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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Energy Research Institute
@ Nanyang Technological University, Singapore

OCEAN ENERGY IN INSULAR CONDITIONS

MARCH 8-9, 2017
NANYANG TECHNOLOGICAL UNIVERSITY (NTU), SINGAPORE

This workshop looks at the opportunities and barriers to local adoption of ocean renewable energy in islands and remote coastal areas of the Asian region from the perspectives of various stakeholders and the possible solutions to address the challenges. It also tackles the crucial roles of the different stakeholders (academia, policy-makers, industry and end-users) that each has to play to contribute to the uptake of ocean renewable energy in Southeast Asia.

This report summarizes the proceedings of the sessions as interpreted by the rapporteurs and editors. The views and opinions expressed in this report are solely from the authors and do not represent the authors' institution.

In collaboration with:

ENVIROTEK

OceanPixel

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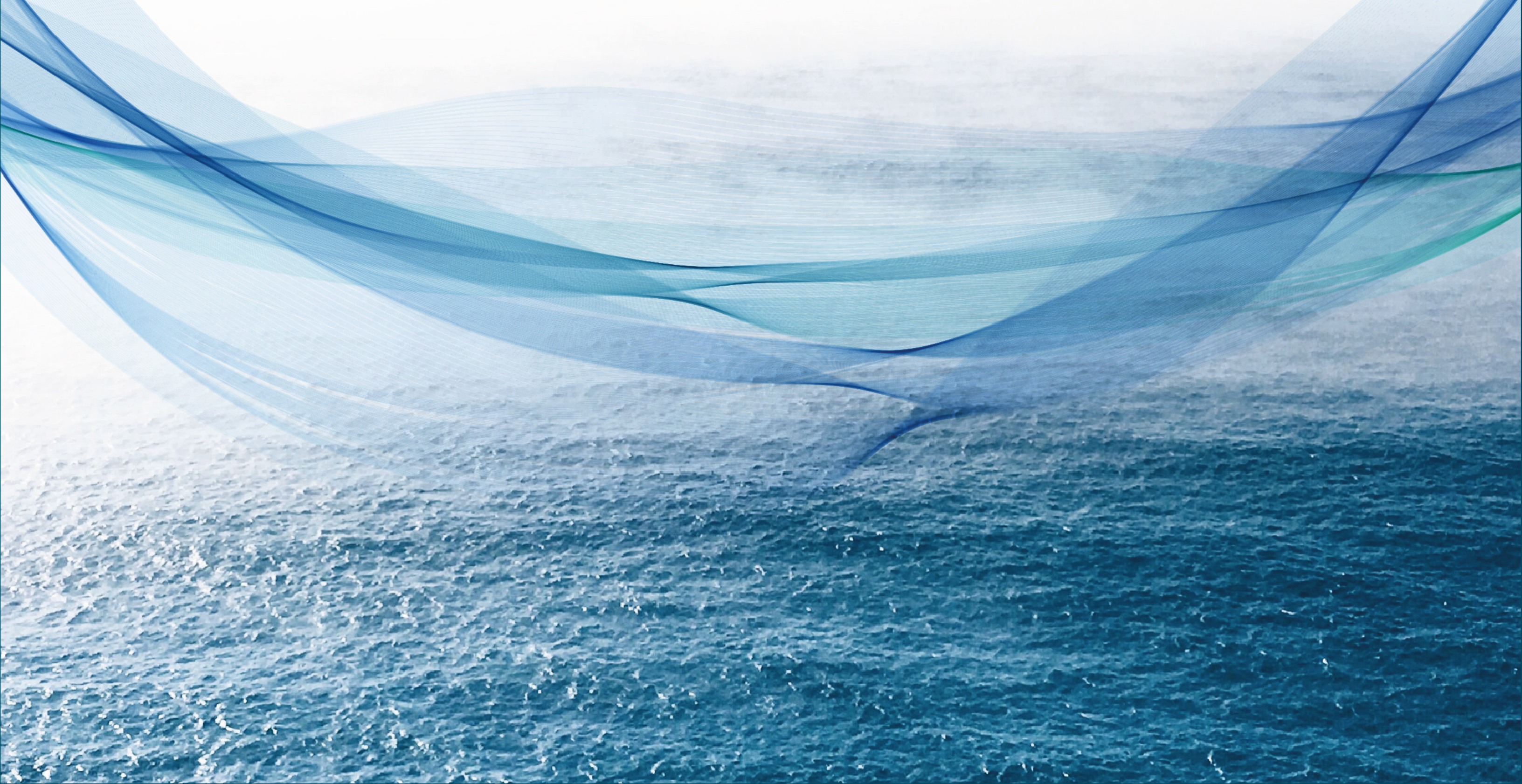
seacore southeast asian collaboration for ocean renewable energy



Event Details

8-9 March 2017
Nanyang Executive Centre, Lecture Room 2
Nanyang Technological University, Singapore

Organised by:
Wind and Marine Renewables Team, Energy Research Institute @ Nanyang Technological University (ERI@N)
International Energy Agency – Ocean Energy Systems (IEA-OES)

With industry partners:
OceanPixel Pte Ltd.
Envirotek Pte Ltd

And regional partners:
ASEAN Centre for Energy (ACE) and its official technical workgroup on offshore renewables, the Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE)

Editors:
Ms. Mary Ann Joy R. Quirapas (mquirapas@ntu.edu.sg)
Dr. Srikanth Narasimalu (nsrikanth@ntuedu.sg)

Recommended Citation:
Quirapas, M., & Srikanth, N. (2017). Ocean Energy in Insular Conditions - a Workshop Report prepared on behalf of the IEA Technology Collaboration Programme for Ocean Energy Systems (OES); www.ocean-energy-systems.org

Publication Date: **October 2017**

Content

Ocean Energy in Insular Conditions

This workshop looks at the opportunities and barriers to local adoption of ocean renewable energy in islands and remote coastal areas of the Asian region from the perspectives of various stakeholders and the possible solutions to address the challenges. It also tackles the crucial roles of the different stakeholders (academia, policy-makers, industry and end-users) that each has to play to contribute to the uptake of ocean renewable energy in Southeast Asia.

Executive Summary

The Energy Research Institute @ Nanyang Technological University (ERI@N) together with the International Energy Agency – Ocean Energy Systems (IEA-OES) in collaboration with Ocean Pixel Pte Ltd and Envirotek and ERI@N's regional partner, the ASEAN Centre for Energy through the Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE) organized a two-day workshop on "Ocean Energy in Islandic Conditions" last 8 - 9 March 2017 in Nanyang Executive Centre, Nanyang Technological University.

The two-day workshop facilitated the discussions of the various stakeholders of the ocean renewable energy field specifically those situated in islands or remote coastal areas of the region. The first day was divided into two sessions, Session 1: Global energy efforts in islandic conditions and Sessions 2 and 5: Fantasy Island Exercise by Aquatera. The panelists for the first session were Ms. Badariah Yosiyana,

Objectives of the workshop

Discussing the opportunities and challenges for ocean renewable energy as alternative source of energy in islandic conditions

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Addressing what has been achieved in the ocean renewable energy field, its development and technology that are applicable and beneficial to islandic conditions

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Discussing the barriers to adoption of ocean renewables in Southeast Asia especially in islands and remote, off-grid communities

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Addressing the contribution and/or challenges of each stakeholder (e.g. technology developer, academic institute, local technology adopter) in making use of ocean energy renewable as alternative source of energy in islands and how can each stakeholder work together to address these challenges

Project Manager for the ASEAN-German Energy Programme (AGEP), Dr. Srikanth Narasimalu, Program Director and Senior Scientist, Wind and Marine Renewables, ERI@N, Dr. Brian Kirke, Adjunct Senior Research Fellow, Sustainable Energy Centre, University of South Australia, Prof. Jiahn-Horng Chen, Professor and Deputy Director, Research Centre for Ocean Energy and Strategies, National Taiwan Ocean University, Dr. Songwei Sheng, Deputy Director of Ocean Energy Research Center, Guangzhou Institute of Energy Conversion, Mr. Bruce Cameron, Prinicipal Consultant, Envigour Policy Consulting, Dr. Mark Leybourne, Senior Engineer, ITP Energised UK, Mr Ravindran Pallaniapan, Program Manager, Global Research and Innovation Centre, ClassNK and Dr. Michael Abundo, Managing Director and Program Integration Manager, Rolls Royce Corporate Lab, Singapore. Mr. Duncan Clarke, Consultant of Aquatera led the session 2 and facilitated a group exercise that discussed the different roles of stakeholders (project developers, regulators, other sea users and local communities) in real-life scenarios if ocean energy technology is to be deployed in an island.

The second day featured the different experts from the Southeast Asian region on ocean renewable energy field and that were the current opportunities and barriers to adoption in each specific country. Session 3 was called "Ocean Energy in Southeast Asia, Opportunities and Challenges in Islandic/ Tropical Conditions." This session was supported by the Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE), the official technical working group of the ASEAN Centre for Energy (ACE) in offshore energy field. The speakers were Dr. Sathyajith Mathew, Deputy Director of the IBM Centre, Universiti Brunei Darussalam (UBD), Mr. Irfan Syarif Arief, Researcher and Lecturer, Institut Teknologi Sepuluh Nopember Surabaya (ITS), Professor Mukhtasor, Professor, ITS, Professor Omar Yaakob, Professor, Universiti Teknologi Malaysia (UTM), Mr Htun Naig Aung, CEO of Kaung Kyaw Say Group Companies, Dr Srikanth Narasimalu of ERI@N, Dr. Duangrudee Kositgittiwong, Lecturer, Department of Civil Engineering, King Mongkut University of Technology Thonburi (KMUTT), Ms. Ho Bich Ngoc, Researcher and Engineer in Vietnam Academy of Science and Technology and Dr. Nguyen The Mich, Professor, Hanoi University of Science and Technology.

Session 4 was one of the highlights of the workshop where the participants were divided into different groups to discuss the critical issues of ocean energy in islandic conditions. There were 5 facilitators and each one had set of questions pertaining to 5 major themes of the workshop. The themes were:

- Socio and political aspects of ocean energy in islands
- Technical aspects/ energy systems
- Supply chain/ logistics
- Resource Availability, Mapping & Environmental Impact Assessment
- Techno-economics aspects of ocean energy in islands

This session was expected to form discussions among the stakeholders about the opportunities and challenges per theme from their field of expertise or industry and how they could contribute to the possible solutions to the barriers.

The next session was composed of presentations from the technical and field level studies and experiences of ocean energy in islands. The following were the speakers: Mr. Jarrod Sinclair, Director of Strategic Partnerships, Mako Turbine, Professor Ir. Dr Andrew Ragai Anak Henry Rigit, Professor Universiti Malaysia Sarawak and Dr. José Joaquín Hernández-Brito, Science, Technology and Innovation Manager, PLOCAN. Session 6 was presented by Ms. Mary Ann Joy Quirapas, Lead SEACORE Secretariat, ERI@N as she wrapped up the two-day workshop by presenting the conclusions and key takeaways from the event.

