



Energy Research Institute @ NTU

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SEAcORE Bulletin

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*The Southeast Asian
Collaboration for
Ocean Renewable
Energy (SEAcORE)
spearheads a regional
initiative to increase the
uptake of ocean
renewable energy in
SEA.*

Ocean Renewable Energy in SIEW 2014

The Energy Research Institute @ Nanyang Technological University (ERI@N) Wind and Marine Renewables (W&M) Team has pioneered once again a conference focusing on ocean and offshore renewables. This is the third successful offshore renewable energy conference organized by the team which happens within the Singapore International Energy Week every year.

The W&M conference organizing team came up with six different technical sessions covering all aspects of offshore renewable energy technology and RD&D.

1. Advancement in Offshore Renewable Solutions and Its Technoeconomics and Policies
2. Wind and Ocean Resource Assessment
3. Advanced Device Development
4. Materials and Structures for Offshore Renewables
5. Electrical Systems and Remote Sensing
6. Simulation, Prototyping and Test-Bedding of Offshore Renewable Systems

The speakers and participants were selected from diverse backgrounds: industries, government agencies or institutes and academic institutions which gave the conference a holistic perspective on the offshore field. ERI@N's Joint Industry Programme firms and students participated as well during the ACES 2014 through industry presentations and student poster presentations throughout the whole two days of the conference.

This year, one of the flagship programmes of ERI@N was also launched during the ACES Opening Ceremony, the Renewable Energy Integration Demonstrator Singapore (REIDS) project in Semakau Landfill. This is the world's largest micro-grid in the tropics that will integrate power from solar, diesel, storage and power-to-gas technologies.

The second Annual Meeting of the SEAcORE Network happened after the two-day ACES Conference. The following country members were present: Brunei, Malaysia, Myanmar, Philippines, Singapore and Thailand delegates. Updates on current state of ocean renewables were presented by each country and more importantly, concrete joint research plans were discussed.

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ACES: Offshore RE Track

Few of the highlights of the presentations were the W&M Team's efforts to counter environmental challenges in turbines presented by Dr. Srikanth Narasimalu, Programme Director of the W&M Renewables Team. The foci of the team are 1) advancing excellent research work in the offshore renewable track which "aims to improve efficiency of current systems while maximizing synergistic effects of alternative energy sources," 2) promoting synergy and innovation through fostering a multidisciplinary environment of technological solutions and policies and 3) initiating collaboration and user-inspired research.

For the ocean renewable side, the team has given emphasis on marine renewable energy applied research which includes turbine device, support structure, research against environmental impact and grid integration studies. The team's efforts stressed the importance of developing technologies that would suit the tropical waters and making these technologies marketable to Singapore and the rest of the region. This inspired the team to take on the lead to initiate a regional collaboration on ocean renewable energy in Southeast Asia, the SEACORE (Southeast Asian Collaboration for Ocean Renewable Energy).

To name few specific projects of W&M Renewables Team are the following: 1) wave energy resource assessment in Singapore. Wave energy resource estimation is a necessary step in identifying areas suitable for siting Wave Energy Converters (WECs) and also in selecting the appropriate WEC for a site. ERI@N, in collaboration with the Tropical Marine Science Institute (TMSI), has done a wave energy resource assessment of Singapore's waters. 2) Marine test bedding activities where the team focused on coming up with cost-effective and modular installations. One such effort is the tidal turbine test bed that was launched at the Sentosa Boardwalk, a themed pedestrian walkway connecting Singapore and Sentosa. Mr. Htet Lin (Research Engineer), Dr. Liu Jing (former Research Fellow), and the team's Senior Research Engineers: Mr. Mahesh Ramanathan, Mr. Maarten Verhoeven and Mr. Paul Hibbard are now working on doing upgrades for this project.

The "Tidal-In Stream and Wave Energy Resource Assessment" led by Dr. Michael Abundo Research Fellow and Mr. Ly Duy Khiem. This project includes feasibility study, device development and prototype installation at Tanah Merah Ferry Terminal in Singapore.

