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Oceans and the law of the sea

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Report of the Secretary-General

Summary

The present report has been prepared pursuant to paragraph 249 of General Assembly resolution 66/231, with a view to facilitating discussions on the topic of focus of the thirteenth meeting of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea, namely marine renewable energies. It constitutes the first part of the report of the Secretary-General to the Assembly at its sixty-seventh session on developments and issues relating to ocean affairs and the law of the sea. It is also being submitted to States parties to the United Nations Convention on the Law of the Sea pursuant to article 319 of the Convention.

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Contents

I. Introduction

1. In paragraph 234 of its resolution 66/231, the General Assembly recalled its decision in resolution 65/37 that, in its deliberations on the report of the Secretary-General on oceans and the law of the sea, the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea ("the Informal Consultative Process") would focus its discussions at its thirteenth meeting on marine renewable energies. The present report addresses that topic.

2. The heavy dependence on fossil fuel, with rising costs and the associated environmental concerns, is making alternative sources of energy a vital component of future development. According to the International Energy Agency, energy demand will increase by 40 per cent over the next 20 years, with the most notable rise occurring in developing countries.[1] Global interest in new and renewable energy technologies has been growing rapidly.

3. The 2002 World Summit on Sustainable Development adopted the Johannesburg Plan of Implementation,[2] which calls for substantially increasing, with a sense of urgency, the global share of energy obtained from renewable sources. New and renewable sources of energy thus constitute an integral element of the global vision for sustainable development and the achievement of the Millennium Development Goals.

4. The oceans, covering more than 70 per cent of the Earth's surface, are attracting increased attention as a vast source of potential renewable energy. Oceans have a capacity for trapping heat as thermal energy, producing offshore powerful winds, currents and waves. The thermal and kinetic energy stored in the oceans represents a considerable opportunity for producing energy, particularly in near-shore areas. In recent years, a number of technologies have been developed and extensive industrial and academic research has been carried out to determine the technical and economic viability of these technologies.[3]

5. However, ocean energy technologies face considerable challenges in their development. Although their cost is expected to become lower than coal in the next decade,[4] their current development requires considerable government incentives. Moreover, the use of ocean energy today faces an uncertain state of regulation under domestic legal systems, including issues related to managing hazards to navigation, providing further financial incentives for wide-scale commercialization of this technology (such as increased research and development funding and feed-in tariffs) and managing its relatively benign environmental impacts.[5]

6. Section II of this report provides information on the various marine sources of renewable energies, while section III recalls the policy framework and legal aspects of the activities relating to marine renewable energies. Sections IV and V, respectively, attempt to identify developments at the global and regional levels, as well as the

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[1] See Secretary-General's message to the Bloomberg New Energy Finance Summit, London, 19 March 2010 (www.un.org/sg/statements/?nid=4447).

[2] See *Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August-4 September 2002* (United Nations publication, Sales No. E.03.II.A.1 and corrigendum), chap. I, resolution 2, annex.

[3] Contribution of the International Seabed Authority.

[4] M. Esteban and D. Leary, "Current developments and future prospects of offshore wind and ocean energy", *Journal of Applied Energy*, vol. 90 (2011), p. 128.

[5] Contribution of the Institute of Advanced Studies of the United Nations University.

related opportunities and challenges within the context of sustainable development. In light of the fact that marine renewable energies are still a nascent but growing field of endeavour in many countries, it was not possible to be exhaustive in the presentation of the information on their development and deployment status, or on the national and regional regulatory frameworks related thereto.

7. The Secretary-General wishes to express his appreciation to the organizations and bodies that contributed to the present report, namely, the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO); the United Nations Environment Programme (UNEP); the International Seabed Authority; the International Hydrographic Organization (IHO); the Organization of American States (OAS); the Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Commission); the secretariats of the United Nations Framework Convention on Climate Change, the General Fisheries Commission for the Mediterranean, the Black Sea Commission, the Convention on the Conservation of Migratory Species of Wild Animals and the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas; and the Institute of Advanced Studies of the United Nations University.[6] The report also contains information drawn from academic sources.

II. Background

A. Sources of marine renewable energy

8. Renewable energy is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy technologies are diverse and can serve the full range of energy service needs. Unlike fossil fuels, most forms of renewable energy produce few or no carbon dioxide emissions.[7]

9. Marine renewable energy is a subset of renewable energy involving natural processes in the marine environment. There are four types of marine renewable energy: ocean energy; wind energy from turbines located in offshore areas; geothermal energy derived from submarine geothermal resources; and bioenergy derived from marine biomass, particularly ocean-derived algae.[8]

10. Ocean energy is derived from the potential, kinetic, thermal and chemical energy of seawater,[9] which can be transformed to provide, inter alia, electricity, or thermal energy, as well as potable water.[10] The renewable energy resource in the ocean comes from six distinct sources, each with different origins and requiring different technologies for conversion: waves; tidal range; tidal current (also known as tidal stream); ocean currents; ocean thermal energy conversion; and salinity gradients.[11]

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[6] The contributions whose authors have authorized them to be posted online are available at www.un.org/Depts/los/general_assembly/general_assembly_reports.htm.

[7] IPCC, *Special Report on Renewable Energy Sources and Climate Change Mitigation* (2011), p. 164.

[8] Ibid., p. 962.

[9] The kinetic energy of an object is the energy which it possesses due to its motion (definition found at http://en.wikipedia.org/wiki/Kinetic_energy).

[10] IPCC (note 7 above), p. 8, box SPM.1.

[11] Ibid., p. 503.

11. Ocean waves are generated by the transfer of energy from wind blowing over water. Tidal range refers to the cyclical rise and fall of tides, and tidal currents are created by the horizontal movement of water resulting from the rise and fall of the tide. Ocean currents occur in the open ocean and are driven by winds and, on a global level, by the rotation of the Earth and the related natural physical forces acting on bodies of water.[12] Ocean thermal energy conversion is driven by the temperature differences which occur between the upper layers of seawater, in which about 15 per cent of total solar input is retained as thermal energy, and colder, deeper waters existing side by side. A salinity gradient is present where the mixing of freshwater and seawater occurs, for example at river mouths; this mixing releases energy as heat.[13] Wind energy is energy which is harnessed from the kinetic energy of moving air, bioenergy is energy produced from biomass through a variety of processes and geothermal energy is energy harnessed from the thermal energy of the Earth's interior.

B. Technology overview

12. There are currently a wide range of technology options to harness ocean energy. The level of development of such technologies ranges from conceptual, through research and development, to the prototype stage. Tidal range technology is the only ocean energy technology which can be considered mature.[14]

13. There is also a wide array of technologies for both capturing and converting wave energy into electricity. The devices can be classified by the way they interact with different wave motions, namely heaving, surging and pitching; the depth of water in which they are placed, from shallow to deep; and the distance from shore at which the device operates, from shoreline to offshore.[15]

14. Tidal range technology consists of a barrage built across an estuary or mouth of a bay where this is a large tidal range. The barrage dams water when the tide changes and, in a controlled fashion, allows water to flow through turbines in the barrage producing electricity.[16] A 240-megawatt (MW) plant has been operational in La Rance, France, since 1966, only being surpassed recently by the Sihwa Lake Tidal Power Station in the Republic of Korea, at 254 MW. Another much larger plant of 812 MW at Incheon, Republic of Korea, is due for completion in 2015.

15. Tidal and ocean current technologies place devices within the current directly and do not work by the damming of water. There are a number of different principles of operation for such devices and hence there are more than 50 tidal current devices which are in proof-of-concept or prototype stages. There are no pilots or demonstration plants to harness ocean currents as technologies which can capture slower velocity currents are not yet available.[17]

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[12] Ibid., p. 506.
[13] Ibid., p. 507.
[14] Ibid., chap. 6.3.1.
[15] Ibid., chaps. 6.3 and 6.4; International Energy Agency (IEA) Implementing Agreement on Ocean Energy Systems, "Ocean energy: global technology development status" (2009) (at www.ocean-energy-systems.org), sect. 2.
[16] IPCC (note 7 above), chaps. 6.3 and 6.4.
[17] Ibid.

