國際海洋資訊 International Ocean Information

藍色經濟特輯

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海洋旅遊
Marine Tourism
海洋能源
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Stepping Forward into the World: Developing Taiwan's Sustainable Blue Economy!

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

A blue economy symbolizes a sustainable marine economy that emphasizes the harmony and symbiosis between human activities and the ocean. This issue of "International Ocean Information", the "Blue Economy Special Issue," offers an introduction to the current development and future trends of ocean tourism, ocean energy, transportation and shipbuilding, marine biological resources, and emerging industries in Europe, the United States, Taiwan and other countries across the world.

The "Marine Tourism" section introduces Taiwan's primary coastal and marine tourism industry and sustainable marine tourism policies. As Taiwan is equipped with the 4S elements (sand, sea, sun and seafood) for the development of marine tourism and leisure, in recent years, huge business opportunities in yacht tourism and cruise tourism have emerged while the government has also proposed a 10-year comprehensive development plan for reinforcing Taiwan's blue highway (2021-2030); The "Marine Energy" section gives a glimpse into the current status of global marine energy innovation technologies and strategies, and highlights important trends, including the fact that the average cost of marine energy power generation is lower than expected, tidal stream energy and wave energy technologies are undergoing exponential development, and that ocean thermal energy conversion, salinity gradient and tidal energy all exhibit development potential within the next decade. The "Transportation and Shipbuilding" section gives a dynamic analysis of the marine transportation, shipbuilding and vessel operation industries. For example, the European Union's shipbuilding industry has gradually shifted its business model in recent years to reduce costs while also establishing cooperations with emerging industries (such as offshore wind power) to create new industry opportunities; the shipbuilding industry in the U.S., on the other hand, has focused almost exclusively on building military vessels. As Taiwan's maritime shipping industry is the sector with the highest output value of the nation's marine economy, the government has been promoting the building of navy vessels domestically and at the same time taken the initiative to drive the offshore wind energy industry even as the yacht industry rises to the forefront among global peers and competitors. The "Marine Bio-Resources" sections sheds light on using marine biological resources for sustainable development, while the "Emerging Industries and Trends" section introduces the challenges and future development potential of emerging industries such as marine renewable energy, blue bioeconomy, marine minerals, seawater desalination, maritime defense, and submarine cables as well as the green growth trends recommended by the United Nations Conference for Trade and Development (UNCTAD) and the 5 priority measures for developing the blue economy proposed by the Ocean Panel. As the above sections span key marine industries in Europe, the United States and other countries, they serve as valuable reference for the future sustainable development of Taiwan's blue economy industry.

Sustainable Development of Taiwan's Coastal and Marine Tourism

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Keywords: Coastal and marine tourism, yacht, cruise, island hopping tourism

The lockdown caused by the 2020 epidemic has prevented many people from going abroad. However, people's demand for sightseeing and leisure travel still exists, which has caused the rise of domestic tourism in Taiwan and become an important opportunity for the government to guide the development of high-quality tourist facilities and improvement in service quality. Among such developments, coastal and marine tourism is one of the key industries in which high-quality tourism must next be created. This article introduces Taiwan's coastal and marine tourism industry and leisure and recreation activities, including yacht tours and cruise tours, and introduces sustainability policies formulated for Taiwan's coastal and marine tourism.

Since Taiwan formed the vision of a becoming a nation of tourism and initiated its plan to double the number of tourists visiting the island in 2002, Taiwan's tourism market has grown steadily year by year, with significant performance in all aspects including number of tourists, output value, and world rankings [1]. From the perspective of tourism performance, about 11.84 million tourists came to Taiwan in 2019, an increase of 7% compared to 2018, and tourism output value also increased to 14.4 billion US dollars. Although the scale is lower than the global GDP contribution of 10%, it also accounts for about 4% of Taiwan's overall GDP, and is progressing year by year, while the overall scale of tourism is ranked 37th by the World Tourism Commission (WTTC). Even with the COVID-19 epidemic devastating the global tourism market in early 2020 and causing the global tourism market to decline, Taiwan's tourism industry still advanced to 36th in terms of world rankings.

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According to The International Coastal and Marine Tourism Society (ICMTS), coastal and marine tourism is defined as follows: Marine tourism consists of recreational activities that entail leaving one's place of residence and traveling to the marine environment and coastal areas. With marine resources as the basis, coastal and marine tourism is defined as offering tourists access to entertainment, fitness, recreation, and leisure, etc. through sea travel, coastal travel and underwater tourism, which in turn produces economic and social benefits. Therefore, from the perspective of geographical location and marine resources, it is clear that Taiwan is a region suited to the development of marine tourism.

Taiwan is located at the intersection of the Pacific Ocean and Eurasia, surrounded by seas. The surrounding sea area is five times that of land, and the natural coastline of the country is about 1,105 kilometers long. With abundant marine tourism resources, the country is equipped with the 4S elements for the development of coastal and marine tourism and leisure, including sand, sea, sun and seafood [2]. The island also features seawater hot springs, a rarity across the globe, about 3,000 species of marine fishes in the world accounting for one tenth of global fish species, 43 species of butterfly fish in coral reefs, and at least 29 species of cetaceans, accounting for more than one third of the world's whale species (79 species) [3]. However, due to the special political climate and the nation's policy of "emphasizing land over sea," the general public have had limited access to ocean activities. It was not until 1988 that the Ministry of the Interior issued the Regulations for the Management of Marine Fishing Activities in Taiwan that maritime leisure and recreational activities such as sea fishing, sailing, windsurfing, surfing, canoeing, jet skiing, parasailing, kite surfing, yachting, cruises and other activities became increasingly popular. In view of this, although Taiwan has been late in developing marine tourism, recreational activities on the coast, on the sea and under the sea have seen rapid growth and huge tourism business opportunities [4], such as the ocean recreational activities, yacht tours or cruising tourism that have become extremely popular in the past 10 years. In the following paragraphs, we will be giving a brief introduction to these activities.

Taiwan's coastal and marine tourism industry and recreational activities

Shi-Wei Huang and Chung-Ling Chen (2019) believe that there are a total of 11 marine industry activities in Taiwan (Figure 1) with a total output value of approximately US$21.14 billion [5]. The coastal and marine tourism/recreation industry accounts for 9.09% (about 1.92 million), including access to three types of tourism activities and recreational services – coast, sea and underwater, and the operation and management of their auxiliary facilities, production and sales of supplies and equipment as well as travel services. Types of activities include fish and biological resource-oriented activities (such as recreational fishing harbors), coastal and water recreation activities (rock fishing, intertidal activities, water activities, water sports), marine education activities (religious activities, art and cultural activities), boat tours (yacht visits, cruise travel, whale watching eco-tourism), and living experience activities (coastal fishery experience, offshore fishery experience). With sightseeing activities on recreational fishing boats as an example, the Fishery Agency has estimated that the total number of tourists going out to sea in 2013 was about 1.19 million, including about 400,000 persons engaging in whale watching on recreational fishing boats, 590,000 engaging in sea fishing, and 200,000 engaging in lagoon sightseeing with annual output value of the above activities coming to approximately US$67.85 million [6].

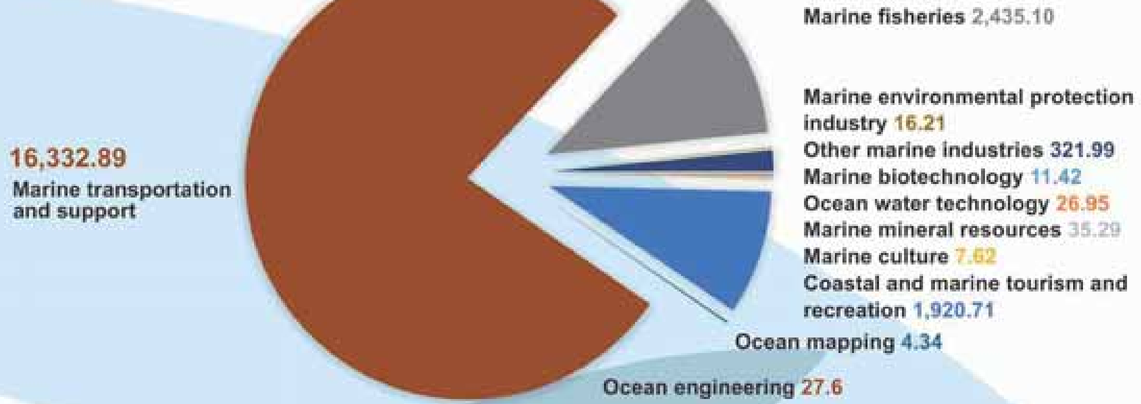

Figure 1/ Taiwan's marine industry activities and output value (Unit: million of U.S. dollars)
Source/ Shi-Wei Huang, Chung-Ling Chen (2019) [5]

In addition, the number of coastal and marine tourist visits in Taiwan reached a total of 52,560,606 from 2016 to 2018 after consolidating visitor data from 9 major tourist and recreational destinations, outlying island national parks and national-level scenic spots (the National Museum of Marine Biology & Aquarium is regarded as part of Kenting National Park), and 21 other marine and coastal tourist attractions.

Yacht sightseeing

Taiwan's yacht industry emerged in 1958. At the beginning, several wooden sampan manufacturers and amateur experts who love yachts worked together on the riverside of Tamsui to start the design and construction of wooden yachts [7]. Due to these origins, Taiwan's yacht industry is equipped with: 1. Sophisticated woodworking techniques; 2. Diligent manufacturers who pursue affordability and are strongly capable of emulating designs gained great popularity among the US military in Taiwan, and then exported to the west coast of the United States, gradually gaining renown, before sweeping the global market for marine leisure amusement. For export convenience, the first wave of manufacturers not only expanded the scale of their business in Tamshui, new entrants also set up factories in Kaohsiung. In northern Taiwan, about 7 manufacturers operated with Keelung Port as the center of export while, in the south, 20 businesses formed industry clusters in Tainan and Kaohsiung, with Kaohsiung Port as the center of export, with most manufacturers operating out of the Kaohsiung coastal areas, Dafa industrial zone, and Cijin.

