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Energy Research Institute @ NTU

Renewable Energy Integration Demonstrator Singapore

REIDS Offshore

REIDS Team

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Renewable Energy Integration Demonstrator Singapore

REIDS

Vision

- Foster technology development and commercialization efforts in the broad energy market in support of Singapore corporate stakeholders, thereby strengthening their position within the rapidly growing renewable energy and micro-grid markets.
- Support Singapore's commitment to a path towards a broader energy mix, including a growing renewable energy portion, and a more rational energy end-use.

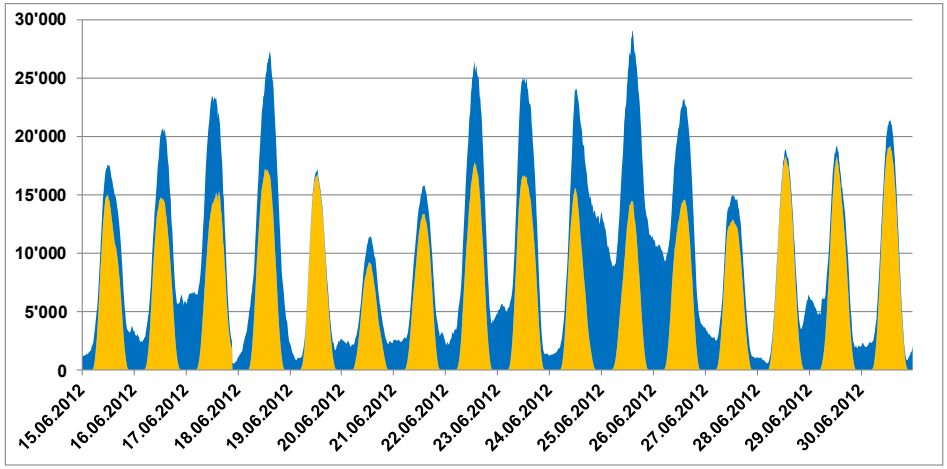
Objectives

- Test and demonstrate, at a large-scale level, the proper integration of a broad range of renewable energy production - onshore and offshore -, energy storage and rational energy end-use technologies to provide for the supply of a wide palette of industrial, commercial and residential loads.
- Provide a unique platform for private and public sector entities in support of their on-going R&D efforts, as required for early testing, followed by large scale demonstration and eventually show-casing all along the usually long energy technology and product development cycle

Key Challenges in Energy Transition

Two-pronged R&D approach:

- Over-the-horizon research to imagine tomorrow's energy technologies and systems
- Large-scale energy production, storage and end-use demonstration projects to comfort the public at large and public authorities that «yes we can» already to-day.



The major challenge for broad and large-scale integration of PV and Wind energy is system integration and energy storage

