Natura Potentia

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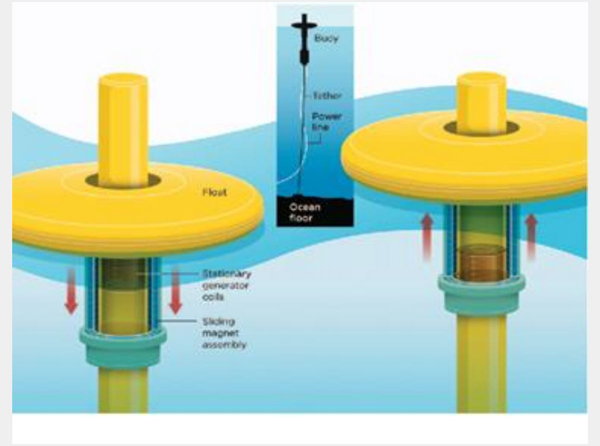
OTC Energy Challenge 2020: Neptune Power

Function

- We propose a system of point absorbers to harness wave energy
- Similar in appearance to an ocean buoy
- Floating structure that captures energy from the vertical motion of waves (NEED.org)
- "Absorbs" energy from waves via an up and down bobbing motion that drives electromechanical or hydraulic energy converters to generate an electric current (NEED.org)
- Typically about three meters (10 feet) above the ocean surface/46 meters (150 feet) below the surface (NEED.org)
- Can serve as a power source for lower consumption areas such as: laundry, kitchen and radio needs (see Table 1)



Direct Drive: OSU L10. This figure shows the stationary generator coils located inside the spar and the sliding magnet assembly coupled to the float. (Image courtesy of Smithsonian Magazine)
E. Rusch, "Catching a wave, powering an electrical grid?," Smithsonian Magazine, July 2009.

Region

- Southern region of the North Sea
- BP has existing assets in the North Sea
- "The world's tallest ocean waves are generated south of Iceland. From there, these giants roll into the Norwegian and North Seas." (Norway Science)
- Based on 38 years of data (Sørensen), the North Sea "at the Norwich and Ipswich coasts P_{wave} is ≤4 kW/m, but exactly across the Central and South Dutch coastlines these have a significant resource of ≥10 kW/m."
- The region near the Irish Republic and Scotland are even more energetic. (Sørensen)
- "Results by the analysis show that in the North Sea, conditions are moderate to high, and the wave energy resource, which has been previously overlooked, is high and easily accessible due to the low distance from coasts." (Sørensen)

Images

Image courtesy of National Geographic

Exploring Ocean Energy and Resources Student Guide. (n.d.). NEED.Org. Retrieved August 29, 2020, from http://www.need.org/Files/curriculum/guides/ExploringOceanEnergyStudent.pdf

Deepsea Aberdeen drilling engineer-Drilling engineer Josephine Anselin on board the semi-submersible drilling rig Deepsea Aberdeen, in the North Sea, west of Shetland in Scotland. ©2015 BP PLC