Ocean renewable energy across the globe

There are increasing activities towards development and utilization of ocean energy technologies in different parts of the world. Countries like UK, Canada and Australia are looking forward to scale up the activities on ocean energy by looking into deployment of higher energy producing turbines into the water. China, Japan, and Taiwan are testing and putting more devices into the water and testing its viability as an alternative source of energy in their own respective islands. Sharing the experiences and challenges across the countries in terms of resource assessment, prototyping, deployment and commercialization were seen to be helpful especially since ocean renewable energy is in its nascent stage in Southeast Asian region, specifically in its islands and remote coastal areas. However, there is a need for readily available ocean energy technologies to be retro-fitted in the conditions that are unique in the tropical, remote and islandic conditions of most of the countries in Southeast Asia.

Opportunities and Challenges in Islandic Conditions of Southeast Asia

Although it is observed that ocean renewables is relatively new in comparison to other renewable energy sources in Southeast Asia, ocean energy activities in the region's water are gradually increasing since 5 to 10 years ago. Level of knowledge and expertise might vary from one country to another but the interest to find alternative source of energy is strong. This is because Southeast Asian countries is faced with the challenge of providing for increasing energy demand with the use of cleaner energy technologies. The recent climate changes talks in Paris pushes the governments to look at renewables as alternative source of energy. The presentations during the workshop undeniably showed the potential of ocean energy to be utilized using the present available resource and technologies in the region. However, speakers also agreed that for full regional or local ocean energy adoption, a spectrum of conditions and challenges should still be addressed. Commercially available devices from UK or other European countries need to be "tweaked" to cater to local islandic conditions of low flow and tropical water conditions. Modular devices or starting with smaller devices are seen as technical solutions for modest tidal and wave resource in the region. Effective resource assessment is a start to find the suitable device to be put in the water.

There is also the economic challenge of cost in terms of ocean energy competitiveness compared to the lower production costs of traditional sources of energy and even the renewable energy sources like solar energy or biofuels. From the end-users perspective, like electric cooperatives of islands and remote coastal areas, "as long as ocean energy can meet the energy demand of the islands" then consumers are willing to pay for the cost." Most of these islands are not usually connected to the national grid and usually dependent to diesel generators. If ocean energy is able to provide alternative sources of energy, complement existing source of livelihood and could be a potential sector for job creation for island dwellers, then acceptance of such new technologies is easier.

Like other renewables, existence of supportive policy framework and political environment to encourage more investments are crucial factors for ocean energy adoption. Establishment of a local supply chain where in stakeholders like policy decision-makers, industry players, end-users and academics play their own roles is seen to be most effective way to develop the ocean energy industry from lab to the field. Funding schemes for R&D and pilot testing, the presence of test-beds, feed-in-tariffs or simple awareness programs about ocean energy will make it a more viable option as alternative and cleaner source of energy. However, as much as most of energy the related policies in the region is state-centric, everyone including local community leaders and consumers are challenged to think more and more about ocean renewables. "It is now asking the government or industry, or anyone when ocean energy will become reality, but rather ask yourself when do you want it to be" as one industry speaker put it in response to when is ocean energy be readily available in Southeast Asia.

Role of Stakeholders and Potential Solutions to Overcome Barriers to Local Adoption

A strong collaboration among stakeholders and supply chain players is a key to strengthen the market of ocean renewable energy in the region. Each sector plays crucial role in shaping the future of niche industries like ocean renewables in Southeast Asia. In the survey done among the participants during the workshop, the top three players to push for ocean renewables are academe, industry and local government. Governments are "expected" to provide regulatory and political framework that are conducive to the development of ocean renewables, e.g. incentives for business to engage in ocean renewables, feed-in-tariff, tax subsidy, etc. They are also seen as one stream of support in terms of funding R&D activities which are crucial for proof of concepts and values of ideas and technologies in ocean renewable energy field specifically catered in water conditions of Southeast Asia. Specifically, there is a need for a more active role for local government units in driving ocean renewable activities which are community-based (e.g. making use of local resources and harnessing local expertise). As most of the islands in the region are off-grid or on the far-reach of the national government, the local government units arethe first line of support that communities can tap in terms of financial (through local funding) and political support (policy incentives for local supply chain; licensing and permitting, regulations, etc).

Ocean related industries, on the other hand, are seen to play role as technology provider, collaborative partner of academic institutes in ocean renewable R&D, source of equipment and expertise, and logistics and supply chain support. Academic institutes are seen to champion the fundamental research and work on the resource assessment, device matching and establishing the collaboration among itself, industry and government agencies to move forward from lab scale work towards, prototyping and eventually to creation of commercial devices in the water. At present, the academic institutes are not only the source of expertise in the region, but also take the role of facilitating the discussion among the technology developers and end-users for ocean renewable energy. Some of the examples are the establishment of the regional network called the Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE).

> "SEACORE is envisioned to be platform for the exchange of ideas, initiatives and experiences from R&D, policy makers and industry. It forms a collated and active core network of expertise and technical know-how in Southeast Asia (SEA) to set, assist, augment, or facilitate adoption of Ocean Renewable Energy (ORE) in the region; and also promotes diffusion of renewables' products and creates new markets for partner industrial firms. Presently cooperation is in the form of joint projects in resource mapping and assessments among the network." (https://blogs.ntu.edu.sg/seacore/about/)

In addition, the other important stakeholders in the development of ocean energy sector in the region are 1) the presence of national government support (through policy mechanisms, like feed-in-tariff, grants, public-private partnership mechanisms, etc.), 2) regional organization involvement in the development of ocean renewable energy in Southeast Asia, Example is the creation of regional standards on wave and tidal devices, environmental impact assessment solely catering the tropical and islandic conditions of the region. Regional entity like the ASEAN Centre for Energy (ACE) can greatly help in creating awareness among high-level officials of different governments to know the opportunities and challenges of deploying ocean renewables in the region. ACE can also be a bridge for regional funding opportunities where in different countries from Southeast Asia can collaborate to work on joint projects, e.g. resource assessment, device matching, pilot testing, etc. Lastly, end-users or energy consumers are crucial part of the successful utilization of ocean energy in the region. During the workshop, participants from electric cooperatives mention that as they are the ones dealing directly with utility providers on reasonable price especially for off-gird energy sources. They needed to be aware of how these new technologies like ocean renewable energy work and can benefit their communities. The local users play an important role especially in the acceptability aspect of ocean renewables; moreover the creation of a local and active supply chain for ocean renewable energy.

Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE) at the "IEA-OES Ocean Energy in Islandic Workshop" hosted by the Energy Research Institute @ NTU with industry partners OceanPixel Pte Ltd and Envirotek and in collaboration with ASEAN Centre for Energy (ACE) last March 8 – 9 2017.

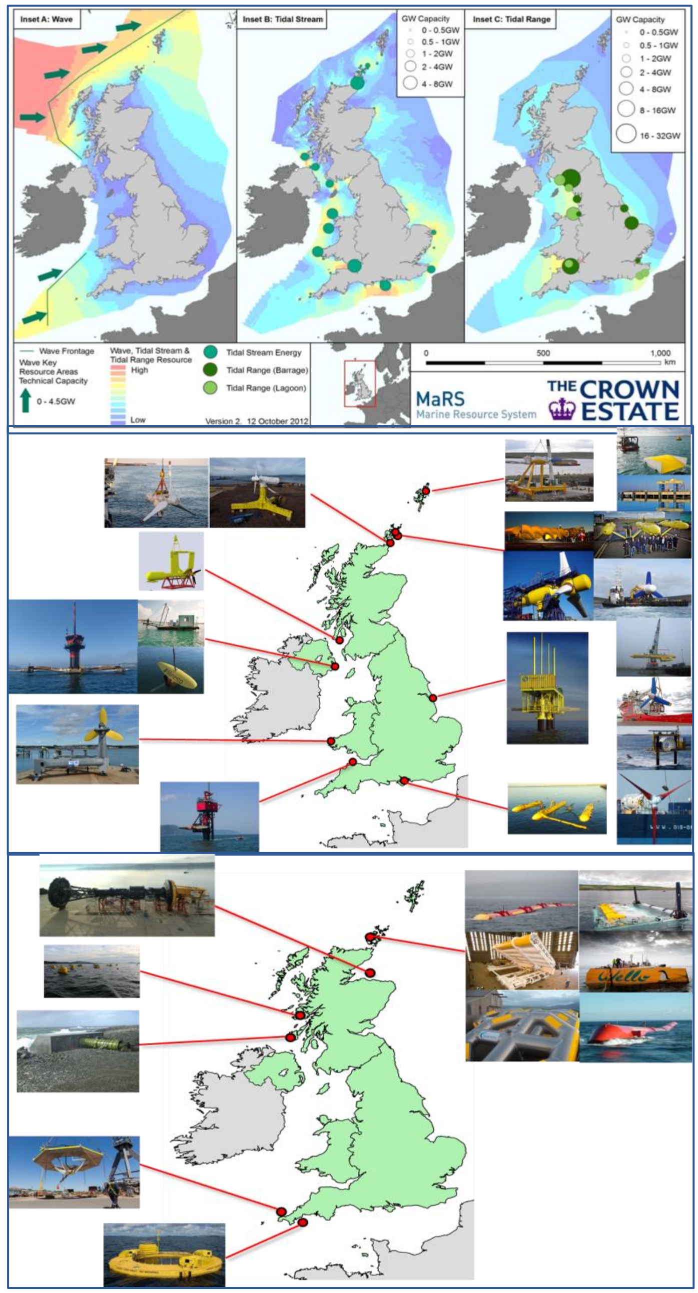
(L-R) Dr. Sathyajith Mathew of Universiti Brunei Darussalam; Mr. Santhanakrishnan Mahesh Ramanathan, ERI@N; Dr. Faizul Amri Bin Adnan, Universiti Kuala Lumpur; Dr. Duangrudee Kositgittiwong, King Mongkut University of Technology Thonburi; Ms, Marianne Eleanor Catanyag, OceanPixel Pte Ltd; Ms. Badariah Yosiyana, ASEAN Centre for Energy (ACE); Dr. Srikanth Narasimalu, ERI@N; Ms Bich Ngoc Ho, Institute of Energy Science, Vietnam; Prof. Omar Yaakob,Universiti Teknologi Malaysia; Dr. Mukhtasor, Institut Teknologi Sepuluh Nopember Surabaya (ITS); Engr. Isabelo Rabuya, University of San Carlos, Philippines and Ms. Mary Ann Joy Quirapas, ERI@N.

(not in this photo) Mr. Htun Naig Aung, Myanmar Industry Association and Dr. Michael Abundo, OceanPixel Pte Ltd

Ocean Energy Efforts in Insular Conditions

This session gave an overview of current state of affairs in the global arena of ocean renewable energy in terms of potential and available resource, technologies and current R&D and industry work. The speakers presented what have been achieved in the ocean renewable energy field, its development and technology that are applicable and beneficial to islandic conditions across the globe.

