BLUE ECONOMY AND ITS PROMISING MARKETS FOR OCEAN ENERGY

Technology Collaboration Programme
by iea

Published by:
The Executive Committee of Ocean Energy Systems (OES)

Edited by:
Ana Brito e Melo, Henry Jeffrey and Yann-Hervé De Roeck

Designed by:
Formas do Possível | www.formasdopossivel.com

Cover:
© Seadam | Dreamstime.com

Suggested Citation:
OES (2020), Blue Economy and its Promising Markets for Ocean Energy. IEA Technology Collaboration Programme for Ocean Energy Systems (OES), www.ocean-energy-systems.org

Disclaimer:
The OES, also known as the Technology Collaboration Programme for Ocean Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of OES do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

Ocean energy is an abundant resource, geographically diverse, predictable and complimentary to other energy sources.

The **"Blue Economy"** covers a wide range of interlinked, established and emerging sectors. Ocean energy is one of the emerging sectors enabling the Blue Economy and with high potential for future development.

The advance of various sectors of the Blue Economy requires access to reliable energy. In new or fast-growing marine industries (including offshore aquaculture, ocean observation, marine robotics, storage, hydrogen production, etc), ocean energy can play a unique role within each of these applications, enabling new capabilities and economic development.

Some recent studies have revealed the importance of exploring potential markets for ocean energy technologies that go beyond their integration into the grid. It has been suggested that these new markets may be a faster route for the development of ocean energy, with lower risks, lower costs and lower energy requirements.

Ocean energy is an innovative sector that can provide solutions to both emerging and existing industries in a unique and environmentally sustainable way, but can be also very attractive for islands markets, where the cost of power or water is high, as desalination is an energy-intensive process.

Potential marine power applications

Adapted from the *Powering the Blue Economy™* report.

INTERVIEW WITH

ALEJANDRO MORENO

DIRECTOR FOR THE WATER POWER TECHNOLOGIES OFFICE IN THE OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY (EERE)

The U.S. Department of Energy's Water Power Technologies Office (WPTO), within the Office of Energy Efficiency and Renewable Energy, systematically investigates potential applications for marine energy. WPTO's initial assessment of near-term opportunities in the blue economy were presented in a 2019 report, *Powering the Blue Economy™: Exploring Opportunities for Marine Renewable Energy in Maritime Markets*. The report highlights a compelling set of eight blue economy opportunities that could be supported by ocean energy technologies. WPTO categorized these eight applications in two overarching categories: Power at Sea (including ocean observation, underwater vehicle charging, marine aquaculture, marine algae, and seawater mining) and Resilient Coastal Communities (seawater desalination, coastal resiliency and disaster recovery, and isolated communities).

What was the major motivation for conducting the Powering the Blue Economy™ study?

Over the last decade, the Water Power Technologies Office (WPTO) has made progress in both research and development focused on marine energy technology development and understanding how these resources could and should serve grid-scale electricity needs. But our motivation for what eventually became the Powering the Blue Economy (PBE) report, and subsequent initiative, was that by taking a broader view of the role marine energy, beyond serving as a power source for the grid, there are numerous near-term blue economy markets where marine energy can provide reliable, affordable energy and unlock the potential to grow the blue economy. This includes markets and applications both nearshore and deep offshore where we believe that marine energy is uniquely suited to remove constraints and enable new capabilities. Removing and addressing energy constraints in the blue economy could accelerate economic growth by strengthening existing - and creating or enabling new - markets and applications for sustainable economic development.

We began investigating the potential for marine energy into these blue economy markets and applications by holding a summit in December 2017 with representatives from blue economy sectors - like ocean observing, aquaculture, and desalination - where we gained insights on their energy challenges and need for new technologies and solutions. The feedback we received at this summit helped confirm the need to assess these opportunities for marine energy and informed how we conducted research for the report. The report - which we did in partnership with the National Renewable Energy Laboratory and the Pacific Northwest National Laboratory - focused on markets, end-users, and partners likely to have a relatively high risk tolerance, reduced price sensitivities, and moderate power needs to allow for small or medium systems and fast iteration cycles. We started this investigation with interviews and a literature review, which then matured into a formal research project leading to the report.

Through this process, we gained a better understanding of the diverse set of markets and applications that represent development pathways for marine energy in the blue economy. This report and subsequent activities have started to illuminate the compelling need for energy innovation in the blue economy as a critical element underlying the future success of multiple scientific, economic, and security sectors.

The report identifies several promising opportunities for providing power at sea and meeting the needs of remote coastal communities. In your view, in which of these markets could ocean energy have a more promising impact?

Though we think all of the markets and applications have promise, we believe that there may be more near-term opportunities. This is true in both of the two thematic challenges under PBE: Power at Sea and Resilient Coastal Communities.

