WAVE DRAGON PRE-COMMERCIAL DEMONSTRATION PROJECT

Name of person filing the form	Date submitted
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Project name: Wave Dragon pre-commercial demonstration project

Project description:

Project Developer: Wave Dragon Wales Ltd. (Wave Dragon ApS)

Technology type: Overtopping

Resource: MHK (wave)

Project scale: Full-scale prototype

Installed capacity (MW): 7 MW

Additional Description: The Wave Dragon Pre-Commercial Demonstrator is a floating slack moored wave energy converter. It is moored (like a ship) in relatively deep water, i.e. more than 25 m to take advantage of the ocean waves before they lose energy as they reach the coastal area. The device allows ocean waves to overtop a ramp, which elevates water to a reservoir above sea level. This artificial 'head' of water is subsequently released through a number of turbines and in this way transformed into electricity. Water is returned to the sea through draft tubes in the base of the unit, which house the turbines, the only moving parts of the device. The unit comprises a central platform, with a curved ramp and a large water reservoir equipped with an array of hydro turbines, and two lateral curved wave reflecting wings which concentrate the power of incoming waves. The Wave Dragon device is designed to remain within a defined movement area regarding wave direction and tidal currents. It is fixed to a forward buoy that remains essentially stationary (in plan view). The mooring system of the device is feature between six and eight concrete gravity mooring blocks and a series of catenary mooring lines (steel chain) fixed to a buoy. In addition there will be one rear mooring block to stop the device from rotating too far in tidal currents.

FERC Document Number:

Launch Date: March 2003

Project Website: http://www.wavedragon.net/

Location: The site is approximately 1.7km (0.9 nautical miles) off the Pembrokeshire Coast at Long Point (the closest point on land), Wale, U.K. Site location coordinates (WSG 84): 51°40.90N 05°15.00W, 51°42.00N 05°15.00W, 51°42.00N 05°13.00W, 51°40.90N 05°13.00W

Coordinates: 51°41'50.0" N, 5°14'0.0" W

Process status: A 1:4.5 scale prototype launched in 2003 was deployed in Nissum Bredning (the Danish Wave Energy Test Center) a fjord in the northern part of Denmark. The prototype was tested continuously until January 2005. In 2006 a modified prototype was deployed to another test site with more energetic wave climate. In May 2008 maintenance and repairs were done and the prototype was re-deployed at the original test site in early autumn 2009 for final testing. The pre-commercial demonstrator (full scale) is planned to be installed in 2011/2012 in Wales and a 50 MW wave farm is considered for deployment in the Portuguese coast. However the financial crisis has caused a delay in the plans for deploying the first full scale device and Wave Dragon Ltd. is currently seeking venture capital.

Licensing information: An offshore consent was submitted to the Department of Trade and industry (DTI) and two were submitted to the Department of Environmental, Food and Rural Affairs (DEFRA) together with the Environmental Statement in April 2007. The concerns arising would be then forwarded and discussed with Wave Dragon before a formal decision is made. Work with The Crown Estates and Pembrokeshire Coastal National Parks Authority towards a Lease and Planning Permission respectively was also planned. Wave Dragon Ltd. was planned to have successfully acquired consents and permissions by the end of 2010 and the constructions would begin at that time in order to deploy the device and connect it to the grid during 2011/2012.

Key Environmental issues: Although there is a specific webpage for environmental issues regarding this project, no documents are available for download.

Environmental webpage: http://www.wavedragon.co.uk/eia-2.html

Monitoring and adaptive management: Wave Dragon pre-commercial demonstration				
General description: Environmental Statement				
Receptor	**Monitoring program description**	**Design and methods**	**Results**	**Status**
Physical Environment	Water and sediment quality.	Desk based analysis and sediment sampling.	High energy site with only small quantities of mobile sediment. The most waterborne pollutants will be readily dispersed. Sediments did not contain significant quantities of contaminants. No impact through elevated suspended sediments or contaminant suspension on existing water or sediment quality.	Completed
	Coastal processes (sediment fluxes, waves	Desk based and modeling study to describe the seabed	The seabed is primarily bed rock with pocket and gully deposits of coarse pebbles and cobbles, apart from the potential cable landfalls which will pass	Completed

