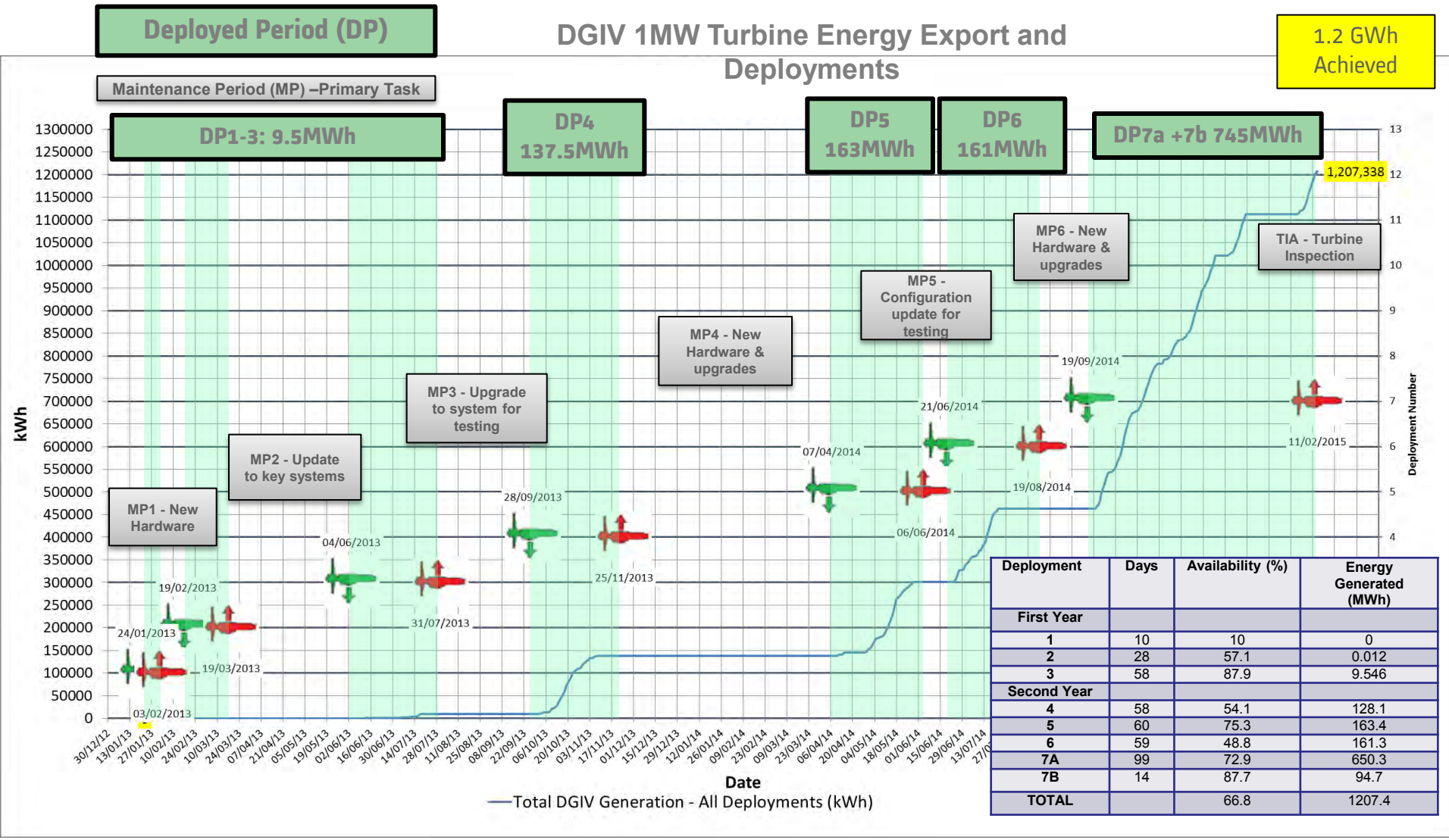
- Buoyant nacelle
- Deployed using a low cost vessel
- Deployed without requiring divers
- Variable pitch blades to control rotor speed, loads, and power
- 3 Position Clamp
  - Detachable from tripod for easy maintenance
  - Ability to yaw to any heading
- Provides grid compliant power at the end of the cable
- Maximum rated power achieved at 2.7m/s flow speed.