Today, Taiwan's yacht industry has become world-renowned for its yacht manufacturing industry, which has enabled Taiwan to become one of the top 10 yacht manufacturing countries in the world. While locally manufactured yachts are mainly for export, the public and private sectors are also actively promoting various water recreation activities, competitions, and encouraging water activities among the general public. According to Boat International's 2019 ranking statistics for the total length of large yacht orders in various countries, Italy ranked first at 14,374 meters, followed by the Netherlands, Turkey, the United Kingdom and Germany. Taiwan ranked sixth in the world with 1,852 meters, no. 1 in Asia. Among the top 20 global yacht manufacturers in 2019, Taiwan's Alexander Marine Co., Ltd. and Horizon Yachts ranked 7th and 9th in the world respectively.

At the same time, Taiwan's yacht export market exhibited a stellar performance with an export value of approximately US$230 million in 2019, accounting for 57% of total ship export value, at an annual increase of 38.0%. Among them, most yacht manufacturers have signed long-term contracts with the United States. Therefore, exports are dominated by the United States, accounting for 68.7%, followed by Australia with 13.8%, Italy accounting for 3.7%, and Japan accounting for 2.6%.

Taiwan's yacht consumer market is dominated by clubs that operate on a basis membership and is concentrated in the high-income group at the top of the social ladder. Argo Yacht Club, for instance, has yacht piers in Kaohsiung Port, Tainan Anping Port, and Penghu Magong Port. With approximately 600 members, basic membership fees cost around US$50,000 while the highest membership fee is US$340,000. Meanwhile, the Lohas Ocean Maritime Academy was established to combine the art of life with yachts and sailing boats, enabling members to enjoy marine life. With Tainan Anping Port as the base, 150 berths, hotel accommodations, luxury villa resorts, theme shopping malls were built. These facilities as well as the nearby Anping Cultural Old Street, etc., regular carnivals and yacht experience activities offered from time to time form a complete system of yacht, water and land activities. There are also similar small-scale yacht clubs in Taipei, while Taichung City Government and Port of Taichung are also actively planning yacht and cruise activities along the blue highway.

Cruise sightseeing

Asia is an emerging blue ocean market for cruise ships in recent years, and Taiwan has become the second largest source market in Asia due to its geographical location and specific traits that imbue the country with great potential in developing the cruise market [9]. In 2019, the Asian cruise market consisted of 39 cruise brands operating in Asian waters with 79 cruise ships deployed and more than 4.02 million passengers. From 2013 to 2019, voyages to and stopovers in Asia continued to grow from 861 voyages in 2013 to 1,917 in 2019. The destination countries with the most stopovers in Asia are, in order, Japan (2,681), China (809), Malaysia (561) and Thailand (550). Individual ports with the most stopovers are, in order, Singapore (400), Keelung, Taiwan (284) and Shanghai, China (276), While home ports with the most number of inbound and outbound voyages are China, Taiwan, and Singapore. The world's top three international cruise companies for the development of cruise tourism include Carnival Cruises, Royal Caribbean International (RCI), and Norwegian Cruise Line. In Asia, the more well-known one is Genting Cruises Lines which includes Crystal, Dream Cruises, and Star Cruises; among them, Star Cruises currently lists Taiwan as the home port out of which its cruise ships operate. On the other hand, in 2019 Keelung Port was the main port for cruise ships coming in and out of Taiwan with travel itineraries mostly designed to accommodate tourists making stopovers. In terms of Keelung's cruise tourism development, the compound annual growth rate (CAGR) was about 31% [10].

However, due to the impact of COVID-19, the market is declining sharply. This is a global risk, nevertheless, and Taiwan's cruise tourism's response is to move towards the establishment of stronger foundations during this period, such as the continuous construction of cruise port service facilities and the optimization of port city ground reception itineraries, etc. [10]. Apart from formulating the Incentives for the Promotion of Visits to Taiwan by Overseas Cruise Ships, the Tourism Bureau of the Ministry of Transportation and Communications of Taiwan also encourages fly cruises that integrate cruise with air travel and comprehensive transportation services between cruise marinas and scenic spots, including implementation of the government's cruise ship north-south dual home port policy, optimization of port facilities in Keelung Port and Kaohsiung Port, and integration of port and tourism resources to promote passenger transportation via the maritime blue highway. In addition, the Bureau is also working to strengthen the international marketing of Taiwanese ports to help cruise peripheral industries expand their business opportunities in Taiwan.

In response to the COVID-19 epidemic, Taiwanese travel agencies have been actively cooperating with Dream Cruises (Explorer Dream), launching island hopping in July 2020 and sending passengers on their journey spanning August to September 2020, thus becoming the world's first international cruise ship to resume services following initial lockdown. Departing from Keelung, the cruise visited Penghu, Kinmen, and Matsu along the way [11]. The price of the 5-day 4-night itinerary is divided into three categories: sea view room (approximately US$400), terrace room (approximately US$500) and palace suite (approximately US$900). With the original 5 voyages sold out within 48 hours and more than 4,000 passengers waitlisted, 4 additional voyages were made available at only 50% passenger capacity (originally 3,630 people) each voyage. At the same time, the "eight-fold prevention and control guarantee" was formulated, including embarkation and disembarkation, guest rooms, public areas, food hygiene, event performances, fresh air systems, medical facilities, crew protection and other core prevention and control measures, to ensure the safety and health of passengers and crew. Following the success of this itinerary, island hopping by cruise is expected to become a new mode of sightseeing.

Sustainability Policies for Coastal and Marine Tourism in Taiwan

To ensure the sustainable development of the coastal and marine tourism industry, the Taiwan government has proposed a 10-year comprehensive development plan for the Blue Highway (2021-2030). Regarding maritime and marine leisure tourism along the Blue Highway, an estimated US$840 million will be allocated to update and subsidize various public transportation facilities such as shipping operations, ports, and vessels. It is estimated that: 1. During the period of subsidized passenger capacity, ticket revenue will increase by NT$77 billion, while at least 100 employment opportunities will become available in the outlying islands every year; 2. Island hopping by cruise will increase outlying island tourism revenue by NT$4.8 billion; 3. The number of cruise passengers entering and leaving Hong Kong will increase to 2 million persons per year, with cruise ships creating economic benefits reaching NT$120 billion; 4. Proprietary brands established by cruise companies will create 300 job opportunities; 5. By organizing international-class sailing racing events and expanding yacht marketing activities, combining the existing tourism resources and special activities offered by various county and city governments, for example, 3,700 job opportunities for example can be created at Anping Port in Tainan through the development of the yacht marina while land development benefits and private investments will amount to NT$10 billion. Lastly, an overview the sustainable development of the coastal and marine tourism industry at home and abroad suggests that it is necessary to actively carry out cross-domain integration to promote the transformation and innovative development of the marine industry, the education and cultivation of marine culture, and the sustainable management of marine environmental ecology, thus securing the core strengths supporting Taiwan's future development of coastal and marine tourism [2].

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Current Status of Global Marine Energy Technology Innovations and Promotional Strategies

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Keywords: Marine energy, Levelized cost of electricity, Sustainable development goals

The definition of marine energy as emerging renewable energy using marine resources are tidal, wave, tidal stream/current and ocean thermal energy conversion [1]. In addition to technological development of marine energy, how to effectively implant government policies are important opportunity for the development of marine energy and related industries. This article briefly describes the main marine energy technologies and characteristics, and introduces marine energy technology development trends and policy planning.

Taiwan faces the Pacific Ocean to the east and China across the Taiwan Strait to the west. It is about 377 kilometers long from north to south, and about 142 kilometers wide from east to west with a natural coastline approximately 1,105 kilometers long, or 1,520 kilometers if including the total length of the Penghu Islands. Under favorable conditions such as the northeast monsoon and the Kuroshio, marine energy reserves such as tides, waves, tidal currents, and ocean thermal energy conversion are abundant. However, due to cost and technical factors, development of the aforementioned marine energy resources is still in the stage of R&D and demonstration.

The development of marine energy contributes to responding to climate change, and can reduce dependence on fossil energy for power generation, thus achieving the reduction in carbon dioxide emissions. Secondly, the development of marine energy can be applied to development of the blue economy such as shipping, refrigeration and air-conditioning and desalination. In addition to increasing employment opportunities, advancement in this aspect can also help us achieve the United Nations Sustainable Development Goals (SDGs) including goals 7 and 14 as well as resolve issues related to renewable energy development and sustainable marine development. Moreover, marine energy technology is more stable than intermittent renewable energy sources such as wind and solar power, and can be used as a base load energy to enhance the stability of national energy supply.

In the development of marine energy across the world, due to the varying characteristics of seas in different geographical environments and Taiwan's climate of frequently occurring typhoons and torrential rains, the same engineering or technology in other countries may not necessarily apply to the cases of Taiwan. At present, Taiwan's marine energy technology research and development are mainly conducted by academic institutions and think tanks such as the Industrial Technology Research Institute. In addition to collecting data on Taiwan's geographic environment and conditions, sea state characteristics and meteorological data, and establishing the conditions and restrictions required for marine energy development, these institutions have also begun developing and demonstrating various marine energy technologies. As marine energy is an emerging renewable energy sources, apart from technological development, the effective introduction of government policies will be an opportunity for the development of marine energy and related industries. This article briefly describes the characteristics of marine energy, and introduces the latest international marine energy technology development trends as well as policy planning.

Primary marine energy technologies and characteristics

Most forms of marine energy consist of the energy produced by the gravitational relationship between the earth, moon and sun and the rotation of the earth. There are 5 energy types according to their power generation characteristics. Firstly, tidal barrage/range is the permanent and stable currents caused by the periodic flow and rise and ebb of water in the sea. Tidal barrage power generation entails converting the potential energy of tidal range into electrical energy. Due to factors such as limited economic benefits and geographical environment restrictions, tidal barrage power generation is subject to many restrictions. For example, tidal range should be more than 5 meters to have economic benefits. The tidal barrage power station at the mouth of the Rance River in France, for instance, has a tidal range of 13.5 meters. In addition, to place tidal barrage generators, dams must be built in the bay of a power generation site. Land for this type of project is difficult to find and the cost is high, and the facilities will ultimately run into problems such as siltation in the reservoir area and equipment corrosion.