16. Ocean thermal energy conversion is a marine renewable energy technology that harnesses the solar energy absorbed by the oceans and is therefore expected to be potentially significant in equatorial and tropical regions. Trials of small-scale ocean thermal energy conversion systems, however, continue to experience engineering challenges related to pumping, vacuum retention and piping. Salinity gradient energy is harnessed either through the reversed electro-dialysis process which works on the difference in chemical potential between fresh and salt water, or the osmotic power process which is driven by the natural mixing tendency of fresh and salt water. The first prototype osmotic power device became operational in 2009 in Norway.[18]

17. Offshore wind energy, while less mature than onshore technologies, is still developing and has opportunities for continued advancements. Offshore turbines are usually larger than onshore installations but are otherwise functionally similar in design. With increasing technology and experience, offshore turbines are being employed in deeper and more distant waters, allowing more exposed locations with stronger winds to be utilized.[19]

C. Status of deployment and potential

18. Marine renewable energy is still at an early stage of development (see also sect. II.C below).[20] In 2008 it represented less than 1 per cent of all renewable energy production. However, the Intergovernmental Panel on Climate Change (IPCC) has highlighted that the potential of technically exploitable marine renewable energies, excluding offshore wind energy, was estimated at 7,400 exajoules (EJ) per annum, well exceeding current and future human energy needs.[21] The first offshore wind power plant was installed in 1991, consisting of 11 450-kW turbines and, as at the end of 2009, 1.3 per cent of installed global wind power capacity, totalling 2,100 MW, was offshore. Estimates for near-shore offshore wind energy generation ranges from 15 to 130 EJ per annum with a greater potential expected from deeper waters.[22] To contextualize these numbers, it should be noted that in 2008, there was a total world energy supply of 492 EJ.[23] The chart below shows, for 2008, the sources of global energy.[24]

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[18] Ibid., p. 90.

[19] Ibid., chap. 7.3.

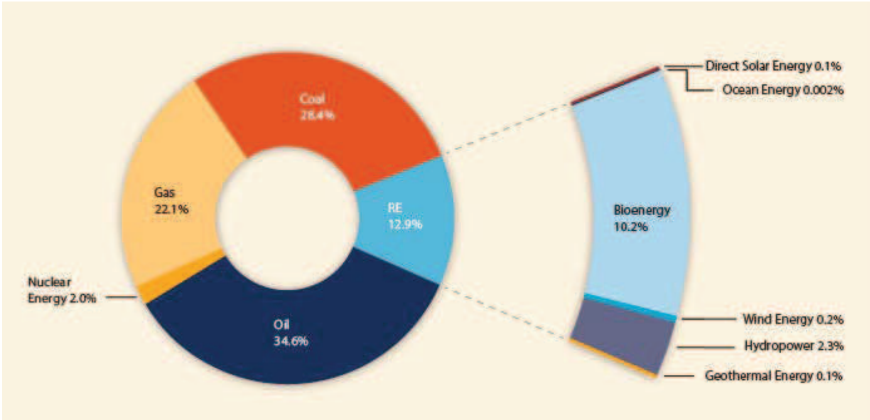
[20] UNEP, *Global Trends in Renewable Energy Investment 2011*, p. 42.

[21] IPCC (note 7 above), p. 501. One EJ equals 10^{18} joules. It is a large-scale unit of energy used in describing national or global energy budgets. A terawatt-year is the energy transferred or expended in one year by one terawatt (1 terawatt=10^{12} watts) of power. One terawatt-year equals 31.54 EJ.

[22] Ibid., p. 539.

[23] Ibid., p. 9.

[24] Ibid., p. 174, figure 1.10. The largest renewable energy contributor was biomass (10.2 per cent), with the majority (roughly 60 per cent) being traditional biomass used in cooking and heating applications in developing countries but with rapidly increasing use of modern biomass (38 per cent) as well. In addition to this 60 per cent share of traditional biomass, there is biomass use estimated to amount to 20 to 40 per cent not reported in official primary energy databases, such as dung, unaccounted production of charcoal, illegal logging, fuelwood gathering and agricultural residue use.



19. Small island developing States, with large coastal populations, little infrastructure in the coastal zones and few alternative energy resources, are well situated for growth of ocean thermal energy conversion.[25] As long as the temperature between the warm surface water and the cold deep water differs by about 20°C (36°F), an ocean thermal energy conversion system can produce a significant amount of power with little impact on the surrounding environment. The oceans are thus a vast renewable resource with the potential to help small island developing States, characterized by limited land and land-based natural resources, produce billions of watts of electric power. This potential is estimated to be about 10^{13} watts of base load power generation, according to some experts. The distinctive feature of ocean thermal energy conversion systems is that the end products include not only energy in the form of electricity, but also several other synergistic products.[26] The Ocean Thermal Energy Corporation is currently designing the world's first two commercial ocean thermal energy conversion plants in the Bahamas, enhancing the development of marine renewable technology in the Western Caribbean region.[27]

20. For ocean energy, the installed capacity is unlikely to become significant until after 2020.[28] Canada's Marine Renewable Energy Technology Roadmap, launched in December 2010, envisages a rapid deployment of marine renewable technologies to reach the installed-capacity goals of 75 MW by 2016, 250 MW by 2020 and 2,000 MW by 2030.[29] However, tidal and wave energies have been noted to be nearing commercial reality.[30]

21. In Europe, the ocean energy resources that are expected to make the most significant contributions to the energy system are wave, offshore wind, tidal current

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[25] Contribution of IOC. See also IPCC (note 7 above), p. 92.

[26] Al Binger, "Potential and future prospects for ocean thermal energy conversion in small island developing States", at http://ict.sopac.org/compendium-documents/CLR_201100149_20040428105917_OTEC_UN.pdf.

[27] See www.otecorporation.com.

[28] IPCC (note 7 above).

[29] See www.oreg.ca/web_documents/mre_roadmap_e.pdf.

[30] Adnan Z. Amin, "Realising the promise of renewable energy", *ClimateAction 2011-2012* (available from www.irena.org).

and tidal range. Osmotic systems are being developed in Norway and the Netherlands,[31] while ocean thermal resources are under study in several European countries.[32]

22. Marine renewable energy technology has recently moved beyond the pilot project stage in Europe.[33] Prominent among the leaders in the development and commercialization of this technology are Belgium,[34] Denmark,[35] Finland, France, Ireland,[36] Italy, Norway, Portugal,[37] Spain[38] and the United Kingdom of Great Britain and Northern Ireland. The latter currently has 3.4 MW of installed capacity and more project leases awarded than the rest of the world combined. Recent estimates indicate that 27 Gigawatts (GW) of ocean energy could be reached in the United Kingdom by 2050.[39] Germany completed its first offshore wind park in 2009 and simultaneously launched a research programme.[40]

23. Wind energy capacity has been developed to a commercial scale and has been installed in offshore locations, primarily in Europe,[41] with a total worldwide capacity of 2,100 MW installed by the end of 2009.[42] Wave and tidal current (or tidal stream) energy units, which are mainly in the demonstration phase, some with limited deployment, have been reported at 2 and 4 MW respectively, as at the end of 2010 by several States.[43] No technologies are currently in use for submarine geothermal energy generation.[44] Although research has started on the extraction of biofuels from algae,[45] its potential role as a source of bioenergy is highly uncertain.[46]

III. Policy framework and legal aspects

24. Renewable energy has featured prominently in sustainable development discussions, with an array of commitments made and initiatives developed since the United Nations Conference on Environment and Development held in Rio de Janeiro,

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31 See www.wetsus.nl.

32 For examples of ongoing projects in Martinique, Réunion Island and Tahiti, see http://en.dcnsgroup.com/energy/marine-renewable-energy/ocean-thermal-energy/.