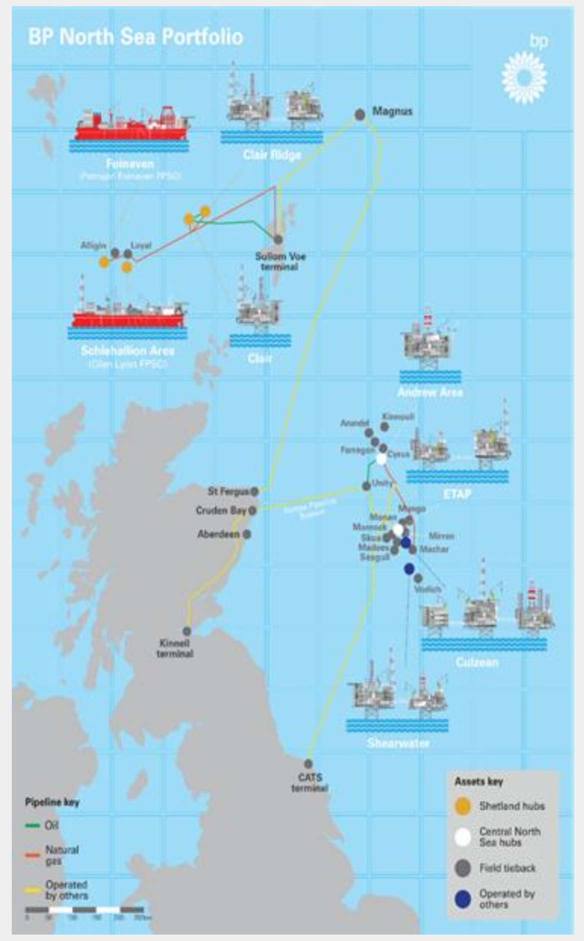
Platform meal time-Canteen at lunch time, on board the Clair Ridge Platform, located west of the Shetland Islands in the North Sea. ©2016 BP PLC

Semi-submersible drilling rig Deepsea Aberdeen-Aerial view of a support vessel alongside the semi-submersible drilling rig Deepsea Aberdeen, in the North Sea, west of Shetland in Scotland. ©2015 BP PLC

Unit	Percentage of Total Energy Use	Power Usage (kWh)
Galley (Kitchen)	5	20
Laundry	3	12
Heating, Ventilation and Air Conditioning (HVAC)	50	200
Lighting	13	52
Elevators	5	20
Safety Systems	8	32
Chillers	6	24
Sewage System	4	16
Water System	5	20
Radio Communications	1	4
Total	**100**	**400 kWh**

Table 1. Average Hourly Energy Demands of Sample FPSO in Angola (Macdonald, 2014).

Macdonald, J., 2014, Providing Scope for Reducing the Carbon Footprint of an Offshore Oil Rig: MS Thesis, University of Strathclyde, Glasgow, United Kingdom, 74 p.



BP. (n.d.). BP North Sea Portfolio [Illustration]. https://www.bp.com/content/dam/bp/country-sites/en_gb/united-kingdom/home/images/freesize/bp-north-sea-region-report-2019.png.img.1024.medium.png

Benefits

- According to Chozas (2011), point absorbers have the highest theoretical power output
- Point absorbers can act as act as UPS and store sufficient electric energy for periods of flat-calm seas (PB3 PowerBuoy)
- Can store sufficient energy in built in batteries to supply during calm seas (Faizal)
- £1.4 million has been secured from Wave Energy Scotland (WES) to develop quick connection systems to improve the installation efficiency and infrastructure of wave power devices
- Wave energy extractors can generate electricity around 90% of the day, thus providing a high yield of power that can supply 4000 mWh per year
- Minimal loss of energy when wave power is converted to different forms of energy for different uses by point absorbers
- The power intensity of waves is usually high, thus making wave energy a reliable energy source.
- Point absorbers can be flexibly positioned to the direction of the waves and function from subsurface 3000 meters below

Drawbacks

- The main drawback for point absorbers is the small size, which would result in small output of power, thus requiring multiple devices.
- However, due to lower cost to less flexible devices, more point absorbers can allow for an efficient grid system, such as the AquaBuOY.
- Further, harsh conditions can corrode devices and result in replacement needs.
- Finally, power of waves will depend on height and period, therefore resulting in low generation at times. This could be resolved with rechargeable batteries and high storing capacity of the devices.