Yellow PV
Blue Wind

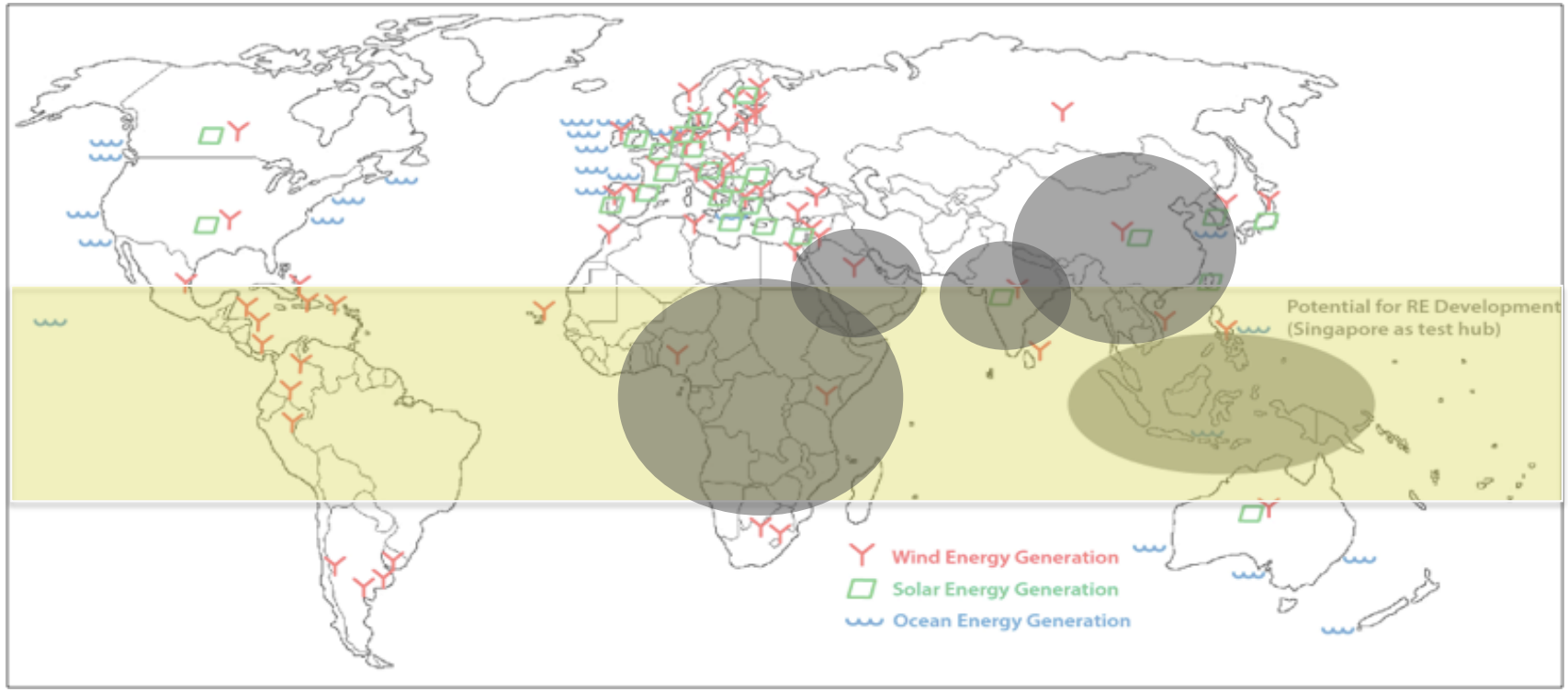
Providing electricity to isolated islands and villages remains one of the core challenges.
The solution can only be by way of micro-grids.

Micro-grid main applications:

- Island systems
- Remote village systems
- Emergency situations (earthquakes, tsunamis, refugee camps)
- Fringe networks
- Military temporary bases

Economic development opportunity

While challenging, energy transitions also represent formidable technology and economic development opportunities for export-oriented industries.



World's top five fastest growing electricity production regions from 2010 to 2030

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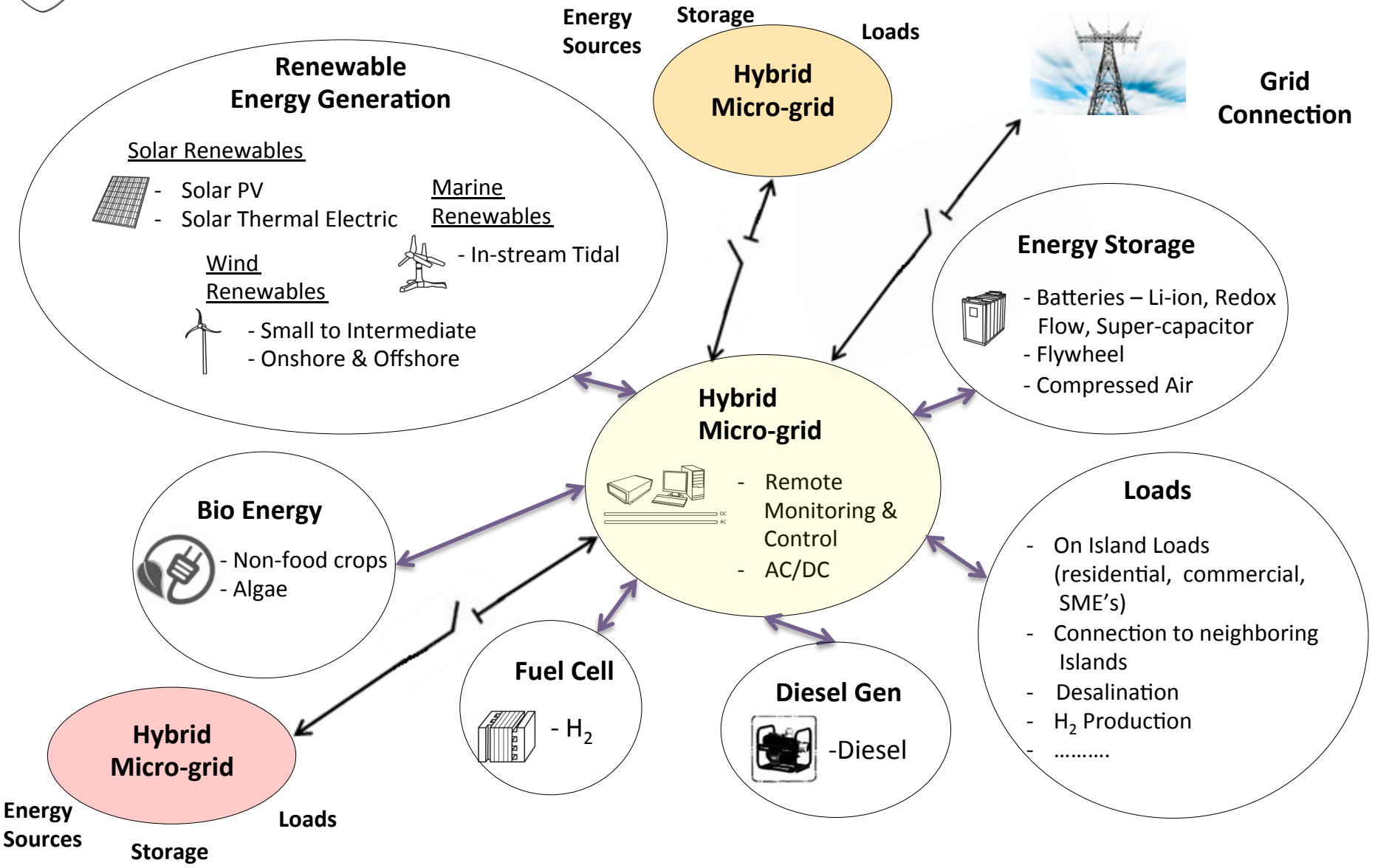
Targeted Technologies