Foundation (Previously used by DGIII)

- Lightweight structure
- Installed using Dynamically Positioned (DP) vessels
- Attached to the seabed using piles
- Able to accept different sized turbines

ReDAPT

Turbine Generation Overview



Deployment	Days	Availability (%)	Energy Generated (MWh)
First Year			
1	10	10	0
2	28	57.1	0.012
3	58	87.9	9.546
Second Year			
4	58	54.1	128.1
5	60	75.3	163.4
6	59	48.8	161.3
7A	99	72.9	650.3
7B	14	87.7	94.7
TOTAL		66.8	1207.4

Deployment 7A: 19/09/2014 – 27/12/2014

Deployment Information	
Duration	99 days
Generating Hours	1262 hours
Energy Generated	650.3MWh
Availability	72.9%
Number of Tests Conducted	13

Key Testing

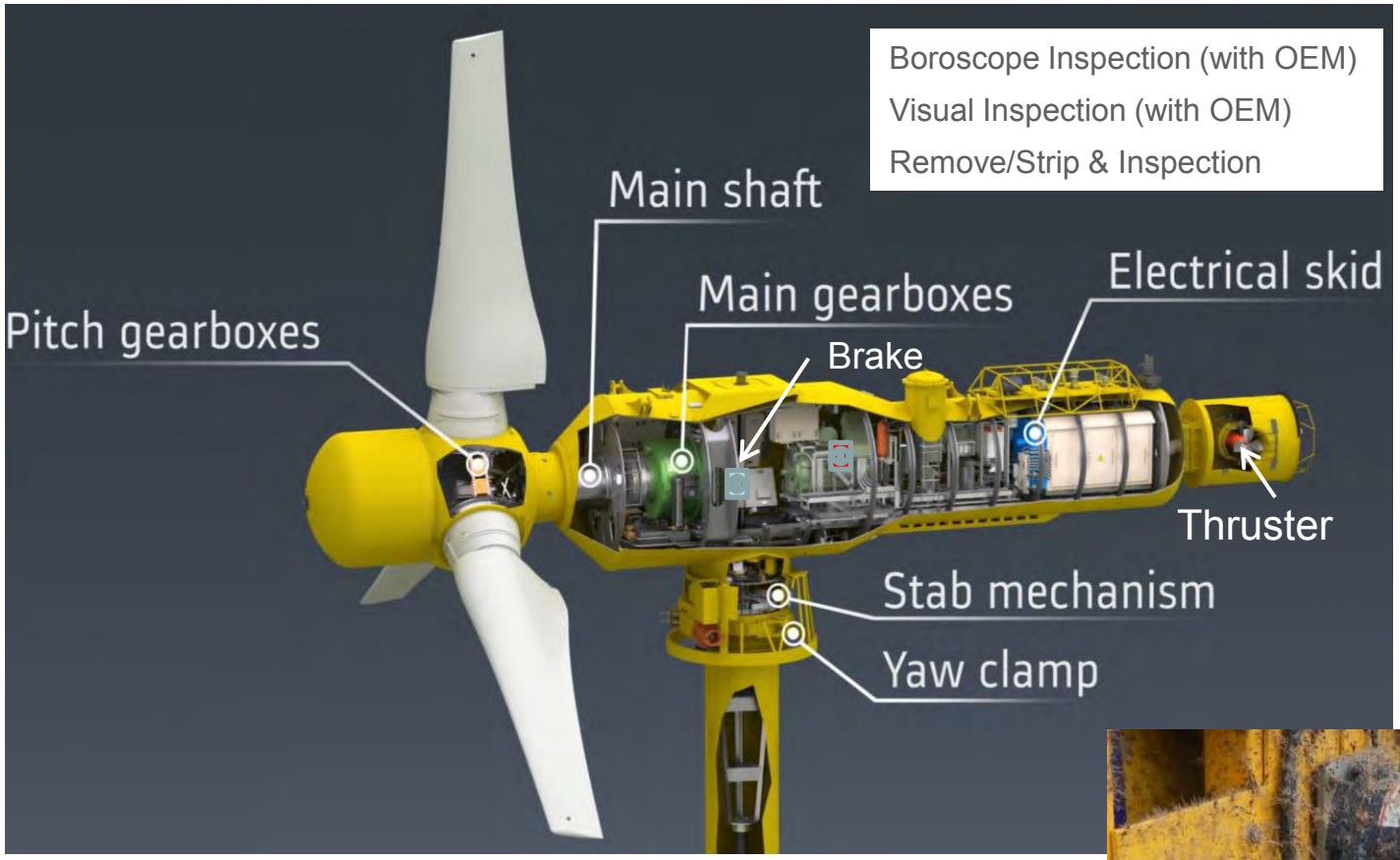
- Controller optimisation and Rotor testing to establish optimal performance
- Full IEC standard power curve
- Completion of all ReDAPT flow data gathering
- Noise survey –characterising acoustic signature of turbine