As part of holistic approach to technological development, policy papers and reports have been generated within the team to integrate its efforts with market and technology creation. This is led by Dr Srikanth and Ms. Mary Ann Quirapas.

Regional Collaboration: ERI@N- SEACORE

ERI@N-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 and creates new markets for partner industrial firms. Joint projects in resource mapping and assessment are now being discussed among the network (includes the following countries: Brunei, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam). The ASEAN Centre for Energy (ACE) also recognizes the efforts done by the network and thus officially made it as the technical working group for ORE in SEA. [full story on page 4](#)

Industry Collaboration: JIP

The Wind and Marine Team has also been active in engaging industry partnerships and collaboration in their projects through its Joint Industry Programme (JIP). The JIP involves PhD students, NTU professors, and local and multi-national companies who are engaged in cutting-edge research into various aspects of Offshore Renewable Energy. Today more than 20 doctoral projects are in progress, spanning resource forecasting, sub-structure studies, power generation, transmission, grid, installation, and maintenance.



Dr. Srikanth Narasimalu presents the Wind and Marine Renewables Team efforts for offshore renewable technologies



ACES Offshore Renewable Energy Speakers and Participants

Among the JIP industry speakers were DNV-GL who was also among the conference sponsors, DHI (also a sponsor), Vestas and cEentek. There were three speakers from DNV-GL namely Mr. Mathias Steck, Regional Manager, Energy-Renewables Advisory who talked about turbine optimization for reduced cost of energy, Mr Zhang Ming Hui, Senior Consultant, Renewables Advisory and Dr. Nguyen Khanh Loc, also a Senior Consultant for Clean Technologies Centre. The speakers had talked about energy yield calculation for wave and tidal energy farms and Smart Asset Management Method for Offshore Rigs respectively. For Vestas, Mr. Yi Zhou, Team Leader and Specialist presented "Grid Integration choices for Offshore Wind Power plant and Dr. Jacob Soerensen, Head of Innovation for Marine Infrastructure and Energy in DHI discussed about "the high quality metocean data and hydrodynamic loads on offshore renewable energy structures." [Full summaries of the presentations on page 5](#)

The W&M Team JIP PhD students had major participation during the ACES Conference by showcasing their technical research work jointly produced with NTU professors and industry collaborators. Most of these works have already been published in peer-reviewed journals and presented in well-known conferences. Up-to-date, there has been seven published journal articles, seventeen conference papers and few technical reports and a book chapter that were done under this team effort. [Full list of the students' publications and the list of posters that were presented during the conference on page 8](#)

Finally, ERI@N W&M conference organizing team had also brought in and invited the different experts both from the academe and industry to give a holistic view of the current trends and development in offshore renewable energy field from its R&D stage to commercialization processes of ORE technologies. Most of the invited speakers are also current collaborators and partners of the W&M Team. To name a few were Prof Abu Bakr Bahaj from University of Southampton who talked about the "Global Marine Energy Technologies and its commercialisation readiness". Prof. Cameron Johnstone of University of Strathclyde, also CEO of Nautricity also presented a topic on "Tidal Engineering and Technology Development." Both of the professors have been closely working with the W&M team on their current marine turbine projects.

We thank ClassNK and Scottish Development International (SDI) for being the major sponsors of ACES which were brought in by the W&M conference organizing team. ClassNK has been a close collaborator of ERI@N in the REIDS project. Mr Hirofumi Takano, General Manager of ClassNK talked about the development of comprehensive certification scheme for renewable energy and the marine renewable energy efforts in Japan including the activities of ClassNK in promoting ocean renewable energy in the region. Prof Ken Takagi of University of Tokyo, also part of ClassNK, discussed about use of floating type turbine has an advantage on this type of setup since it could minimize its weight and easier to install.

SDI's Project Manager, Mr. Jonathan Leucci also presented the activities they are doing in the offshore renewable energy side According to Mr. Leucci, SDI is very much open for collaboration with Southeast Asian counterparts to increase the uptake of ocean renewable energy in the region. SDI also sponsored two of our ACES Offshore Track speakers, Prof. Cameron Johnstone of Nautricity and Mr. Ian Johnstone of Aquatera.