From ocean exploration and navigation to aquaculture, many marine-based applications and markets are located far from shore. In our Power at Sea theme, we recognize that these deep at-sea applications include key offshore challenges, like the fact that delivering power to these systems can be expensive and difficult. But powering systems that use energy derived from the ocean offers a potentially effective alternative. One of the near-term markets we believe offers both an opportunity and an enormous impact is ocean observing. Enabling ocean observation has many critical benefits, including expanding the understanding of the ocean by mapping and observing the more than 90% of the ocean that remains unobserved. And so this year, one of the activities we launched is the Ocean Observing Prize, which challenges innovators to integrate marine renewable energy with ocean observation platforms, potentially revolutionizing our ability to collect the data needed to understand, map, and monitor the ocean. With our partner, the National Oceanic and Atmospheric Administration (NOAA), we are hoping to spur the creation of new marine energy-enabled ocean observing platforms to provide the energy needed to power the systems that help us understand our oceans.

But in addition to deep offshore applications, marine energy can help support coastal communities, making them more resilient in the long term and in the face of extreme events such as tsunamis, hurricanes, floods, or droughts. Many marine energy applications are ideally suited to coastal development by offering relatively easy access for installation and operation and maintenance activities, providing a predictable and uninterrupted energy supply, and potentially reducing land requirements needed by many land-based energy solutions. One example is desalination.

According to the Global Water Intelligence, the U.S. desalination market is anticipated to reach approximately $344 million in capital expenditures and about $195 million in operational expenditures in 2020, up from $129 million and $124 million, respectively, in 2015. The global desalination market is experiencing a similar growth rate, having reached $2.6 billion in capital expenditures in 2015 which is expected to grow to over $4.5 billion by the end of 2020. Aside from the market opportunity, we know that changing weather patterns can create drought and population growth is placing increasing stress on existing water supplies; both of these realities are already contributing to the growing interest in seawater desalination.

But desalination is currently a power-intensive process, meaning electricity is one of the largest cost drivers. But we believe that wave energy can offer a more cost-effective solution. In addition to the potential to provide electricity for desalination, wave energy technologies could be used to directly pressurize seawater for a reverse-osmosis system, eliminating the need for electricity altogether. So building upon research at the labs that uncovered technical promise in wave powered desalination, in 2019 we launched our Waves to Water prize. Waves to Water offers $3.3 million in cash prizes, with the goal to demonstrate small, modular, cost-competitive desalination systems that use the power of ocean waves to provide clean drinking water for disaster recovery and for remote and coastal communities. And in the long term, we believe that marine energy could provide low-cost, emission-free, drought-resistant drinking water to larger municipalities.

While these are just some examples we see within markets in the blue economy, it has been clear through our research and work with partners that there are myriad opportunities for thinking about energy and the blue economy, particularly as it relates to marine energy,

Do you think stakeholders from other blue economy sectors are receptive to investigate solutions powered by ocean energy? Could you describe your interaction with these sectors in the course of your study?

Yes, absolutely. As mentioned, we held a summit in 2017 where we heard directly from blue economy stakeholders. Much of this feedback and subsequent conversations helped us draft the PBE report, but we were also informed by our public Request for Information through which we received more than 400 responses across public and private sectors on marine energy's potential to power the blue economy.

We continue to partner directly with interested blue economy stakeholders; for example, as I mentioned we're partnering with NOAA, the U.S. agency that leads ocean exploration, on the Ocean Observing Prize. The first stage of the prize received more than 60 submissions that ranged from using wave-powered buoys to charge autonomous vehicles to thermal gradient powered systems that can observe the depths of the ocean.The next phase of this prize will involve designing and testing systems of autonomous underwater vehicles powered by marine energy. To inform the rules and requirements of this phase, we hosted a rules workshop that attracted more than 60 blue economy experts across government, academia, and industry.

The Waves to Water Prize has also received a lot of interest from prospective customers and innovators. The first stage of the prize attracted more than 60 submissions nationwide. And we have partners like the International Desalination Association, who are helping promote and amplify the prize. We have had many desal experts help us in evaluating and shaping the prize, and we will be inviting desalination experts to attend the final test for Waves to Water, which in partnership with the Coastal Studies Institute will be held at Jennette's Pier in North Carolina in 2022.

In addition to NOAA, we're working with other federal partners to support the blue economy ecosystem here in the U.S. We partnered with the U.S. Economic Development Administration to launch a $4 million Industry Challenge to support entrepreneurship and accelerate growth within the blue economy. We're very excited about this challenge and expect to announce the selections later this year.

Lastly, we're also engaging the future workforce of the blue economy to consider marine energy's potential. We launched the inaugural Marine Energy Collegiate Competition last year. Through this competition, fifteen interdisciplinary teams of undergraduate and graduate students offered a range of unique ideas, designs, and business pitches with one common goal: to power the blue economy using marine energy.

This report is serving as the foundation of the new R&D initiative Powering the Blue Economy™, announced by the WPTO. What is the goal of this initiative and how is this R&D programme structured?

The PBE initiative expands the WPTO strategic vision to more fully encompass an ocean-centric view of marine energy innovation in close partnership with other offices within the U.S. Department of Energy, other federal agencies, and the diverse set of industries and sectors that make up the blue economy. This creates opportunities to understand and obtain new value from marine energy to address the energy needs of the blue economy, and where those needs intersect with the unique attributes and advantages of wave, tidal, ocean current, ocean thermal, and river current energy.