Regulatory/Policy Concerns

- The United Kingdom follows a licensing system that covers the levels of responsibility over the variations of requirements in different maritime zones
- The Marine Management Organisation (MMO) requires consent in order to operate generate stations with a capacity between 1 and 100 MW under the Section 66 of the Marine and Coastal Access Act 2009; Section 36 of the Electricity Act 1989
- The Section 95 of the Energy Act of 2004 required safety zones
- "Stations that generate over 100 MW are considered Nationally Significant Infrastructure Projects (NSIPs) and require a Development Consent Order (DCO) granted by the Secretary of State"
- The Marine Scotland Licensing Operations Team (MS LOT) is in charge of all of the marine renewable energy development in Scotland.
- The statutory nature conservation bodies in Scotland's Marine covers the Scottish Natural Heritage (SNH), Joint Nature Conservation Committee, Local Planning Authorities, Maritime and Coastguard Agency, Northern Lighthouse Board, and Scottish Environment Protection Agency.
- In June 2015 the Marine Scotland Guidance for Marine Licence Applicants was created to assist applicants
- Applications such as the Marine Renewable Energy Projects in the Territorial Sea and UK Controlled Waters Adjacent to Scotland provides the requirements of the Marine (Scotland) Act 2010
- The guidance document identifies the issues over compliance the regulatory licensing, Health and Safety and electrical safety requirements.
- Mandatory sections that are covered under compliance are Technology Programme Development and Planning, Marin Licensing and Health and Safety including electrical and maritime safety
- Uses a checklist before the plan starts to be aware of the environmental factors and life.
- "It is essential to develop a compliance plan to provide this forward look and highlight the requirements for the following lifecycle stage.

HSE Concerns

- It is advised to follow the guidelines in Renewable UK's set of guidelines for Health and Safety in the Marine Energy Industry (includes guidelines for wave devices)
- In offshore environments, it is important to take the worker's mental and physical health into consideration.
- Workers are exposed to a wide range of activities with environments that are physical, biological, chemical, psychological, and ergonomic hazards.
- Noise and vibration imposes concerns where workers can potentially have hand-arm vibration syndrome and exposure to thermal and radiation extremes.
- Workers can undergo an overload of work, lack of job clarity, and frequent change as stressor.
- Safety concerns arise during installation, commission, and operation of wave technology.
  - For example: marking and lighting of vessels, issue notices to mariners, safety and health procedures for adverse weather conditions.
- Ways to reduce includes improving on planning and management of projects.
- Wave energy has concerning effects towards the environment:
  - Specifically, Point Absorbers affect the crabbing industry and fish/mammal navigation.
  - Furthermore, the mooring device attached to the Point Absorber could affect the shipping industry, causing traffic slowdowns if the device breaks.
  - In the long run, the technology causes localized changes which may result in prey and predator aggregation.

Professional Skills

- General Skills:
  - Willingness to learn, there will be extensive training to prepare you for your job role.
  - Adopt an attitude of safety and reliability as your top priority.
  - In most cases, offshore workers must be willing to work a rotational schedule such as 14 days on/21 days off.
- Sample Job Roles
  - Maintenance team - engineers, planners and operators that keep the rig operating seamlessly and without delays
  - Marine team - engineers, tradespersons and operators (including custodial, food, laundry and medical workers) that ensure the safe day to day operation of the rig.
  - Directors - Help everyone work as a team and communicate
  - Construction Managers - Oversee construction of new technology
  - Research officer - Research and understand how the new technology will impact offshore operations (point absorbers)
  - Compliance officer - Knowledgeable of HSE concerns, observes all interactions and record any infractions
  - Planning Engineer - Work with the research officer to implement the agreed upon plans to construct/install point absorbers
  - Mechanical Engineers - Power Systems/industrial background in heavy electro-mechanical and mechanical equipment and operations (heavy machinery, large welded structures, dynamics analysis, fatigue assessment, corrosion prevention, hydraulics, rigging, electric power generation and distribution, high-voltage packaging, and marine operations)
  - Electrical Engineers - Carry out the layout, assembly and test of electronic circuit boards and electrical systems
  - (Sales Engineers for new technology) - Experience or knowledge in Oil and Gas, Science & Research, Communications and Defense
  - Program Managers - Monitor engineering deliverables; initiate appropriate corrective actions throughout the project lifecycle

Sources

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