African Union

Africa Blue Economy Strategy

(Annex 4: Sustainable Energy, Mineral Resources and Innovative Industries in the context of Africa Blue Economy)

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Acronyms

AUC	African Union Commission
AUVs	Autonomous underwater vehicles
bbl	Barrel
COMELEC	Comité Maghrébin de l'Electricité / Maghreb Electricity Committee
CNG	Compressed Natural Gas
DoE	United States Department of Energy
EAPP	Eastern African Power Pool
EBSA	Ecologically significant areas
EEZ	Exclusive Economic Zones
FPV	Floating Solar Photovoltaic
FSRUs	Offshore floating storage and regasification units
GDP	Gross Domestic Product
GWp	Gigawatt-peak
GWh	Gigawatt-hour
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature
LCOE	Levelized Cost of Electricity
LPG	Liquefied Petroleum Gas
M&E	Monitoring and Evaluation
NREL	United States National Renewable Energy Laboratory
OTEC	Ocean thermal energy conversion
OTR	Ocean Thermal Resources
PV	Photovoltaic
R&D	Research and Development
RED	Reverse Electro Dialysis
REEs	Rare earth elements
REmap	Renewable Energy Map
RES4MED&Africa	Renewable Energy Solutions for the Mediterranean and Africa
SAPP	Southern African Power Pool
SDG	Sustainable Development Goals

SSA	Sub-Sharan Africa
TCM	Trillions of cubic meters
TWh	Terawatt hour
UfM	Union for the Mediterranean
UNECA	United Nations Economic Commission for Africa
USAID	United States Agency for International Development
UUVs	Unmanned underwater vehicles
WEC	Wave Energy Conversion

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Prof. Ahmed El-sawalhy
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Context and Outlook

Context

This strategy focuses on three sectors of blue economy such as sustainable blue energy, mineral resources and innovative industries. Sustainable blue energy is a rapidly growing sector of the blue economy, which includes renewable and none-renewable energy sources. The sources of renewable blue energy include wave, tidal, river, lakes, thermal, salinity and algae-based energy, and the non-renewable blue energy include oil and gas. While the land-based water bodies can provide small and pico-hydropower, they also provide a platform for another emerging energy technology such as floating solar photovoltaics (FPV). These energy technologies, which has a potential of providing electricity, are not yet fully integrated in the energy mix portfolio in Africa. Thus, the oceans, seas and inland water bodies of Africa offer tremendous potential in which only a fraction has been exploited until now. Ocean mining such as deep-seabed and seawater mining of several minerals is another form of blue economy which can substantially contribute to the economy of many African countries. In tapping the potential of sustainable blue energy, mining resources, and other blue energy sectors, the development, application and transfer of innovative technologies is critical, which could accelerate their benefits. Thus, this strategy is expected to increase the integration of sustainable blue energy in the conventional national renewable energy mix and help advance the exploitation of deep-seabed and seawater-based minerals and accelerate the application of innovative industries for job creation and economic development of the continent. The overarching three major drivers of sustainable blue energy, mining resources, and innovative industries are to increase (i) access to electricity to meet the increasing demand, (ii) meeting global demand for minerals and economic development, and (iii) optimizing the blue economy benefits, respectively.

Sustainable Blue Energy for Addressing Energy Demand

Energy demand is on a steep rise and one of the clearest drivers is population growth. It is expected that by 2100 African population could reach 4.7 billion, which will make up about 40% of the forecasted global population of 11 billion . Except in Northern Africa and South Africa, where they have access to electricity, in the rest Sub-Saharan African (SSA) countries, currently, about 600 million have no access to electricity and about 780 million relays on solid biomass for cooking . While progress has been made in increasing access to electricity in many SSA countries, the number of people living without access is on the rise. The ongoing electrification efforts are outpaced by rapid population growth which is expected to be more than double by 2050 . Following current demographic and economic trends as well as national energy plans, by 2030 the total primary energy demand in SSA is expected to grow by 30% . The overall energy demand from the oil and gas sector in Africa for 2030 will also substantially increase (Figure 1).

Probably, one of the overlooked energy demands is energy demand for inland mining. Electricity demand for inland mining represents half of the total electricity demand in the region as a whole, while in countries such as Liberia, Guinea, Mozambique and Sierra Leone consumes as much as three times the amount of electricity used by the other sectors together . Thus, if energy requirement for deep-seabed and seawater mining is included, energy demand will increase.

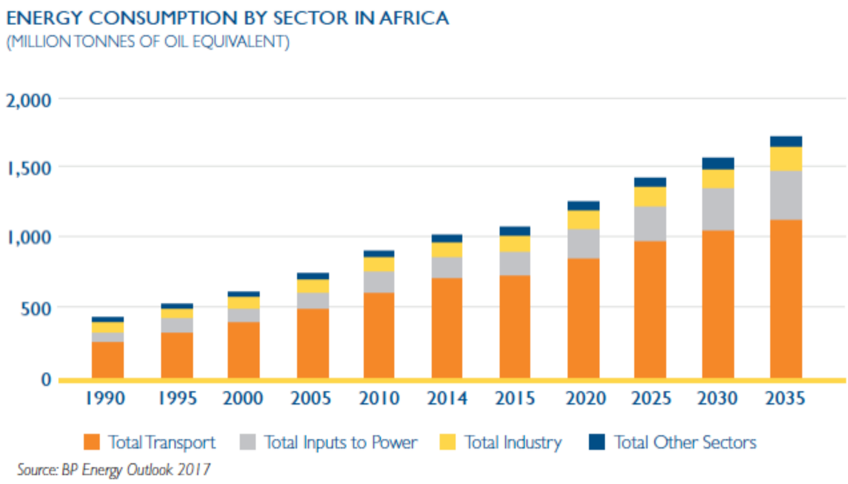

Figure 1: *Energy Consumption by Sector in Africa (Million Tonnes Oil Equivalent)*

Compared to renewable energy contribution of about 5% in 2013, it is expected that renewable energy technologies could supply about 22% of Africa's total final energy consumption by 2030 (Table 1). Electricity demand in Africa is projected to triple by 2030 requiring about USD 70 billion per year investment between now and 2030. Two thirds of the total investments in generation capacity, or up to USD 32 billion per year could account for renewables. It is expected that hydropower and wind capacities could reach about 100GW each and solar capacity over 90GW (Table 1).

Table 1: *Renewable energy use in 2013 and REmap Options for 2030*

Power Transformation Sector (TWh)			
	2013	**2030**	**2030 (GW)**
Hydropower	97	402	101
Solar PV	0	70	31
CSP	1	160	38
Wind	2	304	101
Geothermal	2	21	3
Distributed solar PV	0	46	24
Biomass	5	37	8
Biomass industrial residues (own production)	5	17	4
Share of renewables except hydropower	2%	30%	
Share of all renewables	17%	49%	
Total Energy Consumption			
Share of renewables	56%	32%	
Share of modern renewables	5%	22%	

In order to meet the increasing energy demand and increase access to electricity, the addition of sustainable blue energy resources in the national energy mix is important. It could also play a critical role in meeting the sustainable development goals (SDG7):ensure universal access to affordable, reliable and modern energy services (SDG 7.1); increase substantially the share of renewable energy in the global energy mix (SDG 7.2); double the global rate of improvement in energy efficiency (SDG 7.3); enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology (SDG 7.a); and expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programs of support (SDG 7.b). Thus, unlocking the sustainable blue energy potential and incorporating it in the national energy portfolio could help meet the increasing energy demand for economic development and achieve the 2030 SDG and Africa Union's 2063 objectives of making prosperous Africa.

Ocean Mining for Economic Development

Mining is the single largest industrial activity in the subcontinent, contributing significantly to fiscal revenues and GDPs. Though mining is generally associated with weak direct employment compared to its contribution to GDP and fiscal revenues, it has the potential for large local impacts that can foster change in local economies. As the demand for minerals is increasing to produce various advanced technologies, deep-seabed and seawater mining is becoming an attractive frontier to meet the demand, which could substantially contribute to the national economic development.

Innovative Industries for Accelerating Economic Development Benefits

Optimizing the impact of sustainable blue energy, and ocean mining resources and other blue economy sectors on national economic development requires the use of advanced and innovative industries. Using an outdated technology will not make the outcomes competitive. In this regard, the application and transfer of innovative industries in all sectors of blue economy in general and sustainable blue energy and ocean mining in particular, whenever applicable is critical to optimize their economic, social and environmental benefits. The application and transfer of innovative industries should also be based on research and development, which should be integrated in this sector.

Outlook

This section provides a preliminary assessment of the potential of sustainable blue energy, mining resources and innovative industries in Africa, which could be used as a bases for developing a strategy to meet the energy demand, economic development needs and accelerate economic benefits.

Sustainable blue energy potential

Africa has huge untapped sustainable blue energy potential including offshore wind energy, floating solar photovoltaic (FPV), wave and tidal energy, hydropower energy (small and pico), ocean thermal energy conversion (OTEC), salinity gradient energy, marine algae biofuels, and oil and natural gas. In order to develop sound strategy with concrete targets, a brief description of Africa's sustainable energy potential is discussed in this section. It should be noted that from global perspective, though electricity generation from marine technologies increased an estimated 3% in 2018, the technology is not on track with the Sustainable Development Scenario (SDS), which requires a much higher annual growth rate of 24% through 2030 (Figure 2). Africa should not be left behind in progressing along with the globally ocean energy implementation targets.

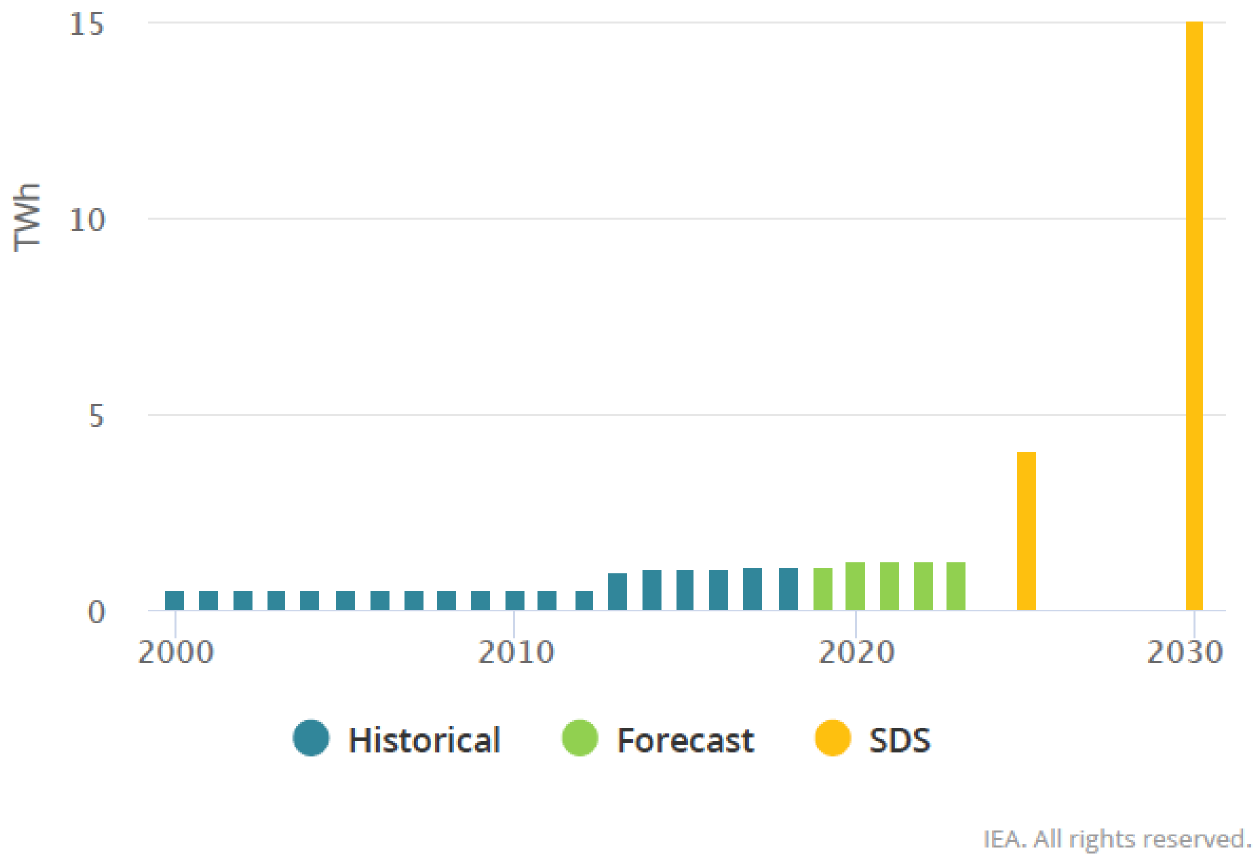

Figure 2 : *Ocean Power Generation*

Offshore Wind Energy

One third of the African coastal could have a very good wind resources potential which include Mozambique, South Africa, Somalia, Madagascar and Morocco. More than 90% of offshore wind resources are concentrated in three African Power Pool regions such as the Southern African Power Pool (SAPP), the Eastern African Power Pool (EAPP), and the Maghreb Electricity Committee (commonly known as the Comité Maghrébin de l□Electricité (COMELEC)) (Figure 3).

