Chapter 45: Wave, Tidal and Ocean Thermal Energy

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Abstract

Ocean renewable energy sources hold the potential to contribute to the options of low-carbon energy sources and enhance the efforts by the global community to slow down climate change. In this Chapter, we provide a brief background on the current state of technology and development of wave, tidal and ocean thermal energy and consider their potential as forms of renewable energy as well as the potential negative environmental footprints of ocean renewable energy installation and development. Secondly, we examine the relevant international legal and policy framework governing ocean energy, highlighting in particular, the absence of a global legal instrument that specifically regulates ocean renewable energy installations at the high seas. Thirdly, we identify current challenges to the roll-out of ocean renewable energy within the international regulatory framework. Lastly, we suggest policy and legal options available to countries to optimize the vast ocean energy resources.

Keywords: ocean renewable energy, wave energy, tidal energy, ocean thermal energy.

Electronic copy available at: https://ssrn.com/abstract=3587308

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1. Introduction

The Ocean provides a significant source of potential sustainable energy resources that can be harvested in many forms: by exploiting the power contained in waves, the tides, and the ocean currents. The global theoretical potential for ocean energy resources is between 20000 and 90000 TWh annually which exceeds the current global electricity consumption of about 16000 TWh annually.[1] In light of this potential, the global ocean energy market is clearly underdeveloped, with ocean energy constituting a small proportion of current global energy supply. According to the International Renewable Energy Agency (IRENA), the total worldwide installed capacity of tide, wave, and ocean thermal energy was 532 megawatts at the end of April, 2019.[2] Technologies to exploit tidal range power are today the only ones to have reached commercialization stages in ocean energy sources although they also involve high investment costs and considerable environmental impacts.[3] As global commitments to renewable energy increases in the future coupled with the widespread concern over global climate change and other environmental impacts of the world's reliance on fossil fuels, more attention will have to be devoted to research and development of ocean energy as an alternative to traditional forms of energy.[4]

In this Chapter, we provide a brief background on the current state of technology and commercial development of wave, tidal and ocean thermal energy and consider their potential as forms of renewable energy (Section 2). Secondly, we examine the relevant international legal and policy framework governing ocean energy, highlighting particular issues that may require attention from policymakers (Section 3). We identify current challenges to the roll-out of ocean renewable energy within the regulatory framework and the opportunities that exist in spite of the regulatory challenges (Section 4). Lastly, we suggest policy and legal options available to countries to optimize the vast ocean energy resources (Section 5).

2. Overview of Renewable Energy Sources from the Ocean

Ocean renewable energies can be extracted with a large variety of technologies that exploit water or the power obtained from the kinetic energy of large bodies of moving water. There are characteristics of ocean renewable energy which make them more attractive as sustainable energy sources when compared with land-based sources of renewable energy. Most ocean renewable energy such as wave, tidal and ocean thermal energy are deployed offshore and therefore do not take up limited land space. Unlike most onshore wind farms, which have outpaced land use planning in many countries, particularly in Europe, and have resulted in public opposition to such renewable energy projects,[5] ocean renewable energy tend to be sited far offshore, often cannot be seen by the casual observer and do not take up limited land space.[6]

1 Dalton *et al* 2015.
2 IRENA, 2019.
3 Ernst and Young, 2013.
4 Pelc and Fujita, 2012.
5 Romana et al, 2017.
6 Hemer *et al* 2018.

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Ocean renewable energy also offers opportunities to satisfy niche markets, such as providing electricity to remote islands and other remote coastal communities,[7] and to serve the energy needs of offshore industries such as aquaculture.

Notwithstanding the above advantages of ocean renewable energy, such sources also pose some serious environmental and ecological challenges. Large-scale development of ocean renewable energy comes with uncertainty about potential impacts because most of the devices are yet to be fully deployed and tested.[8] Potential negative effects include adverse influence on flora and fauna of mammals and birds, their habitats and the entire ecosystem. The mere physical presence of new structures in marine ecosystems can result in fundamental changes to the habitat of mammals, and their behaviour.[9] Behavioural responses may include attraction or avoidance of habitats by marine mammals when they encounter wind, wave and tidal devices.[10] Marine mammals could suffer hearing problems such as changes to their hearing threshold and deeper disturbances could impact the key factors of survival arising from temporary or permanent abandonment of an area, eating disorders and reproductive disorders.[11] Also, Goss-Custard *et al*, suggest that the removal of sufficient tidal energy could alter tidal ranges, which in turn could then have an impact on communities that depend on periodic tidal exposure.[12] In addition, studies also show that the lighting devices that identify ocean renewable energy installations can cause endocrine disruption or behavioural phenomena related to light attraction or light repulsion among wild life or in the case of predatory species affect the food availability and prey distribution.[13]