Although relatively niche compared to other types of renewable energy, ocean energy efforts are advanced in countries like UK, Canada, Japan, South Korea and Japan. UK is leading in terms of wave and tidal power generation (a number of devices deployed under water and contributing to island's power generation). The European Marine Energy Centre (EMEC) was established in 2003, the first and the only accredited wave and tidal test centre in the world which is suitable for testing a number of full scale devices in harsh water and weather conditions. The upper photo on the right shows the resources UK has in terms of ocean energy; middle and below photos show the tidal stream and wave deployments in the country. Recently, "Atlantis Resources Limited has deployed the AR1500 tidal energy turbine, a 1.5 MW turbine that is already exporting to the grid" (Caliendo, 2017).

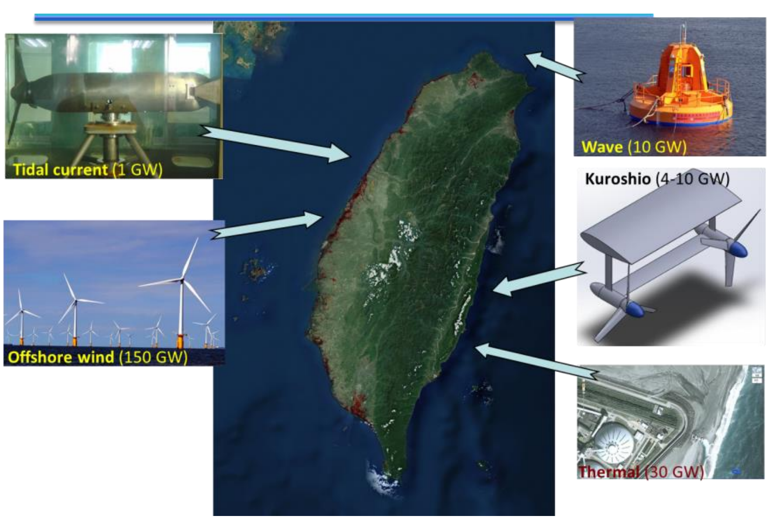


Ocean Energy Resources, Tidal Stream and Wave Deployments in UK (Leybourne, 2017)

In Canada, the Fundy Ocean Research Center for Energy (FORCE) established in 2009 was the first one to operate a tidal turbine demonstration facility and the second one to enable both public and private sectors to engage into such endeavor. At the moment, the country has installed capacity of 9kW and 20MW for wave power and tidal range respectively. Tidal current consented project is around 20.45 MW. The role of the stakeholders and the existence of right public policy measures are among the key aspects of ocean energy growth in Canada. Public policy "sets the table for actions by government, civil society and private sector" to push for ocean renewable energy in the country. It is important because of the following reasons: (Cameron, 2017)

1. It establishes the reason for growing ocean energy supplies.
2. It created the marketplace to make ocean energy economically viable.
3. It sets fair and agreed upon working conditions by all the stakeholders involved.
4. It makes sure that the development of the sector does not harm the environment.

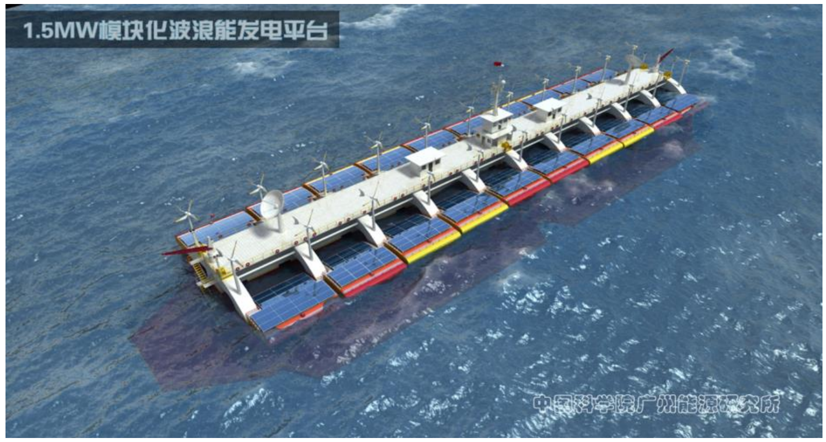
The main challenge in the development of ocean energy is the cost, however for vulnerable areas like islands and remote coastal areas, climate change and energy security also matters. Most of these islands remain to be off-grid and heavily rely on diesel generators as their main source of energy. A sound public policy can encourage an offset of the economic cost considering its contribution to a clean, reliable and stable energy source. In addition, ocean energy projects needs to have attractive benefits to potential investors. The policy process should include addressing potential risks on construction, deployment, operations which takes into consideration the environmental, social and political aspects.



Overview of ocean energy in Taiwan (Chen, 2017)

In the Asian region, the Northeast Asian countries like China, Japan, South Korea and Taiwan have increasingly looked at ocean renewables as possible alternative source of energy. Taiwan (Chen, 2017) has a potential for tidal current (1 GW), wave (10 GW), offshore wind (150 GW) and OTEC (30 GW). The government has set the Offshore Wind Power and Marine Energy Focus Center which mainly focuses on: 1) wave energy power generation system development and demonstration and 2) ocean current energy power system development and demonstration. Technically, floating type of turbines is seen to be the most viable device to harness power from Kuroshio waters (estimated average power is 5.5 GW and can go up to 10 GW). In terms of wave energy, during winter time there is around 10-20 kW per meter which is the average wave energy density in the region. In terms of ocean thermal energy, Taiwan's east coast which is close to the "hot spot" of Pacific Ocean, has annual average temperature difference of 22-24 °C. The water depth is about >1000 m and around 3- 6 km away from the shore. Among the challenges in Taiwan are the maturity of ocean energy technologies and the geographical vulnerability of the country which are the typhoons. However, renewable energy like ocean renewables is being pushed by the government as alternative to nuclear energy and fossil fuels. Private and public sectors are both working together to test devices in the water with a clear roadmap and goals by 2022.

In China (Sheng, 2017), the Guangzhou Institute of Energy Conversion is currently involved in the development of a new kind of wave energy converter called the Sharp Eagle (where the wave energy absorbing buoy resembles like and eagle's beak). It is a combination of wave energy converter and semi-submersible barge. The development started with a 10kW device which was launched last December 2012 and withdrawn May 2014. At present, there are a number of model and real sea tests for the 100kW Sharp Eagle. At its pick, it can produce >1000kWh and in the six months of its sea tests, it has produced above 30,000kWh in total. Future developments for this device include a large floating renewable energy platform with a combination of wave, solar and wind.



Further development for the 100kW Sharp Eagle, China (Sheng, 2017)

Learning from the experiences of the offshore and onshore wind, classification societies in Japan like ClassNK has been successfully in driving the marine energy sector both inside and outside the country to reach certain standards and certification. Among the services they offer are certification for large wind turbines (from type, component and prototype certifications) and for small wind turbines, they provide certification for feed-in-tariff (FIT) scheme. They do certification especially for marine renewable energy convertors (small and large) as well as certification services for marine renewable energy farms. ClassNK also does condition monitoring services for various equipment such as generators, gearboxes, etc. Their experience in condition monitoring is crucial in finding solutions for reducing the maintenance and repair especially for subsea components of marine renewable energy technologies. In addition, they also ensure that the supervision of marine operations is in order and with less risk for their clients and insurers through their marine warranty surveys. ClassNK is currently working closely with different Southeast Asian countries through collaborative R&D projects to create a synergy for knowledge and experience transfer among countries. (Pallaniapan, 2017)

Ocean Renewable Energy in Southeast Asia – Opportunities and Challenges in Insular and Tropical Conditions[1]

This session discussed the current status of ocean renewable energy in different parts of the region. The speakers are the regional and local experts of ocean energy in their respective countries. The presentations are able to pin point the opportunities and barriers to adoption of ocean renewables in Southeast Asia specifically in islands and remote, off-grid communities.

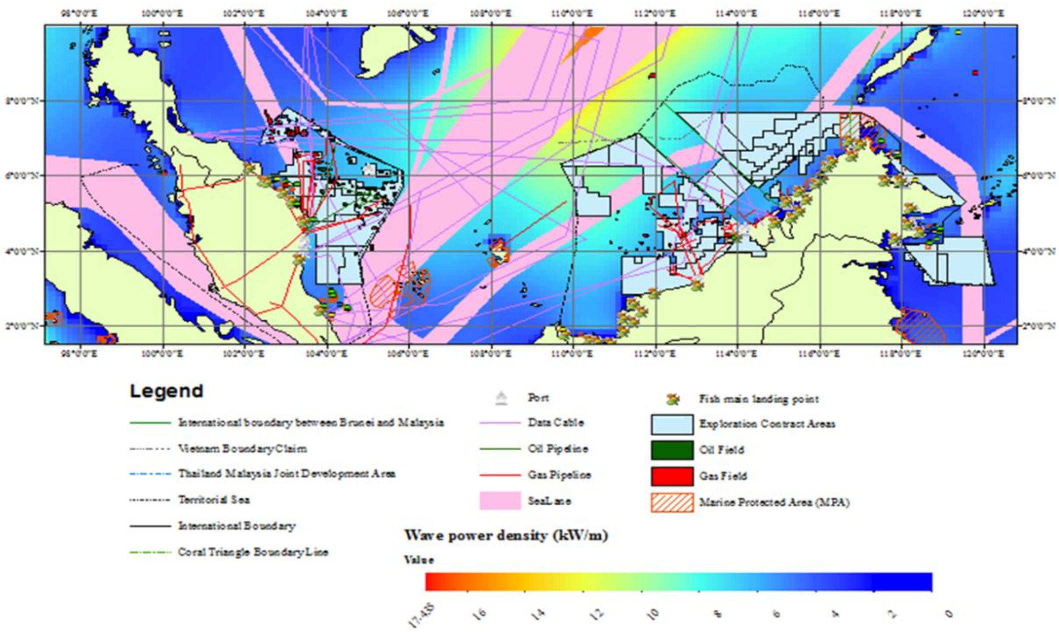
In Southeast Asia, one fifth of its population remains to be not connected to the grid and most of these islands and remote coastal areas are heavily dependent to diesel as their source of energy. The opportunity for alternative sources of energy is present, e.g. solar PV is being used as immediate source of energy after disaster. Hydro dams have been the biggest source of renewable energy in general for the region. Islandic nations like the Philippines, Indonesia and even those in mainland Southeast Asia started to look at ocean renewables as additional alternative source of energy. Wave and tidal are seen to be the most viable energy resource in the region's islands and remote coastal areas. Initial resource assessment is being done to examine the potential types of devices that are suitable for the local sea conditions.