Though the Levelized Cost of Electricity (LCOE) of offshore renewable energy resources is still higher compared to conventional power generation, with a growing interest in offshore resources and considering the capacity of offshore renewable resources, they are anticipated to contribute a larger share of electric power in the next decade . Offshore wind energy can also be used for the production of hydrogen, which could be transported through existing offshore gas pipeline infrastructure or new gas pipelines to the demand centers . In order to harness such a potential, in addition to country specific initiative, it is recommended that a joint regional approach specifically in the three power pools could offer not only national but also regional benefits.

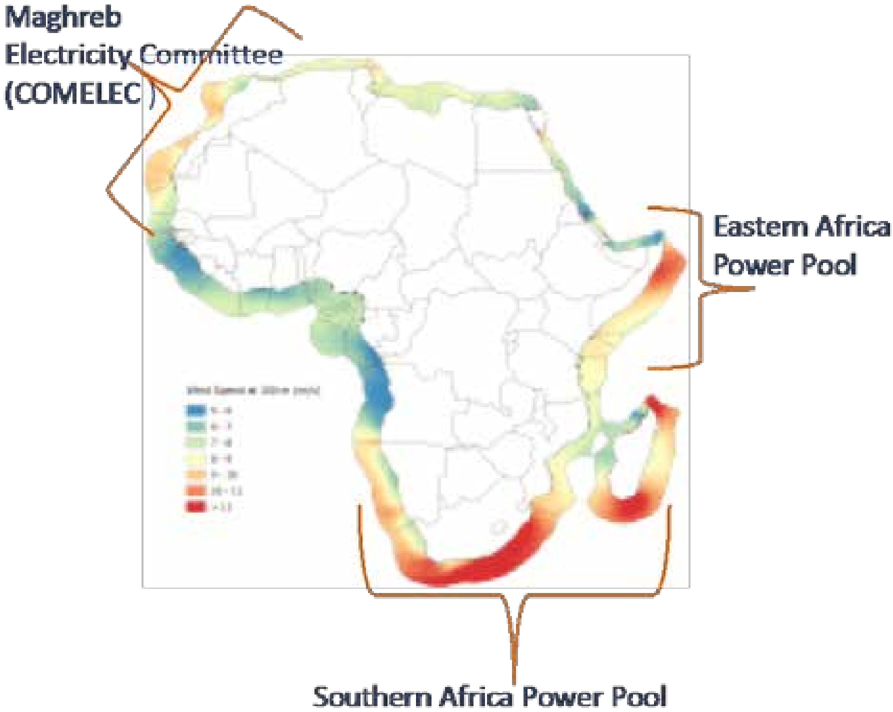

Figure 3 : *Offshore wind resources assessment of Africa*

Floating Solar Photovoltaic

Floating Solar Photovoltaics (FPV) is one of the evolving solar energy technologies making traction in the market. Several African countries, for example, Seychelles, Ghana and Mauritius, are implementing utility scale FPVs. Specifically, its potential of its integration with hydropower is making an attractive energy technology for deployment in many countries. The most recent installable FPV assessment study indicates that if 10% of installable areas are used in African water bodies, about 1,011GWp (Table 2) FPV could be installed with a potential of annual energy generation of 1,671,648.00 GWh/year.

Table 2: *Peak capacity and energy generation potential of FPV on freshwater man-made reservoirs in Africa*

Total surface area available (km2)	Number of water bodies assessed	FPV potential (GWp)			Possible Annual Energy Generation (GWh/year)		
		Percentage of total surface area used			Percentage of total surface area used		
		1%	5%	10%	1%	5%	10%
101,130	724	101	506	1,011	167,165	835,824	1,671,648

Source: SERIS calculations based on the Global Solar Atlas ©World Bank Group (2019) and the GRAND database, © Global Water System
Project (2011). Note: GWh = gigawatt-hour; GWp = gigawatt-peak; km2 = square kilometers; PV = photovoltaic

Wave Energy Conversion

Wave energy converters (WECs) capture the kinetic or potential energy contained in ocean waves to generate electricity. The global distribution of annual wave power flux is provided in Figure 4, where Southern and North Western parts of Africa with the highest potential.

Though the global wave energy potential is still relatively uncertain, the Intergovernmental Panel on Climate Change (IPCC) estimated a theoretical global potential of around 29,500 terawatt-hour per year (TWh/yr) (Lewis, et al., 2011) . Some African countries like Ghana are implementing a 100 MW wave energy, the largest in the continent, with a long-term construction plan of reaching about 1000WM wave energy plant capacity . Probably, Ghana is ahead of its projected 1.4 % contribution of wave energy conversion by 2050.

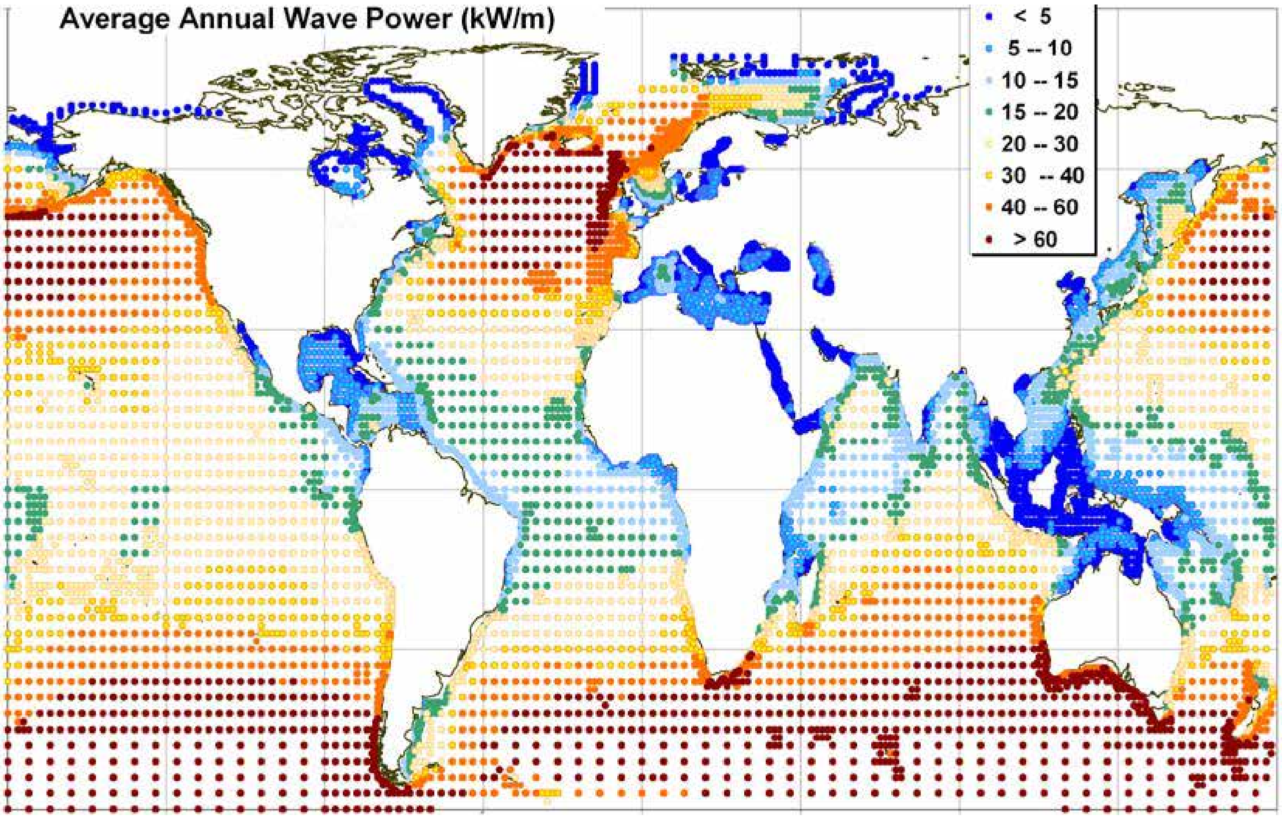

Figure 4 : *Figure 2 Global Distribution of Annual Wave Power Flux from Fugro OCEANOR WorldWaves Model (kilowatt per meter)*

The wave energy conversion (WEC) technology close to commercialization is in the range of 10 MW . While the capital cost of first generation WEC is about 10,000 $/kW, the capital cost of future generation with the capacity of 90MW, which is about $3000/kW , is expected to be cost competitive. The first generation refers to a single device and future generation refers to wave farms that consists numerous devices. The levelized cost of the future generation ranges from 0.13 – 0.45 $/kWh, which could be competitive with other energy sources. One of the most attractive aspect of the WEC is its efficiency: WEC can generate 65% of energy per year compared to wind and PV which has the efficiency of 22-24% energy production per year .

Ocean Thermal Energy

Ocean thermal energy conversion (OTEC) is the type of ocean energy, which uses the temperature difference between surface warmer water and deeper colder water encountered in tropical oceans as the source of thermal energy. The global ocean thermal energy resources with a potential for development are shown in Figure 5 . Twenty three African countries, seventeen mainland and six islands, with potential Ocean Thermal Resources (OTR) within their 200-Nautical Mile Exclusive Economic Zones (EEZ) have been identified (Figure 5 and Table 3). Though most of the OTEC technologies are at pilot stage, they have a promising potential. The size of the first commercial design ranges from 50–100MW, with a capital investment requirement of about $750 million for a 100MW plant.

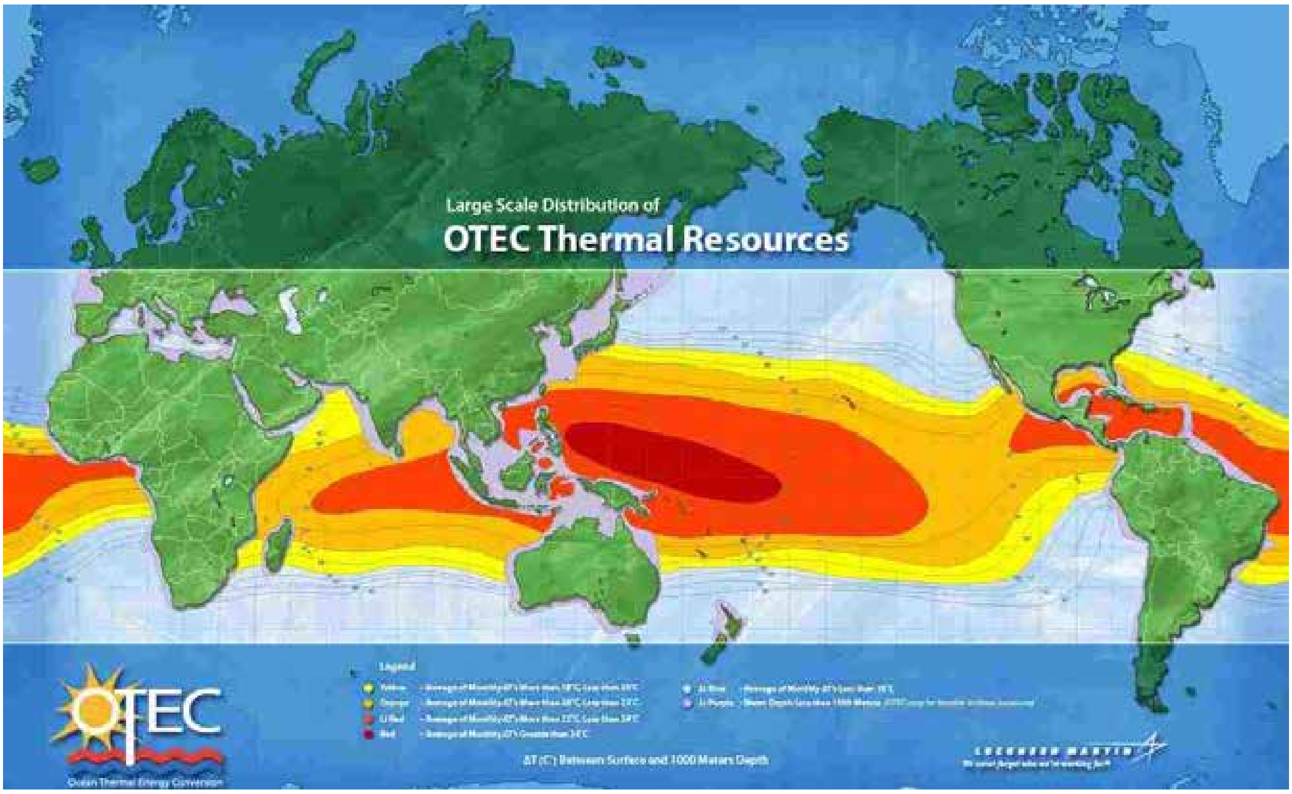

Figure 5: *Ocean Thermal Energy Conversion World Potential Locations*

Table 3 : *Areas with Appropriate Ocean Thermal Resources within Their 200-Nautical Mile Exclusive Economic Zones and annual electricity generation with 100 MW OTE Conversion Plant*

Country	Annual Production (GWh)	Country	Annual Production (GWh)
Angola	750	Nigeria	1500
Benin	1250	Sierra Leone	1500
Cameroon	1500	Somalia	650
Congo, Dem. Rep.	750	Tanzania	1000
Congo, Rep.	750	Togo	1500
Cote d'Ivoire	1500	Aldabra	950
Equatorial Guinea	1500	Ascension	1000
Ghana	1500	Comoros	800
Guinea	1500	Gabon	1250
Kenya	900	Madagascar	800
Liberia	1500	Sao Tome & Principe	950
Mozambique	850		

Source: Extrapolated from Vega. L.,2010.

