Marine Renewable Energy

Commonwealth Blue Economy Series, No. 4

The Commonwealth

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Acronyms and Abbreviations

AOSIS	Alliance of Small Island States
CARICOM	Caribbean Community
C-SERMS	Caribbean Sustainable Energy Roadmap and Strategy
EIA	environmental impact assessment
EIB	European Investment Bank
IRENA	International Renewable Energy Agency
MRE	marine renewable energy
MSP	marine spatial planning
MW	megawatt
ODA	Overseas Development Assistance
OEF	Ocean Energy Forum
OTEC	ocean thermal energy conversion
RRA	Renewables Readiness Assessment
SAMOA	SIDS Accelerated Modalities of Action
SDGs	Sustainable Development Goals
SIDS	small island developing state(s)
SRSL	SAMS Research Services Ltd
UN	United Nations
UNEP	United Nations Environment Programme
UNOHRLLS	United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States

Summary

The marine environment provides valuable economic, social and cultural resources, which can contribute to the sustainable economic development of small island developing states (SIDS) and larger coastal states. Traditionally exploited marine resources include living resources, such as numerous species of fish and shellfish, and non-living resources, such as marine aggregates and petroleum, as well as supporting global transport and telecommunication networks. The marine environment also provides human communities with a broad range of essential services that support economic well-being and human health. Furthermore, new opportunities have emerged that are gradually being realised, including marine renewable energy (MRE) and mariculture; currently, there is interest in marine genetic resources with potential pharmaceutical and industrial benefits.

With the growing threats posed by a changing climate, it is increasingly evident that we need to pay more attention to our planet's oceans. The recent concept of the 'blue economy' – which emerged during the 2012 Rio+20 United Nations Conference on Sustainable Development – recognises the need to maximise the enormous economic potential presented by the ocean while preserving it. Over the past three years or so, the blue economy has been embraced by many SIDS as a mechanism for realising sustainable growth around an ocean-based economy. In that time, the idea of the blue economy has emerged as a key component of a new global dialogue about the role of the oceans and seas in sustainable development. For SIDS in particular, the concept of the blue economy presents itself as a promising avenue for economic diversification and growth embedded in fundamental principles of environmental sustainability.

The *Commonwealth Blue Economy Series* aims to support the development of the blue economy in Commonwealth member countries by providing a high-level assessment of the opportunities available for economic diversification and sustainable growth in SIDS.

This fourth volume in the series explores the potential for the development of the blue economy by providing a high-level review of actions needed to progress MRE generation in SIDS. Renewable energy is a key component of enabling sustainable development through the decarbonisation of economies and is being progressed in nations globally. Whereas onshore technologies (e.g. solar and wind) are achieving commercial

success, most marine technologies remain in the early phases of development.

Successful MRE deployment is dependent on critical factors such as available energy resource, indigenous skills (including institutional capacity and skilled labour), supportive policy and effective regulatory frameworks. The general recommendations made in this report provide a guide for action, emphasising the need for integration at national level, between sectors and policies, and for coordination between targeted local studies and collaborative global action.

1. **Clarify realistic local opportunities for MRE**
    - Refine understanding of opportunities through detailed resource assessment and in accordance with specific technology-developer requirements.
2. **Ensure coherent, integrated policy and planning**
    - Develop integrated national action plans for renewable energy that include onshore and offshore options and options for grid and off-grid generation, as well as taking into account energy efficiency and demand.
    - Demonstrate sustained, cross-policy support for stepwise progression of MRE to internal and foreign stakeholders, underpinning policy ambition with a comprehensive planning and regulatory framework.
    - Integrate planning with other sectors to cost-effectively address barriers such as lack of data, skills and institutional capacity.
3. **Use marine spatial planning (MSP) to support practical sector development**
    - Identify appropriate development areas, including opportunities for co-location with other sectors.
    - Provide a stakeholder forum for negotiating and balancing multiple sectors and interests.
    - Enable optimisation of the benefits obtained from the marine area in the blue economy, within ecological and social limits.
4. **Build knowledge and share experience**
    - Connect globally, ensuring transfer of knowledge locally and influencing global forums on the specific needs of SIDS.
    - Develop guidance for businesses, stakeholders, communities, prospective developers, investors, etc., on

when and how to engage with the blue economy, and on opportunities in MRE.

- Develop a strategic research agenda to support continued improvement of understanding of the potential impacts of plans and projects.

5. **Engage civil society early to use local knowledge and engender ownership**

    - Engender acceptance and ownership of energy projects through participation and capitalise on local knowledge in the design of innovative energy solutions.

Although this report highlights considerations specific to MRE, an overarching approach is critical in addressing overlaps and potential conflicts and in enabling sound decision-making. The blue economy approach promoted in SIDS provides significant opportunities to exploit synergies, maximise the value of opportunities and develop sound policies, plans and projects. It provides a framework for rationalising cost and effort in addressing common barriers across multiple objectives and creates a crucial platform for dialogue on sustainable development in SIDS.

Chapter 1

Introduction

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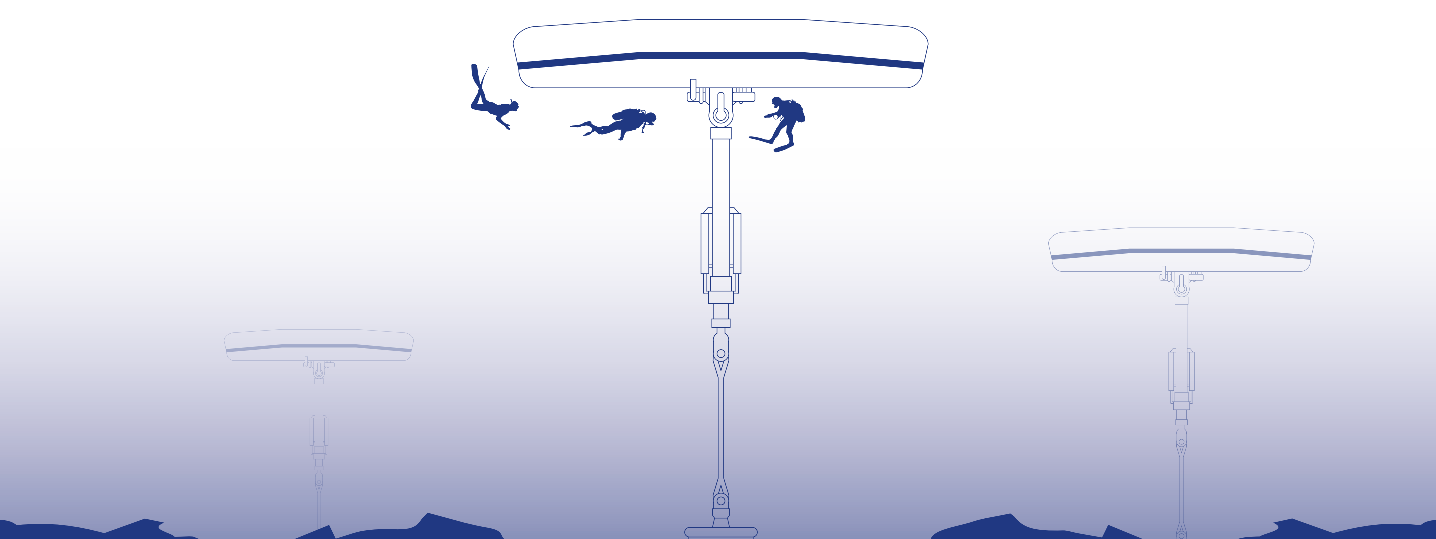
Introduction

1.1 Developing a blue economy

The concept of an ocean-based, or 'blue', economy has its origins in the 'green economy' concept endorsed at the Rio+20 United Nations (UN) Conference on Sustainable Development in 2012. Support for the blue economy at the 2012 conference from small island developing states (SIDS) emphasised the fact that their economies were largely dependent on the health and sustainable use of marine resources.

These low-lying coastal countries have in common similar sustainable development challenges, including small but growing populations, limited resources, remoteness, vulnerability to external shocks, and fragile environments. These challenges are inherent and any effective practical approaches to the development of sustainable economic opportunities from the ocean must take these factors fully on board and be relevant to the SIDS context. Many SIDS also have poorly diversified economies, relying on one or two key sectors to drive the economy. However, they have extensive marine exclusive economic zones and a number of them have been in the vanguard of championing the development of the blue economy as a promising avenue for economic diversification and growth embedded in fundamental principles of environmental sustainability.

In this regard, the Commonwealth has been at the forefront of promoting the blue economy as a holistic concept that can address sustainable development at multiple levels for a number



of years. At their most recent meeting, in Malta in November 2015, Commonwealth Heads of Government recognised that the development of a sustainably managed blue economy offers significant opportunities for economic growth and general development for many Commonwealth states.

The notion of the blue economy refers to those economic activities that directly or indirectly take place in the ocean and in coastal areas and that use outputs from the ocean; it includes goods and services that support ocean activities, as well as the contribution that those activities make to equitable economic growth and social, cultural and environmental well-being.

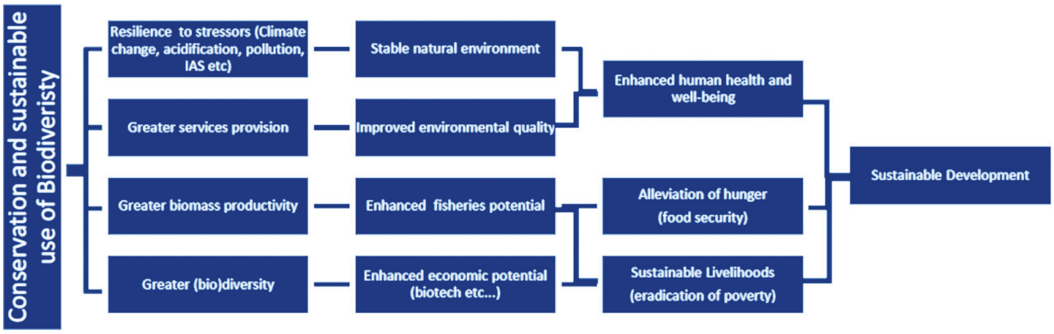
The scope of the blue economy therefore includes activities that:

- explore and develop ocean resources;
- use ocean and coastal space;
- protect the ocean environment;
- use ocean products as a main input;
- provide goods and services to support ocean activities; and
- develop mechanisms to ensure the equitable sharing of national wealth (and benefits) derived from the blue economy.