Ocean current power generation can be divided into tidal stream power generation and tidal current power generation with ocean current mainly caused by the temperature difference of sea water in the ocean. Seawater will cyclically flow between the oceans. When the equator warms, seawater will flow to the north and south poles to cool down, sink, and then return to the equator. Energy is extracted from ocean currents in ways like that of wind power generation, using ocean currents to drive turbines and converting the energy generated into electricity. Tidal current power generation, on the other hand, uses rising and falling tidal water to drive turbines for power generation. As most of the equipment is submerged under water, there is no need to build dams, thus reducing the cost of project land. Meanwhile, compared with tidal stream power generation which takes place in the deep seas, tidal current power generation takes place offshore and is energy is transmitted back onto land, making maintenance easier to perform. The rotation speed of turbine units driven by tidal currents is also lower, effecting only a slight impact on the hydrological environment and marine life. At present, several technologically mature turbine units are available, including the vertical axis, horizontal axis, oscillating hydrofoil and jacket type.

A generator set is used to convert the kinetic energy of waves into electricity, and the wave conversion system can usually be divided into 3 parts. The first part is the capture system, which gathers scattered incident waves into an enclosed area to increase the amplitude and energy density of the waves. The second part is the conversion system, which converts the obtained wave energy into electricity, and the third part is the energy storage system.

Ocean thermal energy conversion (OTEC) is a method of generating electricity that uses the thermal energy of the temperature difference between ocean surface seawater and deep seawater to convert it into electricity. Generally speaking, temperature differences of 20℃ have better utilization value, therefore oceans located between the equator and 30 degrees north and south latitude are more suitable for the development of ocean thermal energy conversion. OTEC power plants are mainly divided into three types: land, shelf and floating.

The salinity gradient power generation system uses the difference in the concentration of the salinity and freshwater salinity of the river's estuary to release chemical energy and convert it into electricity. Currently two main processes to make use of this potential energy are being tested and applied: pressure retarded osmosis (PRO) and reversed electro dialyses (RED).

Table 1/ Characteristics of various types of marine energy

Category	Energy source	Energy-rich area	Energy factor	Stability	Development costs
Tidal barrage/ range	Generated by the tidal force of the sun and moon driving sea water movement on the earth's surface	The continental coast between 45° and 55° latitude	Proportional to the square of the tidal range and the area of the harbor	Very regular	Higher
Tidal stream/ current	Generated by the density, pressure gradient, or wind on the sea surface caused by the rotation of the earth and the uneven distribution of seawater temperature and salinity	Western sides of the Pacific and Atlantic in the northern hemisphere	Proportional to the square of speed and flow	Relatively stable	Low
Wave energy	Generated by the wind on the sea	Eastern sides of the Pacific and Atlantic in the northern hemisphere	Proportional to the square of the wave height and the area of the undulating water surface	Relatively unstable with cycles of about 1~10s	Higher
Ocean thermal energy conversion	Generated by the difference in the absorption of solar radiation heat between the ocean surface and deep seas, and the heat transport of ocean circulation	Low latitude oceans	Proportional to the amount of warm water and temperature difference in sea areas with sufficient temperature difference	Quite stable	High
Salinity gradient	Uses the difference in the concentration of the salinity and freshwater salinity of the river's estuary to release chemical energy and convert it into electricity	The intersection area of sea water and fresh water	The energy is greater than OTEC, and it can generate electricity during the day and night	Relatively unstable	High

Source/ Yu-Shu Kuo et al. (2019) [2]

Important trends in future marine energy development

As technology advances, the International Renewable Energy Agency (IRENA) shows the following trends [1]:

I. Tidal barrage is the most widely deployed form of marine energy, but tidal stream and wave energy are the rapidest technology development

In 2020, marine energy power plants with total capacity of as much as 2.83GW are under planning or demonstration and that, by 2030, commercially viable capacity will reach 10GW. Tidal barrage is currently the most widely deployed form of marine energy, accounting for 98% of all marine energy. The total installed capacity is 521.5MW, mainly in Republic of Korea (254MW) and France (240MW) which have an installed capacity of 494MW, while Canada (20MW), China (4.1MW) and Russia (3.4MW) account for a relatively low proportion. However, because the installation of tidal barrage is greatly affected by topography, no new power plants have been installed in the past ten years.

Tidal stream and wave energy power plants currently operating across the globe amount to 12.91MW, out of which wave energy accounts for the majority (10.6MW) while plants utilizing these two power generation technologies are being continuously built with planned capacity of more than 1MW. As the technological progress of tidal stream energy is rapid and gradually moving towards commercialization, even though wave energy is also moving towards higher levels of technological advancement, the technology is relatively immature and mostly still in the demonstration stage.

II. Ocean thermal energy conversion, salinity gradient and ocean stream/current have development potential within 10 years, but wave energy is under technology divergence

The above energy types used to be small-scale deployments, but are now beginning to expand in scale. However, these three technologies are still in the research and development stage at research institutions or universities with little participation in the private sector. Currently, there are about 31 countries that value marine energy and are willing to invest in planning and deployment, of which European countries account for more than half, followed by Asian countries. The horizontal axis unit is a relatively mature tidal stream energy technology, and is also the main unit technology currently planned by various countries. However, the application of another kite-type technology cannot be underestimated, the main reason being that it can be used in environments with relatively low flow speed. As such, whether the horizontal axis unit continues to be the mainstream technology remains to be seen. In contrast, wave energy technology is advancing in all aspects with almost 10 different technologies currently under development simultaneously. Two different directions however can still be observed, one of which is the increase in unit capacity and power plant scale, and the other the construction of smaller capacity or specific purpose equipment, such as powering offshore wind power platforms or pumping seawater to the shore for seawater desalination.

III. The levelized cost of electricity of marine energy is lower than expected

In the early stages of power plant life cycle, the levelized cost of electricity for all forms of marine energy power generation is uncertain and difficult to predict. Currently, tidal stream electricity generation costs anywhere from US$0.2 to US$0.45 per kWh, while wave energy costs between US$0.3 and US$0.55. At this stage, moreover, development costs are still likely to fall again. For example, tidal stream power generation can drop to US$0.11 per kilowatt-hour of electricity generation between 2022 and 2030, while wave energy can drop to US$0.22-0.165 between 2025 and 2030. [1]

IV. Effective guarantee of income and policy subsidies are key factors boosting the development of marine energy

As mentioned above, the levelized cost of electricity generated from marine energy is still higher than the current cost of wind power, solar photovoltaic, and biomass power generation. Therefore, building a financing environment and creating innovative financing opportunities to reduce power generation costs is an indispensable part of the development of marine energy. After providing the corresponding resources, the development of marine energy will rise to become an important part of the blue economy, and can bring synergistic effects when utilized in combination with conventional ocean renewable energy (oil, natural gas), offshore wind, fishery, seawater desalination and other industries. On the other hand, marine energy is greatly suited to the energy development of island countries or outlying island regions. Since traditional energy pipelines and other infrastructure are of relatively higher costs in offshore areas, with incentives offered by policy subsidies and the premise of sustainable development, marine energy can not only reduce levelized cost of electricity, but also attract corporate investment (corporate social responsibility and sustainable development).

V. The development of marine energy can be integrated with marine protection facilities

Due to climate change, the risk of future sea level rise continues to increase. As such, integrating marine energy facilities with relevant offshore dams, seawalls, bridges, and other facilities are feasible solutions for mitigating or adapting to climate change. The cost-benefit analysis can also be evaluated at different stages through a standardized model.

VI. International cooperation and multilateral cooperation are the focus of marine energy development

Current marine energy technology development needs a breakthrough with appropriate use of international knowledge, information sharing and international cooperation the key to the improvement of marine technology. Cooperation with existing mature marine energy manufacturers such as oil, natural gas and offshore wind power can effectively reduce technical bottlenecks or improve management of the industrial supply chain and reduce operational risks related to marine energy.

Government policy support is crucial to the success of marine energy

The core issue of marine energy development lies in how to reduce its technical cost so that it can compete with other types of renewable energy. The establishment of individual business models applied in conjunction with various financial tools provided by the government can effectively reduce the risk of investment in marine energy. There are 7 major action strategies that provide different participants (stakeholders) with corresponding measures for promoting the development of marine energy: 1. Enhance the Business case; 2. Improve access to financial support; 3. Set up and strengthen resource and site assessment; 4. Build supply chain; 5. Boost ocean energy policy and regulartory schemes; 6. Minimise risks by improving reliability and efficency of the technology; 7.Develop capacity through enhanced co-operation [1].

Conclusion

Marine energy is inherently conducive to sustainable development. Compared with the offshore wind power, solar energy and other intermittent renewable energy sources currently utilized, it has the benefits of stable power generation, and can be used as a base load energy that complements the development of the former to maintain greater energy stability. The development of marine energy is an important part of the development of the blue economy. As Taiwan is surrounded by the sea, it is fully equipped to engage in the advancement of marine energy even as developments in other parts of the world still face various issues. In addition to technology, effectively reducing power generation costs, offering adequate financial support, and formulating incentive policies are all strategies that the government should give priority to considering its obligation to create a favorable environment for the development of the marine energy industry.

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Dynamic Analysis of the Marine Transportation and Shipbuilding

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Ocean transportation is extremely crucial to the global economy and is one of the key modes of transportation in international logistics with its transportation volume accounting for more than 80% of total international transportation volume [1]. In addition, the global Greenhouse Gas (GHG) emissions of international shipping account for only about 3 to 4% of global GHG emissions [2], making marine transportation an effective and energy-saving method of transportation. Marine transportation is an important link in the marine industry, while shipbuilding and maintenance are industries full of innovation and competition closely intertwined with the global economy. This article offers a dynamic analysis and report of the marine transportation, shipbuilding and maintenance industries in Europe, the United States, and Taiwan.

Marine transportation relies on the natural environment, ship navigation and port facilities, and has the following characteristics [3]:

I. Natural waterways

Marine transport vessels sail in natural seas and are not restricted by roads and railway tracks. With changes in politics, trade environment and marine environmental conditions, shipping routes can be flexibly adjusted to complete shipping tasks. On the flip side, marine transportation is also easily affected by the marine environment, voyages are not always on schedule, and the possibility of encountering severe sea states is also high.