Salinity Gradient

Salinity gradient energy is a form of energy that could be harvested from the difference of salt concentration between seawater and fresh water. Salinity gradient power is available around the clock and could be used to stabilize the intermittent power supply of variable energy sources such as wind, wave, and solar. The availability and predictability of salinity gradient energy is very high, which makes it a solid baseload energy source. One of the salinaity gradient technology such as Pressure Retarded Osmosis (PRO) is shown in Figure 6.

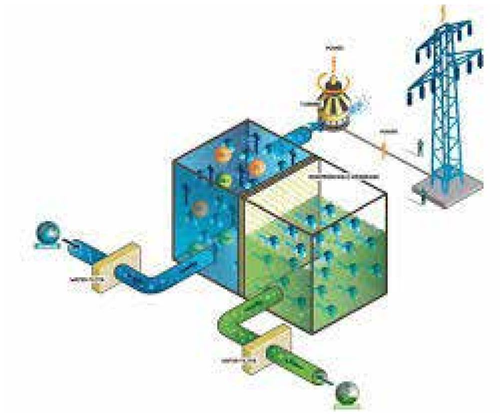

Figure 6: *Schematic diagram of Pressure Retarded Osmosis (PRO) technology*

The total technical potential for salinity gradient power is estimated to be around 647 gigawatts (GW) globally, which is equivalent to 5177 terawatt-hours (TWh), or 23% of electricity consumption in 2011 . The Ocean Energy Europe indicated that the energy released from 1m3 fresh water is comparable to the energy released by the same m3 falling over a height of 260 m. Nevertheless, the technology is not mature and not yet economically feasible, which requires more technical and financial viability studies. The most advanced salinity gradient technology is Reverse Electro Dialysis (RED). While the first world's tidal power farms were hit in the UK, Netherlands and France in 2016, pre-commercial wave energy, OTEC and salinity gradient farms will soon follow across Europe . This indicates that it is time for Africa to positions itself on how to make use of the evolving technologies.

Marine Algae Biofuels

Marine algae specifically macroalgae (seaweed) and some microalgae can be grown at sea to produce biofuels, animal feed, and other coproducts. Biofuels from algae are more expensive than from terrestrial biomass, but improvements in yields, scale, and operations could see algae become cost competitive with terrestrial crops . In addition to their use as biofuels, they can also be used as sources of foods, feeds and high-value bio-actives with high potential to meet sustainable development goals in Africa. For example, Kenya is aiming to transform into a newly industrialized country with a high quality of life for all its people by the year 2030 and a study indicated that not only does Kenya lie in an optimal geographical region for microalgal cultivation , but that microalgae has the capability to fulfil some of the 'Kenya Vision 2030' goals of which is biofuels.

Oil and Gas

Though there are uncertainties in the exact estimate of oil and gas in Africa, the most recent geological survey sets the upper bound of Africa's potential at 1,273 billion bbl of oil (including condensate gas from gas extraction) and 82 trillions of cubic meters (tcm) of natural gas (including associated gas from oil extraction). It is estimated that it would be "technically and economically feasible" to recover about 381 billion bbl of oil and 73.8 tcm of gas .About 70% oil and gas are available in a deep or ultra-deep-water offshore fields. Based on known reserves, there is potential for approximately 400 gigawatts (GW) of gas-generated power in sub-Saharan Africa. It is estimated that Côte d'Ivoire, Senegal, South Africa, Ghana, Angola, Kenya, Nigeria, Mozambique, and Tanzania, all located in coastal areas, hold the potential for around 16,000 MW (86 percent) of new gas-fired power generation projects through 2030 (Figure 7). This potential could be unlocked through investment in developing indigenous gas resources, gas infrastructure, and liquified natural gas (LNG) import projects. These countries, which relatively have large populations and high gross domestic product (GDP), either have local gas resources (in operation or under development) or are planning LNG import projects. Making use of such huge resources for economic development and increases access to electricity has a paramount importance.

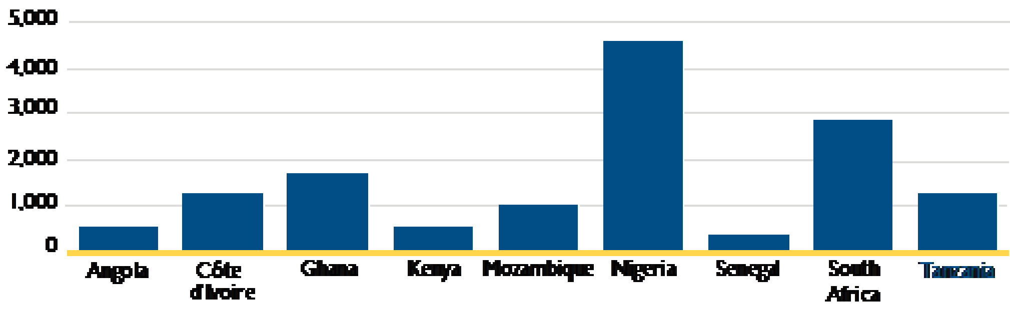

Figure 7 : *Projected gas-fired generation capacity in focus countries through 2030*

Marine Mining Resources Potential

The two major blue economy in the mining resources are deep-seabed and seawater mining. They are one of the untapped potentials in Africa with a potential for meeting global demand and national economic development needs. Here under are a brief overview of their potential.

Deep-Seabed Mining

Marine mining could be defined as "the production, extraction and processing of none-living resources in seabed or seawater" . These activities usually take place in areas below 200m. For many years, marine mining has been limited in shallow areas near shores for mining diamonds, tin, magnesium, salt, sulphur, gold, and heavy minerals. As inland minerals are being exhausted, countries are going into deeper water bodies where phosphates, massive sulphide deposits, manganese nodules, platinum, and cobalt-rich crusts are regarded as potential future prospects. The three main marine mineral deposits are polymetallic nodules; polymetallic or seafloor massive sulfides; and cobalt-rich ferromanganese crusts (Figure 8). Red Sea and Indian Ocean have massive sulfide deposits. Western and south western parts of Africa have deposits of polymetallic nodules and cobalt-rich crusts. Some of these minerals have a very high demand for high-tech companies and clean energy technologies.

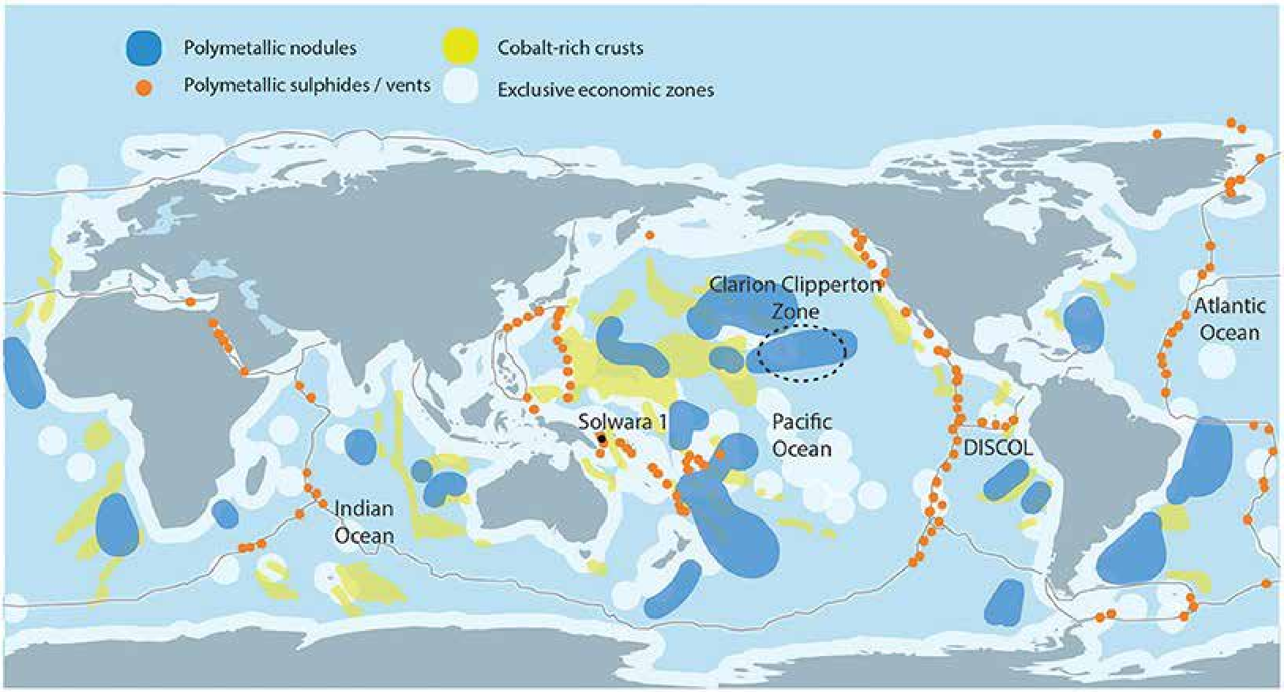

Figure 8 : *A world map showing the location of the three main marine mineral deposits : polymetallic nodules (blue); polymetallic or seafloor massive sulfides (orange); and cobalt-rich ferromanganese crusts (yellow). Redrawn from a number of sources including Hein et al. (2013) .*

Namibia is one of the African countries that has started marine mining in 1960's. As its land mining is waning it is moving aggressively exploiting it's ocean-based mining. As a result, in 2017, the country's marine diamond mining company and the Namibian Government produced 1.378 million carats of diamonds. Debmarine Namibia is also planning to construct a $142 million ship-cum-tanker for seabed mining, the largest in the World by 2021. Some of the potential countries for seabed mining include South Africa, Namibia, Mozambique, and Senegal.

Though about 50 exploration licenses for deep-sea mining have been granted worldwide, no concrete results have achieved mainly due to the low technological advancement and lack of the regulatory system. As of 2017, only two deep-seabed mining projects have been granted : Solwara 1 in Papua New Guinean and Atlantis II in the Red Sea of Sudan/Saudi Arabia , in which extraction has not yet started .

In the exploration of deep seabed mining, in addition to the need for a regulatory framework, as most of the locations where the minerals are deposited in ecologically significant areas (EBSA) and ecological hotspots (Figure 9), developing an environmental management plan is critical to preserve the marine ecology.

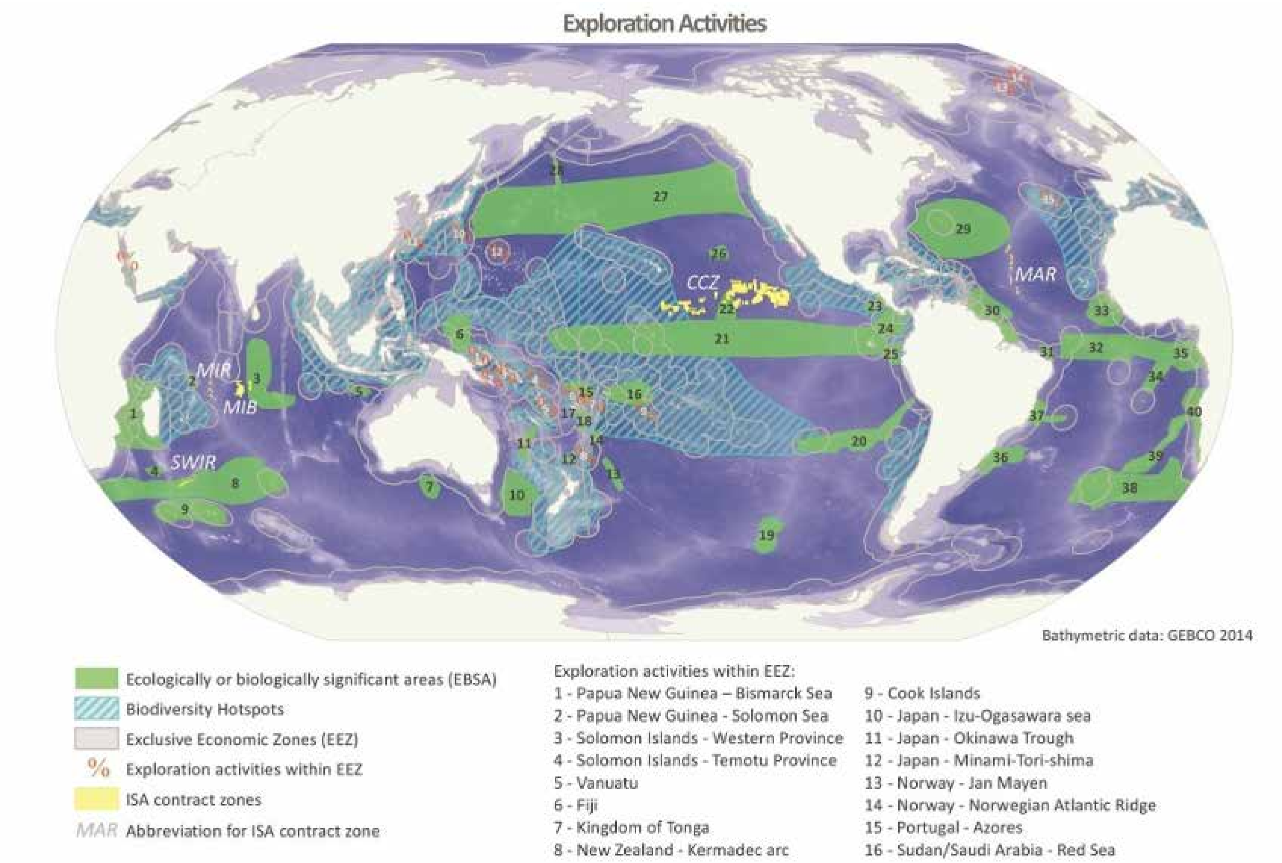

Figure 9 : *Global seabed mining exploration activities, and bathymetric map of ecologically significant areas (EBSA) and ecological hotspots*

Seawater Mining

Seawater contains large amounts of minerals in which some of the most valuable minerals include rare earth elements (REEs), precious metals, lithium, and uranium. Although land-based minerals are concentrated in specific geologic formations and geographic areas, seawater minerals are generally distributed evenly in seawater with some higher concentrations near the mainland. If about 10% of the present worldwide market for minerals could be mined from seawater, the markets would be substantial (Table 44). For example, about 10% Pb could add about USD 0.6 trillion to the global economy in which Africa should be able to extract it's share for its economic prosperity.