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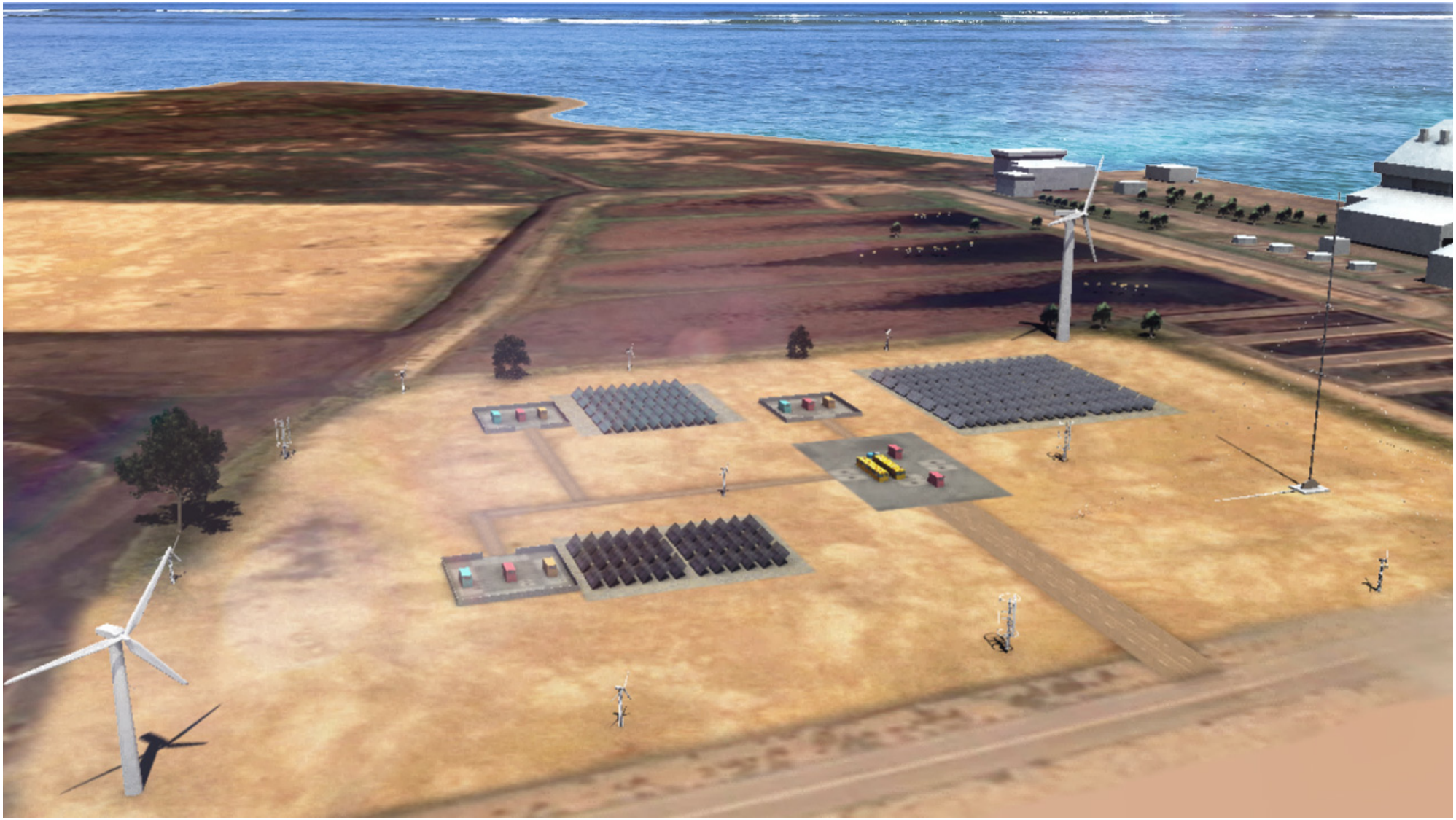
3D rendering of REIDS