For example, Indonesia is estimated to have a practical potential for wave as 2 MW, OTEC 18 MW and tidal 41 MW (Arief, 2017). There are also different marine renewable energy case studies in Indonesia. Some of the devices that were deployed are being tested currently e.g. Cobold di Lombok, T-Files from ITB, vertical axis turbine for tidal energy, tidal energy platform, and for waver are wave energy system pendulum and wave energy-system vertical pendulum. Aside from the development of the technological capacity, Indonesia local experts also focus on capacity building for

Wave energy system vertical pendulum (Arief, 2017)

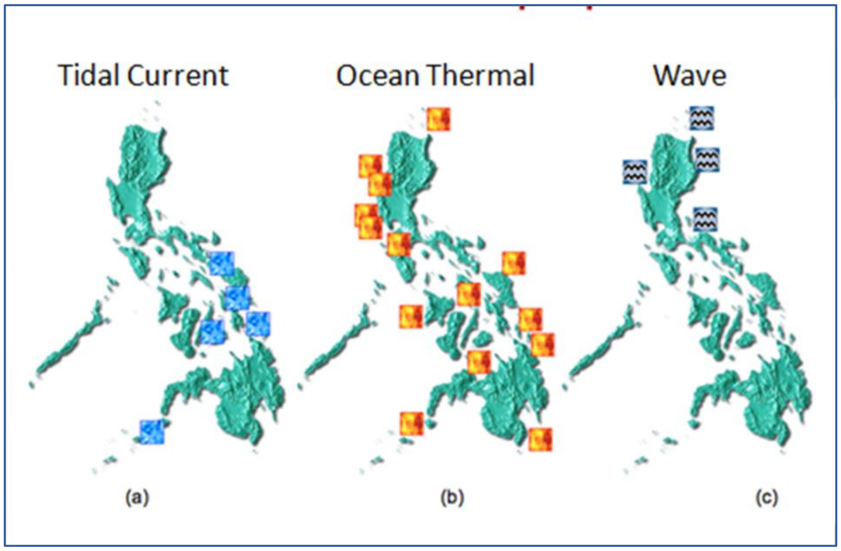
[1] This section can also be found in OceanPixel Pte Ltd. (2017). Marine Renewable Energy in Southeast Asia: A Status Report 2017. Singapore: OceanPixel Pte Ltd. For more and updated details about the status of marine renewable energy in Southeast Asia, please see http://www.oceanpixel.org/ (OceanPixel Pte Ltd, 2017) and SEACORE https://blogs.ntu.edu.sg/seacore/.

marine renewables in terms of workshop and training, which target multi-stakeholders, i.e. academe, business, government and the energy consumers. With such engagements, local experts aim to have pilot projects, perform endurance tests on these devices and eventually a supportive policy framework towards ocean renewables, e.g. feed-in-tariff. (Arief, 2017)



Practical Wave Energy Source in Malaysia (Yaakob, 2017)

Small island projects are seen to be more viable option for ocean renewable energy in Malaysia. Small islands, like in most of Southeast Asian countries, are dependent to diesel which is relatively expensive and there is also problem for transportation of diesel during monsoon season. Development of such technology should be "tailored towards local grids for remote areas and coastal communities" (Yaakob, 2017). As such, ocean renewable energy activities is mainly focused on resource assessment and development of laboratory and small scale prototypes of various marine energy devices. The Universiti Teknologi Malaysia (UTM) has been doing resource assessment through the use of marine tidal current devices (both vertical and horizontal) and ocean energy wave converters. The UTM Laboratory measures and tests lab-scale oscillating water column waver energy device, wave point absorber and savonius tidal ocean current turbine. In terms of demonstrations, there are plans of putting up a 1kW combined ocean renewable energy system demonstration platform in Pulau Tinggi. In addition, they are also looking at the ocean thermal energy conversion (OTEC) as a possible source of ocean energy in the Sabah peninsula. They are looking at the east side of Sabah and Sipadan Island (within the National Marine Research Park) as potential sites for OTEC technology development (Yaakob, 2017).



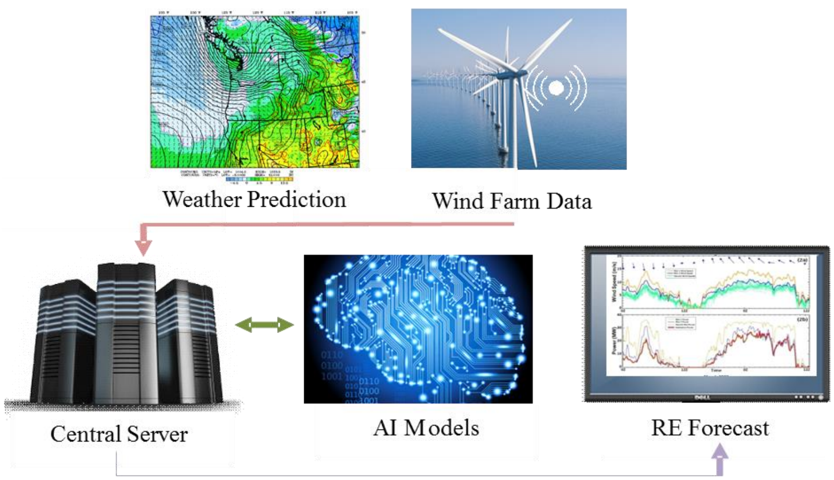
Identified Potential Sites in the Philippines (Rabuya, 2017)

The Philippines, on the other hand, started to work on ocean renewable energy in 1980 where the Mindanao State University has estimated 150 GW potential of ocean energy in the country. The Department of Energy has later on verified the resource to be 170 GW) and the department released official maps where different site for tidal-in-stream, wave energy and OTEC could be found in the Philippines (together with industry partners like Fugro OCEANOR). Different government bodies like the Department of Science and Technology together with the National Power Cooperation and academic institutes like the University of San Carlos have done marine current energy resource assessment (i.e. Kobold marine turbine demonstration for the latter). At present, the government supports ocean renewable initiative through funding of a tidal current energy integrated resource assessment and spatial planning tool. From 2014 – 2015, there was pre-front end engineering design (pre-feed) of ocean power plant y H&WB (a renewable energy developer) in San Bernardino Strait. (Rabuya, 2017)

Singapore has been pioneering the advancement in the field by making use of pilot testing in Singapore waters (retrofitting the commercially available device to suit local conditions) and creating a collaborative atmosphere for industry, academic institutes to work and discuss project development inside and even outside the country. The Energy Research Institute at Nanyang Technological University (ERI@N) Wind and Marine Renewables (Narasimalu, 2017) team has been doing work on ocean renewables from lab scale to field deployments through resource assessment and measurements (specifically on tidal energy), development of small scale to larger scale turbines which are adaptive to the tropical conditions of the region, environmental impact assessment (e.g. biofouling and coating, underwater acoustics) techno-economics and policy studies of marine energy viability in Southeast Asian conditions. Recently, from collaborative work of ERI@N and industry partners, a 50kW turbine has been deployed in Sentosa waters and another case study of tidal energy deployment in West Papua, Indonesia.

The Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE) (https://blogs.ntu.edu.sg/seacore/) is also initiated in ERI@N together with partners from

Brunei, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Vietnam. SEAcORE is currently the official technical working group for offshore and ocean renewable energy in the region under the ASEAN Centre for Energy (ACE) Renewable Energy Sub-sector Network (RE-SSN). Presently, cooperation is in the form of joint projects in resource mapping and assessments among the different member countries in Southeast Asia.



Short term offshore wind power forecast using artificial intelligence (Mathew, 2017)

Countries like Brunei, Myanmar, Thailand and Vietnam are developing technologies in marine renewable energy as well, from resource assessment, simulations, site selection or creating complimentary technologies where knowledge transfer to ocean renewables development can be possible. For example, Brunei aims to have at least 10 percent of total power from new and renewable energy sources by 2035. The Universiti Brunei Darussalam (UBD) with UBD IBM Centre has been conducting studies that make offshore wind a possible alternative energy resource (Mathew, 2017). The research areas that the team is looking at are optimal micro-siting of offshore wind farms, short term wind power forecast using physical weather models combined with artificial intelligence and development of small low wind speed turbines for offshore platforms.

Myanmar has also started looking at potential site for ocean energy in the country. One project is the Sittwe Reclamation Project on the river bank of Pyisakanadi River which local experts look at the wave energy resource availability and the other project is looking at potential resource assessment project in three islands along the coastal area of the country. There are also efforts to undergo ocean energy device development, a model of plug and play with 20kW output electricity. (Aung, 2017)

Plug and play model of ocean energy device in Myanmar ((Aung, 2017)

Potential site in Andaman Sea for wave energy (Kositgittiwong, 2017)

In Thailand, the Joint Graduate School of Energy and Environment (JGSEE) of the King Mongkut University of Technology Thonburi (KMUTT) has initiated work on ocean renewable energy in Thailand by implementing SWAN modeling in Gulf of Thailand and Andaman Sea. The team has evaluated the potential of natural ocean wave energy in both sites and recently has created a season wave energy map. The team is presently working with government agencies to seek further public funding to move further with the resource assessment of the potential sites and eventually move forward to device matching and development. (Kositgittiwong, 2017)

Vietnam having a coastline of 4,300 km is also looking at the potential of wave energy to be utilized in the country. Tidal energy potential is 200- 500 MW while wave energy is 350 MW in the country (Nguyen, 2017). There are already a number of projects that were conducted since 2000 from the ministry level to different government agencies working with academic institutes and industry collaborators. The Institute of Energy Science, Vietnam Academy of Science and Technology (IES VAST) has conducted some prototyping of overtopping devices which "capture water as waves break into a storage reservoir." This device is chosen because of the local expertise on hydro dam technologies which are common in the country (Ngoc, 2017). Recent projects conducted by the VAST are 1) lab scale of 30W energy generating model tested using the pressure of incoming wave to titled seawall and 2) 55W model that was studied and tested in the deep water seaport of Nghi Son Island, Thanh Hoa (Ngoc, 2017). The team has also created the wave power station economic analysis software (WPSEA) to "estimate main the economic parameters in an ocean energy project in Vietnam which includes electricity prices, investment, supporting mechanism, etc."

Year	Stakeholders	Project
2000-2001	Institute of Transport Science and Technology in collaboration with Department of Environment – Vietnam National University and Vietnam Maritime Administration	Study of wave energy for light buoys on the sea of Vietnam
2000	Vietnam Maritime Administration	Purchase of a TGW-3A-wave activated generator maded in Japan for the Nav. Buoy in Cua Lo port. So far, this device has been

		working well even in dangerous weather conditions.
2002-2003	Graduate University of Science and Technology Project	Estimation of ocean energy potential of Vietnam
2010	National Research Institute of Mechanical Engineering	Study and design of a buoy-type wave generator with a capacity of 10 kW
2012	Hanoi University of Science and Technology	National project: study and design of a HAWT with capacity in the range of 15-20kW
2013	Institute for Hydropower and Renewable Energy	Studied and manufactured a vertical axis current turbine with capacity of 5kW to extract tidal and current energy
2014	National Research Institute of Mechanical Engineering	Studied a buoy type wave generator, combined with a piston rotor driving a generator of 500W
2014	Hanoi University of Science and Technology	study and fabrication of a dual rotor HAWT with capacity of 3kW, employing a permanent magnetic generator, working at low wind speed

Ocean energy projects in Vietnam ((Nguyen, 2017)

Challenges in developing the ocean energy sector in Southeast Asia

A coordinated approach towards the development of ocean energy sector has yet to be developed among the stakeholders of ocean renewables in the region and even more in the country level. For example in Indonesia, the government, businesses and academe want to drive ocean energy but their approaches and end goals are different (Mukhtasor, 2017). Private sectors maybe driven more for profit, while government policies change depending on who is the leader. Academic institutes can work on lab scale prototypes but they would need to scale up to commercial level to test the viability of the device. This can be done if a collaborative environment is established with different stakeholders doing their own roles but in coordinated and cooperative manner.