For the fact that extracting minerals from seawater is a more environmentally friendly enterprise than terrestrial mining , this could have huge potential for Africa, which could boost its economy substantially. Some of the critical minerals, which could be defined as mineral essential to the nation's economy or for national defense purposes, exposed to supply disruptions and are usually needed for development and deployment of clean energy technologies , advanced military applications , and essential civilian and industrial uses, are found in seawater. Based on 2015 USGS mineral price commodity estimate, except for U, the categories of economically feasible and economically challenging are shown in Figure 1010.

Table 4: *Estimates of Global Magnets for Key Minerals that Could Be Mined from Seawater*

Element	2017 Price ($/kg)	2017 Global Production (metric tons)	2017 Market Value ($)	Market Value from Seawater Mining* 10% of Global Production from Seawater ($)
Li	$139.00	43,000	$5,977,000,000	$597,700,000
U	$47.00	62,027	$2,925,193,320	$292,519,332
V	$59.00	80,000	$4,744,000,000	$474,400,000
Cu	$6.27	19,700	$123,519,000	$12,351,900
Co	$59.00	110,000	$6,437,200,000	$643,720,000
Nd	$58.00	130,000	$7,475,000,000	$747,500,000
Dy	$185.00	130,000	$24,050,000,000	$2,405,000,000
Tb	$475.00	130,000	$61,750,000,000	$6,175,000,000
Re	$1,530.00	52,000	$79,560,000,000	$7,956,000,000
Pd	$27,650.00	210,000	$5,806,500,000,000	$580,650,000,000

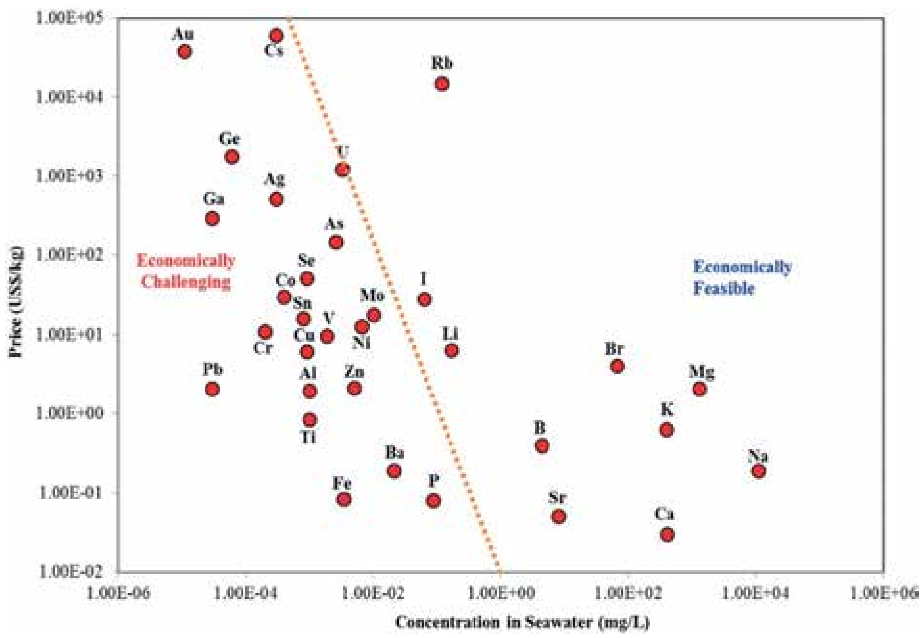

Figure 10 : *Screening of minerals that can be economically extracted from seawater based on current market prices and seawater concentrations of the minerals.*

Innovative Industries

In this sectors perspective, innovative industries could be defined as an introduction of improved or new technology for improving the livelihood of society and business competitiveness. The application of innovative industries should be based on research and development and evidence-based studies with regard to their applicability, scalability, affordability, economic viability and benefits to the society. Though several countries might be using innovative industries, since no assessment has been conducted, the status of the application of innovative industries in Africa is not clear. However, the need for revitalization of obsolete industries and introduction of innovative industries especially in the blue economy sector is timely that benefit the society. In this regard, we recognize that innovative industry should be applied across all blue economy sectors.

Some innovative technologies that could be potentially applicable for several blue economy sectors in general and sustainable blue energy and marine mining industries in particular include:

- Marine Energy - Coastal adaptation (sea level rise) nexus
- Ocean Energy-Desalination nexus
- Marine Energy – Underwater Vehicle Charging for Deep-Seabed Mining
- Floating solar photovoltaic (FPV) powered aquaculture,
- Ocean energy powered ice-making systems for coastal communities,

Marine Energy - Coastal Adaptation Nexus

As most coastal African countries are exposed to sea level rise and are already undertaking adaptation measures, the application of wave energy conversion technologies is ideal that could have a dual purpose: sea level rise protection and energy production for the coastal communities. In some parts of the world, such application is becoming a reality . Thus, such projects should be implemented in vulnerable coastal areas of Africa. As climate change information could play a key role in identifying prone areas for coastal adaptation and wave energy conversion potential locations, its importance could not be underestimated. As such, the schematic diagram of the innovative coastal adaptation – wave energy nexus is provided in the figure below.

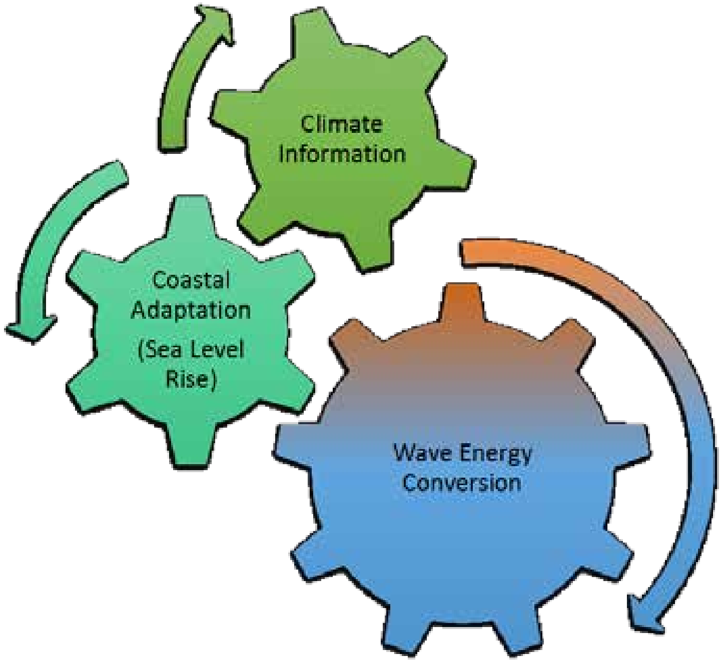

Figure 11 : *Coastal Adaptation (Sea level Rise) – Wave Energy Nexus*
Source: Author's description

Marine Energy - Desalination Nexus

The production of potable water from the sea, using ocean energy is another innovative industry that could help solve water scarce in coastal areas and provide potable water in activities conducted at the sea such as fishing, tourism and shipping activities. The Marine Energy-Desalination nexus (Figure 12) could be applied to address water needs through the application of various ocean energy technologies including offshore wind and wave energy. Several climate projects indicate that most of the coastal mega cities and small communities are expected to suffer from water scarcity, and thus sustainable blue energy powered desalination system to provide potable water has high importance. It should be noted that climate information could be used as a vehicle for risk identification, policy formulation and sustainable blue energy powered desalination system implementation.

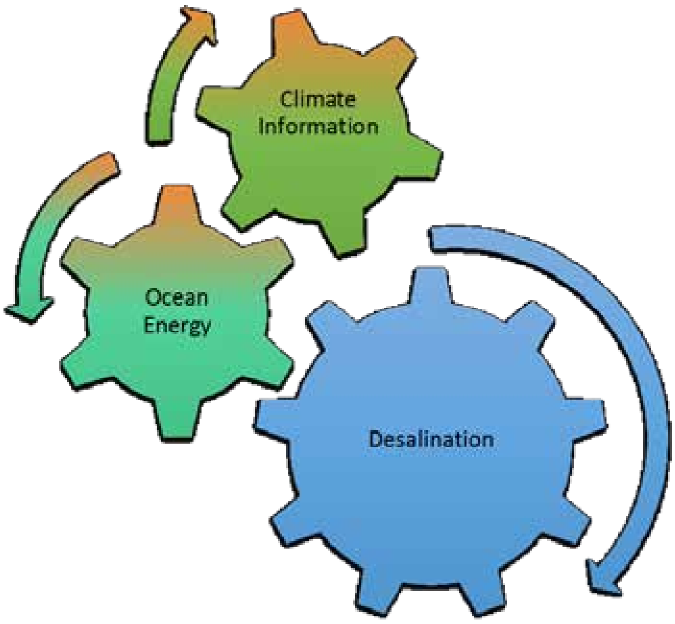

***Figure 12 :** Climate Information – Ocean Energy – Desalination Nexus*
Source: Author's description

Marine Energy - Hydrogen Production Nexus

Though most hydrogen is produced from natural gas, oil, and coal, the application of renewable energy powered water electrolysis for hydrogen production is the most sustainable approach. The production of hydrogen using offshore is a promising innovative technology under consideration especially in South Africa .A technical and economic analysis are also conducted to produce hydrogen using solar energy in Morocco and wind powered hydrogen production in Morocco could be also be economically feasible .Thus, the innovative application of offshore wind, hydropower and wave energy for hydrogen production are some of the innovative industries that could deliver high economic (Figure 13).

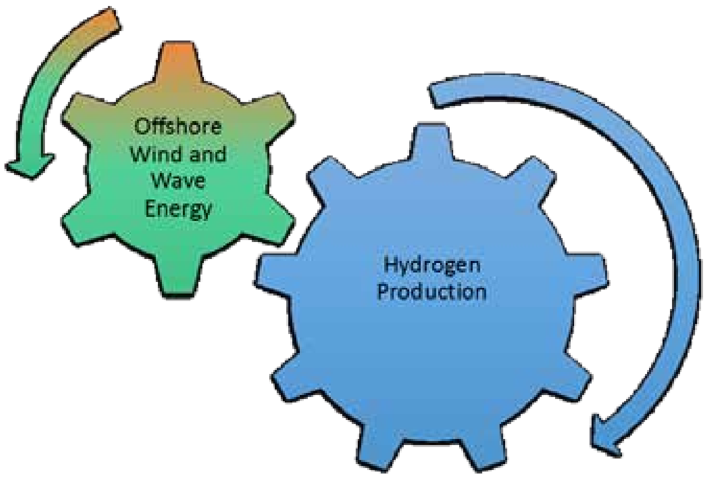

***Figure 12 :** Climate Information – Ocean Energy – Desalination Nexus*
Source: Author's description

Marine Energy - Hydrogen Production Nexus

Though most hydrogen is produced from natural gas, oil, and coal, the application of renewable energy powered water electrolysis for hydrogen production is the most sustainable approach. The production of hydrogen using offshore is a promising innovative technology under consideration especially in South Africa .A technical and economic analysis are also conducted to produce hydrogen using solar energy in Morocco and wind powered hydrogen production in Morocco could be also be economically feasible .Thus, the innovative application of offshore wind, hydropower and wave energy for hydrogen production are some of the innovative industries that could deliver high economic (Figure 13).

