Encouraging a Just Energy Transition Through Wave Energy Converters in Small Island Developing States (SIDS)

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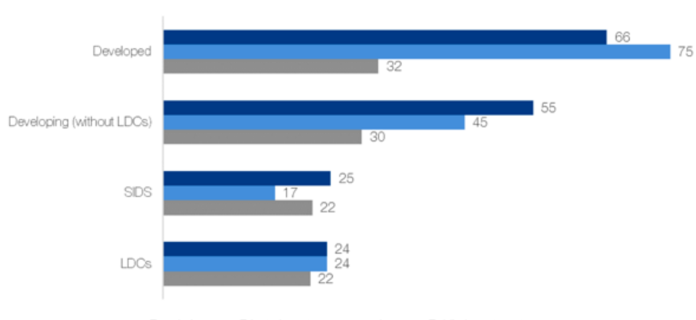
Key Messages

- The potential of wave energy for global production is estimated to be 29,500 TWh, almost ten times the annual electricity consumption of Europe.
- This is an untapped potential to diversify the renewable energy landscape for SIDS energy security and energy demand. It is beneficial for SIDS to have their own renewable energy source to decrease energy prices, making it affordable to everyone.
- The main limitations for implementing Wave Energy in SIDS are skills and knowledge shortage for policymakers and technicians, as well as a lack of data and research regarding life cycle and biodiversity impact of WECs.
- Wave energy can produce 10-12 jobs per megawatt, five times more than wind energy.
- Collaboration among stakeholders in wave energy deployment is key to increase wave energy projects and reduce the cost of energy in SIDS.

The energy system is identified as a central focus of policy response to climate change.[i] Governments are encouraged to shift from fossil fuel dependency in relation to climate change and energy security. In Small Islands Developing States (hereafter SIDS), the energy sector relies heavily on fossil fuels which has distribution and dependency risks. However, some states have shown a progressive shift towards renewables.

Figure 1. Policy aspects addressed in renewable energy policies, by type and category of countries (Per cent of countries)



Source: UNCTAD, based on Climate Change Laws of the World database.

Renewable energy offers a pathway to decarbonization, economic independence, and environmental resilience for SIDS. However, only a third of SIDS have adopted renewable energy policies.[ii] Among renewable energy sources, wave energy holds a particular promise for SIDS given their proximity to vast maritime areas. The integration of wave energy demands a comprehensive approach to funding, regulation, and capacity building.

The transition to renewable energy poses risks to a carbon-intensive economy therefore ensuring a just transition is needed. In this brief, the authors will assess the advantages and limitations of wave energy in encouraging a just energy transition in SIDS. The potential of Wave Energy Converters (hereinafter WECs) is analysed from the political, environmental, technical, and socio-economic sectors. To advance our brief, the authors use a future scenario analysis to show a variety of pathways for SIDS.

Diversifying Renewable Energy in SIDS

As the human population is growing and the global demand for clean and sustainable energy intensifies, the exploration and development of ocean energy technologies hold promise for diversifying the renewable energy landscape and reducing dependence on traditional fossil fuels, marking a significant step toward a more sustainable and resilient energy future.[iii] Because oceans cover a staggering 70% of the world's surface and are always consistently in motion due to the tides and wind, the energy potential for harnessing sustainable power is unmatched.

The perpetual ebb and flow of the ocean waves provide an unlimited source of potential renewable energy, enough to easily exceed current human energy demand.[iv] Wave energy presents an untapped energy source with a far higher energy density than solar or wind energy.[v] Furthermore, compared to wind, waves are significantly more predictable and less chaotic due to their physical characteristics.

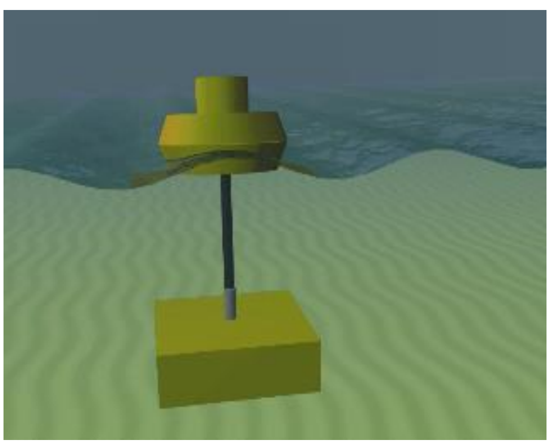
Due to their major reliance on imported fossil fuels, SIDS have some of the highest electricity costs globally due to energy supply chains being severely disrupted.[vi] SIDS NDCs demonstrate that over half of the deployment is reliant on foreign assistance: by 2030, SIDS have committed to installing 11.5 GW of renewable energy capacity.[vii] Many SIDS would undergo radical change because of achieving this goal, most notably in terms of their socioeconomic advancement and energy independence and security.