	and tidal currents.	processes impacts and effects of device deployment.	under the sand and gravel beaches. The site is exposed to high energy waves from the Atlantic making it a dynamic environment. The nearshore areas are designated for nature or geology conservation and are important as a recreational area. A moderate impact of the development on the waves close to the device is expected and some localized impact on the currents and beach processes in its immediate vicinity. There is unlikely to be any noticeable impacts further away from the device towards the shore.	
	Onshore physical environment.	Assessment of the potential impacts of the proposed development on the onshore physical environment.	The geology and hydrology of the area could be sensitive to construction. However best practice and environmental management controls are implemented during the construction phase, the scheme will have no adverse effects on the onshore physical environment.	Completed
Biological Environment	Impact on designated sites.	Assessment of the potential impacts of the device on designated sites in the vicinity.	The device will be deployed within an area designated as a conservation site known as the Pembrokeshire Marine Special Area of Conservation (SAC).	Completed
	Marine ecology.	Study at the existing environment and deployment site to assess the impacts of the deployment.	**Installation effects** Installation of the mooring system may increase the overall diversity of the local seabed communities by providing colonisation areas. Potential impacts: ploughing action of cable burial, pinning of the cable over areas of bedrock and potential damage caused by anchors and anchor lines. It is not envisaged that these activities will have significant impact. **Operation effects** Potential impacts: effect of the mooring chains and structures on sensitive and designated species attached to and protruding from bedrock reef habitat. To mitigate impacts blocks should be located out of sensitive areas. **Decommissioning effects**	Completed

			Have some potential to impact on the marine communities however it is considered to be low.	
	Fish.	Desk based review and consultations to determine the fish species present in the area and to assess any likely impacts to these species.	The area is rick in species such as dab and several species of shark were identified as using the area. Migratory species such as salmon and several internationally protected species such as river lamprey and basking shark are also using the site. Commercial species such as crab, lobster and crayfish are also present in the area. The effects on such species are considered to be negligible in the context of the extent of local fisheries. Fish are unlikely to pass over the ramp structure into the reservoir. Grills prevent large fish to pass through turbines and it is envisaged that they will flow back out of the reservoir unharmed. The turbines turn at a relatively slow speed so any fish small enough to pass through the grills should pass through the turbines unharmed.	Completed
	Electromagnetic fields.	Assessment of the potential impacts of equipment electromagnetic fields on sensitive fish species.	The Wave Dragon device power export cable would be no more than 2.3 km in length and would therefore represent a very small feature within the existing marine environment. The expected magnetic field from the cable is considered to be relatively low and given both the small scale of the project and the low magnitude of the anticipated magnetic field it is not anticipated that there is any likelihood of a significant impact for magnetically sensitive fish species.	Completed
	Marine mammals.	Desk based literature review and local consultations were undertaken in order to assess the potential for impacts on marine	The immediate area of the installation site is not understood to be of high importance for marine mammals in a local context, though Pembrokeshire coastal waters are recognized as being of relatively high importance regionally and nationally. Impact to marine mammals mainly relates to noise issues both during installation and operation.	Completed

		mammals, including cetaceans, seals, otters and marine turtles.	Noise disturbance of marine mammals may occur up to several hundred meters from the noisiest construction activities for short periods of time within the construction period but this is not considered to be significant. There is the potential for greater effects on cetaceans in the area during installation but appropriate measures will be used to minimize noise during the construction process.	
	Onshore and intertidal ecology.	Combination of a walk-over survey and a desk study were used to provide information to support the impact assessment for the ecology in the inter-tidal zone and of onshore habitats and species in relation to potential cable landfall locations at Marloes Sands and Westdale Bay and in the vicinity of candidate onshore cable routes.	The Pembrokeshire coastline has a diverse range of shoreline habitats from exposed bedrock on headlands to sheltered sandy coves and sheltered mud in the estuaries. Hard substrate areas, for example on bedrock or boulders outcropping from sand, typically support communities of algae. The potential cable routes will pass through the Dale and Marloes Site of Special Scientific Interest (SSSI), which is a conservation site designated for its maritime grassland, heath, cliff crevice and ledge vegetation and coastal scrub. The project design aims to minimize disturbance and impacts to rocky reef or inter-tidal areas by avoiding these areas at the cable landfall therefore the impact is likely to be very small. Minor changes in beach profiles arising from the changes in the coastal processes during the operation of the device were found to be possible and may cause some habitat loss caused by moving sands. This impact would be temporary in nature and beach profiles are known to change significantly through natural processes. Certain important species, specifically Scaly Cricket, were identified by the studies in one of the landfall areas on Marloes Sands. These will be investigated further and the finalized design will take this into account. Scaly Cricket habitat will be avoided by moving temporary works away from	Completed