2.1 Wave Energy

Wave energy relies on the wind flows over the ocean and takes advantage of the resulting ocean waves to generate electricity through wave energy conversion devices. Global estimates for wave energy potential are still relatively uncertain. It is estimated that wave energy has a theoretical potential of around 29,500 terawatt-hour per year (29,500 TWh/yr) and a technical potential of about 500GW (or around 146 TWh/yr) assuming that wave energy technologies would only be deployed in 2%of the world's 800,000km coastline.[14] There are several locations across the globe with great wave potential. These locations include the western seaboard of Europe, the northern coast of the United Kingdom, and the Pacific coastlines of North and South America, Southern Africa, Australia, and New Zealand, due to the long expanses of ocean with exposure to prevailing winds that deliver powerful waves to these coasts.[15] While wave energy holds promise, the technology to exploit the waves for energy remains largely experimental in nature.

7 Ibid.

8 Boehlert and Gill, 2010.

9 Ibid.

10 Ibid (n 28).

11 Ibid.

12 J.D. Goss-Custard *et al* "Towards Predicting Wading Bird Densities from Predicted Prey Densities in a Post-Barrage Severn Estuary" (1991) 28:3 Journal of Applied Ecology 1004.

13 Cloe Sotta *et al* ,supra note 21.

14 Kempener and Neumann, 2014.

15 Murray et al, 2011.

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2.2 Tidal Energy

Tidal energy is one of the most advanced forms of ocean energy technology.[16] It is produced from the movement of water in a current or the movement of water in the rise and fall of seawater. The energy is extracted from the tide or currents using in-stream tidal energy converters or tidal barrages or lagoons which make use of the potential energy in the difference in height between the rise and fall of the tides.[17] Globally, it is estimated that the technically harvestable tidal energy resource is about 1 terawatts (1TW).[18] Tidal energy research is continuing across the globe with the deployment of several demonstration projects.

The tidal industry sector, which existed much longer than the wave sector holds much promise. This is because tides are relatively predictable with daily, bi-weekly, biannual and even annual cycles over a longer time span of a number of years. With the potential for energy to be generated both day and night coupled with growing implementation and development in technology, tidal power will become a cost-effective source of energy.

2.3 Ocean Thermal Energy

Ocean Thermal Energy Conversion (OTEC) technologies use the temperature difference between warm seawater at the surface of the ocean and cold seawater in deeper waters to produce electricity. The production of energy from the difference between saltwater and fresh water is most convenient near the ocean. There are now technologies that use wastewater and naturally occurring electricity bacteria to produce electricity – and reverse electrodialysis (RED) – which produces electricity directly from the salinity gradient between salty and fresh water.[19] In November, 2014 the Dutch King Willem-Alexander, commissioned the world's first blue-energy RED power plant.[20] The plant produces electricity directly from the difference in salt concentration in the surface water. The pilot plant produces 50kW blue-energy per hour, enough to meet the energy needs of 500,000 households.[21]

Many countries around the globe have viable OTEC resources, particularly Island States in the Pacific and Caribbean Ocean.[22] Although OTEC may have the highest potential when compared to other ocean technologies, there is little experience in building large-scale OTEC plants beyond demonstration projects. The Makai Ocean Engineering's OTEC power plant is the world's biggest operational facility with an annual power generation capacity of 100KW which is sufficient to power 120 homes in Hawaii.[23] Smaller OTEC projects to provide cooling are being established and prototypes are also being explored in many parts of the world.

3. International Law and the Governance of Ocean Renewable Energy

Ocean renewable energy is not the subject of any specific international agreement. However, various international legal instruments have implications for how wave, tidal and ocean thermal

[16] Magagna and Uihlein, 2015.
[17] Kempener and Neumann, 2014(b).
[18] Ibid
[19] Dutch Water Sector, 2014
[20] Ibid.
[21] Ibid.
[22] Kempener and Neumann 2014(c).
[23] Makai, 2015.

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energy projects should be assessed and how project decisions should be made. This Part reviews the governance framework relating to the jurisdiction of states to exploit the ocean for energy and their environmental protection obligations.