II. Large capacity per ship

With the development of the international shipping industry, modern shipbuilding technology has progressed exponentially with ships becoming increasingly larger. Ultra Large Crude Carriers (ULCC) can reach more than 500,000 tons, and the maximum load of large container ships has exceeded 20,000 TEU (twenty-foot equivalent unit).

III. Low unit transportation cost

Maritime transportation takes place on natural channels, and port facilities are generally government public constructions, allowing shipping companies to save substantially in terms of infrastructure investment. In addition, ships feature large carrying capacities, long service life cycles, long transportation distances, and low unit transportation cost, providing convenient and favorable transportation conditions for the movement of bulk goods.

Over the past few decades, changes in the global economic cycle have greatly affected the development of the marine transportation industry. When the economy improves, ocean freight rates also increase, but when the economy is sluggish, oftentimes freight income may not even cover operating and rental costs. Among them, the freight index is an important indicator that affects the profitability of the shipping industry. As shipping is predicated on the price of oil, trends in oil prices and the collection of additional fees are important aspects that affect the profitability of shipping operators [4].

Ships are the main means of ocean transportation with the main types of cargo ships being: Container ships, bulk carriers, and oil tankers, etc. In recent years, ship construction and operation have exhibited the following trends:

I. **Increasingly large hulls:** Due to advancements in shipbuilding engineering technology, ships continue to increase in size so as to reduce transportation costs by expanding the capacity of a single ship; this, however, also affects the port industry and the surrounding infrastructure, such as the opening of the New Suez Canal in 2015 and the expansion of the Panama Canal in 2016. Following their completion, large ships can now sail through the new canals, including container ships. According to survey statistics released by Alphaliner, a French maritime consulting agency [5], by the end of 2019, container ships of 7,500 TEU to 9,999 TEU accounted for 18% of total capacity, and large container ships of more than 10,000 TEU accounted for about 36% (reaching 573 vessels).

II. **Increasingly younger ages of ships:** By the beginning of 2020, ships of more than 20 years of age accounted for only 7% of the total capacity of container ships, while ships of more than 15 years accounted for 13% [5]. Generally, the designed service life of ships is about 15 to 20 years although, subject to adjustments in operating conditions, some vessels may be scrapped and dismantled ahead of schedule.

Shipyard orders for new ships also change with the operating conditions of the shipping industry. When the economy is flourishing or the demand for ships increases, the price of new ships will rise. At such times, shipowners who place orders may need to wait several years before their vessels are delivered. However, when the economy is declining or there are too many ships in the market, the price of new ships drops, and few ship owners place orders. However, shipping companies who still have vision or courage actively purchase new ships and adjust the size of their fleets during periods of low operating and freight rates, so as to obtain a profitable opportunity when the economy takes an upward turn.

In addition to regular maintenance, ships must be returned to the shipyard for maintenance and overhaul after a certain period of operation. In recent years, moreover, in response to energy conservation trends or regulatory requirements, existing ships are required to install energy conservation and pollution prevention equipment.

EU-related industry dynamics

Ocean transportation plays a key role in the EU's economy and trade and is estimated to account for between 75% and 90% of the EU's foreign trade and one-third of the EU's internal trade. In 2018, more than 410 million cruise and ferry passengers boarded and disembarked at EU ports, an increase of 5.6% over the previous year. In the same year, the total weight of cargo to and from the main ports of the EU via short-distance sea transportation (excluding ocean routes) was 1.8 billion tons. Overall, the maritime industry accounts for approximately 8% of the EU's blue economy job vacancies (approximately 410,000 people), 16% of gross value added (GVA) (approximately €35.6 billion) and 20% profit (about €18.8 billion). The average annual salary of direct employees in ocean transportation is estimated to be close to €41,800 (about NT$1.43 million), an increase of 11% over 2009. Among EU countries, Germany has a leading position in the maritime industry, contributing 32% of job openings and 33% of GVA, followed by Italy, providing 17% of job openings and 13% of GVA, respectively [6]. (Gross value added

[GVA] is to measure the value of goods and services created by a certain region or industry of an economy, product taxes and product subsidies are deducted from GDP [7]; in other words, GVA is closely related to gross domestic product [GDP].)

In terms of shipbuilding in nations such as the UK, Germany, France, Italy, the Netherlands, Spain and other countries, products are primarily high-tech and high-value ships, such as super-large luxury yachts, mega cruise ships, and offshore work support vessels. With impeccable brand design and manufacturing capabilities, these ship yards play an important role in the global shipbuilding industry. In recent years, passenger ships (ferries and cruise ships), offshore work ships and other non-cargo carrying ships (ONCCV), account for more than 95% of the EU's newbuilding orders [6]. The EU shipbuilding industry faces competition from shipbuilding companies in China, Republic of Korea and other countries due to the strong support of Asian policies and the drop in shipbuilding market prices (such as bulk carriers, container ships, and oil tankers). In recent years, in addition to the direct competition between European and Asian shipyards, the number of new ship orders in Asia has declined, indirectly affecting the equipment supply chain in Europe, the reason being that the equipment installed by Asian shipyards is mainly sourced from European companies. Due to the long history of maritime development in Europe and the establishment of authoritative institutions, it is a world leader in the research and development of advanced maritime navigation equipment. For instance, the headquarters of AP Møller-Mærsk Gruppen, the world's largest container shipping operator, is located in Copenhagen, Denmark.

Although the economic and financial crisis has a profound impact on the decline of the global shipbuilding industry, the EU has gradually shifted its business model and labor outsourcing in recent years, and adjusted production plans and supply chains to reduce costs. Figure 1 shows that there are signs of gradual recovery since 2013. However, after several consecutive years of growth, the total order volume of European shipyards has once again declined in 2019 [6]. Overall, the EU shipbuilding and maintenance industry accounted for 6% of total EU blue economy jobs in 2018 (320,000 people, 85% in shipbuilding, 15% in related machinery and equipment), 8% of GVA (17.3 billion Euros), and 5% of profits (€4.7 billion). Among European countries, the United Kingdom leads the shipbuilding and maintenance industry with 14% of job openings and 21% of GVA, followed by Germany with 12% of job openings and 18% of GVA [6].

Figure 1/ Changes in the economic scale of the EU shipbuilding and maintenance industry (unit: million Euros)
Source/ The EU Blue Economy Report 2020 [6]

The EU shipbuilding industry also provides funding, technology, and expertise for blue economic activities, such as capture fishery, offshore aquaculture, non-biological resources, marine renewable energy, coastal tourism, and maritime defense. The EU shipbuilding and equipment industry, especially in terms of cooperating with emerging industries, provides new opportunities, such as work support ships for offshore wind farms, marine structures and other marine technologies.

U.S.-related industry trends

The U.S. ocean transportation industry includes businesses engaged in ocean freight, ocean passenger services, ocean transportation services, warehousing and navigation equipment manufacturing, accounting for 15% of employment in the U.S. ocean economy (approximately 500,000 persons) and U.S. gross domestic product (GDP) 20.2% (approximately US$59.6 billion). Although the U.S. maritime industry accounts for a lower proportion of the marine economy in comparison with tourism, leisure, or offshore mining, it is an indispensable part of the marine economy. The goods carried by ships account for 34% of U.S. international freight trade by value, accounting for 73.4% by weight. In 2017, the average annual salary of each employee was the highest in the United States, reaching US$69,000 (approximately NT$1.93 million). The maritime industry provides approximately 21.1% of employment opportunities and 25.9% of GDP in California. The rest are distributed across the country, concentrated in major seaport areas. Warehousing is the largest component of employment in the maritime industry, accounting for 52.8% of the total employment in this industry in 2017 [8].

The shipbuilding and repair industry includes the construction, maintenance and repair of general ships, leisure boats, commercial fishing vessels, ferries and other marine vessels. The primary features of this industry are that large shipyards are concentrated in certain areas of the United States, but small ship construction and maintenance are more evenly distributed throughout the country, mainly in commercial fishing areas and areas where leisure boats are popular. In 2017, the shipbuilding industry accounted for 4.8% (approximately 160,000 persons) of employment in the U.S. marine economy and 6.6% of the U.S. GDP (approximately US$18.4 billion). The average annual salary per employee is US$69,000, which is much higher than the national average of US$55,000. In 2017, Virginia contributed the most to employment in the shipbuilding industry, accounting for 22.2% of the total shipbuilding industry in the country, whereas Washington State is the largest contributor to GDP in the shipbuilding industry, accounting for 21% of the total shipbuilding industry in the country [8].

Due to low sales profits of general cargo ships worldwide and high domestic labor costs in the United States, domestic shipyards in the United States mainly build U.S. Navy warships. Renowned civil construction shipyards such as Newport News Shipbuilding Company (NNS) [9] is the only shipyard in the United States that builds aircraft carriers and is also one of the two largest U.S. nuclear submarine manufacturers. Furthermore, some shipyards are not directly involved in the design and manufacture of new ships, but only undertake ship maintenance work.

Taiwan-related industry trends

Due to Taiwan's status as an island country, more than 95% of its import and export trade relies on shipping; as such, the marine transportation industry is the industry with the highest output value in Taiwan's marine economy (accounting for more than 40% of the marine industry's GDP) [10]. In 2019, Taiwan's international commercial ports accumulated 15,300,000 TEUs in terms of container throughput, while the cargo handling volume of international commercial ports is 730 million billable tons, which is slightly lower than in 2018, mainly due to the rise of ports in neighboring countries and the impact of the Sino-US trade war. Meanwhile, the number of inbound and outbound passengers at international ports is about 1.5 million. Among them, the number of international cruise passengers increased to 1.05 million, showing a gradual upward turn. The main reason is that Keelung Port has gradually transformed into a tourism and leisure, cruise transport, and actively sought to become a home port for international cruises, making the number of passengers hit a new high in recent years. In the same year, the container loading and unloading volume for direct shipping across the Strait was 2.49 million TEU, the loading and unloading volume for direct shipping across the Strait was about 120 million billable tons, the number of passengers for direct shipping across the Strait was about 2.28 million, and the number of passengers entering and leaving domestic commercial port was about 3.4 million [11], which shows that in conjunction with the development of outlying island construction policies, cross-strait and domestic maritime transport occupy a considerable proportion. In addition, important domestic carriers including container carriers Evergreen Marine and Yang Ming Marine Transport, etc., ranked 7th and 9th in transportation capacity globally in 2020 [5], and bulk carriers U-Ming Marine, Taiwan Navigation, China Steel Express, etc., play important roles in international cargo transportation [12].