			sensitive areas.	
	Birds.	Desk based study, drawing on current knowledge and data to assess the potential for impacts to birds. Consultations were also undertaken with key representatives on bird populations in the area. Lighting required as aids to navigation was also assessed.	The deployment area is proximate to three bird conservation areas and ten bird species were identified as being of importance, including the Manx Shearwater, and Red-billed Chough. For the ten key species assessed the impact was considered to be low. Both the deployment and operation phases indicated negligible negative effects and for species like Storm Petrel, Lesser Black-backed Gull and Kittiwake the device would have no negative effects. Given the high intensity of ships in the area creating artificial lighting at night in the near shore environment, the addition of navigation lighting from the device scheme will present a negligible addition.	Completed
Human Environment	Landscape and seascape assessment.	Desk study and preliminary site survey, baseline seascape landscape and visual assessment (including field survey).	The land within the study area all forms part of the Pembrokeshire National Park and the coastline is designated as heritage coast. Two Landscapes of Historic Interest are located within the study area, Skomer Island and the Milford Haven Waterway. Within the 7 km radius study area and the main users of the area, key viewpoints and key features were identified. The presence of the offshore islands, together with the landform of the Dale Peninsula provides both enclosure and visual interest. It was noted that the absence of any landform in a south westerly direction allows long distance views across open sea. There are several Public Rights of Way routed throughout the mainland study area. Nine viewpoints were identified to be of high sensitivity. The device could be viewed from the setting units identified to the north and south i.e. to the north of Skomer Island, Milford Haven and Pickard. However, any views to the	Completed

			device would be restricted to coastal locations within these areas and any potential effects will be reduced due to the distance and the low height (above sea level) of the device. Sea users may be able to see the device at closer quarters; however this is dependent upon the route through the sea area that the users choose. The proposed development will be a temporary feature, expected to remain in place for up to five years. All readily visual components will be removed and effects to landscape and visual amenity, including seascape, will be reversed.	
	Archaeology and cultural heritage assessment.	Geophysical and desk based studies. The geophysical survey was undertaken of the offshore survey area and cable route to shore, covering both the cable route options to Marloes Sands and Dale including a 2km area of search buffer zone.	The marine survey area was found to contain seven wrecks and sites of archaeological interest; in addition there are 110 reported losses within the area for which there are no known seabed remains. There is the potential for archaeological remains within the deployment area and it is anticipated that the final position of the mooring blocks will need to be informed by a seabed inspection prior to installation. The onshore cable route corridor was found to contain 28 sites and monuments. Further studies will be required to assess the likely impacts to the onshore archaeology and cultural heritage through the onshore construction phase once onshore infrastructure has been further defined.	Completed
	Socio-economics assessment.	Assessment of the social and economic environment in the Pembrokeshire and West Wales region.	Employment in the area was found to be dominated by the service and public sector with tourism featuring as the dominant factor in the Pembrokeshire economy. It was noted that the region attracts large numbers of visitors for the outdoor and marine activities present in the region. The Pembrokeshire Coastal Path and marine leisure activities such as sailing, diving, kayaking and coasteering were all found to make major contributions	Completed