33 Contribution of the European Union.

34 See www.mumm.ac.be/EN/Management/Sea-based/windmills_table.php.

35 See Danish Energy Agency, "Future Offshore Wind Farms — 2025" (2007, updated 2011), at www.ens.dk/en-US/supply/Renewable-energy/WindPower/offshore-Wind-Power/Future-offshore-wind-parks/Sider/Forside.aspx.

36 See the Irish national renewable energy action plan at www.dcenr.gov.ie/NR/rdonlyres/03DBA6CF-AD04-4ED3-B443-B9F63DF7FC07/0/IrelandNREAPv11Oct2010.pdf. Further information is available at www.dcenr.gov.ie/Energy/Sustainable+and+Renewable+Energy+Division/.

37 See http://en.wavec.org/index.php/34/cao-central-pico/ and www.seaforlife.com/EN/FrameIndex.html.

38 The Spanish renewable energy plan for 2010-2020 devotes section 4.4 to the marine energy sector.

39 See RenewableUK, "Seapower: funding the marine energy industry 2011-2015" (2011), at www.wea.com. The United Kingdom Renewable Energy Roadmap identifies offshore wind and marine energy among the technologies that have the potential to lead the United Kingdom to meet its 2020 target for renewable energy (see www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx).

40 See http://rave.iwes.fraunhofer.de/rave/pages/welcome.

41 IPCC (note 7 above), p. 13.

42 IPCC (note 7 above).

43 See A/66/70/Add.2, para. 250.

44 IPCC (note 7 above), chap. 4.6.4.

45 See A/64/66/Add.1, para. 159, and A/66/70/Add.2, para. 166.

46 IPCC (note 7 above), chap. 2.8.5.

Brazil, in June 1992. For example, Agenda 21 recognized that energy was essential to economic and social development and improved quality of life, but that much of the world's energy was produced and consumed in ways that could not be sustained. It therefore called for a number of steps and actions to develop environmentally sound energy systems, particularly new and renewable sources of energy.[47] The 2002 Johannesburg Plan of Implementation, adopted at the World Summit on Sustainable Development, also addresses renewable energy with commitments to increase substantially its global share in total energy supply.[48]

25. In 2011, the Secretary-General launched a new initiative entitled "Sustainable Energy for All" to mobilize urgent global action on three linked initiatives, including doubling the share of renewable energy in the global energy mix by 2030. This initiative aims at contributing to the International Year of Sustainable Energy for All in 2012 (see General Assembly resolution 65/151) by mobilizing action from all key stakeholders.

26. To date, none of these commitments has, however, specifically addressed marine renewable energy.

27. The legal framework for marine renewable energy is anchored in the United Nations Convention on the Law of the Sea, which is complemented by an array of relevant instruments and measures at the global, regional and national levels.

A. International law

28. The international legal framework for marine renewable energy primarily relates to the rights and obligations of States in the various maritime zones and in relation to the resources found therein; the establishment and use of installations and structures in the maritime zones for the exploitation of the energy; the transport of the energy produced; and the protection and preservation of the marine environment from the known or likely impacts of activities aimed at the development, deployment, exploitation and transmission of such energies. In this regard, the development of marine renewable energy requires a careful balance between the interests of various users of ocean space and resources and the rights and obligations of States under a number of instruments.

1. United Nations Convention on the Law of the Sea

29. The 1982 United Nations Convention on the Law of the Sea (United Nations, *Treaty Series*, vol. 1833, No. 31363) provides the legal framework within which all activities in the oceans and seas must be carried out. As such, its provisions and the jurisdictional framework that it establishes also apply to the development and exploitation of marine renewable energy.

30. In their internal waters, coastal States enjoy full sovereignty and are free to regulate the placing of marine renewable energy facilities, subject to the right of innocent passage and the obligation to protect and preserve the marine environment

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[47] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992*, vol. I, *Resolution Adopted by the Conference* (United Nations publication, Sales No. E.93.I.8 and corrigendum), resolution 1, annex II, paras. 4.18, 9.9-9.12 and 9.18.

[48] See Johannesburg Plan of Implementation (note 3 above), paras. 7 (e), 9 (a) and (c), 20, 59 (b) and 62 (j).

(see below). This also applies where the establishment of a straight baseline has the effect of enclosing as internal waters areas which had not previously been considered as such (articles 2 and 8). Similarly, the sovereignty of the coastal State over its territorial sea carries with it the sovereign right to exploit that zone for the production of renewable energy from marine sources, subject to the right of innocent passage (article 17). The coastal State may adopt laws and regulations related to innocent passage, including in respect of the safety of navigation, the protection of cables and pipelines and the protection of the marine environment, for example through the designation of sea lanes and traffic separation schemes around renewable energy facilities (articles 21-22).

31. The Convention specifically recognizes the sovereign rights of the coastal State in the exclusive economic zone with regard to activities for the economic exploration and exploitation of the zone, such as the production of energy from the water, currents and winds (article 56). The reference to energy in article 56 is not exhaustive and can reasonably be understood as encompassing any type of energy produced from the marine environment. The rights of the coastal State in the exclusive economic zone must be exercised with due regard to the rights and duties of other States under the Convention, including navigation (article 56). Of relevance to the facilities for the exploitation and transportation of renewable energy from the marine environment, the Convention also includes provisions on the establishment and use of artificial islands, installations and structures in the exclusive economic zone and on the continental shelf, including the establishment of safety zones around them (articles 56, 60 and 80), and the laying of submarine cables and pipelines on the continental shelf (article 79).

32. The laying of submarine cables and pipelines and the construction of other installations permitted under international law also fall under the freedom of the high seas, subject to Part VI on the continental shelf (articles 87 and 112).

33. The general obligation of States to protect and preserve the marine environment under the Convention (article 192) is also to be borne in mind as marine renewable energy projects may impact the marine environment (see Part V). This includes the obligation to take measures to prevent, reduce and control pollution of the marine environment from any source (article 194) and from the use of technologies under States' jurisdiction or control (article 196). States are also required to monitor the risks or effects of pollution (article 204) and assess potential effects of activities under their jurisdiction or control which may cause substantial pollution of, or significant and harmful changes to, the marine environment (article 206). Parts XIII and XIV of the Convention, which address marine scientific research and the development and transfer of marine technology, respectively, are also relevant to the development and exploitation of marine renewable energy. Similarly, the Agreement relating to the Implementation of Part XI of the Convention may also apply to marine renewable energy projects that may be pertinent for the exploration and exploitation of marine mineral resources and the protection of the marine environment in the Area.

2. Other instruments

34. A number of global sectoral instruments, while not directly or specifically addressing marine renewable energy, are also applicable to the development and exploitation of such energy.

35. Global rules and regulations governing safety of navigation are developed primarily by the International Maritime Organization (IMO). In particular, as regards installations, these include the International Convention for the Safety of Life at Sea, 1974; IMO resolution A.572(14) of 20 November 1985 on general provisions on ships' routeing, as amended; IMO resolution A.671(16) of 19 October 1989 on safety zones and safety of navigation around offshore installations and structures; and IMO resolution A.672(16) of 19 October 1989 on guidelines and standards for the removal of offshore installations and structures on the continental shelf and in the exclusive economic zone.

36. In light of the extension of offshore wind farms above the surface of the water into the superjacent airspace, the provisions of the 1944 Convention on International Civil Aviation (*Treaty Series*, vol. 15, No. 102) and the rules developed by the International Civil Aviation Organization (ICAO) are relevant insofar as they allow civilian aircraft to fly over the land and water territory of a coastal State, subject to compliance with safety and air navigation regulations promulgated by ICAO and domestic regulatory authorities.

37. With regard to the transmission and transport of the renewable energy produced, the 1884 International Convention for the Protection of Submarine Cables, as amended by the Declaration on the Protection of Submarine Cables of 1 December 1886 and the Protocol on the Protection of Submarine Cables of 7 July 1887, is also relevant.