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REIDS Offshore
Marine Renewable Energy Scale-Up Test Facility

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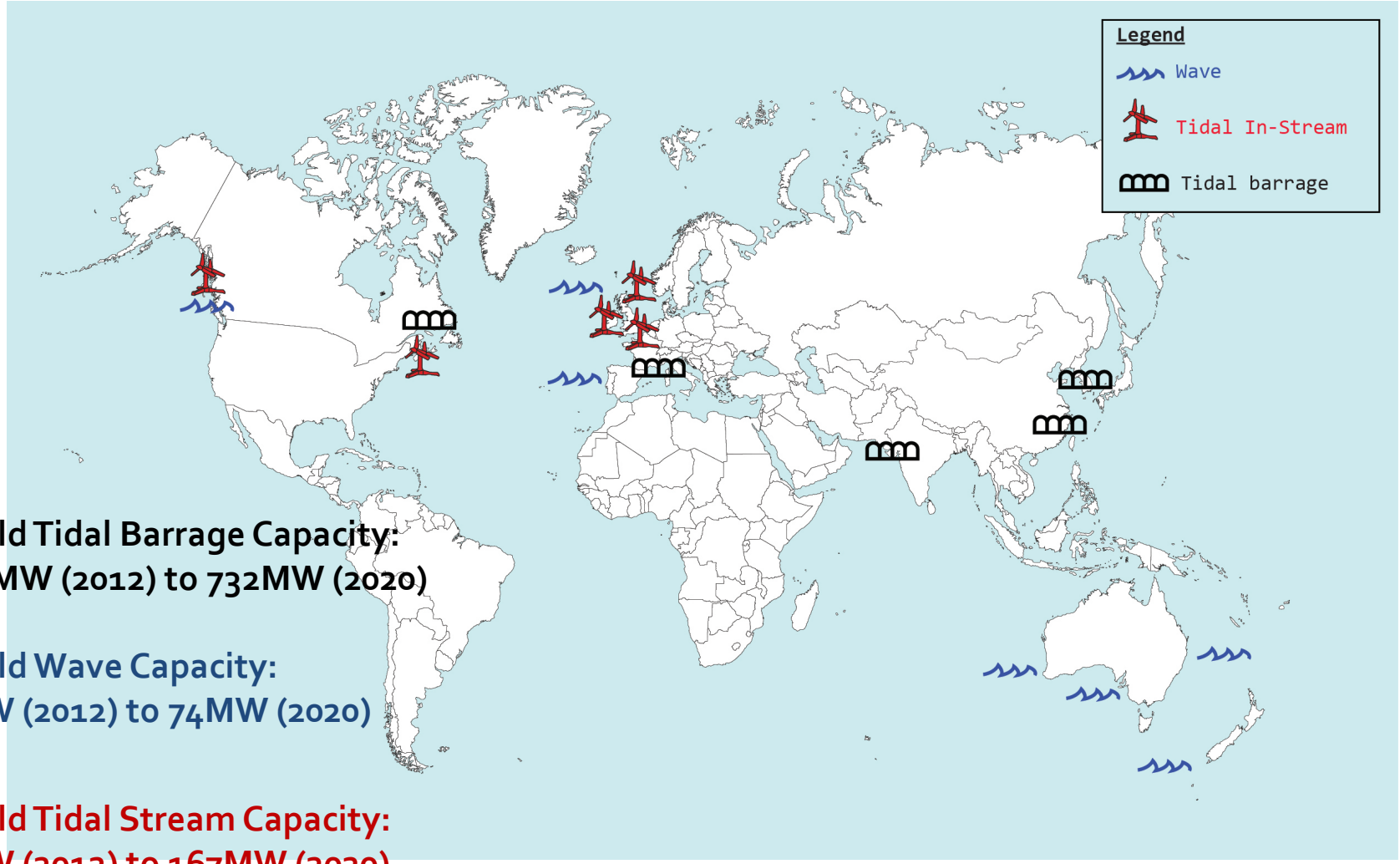
Marine Renewable Energy Project Plans
Global Perspective



