6. Other Technologies

The following section gives a brief description of other aquatic technologies.

- Ocean current
- Ocean thermal energy conversion
- Salinity gradient
- Algae

6.1. Ocean Current

In addition to the tidal currents, caused by the gravitational pull of the moon and sun, there are also ocean currents. Unlike tidal currents, these ocean currents flow in one direction only and are relatively constant. Ocean currents are massive and complex circulatory systems. Some of these currents operate on an ocean scale; others, such as the great ocean conveyor belt, flow around the world. They are driven by a number of factors including: the effect of wind on the surface of the water; the effects of the sun heating the water in equatorial regions; the effect of salinity and density variations; and the effect of the Earth's rotation (the Coriolis Effect). Examples of ocean currents include the North Atlantic drift, the Gulf Stream and the Florida Straits current.

It is possible, as with tidal stream energy, to extract the energy from these currents to drive underwater turbines and produce electricity. The energy density of the Florida Straits current for example is about 1 kW/m^2 [1]. The technology used to extract energy from ocean currents is likely to be similar to that currently under development for tidal stream energy.

As with any project, the environmental implication must be taken into account. On the local scale there may be impacts on the marine environment (e.g. impacts on marine mammals from turning turbine blades). On a global scale, slowing these currents by extracting energy from them may have a greater effect since ocean currents affect the climate. The great ocean conveyor belt, which is a deep water current, bring nutrient-rich water from the deep ocean to the surface where they are important for sustaining the marine ecosystems which are responsible for approximately 50% of the world's photosynthesis[2].

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6.2. Ocean Thermal Energy Conversion (OTEC)

Ocean Thermal Energy Conversion (OTEC) is a method of generating electricity which relies on the temperature difference between surface and subsurface ocean waters. In order for this technology to be economically viable, the temperature difference must be 20℃ and the cold deep water must be no more that 100 m below the surface[1]. The largest temperature differences, and therefore the largest resources for OTEC, are generally near the equator where the effects of the sun heating the ocean surface are greatest. Where this temperature difference exists it is possible to drive a heat engine. The warm water is used to heat and vaporise a liquid, normally one with a low boiling point. As the expanding vapour expands it drives a turbine. Cold water brought up from the deep water is then used to condense the vapour back into liquid[2].

Environmental concerns about OTEC include the leakage of the working fluid into the environment and the effect that large-scale mixing would have on ocean currents, which are often driven by temperature gradients.

References

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6.3. Salinity Gradient

The principle behind salinity gradient power (or osmotic power) is that there is a difference in entropy between salt and fresh water which can be exploited for the production of energy. This form of energy is a complex concept as it cannot be detected in the same way as other forms of energy such as solar, wind or wave. However, considering that the reverse process, desalination of seawater, requires large amounts of energy, the principle behind salinity gradient power is more logical[1].

There are two methods in development: reverse electro-dialysis (RED) and pressure retarded osmosis (PRO). Both of these processes use alternate chambers separated by semi-permeable membranes. The RED method involves the migration of salt ions, by osmosis, through the semi-permeable membrane, thereby creating a low voltage current[2]. The PRO method uses a membrane which is more permeable to water than to salt. Water molecules will be forced through the membrane to the salt water side. As water molecules pass through the membrane, hydrostatic pressure will increase on the seawater side, up to a maximum of 26 bars[2]. This pressurized water is used to drive a turbine and make electricity.

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6.4. Algae

Biodiesel production from Microalgae

Microalgae are microscopic photosynthetic aquatic organisms. Like terrestrial plants, microalgae use energy from the sun for photosynthesis, thereby converting solar energy into stored chemical energy. Microalgae are efficient converters of solar energy because of their simple cellular structure. They are of interest for biofuels production because of their high growth rates, tolerance to varying environmental conditions and high oil content; the oil can be extracted and converted into biodiesel. Algal species have been isolated that have an oil content of up to 50%, which is much higher than any terrestrial plant species[1]. Yields per hectare from algae are predicted to be at least an order of magnitude greater than any terrestrial crops[2] (e.g. oil palm - 6000 litres oil/hectare; algae 90000 litres oil/hectare). The advantage of algaculture over terrestrial crop-based biofuels is that it does not necessitate a decrease in food production as it does not use farmland. Many algal species can grow in brackish water or seawater and will not put a strain on fresh water supplies

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Biogas production from Macroalgae

Anaerobic digestion is a natural process by which microorganisms break down biodegradable material in the absence of oxygen. This process produces “biogas” which consists mainly of methane (50%-80%) and carbon dioxide (20%-50%)[1]. Methane is the major component of the “natural gas” which is used across Europe for heating, cooking and in power stations to produce electricity. If this process occurs in a controlled environment, so that the resulting gas can be captured and stored, then the methane produced can be used as a renewable fuel source. Nutrient-rich bi-products are produced during the anaerobic digestion process which can be used as an agricultural fertiliser.