There is also a need to enhance the expertise and knowledge of local stakeholders in terms of technical, economic and socio-political implications of the ocean energy sector in the region. As countries have already started doing the resource assessment, they need to have a proper methodology for device design and matching with the consideration of the specific conditions of the potential site. Commercially available devices could be tweaked that best suites the selected site. The aim might be to produce energy but environmental impact assessment needs to be done first before deploying the devices under water. The local community needs to be engaged as well as a crucial stakeholder in the ocean energy supply chain (more details in the next section). It was also raised during the presentations that developing human capabilities on ocean renewable in the region should start on earlier stages of research work through encouraging more master and PhD levels types of work.

In terms of economic, in order to scale up from laboratory or prototype scale, there is a need to look at funding support or policy schemes that can help encourage such. This has been among the common challenges of different Southeast Asian countries. Policies might exist in support of the development of ocean energy, but in some cases it changes depending on the political situation or the national agenda of the country from time to time. For example, Thailand has aimed to have a 2 MW ocean energy power by 2030 but the recent policy had removed it and categorise ocean energy under the general umbrella of renewable energy. The Philippines has target of developing an ocean energy facility, however the feed-in-tariff have yet to be developed to support initial production costs. Supportive *and* consistent policy tools or framework is needed to establish the sector. In addition, funding support can also come from the collaboration of different stakeholders. In Singapore, test sites are seen to be encouraging for industries to test their devices in conditions suitable in the region. These test sites are seen as positive result of collaborative effort among the government, industries, academic institutes and end-users.

As for socio-political aspects of ocean energy development, most of the islands and coastal areas still remain to be off-grid and do not have a stable source of energy. There is a need to look at the scalability of ocean energy technologies to address the basic need for energy, like electricity for livelihood (electricity for fishing, farming) or even lighting, cooking, studying and etc. Through addressing the basic needs of the communities, niche technologies like ocean energy can easily be acceptable and seen to beneficial by end-users. This affects how willing they can pay and “invest” in such technology. In addition, the marine space is catering to different conflicting users. Community consultations and effective marine spatial planning are seen to be very important efforts to be done for ocean energy deployment in the region to be successful.

Break-out Discussion: "Identification of barriers to adoption and solutions towards adoption of ocean energy in insular conditions"

During this session, the participants were divided into five groups and each group had answered questions pertaining to the key themes of the workshop which are: 1) Resource Availability, Mapping & Environmental Impact Assessment 2) Technical Aspects/ Energy System, 3) Supply Chain / Logistics, 4) Techno-economics aspects of ocean energy in islands, and 5) Socio and political aspects of ocean energy in islands. Each theme has its own facilitators to stir up the discussions among the groups. The general questions were:

1. *What is the current status of (category/theme) in terms of ocean energy in islandic conditions in the region?*
2. *What are the barriers/ challenges for adoption for ocean energy in terms of (category/themes) in the region?*
3. *Who are the stakeholders that you think are crucial in the (category) in terms of ocean energy adoption in islands?*
4. *What do you think are the solutions to challenges and barriers? And what can the different stakeholders do to address these barriers in terms of (category)?*

Resource Availability, Mapping & Environmental Impact Assessment

In terms of current status of ocean energy in terms of resource availability, mapping and environmental impact assessment, below are the main points from the discussions:

- Lack of alternative energy in many islands aside from fossil fuels, e.g. diesel.
- There is a lack of data availability in terms of resource.
- There is a lack of awareness towards ocean energy among the stakeholders, from the government to the end-users.
- To start the resource assessment phase, special approvals are required for by different permitting agencies. This should be taken into consideration by the project developers.
- Spatial management is crucial in getting the resource assessment done in the initial phase.
- Mandatory environmental assessment should be included in the resource assessment and mapping.

What are the current barriers/ challenges for adoption for ocean energy in terms of resource availability, mapping and environmental impact assessment in the region?

- More local data required in specific places which are prone to typhoons and monsoonal changes.
- Inadequate funding source to kick start the resource assessment for potential sites.
- There is a need to consider other sea users in terms of energy production from ocean renewable energy.
- There is a need to validate the gathered data from initial resource assessment and mapping.
- Engagement of local government for necessary permission and support for resource assessment, test and deployment.

- There is difficulty in getting local suppliers and establishing a local supply chain for ocean renewable energy suitable for the specific condition of the islands.

Who are the stakeholders that you think are crucial in the resource assessment/mapping and environmental impact assessment in terms of ocean energy adoption is islands?

- There is need to engage young researchers like university students especially for predevelopment study.
- Local government is a crucial stakeholder to be part of the projects even in earlier stages of resource assessment and mapping.

What do you think are the solutions to challenges and barriers? And what can the different stakeholders do to address these barriers in terms of resource assessment/mapping and environmental impact assessment?

- Implementation of a central system (resource data) which could be accessible to everyone.
- Feasibility study of ocean energy in a given potential site which includes environmental impact assessment, effect to local community, and other sea users.
- Encourage research and development on ocean renewable energy in the academe through education (e.g. graduate studies that focus more on ocean renewables).
- Creation and building on best practices to develop ocean renewables in islandic conditions.
- Creation of projects that easily achievable and take into consideration local conditions.
- Drive awareness in the local communities and island users who eventually will be the stewards of the ocean energy technology.

Technical Aspects/ Energy System of Ocean Renewable Energy

Current status

- There are already available technologies for ocean energy projects to be started (e.g. UK, France, Germany, Ireland, Netherlands, North America and Australia to name a few).
- Technology should be developed based on the resources available and local conditions.
- Unique energy system solutions should be administered for different conditions based on the geographical conditions.

Current challenges and barriers to adoption

- Lack of production capability by the local manufacturers and difficulties in finding a supplier.
- Marine pollution is an issue.
- Lack of technology in developing the ocean energy which specifically caters to the islandic and tropical conditions.
- Technology to be matched with the local islandic conditions.
- Readiness of the grid to integrate to the energy conditions.
- More development towards small scale projects especially in islandic conditions for easier installation and maintenance.
- Modularity of the energy systems that can be integrated together with other sources of energy.
- Geo politics is playing a crucial role for the technological development of ocean energy.
- Formulating of standards is complicated as the ocean energy industry is still in developing stage.

Crucial stakeholders

- Crucial stakeholders are government, academe and industry players. Until commercial projects are realized in islands or remote coastal areas, the roles of each will be more defined and lessons could be drawn for pilot testing, etc.

Possible solutions

- Design and implementation of technology should be according to the geographical and environmental conditions.
- Data gathering of requirements and resource assessment methodology are necessary in the development of ocean energy in the region.
- Successful feasibility studies and projects under water are key to attract government support and investments.
- System players should be defined for depending on the conditions specific to the islands or remote coastal areas.
- Integration of the government and private organizations is crucial to define how processes and procedures can be standardized in the region.
- A need to implement standards and regulations of oceanic energy systems more towards islandic conditions.
- Political agreement or joint development needs to be established to address geopolitical issues like territorial disputes on certain potential site for harnessing ocean energy.
- Training to be provided to the engineers and local community personnel.
- Data and knowledge transfer between developed countries and developing countries and also from one industry to another.

Supply Chain / Logistics

Current status

- There is lack of transportation and communication problems with the remote islands due to the lack of manpower.
- Technological innovation is done in some places to transport large component parts and also some batteries and invertors.
- Transporting some parts of wind turbines such as blades of turbines weighing more than 600 kg costs much for remote islands (portability).

Current challenges and barriers to adoption

- Transporting the components of the turbine is the biggest challenge faced by many countries for remote islands.
- Collaborator must be efficient on the source of investment.
- Less manpower and transportation resulted in the increase of the cost investment.

Crucial stakeholders

- Collaboration with the private sector make and will make the work more efficient.
- Big companies working with main islands support the large suppliers, instead they can support the local communities (suppliers) which will help them and provide more success.

- In some countries government also show some initiative in the wind and tidal turbines; in some countries government support is comparatively less.

Possible solutions

- Government industrial collaboration mechanism needs to be done to make the work faster. The paper clearance and financial support must be provided by the government to the private sector.
- Monopoly transportation can be adapted by the energy sectors to make their work cost effective.
- Strategic locations of the manufacturer and transporter must be selected by the energy sectors to make the work faster.
- Collaboration with the local communities (e.g. local supplier and manpower) will make a resourceful transportation and efficient work.
- Resourceful innovations must be done to reduce the weight of the components which will help to reduce the installation and transportation costs.
- Standardize the system by selecting the standard port and model a system by sharing the parts from nearby resource.
- In some countries the renewable sources are open to private and by which the government is directly involved in triggering and supporting the activity of the sectors.
- Local people must be educated on the installation, operation, repair and maintenance of the components and parts of turbines, for example in some countries local fisherman are used to visualize the ocean status using their local equipment.

Techno-economics aspects of ocean energy in islands

Current status

- In terms of techno economics of ocean energy, there is not enough cases where we can base our costs from. This includes information on the length of the ocean energy plant (e.g. tidal power plant, or OTEC power plant).
- Real costs can be gotten from deployment projects. More deployment means closer cost figures and estimates.
- Ocean energy technologies are less mature compared to other renewable energy especially in Southeast Asia region. More support from the industrial sector and government to develop it further.
- Funding and support from the government are needed especially in the macro-scale. Currently, there is existing financial support towards mini-scale deployment (20 kW).
- There are existing incentives to develop renewable energy in the region, like tax exemption, subsidy for machinery, non-financial benefits, etc. More specific incentives need to be developed towards ocean renewable energy.

Current challenges and barriers to adoption

- Cost is one of the main challenges in developing the ocean energy in the region.
- Lack of awareness about the benefits to both the local government and communities.
- Usually the policy decision makers need more information and proven results in order for them to support new projects and put funding to it.

Crucial stakeholders

- Both local and national governments
- Project and technology developers
- Support from the industrial sector
- Utility providers
- Existing energy suppliers
- Local tycoon and influential families who usually can put money or investments especially in countries like the Philippines

Possible solutions

- There should be confidence in technology so that government or industrial sector will invest.
- Awareness among local communities and government people about the benefits of the technology.
- There is a need for openness of the investors with regard to the price.
- External funding/ government subsidy to kick start the projects.
- Identifying the technology that fits in the conditions of the islands and the energy needs of the energy consumers, e.g. downscaling the technology to fit the low flow conditions of tropical waters and possibly for potential cost reduction.
- Work together with the utility provider and with the existing energy suppliers so that the project will get implemented.