Wave Converters (WECS) As Technology

WECs, designed to capture the kinetic energy stored in the rhythmic motion of the waves, stand at the forefront of this technological revolution. The Intergovernmental Panel on Climate Change (hereinafter IPCC) estimates the potential of wave energy for global production to be 29,500 TWh, almost ten times the annual electricity consumption of Europe.[viii] In the blooming era of the blue economy, wave energy systems can offer a clean and sustainable source of power that aligns with the global transition to renewables, marking a pivotal step toward a more resilient and environmentally conscious energy future (Annex 2).

In short, the buoys (Picture 2) absorb energy from all directions through movements at or near the water surface, converting buoyant top motion into electrical power. The energy absorbed is transferred via subsea cables and is stored in grid capacity on land. This depends on the type of technologies used to store the energy. A wave cost analysis in the Pacific conducted in 2015 found that a 1MW solar PV system to be connected to the grid would require some 24000m^2-36000m^2 on land, whereas a 750kW WEC would only require some 750 m^2 on land to store power[ix]. The energy of a single device could supply a large proportion of the energy demand of some small island states.

Figure 2. Point absorbers



Just Energy Transition

According to Just Energy Transition Partnership (hereinafter JETP), a just energy transition refers to integrating measures that aim to mitigate the direct, indirect, and induced adverse impacts of the transition on workers and communities that depend on the fossil fuel chain.[x] A substitute must be available and implementable. In addition, Asia-Pacific Economic Cooperation (hereinafter APEC) uses the term just energy transition to ensure the sustainable process which comprises equal distribution of energy, as well as recognizing and respecting local circumstances.[xi] When it comes to the energy transition, there is a dire need to make sure that no one is left behind.

> Most feasible WECs cost 250 to 350 euros/MWh and the price may drop to **100 – 120 euros/MWh.**

There are several ways to pursue this. First, the energy source must be justly distributed, which means that it is beneficial for SIDS to have their own renewable energy source. Independence is an important factor for energy security in SIDS. Then, the energy cost must be affordable so that it is accessible to everyone. In comparison to fossil fuels, wave energy is still expensive (see Annex 3). However, it is worth noting that the more investments are made, the quicker the price decline will happen.[xii] Third is job transition—a shift to clean energy risks job loss. However, wave energy converters will create 10-12 jobs per megawatt.[xiii] The development and maintenance create job opportunities, and a large portion of the device could be built in one of the major ports of the region, strongly reducing the capital cost.[xiv] It is a matter of how to equip the local capacity to reskill to ensure that people can answer the job demand.

Gaps in Resources

Energy transition to renewable energy can improve energy security and diversify energy sources in SIDS, but there are some limitations to implementing wave energy in SIDS – lack of capacity building for policymakers and technicians and lack of research for WECs. Policymakers lack the skills and time to implement a blue economy and to do ocean management through policy documents.[xv] Lack of data collection and management, economic analysis, ocean management foresight and innovation in governance structures and stakeholder engagement slow down wave energy implementation in national policy documents.[xvi] In addition, there is fragmented data and a lack of life cycle analysis and environmental impact assessment for WECs as they are not technically mature yet, which limits information about how corrosive salt water is for the device or what is the effect on biodiversity. It creates a *Catch-22* scenario: regulators are hesitant to approve projects without knowing the details of the impacts, but developers are unable to supply this information until their projects are underway and data has been gathered.[xvii] Capacity building for local technicians is also needed for deploying and maintaining WECs and commissioning electricity from WECs (Annex 3).

How To Accelerate the Implementation?

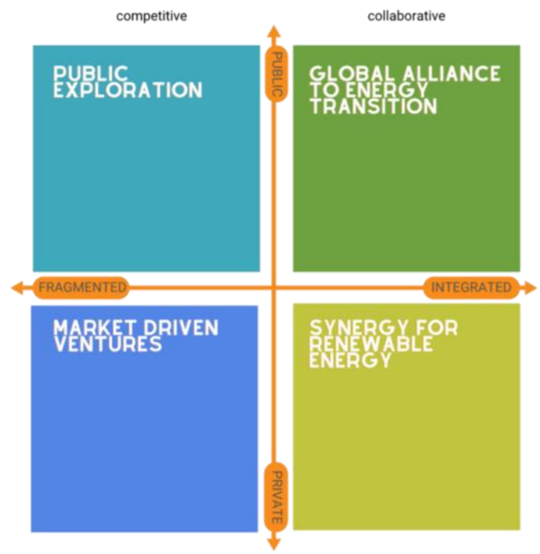
There are two ways of looking at the implementation of wave energy projects, by the public sector or the private sector. When looking at the public sector, the interest of the country towards a blue economy must be reflected in policy regulation. Countries like Mauritius (see Annex 4) are more attractive and receptive to innovation because they have a policy on renewable energy pathways. The policy itself must be comprehensive (across industries) and open to innovative renewable energy.[xviii] Governments are encouraged to actively innovate with policy tools such as providing incentives to adjust the market.[xix]