			to the area's economy. The study was unable to qualify any effects on the levels of tourism caused by the device, however considering surveys on tourism for other renewable energy projects suggest the possibility of the Wave Dragon device to become a tourist attraction. The resulting capital expenditure and direct and indirect job creation is likely to be complemented by additional reputation benefits for the region. It is envisaged that the development would provide employment for the equivalent of 70 people in the construction and deployment stage, and the equivalent employment of 18 people through indirect and induced benefits.	
	Noise assessment	The underwater noise has been estimated from measurements of a single Kaplan turbine in a controlled laboratory environment, and compared to on-site measurements.	**Installation phase** Underwater noise generation as a result of ships propulsion systems, bow thrusters, rotating machinery, generators, dynamic positioning systems (if used) and ship echo-sounders. These sources are likely to dominate the underwater noise environment to a range of a few kilometers. **Operation phase** Noise will be mainly caused by increased vessel traffic in the region. The generator system may cause a behavioral response in marine mammals over a range of a few meters but this is not considered significant. Other mechanisms associated with wave interaction with the body of the device and hydraulic noise can also be considered insignificant. It is unlikely that the underwater noise, produced during any construction and operation activities will kill or cause direct physical injury to fish or marine mammal species. Disturbance to some sensitive species may occur in very close proximity to the deployment but this is considered to be insignificant.	Completed
	Commercial	Desk study on	The maximum number of fishing	Completed

	fisheries assessment.	commercial fishing activity and its value, areas of use and landing data from official records. Consultations with Fisheries organizations and individual fishermen in the region. This information was used to assist and supplement the official statistics. Visual records.	vessels active on site at any one time is three; however these are not always the same vessels. The main impacts identified relate to the loss of access to grounds, restricted access through navigational controls, disruption to the industry through the cable laying and stabilization, loss of habitat (and potentially resource) and increased risk through the potential for accidents and collisions. There is some potential for enhanced fisheries through a mussel seeding scheme, attached to the device, however this is subject to the correct permissions being granted. It is considered that the impact of the deployment and operation of the device will be minimal, provided good liaison and clear early notification is given to the fishing industry.	
	Navigation: detailed navigation risk assessment.	Navigation Risk Assessment: Maritime traffic survey of the area supplemented by research of other available data sources as well as consultation with other navigational stakeholders.	The deployment location is away from the main shipping lanes in the area, which are associated with Milford Haven. The risk of a commercial ship drifting off course and colliding with the structure was assessed to be very low. There is large redundancy in the mooring system and hence there is negligible risk of mooring failure of the device causing it to come adrift. Even if this were to occur, contingency plans will be in place to alert shore-based personnel and respond to the emergency. Based on the best-estimate of fishing activity the frequency of fishing vessel collisions was estimated to be 1 in 100 years. To aid the identification of the device and minimize the likelihood of any collisions, the device will be appropriately lit and marked and awareness of the location of the device will be raised amongst local stakeholders. The generic risks of collision and cable snag are considered low, and risks of	Completed

			stranded personnel will be included within the Emergency Response Plan to be drafted prior to construction.	
	Other relevant projects.	Identification of marine activities or industries in areas surrounding the deployment location.	Six types of marine activities and industries were identified: - Offshore oil and gas - Marine aggregate extraction - Subsea cables and pipelines - Marine waste disposal and dumping - Military and civil aviation - Abandoned munitions	Completed
Reports and papers	• Wave Dragon Wales (2007): Wave Dragon Pre-Commercial Wave Energy Device, Environmental Statement Volume 1: Non-Technical Summary, 36 pp (in English and Welsh) • Wave Dragon Wales (2007): Wave Dragon Pre-Commercial Wave Energy Device, Environmental Statement Volume 2: Technical Report, 434 pp. • Wave Dragon Wales (2007): Wave Dragon Pre-Commercial Wave Energy Device, Environmental Statement Volume 3: Figures 7 pp + 123 figures • Iain Russell & Hans Chr. Soerensen: Wave Dragon: Results From UK, EIA and Consenting Process, Proceedings of the 7th European Wave and Tidal Energy Conference, Porto, Portugal, 2007, 8 pp • Capman, J., Masters, I., Willis, M., Fidler, R.: Investigation into the mixing effect of a 7MW overtopping wave energy converter, Swansea University, School of Engineering, April 2009, April 2008, 14 pp.			
Research Projects	• CMACS: Wave Dragon pre-commercial Demonstrator; Benthic Environmental Impact assessment update Based on supplementary benthic information, document: J3045 v2, February 2008, 46 pp. • Beels, C., Troch, P., De Visch, K., Kofoed, J. P., De Backer, G., 2010. Application of the time-dependent mild-slope equations for the simulation of wake effects in the lee of a farm of Wave Dragon wave energy converters. Renewable Energy, 35, 1644–1661.			