The blue economy concept encompasses economic and trade activities that integrate the conservation and sustainable use and management of biodiversity.

The requirement for sustainability necessitates a paradigm shift in both the mindset of those currently exploiting the oceans' resources and the diversity of ways in which the marine environment is used for the benefit of mankind. It is, therefore, inappropriate to continue with 'business as usual' and to simply re-badge the current uses of marine resources as 'blue'. By conceptualising the ocean as a development space where spatial planning integrates conservation, sustainable use, resource extraction, sustainable energy production and transport, the blue economy offers an alternative economic approach that is guided by environmental principles. It challenges the status quo, whereby oceans have been viewed as a free resource and an unlimited sink for the disposal of waste; instead, it shifts the focus so that ocean values services are included in decision-making and benefits are shared more equitably. The successful implementation of the blue economy model (Figure 1.1), nationally, regionally or globally, will require a more integrated and

Figure 1.1. The blue economy



Source: UNCSD, 2014

holistic approach to assessing development scenarios, and their implications for society.

SIDS face similar challenges to one another in that they tend to be remote but highly sensitive to global processes. Most are dependent on imported fuel and other resources, resulting in exposure to macro-economic variability, and, as low-lying coastal nations, they are acutely vulnerable to climate change-related effects, particularly rising sea levels. Marine renewable energy (MRE) provides an opportunity to diversify current activities and support progress towards renewable energy ambitions.

Recognising the potential of their extensive marine areas, SIDS have been pioneering the blue economy concept, aiming to add value to their economies through sustainable development of their marine resources. This report explores the drivers and necessary conditions for the development of MRE in SIDS as technologies mature. It draws on progress in the development of the MRE industry worldwide, as well as highlighting specific actions under way in SIDS, to provide recommendations to support SIDS in realising the potential of MRE within their specific contexts.

Reference

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Chapter 2

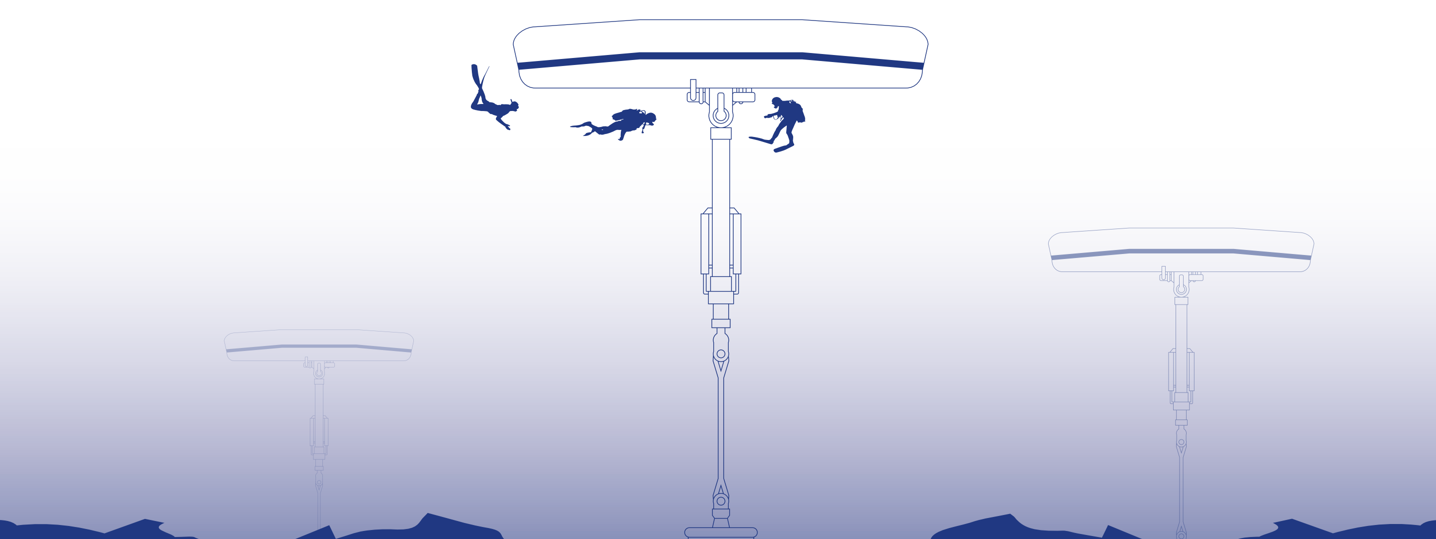
Powering the Blue Economy: Marine Renewable Energy

Chapter 2
Powering the Blue Economy: Marine Renewable Energy

2.1 Introduction

Sustainable energy provision is fundamental to the transition to a low-carbon economy, and the basis for progressing towards sustainable development globally. It is critical in ensuring progress in areas such as food, water, health, gender equality and poverty alleviation (International Energy Agency and the World Bank, 2015). The high-level Sustainable Development Goals (SDGs) adopted by the UN in September 2015 outline the importance of sustainable energy and industrial development, referring specifically to SIDS (SDGs 7.b and 9.a) (United Nations Environment Programme (UNEP), 2015).

Although very diverse, SIDS have in common certain drivers for domestic renewable energy generation, including reducing dependence on imported fossil fuels and exposure to extreme variability in the price of oil and providing long-term access to affordable, reliable, modern energy services. SIDS are vulnerable to the effects of climate change, particularly rising sea levels, which threaten communities and tourism assets on a large scale (around a third of populations across SIDS live less than 5 metres above sea level, with all land area below this level being in the Maldives). Although their emissions are tiny on a global scale, their 'frontline' experience of such effects is increasing



the emphasis on action for climate change mitigation and adaptation, and their action on renewable energy is described by SIDS in the Barbados Declaration as a 'demonstration of our moral leadership in the fight against climate change' (Alliance of Small Island States (AOSIS), 2012).

The emerging integrated policy of the blue economy aims to add value to the economies of SIDS through sustainable development of their extensive marine resources, emphasising protection of ecological quality and increasing the resilience of communities. Within this context, opportunities are being explored to capitalise on the marine energy potential of adjacent seas, further diversifying energy generation and increasing energy independence.

MRE is used in this report to refer to all technologies that require the installation of devices at sea (i.e. wind, wave and tidal energy, ocean thermal energy conversion (OTEC), etc.). Given the rapid progress in the sector globally, MRE is a realistic medium- to long-term energy option for many SIDS; it would enable them to utilise locally available resource, reduce pressure for space on land and optimise the value of other marine activities within the blue economy (e.g. biotechnology and aquaculture). In addition to providing a further source of sustainable energy, MRE can supplement terrestrial renewable energy initiatives, and help in balancing the intermittency of these technologies in grid-connected energy systems. For off-grid areas and dispersed inhabited islands, scalable MRE options can address the current and future power needs of remote communities.

Notable challenges are faced in developing renewable energy in SIDS, most significantly access to financial capital, institutional capacity to plan and develop renewable energy projects, local infrastructure and human capacity for engineering works. For MRE, the added cost of the risk associated with early-stage technologies means that financial support, technology transfer and capacity-building are even more important than in the case of terrestrial options. However, the current costs of energy in SIDS mean that cost-competitiveness is more easily achieved, and, through coordinated and collaborative action, the hurdles can be addressed and the renewable energy ambitions of SIDS fulfilled.

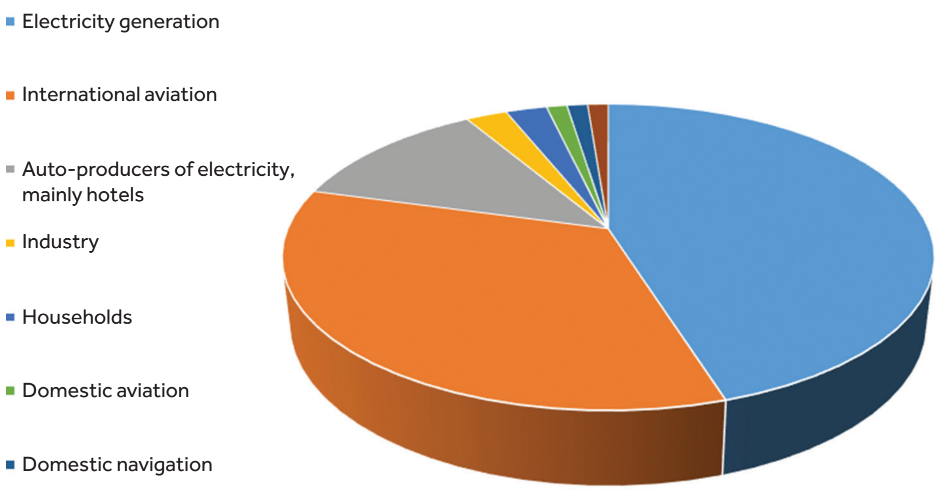
The blue economy provides a critical opportunity for SIDS, providing a new, overarching perspective and integrated framework for development planning across sectors and policy objectives. This report outlines key opportunities, enabling conditions and necessary actions in developing MRE as a core component of the blue economy. It highlights the progress of MRE development in SIDS, in the context of the development of the sector globally, providing an overview of common challenges faced by SIDS and recommendations for addressing them.

2.2 Energy use in small island developing states

SIDS vary widely, in size, sociopolitical characteristics, industrial activities, ecology, etc.; however, there are some general features influencing the context of renewable energy development that are common to many SIDS.

SIDS are primarily dependent on imported fossil fuels, principally for transportation and for electricity generation (see for example Figure 2.1). Transportation accounts for a significant proportion of consumption; this is attributable in particular to aviation and its role in tourism – a highly significant sector in most SIDS (contributing more than 50 per cent to gross domestic product n Antigua and Barbuda, the British Virgin Islands, Anguilla, Seychelles and Vanuatu (United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UNOHRLLS), 2013) – and shipping (including fishing and the import and export of goods).

Figure 2.1. Consumption of imported fuel in Seychelles



Source: data from Energy and Environment Partnership, Southern and East Africa, 2010

Primary domestic industry – including, for example, fish-processing plants (as in Seychelles), mining (as in Trinidad and Tobago), agriculture, hotels and resorts – uses a high proportion of electricity generated from imported fuel oil. Apart from in the larger SIDS (e.g. Haiti, with a population of over 8 million), population levels tend to be relatively low (80,000–90,000 in Seychelles), but most are growing (UNOHRLLS, 2013). Relative to larger nations, in SIDS national energy generation and use are therefore relatively small, but domestic demand is increasing over time as populations develop and new industry is created.