Mr. Takano of ClassNK presents the marine renewable activities in Japan.



Mr. Leucci of SDI speaks about their activities on ocean renewable energy.



Q&A portion with speakers: (L-R) Mr. McIlland, Dr. Starzman, Prof Johnstone and Prof Bahaj

SEAcORE Annual Meeting

The second annual meeting for the SEAcORE Network happened last October 30, 2014 in Research Techno Plaza, NTU Campus. Six representative countries were present during the meeting:

- Brunei: Dr. Chee Ming Lim, University of Brunei Darussalam
- Malaysia: Prof Omar Yaakob, Universiti Teknologi Malaysia and Ms. Lim Khimyan, Universiti Tunku Abdul Rahman
- Myanmar: Mr. Htun Naing Aung, Mynamar Industry Association
- Philippines: Dr. Louis Danao, Marianne Eleonor Catanyag and Francis Corpuz, University of the Philippines
- Singapore: Dr. Srikanth Narasimalu, Dr. Michael Abundo, Ms. Mary Ann Quirapas, Mr. Ly Duy Khiem and Mr. Htet Lin, ERI@N
- Thailand: Dr. Duangrudee Kositgittiwong, King Mongkut University of Technology Thonburi

The meeting was preceded by a workshop led by Ms. Desiree Latimer, Director of Energy Island Bell-Pirie Ltd and also an experienced project developer specifically on OTEC technologies in the Philippines.

The focus of her talk was on the strategies on effective project development point of view specifically on ocean renewable energy in the region. She took the case of the 10 MW OTEC plant in Zambales, Philippines. Some of the key take-away points from her presentations were the importance of building a good and convincing business case and model and financial which shows the developer's both wide and in-depth knowledge of the market (OTEC and electricity markets) in the country and how different players in the market could be integrated in one plan that would be beneficial to producers, developers and consumers. A developer should also be aware of the existing policies and roadmaps that could support the business case. In the case of the Philippines, there is tight power supply and the government has placed a renewable energy target of 15, 304 MW by 2030. An ocean renewable energy roadmap and incentives (fiscal and non-fiscal) have also been put in place by the Department of Energy. All such activities should be seen as opportunities from project development perspective.



From right to left: Mr. Francis Corpuz, Dr. Michael Abundo, Ms Marianne Catanyag, Mr. Htun Naing Aung, Mr. Htet Lin, Ms. Mary Ann Quirapas, Dr. Srikanth Narasimalu, Dr Louis Danao, Ms. Desiree Latimer, Ms Lim Khim Yan, Pro. Omar Yaakob, Dr. Duangrudee and Dr. Chee Ming Lim

Second lesson is to prepare counter arguments on common perception about the technology that could hinder project development. For the Zambales case, two arguments were presented – 1) 10 MW OTEC is not competitive and 2) there is a high upfront cost for OTEC. These two could be argued otherwise when statistics spot market prices off-grid true generation costs are presented and to prove that fossil fuels cost are considerably more beyond their initial project cost.

After the talk, each representative had updated on the current status of ocean renewable energy for their country. Notably, there are increasing number of ORE studies and activities in each country. The Secretariat team also updated the group of the different SEAcORE activities done this year. To name few are: SEAcORE being the technical working group of the ASEAN Centre for Energy, SEAcORE Website and the signed MoUs among the members as start of project collaboration. Asian Wave and Tidal Energy Conference (AWTEC) is also announced to be happening in Singapore in 2016 and this is seen to be one of the major events of SEAcORE. As for the next action steps for SEAcORE, different RCAs would be signed to kick-start the research projects on ocean renewables in the region.

ASEAN Centre for Energy through Acting Executive Director Christopher Zamora had officially recognized the efforts done by the SEAcORE network in increasing the uptake of ORE in SEA -- making it as the ACE's technical working group on ocean in the region.