Marine Operations

- Contingency re-energisation operation:

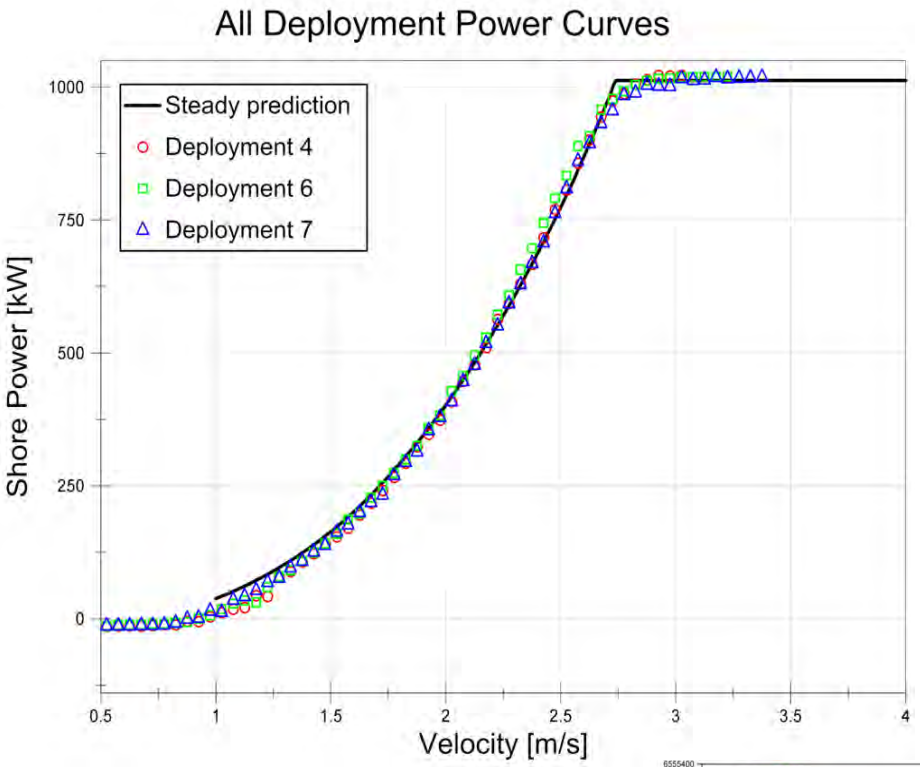
Following the communications loss the turbine could not be re-energised without the risk of damage to the frequency converter – vessel connection required to set the turbine up in a safe state for re-energisation.

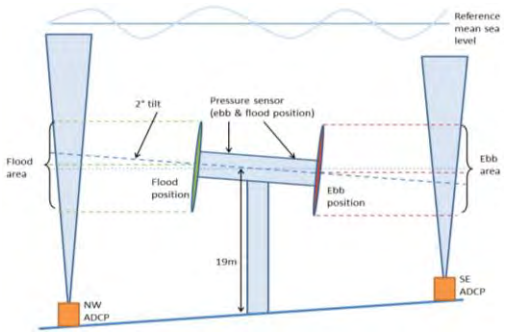
Turbine Strip – focus areas

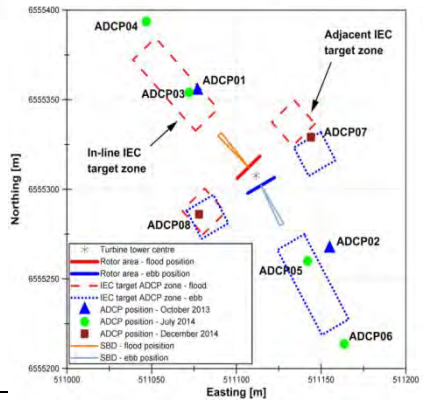


- The inspections resulted in no major unexpected findings, however some Biofouling was seen.
- Investigations yielded many valuable lessons learnt to carry forward to future turbine designs.