World Tidal Barrage Capacity:
516MW (2012) to 732MW (2020)

World Wave Capacity:
1MW (2012) to 74MW (2020)

World Tidal Stream Capacity:
1MW (2012) to 167MW (2020)

Source:
Bloomberg New Energy Finance, Feb 2013
-Project plans from major technology developers

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Regional Market Potential
South East Asia

Country	Potential	Installed	Planned
Brunei Darussalam	335 kW/yr (tidal energy) 66MW/yr (wave)		
Indonesia	160 GW (tidal) 510 GW (wave) 57 GW (OTEC)	3kW	1MW tidal (2014) 1MW wave (2014) 600MW (2050)
Malaysia	4,800MW (tidal) 1,200MW (wave) 43,000MW (OTEC)	1 kW	10 kW (2013) 100kW (2015) 2MW (2019)
Myanmar	11.5 to 23GW (wave) 28.92 to 64.58 GW (salinity gradient)		
Philippines	170,000MW 80GW (Tidal)		10MW OTEC (2015) 35.5MW (2020) 70.5MW (2025)
Singapore	300 GWh/yr (tidal) 100 GWh/yr (salinity gradient)	1kW	
Thailand		0MW	3MW(2021)
Vietnam	1,118 GWh/yr (tidal)		

Sources: mainly from local Government set targets

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Marine Renewable Energy Value Chain

Support Activities

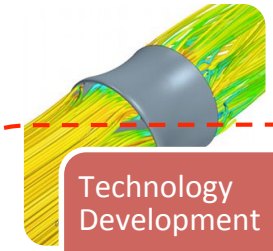
ClassNK — **Standards Development**

TOKIO MARINE — Insurance / Power Certainty

ClassNK ISO IEC — Quality Systems

SOPs

ClassNK — SOPs

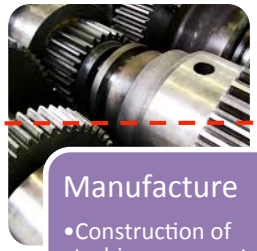


Technology Development
- R&D
- Pilot Scale Testing
- Full Scale Testing

DHI
ATLANTIS RESOURCES CORPORATION
SIEMENS
ALSTOM
ANDRITZ Hydro
ABB

Project Development
- Feasibility
- Planning
- Consent

DHI
ATLANTIS RESOURCES CORPORATION
MEYGEN
Morgan Stanley
GDF SUEZ BY PEOPLE FOR PEOPLE



Manufacture
- Construction of turbines, supports & grid infrastructure

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SIEMENS
sembcorp marine
ABB

Installation
- Subsea turbines
- Subsea cables
- Subsea sub-grid
- Grid connection