38. In relation to the environmental impacts of activities related to marine renewable energy, the provisions on environmental impact assessments in article 14 of the Convention on Biological Diversity (*Treaty Series*, vol. 1760, No. 30619), which apply to processes and activities, regardless of where their effects occur, carried out under its parties' jurisdiction or control, are to be borne in mind. A number of the regional seas conventions or their protocols contain provisions relevant to offshore installations and pipelines and/or to the conduct of environmental impact assessments.[49]

39. The United Nations Framework Convention on Climate Change (*Treaty Series*, vol. 1771, No. 30822), insofar as it directs its parties to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system, also provides context for the development of marine renewable energy. Under the Clean Development Mechanism (CDM) established pursuant to article 12 of the Kyoto Protocol to the Convention (*Treaty Series*, vol. 2303, No. 30822), parties listed in annex 1 to the Protocol can implement emission reduction projects to benefit parties not included in annex 1, thereby earning certified emission reduction credits, with each credit being equivalent to one ton of carbon dioxide. In that regard, marine renewable energy projects have the potential to be developed as Clean Development Mechanism activities.

[49] See, for example, the 1974 Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention); the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic; and the 1995 Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention).

B. National enabling frameworks

40. It is advisable for Governments to adopt renewable energy policies as drivers of the growth in renewable energy use. The number of countries with such policies or legislation has more than doubled from an estimated 55 in early 2005 to 119 by early 2011.[50] At the domestic level, the regulatory experience worldwide has been a matter of "learning from doing".[51] Regulatory and policy measures include legislation or regulations that govern the consent or approval process (including any special processes for demonstration projects); procedure for obtaining a lease or rights to use space for the project; review of project impacts, including environmental, navigation, fishing and recreational use; and grid access. In many States there appears to be no single identifiable licensing agency, and projects have to be undertaken in the context of a patchwork of sectoral laws and regulatory processes. Governments are increasingly putting in place incentives for new renewable energy developments such as feed-in tariffs, grants, subsidies and tax credits.[52]

41. The following non-exhaustive examples aim to provide information on certain aspects of policies, legislation and measures currently in place or in elaboration in some regions.[53]

42. In Africa, the example of South Africa reveals that while there is no specific national policy for ocean energy, feed-in tariffs for ocean energy are used in the context of the regulatory guidelines of 2009 relating to the renewable energy feed-in tariff under the 2004 National Energy Regulator Act.[54]

43. In Asia and the Pacific, several States have introduced incentives and support measures for renewable energy, including, in most cases, wind and ocean energy. Australia's Victorian Renewable Energy Target Scheme is a market-based measure to increase the share of electricity consumption in Victoria from renewable energy sources to 10 per cent by 2016. New Zealand's national energy strategy released in 2011 aims to increase the proportion of electricity generated from renewable sources to 90 per cent by 2025. In 2004, legislative amendments were introduced to streamline the consent processes for renewable energy projects.[55] New Zealand has also launched a national policy statement on renewable electricity generation.[56] The Philippines Executive Order 462 on new and renewable energy (1997, modified 2000) aims to, inter alia, accelerate the exploration, development, utilization and commercialization of ocean, solar and wind energy. Following a 2009 amendment to the Renewable Energy Law (2005), which covers all the main sources of renewable

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[50] Renewable Energy Policy Network for the 21st Century, *Renewables 2011 Global Status Report* (July 2011).

[51] International Energy Agency, *Offshore Wind Experiences* (2005).

[52] UNEP et al., *Green Economy in a Blue World* (2012), available from www.unep.org. See also Intergovernmental Panel on Climate Change, *Special Report on Renewable Energy and Climate Change Mitigation* (2011).

[53] Further examples are available from the IEA/IRENA Global Renewable Energy Policies and Measures Database at www.iea.org.

[54] See Ocean Energy Systems, "Ocean energy in the world — South Africa" at www.ocean-energy-systems.org/country-info/south_africa/. See also National Energy Regulator of South Africa Consultation Paper, "Review of renewable energy feed-in tariffs" (2011).

[55] Resource Management (Energy and Climate Change) Amendment Act (2004).

[56] See *New Zealand Energy Strategy to 2050: Powering our Future* (2007).

energy, China drew up an ocean energy development plan and incentive policies for marine energy.[57] The Republic of Korea has put in place differentiated feed-in tariffs for wind energy and tidal/ocean energy.[58]

44. Within the European Union, directive 2009/28/EC on the promotion of the use of energy from renewable sources establishes the basis for the achievement of the 20 per cent renewable energy target by 2020. Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment is also applicable to renewable sources of energy and requires strategic environmental assessments in the early stages in the decision-making process.[59]

45. A number of European Union members have also extended feed-in tariffs to renewable energy generated from wave and tidal energy. More specifically, in Denmark, the Danish Energy Agency is the authority responsible for coordinating the authorization process among relevant agencies and granting coordinated permits for offshore energy. Environmental monitoring programmes are in place to ensure that substantial adverse impacts can be avoided or diminished.[60]

46. In Germany, the latest amendment to the Renewable Energy Sources Act, which entered into force on 1 January 2012, establishes a system of spatial planning, including the designation of priority areas where uses which are not compatible with the designated priority are disallowed or denied authorization, thereby ring-fencing potential locations for offshore wind farms.[61] Similarly, in 2008, a maritime pilot zone was created off the Portuguese coast for wave energy extraction to support the deployment of offshore wave energy prototypes and farms. This zone is meant to guarantee simplified and fast licensing and permitting through a managing body that will also identify and promote the establishment of offshore corridors and the construction and maintenance of surrounding (including land-based) sector infrastructure.[62]

47. The 2004 Energy Act and the 2009 Marine and Coastal Access Act of the United Kingdom established a renewable energy zone extending up to 200 nautical miles from the baselines from which the breadth of the territorial sea is measured. The 2009 Act also establishes a marine planning system and a marine management organization to act as the main planning and management body.[63] A marine energy programme was also set up in 2011 with a view to developing and deploying wave and tidal devices at a commercial scale.

48. Elsewhere in Europe, the 2010 Norway Offshore Energy Act financially supports research and prototypes projects. It also provides for project licensing

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[57] Ocean Energy Systems, *Annual Report 2011*, annex I. Ocean Energy Systems is an intergovernmental collaboration between countries, which operates under a framework established by the International Energy Agency.

[58] Feed-in Tariff for Renewables (Electricity Business Law), 2001 (Adjusted 2009). See also International Energy Agency, *Energies Policies of IEA Countries: The Republic of South Korea 2006 Review*. A feed-in tariff is a policy mechanism designed to accelerate investment in renewable energy technologies.

[59] Contribution of the European Union.

[60] Ibid.

[61] Ocean Energy Systems, *Annual Report 2010*.

[62] Decree Law No. 5/2008.

[63] Marine and Coastal Access Act 2009.

processes and infrastructure deployment and creates specific assessment guidelines for offshore resources exploitation.

49. In Latin America, Chile adopted the Non-Conventional Renewable Energy Law in 2008, which applies to renewable energy sources such as geothermal, wind and tidal energies. It establishes a quota system requiring companies providing energy to show that, by 2024, 10 per cent of their total energy trade will be in the form of renewable energy sources.[64]

50. In North America, in 2010, Canada initiated the development of a strategy to support an efficient regulatory framework for ocean renewable and clean energy initiatives. A marine renewable energy technology road map was launched to provide a clear strategic vision for Canada's participation and key capabilities to support the marine renewable industry and move it towards commercialization.[65]

51. The United States of America is endeavouring to streamline permitting processes and resolve regulatory uncertainty concerning the development of marine renewable technologies. The United States Final Rule on Renewable Energy and Alternative Uses of Existing Facilities on the Outer Continental Shelf was issued in 2009.[66] The National Ocean Council has released a draft national ocean policy implementation plan, which includes supporting steps for emerging sustainable uses of resources including renewable energy.[67] Two reports released by the Department of Energy in January 2012 demonstrated that wave and tidal energy production off the coasts of the United States could provide 15 per cent of the country's electricity by 2030.[68] The Federal Energy Regulatory Commission issued its first pilot project licence for a tidal energy project located in New York City's East River on 23 January 2012.[69]

52. These examples show the role of Governments in promoting marine renewable energy by creating a predictable and stable environment for research, development and investment. Measures may include introducing research and innovation policies, establishing market-based policies that provide an enabling market framework and developing clear regulatory frameworks for streamlined permitting processes. The development of an appropriate legal framework and suitable financial incentives could provide a transparent process that will benefit community stakeholders, the emerging industry and regulators.[70]

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[64] See www.cne.cl/cnewww/opencms/03_Energias/Renovables_no_Convencionales/tipos_energia.html.