When it comes to the private sector, limited actors are working with wave energy.[xx] However, they respond well to demand. Seabased for example, has signed a Memorandum of Understanding (hereinafter MoU) with Tonga to develop a 10 MW Wave Power Park in Tongaptu.[xxi] There is an exceptional need for investments to accelerate wave energy. Many initiatives provide funding for partnerships in wave energy (Annex 5). SIDS Dock, on the other hand, facilitated the agreements between Tonga and Seabased. It is visible that the governance of wave energy projects plays an important part in encouraging more projects.

Future Scenario Analysis

Energy security and the role of wave energy were portrayed in future scenario analysis. This future scenario analysis portrays driving forces that have a key role in the future of wave energy in SIDS characterized by different governance approaches. Based on expert interviews and research, two main factors in the implementation of wave energy converters are **the sector** and **the governance**. Sector refers to whether the projects are initiated by, and is funding coming from, the **public or private sector**. Project governance refers to the system the projects are directed, whether it's **fragmented or integrated**.

Figure 3.



Scenario 1 (Public Exploration) public sector is at the forefront of technology development, with capaity building in one renewable energy sector, thus not adopting multiple renewables at once. The private sector predominates in **Scenario 2 (Market Driven Ventures)**, where it places a higher value on expenditure-based incentives and a competitive climate that could spur technological advancement. **Scenario 3 (Global Alliance to Energy Transition)** envisions integrated public sector governance dedicated to renewable energy research through financial instruments, such as grants and feed-in tariffs. In **Scenario 4 (Synergy for Renewable Energy)**, the private sector is governed in an integrated manner with long-term collaboration with local governments, strong encouragement of private investment, and an emphasis on national and international incentives (Annex 6).

Towards a Just Transition with Wave Energy

Only one-third of SIDS have renewable energy policies in place, although renewable energy – including wave energy - can help SIDS become economically independent and improve energy security. WECs are promising technology for clean energy and energy security, but more research needs to be done. It is important to shift our focus to the energy transition, putting an effort into making sure it does not have a negative impact on communities and workers who rely on fossil fuels. SIDS are dealing with some challenges in just energy transition, such as not having enough financial support, a shortage of skilled technicians and policymakers, and a lack of regulation about wave energy.

Policy Recommendations

Two key drivers in promoting the implementation of wave energy converters to encourage a just transition in SIDS are the sector (public/private) and the structure (fragmented/integrated). Stakeholders involved must first identify the conditions of the states where the WECs are going to be deployed in terms of national capacity, regulations, and funding source.

To ensure a just energy transition, here are the following recommendations:

- Increase capacity building for policymakers, such as skills and knowledge for economic analysis (e.g. cost-benefit analysis), data collection and management, and ocean governance, and for technicians, such as technical skills and knowledge for WECs deployment and maintenance, in SIDS. In addition, focus on empowering localized development by giving scholarships in engineering programs focused on renewable energy technologies.
- Accelerate research on WECs regarding biodiversity impact and life cycle analysis, as well as do seafloor mapping of the biological, habitat, and deep-sea terrain around SIDS. To further advance the development of wave energy in SIDS, engagement with research institutions and arm's length institutions is necessary to improve evidence-informed policymaking in SIDS regarding renewable energy policy.
- Work towards a comprehensive renewable energy project it should be made mandatory to consider biodiversity impact from local knowledge, engaging with bodies like IPBES or local biodiversity agencies to ensure ecological zoning, mitigation measures, and monitoring.
- Encourage the transition from fossil fuels to the renewable energy mix by pairing renewable energy sources with each other, creating baseload electricity and a day demand electricity, such as wind and wave power, together with sufficient power storage facilities.
- Attract foreign direct investment and financing for deploying WECs using international projects, such as the EU HORIZON project or the SIDS Clean Energy Toolkit. Implementation of a transparency policy will increase the attractiveness of wave energy projects.
- Embrace local conditions such as the energy grid, coastline, human resources, legislation regarding offshore energy, and access to the internet, and implement the blue economy policy based on local conditions and resources. This includes identifying areas of resource gaps and addressing them in WECs project planning.
- Encourage investment in different renewable energy by stimulating investment and providing revenue predictability. Governments must provide incentives to renewable energy sources and implement reliable Power Purchase Agreement. Policymakers are encouraged to use policy tools on targeted energy incentives, both in fiscal and non-fiscal incentives.