Energy use is disproportionately higher in higher-income SIDS; although average use is around 1,520 kilograms of oil equivalent per capita, only seven countries surpass this. Trinidad and Tobago has the highest rate of energy use per capita, at over 15 tonnes of oil equivalent per year. In global terms, the energy use and CO_2 emissions of SIDS are low, with CO_2 emissions averaging 4.7 megatonnes per year; however, there is an extreme difference between the highest and lowest emitters. Higher-income countries are the highest emitters; they include Trinidad and Tobago (the highest emitter, with 50 megatonnes per year), Dominica and Jamaica. The lowest emitters are Kiribati and Niue, where country-level emissions are almost zero (UNOHRLLS, 2013).

Energy access is variable. Nearly all SIDS are middle- to higher-income countries where the majority of households use electricity (e.g. Seychelles), but many remote and rural communities in SIDS still have little or no access to modern and affordable energy services, particularly in the Pacific islands (AOSIS, 2012).

Electricity is generated from fuel (usually diesel) at generating stations. The main inhabited islands in wealthier SIDS generally have distribution networks and transmission infrastructure, with outer islands and remote areas relying on off-grid production and generation of electricity from separate systems. Single islands such as Dominica and Saint Lucia and small consolidated groups of islands including Antigua and Barbuda, Saint Kitts and Nevis, Grenada, etc., are easier to connect through grid systems, whereas for SIDS comprising many islands spread over vast waters (e.g. Seychelles with 115 islands; Solomon Islands, made up of nearly 1,000 islands; and Kiribati, which contains 33 atolls over 3.5 million square kilometres) off-grid renewable energy solutions at an island scale are essential.

2.3 Progress towards the development of marine renewable energy in small island developing states

Momentum has increased sharply in recent years in developing the policy and actions to support transition to renewable energy in SIDS; however, progress in implementing projects on the ground remains at an early stage. In the Barbados Declaration (adopted in May 2012) several SIDS voluntarily committed to achieving specific energy-related targets with the support of the UN and developed nations (see Table 2.1).

Renewable energy installation is expanding through terrestrial initiatives, wind farms, solar panels and water heating, with some hydropower (in Dominica). MRE installation so far includes pilot studies of OTEC projects (e.g. in La Réunion), with promising developments in the form of partnership agreements between SIDS and wave and tidal energy technology developers (see Chapter 3). With the policy environment growing more supportive, the cost-effectiveness of renewable energy improving and increased activity in obtaining support for SIDS through various mechanisms, the emphasis on the MRE potential of SIDS will continue to grow.

To implement renewable energy in capacity-limited SIDS, external support for energy sector reform is critical. At global level, development is being supported through cooperation

Table 2.1. Examples of renewable energy targets set out in the Barbados Declaration 2012, Annex I

Country	Renewable energy target
Cape Verde	decrease fossil fuel imports for energy production by 20% by 2020
Cook Islands	increase renewable energy consumption to 100% for inhabited islands by 2020
Dominica	increase renewable energy generation from the current 30% to 100%, and become carbon negative by exporting renewable energy to its neighbours (Guadeloupe and Martinique) by 2020
Tuvalu	reach 100% power generation from renewable energy by 2020

Source: AOSIS, 2012

mechanisms that enable sharing of knowledge and capacity across SIDS, with much activity led by the UN; such mechanisms include the SIDS Accelerated Modalities of Action (SAMOA) Pathway, adopted in 2014 at the Third International Conference on SIDS. The SAMOA Pathway stresses the importance of renewable energy generation and energy efficiency measures as a basis for sustainable development in SIDS and calls for innovative partnerships to strengthen SIDS–SIDS cooperation (SIDS, 2014).

Also under the auspices of the UN, the SIDS Sustainable Energy and Climate Resilience Initiative (SIDS DOCK) has been established as an international organisation enabling coordination of technical and financial support between SIDS and is expanding implementation through a network of regional sustainable energy centres for SIDS in Africa, the Caribbean, the Pacific and the Indian Ocean (SIDS DOCK, 2015).

Regional cooperation enables strategic use of capacity, mobilisation of donor resources and development of a stronger collaborative vision to support national-level action. There has been notable progress in this regard through CARICOM (the Caribbean Community), resulting in the production of a Regional Energy Policy (CARICOM, 2013), followed by the Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS). C-SERMS includes recommendations for renewable energy targets, along with targets for energy efficiency gains and carbon emissions reductions, in the short term (2017), medium term (2022) and long term (2027) for the CARICOM region and aims to provide CARICOM member states with a coherent strategy for transitioning to sustainable energy (Worldwatch, 2013).

The role of non-governmental actors is also important; organisations such as the Clinton Climate Initiative and Richard Branson's Carbon War Room are working with island communities to develop market-based solutions to low-carbon economies (including development of renewable energy projects), focusing particularly on Caribbean islands but also providing a platform for international information exchange.[1]

The International Renewable Energy Agency (IRENA) is playing an important role politically and practically by funding activities and providing a hub for international cooperation in achieving the commitments of the Barbados Declaration (through the Global Renewable Energy Islands Network. The SIDS Lighthouse Initiative, launched by IRENA at the UN

Climate Change Summit in 2014, aims to mobilise funding (US$500 million within 5 years) and provide a framework for action to enable SIDS and partners to 'move away from a piecemeal approach and transform their energy system in a structured, holistic and sustainable manner' (IRENA, 2014). Other IRENA enabling activities have included production of reports for most SIDS assessing renewable energy policies and the power, heating and transport sectors and of Renewables Readiness Assessments (RRAs) for South Pacific island nations (Fiji, the Marshall Islands and Vanuatu) (IRENA, 2015).

Implementing activities at national level presents challenges, and the extent to which such initiatives can coordinate actions within SIDS depends on how well they are integrated with the activities of national governments across their departments. This requires institutional capacity within SIDS to engage globally and act locally; support for governments to enable engagement with supra-national mechanisms is essential for the practical implementation of energy transitions.

2.4 Marine renewable energy in a global context

Supportive energy policy has had a positive influence on the development of offshore renewable energy activities worldwide, with notable success in the implementation of solar and offshore wind farms, achieving commercially competitive prices in some markets (e.g. the USA). MRE development has been slower to advance, and as an emerging sector it is highly vulnerable to changing market conditions, particularly in relation to fossil fuels, and fluctuations in national energy policy. Most marine technologies (apart from wind) are not yet proven commercially. However, with continued political support for renewable energy as a source of clean, secure and reliable energy, technologies are expected to develop in the coming decade, and to become increasingly attractive and cost-competitive.

MRE development is being pioneered by industrialised regions (e.g. the United Kingdom, France, the USA, Canada, etc.) and these countries' situations are, in many ways, markedly different from those in SIDS. A combination of significant available resource (including wind, wave, tidal stream and range), high energy demand and the resulting large scale of potential development has led to a highly market-driven approach to MRE in these countries. A combination of public funding regimes, including subsidies and incentives, and ambitious strategic planning of large-scale renewable energy development zones has aimed to attract significant private investment and establish a large and competitive industry, where grid parity with other, non-renewable, energy sources is achieved. Such growth and expansion of the renewable energy sector has been politically attractive for countries trying both to recover from financial crises through the development of infrastructure projects and associated industry and to address renewable energy targets. However, issues relating to unpredictable national policy regarding subsidies, technology, costs and complex planning processes have in some cases meant that it is taking longer than anticipated to reach large-scale installation and cost-competitive energy.

As the scale of potential development in SIDS is significantly smaller, strategies for development of MRE must more realistically focus on small-scale projects driven by the availability of physical energy resource and current and future energy demand (including expansion and development of activities) and must be appropriate to transmission requirements across islands. From a general market perspective, economies of scale may not feasibly be reached in SIDS; however, for more novel technologies, the opportunity to test small-scale devices in island nations, along with possibilities of exploring innovative project design around integration with other marine activities and models of community ownership, presents an attractive option for some smaller-scale developers, and such models can be transferred to other countries. They require coordination and collaboration, utilising international funding mechanisms and strategic political alliances and attracting partnerships with relevant technology developers.

Endnote

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Chapter 3

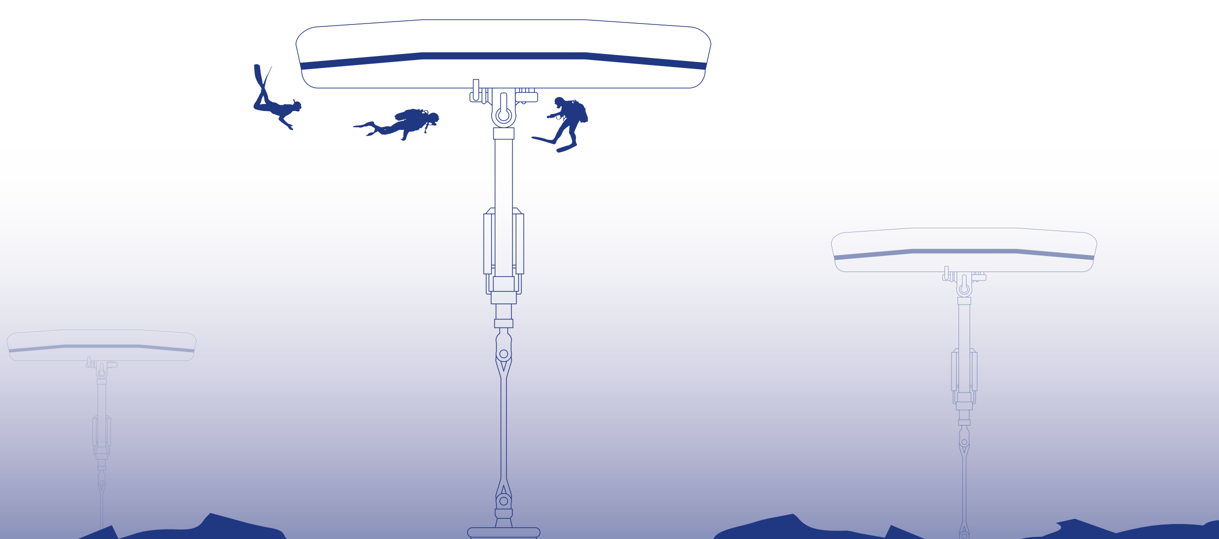
Technology Options for Marine Renewable Energy in Small Island Developing States

Chapter 3
Technology Options for Marine Renewable Energy in Small Island Developing States

There is an increasing diversity of MRE technology options, including offshore wind (including floating turbines), wave energy, tidal stream, tidal range (lagoons and dams), OTEC and salinity gradient technology. Progress towards commercialisation varies widely across technology types, with those in the earlier stages of development (small-scale prototypes or single-device 'demonstrator' projects) being more costly and a higher risk investment. This section provides a brief overview of MRE technologies that are currently a focus of development globally and their relevance to SIDS. This is not an exhaustive list and the dynamic nature of the sector and ongoing technological advancement mean that the involvement of SIDS in international groups (e.g. IRENA) is important to enable them to gain knowledge on recent developments, inform such forums on the specific needs and challenges of individual nations and build relationships with industrial partners.