ACES Offshore RE Track: Highlights and Summaries

The Offshore Track was a two-day conference of the ACES. The six sessions were the following:

1. Advancement in Offshore Renewable Solutions and Its Technoeconomics and Policies
2. Wind and Ocean Resource Assessment
3. Advanced Device Development
4. Materials and Structures for Offshore Renewables
5. Electrical Systems and Remote Sensing
6. Simulation, Prototyping and Test-Bedding of Offshore Renewable Systems

Advancement in Offshore Renewable Solutions and Its Technoeconomics and Policies

Prof AbuBakr Bahaj, Head of Energy and Climate Change Division of University of Southampton gave an interesting presentation about global marine energy technologies and an assessment on its commercial readiness. According to his study, mostly of the successful prototypes are already grid-connected through test centers or specific sites. He also mentioned that marine developers now are into small scale array development which is up to 10 MW. Tidal current technologies are more likely to have consensus on using the three bladed horizontal axis turbines while wave technology devices are more diverse. In terms of cost of marine renewable energy technologies, it would most likely to fall down because of the increased installed capacity and technological innovations. However, its continuous progress still depends on "clear and stable national and international support mechanisms."

Following him was a presentation of Mr. Ian Johnstone, a Senior Consultant in Aquatera. Mr. Johnstone gave an interesting case study on the marine energy laboratory of Orkney and the lessons that can be learned from it. Aquatera, a world-leading business in sustainable island energy, has been a crucial actor in developing the sustainable island initiatives in Orkney. Orkney has been considered the world's largest energy laboratory and among the few of its achievements in the marine energy field are: having the world's largest marine energy test centre, first grid connected offshore wave energy, 19 marine energy technologies tested and houses the world's largest permitted marine energy projects.

Ocean Resource Assessment

In terms of ocean resource assessment, different case studies were presented from European to Southeast Asian region. Ms. Desiree Latimer, Director of Energy Island Bell Pirie Ltd, shared her experiences from a project developer's point of view in ocean thermal resource assessment in the Philippines. According Ms. Latimer's presentation, the process of resource assessment is a key starting point for project developers however, it is just among a number of tasks that they need to accomplish. The ultimate goal is to achieve a financial closing. An important aspect of resource assessment is having the knowledge of electricity cost of OTEC technology for a specific site. Three key steps to successful costing are gaining theoretical, technical and practical knowledge on the site being developed.



Ms. Latimer of Energy Island Bell Pirie talks about the OTEC Resource Assessment in the Philippines.



Speakers were given time to answer the questions from the audience during the Q&A session.

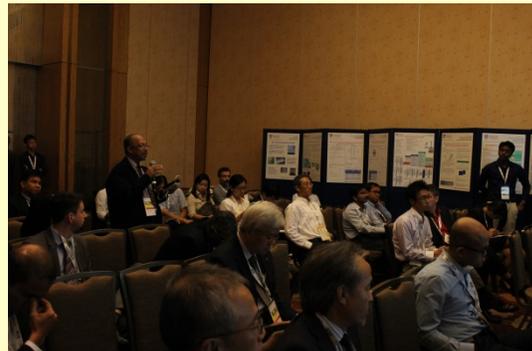
Dr. Valliyil Mohammed Aboobacker, Research Fellow, Tropical Marine Science Institute, National University of Singapore presented a joint study done with ERI@N on the Estimation of Wave Energy in Southeast Asia. The study explores wave energy resource in the Southeast Asian region through the application of numerical wind-wave modelling. The conclusion from the study includes the map of "annual mean wave power of the region." It also shows that the highest wave power is in the western side of the Sumatra Island, the Adaman Sea part offshore of Myanmar, then South China Sea (area between Philippines and Thailand). For Singapore, wave energy in Singapore Strait is strongest in the south east area and the greatest magnitude is during the northeast monsoon.

Among the industry speakers was Mr. Jean-Christophe Allo, Project Manager of Sabella. He presented Sabella's experience from first real scale unit "Sabella D10" to tidal turbine pilot power plant "Eusabella in the Fromveur strait, France.