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Annex

Annex 1. Expert Interviews

For this policy brief, 8 experts were interviewed. Interviews happened mainly online, two interviews were held in person and one via email. Only 2 meetings were recorded.

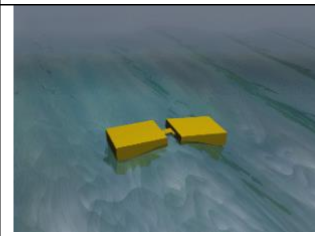
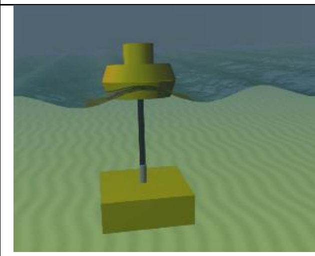
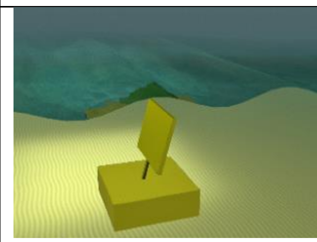
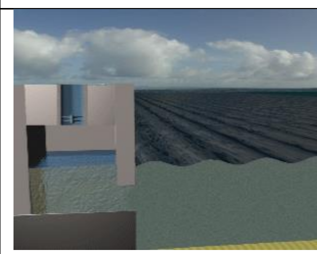
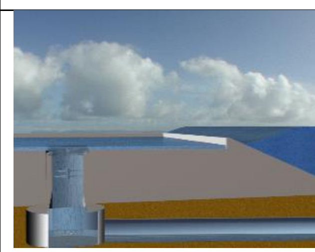
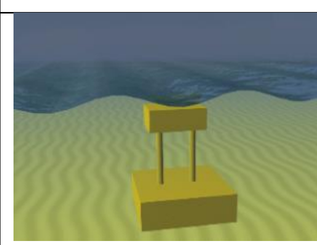
Table Interviews

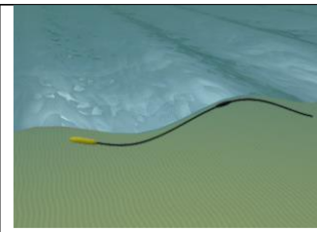
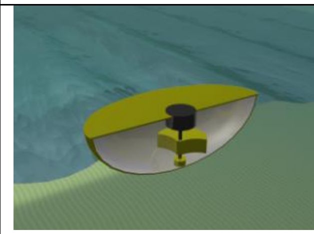
No.	Institution	Topic	Country	Date
1.	TU Delft MRE Lab	WECs technical and socio-economic benefits and limitations	The Netherlands	17.11.23
2.	MARENA	Wave energy in Mauritius	Mauritius	17.11.23
3.	Global OTEC	Ocean energy in SIDS	The United Kingdom	21.11.23
4.	Carnegie	Wave energy in Australia	Australia	23.11.23
5.	University of Aveiro	WECs benefits and limitations, Iberian Peninsula as a case study	Portugal	23.11.23
6.	Maritime Research Institute Netherlands (MARIN)	WECs technical benefits and limitations	The Netherlands	22.11.23
7.	European Marine Energy Centre (EMEC)	Wave energy benefits and limitations in the Global South	The United Kingdom	24.11.23
8.	The Pacific Community (SPC) Geoscience, Energy and Maritime Division (GEM)	Wave energy developments and potential for Pacific Island Countries	Fiji	25.11.23
9.	Wageningen University and Research	Just energy transition	The Netherlands	28.11.23

Annex 2. Different WECS And How They Work

Wave energy converters (hereinafter WECs) capture kinetic energy from the continuous movement of the ocean and sea waves and convert it into energy through various mechanisms. WECs come in three main categories, namely onshore, nearshore, and offshore devices, each one tailored to specific coastal conditions. Onshore devices are fixed on land, integrated into structures like breakwaters, and work best in areas with rocky platforms and steep bathymetry. Nearshore devices, anchored to the seabed, capture wave energy close to the shore and transmit it to onshore facilities for conversion, ideal for depths under 25m. Offshore devices, moored to the seabed, transfer generated electricity through sub-sea cables, thriving in depths from more than 25m to less than 200m and proving more cost-effective in the face of larger waves.[xxii] Within these three categories, the WECs can be divided into eight categories which can be found below. This policy report will focus on case studies utilizing one of these prototypes, namely point absorbers, which are floating structures reminiscent of oceanographic buoys that absorb energy from all directions through movements at or near the water surface, converting buoyant top motion into electrical power.[xxiii]