3.1 Offshore wind

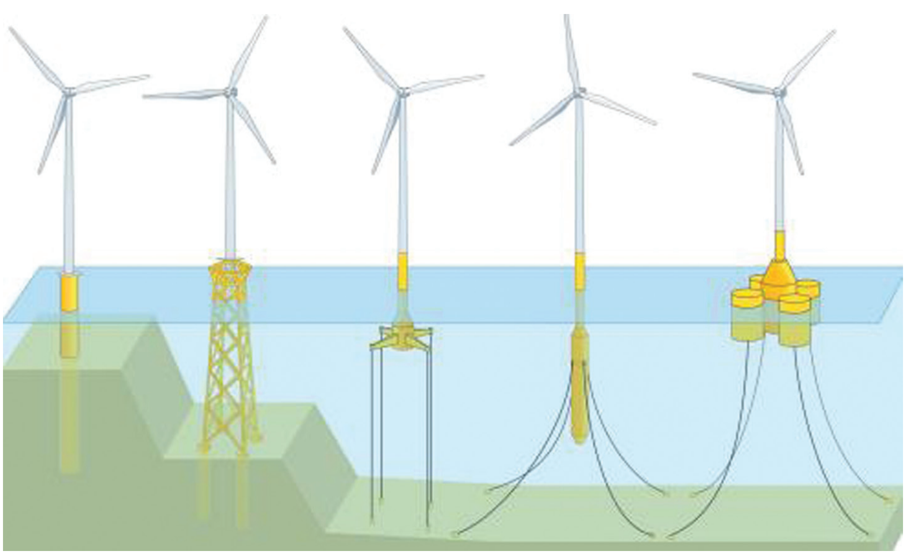
Of the marine renewable technologies, offshore wind is the most 'installation-ready', with wind farms being constructed and operated at a large scale (particularly in China, Europe, the USA and Canada). It is increasingly competitive, although



a significant cost gap remains relative to more conventional power (including onshore wind) (Global Wind Energy Council, 2013). Primary advantages of constructing wind farms offshore include reducing demand for space on land and reduced visual impacts; furthermore, intermittency is less because of the more constant wind speeds offshore.

The capacities of offshore wind turbines range from less than 1 megawatt (MW) up to around 5 MW, with turbines of up to 7 MW being tested (European Wind Energy Association, 2015). The average size of offshore wind turbines installed at windfarms across Europe in 2014 was 3.4 MW. Progress in foundation design means that installation can be considered for a range of environments, from traditional hammer piling of monopile turbines into sandy sediments in shallow waters (< 40 metres water depth), concrete gravity bases for harder seabed types and jacket structures for deeper water depths, secured with smaller 'pin piles'. Recent developments in floating wind use tensioning cables to install turbines in water over 100 metres deep (see Figure 3.1), extending the possibility of wind farm construction to deeper offshore areas. Costs increase along with the size of turbine, and, for SIDS, 'off-the-shelf' smaller-capacity turbines with traditional foundation designs are the cheapest to install, and hence the most realistic option, at least in the short term.

Figure 3.1. Offshore wind turbine foundation designs (l-r: monopile; jacket foundation; tension leg with pin piles; and floating concepts with catenary anchors securing buoyant bases



Source: www.aquaret.com

3.2 Ocean energy

Ocean energy is used here to refer to wave and tidal energy conversion projects, which, alongside OTEC, have been identified as a priority area under the SIDS DOCK initiative.

A number of companies are focusing on the development of ocean energy conversion systems, with notable progress in Europe and particularly the United Kingdom, supported by strong policy, public investment and initiatives such as testing facilities for the demonstration of technologies at the European Marine Energy Centre in Orkney, northern Scotland. In general, technologies remain in pre-commercial phases, existing as single devices or prototypes; the European Commission, in collaboration with EU Member States, industry and other stakeholders, is driving coordinated efforts to address barriers to progress through the Ocean Energy Forum (OEF).[1] The OEF is preparing a strategic roadmap for the development of ocean energy to 2020, and, although it focuses on the specific needs and challenges of European maritime nations, the activities of the OEF are relevant to the wider ocean energy community, and its identification of issues and solutions are key measures of progress in the sector. The policy and knowledge developed through this process will also help to inform the role of the European Union in supporting other countries, including SIDS, in relation to ocean energy, such as through the European Investment Bank (EIB) and other grant mechanisms.

The priority technological challenges identified based on European experiences include the improvement of component and device technology, installation and logistics, survivability and reliability (of machinery in harsh ocean environments), power generation and transmission, and cost reduction (of components and installation, operation and maintenance strategies) (OEF, 2015).

3.2.1 Tidal energy

Tidal energy technology (tidal stream and tidal range) is more mature than other ocean energy technologies, with operational commercial-scale devices, and its devices are generally reliable in terms of output owing to the predictability of the tides.

Tidal range projects, using the vertical difference in height between the high tide and the succeeding low tide, builds on experience with traditional hydro-electricity projects and early projects such as La Rance, France (built in 1966 with a capacity of 240 MW). New and innovative technological designs are proposed in the Swansea Bay Tidal Lagoon project, which is intended to be operational in 2019, with a capacity of 320 MW.

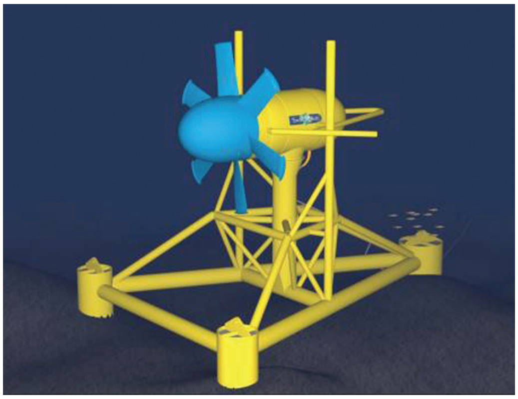
Although large projects are costly and unrealistic for SIDS, technologies are scalable, including dam-like structures built across narrow bays or river mouths and more novel designs of tidal lagoons. Where appropriate resource exists, tidal range is a feasible option, and in countries where hydropower is established there is an opportunity to use infrastructure, skills and experience already acquired to facilitate construction. It is also possible to integrate tidal range technology with other services, such as mariculture, shoreline development, flood protection and transport links between islands.

Tidal stream devices use energy from the constant flow of water as the tide ebbs and floods to drive turbines mounted on separate devices. Most tidal stream projects are planned in areas where tidal flow speeds are 4–5 metres per second, usually close to shore and particularly where there are constrictions between land, such as straits or channels between islands. Designs include horizontal axis turbines (similar to traditional wind turbines), vertical axis turbines that can operate at lower current speeds and in shallower waters, and oscillating devices with aerofoil blades that oscillate parallel to the surface and perpendicular to the tidal stream.

Tidal stream technologies are approaching commercial scale, in that full-size devices are deployed and running, and construction of commercial arrays of multiple devices is imminent (construction of the initial phase of the Meygen Tidal Energy Project is expected in 2016 in Scotland (Meygen Limited, 2013)). European ambitions are for tidal stream to be a competitive source of marine power during the 2030s, with action now focusing on overcoming technical issues around reliability and component improvement, the optimisation of project design and turbine layout, hydrodynamic characterisation and understanding specific environmental impacts.

Proposals for commercial-scale tidal energy projects are emerging in island nations, with the French tidal energy developer Sabella reaching an agreement with H&WB Asia Pacific to develop a 5 MW tidal power project in the Philippines (Tidal Energy Today, 2015) (Figure 3.2).

Figure 3.2. The Sabella D15 device proposed for installation in the Philippines



Source: www.offshorewind.biz

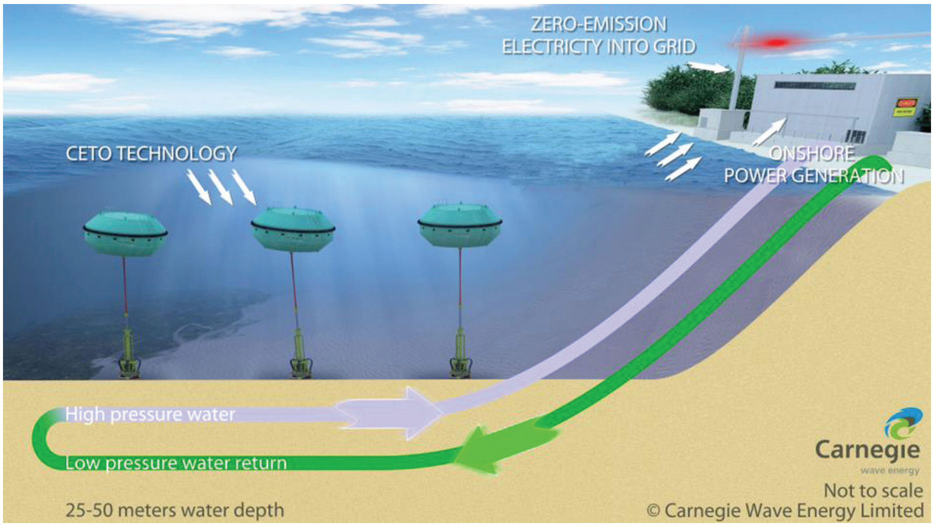
3.2.2 Wave energy

Wave energy technologies are at an earlier stage of development and not yet operating at a commercial scale. Costs remain high, as investment in technology globally is spread across a wide range of wave energy device designs.