Taiwan's large shipyards, with CSBC Corporation Taiwan (CSBC) as the representative (previously known as China Shipbuilding Corporation), focus primarily on manufacturing container ships, bulk ships, warships and special ships. After regeneration plans and privatization, the company now aims at diversified operations. Medium-sized shipyards including Jong Shyn Shipbuilding, LungTeh Shipbuilding, and San Yang Shipbuilding, mainly build coast guard cruisers, official ships, transportation ships, and ocean-going fishing vessels. In recent years, in response to Taiwan's national policies of building naval vessels and submarines domestically, the Ship and Ocean Industries R&D Center (SOIC) has cooperated with medium and large shipyards to successively undertake the design and manufacturing of many naval ships and submarines, thus reinforcing the vessel manufacturing abilities of Taiwan's navy. In addition, as Taiwan's climate is conducive to the production of yachts using glass fiber reinforced plastic (FRP) manufacturing technology, Taiwanese yacht manufacturers, such as Horizon Yachts, Monte Fino Yachts, Ocean Alexander and Tania Yacht, have been able to enter the market for super yachts with comprehensive services from OEM to customization. Today, the total length of orders for yachts manufactured in Taiwan has reached sixth in the world [13], showing that Taiwan's yacht manufacturing strength is recognized internationally. Ship propeller manufacturers, such as SOLAS, ZF Marine Group, and Hung Shen Propeller etc., specialize in the production of civil and military ship propellers. In recent years, to promote green energy and reduce waste gas emissions from coal-fired power station, the Taiwanese government has been actively building the offshore wind power industry in collaboration with the private sector, including shipyards and related mechanical and electrical industries, so as to increase Taiwan's energy independence rate. Overall, the output value of Taiwan's shipbuilding and maintenance industry was NT$42 billion in 2017 [14], while the number of employees in the shipbuilding and maintenance industry was approximately 25,000 [15].

Green shipping

To combat the greenhouse effect caused by the emission of greenhouse gases (GHG), the International Maritime Organization (IMO) was entrusted to undertake GHG-related emissions reduction in international shipping in the 1997 Kyoto Protocol, an extension of the 1992 United Nations Framework Convention on Climate Change. IMO started to work towards reducing GHG emissions in 2008, and began to implement emission regulations for international shipping on January 1, 2013. In 2018, IMO reached the first global agreement which specifies that, by 2050, total greenhouse gas emissions of the shipping industry will be reduced by at least 50% (compared to 2008). The specific method is to use Energy Efficiency Design Index (EEDI) to express energy consumption efficiency. The higher the EEDI index, the lower the energy efficiency. EEDI involves various design improvements in ship type, propeller, propulsion system and all kinds of carbon reduction equipment. IMO requires that new ships must undergo a model test within the towing tank to confirm that they meet EEDI emission standards before they can be built.

Furthermore, the IMO announced that the "Global Sulphur Cap" will be implemented on January 1, 2020 [1]. All ships must use low sulfur fuel oils (LSFO) with a sulfur content of less than 0.1% when navigating in the Emission Control Area (ECA); and when navigating in non-emission control areas, low-sulfur fuel oils with a sulfur content of less than 0.5% must be used to reduce sulfur oxides (SOx) emissions. The regulations will increase the fuel cost of marine vessels. Some ships have installed Scrubbers to reduce sulfur oxide emissions. The existing ECA includes the Baltic Sea (SOx, adopted in 1997; enforced in 2005), the North Sea (SOx, adopted in July 2005; enforced in 2006) [16], the North American ECA includes most of the United States [17], the Canadian coast (NOx and SOx, 2010/2012) [18] and the US Caribbean ECA, including Puerto Rico and the U.S. Virgin Islands (NOx and SOx, 2011/2014) [19]. Based on the agreement in Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), other areas can be added as emission control areas.

Conclusion

Ocean transportation is an important mode of transportation in international logistics that has driven the vigorous development of import and export trade, tourism and manufacturing. To effectively reduce pollution, moreover, the shipbuilding industry has introduced ship weather routing applications in conjunction with the maritime industry through innovative designs, reducing energy consumption through appropriate route planning. In the future, the marine transportation and shipbuilding industry will continue to adopt more flexible strategies in response to shifts in the global economy and climate change.

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The Current Developments and the Prospects in Taiwan's Marine Bio-Resources Industries

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Keywords: Marine ecology, fishery resources, biotechnology, marine spatial planning

Surrounded by the ocean with abundant marine resources, Taiwan has an advantage in developing "blue economy" marine industries. The so-called "blue economy" includes relevant economic activities based on marine industries, such as engineering and energy, marine chemistry and mining, marine bio-resources and leisure and relevant tourism industries. Under the concept of sustainable development, the "blue economy" emphasizes a rational use of marine resources in recent years. The development of bio-resource industry therefore plays an important role in this field, covering traditional utilization of fishery resources to emerging industries in marine biotechnology and tourism. Other relevant marine industries, such as marine engineering and energy, ship building and transportation, highlight the importance of marine ecosystem recovery and conservation as well. However, how to develop the marine bio-resource industry sustainably has become one of the most important issues when talking about "blue economy" marine industries.

Fry release for sustainable development of coastal fisheries
Images by Taiwan Ocean Conservation and Fishery Sustainability Foundation and Research Team of Professor Chen-Hsin Liao

Coastal and marine ecosystems are among the most productive ecosystems in the world, supporting the development of "blue economy" marine industries. Land resources are limited in Taiwan; therefore it is more important to emphasize sustainable use of marine biological resources and conservation through the reduction of pollutant and lowering impacts on marine ecosystem from human activities. Marine bio-resource industry is based on the use of marine organism, including biochemical technology to understand the mystery of marine ecosystem life, and advanced into further development and application in biotechnology, conservation and pharmaceutical industries. The exploitation and utilization of fishery biological resources needs to take into account of biodiversity conservation, with marine ecological environment assessment, in order to prevent over-exploitation of biological resources and seek the prefect balance between economic development and ecological conservation. Ecological management integrates ecological conservation, ecological tourism, planning and other tourism elements. Regional natural resources should be taken as the basis for the development of marine tourism industry to assist in the management of marine living resources and conservation due to human activities and development.

Marine bio-resources industry in European and American

The "blue economy" of the United States is dominated by six marine-related industries, including biological resource utilization, ocean engineering, ocean transportation, energy and mining, ship building and leisure tourism. After 2010, there has been a clear upward trend in terms of investment cases, employment opportunities, salary income, and product manufacturing and services. Compared with the level of 2016, the marine bio-resource utilization industry has the highest growth rate, including commercial fishing, aquaculture and aquatic product processing and marketing. Although the employment opportunities, salary income and product manufacturing for marine bio-resource industries only account for a small part of the overall U.S. economy, this industry supplies most of the aquatic products for consumption in U.S. in terms of their importance on product processing and marketing. In this regard, the productivity is similar to the highly productive agriculture industry in U.S. [1].

In the United States, under the concept of "blue economy" and "blue revolution", the utilization of marine life and aquatic resources is much important than before in order to maintain the health of coastal and marine ecosystems. Conservation of fishery resources and marine habitats and feeding grounds is also important in inheritance of the marine culture. Many traditional marine industries are based on related marine activities and utilization of biological resources. Currently the "blue economy" has been developed towards the field of "blue technology"; in general, blue technology can be defined as the design and provision of any technology and services related to improving the marine environment, such as navigational technology and ship building, ocean data collection and scientific research needed electronic instruments, mechanical technology and supporting software. This emphasizes that improving or reducing possible impacts through development of marine activities and practical actions, which contributes to the development of the overall "blue economy" through innovation in industries [2][3].

The biological resource utilization in the "blue economy" industries in EU focuses on the development of marine fisheries and coastal tourism. It emphasizes that economic activities must implement under sustainable management and adjustment to the environment, to reduce the impact of human activities on the ocean and strengthen recovery ability for the marine and coastal ecosystems. Directly related to the ocean, marine capture fisheries (including coastal artisanal and large-scale commercial fleets) and aquaculture fisheries (including seawater and freshwater aquaculture fish and shrimp) are regarded as the most important bio-resource industries of the "blue economy". Other bio-resource related industries include aquatic product production and processing, preservation and sales marketing, and the application of biological science and technology; more broadly speaking, this includes any economic activity that uses renewable aquatic resources, such as food additives, animal feed, pharmaceuticals, cosmetics and energy utilization, which establishes the blue bio-economy industry [4].

The production from capture fisheries of EU has continued to increase in recent years, which highly relates to the recovery of fishery resources, the increase in fish prices and the decrease in cost with more employment. As assessed by experts, this growth in economic performance can continue for couple of years [4]. However, these benefits and economic performance have not yet been achieved in the Mediterranean Sea basin where most fisheries have not yet moved towards sustainable fishing conditions. In comparison, the EU aquaculture production has stagnated over the last decades. Considering the increasing demand of seafood products in the EU, it seems reasonable to expect growth of aquaculture products in EU. At this stage, the EU marine biological resource industry is still dominated by renewable fishery resources, mainly supplying food, feed, biological-related products and processing, transportation and marketing, as well as bio-energy industries. The EU is now the top five suppliers and importers of aquatic products in the world, supporting the EU's overall aquatic product processing and transportation industry.

The most critical part of the "blue economy" is the implementation of the "Farm to Fork" policy. The conceptual basis is to ensure the environmental sustainability of the food supply system, which is used to change the food production and consumption system in the EU. The impact on the marine environment could be reduced to a minimum level, without lowering the safety, quality and supply of healthy food [4]. This policy implements every link of the food production and marketing industries, from production and processing to sales of food, as well as international trade, reducing unnecessary waste in transportation, storage, and packaging. This will be able to establish a new food system in EU, as a global standard of sustainability, contributing to the objective of making Europe the first continent by 2050. In addition, this strategy will continue to include actions to launch a process to identify new innovative food and feed products, such as seafood based on algae. European farmers and fishers are key roles to managing this transition in "blue economy" in the future. The "Farm to Fork" strategy will strengthen the efforts to tackle climate change, environmental protection, and biodiversity preservation, in particular during the current health and economic crisis. Sustainable food systems are resilient by nature and support economic recovery ensuring a fair transition to all [4].