Point absorbers have been identified as particularly applicable in the Pacific region and around SIDS. Increased deployment of wave technology could significantly cut costs for individual wave energy devices, potentially eliminating the need for small Pacific Islands to invest in large-scale wave farms. This shift is driven by the expectation that power production will exceed local demand.[xxiv] With anticipated fuel price hikes in the coming decades, single WECs could be a competitive option against fossil fuel generators because of the high cost of imported fuel. Deploying WECs in the Pacific offers a prime opportunity for the technology to showcase its effectiveness, attracting the attention of investors, policymakers, and decision-makers and garnering support for the advancement of wave energy in the region.[xxv]

Prototype	**How it works**	**What it looks like**
Attenuator	A floating device that operates parallel to wave direction, capturing energy from the relative motion of its two arms as waves pass.	
Point Absorber	A floating structure that absorbs energy from all directions through movements at/near the water surface, converting buoyant top motion into electrical power.	
Oscillating Wave Surge Converter	Extracts energy from wave surges and water particle movement by utilizing an arm that oscillates as a pendulum on a pivoted joint.	
Oscillating Water Column	A partially submerged, hollow structure with an open base to the sea. Waves cause the water column to rise and fall, compressing and decompressing an air column, which powers a turbine for electricity generation.	
Overtopping/ Terminator Device	Captures water as waves break into a storage reservoir. The water is returned to the sea through a low-head turbine, generating power. Collectors may concentrate wave energy.	
Submerged Pressure Differential	Located near shore and attached to the seabed, these devices use wave-induced sea level variations to create pressure differentials, pumping fluid through a system to generate electricity.	

Bulge Wave	Consists of a rubber tube filled with water, moored to the seabed. Passing waves cause pressure variations, creating a 'bulge' that gathers energy to drive a low-head turbine.	
Rotating Mass	Utilizes the movement of the device heaving and swaying in waves. This motion, attached to an eccentric weight or gyroscope, powers an electric generator inside the device.	

Source: All images taken were modified from EMEC, 2023.

Annex 3. Advantages And Limitations of Wave Energy

Advantages	
Improved energy security	Energy security has been one of the global challenges, hence wave energy could contribute to countries' energy security policy. Wave energy can reduce the country's energy dependency on fossil fuels, and ocean energy can play a key role in the energy transition to renewable energy.
Job Market	In addition to improving energy security and diversification, the development of renewable energy can present substantial job and regional development potential.[26] Because WECs are modular converters, local job growth benefits from the need for construction/assembly and maintenance facilities close to the installation site.[27] While offshore wind can produce two jobs per megawatt, wave energy can produce 10-12 jobs per megawatt.[28]
Wave energy converters have a significant impact on coastal processes and attracts new marine life and protects it from other activities such as fishing or tourism.	WECs as physical structures in the ocean can attract marine life, for example, small fish using WECs to hide from predators or use fouling organisms as feed. Wave Energy devices might affect the natural environment, thus creating the possibility for some species to colonise the structures.[29] In addition, WECs can function as artificial reefs for habitat.
Limitations	
High Upfront Cost.	Most feasible WECs will be in the range of 250 to 350 euros per megawatt hour and the price may drop to 100 – 120 euros per megawatt hour.[30] The industry's ability to reduce costs in every aspect of the supply chain and become more competitive with respect to other energy sources—both conventional and renewable—is essential to the growth of offshore wind capacity.[31] For WECs to be cost-effective most viable option would be the increase the technology readiness level of the WECs by focusing on a couple of technical principles. This way will lead to reduced costs and higher WECs performance.
Regulatory framework to increase skills in technicians and policymakers.	The regulatory framework regarding energy policies and ocean governance is fragmented. Policymakers lack the skills and time to implement an ocean economy implementing ocean energy in the national documents.[32] Policy makers need to use economic analysis and economic instruments to assess the wave energy implementation in national energy policies. The energy transition is a short period for one of the government's terms, thus creating a scare of upsetting voters and losing power in the government.[33] In addition, capacity building is needed for technicians, thus the government or private