3.1 Jurisdiction of States

The United Nations Convention on the Law of the Sea (UNCLOS) establishes the international legal order for the seas and oceans and provides a reasonably comprehensive governance framework.[24] UNCLOS sets out the overall governance framework for offshore renewable energy projects by establishing the rights and responsibilities of states.[25] UNCLOS recognizes the sovereign rights and jurisdiction of coastal states to their internal waters, territorial seas and exclusive economic zones. Several provisions of the convention underscore this point. Article 87(1)(d) provides that all states have the "freedom to construct artificial islands and other installations permitted under international law, subject to Part VI."[26] The relevant provision of Part VI is Article 80 which states that "Article 60 applies *mutatis mutandis* to artificial islands, installations and structures on the continental shelf."[27] Article 60 provides that in the "exclusive economic zone, the coastal State shall have exclusive right to construct and to authorize and regulate the construction, operation and use of...(b) installations and structures for the purposes provided for in article 56 and other economic purposes."[28] Coastal States are required to give due notice of the construction of offshore installations and structures and remove abandoned or disused structures to ensure safety of navigation.[29] Article 56 of UNCLOS specifically recognizes the sovereign right of coastal States in their exclusive economic zone to explore and exploit the zone for the "...production of energy from water, currents and winds."[30]

The UNCLOS also has environmental implications. It imposes an obligation on nation-states to adopt, implement and enforce national legislation to protect the world's marine environment.[31] The Convention requires States to subject proposed activities under their jurisdiction or control to environmental assessment if the planned activities may cause significant and harmful changes to the marine environment.[32] The threshold of "significant and harmful" is not defined under the Convention and its application to ocean renewable resources would likely depend on the type of technology and size of operation being proposed.

Similarly, legal issues may arise regarding installation of ocean renewable energy structures in certain areas of the high seas, because while all states are entitled to lay submarine cables on the bed of the high seas,[33] "[n]o State may validly purport to subject any part of the high seas to its sovereignty."[34] The prospects of exploiting renewables in the high seas a few decades ago would have been deemed to be extremely ambitious or less realistic, but developments in research puts that within reach and requires States to address the gaps within the law of sea framework. The United Nations General Assembly has already commenced negotiations for

24 UNCLOS.
25 McDonald and VanderZwaag, 2015.
26 UNCLOS, Article 87(1)(d).
27 Ibid, Article 80.
28 Ibid, Article 60(1).
29 Ibid, Article 60(3).
30 Ibid, Article 56(1)(a).
31 McConnell and Gold, 1991.
32 UNCLOS, Article 206.
33 UNCLOS, Article 112.
34 UNCLOS, Article 89.

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the development of an international legally binding instrument under the UNCLOS on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdictions.[35]

3.2 Environmental Protection

There are several international agreements that address the world's environmental challenges and need to be taken into consideration in the development of ocean renewable projects. Three these instruments relevant for ocean renewable energy development are discussed in this part.

The Paris Climate Agreement which aims to hold the "increase in the global average temperature to well below 2°C above pre-industrial levels" and to pursue efforts to "limit the increase to 1.5°C" is the most significant framework that can be used to spur the development of ocean renewable energy.[36] The historic importance of the Paris Agreement lies in its universality, rapid ratification and entry into force.[37] Although the Paris Agreement does not make a direct reference to renewable energy, the Adoption Decision in its preamble acknowledges the need to promote universal access to sustainable energy in developing countries, especially in Africa through the enhanced deployment of renewable energy.[38]

Furthermore, it is generally recognised that the transition from fossil fuels to renewable sources of energy is critical to the success of the Paris Climate Agreement.[39] The Agreement commits nations to stimulate investment and innovation in renewable energy (including offshore) as part of wider efforts to cut back on greenhouse gas emissions. The implementation of incentive schemes for the development of clean technologies within the broader framework of incentives for mitigation is key to countries' objectives of achieving their nationally determined contributions.[40] This is because countries' goal of holding the global average temperature increases to well below 2°C above pre-industrial levels will require significant increases in renewable energy generation generally, including its ocean renewable energy component. Ocean renewable energy, therefore, can become an important contributor to meeting countries' obligations under the Paris Agreement. The provisions of the Paris Agreement relating to capacity building,[41] the provision of financial resources for mitigation and adaptation efforts[42] and the importance of technology development and transfer to improve resilience to climate change and reduce greenhouse gas emissions[43] are all relevant to the ocean renewable energy context.