Sabella is a French company for turbine technologies deployment on marine and river applications. At present, it has 10 working or under construction real scale individual unit in the world; 4 to 5 pre-commercial farm projects (2016 to 2018) and a commercial deployment has yet to be planned (2020 to 2022).



Mr, Ming Hui Zhang of DNV-G talks about the importance of establishing and validating numerical models.



Prof Omar of UTM raises a question to the Ocean Resource Assessment panel of speakers.

Mr. Ming Hui Zhang, a Senior Consultant of DNV-GL had discussed the importance of establishing and validating numerical models to predict the hydrodynamic performance of wave and tidal energy converters (WECs and TECs) operating in arrays. He introduced two softwares for project planning: WaveFarmer and TidalFarmer. The main features of these softwares are the following: 1) provide assistance in designing and analyzing arrays of wave and tidal energy converters; 2) accurate estimation of annual energy yield from the array; 3) can be used to help to spatially planning marine energy farms and 4) are both compatible to all market leading device types.

Advanced Device Development

Enhancement in the turbine design performance and further cost reduction are important to learn to give maturity on developing devices in water. In this session, Dr. Ralf Starzman, R&D Manager of the Schottel Group presented its experiences on Tidal Generator-Form Prototype to commercialization. Schottel is "specializing in the development, design, production and servicing of azimuthing propulsion and manoeuvring systems, controllable pitch propellers. It is also into propulsion systems with power rating of up to 30 MW for vessels of different sizes and types." Few applications of its technology are on modular power which allows optimal configuration for the requirement of any site. Another is on floating platform (uni- and bi- directional flow). Schottel's projects include Triton + STG Demonstration Project with FORCE in Minas Passage, Canada.

Mr. Albert Mcllelland, Senior Managing Director of AmPac Strategic Capital LLC, presented the different traditional challenges that wind renewable energy industry faces despite the opportunities for it to further thrive.

He discussed that these could be solved given the right technological innovation. He suggested the use of the magnetic power generation to answer the efficiency and energy conversion dilemma for most of renewable energy technologies.

Nautricity CEO. Prof. Cameron Johnstone, shared elaborated on various strategies on how to successfully develop the tidal technology (presentation title was Tidal Energy: Technology Development). He used PCAR (Progressive, Appropriate, Commensurate and Realistic) as the guiding principle in tidal technology development). He also showed some of Nautricity's technology ideas on tidal like the contra-rotating and CoRMaT technology.

Materials and Structures for Offshore Renewables

This session talks about the potential for disruptive innovation through enhancing performance and quality of offshore renewable materials and structures technologies. Prof. Ken Takagi of University of Tokyo discussed about the "Development of a Floating type Ocean Current Turbine System."

He discussed that ocean current is one of the major source of ocean renewable energy in Japan. The use of floating type turbine has an advantage on this type of setup since it could minimize its weight and easier to install.

Peter Weber, CEO of ceEntek Pte Ltd focused on the importance of stable, durable and service-free foundation to harvest energy effectively from moving masses like wind, tidal and wave energy turbines. He introduced the carbon nano-fiber enhanced Ultrahigh Performance Concrete (ceUHPC) technology. This material is non-permeable, easy to prepare, provides no chloride penetration and guaranteed to be used for lifetime.

Coating and paints of turbines is a crucial element is sustaining the effectivity of its performance. Dr. Pritesh Patel, Section Manager of AkzoNobel addressed the need to look at marine fouling and how it affects marine energy assets. According to Dr. Patel, "to inhibit the build-up of marine fouling ultra-smooth, flouropolymer foul release coatings can be utilized." Its "ultra-smooth surface can assist in reducing the hydrodynamic drag, regardless of the presence of marine life." These characteristics could effectively generate power from the asset which can deliver the expected energy output.

Mr. Chang-beom Park of Hyundai Engineering and Construction discussed about the Caisson-type of support structure for tidal current power generators. Some of his findings include: a caisson support structure "enables to reduce the relative displacement at tower and to avoid the stress concentration on the concrete basement;" "support structures using perforbond connection type is the most effective resistible against tensile forces among plates with bolt-, stud-, perfobond- and the hook-type connections."