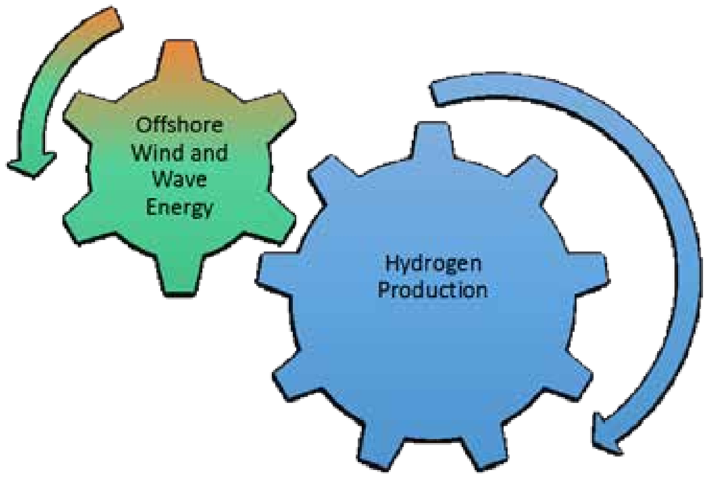

***Figure 13 :** Offshore Wind and Wave Energy – Hydrogen Production*
Source: Author's Representation

Marine Energy – Underwater Vehicle Charging for Deep-Seabed Mining

An autonomous underwater vehicles (AUVs) and unmanned underwater vehicles (UUVs) are vehicles that perform underwater tasks without a tether or line to a surface ship, carrying instruments and sensors to monitor or inspect underwater environments. Powering such vehicles by the marine energy could be beneficial not only for maritime related tasks, but also for deep-seabed mining activities. As most seabed mining operations envisage the use of remotely operated vehicles mechanical or pressurized water drills, powering these machines using marine energy could the best sources of electricity.

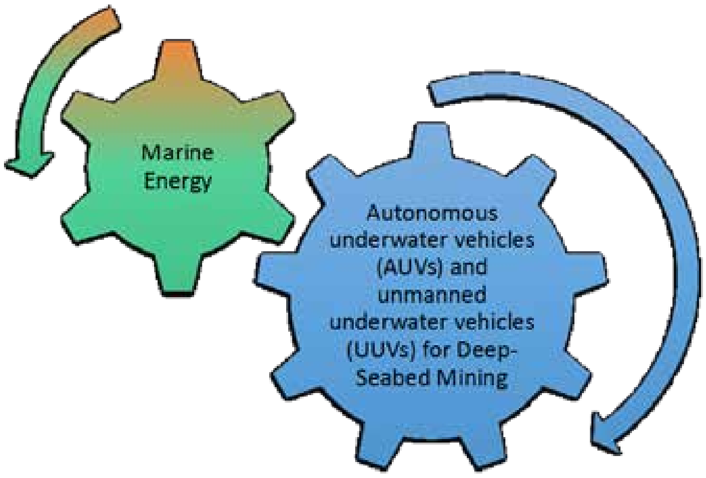

Figure 14: *Marine Energy and Autonomous underwater vehicles (AUVs) and unmanned underwater vehicles (UUVs) for Deep-Seabed Mining*

Other Innovative Industries

Other innovative industries in blue economy in general and sustainable energy and mining resources in particular should be further investigated for potential application to meet a multidisciplinary sector such as energy, food and water. Some of the innovative industries that could be investigated could include:

- Floating solar photovoltaic (FPV) powered aquaculture, and
- Ocean energy powered ice-making systems for coastal communities.

GDP Contribution and Job Creation Potential

GDP Contribution: Energy, Mineral and Oil and Gas

Sustainable Blue Energy: Blue energy penetration has already started in many African countries such as Ghana (Wave Energy), Mauritius (FPV) and Offshore wind projects. Considering Ghana's electricity contribution to GDP of about 1.5% as our reference and assuming that progressively the share of the BE will be 5% of the total energy contribution in 2030 and 7% of the total energy contribution in 2063 the GDP contribution of the blue energy could reach about USD1.6 billion and USD2.3 billion, respectively (Table 5).

Ocean Mining: One of the only estimated value of deep-sea minerals is in Papua New Guinea deep-sea mineral potential worth of hundreds of millions of dollars for gold, cobalt, zinc and copper. Moreover, some African countries such as Namibia has already started exploring diamond. Thus, assuming that the coastal African countries has similar potential of Papua New Guinea and few South Western Africa started to exploit diamond, the value added from deep-sea mining is about 6 billion. On the other hand, if African countries exploit about 2% of the market value from seawater mining of 10% of global production from seawater potential, USD 56 billion. On the other hand, if African countries exploit about 2% of the market value from seawater mining of 10% of global production from seawater potential, it is worth about USD 50 billions of value added. This gives a combined value added of about USD 56 billion. It could reach about USD 76 by 2030 and USD 123 by 2063 (Table 5), respectively.

Oil and Gas: In 2018, the total GDP contribution of oil and gas in the major producing countries such as Angola, Congo. Dem. Rep., Cote d'Ivoire, Equatorial Guinea, Ghana, Mozambique, Nigeria and South Africa is about USD 80 billion. Assuming the oil and gas exploration and new exploitation like South Africa starts producing, by 2030 and 2063, the value added could reach about USD 100 billion and USD 138 billion, respectively (Table 5).

Table 5 : *GDP Contribution (value added) by the energy, minerals and oil and gas sectors*

Sector/component	VA 2017	VA 2030	VA 2063	Comments
Energy	0.5	1.6	2.3	In Ghana electricity contribution to GDP is about 1.5%. This assumes that blue energy contribution to GDP will be about 1.5%, 5% and 7% share of the traditional electricity by 2020, 2030 and 2063.
Mineral	56	76	123	Total Added Value Assuming about 1% annual production rate of the 2% global production share.
Oil and Gas	80	100	138	Annual value added based on 2017 constant over the years.

Job Creation Potential: Energy, Mining, and Oil and Gas

Mining Job Creation: In Ghana, from 2004-2014 jobs in mining sector has created increased by about 11%-fold to reach about 48,631 .This is an annual addition of direct jobs of 4421.The Ghana's experience disputes the general assumption that mining industries doesn't create much jobs. Assuming that the potential of the deep-sea mining and seawater mining could immediately create about 4,421, by 2030, it could create about 2 million jobs in 38 coastal countries and about 4 million by 2063 (Table 6).

Energy Job Creation: The current number of employments in Africa is about 322,000 . In Egypt in Benban solar complex of 1,650 MW opened in early 2019, employed 650 people .This is without considering the job created during construction (10 000 workers) and operations and maintenance (4000 workers). Assuming that the 54 African countries exploited their energy potential and immediately start the use of the energy using the Egypt project as a baseline, by 2030 and 2063, the number of jobs could reach about 0.2 million to 0.5 million, respectively (Table 6).

Oil and Gas Job Creation: In the USA, oil and gas industry created about 5.6 percent of the total U.S. employment, which is about 9.8 million jobs .Assuming Ghana's 1% job created assumption by the mining sector, which could be translated to about 22,105 jobs by oil and gas (using 5% of the total of the USA), the jobs created in the oil and gas sectors in major eight African countries such as Angola, Congo. Dem. Rep., Cote d'Ivoire, Equatorial Guinea, Ghana, Mozambique, Nigeria and South Africa, the total jobs could be about 1.8 million in 2030 and about 5 million in 2063 (Table 6).

Table 6 : *Direct Job Creation in Mining, Energy and Oil and Gas*

Sector/component	2020	2030	2063	Comment/Reference
Mining	1.70	2.00	4.00	Assuming 38 coastal countries with the base case of Ghana mining job creation.
Energy	0.16	0.20	0.50	Assuming 0.5% (2020), 5% (2030) and 10% (2063) of the current renewable energy related jobs (322,000) comes from blue energy. IRENA, 2019.
Oil and Gas	1.20	1.80	5.00	Assuming 5.6% percent jobs comes from oil and gas focusing on eight African countries and with 2.79% and 5% increase in 2030 and 2063, respectively. API, 2013.

Challenges and Interventions

In unlocking the potential of sustainable blue energy, mineral resources and innovative industries, technical, institutional, regulatory, human skills and other barriers exist that hinder the realization of substantial benefits. This section identifies respective sector's potential challenges and suggests potential interventions.

Challenges

Sustainable Blue Energy Challenges

The major challenges that drives the need for the application of sustainable blue energy and the challenges potentially hindering its application are technical, institutional, financial and regulatory in nature. Here under are the major challenges identified including:

- ***Not Adequately Sustainable Blue Energy Potential:*** Knowing the potential of sustainable blue energy and their monetization could drive investment in an expedited manned. However, though global scale potential assessments are available, continental and country specific sustainable blue energy potential are not adequately quantified and monetized. Thus, there is a need for monetize and quantify their potential in respective countries.
- ***Unavailability of Enabling Policy Frameworks:*** Though progress has been made in

increasing the share of renewable energies there are some key challenges such as the lack of enabling policy frameworks and adaptive regulations as well as strong support from governments and other policymakers. These are the driving forces for attracting businesses to invest in sustainable blue economy.

- ***Lack of Policies That Promoting R&D:*** The lack of policies promoting R&D are hindering the integration of ocean energy in the energy mix albeit further cost reductions and large-scale development could be needed.
- ***Lack of Access to Finance:*** There is not adequate finance which supports the implementation of such an innovative project that need to be addressed.
- ***Unavailability of Affordable Energy:*** Due to high electricity prices and high connection fees, and low economic status of users in most Sub Sharan African (SSA) countries, energy affordability could also inhibit energy access and remains a serious concern. Some African countries are subsidizing electricity prices to resolve social concerns, which is not a lasting solution especially for attracting new sustainable blue energy.
- ***Unsuitable Centralized Systems:*** In most African countries, the electricity general and distribution, and evacuation is centralized, which is proved unsustainable. Under such scenario, it might be risky to aggressively invest in sustainable bleu energy technologies.
- ***Inadequate Power Grid Infrastructure:*** The lack of sufficient power grid infrastructure necessary to process, transport and distribute energy to the final users is a characteristic of the Sub-Sharan Africa (SSA) region except in South Africa, which has a fairly decent power grid, and the North African region with its far-reaching power and gas infrastructure. Nevertheless, in most SSA countries the insufficient infrastructure could eventually hamper the development and distribution of sustainable blue energy infrastructure especially hydrogen production, and natural gas and oil pipeline and power transmission grid.
- ***Unreliable Electricity Supply:*** The lack of reliable and affordable electricity in Sub-Sharan Africa is hampering the growth of businesses. Thus, as reliable and affordable power supply is an essential prerequisite for economic growth, sustainable blue energy can play a key role in improving electricity supply and blue energy could expedite the achievement of reliable and affordable power supply.
- ***Unconducive Regulatory Systems and Capacity to Drive Competitiveness and Ensure Profitability:*** Electricity demand, profitability and competitiveness are the major drivers for booming renewable energy technologies in Africa. The application of sustainable blue energy will also depend on electricity demand, profitability and competitiveness. The regulatory system should allow the availability such platform. Most sustainable blue energy might become more effective and profitable, if there is high demand and a very

good regulatory system that gives confidence for collaboration. The unavailability of a regulatory system could deter collaboration among countries.

- ***Lack of Sustainable Blue Energy Specific Environmental Management Plan:*** Sustainable blue energy resources should be exploited in manner that they don't impact the environment. Thus, marine ecology related environmental conditions and sensitive areas and legal matters should be in place to minimize environmental impacts and expedite the application of sustainable blue energy resources.

Mining Resources Challenges

The challenges in the implementation of mining resources are similar to the sustainable blue energy, which could be summarized as follows:

- ***Not Adequately Known Ocean Mining Potential:*** Though a very rough potential of minerals both in deep-seabed and seawater exist, they are not accurate. Moreover, as it is a new emerging territory, there are many unknowns and there is no detailed baseline assessment that provides state and potential of mineral resources.
- ***Lack of Regulatory Framework:*** Though many inventors could be interested in the exploration of ocean mining, due to the lack of regulatory framework, such initiatives could not be encouraged to proceed. Thus, the development of regulatory framework and system for licensing and exploration is needed.
- ***Lack of Strategic Plans:*** Deep-seabed mining also requires long range planning in which most countries not yet have that guides them on how to proceed.
- ***Unavailability of Economic Value:*** Economic viability of any mining is a prerequisite for implementation and in order to extract such potentials, potential knowing their monetary value is critical. Thus, economic Valuation of its potential and how it contributes to the national economic development should be determined.
- ***Lack of Environmental Management Plans:*** Deep-seabed mining requires the availability of stringent policy guidelines that protects the marine environment, which are the sources of tourism, water quality and fisheries. According to the International Union for Conservation of Nature (IUCN) , regulations under development at the International Seabed Authority (ISA) to manage deep-sea mining are insufficient to prevent irrevocable damage to marine ecosystems. Thus, environmental impact assessment regulation specific to the deep-seabed mining need to also be in place.