The future "blue economy" potential fields include blue bio-economy and biotechnology sector and the non-traditionally exploited groups of marine organisms and their commercial biomass applications. These organisms comprise macro algae (seaweeds), microorganisms (microalgae, bacteria and fungi) and invertebrates (e.g., sea stars, sea cucumbers, sea urchins). Algae and invertebrates are important biological resources that support the bio-based sectors and the development of economic activities in coastal areas. Although some of these biomass sources have been traditionally been used as food, feed or fertilizers in the past, new commercial applications using these resources, are under development in recent years. The extraction of high-value bioactive compounds has the highest market potential, e.g., for pharmaceuticals and cosmetics. Other innovative applications are also in the pipeline such as biofuel, the production of biomaterials and bio-mitigation services. Algae and invertebrates have the potential to contribute the sustainability of the food systems and releases pressure off of overexploited marine resources, in addition to their commercial benefits, and also provide environmentally sound solutions by removing nutrients in excess from the water [4].

Marine bio-resource industries in Taiwan

Taiwan has been actively developing a "blue economy" industry in recent years. In addition to the traditional marine engineering and transportation industry, marine leisure and tourism are currently the emerging industries in this field. However, all of that rely on the sustainability of marine ecology and aquatic resources, which many tourism and events relating to cultural experiences in fishing village are based on. In Taiwan, the coastal fishery resources have been exhausted gradually during the past decades. Conservation of marine environment and ecosystem and increasing the fishery resources has become one of the important research at present. Taiwan could develop unique marine bio-resources industry in "blue economy" by taking the advantage of innovative biotechnology and fishery science integrated with traditional social and cultural resources.

Taking the demonstration area of coastal cultivation fishery or fish farming developed in recent years as examples, the concept of "blue economy" or the so-called "blue revolution" aims to integrate the natural environment, fishery resources, economic development and social culture, which potentially promotes the transformation of the original traditional fishing village and their economic industry and integrates with tourism and commercial resources. This makes the cultivation fishery demonstration area to be independently managed to reach the goal of sustainable development [5]. The Mao'ao cultivation fishery demonstration area in New Taipei City can serve as an excellent example at present, which involves the cooperation of government authorities, fishermen and fishermen's associations, as well as researchers and scholars. The marine environment and fishery resources of Mao'ao Bay could be recovered by improving marine ecological functions and increasing fishery resources. This makes the Mao'ao fishing village a successful demonstration area of cultivation fishery in symbiosis with slow living and customs fishing village [6].

The most important contribution of the cultivation fishery demonstration area is to increase and recover fishery resources, in which it is essential to investigate and monitor the status of released fish. For regularly released species such as black sea bream, grouper, snapper, and porgy in Mao'ao area, they are well adapted in the ecosystem in the demonstration area, through the real-time monitoring system and visual survey by scuba diving, as well as the observation of overspill for the released species and increasing number of investigated species in the area year by year. The fish community varies between winter and summer, which reveals that the released species in the demonstration area are well using the natural habitats in the area, as an evidence of the fish farming benefit [7].

One of the most important parts in developing "blue economy" is to drive the fisheries toward conservation and lead transformation in economy and sustainable development for local fishing villages. In addition to marine environment and ecosystem recovery and the increase of fishery resources, we could also promote the development of innovative industries and aquatic products with local characteristics. The Mao'ao fishing village could be an excellent example; with annual production at 30,000 kg, the gelidium has been assessed as a potential leisure industry full with local characteristics to be developed further, which producing more than 10,000 tourists and experiences in fishing villages every year. Cooperated with fishery production marketing and fishing village regeneration plan, we could further educate the fishermen to actively participate in fishery resource recovery and marine education to establish tourism-oriented leisure parks relating to fishery and "blue economy" bio-resource industries with local characteristics [6].

Except for the cultivation fishery demonstration area, Taiwan is also actively promoting the growth of the "blue economy" biological industry through the release of fry, and establishing a gene bank for the released fry to identify species and assess the risk of inbreeding depression and genetic structure of wild populations, as well as other related tests, cooperated with benefit assessment and relevant scientific research and investigation. We also evaluate the production contributed from fry release and relevant ecological, economic and social benefits according to the catch information and increased fishery resources [8]. In terms of assessment of suitable habitats and location to release fry, research team used habitat models to analyze the temporal and spatial distribution of released fry. Analysis of environmental factors such as habitat suitability of sea surface water temperature, chlorophyll concentration, depth and current speed, and catch at length information is conducted to provide scientific management suggestions for fry releasing policy. Taking black sea bream as an example, it is recommended that the most suitable release location is along the coast from Changhua to Chiayi from April to September, and coastal area off Miaoli from September to October. The fourfinger threadfin is suggested to be released in the coastal area from Yunlin to Chiayi from quarter 3 to quarter 4 of the year. It is better to release fish fry of the snubnose pompano in the coastal area of Chiayi in the third quarter of the year [9].

The innovation and application of biotechnology will be potential fields to develop future bio-resources industries. Polymorphic gene database and identification and testing standards will be established for targeting important released fry for wild and breeding species, which could be used to assist and benefit the assessment of fry release, and clarify the concerns of genetic risk and inbreeding depression. Numerical analysis results of genetic diversity for regularly released fry show that most groups are in a state of hybridization, with high degree of genetic diversity and low risk of inbreeding depression and genetic risk. It is demonstrated that the increased coastal fishery resources could provide opportunity for the marine ecosystem to recover [10].

On the other hand, Taiwan is also actively developing breeding technology for key cold-water species. Under the goal of energy saving, carbon reduction, effective use of energy and promotion of the transformation of the aquaculture industry, a new type of fish farming using cold energy produced from coastal Liquefied Natural Gas (LNG) plant is the current "blue economy" emerging bio-resource industry. This includes the development of new type breeding model with breeding technology for high-priced cold-water species, such as Atlantic salmon, sea cucumber, abalone, sea fungus, flounder and algae. Implementation of the policy could reduce the import of cold-water fish product and alleviate the pressure of over-utilization of land resources and groundwater. The goal is to establish a marine science and technology park to help the promotion and improve the environment for "blue economy" bio-resource industries, which strengthens the competitiveness of Taiwan's unique marine aquaculture industry [11].

Conclusion

Every sector in "blue economy" relies on the support and outputs from the other sectors. For example, the development of offshore marine energy, transportation, coastal tourism, bio-technology and aquaculture highly depend on healthy marine ecosystems and the sustainable use of fishery resource. The impact of marine activities should be reduced to a minimum level following the concept of environmental sustainability. Many fields have been considered with great potential to be developed as future core industries in "blue economy", such as offshore wind power, oil and gas extraction, marine aquaculture and bio-technology and recreational fisheries. There are multiple competitions and cooperation among sectors in the use of marine space. Marine spatial planning (MSP) could be used as a powerful and suitable tool to solve the conflicts and problems from different sectors, reaching the balance between economic development, environmental protection and resource utilization.

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EU's Emerging Marine Industries: Moving Beyond Traditional and Toward Technology-Driven Industries

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Keywords: EU, technology, innovative marine industries

Marine industries are diverse with traditional ones being commonly known by the public such as fisheries, maritime transport, port activities, shipbuilding and repair, fixed offshore wind and coastal tourism. Besides, developing these traditional blue economy activities, the European Union (EU) has launched to develop technology-driven innovative marine industries: marine renewable energy, blue bioeconomy, marine minerals, desalination, maritime defence, and submarine cables. This article provides an overview of these emerging industries, including the challenges faced and the potentials of their future development. (Most content of this article is excerpted from 'European Commission (2020). The EU Blue Economy Report 2020. Publication Office of the European Union. Luxembourg.')

Marine renewable energy

The marine renewable energy sector utilizes different technologies for the production of renewable energy: offshore wind (fixed or floating offshore wind), wave and tidal energy, floating solar energy and offshore hydrogen production. Fixed offshore wind has developed advanced technology. Other technologies are at an early stage of development, with a significant focus on technology research and development as well as commercialization. The market and supply chains of these technologies are not yet consolidated.

I. Floating offshore wind

Floating offshore energy is a growing sector that is strengthening Europe's leadership in ocean energy. With a total installed capacity of 45 MW in 2019, Europe's floating wind fleet is the largest worldwide (70%). The development and commercialization of floating wind technology will open up the possibility to harvest the most resourceful wind energy sites in Europe. Nearly 80% of the wind in Europe blows in waters that are at least 60 meters deep, where it is too expensive to fix structures to the bottom of the sea. It is estimated that the potential for floating offshore wind in Europe is about 4,540 GW, of which 3,000 GW would be located in deep sea locations (water depth between 100 m and 1,000 m). Moreover, the majority of shallow offshore regions for conventional offshore wind deployment are located in North and Baltic Seas that are not adjacent to this region.

Floating offshore wind employs a floating device anchored to the seabed, such as spar-buoy, semi-submersible platform, tension-leg platform (TLP), barge, and multi-platforms substructures. So far, no concept prevailed over the others. However, spar-buoy concept has already been deployed in a commercial project (the 30 MW Hywind Scotland). It is noted that through various instruments of EU-funding, several floating offshore wind technologies were brought from concept to a pre-commercial stage. This is pivotal, particularly when demonstrating the technology's capabilities in a deep water setting as in the case of a 2 MW floating prototype in France (Floatgen Project) and a 25 MW floating wind farm in Portugal (WindFloat Atantic).

Major challenges for the development of floating offshore wind are high investment and finance cost, and its future development must lower costs and increase output. Currently only 40 MW of floating wind capacity are operational. A further 300 MW are planned to be deployed between 2020 and 2022.