[65] See Ocean Energy Systems, "Ocean energy in the world — Canada" at www.ocean-energy-systems.org/country-info/canada/.

[66] See www.iea.org/textbase/pm/?mode=re&id=4445&action=detail.

[67] See www.whitehouse.gov/administration/eop/oceans/implementationplan.

[68] See "Mapping and assessment of the United States ocean wave energy resource" and "Assessment of energy production potential from tidal streams in the United States" at http://energy.gov.

[69] See www.ferc.gov/media/news-releases/2012/2012-1/01-23-12-order.pdf.

[70] Michelle E. Portman, "Marine renewable energy policy: Some US and international perspectives compared", *Oceanography*, vol. 23, No. 2 (2010).

IV. Developments at the global and regional levels

53. A combination of factors, including climate change, higher oil prices, population growth, increasing energy demands and the search for affordable, clean and secure energy, has stimulated the progressive development of marine renewable energies. At the seventeenth Conference of the Parties to the United Nations Framework Convention on Climate Change, held in Durban, South Africa, from 28 November to 11 December 2011, renewed commitments were made towards limiting or reducing greenhouse gas emissions. The development of renewable energy, including marine renewable energy, is therefore likely to advance. Governments agreed on a second commitment period under the Kyoto Protocol that will start in January 2013. Governments also affirmed the mitigation pledges made by 89 countries, both industrialized and developing, under the Framework Convention, covering 80 per cent of global emissions over the time period from now until 2020. Parties also agreed on an immediate work programme to increase mitigation action.[71]

A. Global level

54. The International Renewable Energy Agency (IRENA) is an intergovernmental organization mandated to promote the widespread and increased adoption and sustainable use of all forms of renewable energy, including the ocean's wave, tidal and thermal energies. IRENA was founded in 2009 by 75 States which signed its statute. As of January 2012, its membership comprised 155 States and the European Union, of which 86 States and the European Union have ratified the statute. IRENA positions itself as a platform for all-inclusive cooperation aimed at creating a central hub for a range of reliable services to the renewable energy community.[72] Economic and structural challenges associated with renewable energy sources are particularly challenging for developing countries. For this purpose, IRENA promotes the exchange of information and capacity-building in this field. Similarly, the United Nations Industrial Development Organization has established a trust fund for renewable energies aimed at scaling up the use of renewable energy for productive uses in developing countries and countries with economies in transition.

55. Ocean Energy Systems (also known as the Ocean Energy Systems Implementing Agreement), launched in 2001, is an intergovernmental collaboration operating under the International Energy Agency. Currently, it consists of 18 member States.[73] It has set a global target of 748 GW of ocean energy by 2050, which could save up to 5.2 billion tons of carbon dioxide by that year and create 160,000 direct jobs by 2030. In its report entitled "An international vision for ocean energy",[74] Ocean Energy Systems describes the current status, opportunities and challenges for global uptake of ocean energy.

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[71] Contribution of the secretariat of the United Nations Framework Convention on Climate Change.

[72] Available at www.irena.org/menu/index.aspx?mnu=cat&PriMenuID=13&CatID=9.

[73] Belgium, Canada, China, Denmark, Germany, Ireland, Italy, Japan, Mexico, New Zealand, Norway, Portugal, Republic of Korea, South Africa, Spain, Sweden, United Kingdom, United States.

[74] Available at www.ocean-energy-systems.org/news/international_vision_for_ocean_energy/.

56. The Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization sponsors the Global Ocean Observing System, which provides ocean and coastal observations, including socio-economic data, for climate services and science. It has the potential of providing baseline data needed by marine spatial planning for ocean energy projects. IOC noted that, given the variety of marine renewable energy technologies utilizing tidal currents, wave action, ocean thermal gradients and even the osmotic pressure of salt water, detailed environmental information is required to match the technology to the site and make effective environmental impact assessments.[75]

57. Since the development of renewable energy depends on the availability of metals (copper nickel, cobalt and manganese) at affordable prices, the International Seabed Authority noted that it was well placed to contribute to policies related to marine renewable energies.[76] In addition, the industrial production of renewable energy technologies requires increasing amounts of rare earth elements and other metals. Recently, the Authority initiated a study to investigate the economic and technical viability of extracting rare earth elements from seabed deposits, as well as a resource assessment. The Authority also indicated that the use of renewable energies, such as floating or drifting ocean thermal energy plants to generate electric power for mining operations, as well as the use of wind turbines and wave energy, was being considered on future mining platforms.

58. The development of marine renewable energies requires detailed hydrographic information if the activity is to be conducted in a safe, efficient and environmentally friendly manner. The required information includes, but is not limited to, seabed topography and composition, water level variation, wave statistics and the occurrence of severe marine conditions. On the basis of this information a wide range of nautical charts and other products can be prepared to assist in the establishment of the infrastructure required for generating marine renewable energy. The International Hydrographic Organization (IHO) is the intergovernmental body that brings together the national hydrographic agencies responsible for the conduct of hydrographic surveys, the production of nautical charts and the distribution of maritime safety information. IHO member States have established 15 regional hydrographic commissions covering the globe that provide regional cooperation and support for these hydrographic activities.[77]

59. The United Nations Environment Programme (UNEP) has undertaken assessments of wind energy resources and research studies to inform public and private sector decision-making. It also, inter alia, provides advice to developing countries on broad policy approaches to bolster renewable sources of energy and supports the creation of an enabling environment for small and microbusinesses in the area of renewable energy.[78]

60. The secretariat of the Convention on the Conservation of Migratory Species of Wild Animals noted that marine renewable energy production could mitigate the effects of climate change, which has potentially severe consequences for the quality, suitability and availability of the habitats of many marine migratory species, as well as direct effects on the species themselves. However, marine renewable energy

[75] Contribution of IOC.
[76] Contribution of the Authority.
[77] Contribution of IHO.
[78] See www.unep.org/climatechange/mitigation/RenewableEnergy/tabid/29346/Default.aspx.

could also cause severe disturbance to marine migratory species, in particular cetaceans and migratory birds, by introducing underwater noise, a higher risk of collision with turbines or service craft and habitat alterations, including alterations to water flow and sea level. A number of resolutions have been adopted to address these issues.[79]

B. Regional level

61. In Asia and the Pacific, a number of research and development projects are being implemented, in particular in Australia, Japan, New Zealand and the Republic of Korea.[80] To further explore marine renewable energy technology the IOC Subcommission for the Western Pacific held a workshop on the status of marine renewable energy technology development in the Western Pacific, in Melaka, Malaysia, from 16 to 18 February 2012. The workshop aimed at facilitating the establishment of a research and development network, development and implementation of marine renewable energy technologies, sharing of best practices and identification of pilot projects among the member States.[81]

62. The European Commission has supported 48 energy research programmes in the past 20 years.[82] In 2010, the European Ocean Energy Association published a road map for the potential development of ocean energy (wave and tidal stream) in Europe, envisaging the realization of approximately 188 GW of installed capacity, or 15 per cent of projected European consumption, by 2050.[83] In September 2011, on behalf of the Offshore Renewable Energy Conversion Platform Coordination Action Project funded by the European Commission,[84] the University of Edinburgh (United Kingdom) published a combined road map up to 2030 for the offshore wind, wave and tidal stream energy sectors. The road map reported on the location of such resources across Europe, projected different development timelines for the ocean

[79] Convention on the Conservation of Migratory Species of Wild Animals: resolution 10.24 on further steps to abate underwater noise pollution for the protection of cetaceans and other biota (2011); resolution 9.19 on adverse anthropogenic marine/ocean noise impacts on cetaceans and other biota (2008); resolution 7.5 on wind turbines and migratory species (2002). Meeting of the Parties to the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area: resolution 4.17 on guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area (2010). Meeting of the Parties to the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas: resolution 6.2 on adverse effects of underwater noise on marine mammals during offshore construction activities for renewable energy production (2009).