Innovative Industries Challenges

Innovative industries are important in realizing the benefits of blue economy in general and sustainable blue energy and mining resources in particular. The following challenges are identified that need to be addressed if the application of innovative industries is to be realized including:

- ***Lack of Policy Framework for Innovation and Development:*** In most cases, innovative technologies are ahead of policy, enforcement and capacity that need also be addressed. This is to highlight that policy seems lagging behind and need to catch-up if the benefits of innovative industries to be realized that include transfer and application of innovative industries.
- ***Lack of Research and Development (R&D):*** In Africa is going to benefit from the innovative technologies, it should invest in R&D so that the application and adaptability of innovative technologies could be implemented. The application of innovative industries should be preceded by research and development (R&D), which is not the case at the moment in most African countries. Implementing innovative industries without evidence based scientific studies could lead to failures.
- ***Lack of Adequate Skills:*** An implementation of innovative industries requires skilled and competent manpower. In Africa, the lack of capacity chronic and the availability of skilled manpower is very low. In order to have an impact, the necessary skills must be identified and integrated in the educational system.
- ***Weak Institutional Capability:*** The application of innovative industries also requires, the availability of dedicated institutions. Currently, in most African countries, there are no dedicated institutions to deal with blue economy in general and innovative industries in particular. Institutionalizing the development, application and implementation of innovative industries need to be institutionalized to deliver the needed results.
- ***Unavailability of Centralized Innovative Industry Data Base:*** The availability of data is also very critical for implementing innovative industries and information need to be collected and made available for decision-making.
- ***Lack financial support:*** Lack financial support for existing research and development (R&D) institutions is also a challenge.

Interventions

As challenges are complex in nature that require multidisciplinary intervention actions to match the need for solutions. Though specific interventions are identified in the following section, here under some existing, planned and additional suggested interventions are described for sustainable blue energy, oil and gas, mining resources and innovative industries, respectively.

Sustainable Energy Interventions

- ***Undertake Sustainable Blue Energy Potential:*** Undertake sustainable blue energy potential for ocean based and inland potentials for land locked countries.
- ***Increasing Sustainable Blue Energy Mix:*** By 2030, Africa's power capacity is expected to add about 30,000 MW power capacity. This is in accordance with the prioritization and support for transactions rooted in a country's national power strategy, particularly those using renewable technologies, such as solar, wind, biomass, and geothermal. The sustainable "blue energy" should be integrated as part of the energy mix to achieve the target and go beyond. On the other hand, the share of each renewable energy is proposed at national as well as continental level. In order to harmonize with the development of blue economy, the share of sustainable blue energy should be identified and integrated.
- ***Increasing Grid Infrastructure to Support Sustainable Blue Energy:*** In order to mitigate the lack of insufficient power grid infrastructure, by 2030, Africa is expected to get about 60 million connections, which will double the electricity connections in Sub-Sharan Africa. This is because, creating new generation capacity is not an end unto itself, without being delivered to homes and businesses. Thus, SSA countries should integrate and address the grid connections needs for sustainable blue energy.
- ***Developing Regulatory Frameworks:*** Developing appropriate legal and regulatory frameworks nor only to achieve the 30,000 MW capacity and 60 million connections, but also to accelerate the implementation of sustainable blue economy. Thus, developing clear and stable national policy frameworks that enable the private sector to invest with confidence .
- ***Promote Market Driven Electricity System:*** Promote market driven electricity system design, which is not widely practiced in most African countries, is regarded as the preferred approach to finance energy infrastructures and attract investment.
- ***Promote Regional Power Sector Integration:*** Regional power sector integration in sustainable blue energy regional opportunities in regional power pools especially in the case of offshore wind projects. For example, developing a join and integrated plan for offshore wind energy in three regions with the highest potential that include the Southern African Power Pool (SAPP), the Eastern African Power Pool (EAPP), and the Comité Maghrébin de l□Electricité (COMELEC) could be a very important step that could also be used for other ocean energy sources.

- ***Implement De-centralized Electricity Power Systems:*** Implementing de-centralized electricity generation, distribution and evacuation are viewed as a solution to deliver socio-economic dividends faster and at lower costs than the conventional past solutions especially in rural and remote areas. Thus, decentralized systems, which continues to be considered a critical uncertainty should be addressed through the development of a regulatory framework that allows the integration of new energy opportunities.
- ***Financial Support:*** To ensure long-term sustainability of reforms and new power generation by investing in African institutions; supporting capability building in local governments and civil society organizations; and promoting the establishment of private sector trade associations.
- ***Promoting Dialogue:*** Facilitating dialogue between the private sector, governments, civil society, and development partners.
- ***Opening Business Opportunities for Local Manufactures:*** Exploring opportunities for local manufacturing as a means to reduce capital costs, create local employment opportunities, and improve trade balances .
- Integrate sustainable blue energy in the ***renewables in economic development strategies***, develop long-term energy sector scenarios and strategies, and develop business/entrepreneurship models for renewables and their productive use.
- ***Develop Location Specific Road Map:*** In order to optimize the application of sustainable blue energy, assess and identify specific sustainable blue energy technology needs and applications. As a result, strategies and roadmaps that help to tailor blue energy technologies to local conditions and accelerate their deployment should be developed.
- ***Develop Decision-Making Tools:*** Develop spatial maps of blue energy potentials and make the information publicly available to accelerate investment opportunities and increase knowledge.
- ***Tariff-restructuring:*** Tariff-restructuring is important for renewable energy integration. For example, when using PV, it is available during day and at night stored energy could be used in such away price could be adjusted accordingly.
- ***Development of An Integrated Sustainable Blue Energy Planning:*** Sustainable blue energy planning is needed which requires data collection and exchange of information for informed decision-making.
- ***Undertake Regional analysis for Integrated Approach:*** Sustainable blue energy potential could not only support coastal countries, but also land locked countries. Thus, in order to optimize and increases access to electricity at regional level, a regional assessment need to be conducted and applicability presented for regional benefits.

Oil and Gas Interventions

Oil and gas are another top blue energy resource that could transform the economic development of the continent. While most countries who are already engaged in the exploration and production have strategic plans, there are new opportunities that require a concerted effort for their sustainable use. For example, South African is new oil and gas frontier. In South Africa's oil and gas related blue economy priority focuses in enhancing the enabling environment for exploration of oil and gas wells, resulting in an increased number of wells drilled, while adding value to the country. According to their plan, they are expected to drill about 30 deep-water oil and gas exploration wells, which is expected to create 130,000 new jobs. The mechanisms are intended to achieve an enhanced enabling environment including

- Providing an enabling policy and legislative environment;
- Promoting inclusive economic growth;
- Addressing the skills gaps, and
- Overcoming infrastructure challenges.

Thus, the oil and gas specific sustainable blue energy should also address outstanding challenges and device interventions. Some of the top strategic interventions (in no specific order) extracted from the Africa's Gas Master Plan and discussion with experts are outlined here under.

- ***Integrated Gas Economy Planning:*** Develop an integrated gas economy planning tool for each country and region, which focuses helping in quantifying current and future market and supply options.
- ***Gas Master Plan:*** Develop and/or update gas master plans to ensure streamlining, relevancy and correct implementation;
- ***Update Regulations:*** Update regulations and policies to fit the current requirements to support the increase of gas in the energy mix;
- ***Financial Capacity:*** Strengthen the financial capacity and creditworthiness of state entities.
- ***Strength Institutional Entities:*** Create a simplified and streamlined protocol for more efficient decision making within and among each of the various state entities and regulators to provide certainty regarding approval and permitting procedures for potential investors in the sector.
- ***Implement Compressed natural Gas (CNG) and Small-Scale LNG:*** Assist development of CNG and small-scale LNG projects to monetize local gas resources, as well as serve

local demand centers.

- ***Develop Regulatory System:*** Enhance an enabling environment for exploration and develop environmental sensitive areas of corridors to expedite the exploration and licensing of oil and gas resources.
- ***Engage Oil and Gas Companies:*** Engage oil and gas companies so that they can make sure they create local jobs not focus in exploiting the natural resources.This is becoming a concern as oil and gas, and seabed mining can be exploited without being stationed for a long time at a site and without constructing pipelines.

Mining Resources Interventions

Deep-seabed and seawater mining are the new evolving territories that require new approach and innovative intervention strategies. Some of the proposed interventions are described below.

- ***Regulatory system:*** Regulatory system should be developed with respect to licensing for exploration and mining, which could expedite the process for exploration and minimize risks.
- ***Assess Mining Potential:*** Determine deep-sea mining potential and undertake its economic valuation to determine its national economic contribution potential.
- ***Develop Environmental Management Plan:*** Undertake environmental surveys and develop effective regulation and mitigation strategies to limit the impacts of deep-sea mining. It also includes undertaking comprehensive baseline studies that should be conducted to improve our understanding of the ecosystem of deep-sea floor.
- ***Engage Mining Companies:*** Engage mining companies so that they can make sure they create local jobs not focus in exploiting natural resources.This is becoming a concern as companies can use innovative mining technologies without being stationed for a long time at a site.

Innovative Industries Interventions

The application of innovation industries requires the availability of adequate technical capacity and the ability to adapt to the innovative industries.A lesson should be learned from the early days, where renewable energy projects especially in rural areas were not delivering because of the lack of knowhow and technical capacity to make minor repairs.

Here are some of the proposed interventions.

- ***Develop National Policy that Drives Innovation:*** Development of national policy is critical if countries are going to accelerate the application of innovative industries at national level and garner collaboration among nations. This has many benefits:

- encourages the application of innovative technologies,
- gives countries a guarantee for collaboration, and
- helps to countries to revitalize obsolète industries.

- ***Financial Support:*** Policy without financial support and adequate technical capacity could not be effective if blue economy is to succeed.
- ***Capacity Building:*** Capacity building is critical to increase the ability for scaling-up and adaptability.
- ***Undertake Assessments:*** Undertake assessments of innovative technologies that increase job creation, improve livelihoods, and resilience of communities. This also helps to share information that could be used for scaling-up.
- ***Create Innovative Industry Database:*** Develop a database of innovative industries accompanied with decision-support tools useful for information sharing and decision making.
- ***Regional Collaboration:*** Encourage collaboration beyond national jurisdiction especially in offshore wind, oil and gas, and seabed mining.
- ***Monitoring and Evaluation:*** Set-up monitoring and evaluation (M&E) of innovative industries that could help for scaling-up and replication in a wider area.
- ***Undertake Feasibility Studies and Implement Innovative Pilot Projects:*** Assess the feasibility and viability of potential innovative industries identified in this document such as
  - Marine energy - desalination nexus,
  - Marine energy - coastal adaptation (sea level rise) nexus,
  - Marine energy – hydrogen production,
  - Marine energy and deep-seabed mining nexus for charging an autonomous underwater vehicles (AUVs) and unmanned underwater vehicles (UUVs) in the deep-seabed mining and other activities, and
  - Other innovative industries.
- ***Undertake Study Tours:*** Arrange study tour in countries where they are either planning and/or implementing innovative industries in general and sustainable blue energy in particular.

- ***Systematize Climate Information to Drive the Innovation and Application of Innovative Industries:*** Undertake assessments and collect hydro metrological information relevant for advancing innovative industries including

- Sea surface temperature observation system for accurate reading, and
- Information of the application of sustainable blue energy technologies.

Strategic Goals

In order to contribute in increasing access to electricity, meet global mineral resources demand, substantially contribute to the economic development, and harness the potential of innovative industries for through research and development (R&D), the challenges should be tackled and measurable targets identified. The following four goals are proposed to help identify targets and actions so as to make use of the huge potential of sustainable blue energy, mining resources and innovative industries.

- **Goal 1:** *Unlock sustainable blue energy potential (Technical Aspect):* Despite the huge untapped sustainable blue energy potential, no assessment and technical viability is being conducted. Thus, assessing its potential, investing in research and piloting, and implementing several projects should be one of the continent's top strategic goal. This strategic goal is aimed to address the technical aspect of the sustainable blue energy.

- **Goal 2:** *Creating conducive regulatory environment for the development and application of sustainable blue energy (Policy Aspect):* The current clean energy infrastructure suffers from the lack of clear policy, and institutional and regulators challenges. To ensure the success of assessing and implementing sustainable blue energy potential, technical considerations are not enough, and a conducive environment should be achieved through re-structuring of the developing regulatory frameworks, financial mechanisms, and updating renewable energy policies to incorporate blue energy so as to expedite the integration of sustainable blue energy. This goal is aimed to address the policy aspect of sustainable blue energy.

- **Goal 3:** *Meeting the growing demand of mineral resources for economic prosperity:* As deep-seabed and seawater minerals could play an important role in the continent's economic prosperity, developing regulatory frameworks, long-range seabed mining plans, integrated marine management, and effective social and environmental impact procedures, and strengthening human, regulatory and institutional capacity, and promoting regional cooperation, and technology transfer are some of the components required to achieve the intended benefits.

- **Goal 4:** *Harnessing the potential of innovative industries through research and development:* Harnessing the potential of innovative industries and applying for the advancement of sustainable blue energy and mineral resources in particular and other blue economy sectors through R&D is core objective of this goal if the success of the blue economy is going to be achieved.