WPTO has set out three interwoven goals for PBE. These goals are: (1) quantify the value of marine energy in the blue economy; (2) accelerate technology readiness; and (3) work with private and public sector partners to commercialize technologies developed.

Many of the foundational, analytical, and operational activities for PBE are led by the national labs, primarily the National Renewable Energy Laboratory and the Pacific Northwest National Laboratory. As I mentioned, the labs helped author the PBE report, and they are currently conducting some key foundational research to enable marine energy in the blue economy. They also administer our technology development prizes and the collegiate competition alongside our office. And in addition to these prizes and competitions, we have also launched multimillion dollar funding opportunity announcements and are leveraging the Small Business Innovation Research (SBIR) Program to support projects led by industry and academia to demonstrate the technical feasibility of marine energy systems to power the blue economy.

We believe that by funding foundational research at our labs and universities, supporting prototyping through prizes, SBIR and other financing mechanisms, and by continuing to expand our partnership opportunities with federal and private sector partners, we are supporting the future of the blue economy powered by marine energy.

INTERVIEW WITH

DR. IR. MATTHIJS SOEDE

RESEARCH POLICY OFFICER
DG RESEARCH & INNOVATION, EUROPEAN COMMISSION

The European Commission has recently published its second Blue Economy Report (2019) which describes the scope and size of the EU blue economy. It provides an overview of the most recent trends in several socioeconomic indicators and analyses the drivers behind such trends. This new edition incorporates more detailed and extensive analysis on innovative and emerging sectors including ocean energy. Also in 2019, 26 European islands have officially launched their clean energy transition with the support of the European Commission.

The 2019 Blue Economy Report launched by the European Commission is intended to support policymakers and stakeholders in creating new business opportunities and in managing the resources of oceans in a sustainable manner. Which opportunities can bring emerging industries, like ocean energy?

For enabling successful blue growth it is needed for policy makers, researchers but also developers to have the availability of better data, analysis and knowledge about the sea. Therefore, the European Commission is collecting the data now and makes it available via its EU Blue Economy Report. Recently, we have published the third version already. A very interesting source of data! The report shows that seas and oceans are a source of food, that we cross them from continent to continent with large amounts of goods and that they are attractive for tourism/leisure.

As we all know they can be a great source of energy. The Commission has the ambition to become climate-neutral in 2050 and to realize this we really need to decarbonize our energy supply. We make already use of the sun and wind, but we need to make use of all potential resources and so we should really try to capture the energy of the seas and oceans. We think that the Blue Economy is indispensable to our future welfare and prosperity and that it is a driver for new jobs and innovation. Especially, the marine renewable energy (MRE) sector presents a great potential to generate economic growth and jobs, enhance the security of its energy supply and boost competitiveness through technological innovation.

To what extend do you agree that niche markets can serve as a development step for ocean energy technologies?

I fully agree with this.... But the question is of course why? There is a high pressure on each new emerging technology to get fast into the market. But the electricity market is competitive and wind and PV are ahead. In my view ocean energy can show its added value and be used for niche applications, where other resources are not available or where the customer considers ocean energy to have an added value to its project. Is ocean energy maybe more sustainable than other technologies, considering for instance the overall use of materials for electricity generation? Niche sectors are not pushing for big, but for quality. And that is what ocean energy has to deliver. Ocean energy has to proof to be a reliable and sustainable technology via niche applications in the next years, and by doing this it will be able to reduce its costs and to enter other markets as well.

Ocean energy is still a costly sector to invest in. In your perspective do you think there is an increased commitment in recent years?

Recently we published the 2020 Blue Growth report. In this report offshore wind has been for the first time labelled as an additional established sector and not as an emerging technology. This because offshore wind has been growing over the past years delivering growth and jobs and the future outlook is also positive. Ocean energy is not yet there, but in 2019 the EU R&D investments have never been so high, and we see that projects are delivering and that is an important signal for investors.

INTERVIEW WITH

RÉMI GRUET

CEO OF OCEAN ENERGY EUROPE (OEE)

‘Powering Homes Today, Powering Nations Tomorrow’, launched in 2019 put a spotlight on the ocean energy technology’s progress over the past 2 years and set out clear actions to bring ocean energy to the point of industrial roll-out.

From your perspective, which key milestones has the ocean energy sector reached?

Ocean energy has made huge progress in recent years, both in terms of the technology and power generation. At the start of 2020, the European tidal energy sector reached 50GWh of cumulative power production. A big chunk of that production comes from the development and expansion of multi-device farms, a key milestone for tidal.

Pilot farms are now taking off, with the flagship TIGER project set to install 8MW of tidal energy capacity in the Channel and 20MW of tidal farms using European technology being developed in Canada. That the sector is at this stage shows just how far it has come in the past decade.

These projects will bring economies of scale, which will in turn push the costs of producing energy from the sea further down. Tidal power’s cost of energy has already dropped by 40% over the past five years – another key milestone!