Monitoring and adaptive management: Wave Dragon pre-commercial demonstration				
General description: No formal monitoring plan has been put in place; this was going to be done when the GIS database was completed and it would have been written in line with the Normal Operating Procedures and Emergency Action Plan. Monitoring actions described below are proposed in the Environmental Statement.				
Receptor	**Monitoring program description**	**Design and methods**	**Results**	**Status**
Physical Environment	Coastal processes monitoring to address any FEPA licence conditions.		N/A	Proposed
Benthos	Analysis of the ecological	Drop down camera and diver surveys focusing on:	N/A	Proposed

	sensitivities on bedrock areas including cable routes.	1) nearby extensive bedrock areas that might be affected during the emplacement of the structures; in particular, if any significant colonies of pink sea fan *Eunicella verrucosa*, or other species of importance in their own right, were discovered in vulnerable situations, for example on the edges of bedrock where dragging blocks could potentially cause damage, or where jack up legs are likely to be placed, then these would be the subject of specific monitoring plans. 2) The mooring blocks themselves, in order to monitor the development of epifauna. The monitoring should be carried out by divers and should cover both horizontal and vertical faces of the blocks. Vertical faces should include examples facing in different directions to see if there are significant differences caused by variations in exposure to waves and currents. The conjunction between the block and the sediment should be monitored as part of this exercise. 3) Areas of sedimentary habitat upon which the mooring blocks are placed, including any significant areas of bedrock or more stable boulders within this area. Unless the site specific survey reveals any unexpected communities or species, monitoring of this habitat should take a relatively low priority since it is expected to be a scour tolerant community on mobile sediments with a large component of cobble.		
Fish	Post construction survey to monitor device effects on the fish species of the area. It is suggested that this program considers the Wave Dragon as a Fish Aggregating Device (FAD) and moorings as artificial reefs.	Diver surveys or ROV as part of any benthic monitoring programme suggested and should be developed using statutory guidance and after consultation with the relevant statutory authorities e.g. Countryside Council for Wales (CCW) and Centre of Environment, Fisheries and Aquaculture Science (CEFAS).	N/A	Proposed
Marine Mammals	Marine mammal monitoring particularly common dolphin	Wave Dragon Ltd has expressed willingness to support ongoing marine mammal monitoring currently being undertaken in local Pembrokeshire waters by Sea trust. Sea Trust	N/A	Proposed

	surveys.	have indicated that their surveys could be tailored to take in a routine pass by the Wave Dragon deployment site, before, during and after construction, which would provide useful additional information on marine mammals usage of the immediate and surrounding area. These surveys would be based on visual observation from a boat, in line with previous work in the area reported in Earl et al. 2004 and 2005. It would also be beneficial if any visiting vessels could log marine mammal sightings on standard pro forma, for example those used by Sea Watch Foundation, or via reporting arrangements with the local Sea Trust.		
Commercial Navigation	Safety zones surveillance.	Video surveillance onboard the device with remote viewing capability to monitor activities as well as to detect potential trespassers.	N/A	Proposed
Reports and papers	• CMACS: Wave Dragon pre-commercial wave energy device; Scaly Cricket Survey; document: J3045 v1, August 2007, 24 pp. • CMACS: Wave Dragon Subtidal Benthic Ecology Visual Survey, Field Report v2; document: J3045 v2, August 2007, 24 pp. • Iain Russell & Hans Chr. Soerensen: Wave Dragon: Results From UK EIA and Consenting Process, Proceedings of the 7th European Wave and Tidal Energy Conference, Porto, Portugal, 2007, 8 pp.			
Research Projects	N/A			