	sector needs to identify and provide via training the necessary skills for recent graduates to enter the job market.[34] Government support could include scholarships for local students in marine renewable technologies.
Noise pollution due to constructions.	Underwater noise from WECs can be created during installation and operation as well as electricity's decommission.[35] Underwater noise can lead to changes in animals' behaviour and physiological stress. The cost of these reactions may change the energy balance and activity budget of the animals, which may have an impact on population dynamics.[36] For minimizing noise pollution possible solutions could be not doing maintenance or instillation of WECs during migration and mating seasons or investing in the bubble curtain, that can be deployed around WECs.[37]
Limitation of existing LCA.	As WECs are deployed in the ocean, seawater is a limiting factor in the lifespan of the devices, as well as surviving storms. WEC's lifespan is 20 years, which is competitive with some wind devices.[38] As WECs are made from steel, thus allow devices to be recyclable or even reusable.
The need of skills and costs for maintenance.	The energy transfer will require submarine cables and a power grid close to the shore. These infrastructures need to be close to maintenance centres (harbours) for affordable maintenance. Since most of the major cities around the world are close to the shore, this task will be easier because there will be major power grids connecting the cities. In addition, the need for expertise in installations in SIDS presents an opportunity for local development, emphasizing the importance of acquiring and maintaining specialized knowledge.
Increasing crowd of sea use.	Ocean space in many regions faces a risk of becoming more overcrowded, like the North Sea, due to maritime trade, offshore energy, coastal tourism, and marine aquaculture.[39] WECs can be deployed in many spaces from deep to low-depth waters, and surface to bottom, thus allowing WECs to avoid potential conflict between other maritime sectors.[40] The requirement for placing the devices should always be considered where no tourism, fisheries or transportation is happening.

Annex 4. Case Study: Mauritius, Barbados, Tonga, and Fiji

Mauritius stands out among SIDS with its ambitious and advanced renewable energy roadmap. The nation has set impressive national targets and implemented integrated policies and regulations to facilitate easier and faster integration of renewables, including ocean energy. The nation relies on imported fossil fuels, particularly oil and coal, for 84% of its primary energy needs. 62% of the countries' overall greenhouse gas emissions currently come from the energy sector, emphasizing the ongoing urgency of transitioning away from fossil fuel dependence.[xxvi] The Government of Mauritius exemplifies this commitment through the establishment of ambitious climate targets aligned with the Paris Agreement. The Mauritius Strategy, which entails a detailed roadmap for achieving the country's NDCs, states that the country wishes to achieve 60% of its energy using renewables in the electricity mix by 2030 and hopes to reach net-zero emissions by 2050. The renewables in question to see this plan through include wave and tidal devices, as well as a 40MW wind farm, multiple 10MW Utility Scale PV farms, and a floating solar power plant.[xxvii] According to the Mauritius Renewable Energy Agency, these actions have advanced the nation enough in their energy transition that they are already inviting external companies to submit proposals for innovative technology deployments, including solar and wave energy arrays.[xxviii] According to MARENA, the island nation included marine renewables so early in its energy roadmap because even though Mauritius has limited land, the potential of the surrounding ocean is quite exponential. By building up an energy mix that includes various renewable energy sources, the country can move towards a low-carbon economy while increasing its own energy security and creating new employment opportunities.

Barbados stands out for its robust climate ambition, demonstrating a strong commitment to phase out fossil fuels. The nation has solidified its dedication to combating climate change by firmly endorsing the Paris Agreement in 2015 and updating its NDC in 2020. In its latest NDC version Barbados has elevated its climate commitments by aiming at generating a capacity of 606 MW from renewables. Furthermore, in its National Energy Policy Barbados sets an even more ambitious goal, which is to run entirely on renewable energy by 2030, accounting for a total of renewable energy capacity goal of 625 MW.[xxix] To achieve this goal, it is necessary to adopt an efficient mix of renewable energy sources. Apart from technologies with are already largely commercialized such as solar PV, this mix will likely include ocean energy. This small island developing state, in fact, holds an ocean space 400 times larger than its land space, putting it in an especially advantageous position when it comes to the potential implementation of marine energy.[xxx] When it comes to wave energy specifically, Barbados is considered to have various suitable development sites, especially around its eastern coastal area. At the moment wave energy converters are not deployed yet, but they are expected to reach commercial readiness in five to ten years.[xxxi]

Tonga in its 2020 NDC version, has pledged to generate 70% of the energy it is going to use from renewable energy sources, for a total of 31 MW. Similar to Barbados, Tonga pushes further its goals in its domestic renewable energy target, aiming to run entirely on renewables by 2035. This would also escalate the energy production from renewable energies to a total of 63 MW.[xxxii]Tonga is already taking action to improve its energy resilience, and the plan also accounts for wave energy usage: in March 2023, the country has in fact signed an agreement with Seabased, a company that will install a wave power park in Tongatapu. The project will be carried out in two phases.