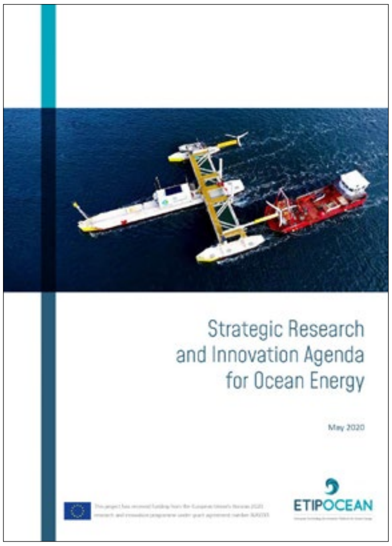
Other ocean energy technologies are not far behind. A new generation of wave devices is proving its worth, surviving stormy seas whilst generating power. That these machines are now being built at full-scale and put in real sea conditions is another indicator of the shift towards industrialisation. Engie’s SWAC project, Thassalia, heats and cools an entire district in the city of Marseille.

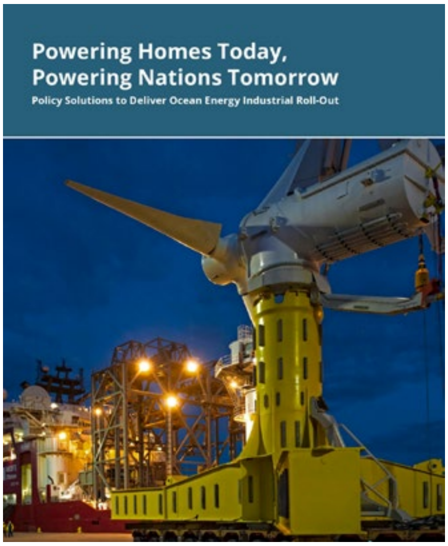
There are many clever technologies to explore the energy of the oceans, but they all face enormous challenges. The hurdles to commercializing ocean energy are still high. How do you see the ocean energy sector going into the future?

Going strong! The main question will be where. Europe developed the first prototypes, the first pilot farms and put in place good R&D programmes to support this. But the transformation of technological innovations into commercial products has always been Europe’s weakness, contrary to the US or China.

Today the EU still enjoys a technological advantage and most projects around the world are being planned with European technology. But the US, Canada and China, among others, are investing significantly in their devices and companies and also benefit from a good resource. Europe needs to gear up financing and enable its companies to cross the valley of death into commercialisation.

Devices must be put in the water, in real-sea conditions, for extended periods. The ‘**Powering Homes**’ report gave a number of options for financing ocean energy, and the recent **Strategic Research & Innovation Agenda for Ocean Energy** sets out the priority areas to advance these technologies over the next five years. This is where the finance needs to focus to deliver a viable European sector and avoid the fruits of European R&D being harvested by other countries.





Engineering and economic challenges co-exist with governance challenges in the development of large-scale ocean energy projects. What is your message for policy makers for creating the enabling conditions for the successful ocean energy development?

The long-term objective is to reach a point where private investment becomes the primary driver for ocean energy development. Overcoming technical challenges is clearly a big part of this, but they cannot happen in a vacuum. Mature renewables wouldn't be where they are today without large scale deployment underpinned by a supportive policy landscape – and it is no different for ocean energy.

For European countries, providing the stimulus for 100 MW of ocean energy by 2025 and 3 GW by 2030 will give a clear signal to both the sector and investors. Now is the right moment to widely deploy a second-generation of renewables, such as wave, tidal and OTEC/SWAC, alongside mature wind and solar power.

We also need actions and programmes to reach those targets. I am encouraged by a number of innovative financing mechanisms emerging at the EU level. The European Innovation Council's Accelerator, and the new Blue Invest Platform both offer an unusual blend of grants and equity. The forthcoming Innovation Fund and the InnovFin EDP debt programme are equally interesting. Yet it is crucial that those programmes enable as many projects as possible. We will not cross the valley of death with just two pilot farms!

Continued funding for R&D should run alongside market-oriented programmes. Europe is the global leader in ocean energy, and much of this success is down to robust investments in research and innovation. Since 2014, the EU has invested €250m in ocean energy projects via its research programmes, which has accelerated technological advances and provided important leverage for the sector to secure private financing.

Support at national level is also key to provide long-term market visibility. Providing revenue support, to 'top-up' electricity market prices is key to harnessing investor finance and providing manufacturers with a market for their products. This should be backed up by renewable energy targets, decarbonisation strategies and tendering processes.

The ocean energy sector is asking for €1bn over the next five years to deliver an entirely new industry, which in turn will create new supply chains across many countries. By contrast, €1bn covers just one year of subsidies for the ITER nuclear fusion project, and is equivalent to a mere 2-3% of the UK Hinkley Point reactor's total subsidy. A great deal for Europe!

INTERVIEW WITH

DR. JOHN WHITTINGTON

CEO OF BLUE ECONOMY COOPERATIVE RESEARCH CENTRE (BE CRC)

Launched in 2020, Australia's Blue Economy Cooperative Research Centre (BE CRC) brings together the aquaculture, offshore engineering and renewable energy sectors to help build sustainable production of food and energy in Australia's offshore environment. The BE CRC is a 10-year program, backed by a Commonwealth grant of $70 million, with further contributions of $157 million in cash and in-kind from across its 40 industrial, research and government participants.

What is the main role of the recently created Australian centre - Blue Economy CRC - and how do you see its interaction with different sectors of the Blue Economy?