Table 7: *Summary of Goals and Objectives*

Goals	**Goal 1** Unlock sustainable blue energy potential	**Goal 2** Create conducive regulatory environment for the development and application of sustainable blue energy	**Goal 3** Meeting the growing demand of mineral resources for economic prosperity	**Goal 4** Harnessing the potential of innovative industries through R&D
Approach	In order to unlock the untapped sustainable blue energy resources, make use of deep-seabed and seawater mineral resources for creating prosperous continent, and harnessing the potential of innovative industries clear objectives with concrete milestones are needed.			
Objectives	1.1 Increase blue energy penetration in the energy mix	2.1 Reform unsustainable financial structure and create conducive energy finance instruments	3.1 Increase deep-seabed and seawater mining production for meeting demand and economic prosperity	4.1 Develop policy framework to accelerate the transfer and application of blue economy technologies
	1.2 Contribute in increasing reliable, affordable and modern energy	2.2 Develop sustainable blue energy master plan and policy derivatives	3.2 Create conducive regulatory frameworks for exploration of deep seawater	4.2 Strengthen institutional, infrastructural and human capacity
	1.3. Assess the availability of sufficient infrastructure at (a) national (b) regional, (c) and continental level	2.3 Develop environmental impact assessment guidelines	3.3 Promote sustainable and environmentally friendly deep-seawater exploration	4.3 Promote the application of innovative industries
	1.4 Power the blue economy		3.4 Capacity building and technology transfer	4.4. Create innovative industry database and support tools

Detailed Presentation of Strategic Goals and Specific Objectives

Table 8: *Presentation of objective 1 of Goal 1*

Goal 1 – Unlock sustainable blue energy potential
Energy demand in Africa is on a steep rise and one of the clearest drivers is population growth. It is expected that by 2100 African population could reach 4.7 billion, which will make up about 40% of the forecasted global population of 11 billion. The ongoing electrification efforts are generally outpaced by rapid population growth which is expected to be more than double by 2050. Meeting such demand requires the application of not only the conventional energy resources, sustainable blue energy sources, which are not yet mostly known. Thus, there is a need for determining the sustainable energy potential, availability of sufficient infrastructure, and identification of potential users.
Objective 1.1 – Increase blue energy penetration in the energy mix
Following current demographic and economic trends as well as national energy plans, by 2030 the total primary energy demand in SSA is expected to grow by 30%. It is expected that renewable energy technologies could supply about 22% of Africa's total final energy consumption by 2030, compared to 5% in 2013.

Targets	**Actions/Activities**	**Indicators and Timeframe**
1.1 Assess blue energy potential	1.1.1 Assess and determine the potential of sustainable blue energy mix.	Assessment of priority SBE completed 2020 – 2024
1.2 Pilot sustainable blue energy mix for deployment	1.1.2 Assess the possibility of integrating geothermal energy with sustainable energy wherever applicable i.e. if the blue energy is in proximity to geothermal energy potential.	Potential geothermal energy sites that could be integrated with SBE identified
	1.2.1 Conduct feasibility studies of selected potential projects that could be implemented in the short (2024), medium (2035) and long term (2063) of which 2020 could be a baseline.	Feasibility studies completed 2021 - 2024
	1.2.2 Pilot test the technical and financial viability of a selected sustainable blue energy technologies.	Pilot test at least five SBE projects 2021 - 2025

Table 9: *Presentation of objective 2 of Goal 1*

Goal 1 – Unlock sustainable blue energy potential
Objective 1.2 – Contribute in increasing reliable, affordable and modern energy
In order to realize the use of the sustainable blue energy, it must be technically and economically viable and of course should contribute to increase reliability. This might lead to prioritization these energy technologies in a manner that meets the demand where most needed. While some sustainable blue energy technologies such as floating solar photovoltaic (FPV) and wave energy conversion are under implementation in some African countries, other technologies could be realized by 2030, 2050, and 2100. Thus, action need to be taken in prioritizing the affordable and mature technologies that help to increase reliability and affordability.

Targets	**Actions**	**Indicators and Timeframe**
2.1 Identify mature sustainable blue energy technologies that could be implemented in the near future	2.1.1. Determine potential locations for mature and economically and technologically feasible sustainable blue energy technologies such as the application of floating solar photovoltaic (FPV), where hydropower plants are already in operation.	Potential lakes for FPV installation identified and feasibility study completed 2020 - 2021
	2.1.2 Determine potential locations for all other blue energy locations	Potential SBE potential areas identified ready for implementation as well as for R&D 2020 - 2025

Targets	Actions	Indicators and Timeframe
2.2 Implement sustainable blue energy projects	2.2.1 At least 15% of energy to come from sustainable blue energy such as Offshore Wind Energy (30%) Floating Solar Photovoltaic (20%) Wave Energy Conversion (20%) Marine Algae Biofuels (10%) Oil and Gas (20%)	At least about five types of SBE projects implemented 2020 - 2030
2.3 Promote the application of offshore wind energy for the production of hydrogen	2.3.1 Pilot test the production of hydrogen from off-wind energy	Pilot project completed 2020 - 2021
2.4 Undertake study tour to share experiences in the implementation of sustainable blue energy technologies	2.4.1 Undertake a study tour to share experience in the development and application of some of the promising technologies such as FPV, wave energy conversion, and hydrogen production.	Study tour conducted in selected African and other countries 2020 - 2030
2.5 Identify sustainable blue energy resources that could help the transition of more sustainable and applicable targets of beneficiary communities	2.5.1 Identify beneficiary targets that could benefit from sustainable blue energy.	Beneficiary communities identified 2020 - 2025

Table 10: *Presentation of objective 3 of Goal 1*

Goal 1 – Unlock sustainable blue energy potential
Objective 1.3 – Assess the availability of sufficient infrastructures at (a) national (b) regional, (c) and continental level
Some of the sustainable blue energy technologies, for example, offshore wind, and oil and gas, have high potential in providing services beyond a national judication. Without having reliable power grid infrastructure in case of electricity, and pipeline in case of hydrogen, oil and gas, their benefits might not be realized adequately. Thus, sufficient assessment and implementation of reliable infrastructure is required that increases benefits and reliabilities beyond national jurisdiction.

Targets	Actions	Indicators and Timeframe
3.1 Conduct national infrastructure reliability and readiness assessment	3.1.1 Undertake energy infrastructure (grid electricity and pipeline) availability and reliability study to accommodate the blue energy development and evacuation	Energy infrastructure assessment completed 2020 – 2023
	3.1.2 Undertake feasibility studies for grid power integration where sustainable blue energy can benefit from and also benefit land locked countries	Grid infrastructure feasibility studies completed
	3.1.3 Identify gaps that require investment and infrastructure development to realize the application of sustainable blue energy	Gaps identified in existing infrastructures 2020 – 2023
3.2 Determine regional infrastructure needs	3.2.1 Undertake the availability of regional electricity grid infrastructure especially for the three African Power Pool regions of offshore wind energy potentials such as the Southern African Power Pool (SAPP), the Eastern African Power Pool (EAPP), and the Maghreb Electricity Committee (COMELEC))	Regional energy infrastructure needs identified and proposal for implementation completed 2021-2025

Targets	Actions	Indicators and Timeframe
	3.2.2. Determine gaps in the already ongoing gas pipeline infrastructures and propose needs for implementation	Natural gas pipeline capability gaps identified and proposal for implementation completed 2020 - 2025
	3.2.3 Determine natural gas infrastructure needs in countries where new oil and gas are discovered.	Potential natural gas pipeline needs completed 2020 – 2022

Table 11: *Presentation of objective 4 of Goal 1*

Goal 1 – Unlock sustainable blue energy potential
Objective 1.4 - Power the blue economy
Several sectors of blue economy activities such as tourism, aquaculture, mining, desalination, maritime shipping, and other blue economy related coastal activities require energy and sustainable blue energy could provide on-the-spot energy needs without requiring expensive transmission lines. Thus, the identification of potential blue economy and other sectors that could directly benefit from sustainable blue energy technologies without the need for building extensive infrastructure should be identified to benefit from sustainable bleu energy.

Targets	Actions	Indicators and Timeframe
4.1 Identify blue economy energy requirements	4.1.1. Determine blue economy energy requirements for different applications operating in the blue economy including offshore marine aquaculture, marine algae, mining seawater minerals, desalination, coastal community power grids, ocean observation and navigation, and underwater vehicles.	Potential energy demand for blue economy sectors that could be powered by SBE activities determined 2020 - 2025
	4.1.2 Determine blue economy energy requirements operating inland that could benefit from sustainable blue energy such as aquaculture production, communities along rivers and lakes that could benefit from FPV, agriculture i.e. powering irrigation and production.	Potential inland target communities and activities identified and implemented 2020 - 2025
4.2 Identify sustainable blue energy powering devices	4.2.1 Identify applicable blue economy powering technologies that could be applied for various services	List of innovative powering devices in the ocean identified and recommendation provided on annual bases 2020 - 2030

Table 12: *Presventation of objective 1 of Goal 2*

Goal 2 – Create conducive regulatory environment for the development and application of sustainable blue energy
Sustainable energy potential assessment and implementation plan is not enough without having conducive regulatory framework, adequate governance, financial structure, and environmental guidelines. Moreover, as the electricity demand in Africa is projected to triple by 2030 requiring about USD 70 billion per year investment between now and 2030 in which about two thirds of the total investments in generation capacity, or up to USD 32 billion per year could account renewables, without creating conducive regulatory environment could not be attained. Such projected investments could be hampered by the lack of conducive regulatory environment that discourages investors and deter regional and international collaborations. Thus, in order to realize the application of sustainable blue energy, the development and enforcement of conducive policies, governance structures, tariff structures, and regulatory frameworks should be prepared.
Objective 2.1 – Reform unsustainable financial structure and create conducive energy finance instruments
As in any other energy sources, especially renewable energy sources, sound financial structure is key to ensure profitability, sustainability and competitiveness in the market. However, in most cases, utilities don't have profitable financial structure and are subsidized. This needs to change and sustainable financial structure that attracts investment should be developed.

Targets	Actions	Indicators and Timeframe
1.1 Reform energy subsidies and reform tariff restructuring	1.1.1 Transform current electricity tariff subsidy into market driven electricity tariff system	Transformation of electricity tariff completed 2020 – 2025
	1.1.2 Introduce innovative financing mechanism and create "Blue Energy Fund" mechanism similar to "Green Bond" for renewable energy.	Introduction of innovative financing mechanism completed and "Blue Energy Fund" created 2020 - 2025
	1.1.3 Introduce new and update energy data management system to increase efficiency and transparency, and reliability	Utility data management system 2020 – 2025
1.2 Strengthen the financial capacity and creditworthiness of state entities	1.2.1 Transform utility structures in line with the development aspirations in a manner that could encourage investments in sustainable blue energy.	Transformation of utility structures completed 2020 - 2025
1.3 Develop clear and stable electricity tariff policy frameworks that enable the private sector to invest	1.3.1 Develop and implement tariff policy that encourage investors and users. It should be open and transparent process i.e. procurement etc…	Tariff policy developed and updated 2020 - 2025

Table 13: *Presentation of objective 2 of Goal 2*

Goal 2 – Create conducive regulatory environment for the development and application of sustainable blue energy
Objective 2.2 - Develop sustainable blue energy master plan and policy derivatives.
Without a masterplan and proper planning, targets could not be achieved, and penetration of sustainable blue energy not guaranteed. While some master plans such as renewable energy plans and natural gas master plans are in place, a master plans that reflects the application of sustainable blue energy should be developed.

Targets	Actions	Indicators and Timeframe
2.1 Assess the state of renewable energy and sustainable blue energy strategy	2.1.1. Identify the need for independent blue energy national strategy development and undertake actions to develop the strategy	Assessment of renewable energy strategies revised and the need for an independent SBE strategy identified 2020 - 2011
2.2. Develop and incorporate sustainable blue energy in the national strategy	2.2.1 Develop sustainable blue energy strategy	Sustainable blue energy strategy developed 2020 – 2022

Targets	Actions	Indicators and Timeframe
	2.2.2 Incorporate sustainable blue energy mix in the national renewable energy strategy or road map	Incorporate sustainable blue energy in renewable energy strategy 2020 – 2023
	2.2.3. Develop long-term sustainable blue energy strategy and quantify it's contribution (low carbon scenario analysis).	Low carbon development scenario analysis completed that include SBE. 2020 – 2025
2.4 Updating of regulations and policies to meet new development and requirements	2.4.1 Update regulatory frameworks to meet sustainable blue energy requirements	National regulatory frameworks updated 2020 – 2025
	2.4.2 Harmonize regional regulations and policies to reduce risk and encourage collaboration	Regional regulations harmonized 2020 – 2025
2.5. Investigate how blue energy empower local productivity to use energy	2.5.1 Assess the contribution of SBE in eradicating poverty and increase income of communities especially in coastal areas.	Disadvantaged communities and SBE projects identified to spur local economy 2020 – 20205
	2.5.2 Synergy blue economy with economic development so that electricity consumption per capital increases	Contribution SBE to national economic development quantified 2020 – 2030

Table 14: *Presentation of objective 3 of Goal 2*

Goal 2 – Create conducive regulatory environment for the development and application of sustainable blue energy
Objective 2.3 – Develop environmental and social impact assessment guidelines
For some sustainable energy sources especially oil and gas, the availability of environmental and social impacts assessment guidelines is very important. This is because, in addition to helping to mitigate environmental impacts, it could expedite the licensing for exploration and implementation of some sustainable blue energy sources such as oil and gas.