Turbine Performance







Overview

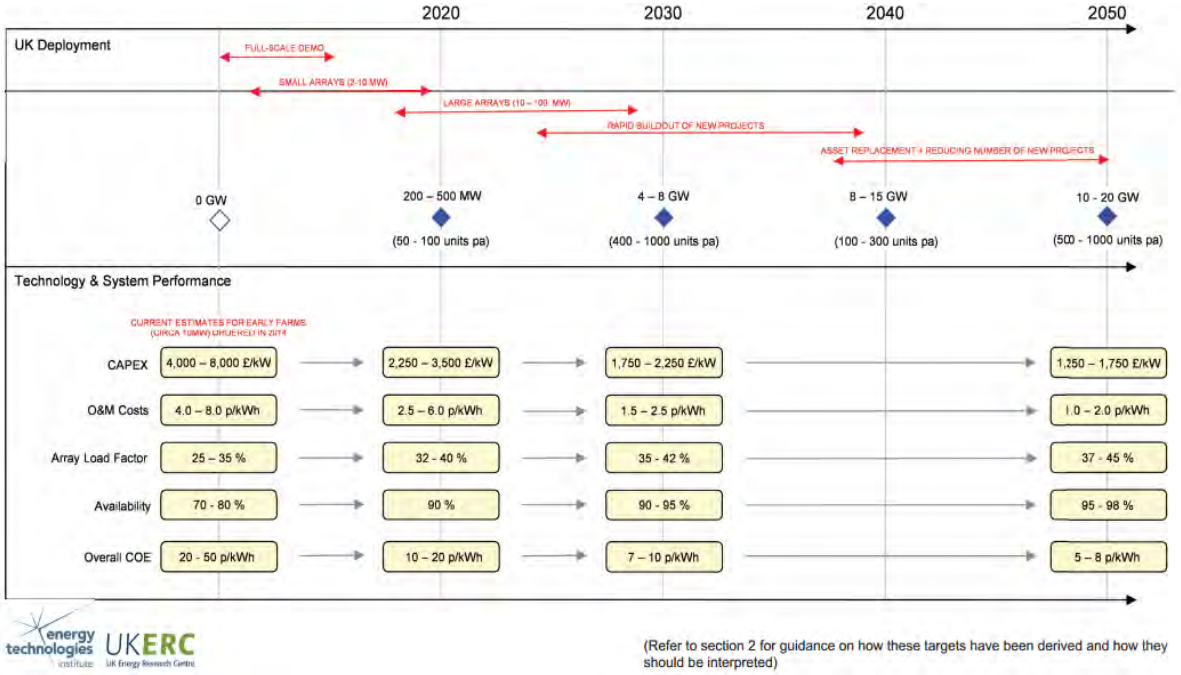
- Power curves measured and reported following methodology in IEC/TS 62600-200 during deployments 4, 6 and 7.
- ADCP position / orientation changed to investigate sensitivity to produced results.
- Full-deployment power curves (average of Flood and Ebb) shown in figure.

Lessons Learned

- Difficult to meet IEC/TS 62600-200 acceptance criteria. Specific TRN advised to measure power curve.
- Power curve impacted by other performance testing. Keep tests separate.
- Reference height of ADCP and turbine needs to be well understand to reduce uncertainties.
- ADCP siting and orientation is key to ensure accuracy of heading
- Care needs to be taken in the time synchronisation of the discrete datasets for analysis.