Another relevant international agreement is the Convention on Biological Diversity (CBD).[44] The CBD recognizes the intrinsic value of biological diversity and has the three core objectives of conserving biological diversity, promoting sustainable use of its components and ensuring the fair and equitable sharing of the benefits of genetic resources.[45] In general terms, renewable

[35] UNGA, 2017.
[36] Paris Agreement, Article 2(a).
[37] Moomaw *et al*, 2017.
[38] Paris Agreement, Preamble to the Adoption Decision.
[39] IEA, 2015.
[40] Segger, 2016.
[41] Paris Agreement, Article 11.
[42] Ibid, Article 9.
[43] Ibid, Article 10.
[44] CBD
[45] CBD, Article 1.

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energy projects and biodiversity policies should be largely complementary due to their lower environmental impact when compared with fossil energy projects. However, conflicts between biodiversity and renewable energy projects are inevitable given that they still have an impact on the local environment, particularly as countries push to meet their renewable energy and emission reduction targets by pursuing more and larger renewable energy projects.[46] As discussed in section 2 of this Chapter, Ocean renewable energy technologies have the potential to impact the biodiversity of the environments in which they are located. This is because half of the ocean energy's global potential is concentrated within the top biodiversity areas.[47]

The CBD requires Parties to subject proposed projects likely to have significant adverse effects on biological diversity to environmental impact assessment with a view to avoiding or minimizing such effects.[48] The CBD also encourages Parties to consider the biodiversity impacts of proposed programmes and policies through strategic environmental assessment [SEA].[49] Draft guidelines on environmental assessment and strategic environmental assessment have been developed,[50] which should be followed in the ocean renewable energy context. The guidelines emphasize the need to develop biodiversity criteria for impact evaluation and to have measurable standards or objectives against which the significance of individual impacts can be evaluated.[51] The guidelines highlight the importance of applying strategic environmental assessment, for example to national energy policy, in order to streamline the incorporation of environmental concerns into the decision-making process and to make project-level environmental impact assessment more effective.[52] In 2012 the CBD Guidelines were updated to include among other things, the application of the precautionary principle in decision-making in cases of scientific uncertainty.[53]

The CBD framework envisions the development of ocean renewable energy that takes into account environmental impact assessments, and the exchange of information provided through wider spatial planning processes. These processes would require many countries to update their legal frameworks, policies and practices to promote the mainstreaming of biological diversity in renewable energy developments.

Additionally, the Convention on the Conservation of Migratory Species (CMS) imposes an obligation on Parties "to prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities, or obstacles that seriously impede or prevent the migration of species".[54] A couple of COP resolutions under the CMS are relevant to ocean renewable energy. Resolution 9.19 on *Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota* entreats parties to control the impact of noise emissions in habitats of vulnerable species and in areas where marine mammals or other endangered species may be concentrated.[55]. Furthermore, the resolution advises that parties should consult with marine renewable energy companies and scientific researchers and recommend best practices for noise pollution avoidance or mitigation. Also, Resolution 11.27 on *Renewable Energy and Migratory Species*, urges Parties exploiting ocean renewable energy to "give attention to possible impacts

46 Jackson, 2011.
47 Santangelli *et al* 2016.
48 CBD, Article 14(1)(a).
49 CBD, Article 14(1)(b).
50 CBD Decision VI/7, 2002.
51 Ibid at para 24.
52 Ibid at para 1(b).
53 UNEP/CBD/COP Decision, 2012.
54 CMS, Article III 4(b).
55 UNEP/CMS Resolution 9.19, 2008.

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on migratory species of increased noise and electromagnetic field disturbance especially during construction work in coastal habitats, and injury."[56]

4. Legal Barriers to Ocean Renewable Energy Development

There are important drivers for ocean renewable energy that make it an attractive alternative to traditional fossil fuel sources. To facilitate commercialization of ocean renewable energy resources, it is important that the international legal framework addresses several key barriers facing the development of ocean energy related to jurisdictional, regulatory and environmental issues.[57] First, ocean renewable energy development is largely private sector driven but the oceans are public spaces which are governed by international agreements and domestic laws. Thus the demand for private or quasi-private rights by developers of ocean renewable energy technologies is challenging the way we conceptualize ocean governance.[58] Ocean renewable energy developers tend to expect exclusive access to marine resources and space which implies an exclusion of other users of ocean resources and this effectively privatizes a common good and gives rise to conflicting uses of the high seas such as commercial navigation, military uses, fishing, and the laying of submarine cables and pipelines.[59] These freedoms which are recognized by the general principles of international law are to be exercised by all states with reasonable regard to the interests of other states in their use of the high seas. Nonetheless, several questions including the relationship between rights granted for ocean energy and other forms of rights in the marine environment remain.[60]