[80] Ocean Energy Systems, *Annual Report 2010*.

[81] Contribution of IOC. See also the workshop announcement at http://kocean.or.kr/admin/upFile/Announcement_Workshop_Marine_Renewable_Energy_edited_2510-final.pdf.

[82] Contribution of the European Union.

[83] See "Oceans of energy: European ocean energy road map 2010-2050" (2010) at http://eu-oea.com/index.asp?bid=436.

[84] European Union-funded research within the Seventh Research Framework Programme is aimed at supporting offshore renewable energy development and optimizing marine spatial planning. See also European Commission communication COM (2010) 771 final of 17 December 2010 and www.orecca.eu.

energy and offshore wind sectors and revealed the potential for combined resources.[85]

63. More recently, the European Commission has funded the Marine Renewables Infrastructure Network, which aims at accelerating the development of marine renewable energy technology by bringing together a network of specialist marine research facilities in various countries.[86]

64. In the Americas, the Organization of American States (OAS) is collaborating with the Agence Française de Développement (AFD) and UNEP in the Eastern Caribbean Geothermal Development Project.[87] The project countries are Dominica and France in respect of Guadeloupe and Martinique. In terms of hydrothermal potential, the occurrence of seismicity beneath southern Dominica suggests that an active hydrothermal system exists and fracture permeability at depth could enhance geothermal exploitation potential.[88]

65. In September 2011, the Economic Commission for Latin America and the Caribbean (ECLAC), the Development Bank of Latin America, and the Governments of Canada and the United Kingdom co-organized the First Latin American Regional Conference on Marine Energy at ECLAC headquarters in Santiago. The meeting addressed marine energy research and development in Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador and Venezuela. It also provided a regional overview of the work of ECLAC in renewable energy.[89]

66. In Africa, ocean thermal energy conversion, as well as wave and ocean current energies, constitute an important potential for the continent.[90] In East Africa, pilot conversion plants and ocean current power projects are being developed, while commercial devices are currently available for wave and tidal stream power.[91] In South Africa, recent assessments suggest that the potential resource of wave power could contribute between 8,000 and 10,000 MW of South Africa's future electricity supply. More specifically, wave power potential could contribute 84 Gigawatt-hours (GWh) to the overall target of 10,000 GWh set for 2013 by the South African Department of Minerals and Energy.[92]

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[85] The road map is structured around five key streams, namely: resource; finance; technology; infrastructure; and environment, regulation and legislation. See ORECCA, European Offshore Renewable Energy Roadmap, 2011, at http://orecca.eu/web/guest.

[86] See www.fp7-marinet.eu/. Other EU-funded relevant projects include NER 300 (www.ner300.com/), WaveTrain2 (http://www.wavetrain2.eu/) and WavePlam (www.waveplam.eu/page/).

[87] The Global Environment Facility provided funds for the project in the amount of $700,000 from 2003 to 2007. While the OAS role in the project has completed, AFD has continued its work.

[88] Contribution of OAS.

[89] See http://larc.iisd.org/news/eclac-hosts-first-latin-american-conference-on-marine-energy/.

[90] See Economic Commission for Africa, *Ocean as a source of energy in Africa*, document. ECA/NRD/E/80/INF.17 (17 December 1980).

[91] See report No. 2011:3, Chalmers University of Technology, Department of Energy and Environment (Gothenburg, 2011).

[92] See South Africa National Energy Research Institute, *Annual Report 2009/10*, at www.saneri.org.za.

V. Opportunities and challenges of marine renewable energies within the context of sustainable development

67. The development and use of renewable energy sources can enhance diversity in energy supply markets, contribute to securing long-term sustainable energy supplies, help reduce local and global atmospheric emissions and provide commercially attractive options to meet specific energy service needs, particularly in developing countries and rural areas, helping to create new employment opportunities there.[93]

68. The promotion of marine renewable energy provides both opportunities and challenges of a technological, financial, environmental, social, legal and institutional nature, as outlined below.

A. Potential benefits

69. The potential benefits of renewable sources of energy have received increasing attention at global conferences and summits. For example, the Johannesburg Plan of Implementation called for a major focus on energy for poverty eradication, for changing unsustainable patterns of consumption and production and for the sustainable development of particular regions and groups of countries, including African States and small island developing States.[94]

1. Environmental aspects

70. The study of the potential environmental benefits of using marine renewable energy is at a nascent stage. It has been noted that the information base needed to study the positive impacts of marine renewable energy remains poor, and that further multi- and interdisciplinary research is needed,[95] especially biodiversity-oriented studies.[96]

71. However, a clear benefit that would result from the development of the use of marine renewable energy is a lesser dependence on traditional sources of non-renewable energy. The use of new and renewable sources of energy for electricity generation offers important options for reducing anthropogenic emissions of greenhouse gases that result from the combustion of fossil fuels in both developed and developing countries.[97] Renewable energy sources will become more desirable when their exploitation is cost-effective and they can compete with traditional sources which have a higher impact on the environment. A recent UNEP report noted that renewable energy sources posed an increasing threat to the dominance of fossil-fuel generation sources owing to further improvements in solar, wind and other technologies. Through these advances, it is expected that the cost of

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[93] Antonia V. Herzog, Timothy E. Lipman and Daniel M. Kammen, “Renewable energy resources”, at www-fa.upc.es/personals/fluids/oriol/ale/eolss.pdf.

[94] Johannesburg Plan of Implementation (note 2 above), paras. 7 (e), 9 (a) and (c), 20 (c), (d), (e), (g), (j), (k), (n) and (t), 40 (b), 59 (b) and 62 (j).

[95] George W. Boehlert and Andrew B. Gill, “Environmental and ecological effects of ocean renewable energy: A current synthesis”, *Oceanography*, vol. 23, No. 2 (June 2010).

[96] Richard Inger et al., “Marine renewable energy: potential benefits to biodiversity? An urgent call for research”, *Journal of Applied Ecology*, vol. 46, No. 6 (2009), p. 1151.

[97] See A/62/208.

marine renewable energies will become more competitive, thus building market share and perhaps replacing non-renewable sources.[98]

72. Recent studies focusing on the possible benefits of marine renewable energies to biodiversity have noted that artificial structures placed on the seabed or in the water column can increase substrate availability and complexity and thus may augment local colonization and recruitment rates of many marine organisms.[99] Fishing vessels may also be dissuaded from using many gear types in the immediate vicinity of marine renewable energy installations, even in the absence of formal enforcement, owing to the possibility of collision and gear entanglement, thereby limiting the negative impacts of certain destructive fishing practices.[100] However, further research is needed to balance these positive effects with the potential negative effects, including attraction of non-native species, modification of the benthic habitat and overpopulation by predators.[101] Yet further research is needed to study the impact of wave and tidal energy devices on coastal, estuarine and shoreline environments.[102]

2. Economic prospects

73. Renewable energy has become, over the last decade, an international industry with supply chains spreading around the world. Important wind turbine manufacturers operate in both developed and developing countries. Renewable energy projects are under way on all continents, often as a result of private-public partnerships. Financing is provided by domestic and foreign institutions and by international financial institutions.[103] Global investment in renewable energy jumped 32 per cent in 2010, to a record $2.11 billion.[104] Technology improvements and market maturity are driving down the costs of most renewable energy technologies.