Almost any organic material can be processed by anaerobic digestion. This includes biodegradable waste materials, such as waste paper, grass clippings, leftover food, sewage, animal waste and macroalgae (marine seaweed). One advantage of using marine algae as the feedstock over terrestrial plants is that it overcomes the displacement of food crops with biofuel crops, because marine algae need neither land nor fresh water.

References

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7. Supporting Activities

The successful deployment and operation of aquatic renewables will require a wide range of associated support facilities and other supporting resources. This support will include materials, buildings, ports, connections and markets.

The significance of these supporting factors is that if they are not present, or planned for, then the deployment of aquatic renewable energy will be more difficult, less effective and may even fail.

The aim of this section is to provide a brief introduction to how these support factors will play a role in the future development of aquatic renewables.

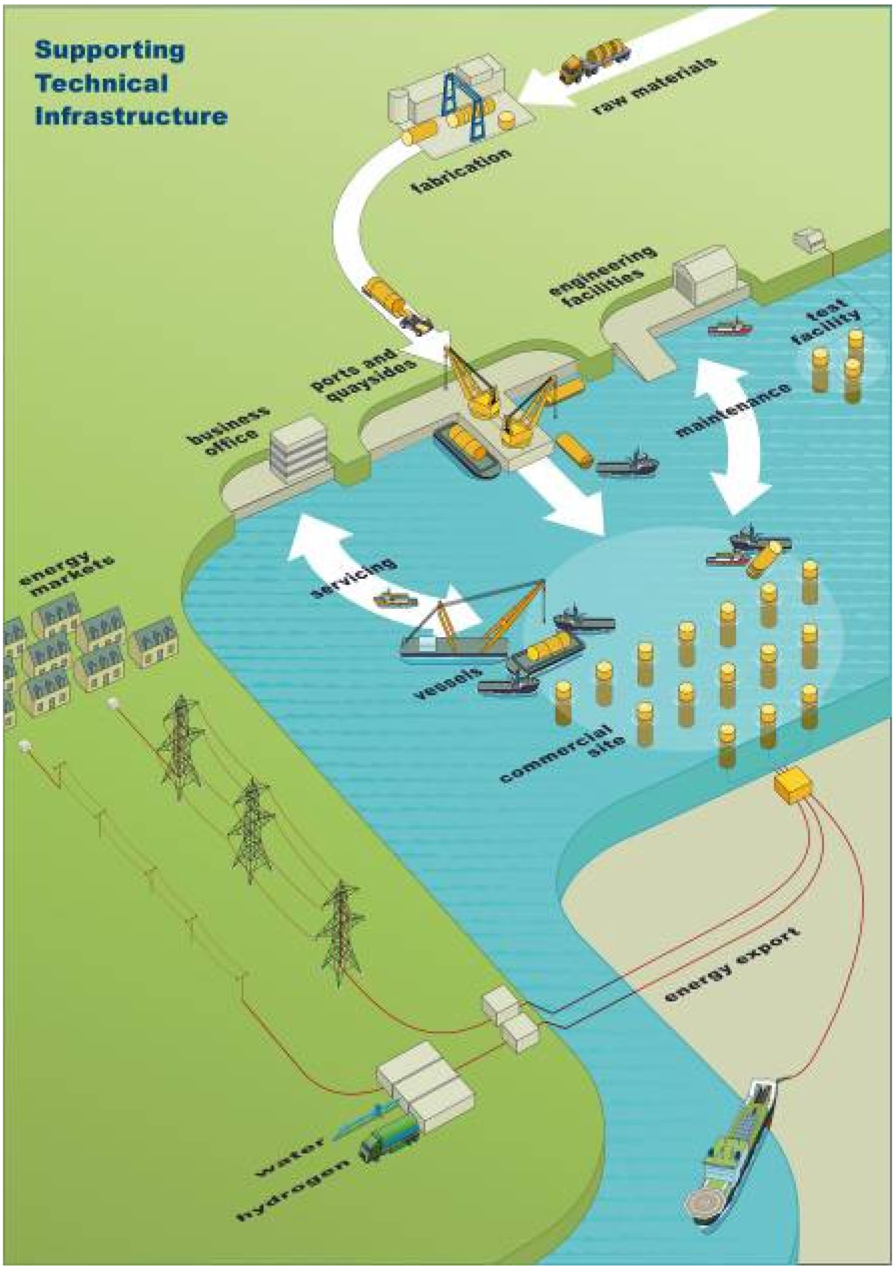

Figure 1 Generic illustration of supporting infrastructure needs

7.1. Raw Materials and Fabrication

Raw materials

The basic raw materials for aquatic renewable devices are likely to be steel, concrete and composites. These are available throughout Europe although prices and usability may vary. In the early stages of technology development local sources of materials are likely to be used, but as fabrication develops, cost effective sources of supply will be sought.