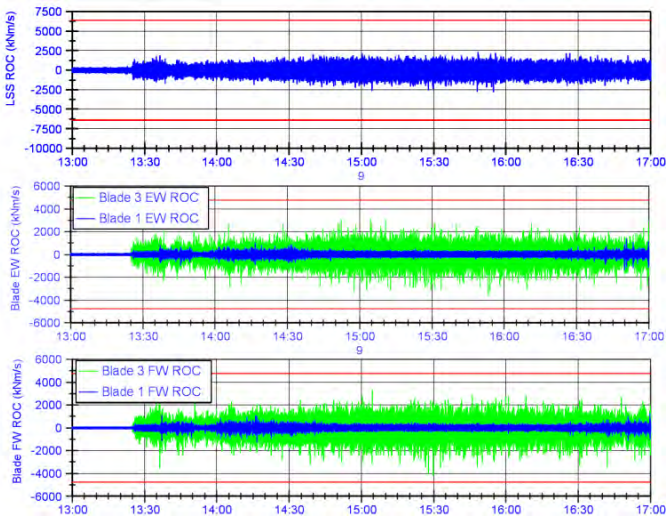
Cost of Electricity Modelling

- The measured performance of the DEEP-Gen IV turbine is in line with the predictions, adding confidence to the fact that given the site conditions yield for a single turbine (or even a small array) can be determined.



- Availability of DEEP-Gen IV is in line with ETI roadmap in latter deployments. Alstom are confident that the ETI roadmap target of 90% availability for first large arrays will be achievable.
- Challenges in terms of maintenance turn-around still remain.
- Studies agree that early small arrays still require significant capital support and/or risk mitigation support mechanisms. Once the sector has delivered several small arrays, the level of capital support can be reduced.

Environmental Interaction



Deck Plate Mounted Camera

- Very little success has been had with a deck plate mounted camera due to camera complexity and cable failure
- Further to this all cameras suffered with visibility in the turbid flow field

Acoustic Survey

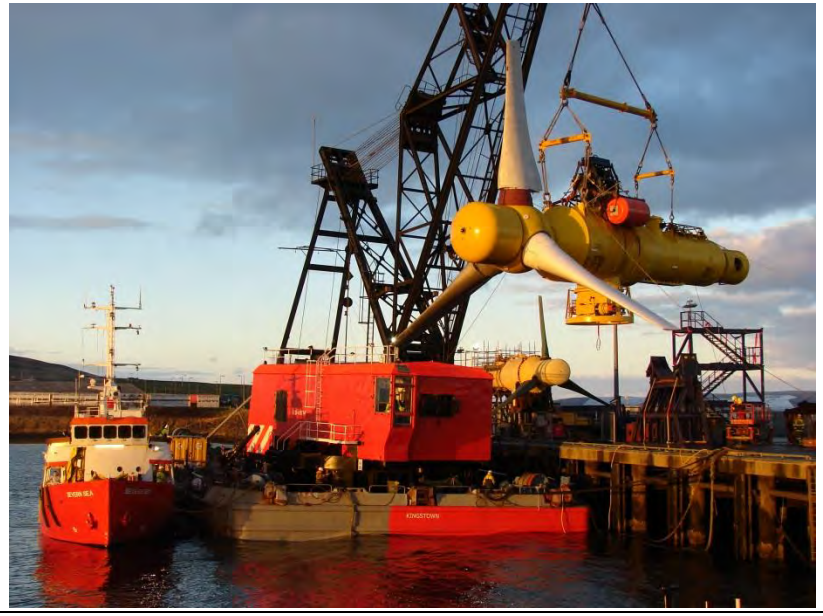
- Acoustic surveys began to characterise the noise associated with a tidal site and that associated with the turbine.
- The noise levels of the turbine were characterised at an appreciably low level when generating, idling and yawing.
- The frequency of the noise produced by the turbine was predominantly lower frequency noise <500Hz and there was little noise associated with high frequencies.
- It was also noted that the noise of the tidal flow passing through the site was quite significant.

Strain Gauge Monitoring

- In order to highlight potential marine life interactions the strain gauge data from the blades was analysed
- Thresholds were established and signals monitored that could be used to characterise an interaction
- Initial studies helped to identify brake events, shutdowns and signal losses, such that these could be quickly interpreted.
- No events representing a potential mammal interaction were observed.