74. There is a potential for job creation in the renewable energy sector, as these technologies typically involve processing of raw materials; the manufacture of technology; project design and management; installation and/or plant construction; operations and maintenance; and eventual decommissioning.[105] A recent working paper from IRENA estimated gross employment in the renewable energy industry for 2010 at over 3.5 million jobs.[106]

75. While specific figures for marine renewable energy are not available, the patterns and trends outlined above for renewable energy in general provide an indication of the future potential in the sector.

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[98] UNEP, “Global trends in renewable energy investment 2011: analysis of trends and issues in the financing of renewable energy” (2011).

[99] Inger (note 96 above), pp. 1148-1149.

[100] Ibid., p. 1149.

[101] See Boehlert and Gill (note 95 above).

[102] Mark A. Shields et al., “Marine renewable energy: the ecological implications of altering the hydrodynamics of the marine environment”, *Ocean and Coastal Management*, vol. 54, No. 12 (2011), p. 7.

[103] UNEP (note 98 above), p. 28.

[104] Ibid., p. 12.

[105] Ibid.

[106] “Renewable energy jobs: status, prospects and policies” (2011), p. 4, at www.irena.org/DocumentDownloads/Publications/RenewableEnergyJobs.pdf.

3. Social benefits

76. Marine renewable energy sources may be a viable and sustainable solution for coastal communities that have limited or no access to modern energy services. One of the greatest technical problems for marine renewable sources that must be overcome lies in the fact that the energy generated by offshore wind farms or wave, tide, salinity or thermal devices must be cabled to shore and connected to the existing energy grids. Moreover, renewable energy equipment used in that regard must also conform to certain standards of grid voltage, frequency and waveform purity requirements so that its benefits can be accessed by remote communities.[107]

77. The IPCC noted that access to modern energy services is an important precondition for many fundamental determinants of human development, including health, education, gender equality and environmental safety.[108] In fact, the experiences of many countries during the past several decades show that higher levels of development are linked to sufficiently high levels of energy consumption.[109] The achievement of the Millennium Development Goals and of more equitable socio-economic development will depend on providing the poor with increased access to modern energy services to enable them to meet their basic needs and for income-generation.[110] The persistent lack of access to energy is seriously impeding socio-economic development, particularly in sub-Saharan Africa and in countries of South Asia, but also in many other developing countries, including many of the small island developing States.[111]

B. Potential challenges of marine renewable energies, including for developing States

78. There are a number of challenges to the full realization of the promises and opportunities which the development and use of marine renewable sources of energy are expected to bring.

79. This stems largely from the fact that such sources are still at an early stage of development. Therefore, their impact is not entirely known and their status in the legal, institutional and market frameworks remains unclear.

80. Developing and developed countries face environmental, economic and social challenges. However, the costs associated with research and development as well as the gaps in scientific research and technological know-how represent a special challenge for developing countries.

81. Of the various ocean energy technologies, wave and tidal energies are attracting most of the investments, which are in the form of venture capital or government grants rather than asset finance. It has been noted that current investments are insufficient to fully develop the potential of marine renewable energies. Even with an assumption of improving technologies for newer energy sources, energy production costs using average estimates in the European Union are

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[107] See also World Bank, “Transmission expansion for renewable energy scale-up: emerging lessons and recommendations”, Energy and Mining Sector Board discussion paper No. 26, June 2011.
[108] IPCC (note 7 above), p. 120.
[109] A/64/277, para. 6.
[110] A/62/208, para. 7.
[111] Ibid., para. 5.

higher for most marine renewable energies when compared to many currently employed technologies. For example, when projected to 2020, only offshore wind production is estimated to be cheaper than coal. In addition to the high capital costs required for marine renewable energies to become commercially viable, there are also costs related to the storage of energy and its transmission into the grid.[112] Research and development is therefore occurring in these related fields.[113]

1. Environmental challenges

82. The monitoring of the effects of these sources is rendered even more challenging by the absence of baseline data concerning prospective development sites.

83. The identification of environmental impacts is further compounded by the fact that each type of marine renewable energy device may have specific effects requiring individualized assessments. It is still largely unknown whether these effects are simply proportional to the number of devices employed or more complex. For example, by interacting with other uses and the ecological conditions of an area, these devices might produce an impact on marine life greater than expected for any renewable energy unit or source, or even greater than the sum of all existing stressors present in that area.

84. In the assessment of marine renewable sources of energy, the duration of their impacts should also be taken into account. The activities and effects associated with the construction and decommissioning of energy source devices and installations (e.g. seismic explorations; construction noise caused by drilling, use of explosives, ramming and piling; dredging; cable laying; water turbidity; construction vessel activities) may have short- or medium-term impacts. The electromagnetism and physical presence of structures could have long-term impacts.[114]

85. Researchers, industry experts and government agencies recognize that the most common environmental impacts of renewable energy technologies may include reduction of the velocity of marine currents and decrease in the heights of waves resulting from extraction of wave or tidal energy; alteration of benthic habitats and sediment transport or deposition by the construction activities and the continuous presence of marine renewable energy devices; killings or change in the behaviour of fish and mammals from noise and electromagnetic fields; interference with the movement, feeding, spawning and migration paths of fish, mammals and birds, which may get hurt or entangled or may be attracted or hauled out; and release of toxic chemicals as a result of accidental spills and leaks or the accumulation of metals or organic compounds. Other uses of the oceans, including enjoyment of their visual appearance, may be hindered by the installation and presence of renewable energy devices and sites.

86. It is believed that the only effective way to fill the existing knowledge gap is by testing the devices in situ and monitoring and evaluating their impacts, taking into account the precautionary approach.

87. In addressing the environmental impacts of marine renewable energy sources, due consideration should be given to mitigation measures. Marine spatial planning,

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[112] IPCC (note 7 above), chap. 6.
[113] See A/65/69/Add.2, para. 160.
[114] Contribution of the OSPAR Commission.

for instance, can be applied to the areas in which renewable energy technologies would be employed, including with a view to minimizing interference with other uses of the oceans. Measures taken in the context of marine spatial planning include the avoidance of protected areas, sensitive habitats, migratory pathways, spawning, nursery, overwintering and feeding grounds and of areas with contaminated sediments. Other measures may be specific to the various types of devices, installations or sites. They include shielding; cable burial and/or sheathing; optimization of device shapes and design as well of the spacing between individual devices; sound-insulation; installation of thick mooring lines which pose smaller risks of entanglement than thin and slack lines; minimization of horizontal surfaces above water to reduce perching and haul-out; utilization of measures to contain and reduce spills; and utilization of non-biocidal coatings.

2. Economic and institutional challenges

88. The high costs of the scientific and technological development of installations for marine renewable energy sources as well as the long-term nature of the projects required to bring them to fruition pose economic challenges. The current comparative market cost of energy derived from renewable marine sources, as compared to traditional sources of energy, remains high.

89. As is typical for new technologies that require large up-front financial investments, private-public partnerships are considered critical for the launch of marine renewable energy sources as well as for the development of a market for them. Since the world economic crisis began in 2008, however, private funding has progressively declined, rendering the public component more critical. In this connection, it should be noted that the importance of public sector support is not confined to the funding of the early stages of development of new technologies. The creation of a favourable private investment environment through financial and fiscal incentives, renewable portfolio standards, offsets or "feed-in" tariffs has proved equally, if not more, important.[115] The ultimate increase in the costs of fossil fuels will also inevitably lead to greater interest by the private sector in renewable sources of energy.

90. The patchwork of existing legal, policy and administrative frameworks poses additional difficulties to private investors. In the absence of legislation tailored to the specific needs of a new technology, developers and investors may find that licensing and fiscal policies are inadequate because of the lack of a centralized authority or competent government agency.[116]

91. Renewable resources such as wind, waves, salinity and tides are variable by nature. While this problem can be addressed through supply and production forecasting, a regulatory framework can both make forecasting mandatory and establish mechanisms to defray its costs.