In the international arena there does not yet exist any global legal mechanism or instrument that would specifically regulate ocean renewable energy installations. However, it would be possible to adapt existing international conventions and limited regional treaties to various aspects of ocean renewable regulation. As seen in the previous section, several international instruments could be used to regulate the operations of ocean renewable energy. Also, many international institutions may exercise jurisdiction over ocean energy. However, the existing international standards and regulations on safety, design and construction, collision, navigation, and communication, do not explicitly apply to ocean renewable energy devices. Most of these regulations need to be modified in order to meet ocean renewable energy needs. Otherwise, new arrangements will have to be devised. The primary purpose of providing a regulatory framework is to reduce uncertainty and risks attendant in pursuing ocean renewable energy activities. This is an important consideration not only for prospective investors, but also for eventual commercialization of ocean renewable projects. In the national context, countries would have to adopt domestic legislations to fill the gaps. However, in many jurisdictions with potential ocean renewable energy resources, there are no dedicated laws governing the resource. States still largely depends on the utilization of pre-existing laws that in some cases, are not suitable for the unique character of the ocean renewable energy industry.

There is also considerable international concern over the preservation of the environment. As a result, ocean renewable energy development may be subject to a number of international conventions. Large-scale development of ocean renewable energy comes with uncertainty about potential impacts because most of the devices are yet to be fully deployed and tested, but like any other large scale development in the oceans, they are not without adverse

56UNEP/CMS Resolution 11.27, 2014. "e COP, November, 2014.
57Wright *et al,* 2015.
58 Ibid.
59 Ibid.
60 Ibid.

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environmental impacts.[61] Thus, environmental impact assessment (EIA) needs to be done before a project is approved and/or before an area is opened up for development. For projects within the exclusive economic zone and the continental shelf, there are some rules to ensure that activities within such jurisdictions do not cause damage to the environment or harm to biodiversity. However, in areas beyond national jurisdictions, there are currently no international rules requiring environmental impact assessment to ensure that renewable energy activities conducted in these areas are not destructive. This creates uncertainty as to the regulatory framework to apply to projects within such areas. Luckily, the Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO Convention) and its Protocol on Strategic Environmental Assessment[62]which entered into force as a regional instrument sets out procedures for cooperation to prevent, manage and mitigate environmental impacts. The Convention requires environmental impact assessment as a national instrument to be undertaken for proposed activities that are likely to have a significant impact on the environment including installations for energy production. States are also to provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with these States at an early stage and in good faith.[63]

The ESPOO Convention and its Protocol on Strategic Environmental Assessment aim to promote environmental governance and the integration of environmental and health considerations into ocean renewable development. However, the two treaties do not have universal applicability. As at December, 2019 the Espoo Convention had been ratified by only 44 states and the European Union.[64]

5. Conclusions

There is no doubt that ocean renewable energy sources hold the potential to contribute to the options of low-carbon energy sources and enhance the efforts by the global community to slow down climate change. The international regulatory framework for the installation and development of ocean renewable energy projects is largely inadequate. The absence of a global legal instrument that specifically regulates ocean renewable energy projects in the high seas and the lack of a global instrument requiring EIA and SEA before the development of ocean renewable energy is not good news to the environment. To address these challenges, policy makers will have to device different processes to support ocean renewable energy. The environmental impact of ocean renewable installations must be considered both within the international context and under domestic law. At the international level, policy makers need to realistically consider rules on environmental impact assessment within the oceans particularly in areas beyond national borders as well as issues related to responsibility for environmental harm and damage. This will then be complemented by national regulations that are aimed at identifying the environmental impacts associated with ocean renewable energy so as to reduce the risks around environmental uncertainties posed by such devices.[65] A well designed and implemented strategic environmental assessment programme which encourages integrated decision making that considers environmental, social, and economic factors such as the various environmental impacts and benefits, energy security, economic development opportunities and

61 Boehlert and Gill, 2010.
62 Espoo Convention
63 Ibid, Article 3 and 5.
64 UNECE, 2020
65 Doelle, 2015.

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the interaction with other ocean users will lay the foundation for good decision making at the project level.[66]

Additionally, scientific knowledge regarding the true impact of offshore devices on the environment, is not yet fully known or understood. As such, the evolving international and domestic legal and regulatory framework needs to be flexible enough to accommodate new innovations.[67] Incremental steps in the development of the industry in combination with research connected to approved projects may help regulators and project proponents to better understand the impacts of ocean renewable installations and devices on the environment.[68]

66 Ibid.
67Higgins, 2009.
68 Doelle, 2009.

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