Keppel Offshore & Marine
ATLANTIS RESOURCES CORPORATION
sembcorp marine

Operations & Maintenance
- Performance monitoring
- Maintenance

DHI
ATLANTIS RESOURCES CORPORATION
sembcorp marine

Primary Activities

*SOP : Standard Operating Procedures

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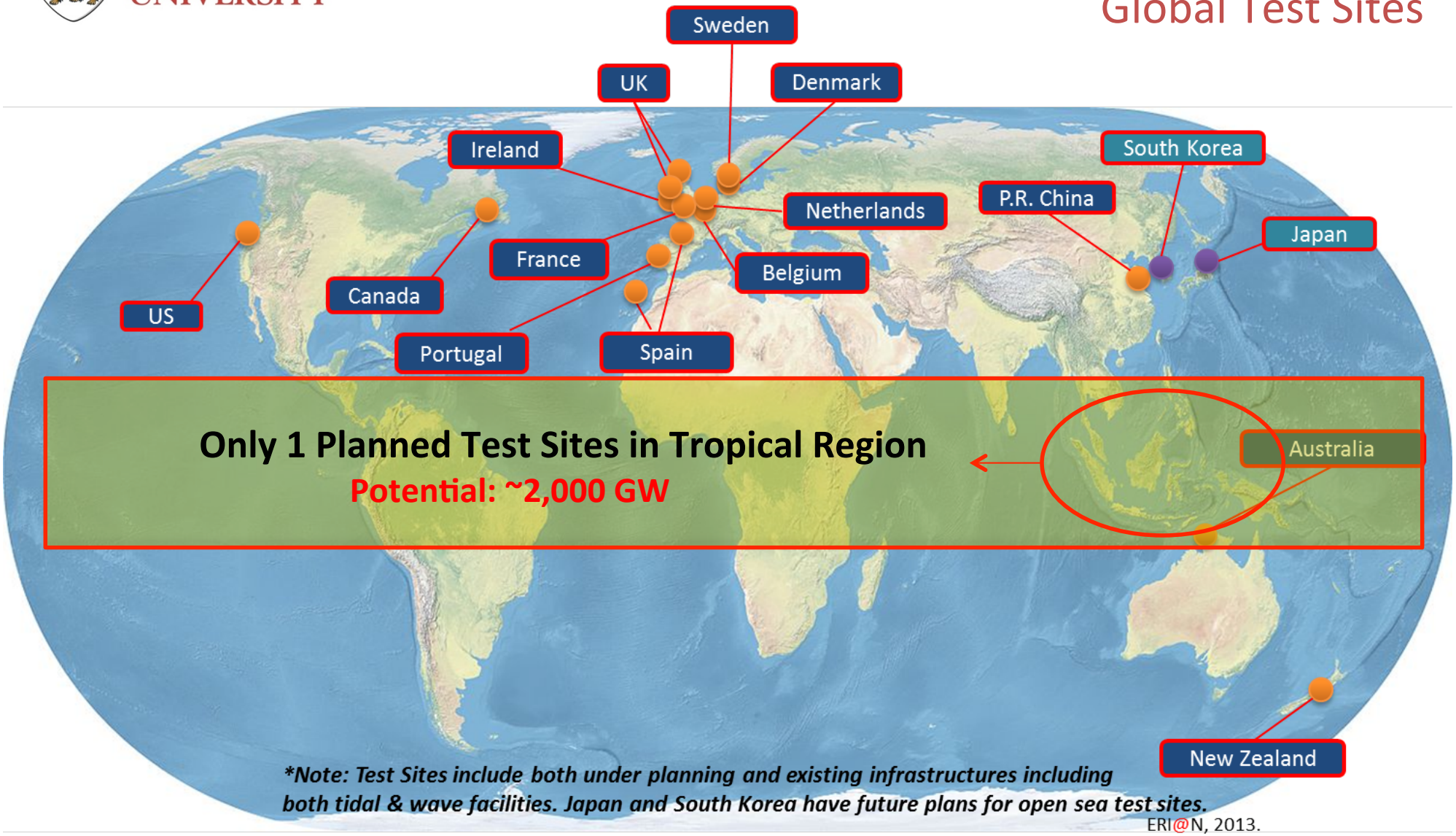
Marine Renewable Energy Global Test Sites



Ref: OES 2012 Report.

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Why scale-up test facility in Singapore ?