Fabrication

Fabrication of single and small numbers of multiple devices can take place at a variety of locations and shipment of technology from the fabrication site to the deployment site is feasible, particularly by sea. There are issues over the cost and reliability of long distance supply routes. As capacity requirements increase it is likely that forward assembly areas will be sought where the devices can be assembled. Such sites may in time have to deal with hundreds of devices at one time and may need considerable space.

7.2. Installation, Operation and Maintenance

Ports and quaysides / Wharfage

There are a few types of quayside facilities that will be required. During installation there needs to be a place where equipment can be assembled or prepared near to the deployment site. For experimental deployments these areas do not necessarily have to be very large, but once commercial deployment is underway the requirements in terms of quay length, the working draft and the load baring capacity, and area of the quay, could all be considerable. There will also be a need for quayside or slipway working areas for device maintenance, although these could share the installation facilities if suitable. If devices have a ten year shore side service requirement, 10% of any commercial arrays may be being maintained at any one time. There may also be a need for additional or new port areas nearer to deployment areas for routine work boats.

Engineering facilities

During the final assembly, operation and maintenance periods there will be a need for local engineering facilities. These may include welding, fabricating steelwork, machining, instrumentation, electrical cabling, power systems, mooring lines and anchors, civil engineering, concreting, composites, or marine engineering. Some of the materials and technologies that will be needed will mean that these engineering facilities are more likely to be state of the art rather than typical.

Vessels

In order to service a commercial array of marine technologies, a fleet of vessels will be required over the lifetime of the project. The installation and ongoing major maintenance intervention vessels could be rather large and complex. A range of smaller workboats for carrying out more routine servicing of the array will also be required. Within a regional development area there may be a need for an emergency intervention vessel or tug. A specialised ship to handle grid connection options may also be useful. There could be three to five vessels associated with a commercial operation.

7.3. Testing Facilities

Although some aquatic renewable technologies have been established for some time there are a number of new technologies and technological innovations that are now taking place. A number of countries and regions are working to establish testing and demonstration sites for aquatic renewable energy technologies, particularly in the wave and tidal sector. Test sites can:

- Provide assistance for new technology developers to get devices into the water
- Provide a pathway for project development
- Encourage R&D and other related industrial activity
- Encourage early introduction of renewable energy into the grid
- Provide opportunities for rural development in remote but resource-rich coastal areas

Test sites need not necessarily be co-located to commercial sites.

7.4. Operational Bases

Commercial sites

Commercial development sites will need to have a scale, access to market and operability that makes generating power profitable. The locations of such sites will be technology specific and may even be device specific. There could be important synergies between technology sectors such as wave, wind, tide, and run-of-river. In order to create a spatial plan for long term commercial development it will be necessary to undertake a strategic assessment before commercial sites are allocated. This will help to ensure that negative impacts are minimised and positive effects are maximised.

Business offices

Larger projects will require office based support to manage the operation. With newer technologies, such as wave and tidal stream, office space may be considerable and may need to be close to the deployment site. With other more proven technologies the needs may be less. Resource-rich rural areas may lack office space and there may be a need for new facilities.

7.5. Energy Export and Markets

Energy export

The energy generated by aquatic renewables projects may be delivered directly to energy markets through grid connections, may be converted to alternative energy carriers, or transformed into energy intensive product. The provision of suitable grid connections from resource rich areas to key markets may require extensive upgrades or new grid links. Any such investment needs to be considered with the direct and indirect costs of servicing existing grid infrastructure and existing power needs. Alternative energy carriers such as hydrogen are proven at the small scale but have yet to break through in terms of large scale production. Options for energy storage, possibly as heat, pump storage or in batteries, may also be important and can have considerable infrastructure implications. Given the rural locations of many resource-rich areas, route to market and local onshore energy storage infrastructure can be controversial planning issues.

Energy markets

Energy markets have matured around energy supplied from fossil and nuclear fuels. Although these energy sources are intermittently supplied from mine to power station, stockpiling and other storage mechanisms lead to electricity reaching the customer consistently. Aquatic renewable energy varies in power supply but to date there are no widely used storage systems downstream of electricity generation. There may be a need to develop energy storage or balancing supplies of energy in order to exploit the benefits of aquatic energy. Flexibility in the patterns of energy use may prove valuable.

8. Further Reading

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A portal which manages the US National Oceanic and Atmospheric Administration's collection of oceanographic and meteorological data. Includes a glossary of Tide and Current information.
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