Australia is uniquely situated in the Asia-Pacific region adjacent to the world's largest markets for seafood and energy. Australia's high value seafood products have tremendous growth opportunities, currently constrained by access to coastal sites. The Blue Economy CRC seeks to assist growth of the sector, by enabling accessibility of aquaculture to prospective opportunities in Australia's offshore environments. Drawing together knowledge, skills and experience of its partners, the Blue Economy CRC will develop systems, structures and capabilities that will transform the future of Australia's marine-based industries.

The CRC's vision is to enhance the development of Australia's sustainable blue economy through delivery of world-class and industry-focused research into integrated seafood and renewable energy production systems. Developed through iterative dialogue with industry, key activities are focused around five integrated user-defined research programs:

- The Offshore Engineering and Technology program provides offshore infrastructure engineering solutions using latest construction, installation, automation, monitoring and maintenance technologies, to support growth of sustainable offshore industry.
- The Seafood and Marine Products program will develop innovative aquaculture systems to provide solutions in animal and plant husbandry and feed design.
- The Offshore Renewable Energy Systems program will develop and demonstrate remote area power systems to support offshore off-grid industrial application, including energy export opportunities.
- The Environment & Ecosystems program will deliver innovative solutions for monitoring, modelling and mitigating the environment impacts of new offshore developments.
- The Sustainable Offshore Developments program will develop new 'fit for purpose' policies, regulatory instruments and sustainable business development and commercialisation models for the growth of Australia's blue economy.

Ocean energies are strategically important in the Blue Economy CRC. Can you unveil your plans related to promoting the development of the ocean energy sector?

The Blue Economy CRC identifies decarbonisation of offshore industry as an exceptional remote area power system market opportunity. Offshore growth presents energy focused challenges for Australia's aquaculture sector; increasing demand for transport fuel, severing connection to coastal based resources (electricity and freshwater), and increasing risk associated with diesel transport for offshore electricity generation. The CRC seeks to develop sustainable, reliable, secure and affordable offshore energy systems to meet the energy demands of Australia's future blue economy.

Further to meeting the energy demands of offshore industry, the CRC seeks to build offshore sustainable energy export opportunities. Offshore production of green Hydrogen presents potential additional revenue for offshore platforms, contributing to Australia's global export opportunities and anticipated future domestic Hydrogen demand.

The Offshore Renewable Energy Systems Research Program spans three themes:

- R&D to support development of affordable, robust, and reliable offshore renewable energy conversion technologies. Partner interests span floating wind, wave, tidal and floating PV technologies.
- Renewable Energy/Resource management in offshore environments, with consideration of electricity, freshwater and hydrogen (for platform storage/ firming application, transport fuel, and local application) demand management.
- Offshore renewable resource characterisation, industry energy demand, market and supply chain development/assessments.

Further environmental and social research associated with offshore renewable energy systems are encompassed within other CRC Research Programs, accounting for co-benefits and cumulative effects associated with co-located offshore industries.

Which major challenges do you anticipate at this stage at the Blue Economy CRC in pursuing its objectives?

The Blue Economy CRC recently announced the commissioning of 17 research scoping projects. Further information is available at https://blueeconomy-crc.com.au/projects/

The purpose of these projects is to help the Blue Economy CRC develop a clear understanding of existing technologies, solutions, knowledge and trends, and to identify the major challenges and opportunities for which the CRC can optimally contribute across its R&D Scope.

These projects, with outcomes anticipated at the end of 2020, will not only guide future research investment by the BECRC, but are also establishing strong collaborative ties across the CRC's 40 partners, that operate individually across Australia's multi-sectoral sustainable blue economy. This engagement will further strengthen Australia's world-class, industry-focused research capability to meet emergent challenges identified by the Centre.

How do you see that international collaboration could accelerate ocean energy growth? What are your plans for international collaboration?

The Blue Economy CRC brings together Australian national and international expertise in aquaculture, offshore renewable energy, and marine engineering within a single collaborative Centre. The CRC brings together world leading R&D expertise from across 40 partners, from industry, research and Government, from 11 countries, to help accelerate growth of Australia's sustainable blue economy.

Through international collaboration and linking of innovation ecosystems from across its existing partners, and with third party collaborators, the CRC seeks to be a major contributor to future innovations to accelerate growth of offshore renewable energy technologies globally.

Future calls for allocation of BECRC funds will be sufficiently flexible, to pivot to identified opportunities where the BECRC can deliver optimal value for growth of Australia's sustainable blue economy. Enhancing global engagement, building business-research collaboration, drawing talent and investment into Australia, and increasing links to global value chains are all components of the BECRCs strategy to see success for the program, and ocean energy sector globally.

INTERVIEW WITH

DR. SRIKANTH NARASIMALU

PROGRAM DIRECTOR & PRINCIPAL RESEARCH SCIENTIST,
ENERGY RESEARCH INSTITUTE @ NTU

Singapore is taking large-scale decarbonization measures and as a first step it has been looking into remote energy needs that are powered by diesel and it is trying to adopt various renewables including ocean renewables. Consumers like aquaculture, anchored ships, isolated lighthouse and desalination systems are being benefitted with energy security that are contributing towards Singapore's low-carbon and climate resilient future.