II. Wave and tidal energy

The potential of wave and tidal energy in Europe is vast, thus can play a key role in decarbonizing energy supply and increasing energy security and fueling economic growth in coastal regions. The theoretical potential of wave energy in Europe is about 2,800 TWh annually, whiles the potential for tidal current was estimated at about 50 TWh. It is expected that in the short-medium term (up to 2030), ocean energy development in the EU will be largely dependent on the deployment of tidal and wave energy converters.

At the end of 2019, the total global ocean energy installed capacity was 55.8 MW, with most of it located in EU waters (39.5 MW). The EU is the global leader hosting with 58% of the number of tidal energy technology developers and 61% of the wave energy developers. The development of ocean energy technologies is still primarily at the R & D stage, nevertheless some technologies have already progressed towards first-of-a-kind demonstration and pre-commercial projects. Tidal energy particularly had made the most significant stride forwards with over 50 GWh of electricity generated from demo projects. In contrast, wave energy technologies are lagging behind tidal energy in terms of performance, especially in terms of electricity generation.

Between 2007 and 2019, total R & D expenditure on wave and tidal energy amounted to a total of €3.84 billion with the majority of it (€2.74) coming from private sources. The continuous development of wave and tidal energy technologies and the reduction in technology costs are expected to lead to a significant increase of the deployed ocean energy capacity in the near future. Market scenario assessments from the international Energy Agency (IEA) show that the total European wave and tidal energy installed capacity could range between 0.5GW and 2.6 GW by 2030.

III. Floating solar photovoltaic energy

Floating solar photovoltaic (FPV) installations open up new opportunities for employing conventional photovoltaic installations whilst reducing the impact on land. FPV consists of a floating structure on which traditional solar panels are installed. To date, most FPV structures have been installed on lakes and in the proximity of hydro-power reservoirs.

Deploying FPVs at sea requires overcoming a number of challenges related to the survivability of the structure at sea, as well as understanding the influence of the marine environment such as of algae growth, pollution, and slat deposits on the conversion system. At the end of 2019, the state of the art of FPV offshore is predominantly at R & D and demonstration phase. Demonstrations are taking place in the Netherlands (Oceans of Energy, TNO) and in France (HelioRec), with the projects designed to validated technology design, to prove its efficiency conversion and survivability in harsh conditions. In terms of survivability, the 17 kW system designed Oceans of Energy, has withstood different storms with waved above 5 m high. In addition, developers are now looking to expand the project to reach a power rating of 50 kW.

A number of challenges remain to be addressed in order to facilitate deployment of FPV at a commercial scale such as long-term reliability, costs, integration in the grid system and the deployment of substations. In particular, the technical viability in the harsh and remote environment and the potential for FPV production costs still needs to be demonstrated. Furthermore, a key step required for the commercialization of FPB at sea is the assessment of its potential contribution to the EU Green Deal, and the interaction with other maritime uses to identify ideal sites for deployment.

IV. Offshore hydrogen generation

The generation of hydrogen offshore has a number of advantages. Hydrogen transportation and storage can be done at a large scale and a relatively low cost. Furthermore, offshore oil and gas platforms could be re-purposed for renewable hydrogen production. However, the foremost technical challenge is the development of an electrolyser module, which is compatible with the ocean environment, able to operate effectively and achieve high rates of hydrogen production when coupled with intermittent renewable power. A number of projects are already exploring the possibility of specific options for the coupling of offshore energy and green hydrogen production. For example, ITEG project combines the 2 MW tidal turbine with a 500 kW hydrogen electrolyser and an onshore energy storage and management system.

Blue bioeconomy

The blue bioeconomy and biotechnology sector (collectively called bioeconomy) refers to the non-traditionally commercial applications of marine organisms, which are different from the traditional applications such as food, feed or fertilizers. These organisms comprise macroalgae (seaweeds), microorganisms (microalgae, bacteria and fungi) and invertebrates (e.g., sea stars, sea cucumbers, sea urchins). The extraction of high-value bioactive compounds has high market potential e.g. for nutra/and pharmaceuticals as well as cosmetics. Other innovative applications are also seen in the production of biomaterials or biofuels. Besides their commercial benefits, algae and invertebrates have the potential to contribute to the sustainability of the food systems, release pressure off of overexploited marine resources, and remove nutrients in excess from the water, providing environmentally sound solutions.

The EU is supporting innovations of local action through the design and implementation of Smart Specialization Strategies. To date, 12 Members States and 53 regions present linkages to the blue biotechnology in the Smart Specialization Strategies. The topics covered is broad, including energy production (e.g., microalgae biodiesel production), agriculture (e.g., microalgae capable of handling liquid manure), climate change (e.g., production of new microalgae products, increasing CO_2 capture capacity), medicine (e.g., algae as nutrition component that strengthens the immune system in humans and animals), environmental remediation (e.g., treating waste water with microalgae bacteria), and biomaterial.

However, this emerging sector still faces several challenges and constraints. Among the most commonly cited are: complexity of the regulatory and administrative procedures, small size of the market, consumers' awareness and acceptance, lack of reward schemes for the provision of environmental services to the marine ecosystems, lack of European origin certification and harmonization of market requirements, the need for funding mechanisms, and the optimization of the production chain to reduce waste.

Desalination

Desalination is a common technology and an alternative for water supply that can alleviate the growing pressure on freshwater resources. It is used to overcome water shortages in areas where freshwater resources are limited, such as in big coastal cities (e.g., Barcelona and Alicante in Spain) and islands. In the long term, it is expected that with the impact of climate change on freshwater availability, demands for desalination and other water management solutions (e.g., water reuse) will increase. In particular, by 2050, many regions in the EU are expected to face severe water scarcity, including the coastal Mediterranean regions as well as regions in France, Germany, Hungary, Northern Italy, Romania and Bulgaria.

In 2019, there were a total of 1,573 desalination plants, producing a total of 6.9 million cubic meters per day (2.5 billion m^3/day) of fresh water. 74.2% of the desalination capacity is located in the Mediterranean Sea basin, with 821 facilities supplying 5.1 million m^3 /day of freshwater. Among the freshwater produced by desalination facilities, 64.4% is for public consumption managed by the municipalities, 24% for industrial applications, 9.5% for irrigation purposes, and 2.1% for the production of drinking water to serve tourist facilities.

Reverse Osmosis (RO) is currently the most widely used desalination technology in Europe with 85.5% of total capacity using this technology. Capital and operational costs associated with desalination plants depend on a number of factors, including the dimension of the plant, the type of technology employed, and the salinity of the water to be treated. The costs determine the price of water. The average cost of one cubic meter of desalted water produced using RO technology is of €0.86. This means that the daily cost of supplying 5.9 million m^3 of desalted water in the EU with RO is of €5.1 million, or €1.86 billion a year. The total cost of desalination is estimated at €2.2 billion year when including all technologies. Most of European facilities have been designed and built by European engineering firms. However, when it comes to the key component such as RO membranes, the market is dominated by non-European players. The EU contribution to R & D on RO is only 5% of the inventions.

Marine minerals

Marine minerals include sand and gravel, metals (e.g., manganese, tin, copper, zinc and cobalt) and chemical elements dissolved in seawater (e.g., salt and potassium). While the extraction of sand is a long established activity, the extraction of other minerals and metals is an emerging sector. In particular, high tech metal play a critical role in the development of innovative environmental technologies for boosting energy efficiency and reducing greenhouse gas emissions. However, the extraction of minerals and metals, in seawater and on the seabed, has several challenges to face, including the mapping of reserves, developing appropriate technology, and taking adequate mitigation and management measures to deal with the irreversible environmental impacts.

As of the end of 2019, the International Seabed Authority (ISA) has 30 contracts/licences into force for exploration. They are allocated to eight explorative areas, spread across the Atlantic, Pacific and Indian Oceans. Among the EU Member States, Belgium, France, Germany, Bulgaria, Czechia, Poland and Slovakia have sponsored licences in the Atlantic. For the time being, no commercial deep seabed-mining project exist in the Area (The Area refers to the seabed and its subsoils beyond the limits of national jurisdiction.) nor in the areas under national jurisdiction of the EU Member States. Although the industry players have in general expressed confidence in future developments, the outlook for seabed mining at great depths (e.g., the seabed rich of cobalt and manganese deposits occur at depths of about 800-2,500 meters) remains uncertain. In particular, the extent to which the seabed will be tapped of its resources on a commercial scale, the high costs, and the potential environmental impacts and its sustainability are still unclear.

Marine Defence

The focus of the marine defence sector is navies. European navies account for at least 564 commissioned warships with a total tonnage of 1.5 million. According to data from the European Defence Agency, the total number of maritime personnel was estimated at 177,090 in 2017, showing a decrease from 2006 (277,309).

The yearly expenditure is more than €10 billion for naval shipbuilding and more than €4 billion for maintenance and repair. The naval shipping industry is an innovation-driven industry and is one of the sectors with the highest investment intensity in research, development and innovation (RDI). 8.7% of naval industry sales is invested in RDI every year.

The economic benefits and job opportunities brought from the navies are considerable. For instance, for every €1 invested in the Navy, €2.3 are generated for the Spanish economy. Additionally, it increases gross value added by €2.2 and multiplies employment by 2.3. These figures are higher than those for the entire Spanish public administration.

Submarine cables

Submarine cables are critical infrastructure, channeling more than 99% of international data transfer and communication, including more than €10 trillion in daily financial transactions. It is important for the EU's economy as well as the global economy. There are 378 cables in service in 2019, spanning over 1.2 million kilometers globally, with 205 ones connected to EU Member States.

In general, submarine cables are designed to last 25 years; however, because cables with a greater capacity continue to be released at lower cost, they are often replaced or abandoned before the end of their life cycle. The ways to deal with submarine cables that are no longer used include: 1. cables remain on the ocean floor in an inactive state, 2. cables are recovered and recycled for their raw materials, and 3. cables are repositioned to new routes. Most of the EU submarine cables were laid in the early 2000s or before, indicating that these cables will be replaced in the next years.

Cable ships are mainly used to lay and repair submarine cables. Most cable ships are equipped with remotely operated vehicles (ROVs) and ploughing equipment to carry out their repair and cable-laying services. There are 54 cable ships worldwide. Out of 54, 21 ships are registered in the EU. In light of this, the EU plays an important role in the submarine cable sector.