Socio-political aspects of ocean energy development

Current status

- In Thailand, there is a lack of community awareness due to the lack of on-going projects.
- For Singapore, government has been supportive to innovative solutions like ocean energy.
- For Vietnam and Taiwan, local sea users like fishermen are still unaware of ocean renewable energy. The local communities still need to be aware of such technology.
- They are handful of different players are involved in the development of ocean renewables in the Philippines. However, there is still need to educate the government and the local community about this to ensure the continuity and sustainability of the projects.
- In Malaysia, government accepts hydropower so they are more amenable to support ocean renewable. They provide resources for further research and development.
- In Brunei, ocean renewables is politically accepted; however the main barrier lies with the commercial acceptance and viability.

Current challenges and barriers to adoption

- Lack of awareness and education of some sectors of the society about ocean renewable energy, e.g. policy makers, end-users like community people, indigenous people, environmental protection groups, and etc.
- Government instability is one challenge. Changing government disrupts continuity of previously decided projects.
- Most of fossil fuels plants are still highly subsidised by the government.

- In some countries, tedious bureaucratic procedures and even corruption is among the major challenges to get things done in the country.
- Government needs more convincing if ocean renewable energy technology actually works in order for them to support it and how it works as alternative to solar or wind which are cheaper at the moment compared to ocean renewables.

Crucial stakeholders

- Government both local and national
- Local community players like NGOs, electric cooperatives and associations
- Academic institutes

Possible solutions

- End-users feel that they are paying too much for electricity. If ocean energy can be an alternative source and makes electricity cheaper, then acceptability of the technology is high.
- Engagement of local community in the development of the technology so that they will be aware and feel the sense of ownership towards the technology.
- The socio-economic benefits to the local community of ocean energy should be highlighted especially for developing countries (e.g. job creation, long-term energy security from cheaper sources compared to fossil fuels).
- Education program about ocean renewable energy across sectors. This can be through academia (e.g. university curriculum, etc), NGOs and associations working closely with the communities and local governments, electric cooperatives who directly work with utility providers.
- Establishment of link among the crucial players of the sector, government, academe, technology developers and local community for knowledge and expertise sharing.

Fantasy Island Exercise – A real life case study of ocean renewables in islands[2]

These two sessions were group exercises for participants to discuss real-life case studies of ocean energy in islandic conditions. During the first session, they were divided into groups of regulators, developers, other sea users and local communities and they were given series of maps to issues affecting each group. Each group (playing their given role and given the map information) would need to discuss the possible areas where they can and cannot develop the technology. For the second session, the participants were mixed to form new groups (still playing their original role, i.e. each group having regulator, developer, local community and other sea user). The groups were asked the necessary challenges that the sites may encounter and how they can resolve them in order to deploy the ocean energy technologies. The facilitator for these sessions was Aquatera Ltd.

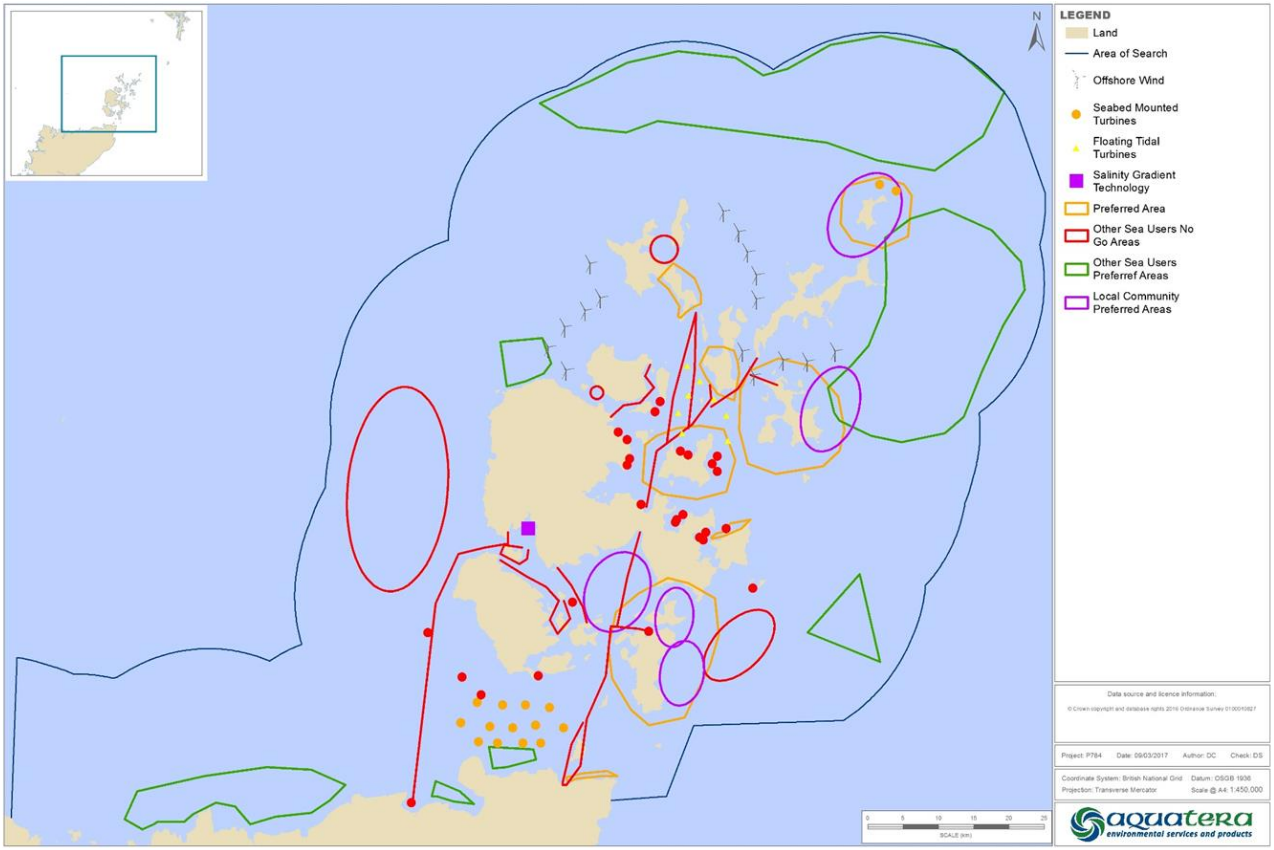
Summary of the first session:

Given the specific information given to each group, each has produced their own map with the following considerations:

<table>
<tr><th>Developers</th><th>Regulators</th><th>Other Sea Users</th><th>Local Community</th></tr>
<tr><td>Focused on resources available</td><td>Looked at environmental designations</td><td rowspan="3">Looked at the data relating to fishing, aquaculture and ferries</td><td rowspan="3">Looked at the same data as regulators and other users but looked specifically on what will have an impact to the community</td></tr>
<tr><td>Looked for suitable parameters for installation and survivability</td><td>Focused also on the impact of the technology to other sea users</td></tr>
<tr><td>Had no sight of data relating to impact on others</td><td>Decided they needed to see the resource so they could make a management plan</td></tr>
</table>

The first exercise showed that various groups given that they have their own interests to protect also look at the same map differently. For example, the regulators also thought about the other sea users before making the decision where to put the potential sites, while the developers focused mainly on which areas have the highest available resources. These could cause potential conflict of interests that needed to be addressed in order to come up with a compromised solution. Transparency of information and data and most importantly, working together were the key highlights of the exercise.

[2] A full separate report for this session has been provided by the session's facilitator, Aquatera.



This is the combined version from the different maps that each of the group had produced. In this map, one can see potential areas of cooperation and conflict when designating the crucial areas from the perspective of each group. (Clarke , 2017)

Summary of the second session:

The second session showed the dynamics among the different stakeholders with their own expertise and interests while coming up with the decisions on which technology could be deployed, where and what were the considerations to think about when deciding. One group decided to have tidal and wave energy near shore as it will entails less repair and maintenance costs; while another group decided to put an a hybrid offshore wind and wave energy to be deployed in the farthest island to avoid affecting other sea users and having impact on marine life. In terms of risks, typhoon, oil spill and ship collisions are seen to be the vulnerabilities that need to be addressed. Lack of information and data is a challenge that most of the groups had in terms of deliberating possible technological solutions. Given the time pressure, some groups resort to finding the easiest solutions to the problems.

The simulation had given each participant a glimpse on how decisions are made and the challenges that stakeholders face in terms of deploying renewable energy systems in islands. There is a need a thorough examination of the collected data (or lack of) and be able to come up with the solutions that different concerns of each sectors.

Conclusion and Takeaways from the Workshop

Increasingly, the viability of ocean renewable energy in Southeast Asia as an alternative source of energy specifically in islands and remote coastal areas is perceived to be positive from different sectors of the society. Prototype and small scale deployments have already started in countries like Malaysia, Indonesia, Singapore, and Philippines while Myanmar, Thailand and Vietnam have been looking at resource assessment and possible sites where they can test their devices. The availability of the potential resource is no longer a question but how to harness it is a challenge to address moving forward.

Among the challenges for adoption especially for islands is the presence of local supply chain, e.g. local suppliers of technology, potential end-users, support of affirmative policies towards ocean renewable development, investors or industries willing to fund, etc. With local supply chain and collaboration in place, the cost can be expected to be lesser compared when putting commercial devices or using external expertise to deploy will be used. It is also believed that the presence of local players and stakeholders on ocean energy sector alone reflects that there is a supportive political framework in place to support the collaboration and cooperation among different stakeholders to exist.

In addition, there is a need to drive more awareness and education especially to policy makers and the end-users of what are the benefits and challenges of deploying ocean renewable energy. More than the technological expertise, engagement to these groups is crucial in order for such new technology to accept it as viable alternative energy source. They should be involved in planning and implementation of any projects so that non-technical barriers could be overcome even on the onset of project development. There is also a push for technical expertise to be honed earlier through presence of graduate and post graduate degrees on ocean engineering, marine renewable studies, etc.

The economic challenge remains to be one of the major things that need to be addressed for ocean energy sector to be developed in the region - the funding for the high initial for deployment, installation and maintenance and repair; how to convince potential investors and the government to support funding for R&D and demonstration and how competitive is ocean renewables compared to other renewable energy like solar and wind are some of the questions to be addressed.

There is also the question of how consistent present policies are in terms of ocean renewables. For some countries, they have created a certain target for tidal and wave but eventually removed or changed it when leadership changed. The stability of governance highly affects the consistency of policies. In this regard, the presence of policies supporting ocean renewable can be necessary to kick start few projects but they should be consistent in order to encourage more devices in the water. In addition, policies towards ocean renewables should also emphasize the need not only for stable energy source but also the economic benefits that the sector can create, e.g. job creation, expertise development, etc.