Technologies generally fall into three categories: open-water, seabed-mounted and shore-based devices. Most devices are deployed in shallower near-shore locations, as most methods of converting kinetic to electrical energy ('power take-off') currently take place on land (Aquatera, 2013), although new methods are now being proposed. Shore-based designs (including the oscillating water column and overtopping devices) can be fixed to existing infrastructure, such as harbour breakwaters, or built directly into the shore, requiring varying degrees of shoreline modification.

Different designs exploit different wave environments; therefore, the feasibility of different technology types in SIDS will depend on the local conditions. As they are at an early phase of development, wave energy developers are now focusing on lower-output devices, to be scaled up when designs are fully tested. Such smaller-scale devices may be more suited to island use in SIDS, so partnering with the industry now is important. Some developers are also exploring the potential for other products and integration with services from other MRE projects, increasing the attractiveness to SIDS.

Figure 3.3. Carnegie Wave Energy CETO installation, providing energy and desalination in Perth, Australia



Source: Carnegie Wave Energy Limited

Promising developments include those by Carnegie Wave Energy Limited, which installed a wave-powered energy and desalination plant on Garden Island, Western Australia, in 2014 (Figure 3.3). This uses 'CETO' devices with submerged buoys tethered to pumps that funnel pressurised water to turbines onshore, to provide electrical energy (there are plans for capacity of up to 3 MW) and desalinated water for the adjacent naval base (Carnegie Wave Energy Limited, 2015a). Provision of multiple services is desirable for remote, resource-limited communities. Carnegie Wave Energy recently signed a memorandum of understanding with the governments of Seychelles and Mauritius to explore development potential in both countries (Carnegie Wave Energy Limited, 2015b).

3.2.3 Ocean thermal energy conversion

OTEC technology dates back to the late 1800s, but there continues to be little progress in developing projects on a commercial scale, primarily as a result of high capital costs and engineering challenges, coupled with an unstable economic and policy landscape. OTEC uses the natural temperature gradient of the ocean to drive a turbine connected to a generator, and installation options include shore-based, shelf-based and moored/floating offshore projects. Offshore systems presents the greatest costs because of the length of pipeline required, so distance to deep waters from the coast is a key factor in viability (Figure 3.3).

Prerequisites for viable OTEC include approximately 20ºC of temperature difference between surface water and deep-ocean water (highly likely in equatorial countries) relatively close to shore. The stable provision of reliable base load and the additional products (desalinated water, hydrogen and ammonia) are attractive characteristics of OTEC, as these can be combined with other systems (e.g. cooling/air conditioning, mariculture/aquaculture and irrigation).

For the past few decades, the US Government (and in particular the Department of Defense) has supported the development of OTEC technology, including a pilot plant in Hawaii, operational since 1981. The US Naval Facilities Engineering Command is the main funding source for the project being developed by Lockheed Martin and Makai Ocean Engineering, consisting of a MW closed-cycle pilot plant in southern China (with plans to expand to 100 MW) (OTEC Foundation, 2013).

Ambitions for OTEC in SIDS have fluctuated, affected by changes in oil price and energy policy. Eleven CARICOM member states are taking steps to advance pilot projects for OTEC, and in 2014 two projects were proposed for Martinique, led by the French Government, DCNS (a French industrial group specialising in naval defence and energy) and other companies. These projects are NEMO, an offshore OTEC project; and a 5.7 MW project, NAUTILUS, planned for

Figure 3.4. Visualisation of an offshore OTEC facility

Source: Akuo Energy

construction in 2016. The NAUTILUS project will combine air conditioning, freshwater production and aquaculture solutions with electricity production (OTEC Foundation, 2014).

DCNS indicates that it has ambitions for full-scale commercial projects, starting with onshore 4–7 MW power plants, followed by offshore power plants with capacities of at least 16–30 MW (expected in 2018). Other potential projects include developments in La Réunion and Tahiti (Kalanquin, 2014). An onshore OTEC project has been proposed in the Virgin Islands, where Ocean Thermal Energy Corporation and DCNS are investigating the feasibility of a commercial plant that would produce electricity, fresh water and seawater cooling (Reuters, 2014).

OTEC technology is capital intensive and unviable at a small scale of power output, but it can become viable when approached as a sustainable integrated solution to co-generate other services. As the scale of development increases, OTEC will become more cost-effective and there is financial support (primarily through public–private partnerships) for development of commercial-scale projects. Engineering challenges remain and it will take time to demonstrate competitiveness with alternative generating technologies.

3.2.4 Salinity gradient

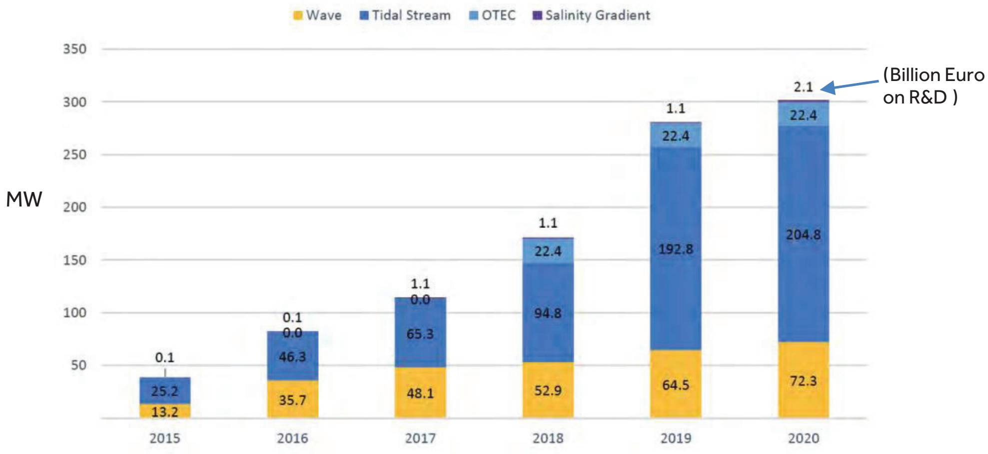
Salinity gradient technology uses the energy created from the difference in salt concentration between fresh and salt water, and is at an early stage of development for renewable energy purposes. Salinity technology requires an adequate and accessible river system, which is not available in all SIDS (Seychelles, for example).

Progress in recent years has followed the development of membrane-based techniques for extracting energy from water salinity, such as pressure-retarded osmosis and reverse electrodialysis; other novel methods for harvesting energy from water-mixing processes, including electrochemical capacitor and nano-fluidic energy harvesting systems, have been proposed (Jia et al. 2014). The technology is at a very early stage; however, the advantages of salinity gradient technologies include reliability of energy provision and the potential to integrate with other solutions (including desalination).

3.2.5 European outlook on ocean energy

Europe is seen as a world leader in ocean energy; an estimated €10 billion has been invested since 2005. There are ambitions for

Figure 3.5. Expected cumulative deployed ocean energy capacity in Europe, by technology



Source: OEF, 2015

an overall capacity of 100 gigawatts in Europe by 2050, producing around 350 terawatt hours of electricity with an estimated global market worth €653 billion between 2010–2050 (OEF, 2015). Europe is not the only area of technology development, but the success of projects in a European context will strongly influence the status of different ocean technologies worldwide. It is estimated that ocean energy deployment will reach a cumulative capacity of 850 MW by 2020, split across the different ocean energy technologies as shown in Figure 3.5.

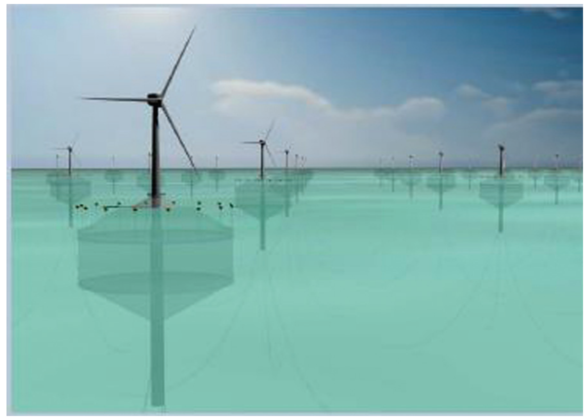
3.3 Co-location and multiple service provision

Optimisation of resource use and adding value through multiple service provision and integration of activities is essential for improving cost-competitiveness across the development of marine activities, fitting in with the cross-cutting, holistic objectives of the blue economy.

As outlined above, some technologies result in multiple service provision from the processes involved in energy generation and present a good option for SIDS. The production of fresh water and ammonia in addition to energy in OTEC plants can be used in desalination plants, air-conditioning systems, etc., and the Carnegie Wave Energy device in Perth also produces desalinated water.

Co-location of MRE and other activities is a focus in Europe; it is particularly desirable where maritime space is under

Figure 3.6. Visualisation of possible co-location of wind turbines and aquaculture



Source: Meneses, 2014

increasing pressure. Options include sharing infrastructure, such as between aquaculture and wave energy or offshore wind initiatives (Figure 3.6). It is currently in the research phase, with European research projects including the EU MERMAID[2] and the EU TROPOS[3] projects.

Such integrated solutions require a cross-sector perspective in order to evaluate the opportunities and risks. The blue economy framework provides a key opportunity to explore the feasibility and benefits of co-location and integration options, enabling development of innovative projects with multiple economic, ecological and social benefits across several scales. However, this requires a step-change in traditional approaches and implementing such an approach at national level would require sustained capacity and commitment to transforming planning and management practice. Marine spatial planning (MSP) provides a practical tool for supporting co-location of activities by identifying appropriate areas and facilitating cross-sectoral engagement involving local stakeholders, and enables transition away from a traditional activity-specific 'zoning' approach (see section 4.2).