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[115] Megan Higgins, "Is marine renewable energy a viable industry in the United States?" *Roger Williams University Law Review*, vol. 14, No. 3 (2009), p. 595.

[116] Erica Schroeder, "Turning Offshore Wind On", *California Law Review*, vol. 98, No. 5 (2010), p. 1659.

3. Social challenges

92. The deployment of wind farms and other installations for the production of offshore renewable energy sources has been perceived as a challenge by local communities. The concerns expressed relate to the adverse impact on the aesthetics of the landscape, a consequent potential decline of coastal property values, public safety risks and environmental impacts that may not be offset by the possible increase in the number of jobs created by the new energy technologies.

93. In certain cases, marine renewable energy sources may have cultural impacts by reason of their placement in historic properties, archaeological sites or sites devoted to traditional uses.[117] For this reason, it is very important that local communities be directly involved in identifying the sites for the installation of generators of marine renewable energy as well as the landing sites of related cables, and assessing benefits and costs connected with them. Dissemination of information and education of stakeholders are crucial for a meaningful involvement of local communities in this decision-making process.

C. Opportunities for enhanced cooperation and coordination, including for capacity development

94. As marine renewable energy is a nascent and diverse sector, research, development and demonstration programmes are sometimes undertaken in isolation from one another or with limited cooperation and coordination. New technologies frequently require significant investments which are often leveraged in the hopes of securing patents and obtaining new market shares. Furthermore, the development of the sector necessarily requires enabling policies, legal frameworks and financial support at the local and international levels.

95. To date, the sector appears to be characterized to some extent by a patchwork of research, technologies and regulatory and financing frameworks. Thus enhanced cooperation and coordination across all components of the sector, and at all levels, is increasingly necessary as the sector continues to develop.

96. Many States are in the process of adopting and/or implementing renewable energy programmes. Still, it appears that an important institutional and human capacity gap may need to be addressed. Particular attention must be paid to capacity-building.

1. Global level

97. At the global level, opportunity for enhanced cooperation and coordination lies in a number of intergovernmental bodies. IRENA is mandated by its member States to promote the widespread and increased adoption and sustainable use of all forms of renewable energy, and could eventually serve as a focal point for intergovernmental cooperation, coordination and capacity development (see also sect. IV.A above). Other intergovernmental organizations are also active in this field and include, inter alia, the International Energy Agency and the Organization for Economic Cooperation and Development. The recently launched initiative of the

[117] Ibid., pp. 586-588.

Secretary-General, Sustainable Energy for All, also seeks to mobilize urgent global action through all sectors of society.

98. As regards cooperation and coordination in relation to the environmental aspects of marine renewable energies, the secretariat of the Convention on the Conservation of Migratory Species highlighted the need for close cooperation at the national level, between focal points for that Convention and for the United Nations Framework Convention on Climate Change in providing expert guidance on how migratory species can be affected by adaptation and mitigation activities, such as renewable energy and bio-energy development, and in developing joint solutions aimed at reducing negative impacts on migratory species. It also drew attention to the need to develop voluntary guidelines on offshore construction activities, which should wherever possible be harmonized and developed in cooperation between different intergovernmental instruments.

99. An example of global capacity development opportunities can be found in the IRENA policy advisory and capacity-building programme, which aims to strengthen countries' abilities to design and implement appropriate policies and supportive financial frameworks as well as build the human and institutional capacities necessary for a rapid deployment of renewable energies. Another example is the Transfer Renewable Energy and Efficiency programme, which has as its goal to train relevant stakeholders on technical, economic, financial and legal aspects of renewable energy and energy efficiency technologies and to provide an effective framework for market growth in the countries of origin, so as to develop sustainable capacity-building strategies in cooperation with the partner countries, especially developing and emerging countries.

100. Capacity development also may take the form of formal academic training. For example, in the field of natural sciences, the IRENA scholarship programme offers, in partnership with the Government of the United Arab Emirates, 20 annual Master of Science scholarships to be undertaken at the Masdar Institute of Science and Technology in the United Arab Emirates. In the field of financial, legal and institutional capacity development, the Masters in Business Administration in Renewables is offered by the Renewables Academy in cooperation with the Beuth University of Applied Sciences (Berlin).

101. There are examples of international industry associations and non-governmental organizations operating globally (some focusing on specific technologies or geographical regions) to promote international cooperation in the fields of research, development, deployment, policy and finance. Certain associations and organizations are active in capacity-building in the finance and regulatory areas, while others support standardized research, development and deployment methodologies. Generally, these initiatives are ultimately aimed at fostering cooperation, coordination and integration, harmonizing regulatory frameworks and opening of capital markets in accordance with their respective areas of focus.

2. Regional and national levels

102. Programmes of cooperation and coordination within the marine renewable energy sector appear to lie in particular, in the realms of scientific research, technology development and deployment, and the accompanying policy and regulatory regimes.

103. While cooperation and coordination, even harmonization, can already be observed within numerous States and in some regions of the world, the development of human capacity remains of utmost importance.

104. Beyond building the capacity to develop, deploy and monitor new technologies, there is a need to reinforce capacity in several key areas including: institutional, policy and regulatory; financing; private-sector actors; and technical and data management. The capacity of communities and end users also needs reinforcing.

105. There are examples of industry associations and non-governmental organizations conducting in-country specialized training programmes aimed at relevant institutions and individuals. Bilateral and multilateral programmes of assistance are also undertaken, and may include private sector participation.

106. The same capacity needs have been identified at the regional level. It has also been noted that capacity-development initiatives must reach from the regional to the national level, involve all stakeholders, and be customized to national circumstances.

107. Furthermore, as the renewable energy sector is developing, capacity-building initiatives must remain flexible and responsive to the rapidly changing needs.

VI. Conclusions

108. A sustainable future will involve a combination of renewable energy and energy efficiency solutions. The oceans contain a large amount of energy with different origins that can usefully be exploited. These gifts of nature can assist in alleviating poverty, promoting green growth, combating climate change and enhancing energy security.[118] Renewable energy, including marine renewable energies, can play a significant role in meeting sustainable development goals, enhancing energy security, creating jobs and meeting the Millennium Development Goals. Yet, marine renewable energies constitute untapped potential in many regions of the world.

109. Economic, regulatory and policy mechanisms are needed to support the wide dissemination of renewable energy technologies, unleash innovation and investments and promote the scaling up of successful models. Marine renewable energy sources are crucial alternatives for sustainable development.[119]

110. Countries could consider systematically increasing the use of renewable energy sources, including marine renewable energies, according to their specific social, economic, natural, geographical and climatic conditions.[120] In order to support the development and deployment of marine renewable energies, further investments in technology, research and development are required together with

[118] Special address by Sha Zukang, Under-Secretary-General for Economic and Social Affairs and Secretary-General of the 2012 United Nations Conference on Sustainable Development, at the second session of the IRENA Assembly, Abu Dhabi, 14 January 2012.

[119] United Nations News Centre, “At Abu Dhabi forum, Ban calls for ensuring clean energy future for all”, at www.un.org/apps/news/story.asp?NewsID=40947.

[120] Programme for the Further Implementation of Agenda 21 (General Assembly resolution S/19-2, annex), para. 46.

increased efforts to undertake resource potential assessments and mapping, data collection and monitoring and economic modelling.[121] Building the technological know-how and establishing regulatory frameworks that encourage investments, cooperation and coordination, capacity-building and technology transfer, could facilitate the scaling up of marine renewable energy to its full commercial potential. Such measures are necessary if we are to reach the goal of doubling the renewable energy share in the overall global energy mix by 2030 as envisioned in the Secretary-General's initiative "Sustainable Energy for All".

[121] "Ocean sustainability: Monaco message" at www.earthsummit2012.org/preparatory-process-news/ocean-sustainability-monaco-message.