ReDAPT Key Outcomes

- Product Design
  - Good validation of design process models including methods to interpret environmental data and predict loads
  - Tidal Bladed validation with site data and strain gauge measurements
- Design Verification and Rotational Testing
  - Importance of sub-system and software design/technology proving by rig test
- Deployment and Retrieval
  - Minimise the number of ROV operations and umbilical's in the water
  - Validation of deployment method, battery power margins and contingencies
  - Free ascent optimised
- Performance and Yield
  - Power curve and yield as expected
  - Grid compliant power quality
- Turbine Control
  - Importance of sub-system and software validation
  - Pitch control optimised
  - Power, Torque, Speed control Validation
  - Yaw and clamp performance optimised
  - Safety system and contingencies



Further Information on ReDAPT

- ETI Website contains links to the Public Domain Reports

http://www.eti.co.uk/project/redapt/

- UKERC – Energy Data Centre (EDC) database for ADCP measured flow data

http://data.ukedc.rl.ac.uk/browse/edc/renewables/marine

- Alstom – Paul Chesman – ReDAPT Programme Manager

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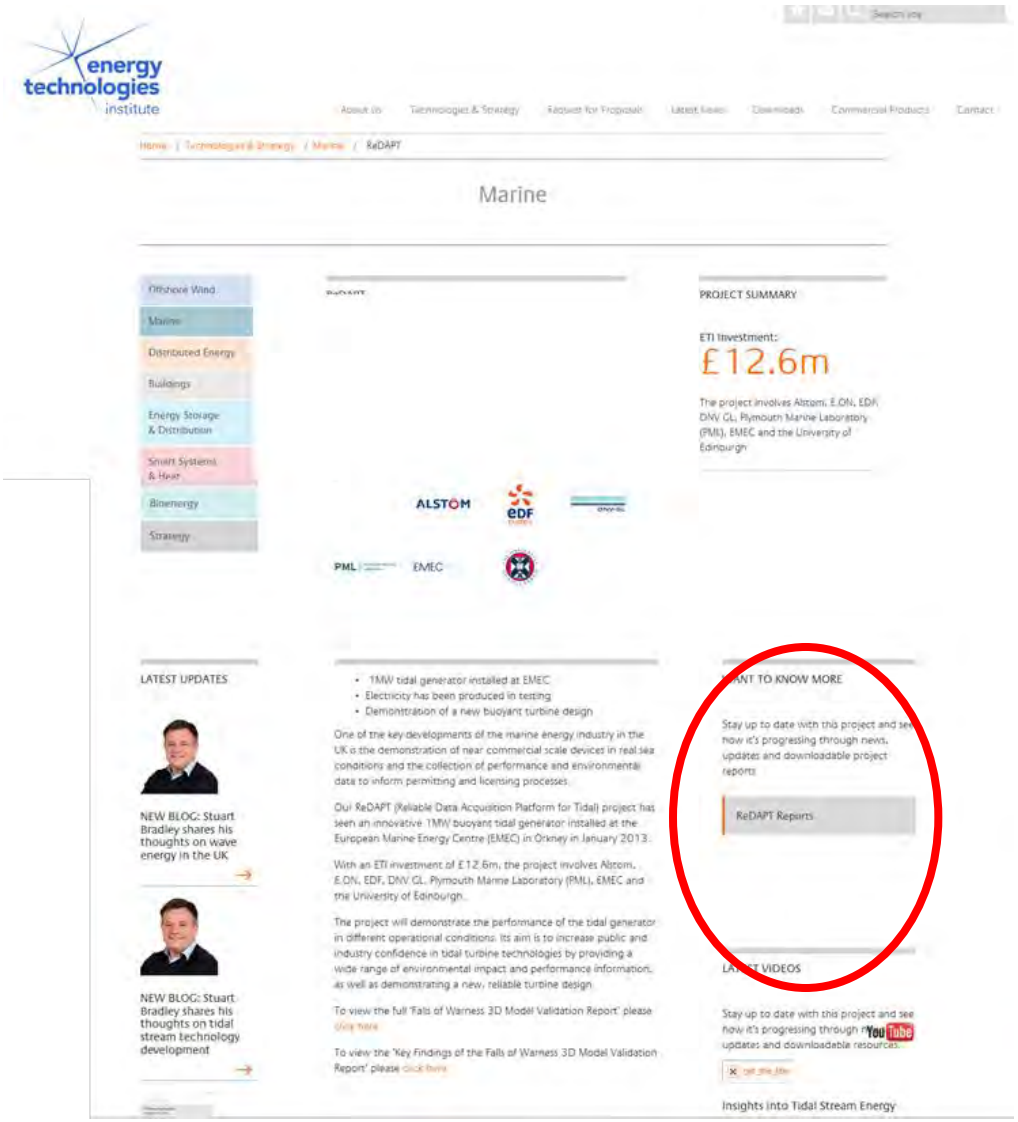

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