Conclusion

The EU foresightedly develop technology-driven marine industries, demonstrating its emphasis on the utilization of marine resources (living and non-living). This is in line with the EU Marine Strategy Framework Directive, which sees the seas as an asset with economic potentials.

Taiwan is surrounded with the sea. While we have long developed traditional marine industries, it is right to take steps to develop technology-driven marine industries, particularly the offshore floating wind and floating solar photovoltaic. In light of this, we should continuously watch recent technological progresses in various marine industries globally and in the EU and keep a close eye on the cases. Additionally, we should prioritize the research on critical technologies, develop the technologies and the associated equipment that are suitable for the development of marine industries, and just as the EU, similarly care about marine ecological and environmental issues. By doing so, the development of innovative and technology-driven marine industries will be progressively carried out.

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International Blue Economy Policy Trends Under the COVID-19 Epidemic

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Keywords: COVID-19, blue economy, sustainable development, climate change

Since the beginning of 2020, "Severe Pneumonia with Novel Pathogens (COVID-19)" has triggered a global pandemic, rapidly spreading to multiple countries across the globe. Based on the literature provided by international organizations, this article summarizes the international blue economy policy trends that have emerged under the epidemic in hopes of providing Taiwan with a basis for promoting blue economy policies in the future.

Introduction

According to World Health Organization (WHO) statistics [1], as of January 26, 2021, 224 countries and regions around the world have accumulated a total of more than 98.79 million confirmed cases. The COVID-19 epidemic has severely hit the global economy and trade. According to the World Bank's January 2021 estimate, the global economic growth rate in 2020 will be negative 4.3% [2]. Besides, the United Nations Conference on Trade and Development (UNCTAD) estimates that the COVID-19 epidemic has caused a 27% drop in overall global trade in 2020 [3].

UNCTAD [3], the Organization for Economic Cooperation and Development (OECD) [4], and the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) (2020) [5] believe that although, during the COVID-19 epidemic, marine tourism, maritime shipping, fishery and other blue economy-related industries suffered the significant impact, opportunities for the development of the blue economy have also arisen.

Creating a healthy marine environment and promoting resource sustainability are the foundations for developing the blue economy. During the COVID-19 epidemic, we must strengthen the economic, social, and environmental resilience of the blue economy, reduce its vulnerability, and solve environmental issues such as marine plastic waste, marine chemical pollution, greenhouse gas emissions, and resource over-exploitation to ensure sustainable development of marine ecology and marine industries, thus gradually achieving the carbon reduction goals advocated by the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement. At the same time, as promoting the blue economy can also accelerate the recovery of the global economy, the above-mentioned international organizations have successively proposed blue economy green growth measures and priority measures [3][4][5].

Blue economy green growth measures are cost-effective and helpful to economic recovery and are worthy of prioritizing. According to an analysis conducted by the Ocean Panel in 2020, the return on investment of sustainable blue economy solutions is about 500%; for every US dollar invested, at least 5 US dollars can be obtained. Specifically, between 2020 and 2050, if global investments of US$2 to 3.7 trillion are placed in the four areas of restoration and conservation of coastal and marine ecosystems, offshore wind power, maritime carbon reduction measures, and sustainable fisheries, these efforts will generate economic, environmental and health benefits as high as US$10.3 to 26.5 trillion. It is estimated that there will be a return on investment of as high as 400 to 615% (calculated based on a 30-year net benefit of US$8.2 to 22.8 trillion) [5][6].

This article summarizes the international blue economy policy trends that have emerged under the COVID-19 epidemic in hopes of providing Taiwan with a basis for promoting blue economy policies in the future.

International blue economy policy trends under the COVID-19 epidemic

I. Green growth measures for the blue economy

UNCTAD (2020) proposes that the promotion of a sustainable blue economy under the COVID-19 epidemic will help maintain the marine ecosystem's functional integrity and contribute to economic growth and increased employment. Specifically, the government is recommended to transition towards a sustainable blue economy and strengthen various green growth measures in the marine industry [7]:

[I] Rethinking fishery subsidies and transitioning to supporting the sustainability of small-scale responsible fisheries

More than 200 million people are employed globally to capture fisheries, with nearly 90% of fishers living in developing countries. At present, in order to take care of the livelihoods of capture fishers, governments of various countries subsidize fishery fuel with preferential oil prices. However, since the COVID-19 epidemic, international oil prices have been at a low point in recent years, fishing costs have gradually decreased, and fishery trade has decreased. Government agencies are therefore recommended to rethink the applicability of fishery subsidies and consider replacing old and inefficient fishing boats with new ones, supporting small-scale responsible fisheries and sustainable governance to promote the sustainable development of capture fisheries.

[II] Promoting coastal and marine tourism 2.0 measures to ensure sustainable development

Tourism is one of the critical economic sources of small island developing countries (SIDS). As the COVID-19 epidemic has led to a significant reduction in the number of international arrivals, which has caused a significant impact on the tourism industry of SIDS countries, these countries are recommended to promote coastal and marine tourism 2.0 measures that focus on implementing various sustainable development measures for marine tourism, including integrating the local ecological environment and cultural characteristics, and developing eco-tourism, low-carbon sightseeing and experience activities.

[III] Digitalized maritime shipping trade procedures and processes

Due to the global supply chain crisis caused by the COVID-19 epidemic, UNCTAD has proposed 10 action plans to enhance the convenience of international trade and transportation, including ensuring uninterrupted shipping, keeping ports open, protecting international trade of critical goods, and speeding up customs clearance and trade facilitation, facilitating cross-border transport, ensuring the right of transit, safeguarding transparency and up-to-date information, promoting paperless systems, addressing early-on legal implications for commercial parties, protecting shippers and transport service providers alike, and prioritizing technical assistance [8].

If the above action plans include the introduction of digitalized measures, this will greatly enhance trade facilitation in the maritime industry. For instance, the "Automated System for Customs Data (ASYCUDA)" has assisted in more than 100 countries and regions with digitalized one-stop services, modernized customs declaration systems, and digital trade solutions.

II. Five priority measures for the blue economy (Ocean Panel)

The Ocean Panel (2020) has proposed five priority measures for the blue economy under the COVID-19 epidemic. As the cost-effectiveness of these five priority measures is higher than other measures, they are worthy of prioritizing [5]:

[I] Restoring and preserving coastal and marine ecosystems

Coastal habitat protection, wetland maintenance, ecological afforestation projects, coral and algal reef conservation, and other coastal and environmental restoration and conservation projects help maintain the functional integrity of coastal and marine ecosystems, reduce the impact of floods and storm surges, filter and improve water quality, and enhance the productivity of small and aquaculture fisheries. Governments are advised to utilize public finance, government bonds, or private investment to direct funds toward the restoration and preservation of coastal and marine ecosystems, which will bring long-term development potential for eco-tourism, fishing, and coastal community development.

[II] Investing in coastal and marine ecosystem restoration and protection

Sewage drainage and wastewater treatment are directly related to eutrophication. If not properly treated, over the long term, they will lead to water-borne diseases, loss of fish resources, damage to sea ecology, etc., threatening public health, food security, and industrial development. The government is advised to adopt a dual-track approach of both incentives and supervision. The former includes budgeting public funds to improve sewage drainage and wastewater treatment infrastructure. Simultaneously, the latter entails reinforcing the management of specific high-polluting industries, implementing coastal buffer measures, reducing the use of inefficient fertilizers and chemicals, etc.

[III] Promoting sustainable community-led marine aquaculture

Sustainable community-based marine aquaculture is a future development trend characterized by a self-supporting system formed by the community. It conserves water and energy, reduces the input of feed, fertilizer, and pharmaceuticals, helps maintain the ecological system of the aquaculture environment, and improves the efficiency of marine aquaculture, thus realizing sustainable development. The government is advised to assist in optimizing the mariculture environment by providing subsidies or preferential financing measures, thereby encouraging sustainable community-based marine aquaculture. Emerging marine aquaculture technologies, on the other hand, require the establishment of a capacity building and training mechanism as well as community exchange platforms to enhance the development of sustainable community-based marine aquaculture jointly.

[IV] Stimulating Investment in zero-emission marine transport

As global trade relies primarily on maritime shipping, and shipping is a relatively low-cost means of transportation, if the shipping industry can gradually replace old vessels with low-carbon ships and equipment using natural gas fuel, hydrogen energy, electricity, and power storage facilities, this will contribute to reducing the carbon emissions of maritime shipping and mitigate ocean acidification. Government agencies are advised to promote financial incentive policies such as subsidies, financing concessions, tax cuts, and investment incentives, or give priority to policies such as promoting the use of low-carbon public ships, encouraging private companies to invest in low-carbon boats and related equipment, and building low-carbon port infrastructure.

[V] Developing Sustainable Ocean-based renewable energy

According to statistics released by the International Energy Agency (IEA) [9], due to the promotion of green energy and low-carbon policies by countries worldwide, the global offshore capacity of installed wind power will grow by 15-fold in the next two decades. The marine renewable energy industry will create green employment opportunities and empower industries related to marine renewable energy, such as marine engineering, offshore engineering, engineering ships, and marine technology. As such, the government should formulate clear and consistent policies and promote fiscal and financial measures to encourage the marine renewable energy industry's development.

Conclusion

While the COVID-19 epidemic has caused an impact on sectors of the blue economy such as marine tourism, shipping, and fisheries, it also presents new opportunities for the development of the blue economy. Internationally, blue economy policies encourage transformation, innovation, and moving towards sustainable and low-carbon development of the marine environment to gradually achieve the UN SDGs and the Paris Agreement's goals. At the same time, these policies can serve as a driving force for the recovery of the global economy.

Taiwan's intermediary results of the blue economy in the marine tourism and recreation, shipping, and fishery industries have been achieved. Still, its performance in internationally recognized emerging marine industry sectors such as marine biotechnology, marine renewable energy, marine water technology, and marine engineering exhibits considerable room for growth. Going forward, related agencies are advised to refer to international blue economy policy trends that have emerged under the COVID-19 epidemic, review the "Salute to the Seas" policy on a rolling basis, and formulate plans to promote the transformation and innovation of marine industries that constitute the blue economy. (References: see P.30)

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