Targets	Actions	Indicators and Timeframe
3.1 Environmental impact assessment guideline	3.1.1 Develop environmental impact assessment guideline and/or update the existing once	Environmental impact assessment guidelines completed 2020- 20205
	2.2.1 Develop sustainable blue energy strategy	Sustainable blue energy strategy developed 2020 – 2022
	3.1.2 Develop regional strategic EIA for blue energy and harmonize the national strategies to consider the development of blue energy,	Strategic environmental impact assessment guideline completed 2020- 2025
3.2 Develop environmental sensitive areas	3.2.1 Develop environmentally sensitive areas and pre-determine the environmental sensitive corridors with the aim of expediting the licensing for exploration and minimize impacts.	Environmental sensitive areas identified in the SBE corridors 2020 – 2022
	3.2.2. Develop environmental sensitive areas spatial mapping	Spatial mapping completed 2020 - 2025

Table 15: Presentation of objective 1 of Goal 3

Goal 3 – Meeting the growing demand of mineral resources for economic prosperity
Mining is the single largest industrial activity in the subcontinent, contributing significantly to fiscal revenues and GDPs. The global interest of seabed and seawater mining for the extraction several valuable minerals such as rare earth elements (REEs), precious metals, lithium, and uranium is increasing. The types of minerals that could be extracted from seawater, which has minimal environmental impact is also huge. While some African countries are already extracting valuable minerals like diamonds from shallow areas, going deeper to mine untapped minerals to meet increasing demands and economic development needs is timely.
Objective 3.1 – Increase deep-seabed and seawater mining production for meeting demand and economic prosperity
As the demand for minerals is increasing, African should take this opportunity and take a proactive action to increase the production of mineral from deep-seabed and seawater. This requires having a complete potential of such minerals and locations.

Targets	Actions	Indicators and Timeframe
1.1 Asses and map the potential area for mineral extraction	1.1.1 Determine the types of mineral resources and develop a preliminary assessment report	Potential assessment report completed 2020 - 2026
1.2 Determine economic, financial and technical viability of deep-seawater and seawater mining potentials	1.2.1 Quantify the economic viability of deep-seabed mining and seawater mining potential	Economic and technical viability determined 2022-2028
	1.2.2 Undertake risk analysis including financial, environmental, regulatory, and climate risks	Risk assessment report completed 2020 - 2025
1.3 Integrating mining industry to the national and local economy	1.3.1 Quantify the national economic contribution of the potential	National economic contribution report completed 2020 - 2025
	1.3.2 Quantify the contribution of the mining activity for local economy through job creation and economic contribution	Job creation and gender equity report completed 2020 - 2030

Table 16: Presentation of objective 2 of Goal 3

Goal 3 – Meeting the growing demand of mineral resources for economic prosperity
Objective 3.2 – Create conducive regulatory frameworks for exploration of deep seawater
As the world is entering the unchartered territory in ripping the benefits of deep-seabed mining and sweater mining, policies and regulators frameworks are not in place which are the bases for approving licenses for exploration and mining. Under such circumstances, regulatory frameworks should be developed specific to deep-seabed and sweater mining. This paves away for implementing projects which is needed at this time.

Targets	Actions	Indicators and Timeframe
2.1 Regulatory framework developed	2.1.1 Develop regulatory framework in line with international mining rules and regulations and best practices. The regulatory framework should ensure its application not only for exploration licensing but also its application for negotiation so that it can meet national interest.	Regulatory framework developed 2020 - 2023
	2.1.2 Develop continental mandatory minimum operating regulatory standards (AU Mining Operating Protocol)	Operation standards completed 2020 - 2025
2.2 Regulate the application of blue energy for mining activities	2.1. Develop a regulatory framework for the application of sustainable blue energy requirements for mining	Regulation for the application of SBE in mining finalized 2020 - 2025

Table 17: *Presentation of objective 3 of Goal 3*

Goal 3 – Meeting the growing demand of mineral resources for economic prosperity
Objective 3.3 – Promote sustainable and environmentally friendly deep-seawater exploration and mining practices
Assessing the potential of minerals and developing regulatory framework for licensing, exploration and mining is not enough. The minerals must be mined in environmentally friendly manner for the fact that especially deep-seabed mining could destroy marine habitats.

Targets	Actions	Indicators and Timeframe
3.1 Baseline studies	3.1.1 Develop baseline studies which determine detailed environmental conditions in potential locations for mining	Baseline assessment completed 2020 - 2030
	3.1.2 Undertake environmental survey and develop spatial mapping, which identifies sensitive environmental areas.	Specific environmental sensitive areas determined 2020 - 2025
3.2 Regional strategic environmental	3.2.1 Develop an environmental impact assessment guideline specific to deep-seabed mining and seawater mining	Environmental impact assessment guideline for deep-seabed mining and seawater mining completed 2020 - 20205

Table 18: *Presentation of objective 4 of Goal 3*

Goal 3 – Meeting the growing demand of mineral resources for economic prosperity
Objective 3.4 - Capacity Building and Technology Transfer
Deep seawater mining and seawater mining require the application of advanced technologies. In order to make use of these technologies, capacity building, technology transfer, exchange programs, creation of database, knowledge management and institutional strengthening. The following targets and actions are some of the activities aimed to achieve capacity building and technology transfer.

Targets	Actions	Indicators and Timeframe
4.1 Capacity building	4.1.1 Develop deep-seawater and seawater mining skills (technical, policy, financial and negotiation) needs assessment and strategy	Skills needs assessment completed 2020 - 2025
	4.1.2 Develop national capacity for deep-seabed mining and seawater mining	National skills capacity strengthened 2020 - 2030
	4.1.3 Undertake continental capacity readiness assessment (institutional, technical and financial)	Continental capacity readiness study completed 2020 - 2025
	4.1.4 Develop gender specific skills assessment and empowering strategy	Gender specific assessment and empowering strategy completed 2020 - 2024
4.2 Promote technology transfer	4.2.1 Undertake study tour within Africa as well as international to gain more experience for speedy application.	Study tour conducted 2020 - 2030
4.3. Asses and create a database	4.3.1 Create a database on African institutions and strengthen their capacity to conduct deep-seawater and seawater mining	Capacity strengthened and database created 2020 - 2030
4.4 Clearinghouse mechanism	4.4.1 Create continental mining professional's database for concerted experience sharing and capacity building	Professional database created and annually updated 2020 - 2030

Targets	Actions	Indicators and Timeframe
	4.4.2 Develop an integrated knowledge management system	Knowledge management palatiform launched
	4.4.3 Develop a clearinghouse for status of six capitals such as financial, human, natural, physical, political, and social capital.	Clearinghouse created and annually updated 2020 - 2025

Table 19: *Presentation of objective 1 of Goal 4*

Goal 4 – Optimize the application of innovative industries
The world is moving at a faster pace in testing and implementing innovative industries. This highlights that African countries should invest in research and development (R&D), devising regulatory frameworks that encourage the application of innovative industries, increase its institutional, infrastructural and human capacity, and promote the application of innovative multidimensional and multisectoral innovations that being prosperity to the community. The sustainable blue energy is one of the best examples that helps to promote innovations in areas where countries are already in need such as water scarcity, sea level rise, and energy demand.
Objective 4.1 - Develop policy framework to accelerate the transfer and application of blue economy technologies
While technological advancement is progressing at a faster pace than ever, the lack of regulatory framework is deterring the testing and application of innovative industries. Thus, in order to benefit from innovative industries, regulatory framework should be in place that helps the acceleration and adoption innovative industries.

Targets	Actions	Indicators and Timeframe
1.1 Regulatory framework for blue economy innovative industries	1.1.1 Develop policy framework, which promotes the institutionalization R&D for innovative industries	Regulatory framework developed and approved 2020 - 2022
	1.1.2 Develop continental and regional regulatory framework that promotes cooperation and sharing of resources	Continental and regional regulatory framework developed 2020 - 2024
	1.1.3 Develop health and safety standards aligned which are aligned with standards for health and occupational safety specific to all sectors	Health and safety standards finalized 2023 - 2026
1.2. Institutionalize research and development for innovative industries in the blue economy	1.1.2 Institutionalize of research and development for innovative industries	Research and development for innovative industries institutionalized 2020 - 2023

Table 20: *Presentation of objective 2 of Goal 4*

Goal 4 – Harnessing the potential of innovative industries through research and development
Objective 4.2 - Strengthen institutional, financial and human capacity
Policy without financial support and adequate technical capacity could not be effective if blue economy is to succeed. As most of research institutions suffer from the lack of well-defined research and development (R&D) institutional set-up, financial availability and skilled manpower, the application of innovative industries is not advancing as expected.

Targets	Actions	Indicators and Timeframe
2.1 Strengthen institutions	2.1.1 Identify institutional needs and take action to strengthen national level research and development for innovative industries	Research and development strengthened 2020 - 2030
	2.1.2 Strengthen regional and continental R&D and innovation institutions	Regional research and development strengthened 2020 – 2030

Targets	Actions	Indicators and Timeframe
	2.1.3 Develop an institutional framework that encourage, support and promote innovation through enabling mechanisms, for example supporting and creating incubators for innovation, and research and development	Blueprint for encouraging entrepreneurship through incubation implemented 2020 - 2030
2.2 Human Capacity	2.2.1 Determine human capacity needs for blue economy research and development	Human capacity needs assessment completed 2020 - 2025
	2.2.2 Develop national, regional and continental capacity building strategy	Regional capacity building strategy completed 2020-2025
	2.2.3 Develop gender specific capacity building to ensure gender equity is applied.	Gender specific capacity development strategy completed 2020-2025
2.2. Financial support	2.2.1 Determine financial requirements for institutional and human capacity building	Financial needs estimated 2020-2024
	2.2.2 Secure sustainable financial support	Finance secured 2020-2025

Table 21: *Presentation of objective 3 of Goal 4*

Goal 4 – Harnessing the potential of innovative industries through research and development
Objective 4.3 - Promote the application of innovative industries
The application of innovative industries both at testing and application state are happening across the world and in some African countries. It also time to promote the application of new innovative application in the blue economy in general and sustainable blue energy and mineral production in particular. These innovative applications are multidimensional and multisectoral in nature can help increase community's resilience at the time of climate change induced risk such as water scarcity and sea level rise. Here under some innovative applications are identified for action.

Targets	Actions	Indicators and Timeframe
3.1Sea level rise adaptation and wave energy generation	3.1.1 Integrate wave energy conversion (WEC) technology with sea level rise adaptation projects (Coastal Adaptation – Wave Energy Conversion Nexus) and implement at least three projects	At least three wave energy conversion technology integrated with coastal adaptation 2020 – 2030
3.2 Desalination using sustainable blue energy	3.2.1 Implement at least three small to medium scale marine energy technology powered desalination projects (Marine Energy – Desalination Nexus)	At least three SBE powered desalination systems implemented 2022- 2030
3.3. Produce hydrogen using sustainable blue energy	3.3.1 Implement at least three off-shore wind powered hydrogen production facilities (Off-shore Wind and Hydrogen Production Nexus)	At least three off-shore powered hydrogen powered systems implemented 2022-2030
3.4 Powering blue economy activities	3.4.1 Assess the application of marine energy for powering blue economy especially powering unmanned vehicles in deep-seabed mining	Sustainable blue energy powered mining systems introduced and implemented 2020-2030
	3.4.2 Determine and implement the application of sustainable blue energy for different blue energy sectors including: Aquaculture, Ice-making, and Maritime activities.	Feasibility of projects completed and projects implemented

Targets	Actions	Indicators and Timeframe
3.5 Application of innovative industries across all sectors	3.5.1 Develop sectoral innovative industry application potentials and select feasible projects in the blue economy sectors	Blue economy energy needs determined, and projects implemented 2020-2030
	3,5,2 Promote the application of market and production scale economies in blue economy	

Table 22: *Presentation of objective 4 of Goal 4*

Goal 4 – Harnessing the potential of innovative industries through research and development
Objective 4.4 – Create innovative industry database and support tools and promote collaboration
One of the core requirements for advancing innovative industries and technologies is the availability of information and promoting collaborations. Through assessment and measurement, innovative industry and hydro metrological databases should be developed to ensure evidence-based decision-making are exercised. This need to be accompanied by the development of decision-making tools for effective application.

Targets	Actions	Indicators and Timeframe
4.1 Improve knowledge in innovative industries	4.1.1 Study tour in countries already applying innovative industries.	Study tour conducted as needed 2020 - 2030
	2.1.2 Strengthen regional and continental R&D and innovation institutions	Regional research and development strengthened 2020 – 2030
4.2 Compile innovative technology data base	4.2.1 Undertake innovative industry assessment and create database to promote evidence-based decision-making and evaluate their scalability and adaptability.	Innovative industries database of blue economy completed and periodically updated 2020-2030
4.3 Develop climate information database and decision-making supporting tools	4.3.1 Strengthen hydro metrological database and identify locations where innovative industries could be applied.	Climate database and tool completed to help integrate blue economy in general and suitable blue energy in particular
	4.3.2 Develop decision-making supporting tools such as spatial maps	Decision-making support tools developed for blue economy 2020 - 2030
2.4 Promote international knowledge transfer mechanism	2.4.1 Develop a mechanism for international knowledge transfer and capacity building	Mechanism for knowledge transfer completed and operationalized 2020-2025

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