Simulation, Prototyping, and Test-bedding of Offshore Renewable Systems

Andritz Hydro Hammerfest' Sales and Business Development Manager, Mr. Stein Atle Andersen, presented issues faced by "the next phase of developing economically viable tidal-in-stream power plants."

High quality metocean data and hydrodynamic loads on offshore renewable energy structures has been the main focus of Mr. Jacob Sorensen's, Head of Department, DHI Singapore presentation. According to him, coming up with new metocean data standards is crucial and can make difference in the field of ocean renewable energy. This could be achieved if improvement can be done in 1) coupling of scales and media; 2) novel observation, integration and analysis technique. More efforts should be into creating technologies that are durable and value adding for the industry.

Mr. Rodney Bromfield, Director of Hales Water Turbine and a Senior Lecturer in Kingston University presented the "Economics of Vertical Axis Turbines (VAWT) in low velocity water flows. He suggested that the use of VAWT as a turbine design has the following benefits: 1) works in turbulent water; 2) easily protected; 3) marine life and environmentally friendly; 4) robust; 5) entails simple construction; 6) can be deployed "close in" to shore so has low velocity output and finally, 7) VAWT can use large number of positioned arrays which do not affect each other.

The CEO of Ocean Pte Ltd, Mr. Pascal Tridon presented Ocean 17 renewable energy technology. Ocean 17 provides new and suitable design concepts for offshore and marine technologies.

There was also a session on Electrical Systems and Remote Sensing under Offshore Renewable track. This session focused on generators, electrical converters and energy distribution aspects of offshore renewable systems specifically on the wind energy side. The presentations were from Mr. Ankit Kumar Das, a PhD Student from Nanyang Technological University, Mr Yi Zhou, Team Leader and Specialist from Vestas, Professor TT Lie of Auckland University and Dr. Nguyen Khanh Loc, Senior Consultant from DNV-GL.

JIP Student Presentations and Posters

After the technical sessions, masteral and PhD students were given a dedicated time to present their current research work. From this session, they were able to get feedback from the academic and industry experts in the field. Mr. Tan Hong Huat, Ms. Yan Mei Zhang, and Mr. Rejish Jesudasan were the student presenters from NTU.

Posters from the Wind and Marine Team and the Joint Industry Programme (JIP) students were also highlighted during the two full days of ACES.



Poster presentations of the students were strategically placed around the conference room. After sessions, there were discussions between the students and interested parties and industries.

The following are the topics of the posters from the JIP students:

- Alan Koh (attached with Lloyd's Register) – Probability model for ignition of gas ingested by a gas turbine
- Andrew Pang (attached with Lloyd's Register) – Scour Modeling of Offshore Wind Turbine Monopile Foundations
- Ankit Kumar – Meta Cognitive Interval Type-2 Neuro-Fuzzy Inference System for Wind Prediction
- Chew Kok Hon (attached with DNV-GL) – Design Modeling, Analysis and Optimization of Space Frame Structure in Moderate Water Depth Offshore Wind Application
- Koh Jian Hao (attached with DNV-GL) – Development of Tower and Nacelle Influence Model for a Downwind Wind Turbine
- Ken Tay (attached with Lloyd's Register) – Utilising CFD Techniques in mesoscale weather modeling for wind resource mapping
- Martin Koh – Optimisation of a tidal turbine farm by Generic Algorithm,
- Nikhil Garg – Understanding the Effects of Atmosphere-Ocean-Wave Coupling during Tropical Cyclone for Application towards Offshore Structures
- Swaroop Naranayan – Effect of layer waviness on failure of unidirectional GFRP-FE analysis and experimental validation
- Wei Xuan – Simulation of Wind Farm Turbine Wake with Meshfree Methodology
- Xiao Jian Fang – Multi-level Energy Management System (EMS) for Multiple-Slack-Terminal DC Microgrids Real-time Operation