Endnotes

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2 http://www.mermaidproject.eu/wiki
3 http://www.tropos platform.eu

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Chapter 4

Enabling Conditions and Key Challenges

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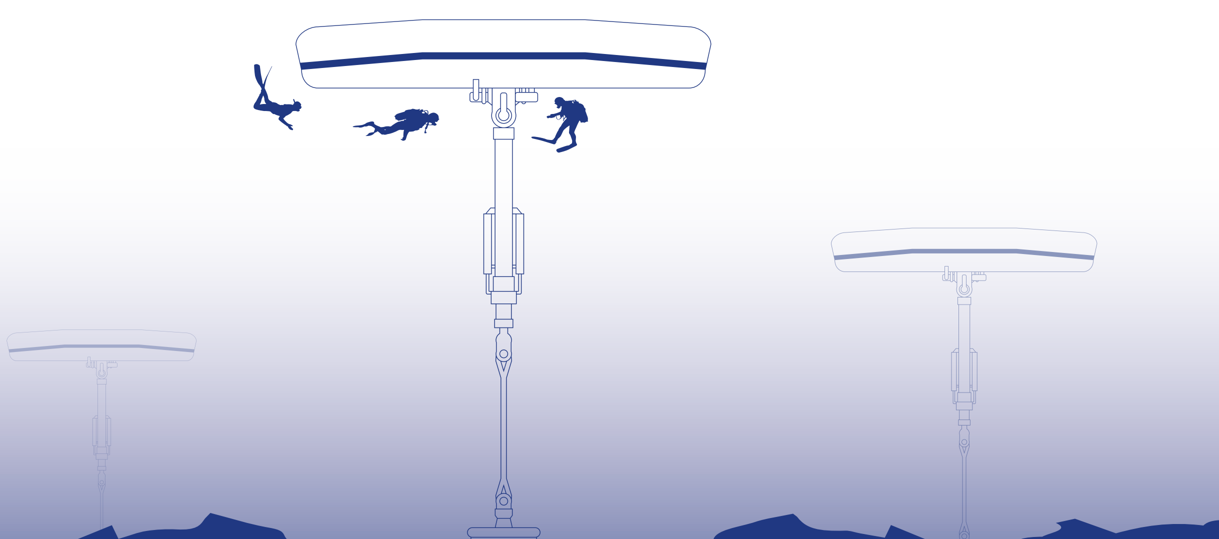
Enabling Conditions and Key Challenges

4.1 Economic conditions and accessing finance

A critical enabler of innovation and development in the MRE sector globally is the availability and effective use of capital finance. Onshore renewable energy technologies are increasingly cost-competitive: onshore wind is the cheapest form of new power generation capacity in Europe, Australia and Brazil, and project costs will continue to decrease, by an average of 32 per cent for wind and 47 per cent for solar by 2040 (Bloomberg, 2015).

However, the risk associated with investment in MRE, compared with in the more mature technologies of solar and wind, is significant, given that many of the technologies are at an early stage. Although the figure is different for each ocean energy technology, total capital expenditure (CAPEX) (including costs of capital) is estimated at 60–80 per cent of the final cost of energy (OEF, 2015). Further to the high up-front costs, the 'costs of doing business' in developing and installing MRE in SIDS in particular, are higher because of remoteness and the consequent costs of importing fuel, people and equipment.

Although there is great disparity in financial status across SIDS, SIDS are generally accountable for high levels of national debt and, particularly in the Pacific, are among the most aid-dependent nations in the world. The World Bank reports



that Overseas Development Assistance (ODA) to the Pacific region amounts to US$469 per capita, compared with US$64 in the Caribbean small states and US$54 in sub-Saharan Africa. Nations such as Tuvalu, Tonga and Solomon Islands are heavily dependent on ODA, which makes up more than 50 per cent of government budgets (World Bank, 2015). Securing external financial support that is sustainable throughout the development of MRE projects, from public–private partnerships and international donor mechanisms, is therefore critical in realistically developing MRE as part of the blue economy in SIDS.

In considering the financing of specific projects, feasibility and cost-effectiveness need to be investigated through detailed economic analysis at the local scale. This requires appropriate expertise to consider costs and benefits, fully evaluating particular proposals and considering factors that are not easily accounted for (e.g. the life-cycle costs of MRE).

4.1.1 International support

Support is being provided through a combination of global mechanisms (e.g. via the UN and IRENA; see section 2.3) and bilateral agreements between SIDS and various countries. These arrangements provide a strong political basis for action to develop MRE in SIDS, access to international finance and opportunities to partner with technological developers in countries that are leading development of MRE technologies domestically, such as Japan, France, Australia and the United Kingdom. France, in particular, supports extensive MRE development in the Caribbean region, where it has a critical leadership role in developing technologies such as wave energy and OTEC, and has signed agreements with other SIDS (including Seychelles).

International aid mechanisms exist for accessing financing that might be used for MRE, such as debt-for-adaptation swap programmes, whereby debt is converted into new government-issued debt, as in Jamaica and Seychelles; the Seychelles programme resulted in a US$31 million funding package to support marine conservation and climate adaptation efforts (Nature Conservancy USA, 2015). Other funding and support mechanisms include the World Bank, Green Climate Fund (supporting climate change adaptation and mitigation in developing countries), the EIB and the Sustainable Energy Fund for Africa (supporting private sector-led initiatives), technology transfer mechanisms (e.g. UNEP's Climate Technology Centre and Network[1]) and various initiatives supported by IRENA.

In addition to these mechanisms, institutional capacity is needed within SIDS to lead and manage activities at national level. This is crucial to ensure ownership of activities by individual governments, and to ensure that actions are integrated and strategically aligned with other actions and specifically suited and adapted to local conditions.

4.1.2 Market-based instruments and incentives

Various market-based mechanisms such as subsidies, feed-in tariffs, production-based incentives (PBIs), renewable energy power purchase agreements and tax-relief mechanisms are routinely used to encourage development of non-conventional energy projects, and some have already been used in SIDS to accelerate development of renewable energy projects, focusing on wind, solar photovoltaic, biomass, hydro and waste-based energy systems.

Such mechanisms may be used to engage the domestic business community and encourage investment in MRE; however, the details of such schemes vary greatly and implementation requires evaluation on a case-by-case basis. They are generally more suited to established energy markets and technologies, as the unpredictability of timelines to technological maturity can prove challenging in terms of long-term public expenditure. The characteristics of the current electricity supply, the potential scale of development and other features would need to be included within a strategy addressing the multiple hurdles to development (relating to infrastructure, capacity, etc.). Incentive mechanisms also rely on the existence of a local capacity to invest in MRE and are therefore dependent on the human and business resources available locally and on interest from potential technology developers.

Given the early stage of industry development, international support and donor mechanisms remain crucial in providing up-front finance and initiating lead-in actions to the development of MRE in SIDS.

4.2 From policy to projects: creating an enabling environment

Strong, sustained and realistic policy is required to demonstrate the long-term political commitment of SIDS to developing MRE as a component of making the transition to sustainable energy systems. Global and regional policy, such as the targets captured in the Barbados Declaration (AOSIS, 2012), is highly positive for sector development, stimulating interest and attracting donor funds and technology developers. However, targets are effective only when they are supported by comprehensive and consistent development mechanisms, including a policy, legal and financial framework. Dynamic leadership by national governments is required to translate policy into realistic action plans that are integrated across policy objectives, including energy efficiency and energy demand management, as well as other areas such as education and the development of key sectors (tourism and aquaculture).

The blue economy framework provides an opportunity to achieve efficiencies in the development of the MRE sector, and emphasis on increasing cost-effectiveness can drive the transition from sector- and policy-specific planning to integrated approaches. Reflecting upon and adapting long-standing planning and regulatory approaches is a daunting process, but it can be hugely helpful in enabling the development of new sectors. The blue economy is also critical in this regard.

Tools can assist capacity-limited SIDS in approaching the complexity of implementing ambitious and integrated policy. Modelling can be used to explore overlapping issues and test various policy and project scenarios, evaluate integrated solutions and address trade-offs and synergies between the range of sustainable development issues (e.g. food, water, energy, development). Such approaches are receiving increasing prominence on the global agenda as a way of framing policy development within a whole-systems approach; exploring this at national level in SIDS is relevant and feasible because of their smaller size. For example, Climate-Land-Environment-Water-Development (CLEWD) nexus modelling was undertaken in Mauritius to investigate interlinkages between policies, and it helped in identifying an innovative policy that seeks to avoid the costly mistakes of isolated sectoral policy-making (UN, 2014). To give another example, the

ISLANDS project[2] aims to institutionalise systems-modelling tools for cross-sectoral medium- to long-term policy planning (Deenapanray and Bassi, 2014) that are relevant to devising viable sustainable energy strategies in SIDS.

4.2.1 Enabling legal and regulatory framework

Complexity and excessive bureaucracy have been noted in SIDS and are risks deterring investors and holding back the development of new sectors. The leadership of national governments and the coordination of various public administrative functions are critical in cost-effectively removing the barriers and clarifying the planning processes for MRE projects.

A key advantage of the small size of SIDS is that governments can be dynamic and act quickly to implement new supportive policies where there is clear national benefit. The principles of good governance, including participatory democracy, accountability, transparency and trust, are all potentially easier to implement in SIDS (Everest-Phillips, 2014).

However, institutional capacity (the availability of skilled and trained staff) is a noted concern in some SIDS. Appropriate resources are needed across public departments to evaluate and address sustainability issues (including energy), manage and implement the planning and decision-making processes (e.g. for managing socio-ecological risks and the effects of potential developments through environmental impact assessment (EIA) processes, developing legally sound licences with conditions for operation and monitoring, etc.).

4.2.2 Planning

Integrated planning across sectors and scales is essential to support the development of MRE. National planning can address issues of overlap and ensure that administrative procedures are linked across land and sea and between onshore and offshore infrastructure requirements, including space for landward development areas (e.g. for construction and maintenance activities for MRE projects). Considering the development needs of other blue economy sectors such as aquaculture, fisheries and tourism, and the need to balance development with conservation priorities, in planning would ensure strategic investment in extensions and optimise the use of space.

Many SIDS are relatively isolated, with no close neighbours of the sort that create challenges of a trans-jurisdictional nature in busier sea areas (as in Europe). Where sea areas are shared, regional cooperation from an early stage can ensure the best use of resources and address issues and opportunities efficiently.

The MSP process can provide a useful tool, as it enables national oversight of spatial and temporal overlap of activities and provides a mechanism for addressing issues early, including those related to cumulative impacts and conflict between multiple sectors, and for exploring the potential for co-location of multiple activities. Depending on its implementation in country, the MSP process can provide a national basis for discussing and negotiating potential development scenarios under a blue economy and for evaluating the comparative socio-economic benefits and risks of multi-sector development options. In this way, it can provide an important forum for engagement with civil society and other stakeholders in dealing with a range of practical issues under the blue economy, including MRE.

Within an integrated planning framework, the administration of regulations needs to be transparent and effective in ensuring compliance and must involve the appropriate engagement of civil society. Procedures must be robust yet proportionate and pragmatic, in order not to hinder project development unnecessarily. This presents a challenge for new-technology proposals, as lack of experience means their effects are less easy to predict, and regulatory processes (particularly around EIA) must deal with significant levels of uncertainty. Processes of phased development and adaptive management are critical in this regard, with well-designed monitoring programmes to ensure effective learning.