How do you describe the role of the REIDS initiative and its importance for Southeast Asia?

Remote coastal and island regions have their energy needs fulfilled mainly through fossil based systems. One of the unique capability of fossil based energy systems is to provide electricity with high certainty and power quality. Renewables are free but experience high stochasticity and intermittencies. Accordingly, Renewable Energy Integration Demonstrator - Singapore (REIDS) was setup as a Singapore-based R3D (Research, Development, Demonstration and Deployment) platform dedicated to designing, demonstrating and testing solutions for sustainable and affordable energy in a tropical condition to provide energy with high certainty and power quality towards remote coastal and island region. This will meet the needs of twenty five thousand over islands of Southeast Asia (SEA) that are challenged by low energy per capita and are presently powered by fossil fuels which gets further disrupted by natural disasters such as typhoons and earthquakes.

REIDS aims to power such remote coastal and islandic region and remote marine operations energy needs through combination of renewables, energy storage and new grid architecture powered by machine learning based energy forecasting and load scheduling methods. Presently, it is demonstrated in Pulau Semakau, an island south of mainland Singapore, which serves to support a variety of electrical loads in the island, purely through renewables, including ocean energy. First of its kind in the region, the hybrid micro grid facilitates the development and commercialization of energy technologies suited for tropical conditions that will help address the growing demand for renewable energy technologies in the remote regions of the overall tropical belt. REIDS integrates multiple renewables and novel technologies such as power-to-gas technologies, energy storage in the form of green hydrogen and electrons, smart hybrid AC-DC grids with vehicle to grid technologies and enable the development of solutions suited for small islands, isolated villages, and emergency power supplies. More details can be obtained from the REIDS home page (https://erian.ntu.edu.sg/REIDS)

What level of support exists for this platform? What are the main strategic lines for next years?

REIDS platform is well supported by Singapore governmental agencies such as Economic Development board (EDB) of Singapore, National Environmental agency (NEA) of Singapore, Energy Market Authority (EMA) of Singapore, National Research Foundation (NRF) and Ministry of Trade and Industry (MTI) of Singapore. Currently, REIDS project also supplies approximately 200 kWh of electricity on average to NEA facility on Semakau daily and envisages supplying all of NEA's as well as Barramundi Asia Pte Ltd (a fish nursery on Semakau)'s electricity requirement. The outcome of the REIDS research is being disseminated in the annual conference held by ERI@N as part of the Singapore Energy Week (SIEW) which brings both technology developers, energy adopters, project developers, ASEAN country policy makers, technology associations such as SEAS and ACE, etc. ERI@N has also setup a network of ocean renewable energy interested institutions made of government, academia and industry players of ASEAN countries called Southeast Asian Centre for Ocean Renewable Energy (SEACORE) to disseminate and exchange knowledge through joint projects, researcher exchange and workshops.

The main strategic lines for next years is to look at renewable energy, integrating them into microgrids, so that it can benefit not only remote islands and villages (in the region), but also urban microgrids that will benefit Singapore and the neighbouring ASEAN region in the longer term in terms of a more stable and resilient power supply.

How do you see its applicability in the Blue Economy context?

The REIDS testbed provides an ideal and unique location for several research and development activities which include:

- Interoperability study of multi-microgrid networks
- Cybersecurity of electricity distribution systems
- Energy trading between different microgrids
- Power Grid dynamics study and evaluation
- Distributed Energy Resource Management Systems
- Resiliency and Reliability study of electrical distribution network

Along with the research and development, the testbed also provides the partners unique opportunity for demonstration of their technologies especially in the field of ocean renewable energy towards marine industries and coastal population's energy needs. For example, the deep-water aquaculture requires energy in the form of compressed air, desalination, cooling loads for the fish catch, electricity for its critical assets and floating workers' quarters. In parallel, new marine operations are evolving such as seabed mining, dredging and other remote ocean-based operations requires energy without hampering the ocean ecology which requires clean energy systems. Hence device makers, grid operators, energy users and other players in the value chain take part in this REIDS demonstration along with multinational subsidiaries and Small and Medium Enterprises (SMEs) companies as well as decision-makers from all across the globe. This would help in development of ocean renewable technologies into commercial products and thereby contributing to blue economy.

As of date, which stakeholders are engaged? And what are your expectations to bring more collaborators in the coming years?

The REIDS technology-roadmap that was originally conceived in 2015 to be built on a Technology-Systems tripod : (a) renewable energy sources, (b) energy storage systems and (c) integration by way of microgrids under the control of intelligent and adaptive energy management systems, later incorporated the fourth pillar of interconnection of the microgrids on a bi-directional electrical network and comprehensive ICT network (called Low Voltage Micro Grid Cluster – LVMGC) to produce the most unique testbed of its kind in the world in 2019.

This unique concept allows the REIDS initiative to feature the following four types of collaborators:

- Independent Microgrid Operator
- Cluster Microgrid Operator
- Software System Operator
- Hardware System Operator

As of date, REIDS engages with collaborators from across the world which includes REC, Sunseap, Schneider electric, Engie, Rolls Royce, EDF, Emerson, ClassNK, etc., to host 5 microgrids along with the core electrical and ICT infrastructure under operation / testing. The testbed expects to add at least 3 more microgrids along with many more collaborators in the coming years.