In terms of technical solutions, there is consensus among the experts in the region that the suitable ocean energy device in the islands and remote coastal areas is small-scale and modular. The needs of the islands differs from one country to another however, in general island energy users would need just enough energy to support and enable their livelihood like fishing, farming, wood working, etc. Most of these islands are also situated in highly disaster vulnerable areas and as such, technology developers should consider the rigidity and resilience of these ocean energy systems. Collation of best practices from the individual ocean energy projects is highly encouraged in order to start the formation of standards of how one can develop ocean energy projects specifically catered to the local conditions of the region.

Overall, there is a higher push from different stakeholders to look into ocean renewable energy as an alternative source of energy especially in islands. This positive outlook should be accompanied with concrete steps and actions items to work together to put more working ocean energy devices under water.

Order of the Events

Program for Day 1 (8th March 2017)

TIME	Agenda	Speaker	Organisation
8:00 – 8:30	Registration		
8:30 – 8:50	Welcoming Remarks	Dr. Srikanth Narasimalu	Energy Research Institute @ NTU (ERI@N)
8:50 – 10:10	**Session 1 – Global Ocean Energy Efforts in Islandic Conditions**		
	Regional Landscape of Marine Energy Policies in the Southeast Asia	Ms. Badariah Yosiyana	ASEAN Centre for Energy
	"Blue Economy:" Ocean Energy Technologies for Islands	Dr. Srikanth Narasimalu	Energy Research Institute @ NTU (ERI@N)
	OTEC Potential for Southeast Asia	Dr. Brian Kirke	University of South Australia
	Taiwan's Experiences on Ocean Energy as an Islandic Nation	Prof . Jiahn-Horng Chen	National Taiwan Ocean University
10:10 – 10:25	Q&A Panel Discussion (15 min)		
10:25 – 10:40	Tea Break (15 min)		
10:40- 12:20	Open Sea Tests of 100kW Wave Energy Convertor Sharp Eagle Wanshan	Dr. Songwei Sheng	Ocean Energy Research Center, Guangzhou Institute of Energy Conversion
	Socio-economic conditions necessary for small islandic projects	Mr. Bruce Cameron	Envigour Consulting
	UK Efforts on Ocean Renewables	Dr. Mark Leybourne	ITPEnergised
	Services and Project Collaboration for Ocean Energy Technologies	Mr. Ravindran Pallaniapan	ClassNK
	Techno Economics of Ocean Energy for Islands in Southeast Asia	Dr. Michael Abundo	OceanPixel Pte Ltd
12:20 – 12:35	Q&A Panel Discussion (15 min)		
12:35 - 1:35	Lunch (60 min)		
1:35 – 3:35	**Session 2 – Fantasy Island Exercise (Mr. Duncan Clarke, Aquatera)**		
3:35 – 3:45	Tea Break (10 min)		
3:45- onwards	Site Tour – Sentosa Tidal Deployment		

Program for Day 2 (9th March 2017)

TIME	Speaker	Organisation
8:00 – 11:30	**Session 3 – Ocean Renewable Energy in Southeast Asia – Opportunities and Challenges in Islandic / Tropical Conditions**	
8:15 – 9:30	Dr. Sathyajith Mathew	Universiti of Brunei Darussalam
	Mr. Irfan Syarif Aried	Institut Teknologi Sepuluh Nopember
	Dr. Mukhtasor	Indonesian Ocean Energy Association
	Dr. Omar Yaakob	Universiti Teknologi Malaysia
	Mr. Htun Naig Aung	Myanmar Industry Association
9:30 – 9:45	Q&A (15 min)	
9:45 - 10:00	Tea Break (15 min)	
10:00 – 11:15	Dr. Srikanth Narasimalu*	Energy Research Institute @ NTU
	Engr. Isabelo Rabuya	University of San Carlos
	Dr. Duangrudee Kositgittiwong	King Mongkut University of Technology Thonburi
	Ms. Ho Bich Ngoc	Institute of Energy Science, Vietnam Academy of Science and Technology
	Dr. Nguyen The Mich	Hanoi University of Science and Technology
11:15 – 11:30	Q&A (15 min)	
11:30 – 1:00	**Session 4 - Break-out Discussion "Identification of barriers to adoption and solutions towards adoption of ocean energy in islandic conditions"**	
1:00 – 2:00	Lunch (60 min)	
2:00 – 2:15	Enhancing Island Micro-grids with Tidal Energy Mr. Jarrod Sinclair	
2:15 – 2:30	Tidal energy mapping for Sabah and Sarawak Prof. Andrew Ragai Henry Rigit	
2:30 – 2:45	Ocean Energy Deployment Experiences of Plocan* Dr. José Joaquín Hernández-Brito	
2:45 – 4:45	**Session 5 – Fantasy Island Exercise (by Mr Duncan Clarke, Aquatera)**	
4:45 – 5:00	**Session 6- Conclusion and Takeaways from the Workshop(Ms. Mary Ann Quirapas, ERI@N)**	
5:00 – 5:05	Closing Remarks	

About the Speakers

Speaker	Position	Short Bio
Ms. Badariah Yosiyana	Project Manager for the ASEAN-German Energy Programme (AGEP)	Ms. Yosiyana joined ASEAN Centre for Energy (ACE) in 2014 and currently acts as the Project Manager for the ASEAN-German Energy Programme (AGEP), a joint cooperation programme with GIZ with the objective to improve regional cooperation in RE and EE&C field in ASEAN region. Prior to her current position, she was the Acting Manager for the Renewable Energy Support Programme for ASEAN. Her recent work includes study on Levelized Cost of Electricity for RE technologies (LCOE) in ASEAN; ASEAN RE Policies Publication; and RE Outlook with collaboration with IRENA.
Dr. Srikanth Narasimalu	Program Director and Senior Scientist, Wind and Marine Renewables, ERI@N	Dr. Srikanth Narasimalu is the program director and senior scientist in ERI@N leading the wind and marine energy activities. Earlier he was with Vestas Wind systems as a senior specialist in the Technology department, leading some of the key research activities related to aeromechanics and condition monitoring specialization of wind turbines. His areas of technical research interests are wind & tidal resource mapping marine & wind and turbine development, structural health monitoring and innovation management studies and has more than 100 journal publications and 30 patents.
Dr. Brian Kirke	Adjunct Senior Research Fellow, Sustainable Energy Centre, University of South Australia	Brian Kirke holds honours and masters degrees in civil engineering from the University of Adelaide, South Australia, and a PhD on wind turbine design from Griffith University, Queensland, Australia. He has taught structural and hydraulic engineering from 1991-2003, and has focused on renewable energy projects since taking up an appointment at the University of South Australia..
Prof Jiahn-Horng Chen	Professor in the Department of Systems Engineering and Naval Architecture and the Deputy Director in the Research Center for Ocean Energy and Strategies	Prof. Jiahn-Horng Chen had received his Ph.D. in 1990 from the Dept. of Aerospace Engineering, The Penn State University, U.S.A. He joined the faculty of National Taiwan Ocean University after graduation, and is currently a Professor in the Department of Systems Engineering and Naval Architecture and the Deputy Director in the Research Center for Ocean Energy and Strategies

		which was found by him. He also proposed to National Science Council in Taiwan the first ocean energy test site in Asia in 2009. His research interests are Computational Mechanics, Ship Hydrodynamics, and Offshore Renewable Energy.
Dr. Songwei Sheng	Deputy director of Ocean Energy Research Center, Guangzhou Institute of Energy Conversion	Songwei Sheng is the deputy director of Ocean Energy Research Center, Guangzhou Institute of Energy Conversion, CAS. He majored in Mechanical and Electronic Engineering (B.S.), Thermal Engineering (M.S. and Ph.D.). He engaged in ocean wave energy conversion research since 2002, hosted and participated in a number of ocean energy development project of national level scientific research. His main research interests are on ocean wave energy conversion. He built a 10kw and 100kw wave energy converter, now the 100kW WEC is working in the China sea.
Mr. Bruce Cameron	Principal Consultant, Envigour Policy Consulting	BRUCE CAMERON is Principal Consultant for Envigour Policy Consulting Inc. He is the former Executive Director Sustainable and Renewable Energy with the Nova Scotia Department of Energy in Canada. During the 15 years he was with the Department, he led the Province's work to transform the electricity sector including Nova Scotia's 2009 Energy Strategy, the 2010 Renewable Energy Plan, among many. He also played a lead role in establishing and evolving Efficiency Nova Scotia as an independent utility for saving energy. Mr. Cameron did his undergraduate work in the social sciences at Carleton University in Ottawa and received a Master of Business Administration degree from Dalhousie University in Halifax.
Dr. Mark Leybourne	ITPEnergised	Dr. Mark Leybourne is a senior engineer in ITPEnergised's offshore renewable energy group, based in Bristol, UK. He studied at the University of Southampton, completing an undergraduate degree in Aerospace Engineering and an Engineering Doctorate in the modelling and testing of a wave energy converter. Mark works on a range of offshore wind, wave and tidal energy projects, providing technical, policy and strategic advice to both public and private clients. After joining the consultancy 9 years ago, he now leads much of the company's offshore renewable energy work in Asian countries such as

		China, India, Taiwan, Singapore, Philippines and Korea.
Mr. Ravindran Pallaniapan	Program Manager, Global Research and Innovation Centre, ClassNK	Ravindran has over 10 years' experience in the cleantech and maritime industries. His passion for innovation, research and development for the maritime industry and renewable energy has helped bridge a variety of R&D projects from infancy stage to commercialization stage. He is now the program manager at ClassNK Global Research & Innovation Centre, managing projects related to maritime technologies and marine renewable energy with industry partners in Singapore and globally. He is also the project lead for initiating Tropical Marine Floating Laboratory in Singapore and a member of the International Executive Committee for Ocean Energy Conference 2018.
Dr. Michael Lochinvar Abundo	Managing Director, Ocean Pixel Pte Ltd and Program Integration Manager, Rolls Royce Corporate Lab, Singapore	Mike is a green technopreneur and is the founder of OceanPixel, a company that specializes in the ocean/marine renewable energy (ORE) sector. Mike hopes to contribute to the development of the ORE sector from R&D, networking, and commercialization. He is concurrently a Program Integration Manager in RollsRoyce Coporate Lab-NTU. Previously, he is Research Fellow for the Wind and Marine Renewables Group in the Energy Research Institute @ Nanyang Technological University (ERI@N).
Mr. Duncan Clarke	Consultant, Aquatera	Duncan joined Aquatera in 2003. Over the 12 years Duncan has been with Aquatera his developmental work has focused on the development of tools and techniques to aid the selection of suitable sites. To date Duncan's work has led to the construction and operation of numerous wind farms, fish farms and substations, with successful test deployments of wave and tidal devices and several successful lease applications for marine energy developments.
DAY 2		
Dr. Sathyajith Mathew	Deputy Director of the UBD, IBM Centre, University of Brunei Darussalam	Dr. Sathyajith Mathew is a Researcher focusing on the areas of Renewable Energy Technologies and Data Analytics. After graduating from the Indian Institute of Technology, Kharagpur, India, he has lead several research and community projects in these areas. He has authored 2 books on Wind Energy, which are published by Springer and translated to Chinese by The China Machine Press.