In the first phase, to be carried out later this year, the park will generate 2MW and is projected to save Tonga $2 million in foreign exchange, reduce carbon emissions by roughly 5.6 kilotons and provide power for 2,800 homes. In the second phase, which is expected to be operational by 2025, 8 additional megawatts are going to be generated, saving up to $10.5 million and 42 million litres of fuel. If the project is successful, it will account for half of Tonga's energy needs and reduce the island's emissions by 20%.

Fiji's National Development Plan aims for 100% renewable energy electricity generation by 2035, for which it only needs 120MW more of renewable energy.[xxxiii] The energy sector strategy comes from the Framework for Energy Security and Resilience in the Pacific (FESRIP), which includes a roadmap to 100% renewable energy from 2021-2030. FESRIP was endorsed by Pacific Leaders in 2021 and launched at COP27 in November of 2022, under joint ownership of five Council of Regional Organizations of the Pacific (CROP) Agencies. The Framework contains six priority categories which cover 23 areas of potential actions to achieve universal energy security. Priority 3, Sustainable Electric Power Development, entails recommendations for increasing the range of Renewable Energy technologies in Pacific Island Countries and Territories. They include the expansion of ocean energies and the adoption of emerging technologies to create a Renewable energy mix in Pacific Island Countries and Territories. This will be up to the relevant CROP agencies in collaboration with the private sector. A 2015 Cost Analysis of Wave Energy in the Pacific found that the most wave energy potential for Pacific Island countries and territories are French Polynesia, Tonga, the Cook Islands and New Caledonia, as they are exposed to the high energy Southern Ocean swells [xxxiv] Following the analysis, the South of Viti Levu and Taveuni, Fiji Islands, were also found to be feasible sites for wave energy resources. In collaboration with AEON Energy based in the UK, the Pacific Community (SPC) received 77k Euro from Innovate UK to implement a Waveflow technology with a target installed capacity of 200KW at Nayavuira village and school on the Northern tip of Viti Levu, Fiji Islands. Currently, the village and school rely on diesel generators to meet their electricity demand and are isolated from the utility grid. The Waveflow technology is due to be deployed between 2024-2026 [xxxv]

Annex 5. Multiple Programs For Financing Wave Energy

Horizon Europe Framework Programme (HORIZON) - the program is implemented by the call for a Sustainable, and competitive energy supply, which foresees the implementation of wave energy. The project aims to increase the availability of WECs in the market, increase trust in this technology, as well as increase knowledge about the positive and negative impacts of ocean energy. This project aims to help achieve the goal of clean and sustainable energy.[xxxvi]

EuropeWave - EuropeWave is a cutting-edge research and development program focused on wave energy technologies, with a 2021–2025 timeline. It will consolidate more than €22.5 million in funding from the EU, national, and regional sources to advance a competitive Pre-Commercial Procurement (PCP) program for wave energy.[xxxvii] The PCP model, which was first introduced by the Wave Energy Scotland initiative, offers an organized method that encourages increased transparency, cooperation, and risk sharing between the public sector and technology companies.[xxxviii] The main goals of the initiative are to design, develop, and demonstrate affordable WEC systems that can produce electricity in the harsh and unpredictably changing ocean environment.

H2OCEAN - development of a wind-wave power open-sea platform, that can produce hydrogen and sustain many energy users. H2OCEAN goes one step further and brings together a collection of independently validated technologies (hydrogen production, aquaculture, renewable energy harvesting, and environmental monitoring) to create a proof-of-concept design for a fully functional, multi component platform that can be used to harvest far-off ocean resources sustainably and evaluate the effects on the environment and the economy.[xxxix]

The SIDS Clean Energy Toolkit - created as part of a collaborative effort between Sustainable Energy For All (SEforAll) and the Commonwealth Secretariat, assists nations in converting their plans for the clean energy transition into viable economic ventures.[xl] The tool facilitates the examination of challenges such as limited project scope and low interest from big global investors, insufficient money in local financial institutions, and stringent legal restrictions on foreign investment.[xli] It enables users to carry out cost-benefit analyses and generate strong commercial prospects for foreign energy investment.