Can you unveil any existing plans to integrate ocean energy in this initiative?

The offshore renewable energy integration and demonstration (Offshore REIDS) project, also termed as Tropical Marine Energy Centre (TMEC), was initiated by ERI@N and financially funded by the ClassNK firm (a Japanese classification society) and it paved way for establishing the world's first scaled marine renewable energy testing facility for tropical needs. In March 2015, the feasibility study for the test sites was officially launched and completed on December 2018. During this project, the resource mapping methodologies were well utilized to identify the ocean energy potential of the southern islands of Singapore that have been identified from the Maritime port Authority of Singapore (MPA). Presently, an environmental impact assessment (EIA) for the test sites has been carried out to understand the impact of ocean energy system deployment on marine life and environment. The EIA includes investigating the baseline conditions, possible effects of the test sites in the surroundings, and other associated research, such as underwater acoustics, water purity, sea level changes, tidal flow effects, etc. Geotechnical and geophysical surveys are also being planned. The outcome of this project is being extended towards Singapore's guidelines and standards development by working with Spring Singapore to support local supply chain's marine energy resource mapping guidelines of new regions, such as our neighboring region of Southeast Asia and other tropical islands and remote coastal regions. For example, institutions such as Jurong Town Corporation is planning to power the Jurong Island, which is a cornerstone of Singapore's energy and chemical industry, through onshore and offshore renewables which includes floating solar and tidal power systems. In parallel, ERI@N has been working with turbine makers like Mako to develop tidal turbines that are integrate with support columns and pylons to power jetties and remote coastal systems. Also ERI@N is focusing its research in the development of floating hybrid renewables that effectively combines both AC and DC energy sources such as tidal and wind energy with floating solar concept through the hybrid AC-DC micro-grid to enhance the energy harvesting capability at an ocean site. ERI@N has also setup spin-off Tropical Renewable Energy Engineering Pte. Ltd. (TREE) which focuses in developing tidal powered navigational buoys and wave energy roller systems that can be integrated to floating pontoons to power utilities in port systems so as to support the Industry 4.0 and enhance the marine navigational systems and marine asset health monitoring.

New marine operations are evolving such as seabed mining, dredging and other remote ocean-based operations requires energy without hampering the ocean ecology which requires clean energy systems. Hence device makers, grid operators, energy users and other players in the value chain take part in this REIDS demonstration along with multinational subsidiaries and Small and Medium Enterprises (SMEs) companies as well as decision-makers from all across the globe.

INTERVIEW WITH

CAMERON MCNATT & CHRIS RETZLER

FOUNDER AND MANAGING DIRECTOR AT MOCEAN ENERGY
&
FOUNDER AND TECHNICAL DIRECTOR AT MOCEAN ENERGY

In your perspective how do you see wave energy as a reliable power source for niche markets? What advantages it brings?

Mocean are currently developing a 10 kW WEC called Blue Star, which will provide power to subsea equipment in the O&G and offshore wind industries.

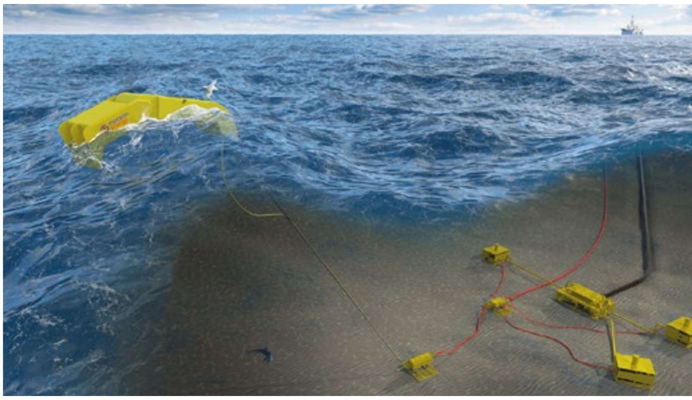
From a technical perspective, wave energy fills a gap between solar and offshore wind in that it is well suited for providing kilowatts of power – solar provides 100's of watts; floating wind is at the megawatt scale, and it would be very difficult to make a survivable small-scale floating wind turbine. There are numerous niche applications within oil & gas, ocean science, offshore aquaculture, where they need kilowatts of power that is currently provided by floating diesel generators or running long subsea umbilical cables.

For the commercial deployment of wave energy technologies, like for most renewable energies, the upfront costs and capital needs are high. What has been missing until now is sufficient investment to take those innovative technologies to the market. Do you think the use of wave energy systems can have a general acceptance by the oil and gas industry? Which obstacles can it face? In your opinion, what arguments can motivate Oil &Gas companies to support wave energy development?

We have really only engaged with the O&G industry for about a year, and within that time, there has been massive changes in the value it sees in low carbon technologies, some of which is due to COVID-19 and the oil-price crash, but much of it started before that. At this point, there is more than a willingness to engage, companies are eager to find solutions that reduce their carbon footprint.