		These books are used as textbooks for Energy programmes in several Universities around the world. Currently, he is an Associate Professor at the Faculty of Science and serves as the Deputy Director of the UBD|IBM Centre, University of Brunei Darussalam.
Mr. Irfan Syarif Arief	Department of Marine Engineering, Institut Teknologi Sepuluh Nopember Surabaya (ITS)	Irfan is researcher and lecturer in Institut Teknologi Sepuluh Nopember (ITS) Surabaya since 1997. His experience is mechanichal, computation fluid dynamics (CFD), marine design and convertion energy. He had created collaboration research between ITS, ESDM (Ministry of Energy and Mineral Resource of Republic Indonesia) and PLN to research about ocean energy since 2009.
Dr. Mukhtasor	Professor, Ocean Engineering Department, Institut Teknologi Sepuluh Nopember	He has previously held various crucial positions in academe, industry, government and non-government organization. He has more than 80 publications which are mostly focused on the field of offshore and marine renewable energy.
Dr. Omar Yaakob	Professor, Universiti Teknologi Malaysia	Professor Omar is currently a Professor in the University Teknologi Malaysia. He has produced more than 130 journal articles and presentations at conferences. The Royal Institution of Naval Architects appointed him as a Fellow in 2010 and the UK Engineering Council accorded him a Chartered Engineer status in the same year. In addition, he was also appointed as an Associate of the Academy of Sciences Malaysia. He has represented Malaysia in many meetings at the International Maritime Organisation dealing with energy efficiency and environment. He is one of the founding member of South East Asia Collaboration on Ocean Renewable Energy (SEAcORE), a member of IOC-Westpac Working Group on Marine Renewable Energy as well as a permanent member of the Organising Committee of Asian Wave and Tidal Energy Conference series (AWTEC).
Mr Htun Naig Aung	Chairman / CEO, Kaung Kyaw Say Group of Companies	Mr Htun is not only the designer and manufacturer of Biomass Gasifier and Bio Fuel Processor, but also the activist in the research and development of renewable energy such as mini hydro power project, the Bio fuel project and Energy Efficiency and Conservation. He is energy auditor certified by ASEAN Center for Energy (ACE)and Energy Conservation Center,Japan(ECCJ).He had served as "National Expert" to UNIDO Representative Office

		in Bangkok and Local Capacity Builder to FAO – ROBKK.
Engr. Isabelo Rabuya	Chair, Department of Electrical and Electronics Engineering, University of San Carlos	Concurrently, he is also an Assistant Professor of the Department. He oversees both the undergraduate and graduate program of Electrical Engineering, Electronics and Communications Engineering. He has Co-Directed different research projects funded both locally and overseas. His research areas include renewable energy, energy efficiency, internet of things, smart grid among others.
Dr. Duangrudee Kositgittiwong	Lecturer, Department of Civil Engineering, King Mongkut University of Technology Thonburi	Duangrudee Kositgittiwong is a lecturer in the Department of Civil Engineering, King Mongkut's University of Technology Thonburi. She joins SEACORE team since 2013. Her team in Thailand is currently working with the topic about the wave energy efficiency and power generator in the Gulf of Thailand and Andaman Sea.
Ms. Ho Bich Ngoc	Researcher and Engineer in Vietnam Academy of Science and Technology	She started working at Vietnam Academy of Science and Technology as an engineer consultant in new and renewable energy. She is also a visiting researcher in University of Science and Technology of Hanoi, Clean Energy Laboratory. Being interested in reducing the over-use of fossil fuel, she has participated into multi-disciplinary research in order to find out the suitable method to generate green power in Vietnam, as well as in anywhere on the globe.
Dr. Nguyen The Mich	Professor, Hanoi University of Science and Technology	Dr Nguyen teaches renewable energy alongside the topics of turbo machines, dynamics of high speed flows and cavitations, helicopters, mechanics of flying objects. He is also the Principal investigator of two major projects concerning wind and current turbines, and key investigator in some ocean energy projects
Mr. Jarrod Sinclair	Director of Strategic Partnerships, Mako Turbine	After graduating in Aerospace Engineering at RMIT University, Jarrod spent 12 years at General Motors automotive research and development in Australia, focusing on fuel efficiency using Computational Fluid Dynamics and High Performance Computing facilities. At MAKO, he was instrumental in developing the unique hydrodynamic shape of the turbine hub and blades. He has established working relationships with research institutions and the energy industry to further develop the MAKO Turbine into a commercial product.

		He currently focuses on working with end-users to form a viable tidal energy solution.
Professor Ir. Dr Andrew Ragai Anak Henry Rigit	Professor, Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak	Dr. Andrew has held various positions in UNIMAS and has a number of students in the course of his teaching in the university. Previously, he has held directorship in UNIMAS Technologies Sdn Bhd. His field of specialization is mechanical engineering and fluid dynamics
Dr. José Joaquín Hernández-Brito	PLOCAN (Consorcio para la Construcción, Equipamiento y Explotación de la Plataforma Oceánica de Canarias)	Science, Technology and Innovation Manager, PLOCAN
Ms. Mary Ann Joy Robles Quirapas	Energy Research Institute @ NTU (ERI@N)	Mary Ann Joy Robles Quirapas is currently the coordinator of the Joint PhD-Industry Program (JIP) of the Wind and Marine Renewables Team and the regional network on offshore renewable energy (SEACORE). She has done her MSc in Asian Studies from Rajaratnam School of International Studies (RSIS), NTU and graduated cumlaude for her Bachelor's degree in University of the Philippines-Diliman. As the coordinator of JIP, she handles and organises technical workshops and annual conferences for JIP students and regional offshore renewable partners respectively, e.g. JIP Quarterly Technical Workshops, ACES 2015 and AWTEC 2016. As for SEACORE, she works closely with the ASEAN Centre for Energy Renewable Energy Subsector Network (RE-SSN) on joint annual reports, technical write-ups and events. Her research focus is on Southeast Asia regional energy security and policy studies on offshore related renewable energy.

About the Organisers

Established in June 2010, the Energy Research Institute at NTU (ERI@N) envisions to be a leading research institute for innovative energy solutions. The Institute distinguishes itself through excellence in basic research directed towards outcomes of high industry relevance, with focus on systems-level research for tropical megacities. The Institute integrates research across NTU as a whole in the context of the energy challenge, and then helps translate outcomes into industry and practice. ERI@N's mission manifests itself into a comprehensive effort on Energy Generation, Conversion and Storage Systems, Grid Systems, and Urban Solutions, in a "Living Lab" environment with a particular focus on solutions for Megacities and for the Tropical Environment. ERI@N has been handling workshops and conferences (e.g. Offshore Renewable Energy Conference 2012, Asia Future Energy Forum 2013, Asia Clean Energy Summit 2014) over the past few years.

ERI@N has led SEACORE (South East Asia Collaboration for Ocean Renewable Energy) activities and its efforts act as evidences to support renewable energy adoption in the region. ERI@N's two flagship projects, EcoCampus and Renewable Energy Integration Demonstrator Singapore (REIDS) are providing significant outcomes in energy efficiency and renewable energy. http://erian.ntu.edu.sg/Pages/Home.aspx

The Ocean Energy Systems Technology Collaboration Programme (OES) was launched in 2001. The need for technology cooperation was identified in response to increased activity in the development of ocean wave and tidal current energy in the latter part of the 1990's and the beginning of this decade, primarily in Denmark, Portugal and the United Kingdom. These three countries were the inaugural signatories to the OES.
For more information, please visit: www.ocean-energy-systems.org

Southeast Asian Collaboration for Ocean Renewable Energy (SEACORE) is envisioned to be a platform for the exchange of ideas, initiatives, & experiences from R&D, policymakers, and industry. It forms a collated and active core network of expertise and technical know-how in Southeast Asia (SEA) to set, assist, augment, or facilitate adoption of Ocean Renewable Energy (ORE) in the region; and also promotes diffusion of renewables' products and creates new markets for partner industrial firms. It is currently the official technical working group in offshore energy of the ASEAN Centre for Energy (ACE). https://blogs.ntu.edu.sg/seacore/

The ASEAN Centre for Energy (ACE), established on January 1, 1999 as an inter-governmental organisation, is guided by a Governing Council composed of the Senior Officials on Energy of the ASEAN Member States (AMS). Established by Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam, ACE is hosted by Indonesia. As host country, Indonesia provides headquarter facilities and other amenities at the ACE building in the compound of the Directorate-General for Electricity and Energy Development of the Indonesia Ministry of Energy and Mineral Resources, Jakarta. For more information, please visit: www.aseanenergy.org

Incorporated in September 2014, OceanPixel is a Singapore start-up company that spun off from the initiative of Nanyang Technological University (NTU) through its Energy Research Institute @ NTU (ERI@N). Strategically partnering and collaborating with experts from the Scotland, UK (e.g. Aquatera) and with access to marine renewable energy thought leaders in the South East Asia (SEA) region, OceanPixel has positioned itself to be the pioneer company dedicated to ocean renewable energy planning in SEA. To date, OceanPixel is currently handling projects in Singapore, Indonesia, and other parts of Asia with potential projects in under development. In February 2015, OceanPixel Philippines Inc. was established as its counterpart in the Philippines. For more information, please visit: www.oceanpixel.org

Based in Singapore, Envirotek is a clean technology investment company that focuses on marine renewable energy. The organisation has been involved in technology development for Wave Energy, through Global Renewable Solutions in Australia, as well as Tidal Energy, with projects like the Black Rock Tidal Power in Canada. In the region, Envirotek works closely with OceanPixel and the Energy Research Institute @ Nanyang Technological University (ERI@N) on the Singapore Tidal Turbine Demonstration. Envirotek and OceanPixel are dedicated to the development of marine renewable energy in Southeast Asia and beyond. They are keen to deploy tidal energy systems in other Southeast Asian countries such as the Philippines. With Schottel Hydro, Aquatera and ERI@N as their strategic partners, Envirotek and OceanPixel are geared to provide a comprehensive and wide variety of services to ensure the success of a Tidal Pilot Project in the Philippines.

Acknowledgement

This workshop will not be possible without the help and support of our regional and industry partners, OceanPixel Pte Ltd and Envirotek, who graciously sponsored the event, its speakers and participants, the International Energy Agency – Ocean Energy Systems (OES), and the ASEAN Centre for Energy Southeast Asian Collaboration for Ocean Renewable Energy (ACE-SEACORE), Aquatera Ltd for handling and facilitating the Fantasy Island Sessions and our partner institutes for participating and encouraging interests to join the workshop. We would also like to acknowledge the Energy Research Institute @ Nanyang Technological University (ERI@N) for its continuous support towards driving offshore and ocean renewables activities in Singapore and in the region. Special acknowledgement goes to the Wind and Marine Renewables team for help during the onsite coordination and organisation of the workshop.

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