Annex 6. Future Scenario Analysis

Drivers of the scenarios:

1. **Capacity building:** Efforts in building capacity within local resources to answer the jobs demand coming from the transition to renewable energy. The format is dependable on the actors behind each program. Programs coming from a multinational company, or public institutions like the department of energy will be different. It can vary whether there are multi-skills trainings or specific (one sector at a time). Examples of skills: engineering, foreign language, administrative.
2. **Incentive:** Refers to the type of incentive used as a policy tool to encourage the transition to renewable energy. There are market-specific incentives and general incentives, which can target local or global markets. It comes in the form of fiscal incentives, and non-fiscal incentives that refer to grants, loans, and subsidies.
3. **Energy mix:** Refers to a mix of renewable energies pursued by the stakeholders to create energy security in SIDS. Some states aim for a variety of renewable energies while other states are in a stage where the only capability is to combine one specific renewable energy with fossil fuel.
4. **Economic feasibility:** the cost of wave energy converters and the process of energy cost decrease as more investments are made.
5. **Jobs creation:** refers to the shift of jobs from fossil fuel intensive industry and the creation of green jobs.
6. **Indigenous knowledge:** indicates to the community specific and place-based knowledge. In this case, wave energy projects might include the participation of local people or there may be limitation. This is in relation but not limited to land-use rights.

Scenario 1 – Public Exploration; A fragmented governance by public sector

The public sector is open to wave energy exploration. The capacity building will be segmented into a specific sector, supported more by the public actor. Local governments offer workshops and trainings for their employees. The states use generic tax incentives to attract investments, mostly on profit-based tax incentives. Due to the development being segmented, there is limited flexibility in building several renewables at a time. It is mainly based on whether countries' national policies still favour the use of fossil fuels or only one source of renewable energy. The cost is higher upfront, and the cost of energy will gradually decrease depending on the mainstreaming rate of WECs projects by the public sector. In here, the market is competitive. A diverse and competitive range of jobs will be created focusing solely on limited sources of energy. Seeing as the public has a big role, there will be public pressure to incorporate indigenous knowledge into the process. Therefore, ensuring the inclusivity of local wisdom are motivated by a bottom-up process.

Scenario 2 – Market-driven Ventures; A fragmented governance by private sector

The private sector is active in encouraging wave energy implementation. The capacity building will be segmented into a specific sector in the form of training programs by the private sector. It could be in the form of employee traineeships or workshops. The industry pushes for more expenditure-based incentives or non-fiscal incentives from the government. Based on the regulatory framework, costs for the integration of renewable energy will be increased. Investments in one specific technology from the private sector will be higher. The competitive environment encourages private sectors to continuously deploy WECs and other forms of renewables, which leads to higher investment and higher demands for jobs. The cost reduction will happen eventually depending on the investment rate. There will be a diverse and competitive range of job opportunities. Job creations are mostly from foreign companies, this encourages talent retention and brings challenge to knowledge transfers. Indigenous knowledge is limited or might take longer to integrate because private sectors have limitations in terms of achieving an inclusive framework.

Scenario 3 – Global Alliance to Energy Transition; An integrated governance by public sector

The public sector is open and committed to renewable energy exploration. The capacity building among sectors will be integrated and continuously answer the jobs demands. Some of the tools used for capacity building would be scholarship offers for local students in the renewable energy sector or using the United Nations trainings, thus attracting trainers from abroad. States aim towards non-fiscal incentives such as feed-in tariffs and auctions to attract more investments in wave energy. There will be common usage of net-metering and net-billing incentives for the public therefore encouraging the usage of clean energy everywhere. As the renewable energy market have the tendency to collaborate, the main incentive is the global market. Opportunity to have mixed renewable energy implemented in national policies or even inter-governmental projects. Renewable energy costs will be lower offset by investing in various renewables and including multi-use frameworks, thus allowing the price for the cost of production to decrease in a shorter period. A diverse range of job opportunities covering all the sectors of implementing renewable energy – technical, political, socio-economic, and environmental. Jobs shift from carbon-intensive industries will smoothly be transitioned to green jobs due to overall support. All projects will actively bring the voice of indigenous knowledge motivated by the overarching goal of SDGs, mainly for local expertise, biodiversity preservation, and land-use.

Scenario 4 – Synergy for Renewable Energy An integrated governance by private sector;

The private sector is open and committed to renewable energy exploration. The capacity building among sectors will be integrated. The enterprises will have long-term collaboration with local governments. Private investment promotion is high because the regulation is firm and supportive. There are also risk reduction measures available. As the renewable energy market tends to collaborate, the main incentives are national and global. Opportunity for having mixed renewable energy sources and multi-use policies, as well as lower cost of integration for renewables. Funding for developing renewable energy technologies mainly will come from the private sector rather than the government. Renewable energy costs will be lower offset. Private companies will have higher initial renewable growth rates than public ones. Energy prices will be driven down by initial competition. A diverse range of job opportunities covering all the sectors of implementing renewable energy – technical, political, socio-economic, and environmental. Indigenous knowledge is respected throughout the process but there is a need to collaboratively work with local communities/NGOs to ensure targeted implementation.