There are two obstacles that wave energy faces. The primary one is low TRL level and less proven technology. The O&G industry is very risk adverse, and for good reason, they operate in an environment that is critical to health and safety and that is very expensive from an OPEX perspective. They want solutions that are proven, so the question is: how to prove it if you won't give it a try?

The second is they are now demanding large CO_2 reductions. Our current product, Blue Star, in some cases, does not have a large enough CO_2 impact. O&G majors are looking to make major changes to their CO_2 footprint and there is a need large-scale solutions.



What other markets you are considering other than oil and gas?

At Mocean, although we are starting small, large-scale wave energy has always been our vision. We see small products as a pathway to utility-scale wave energy. In parallel to Blue Star, we are developing a MW-scale WEC called Blue Horizon.

Ocean science is also a sector where wave energy can add a lot of value. Residential AUVs and high-power sensors like radar need kilowatts of power.

Looking further down the road, what do you envision for wave energy commercialization?

Wave energy is seeing its first commercial successes with small-scale products, where the costs and risks are reduced, and where wave energy can provide a unique value proposition. Deployments of these types of devices will support revenue generation, learning, and investment.

The next phase will be larger devices (100's of kilowatts to a megawatt), but still for non-utility-scale applications where wave energy can be cost competitive, such powering repurposed oil platforms for hydrogen production or in offshore aquaculture.

Then or perhaps in parallel, we'll see combined wind-wave farms, WECs interspersed amongst floating wind turbines. This offers cost savings for both technologies and helps to smooth power production for grid operators.

While wave energy has seen a bumpy road the past few years, at Mocean, we see the sector emerging on a very promising path that will ultimately lead to large WECs in large farms making a significant impact on climate change.

HIGHLIGHTS

There is an imperative need for energy innovation in the blue economy for the future success of various scientific, economic and security sectors.

Many ocean-based applications and markets are located far from the coast, facing important offshore challenges, such the need for clean power. From the experts interviewed here there is a consensus that ocean energy can meet these anticipated needs and unlock the growth potential of the blue economy. The integration of ocean energy for instance, with ocean observation systems will help improving understanding of our oceans and climate. In addition to deep offshore applications, many marine energy applications are ideal for coastal development, such as desalination, which is currently a highly energy-intensive process.

"it has been clear through our research and work with partners that there are myriad opportunities for thinking about energy and the blue economy, particularly as it relates to marine energy."

Alejandro Moreno

A number of organisations are currently progressing ocean energy research and the US Department of Energy has put a focus on quantifying the value of marine energy in the blue economy, accelerating technology readiness and working with private and public sector partners to commercialize developed technologies.

There is enormous pressure on each new emerging technology to enter the market quickly. The renewable sector is in an era of global competition and ocean energy can show its added value and be used for niche applications, where other resources are not available.

"Niche sectors are not pushing for big, but for quality. And that is what ocean energy has to deliver."

Matthijs Soede

The main obstacle that ocean energy systems faces is their emerging status and less proven technology compared with other renewables. Therefore, it is paramount for ocean energy technology to prove its reliability through niche applications in the coming years and. In doing so, it will be able to reduce its costs, in addition to entering other markets as well.

Ocean energy has made great strides in recent years, with projects now being built on a large scale and deployed under real sea conditions, an indicator of the shift of the sector towards industrialization. However, a supportive policy scenario is essential for future large-scale deployment.

The blue economy represents a niche of innovation possibilities for many regions around the world. Working with the diverse set of industries and sectors that embody the blue economy can help create opportunities to understand and gain new value from ocean energy to meet new energy demands. Initiatives like the **Blue Economy CRC** launched by the Australian Government or the **Offshore REIDS project** supported by Singapore governmental agencies are inspiring and promoting innovation and industry-research collaborations in cross-sectoral economic activities related to the oceans. To tackle the challenges lying ahead, Nations can play a major role with robust investments in research, innovation and education with long-term objectives.

"Mature renewables wouldn't be where they are today without large scale deployment underpinned by a supportive policy landscape – and it is no different for ocean energy."

Rémi Gruet

Enhanced collaboration with Blue Economy sectors will deliver numerous benefits and accelerate the growth of ocean renewable energy technologies on a global scale.

"At this point, there is more than a willingness to engage, companies are eager to find solutions that reduce their carbon footprint."

Cameron McNatt & Chris Retzler

ABOUT OES

The **Technology Collaboration Programme for Ocean Energy Systems (OES)** is an intergovernmental collaboration between countries, which operates under a framework established by the International Energy Agency in Paris.

OES FACILITATES

- Access to advanced R & D teams in the participating countries
- Developing a harmonized set of measures and testing protocols for the testing of prototypes
- Reducing national costs by collaborating internationally
- Creating valuable international contacts between government, industry and science

OES MEMBERS

ordered by sequence of joining

Portugal
Denmark
United Kingdom
Japan
Ireland
Canada
United States of America
Belgium
Germany
Mexico
Spain
Italy
New Zealand
Sweden
Republic of Korea
South Africa
China
Nigeria
Monaco
Singapore
The Netherlands
India
France
European Commission
Australia