Planning and licensing procedures will be unique to individual SIDS and implemented according to regulatory requirements and experience. However, sharing of experiences and best practices will provide a basis for improving procedures where possible, and for ensuring that emerging sectors are not hindered. The development of guidance appropriate to particular blue economy sectors such as MRE could greatly facilitate project development, assisting potential developers and investors in navigating the various regulatory requirements and ensuring that stakeholders and the public are appropriately engaged. This should guidance include, among other aspects, clarity regarding seabed ownership, navigation and safety, EIA and approaches to stakeholder engagement.

4.3 Understanding the potential resource for marine renewable energy

Within an enabling institutional framework, a key early action is to understand the resource availability within SIDS. Current studies for SIDS are mixed and data availability is variable, with limited reports specifically addressing the resource availability for MRE.

Some high-level studies, including the RRA report series produced by IRENA for Pacific islands, look into marine and terrestrial options. For example, in these reports IRENA conclude broadly that existing solar, wind, geothermal, marine, biomass and biofuel energy to meet electricity needs reduce energy costs, create employment, broaden energy access and enable progression towards sustainable energy self-sufficiency. More detailed studies are needed in relation to specific technology requirements, and an indication of the local information needed is provided in Table 4.1.

Table 4.1. Summary of resource assessment requirements for MRE options

Wind	A year-round assessment of wind speed is needed. Many SIDS are exposed to trade winds, meaning that there are seasonal differences in wind speed, with two main opposing wind patterns. Such differences need to be assessed over a full year to enable site optimisation for maximum generation potential. Bathymetry and seafloor data enable evaluation of potential foundation options, noting that the advent of new foundation technology means that it is feasible to consider deeper waters, although the cheaper traditional monopiles are appropriate for shallower waters (< 30 m) with non-rocky substrate.
Tidal	Tidal range technologies vary greatly in terms of appropriate resource; in general, large-scale tidal stream devices or large-scale tidal barrage projects require significant tidal range, and they are generally only feasible in particular geographies. The energy potential of tides in equatorial SIDS can be relatively small; however, more detailed analysis is required, and it is feasible to consider smaller-scale devices and technologies, including artificially partitioned 'lagoons', or projects in small closed bays with narrow openings.

(continued)

Table 4.1. Summary of resource assessment requirements for MRE options *(continued)*

Wave	Wave energy is dependent on the joint distribution of significant wave height and wave period, and detailed resource assessment is required to analyse the spatial and temporal variability of wave parameters. To specifically investigate broad-scale wave resource, physical measurement of the wave and current regime using deployed instrumentation, such as acoustic Doppler current profilers and directional wave buoys, followed by numerical modelling of the information obtained is necessary. Combination with other information regarding bathymetry, meteorology, land topography, etc., through spatial analysis can enable a theoretical estimation of the size and distribution of wave and tidal energy resources available, identifying whether 'hotspots' of high intensity exist. Different types of wave energy devices are suitable for different combinations of wave height and period; therefore, such a study should be undertaken in consultation with technology developers if possible to ensure that the design of the study is appropriate and avoid the need for repeat studies.
OTEC	Feasibility criteria for OTEC installation include a water-temperature differential between surface and deep-ocean water exceeding 20°C and a mean annual surface water temperature of at least 25°C; a steep offshore slope to a depth of 1,000 m within a few kilometres of the coast; offshore topography suitable for deploying the cold-water pipe; and a wave height of 4 m or less. OTEC is most cost-effective where there is deep water occurring close to the coast, and more expensive offshore. Where the deep water is a large distance away, more novel floating projects and extensive pipes (and maintenance) are required; this is likely to be cost-prohibitive in the short term for most SIDS. Broad-level studies can be used to assess whether appropriate conditions exist in SIDS to warrant investigation as a priority option (e.g. Rajagopalan and Nihous, 2013). However, precise bathymetry information on SIDS is sometimes lacking and new hydrological information would enhance understanding of the feasibility of OTEC over the longer term (e.g. in Seychelles). This could be combined with other data-gathering exercises regarding the continental shelves of SIDS.

4.4 Electricity transmission and storage options

Combinations of grid-connected and off-grid/micro-grid renewable energy solutions are necessary to take advantage of the opportunities available in and address the specific demand characteristics of disparate island communities. On primary inhabited islands connected to a main energy system, the characteristics of the electricity system and its capacity to receive renewable energy are critical. In most cases, connecting renewable energy will require investment to enable upgrade and extension of existing infrastructure to allow penetration of renewable energy (as explored in a report for Seychelles by Energynautics GmbH (2014)). IRENA is extending its work on grid stability and storage options for islands and can enable sharing of findings of grid integration studies, as well as identifying further such studies required across SIDS.

The intermittency of many technologies (particularly wind and solar) places a strain on grid systems, as they must cope with fluctuating production and be able to maintain supply in times of low production. Intermittency can be addressed through ongoing use of diesel generators to balance the input of renewable energy, using a diverse mix of supply options (across terrestrial and marine technologies) and energy storage. In most cases, an energy mix with some diesel-based generation is preferable in the short term, since it is cheaper and involves less financial risk.

Storage solutions are being assessed in a number of countries, including Antigua and Barbuda, where pumped storage hydropower is being investigated as a component of wind development (IRENA, 2015). Battery technology and performance is increasing, with an associated reduction in costs. Batteries provide a realistic option for SIDS and may provide a solution for the integration of greater amounts of renewable energy into on- and off-grid areas; examples include lighting at an off-grid school in Angola, Africa (IRENA, 2015), and the islands of Aride and Curieuse in Seychelles, which are 100 per cent reliant on a system of solar energy and rechargeable batteries (Seychelles News Agency, 2015).

Electrical integration through cabling between SIDS, such as that being explored in the CARICOM countries, increases the capacity for renewable energy integration, improving economies of scale, and may support regional energy trade (Worldwatch, 2013). Submarine connection is expensive over large distances and unlikely to be a realistic solution for very remote and dispersed SIDS.

4.5 Indigenous skills and knowledge

A lack of indigenous skilled workers and knowledge can limit the development and expansion of sectors in SIDS. For renewable energy, capacity is needed in terms of engineering; power suppliers to evaluate energy scenarios and options; licensing and planning bodies to appropriately and cost-effectively manage development applications; and local scientific research capability to understand and address local benefits and impacts.

This is a strategic issue to be addressed broadly across the blue economy, to include a multi-level approach through education and vocational training. Local capacity can be boosted through training hubs and exchange programmes across regions and between countries. The capacity of non-governmental organisations, universities and other knowledge providers can be utilised to best effect through knowledge-management and research strategies to address critical gaps across the blue economy (Greenhill et al. 2015).

Local limitations need to be tackled through international collaboration, with partnerships developed between national or regional companies that can lead on local aspects (e.g. resource assessment and site permitting and characterisation) and international technology developers that can provide technology and technical expertise. There are a number of international forums on MRE, and ensuring strategic representation of SIDS at key events would ensure transfer of knowledge and build connections with countries that are advancing energy options and MRE technology domestically.

4.6 Understanding the socio-ecological impacts of marine renewable energy

MRE technologies will alter and affect the local environment of SIDS to some extent, and it is essential that potential effects are understood during the planning process, to minimise the risk of negative consequences. Impacts are specific to location, device type and scale, and need to be investigated for each particular proposal. There is considerable uncertainty about impacts that may arise from novel technologies (wave, tidal, OTEC, etc.), as there are limited examples of installation and effective monitoring from which to draw evidence, and methods to account for this during project development are needed, such as phased approaches that allow for 'learning by doing'.

International initiatives collate information on possible ecological effects of MRE projects and document the available scientific basis for assessing likely impacts (e.g. the Tethys Environmental Effects of Renewable Energy from the Sea programme[3] and Sea Web Marine Science Review[4]), providing an accessible evidence base to build upon when ascertaining location-specific implications. Developing studies at local level can best be supported through joint government–industry research initiatives, to reduce the burden on individual developers and encourage proposals.

In addition to ecological effects (including behavioural changes, risk of interaction with devices, habitat alteration, etc.), the visual impacts of offshore development on communities, particularly in the case of wind farms (and other surface-piercing devices), present a planning issue in many countries. Engaging coastal communities to enable the assessment of possible impacts is essential to understand local acceptance or lack of acceptance, as well as possible impacts on tourism, and to design appropriate projects. This requires an appropriate emphasis on social sciences in supporting research, in addition to community involvement in energy projects, and such engagement from the outset can ensure that local knowledge and views are incorporated into project design, as well as encouraging ownership by local people.

Endnotes

1 ctc-n.org
2 ISLANDS (FED/2009/021-331) is implemented by the Indian Ocean Commission through technical assistance funded under the European Development Fund (EuropeAid/129535/D/SER/MULTI).
3 http://tethys.pnl.gov/
4 http://www.seaweb.org/science/MSRnewsletters/msr_current.php

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Chapter 5

Conclusions and Recommendations

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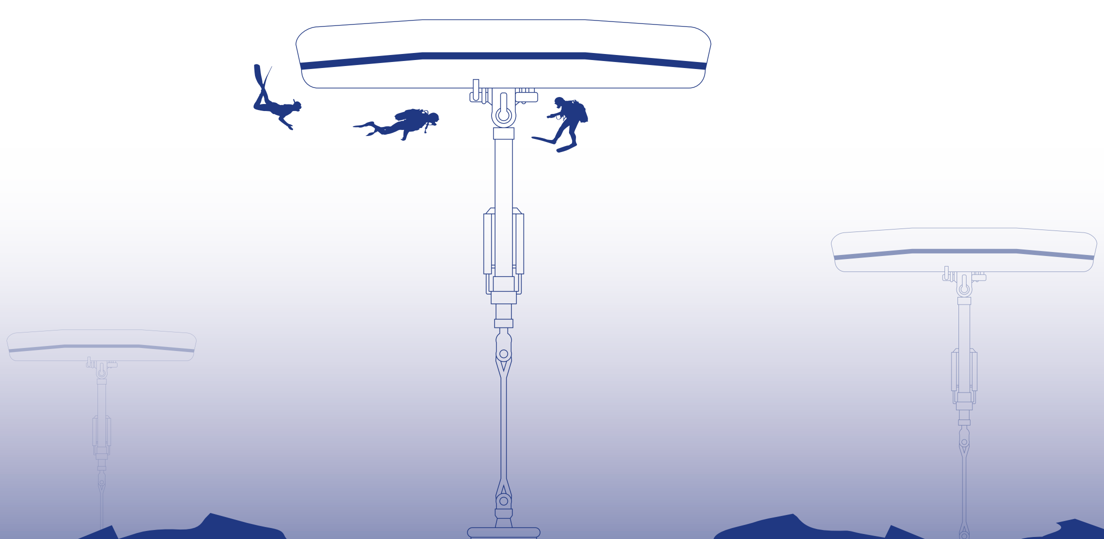
5.1 Conclusions

The drivers for renewable energy in SIDS are clear, and emphasis on expanding renewable energy generation, alongside other policy measures associated with demand management and efficiency, is essential. Extending investigation beyond terrestrial options into the possibilities of utilising marine resources is reasonable, given the proximity of SIDS to extensive marine areas and the emphasis on increasing their value through the blue economy.

As the sector is broadly immature, renewable energy is expensive, with investment in novel MRE technologies being particularly risky. However, costs will decrease and projects will become increasingly favourable as technologies are further developed and the wider benefits of renewable energy are accounted for. The small size of SIDS presents challenges in achieving economies of scale in market-development terms; however, for innovative designs at an early stage (particularly wave energy devices), technology developers are focusing on smaller, situation-specific projects as a realistic strategy for phased technology advancement, and these are suited to the lower levels of demand and specific requirements of SIDS.

Achieving success in developing MRE as a key component of the blue economy requires integrated and strategic action at policy level, to ensure a coherent and supportive policy framework



that creates an enabling environment for project development. Considering renewable energy in the implementation of integrated policy under the blue economy provides a basis for the cross-sectoral and multi-actor approach necessary to make the best use of available capital (financial, human and technical) across MRE and other priority activities.

Renewable energy generation policy also needs to be integrated with measures addressing efficiency and demand in order to develop cost-effective and integrated strategies for decarbonising energy sectors. Furthermore, considering terrestrial and marine options together in renewable energy evaluation and planning is necessary to strategically address aspects that are common to both (onshore infrastructure, transmission, financing, etc.).

Collaboration between local and international private and public actors is already apparent in many SIDS, and is critical in addressing capacity gaps and enabling SIDS to progress. Given that local conditions will vary by country, recommendations made in this report will need to be further contextualised through local investigations and engagement with stakeholders in SIDS and will need to build on progress already being made in particular countries.

5.2 Recommendations

Approaches to developing MRE will be highly country-specific, and dependent on critical factors such as available resource (onshore and offshore), local institutional capacity for implementation from policy to planning and eventually projects. Key overarching recommendations which are broadly applicable to SIDS, are:

1. **Develop a roadmap for MRE as a core aspect of the blue economy**

   An action plan for renewable energy, which set out a stepwise progression in understanding and realisation of energy projects and draws on the cross-policy support for energy and sustainable development, would be beneficial for internal and foreign stakeholders. A practical road map should include the following steps, ensuring that high-level ambition is underpinned by a comprehensive planning and regulatory framework:

a. **Policy:** national policy must be strong, sustained and realistic, related to regional and global agendas but tailored and made specific at country level. This should include steps to address capacity issues at institutional level with regard to delivering transformative energy projects.

b. **Resource assessment:** detailed resource assessment to gather accurate seasonal data on resources, terrestrial and marine (see section 4.3), is essential for decision-making regarding investment in MRE. Undertaking this at an early stage reduces the risk of wasting resources in investigating further options. For novel technologies (e.g. some wave devices), assessment is best done in coordination with technology developers to ensure that their particular requirements are addressed. Data collection should be coordinated with the planning of other blue economy sectors to ensure cost savings.

c. **Strategic planning:** based on an understanding of available resources and national priorities, strategic planning is essential to ensure the selection of the most appropriate locations for MRE development according to resource availability, ecological sensitivity, visual impacts, other activities, etc. MSP as an overarching process is crucial in this regard, and can be used to identify co-location opportunities (see recommendation 4).

d. **Licensing and regulation of projects:** it is necessary to develop an understanding of the potential impacts of specific and realistic project ideas, including the 'baseline' of current socio-ecological conditions, and relate this to the strategic research agenda to ensure that evidence gaps are addressed.

2. **Ensure coherence and efficiency through integrated policy and planning**

Policy and planning must be integrated across MRE generation, with national initiatives addressing terrestrial options, grid and off-grid generation, energy efficiency and demand measures. The blue economy presents an opportunity for greater integration across sectors; however, it must be ensured that new policies interrelate with preceding policy and support planning across the land–sea interface.

Costs are a key issue in capacity-limited SIDS, and opportunities to make savings can be found across policy and planning. The blue economy provides a framework for rationalising cost and effort across multiple sectors and objectives; if the added value of such integrated approaches is recognised, it could enhance political support, driving the transition to cross-sectoral and cross-policy activity.

3. **Engage civil society early to use local knowledge and engender ownership**

   Engaging communities in the planning and consideration of energy projects will enable an understanding of possible impacts and is critical for long-term success and for developing acceptance and ownership through participation. Capitalising on local knowledge can enable the design of innovative and location-specific energy solutions.

4. **Use MSP to support practical sector development**

   A well-designed MSP process provides numerous opportunities to support the planning of new sectors, such as MRE, in the blue economy. Inter alia, it can be used to:

   - identify appropriate development areas, including opportunities for co-location of MRE with other offshore installations (e.g. aquaculture);
   - provide a mechanism for investigating and understanding socio-ecological implications;
   - provide a framework for comparative analysis and for making choices between different multi-sector development options; and
   - provide an important forum for engagement with civil society and other stakeholders in dealing with a range of issues under the blue economy.

5. **Share global experience and develop 'best practice' approaches**

   Available resources should be used in a targeted manner, prioritising the testing and implementation of innovative projects in suitable areas and sharing expertise widely across SIDS. Novel technologies require a stepwise approach incorporating learning through experience (related to technological performance or environmental effects), set within a well-designed programme of monitoring.

Guidance should be developed for businesses, stakeholders, communities, prospective developers, investors, etc., on when and how to engage with the blue economy and on opportunities in MRE. Existing cooperation mechanisms between SIDS (e.g. SIDS DOCK and regional mechanisms such as CARICOM) can be used to share experiences and build a database of best practices in the planning and development of MRE projects. Coordination between SIDS can improve access to donor funding mechanisms, technology developers, international forums on MRE, etc.

Glossary

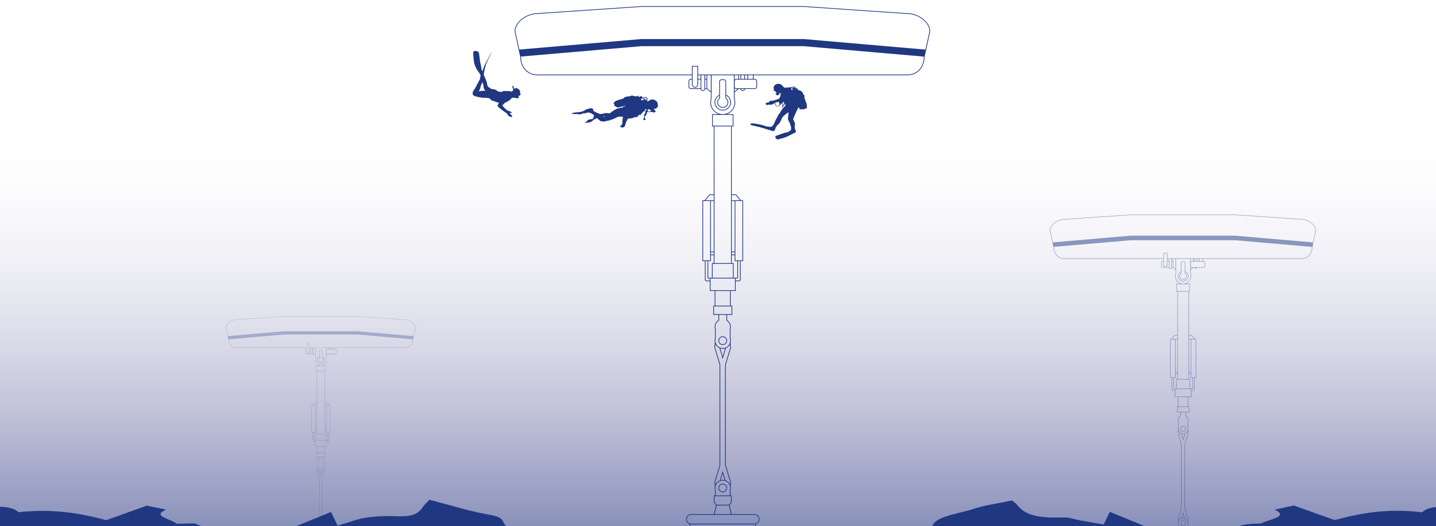
Ocean thermal energy conversion – generation of energy utilising the temperature differential between warm surface waters and cooler bottom layers.

Marine spatial planning – a spatial, cross-sectoral approach to the optimisation of use of marine activities, minimising negative social and ecological effects.

Civil society – residents and communities who may have in interest in, or be affected positively or negatively by development plans and proposals.

Commercial scale – technologies which have been tested as full scale devices, capable of producing electricity to be transmitted to domestic or industrial uses.

Co-location – combining different marine activities within the same space to optimise resource use, perhaps sharing infrastructure (e.g. moorings).



The Commonwealth

The Commonwealth Blue Economy series aims to support the development of the blue economy in Commonwealth member countries by providing a high-level assessment of the opportunities available for economic diversification and sustainable growth in small island developing states (SIDS).

This fourth volume in the series explores the potential for the development of the blue economy by providing a high-level review of actions needed to progress marine renewable energy generation in SIDS. Renewable energy is a key component of enabling sustainable development through the decarbonisation of economies and is being progressed in nations globally. Whereas onshore technologies (e.g. solar and wind) are achieving commercial success, most marine technologies remain in the early phases of development.

Successful MRE deployment is dependent on critical factors such as available energy resource, indigenous skills (including institutional capacity and skilled labour), supportive policy and effective regulatory frameworks. The recommendations made in this book provide a guide for action, emphasising the need for integration at national level, between sectors and policies, and for co-ordination between targeted local studies and collaborative global action.

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