Ideal as ORE Hub
- Maritime Hub
- Financial Hub
- Gateway to Asia
- Links to regional partners/countries

Business
- Ease of Business Setup
- Financial Assistance
- Ease of IP application & IP security

Experience Supply Chain
- Marine & Offshore expertise
- Ease of transition with existing supply chain
  - Marine RE equipment
  - Logistics

Knowledge
- Collaboration with ERI@N
- RA and MSP services
- Close collaboration with SEACORE for Marine RE updates

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Marine Renewable Energy Scale-Up Test Facility

Objectives

- Create HUB for tropical & Southeast Asia Marine Renewable Energy Testing
- Provide accessible scale up test site in Singapore (with LIVE performance monitoring)
- First movers for Marine RE industry in SEA – Opportunity for Singapore-based companies to be part of the value chain in this nascent growth industry

- Technology maturity enhancement
- Resource Assessment & Environment Impact Assessment (Regional)
- Certification of all developments within the facility

- Build Marine RE expertise and regional links (SEACORE)
- Facilitate full scale test sites with regional partners
- Link technology developers to regional partners with full scale test sites

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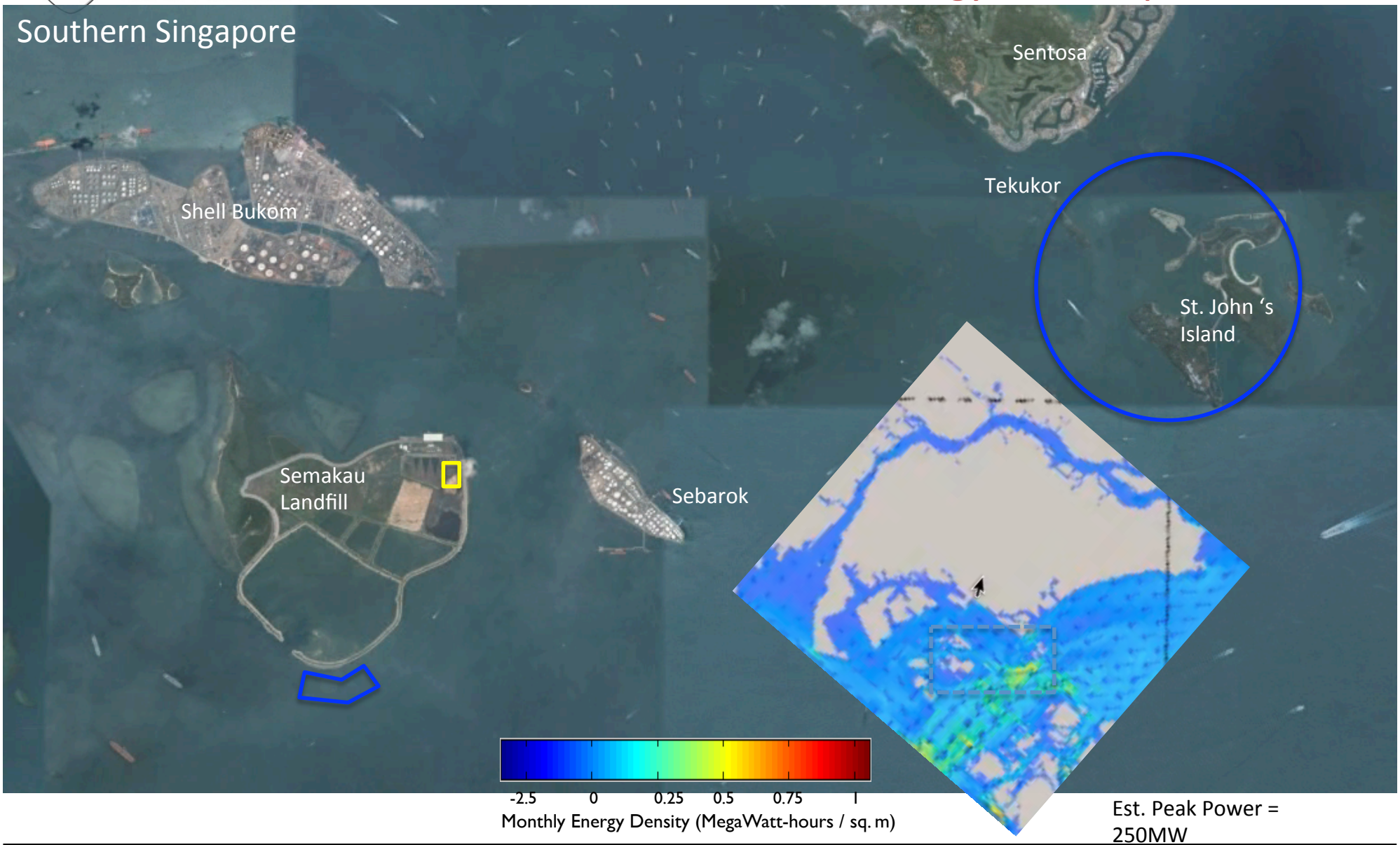
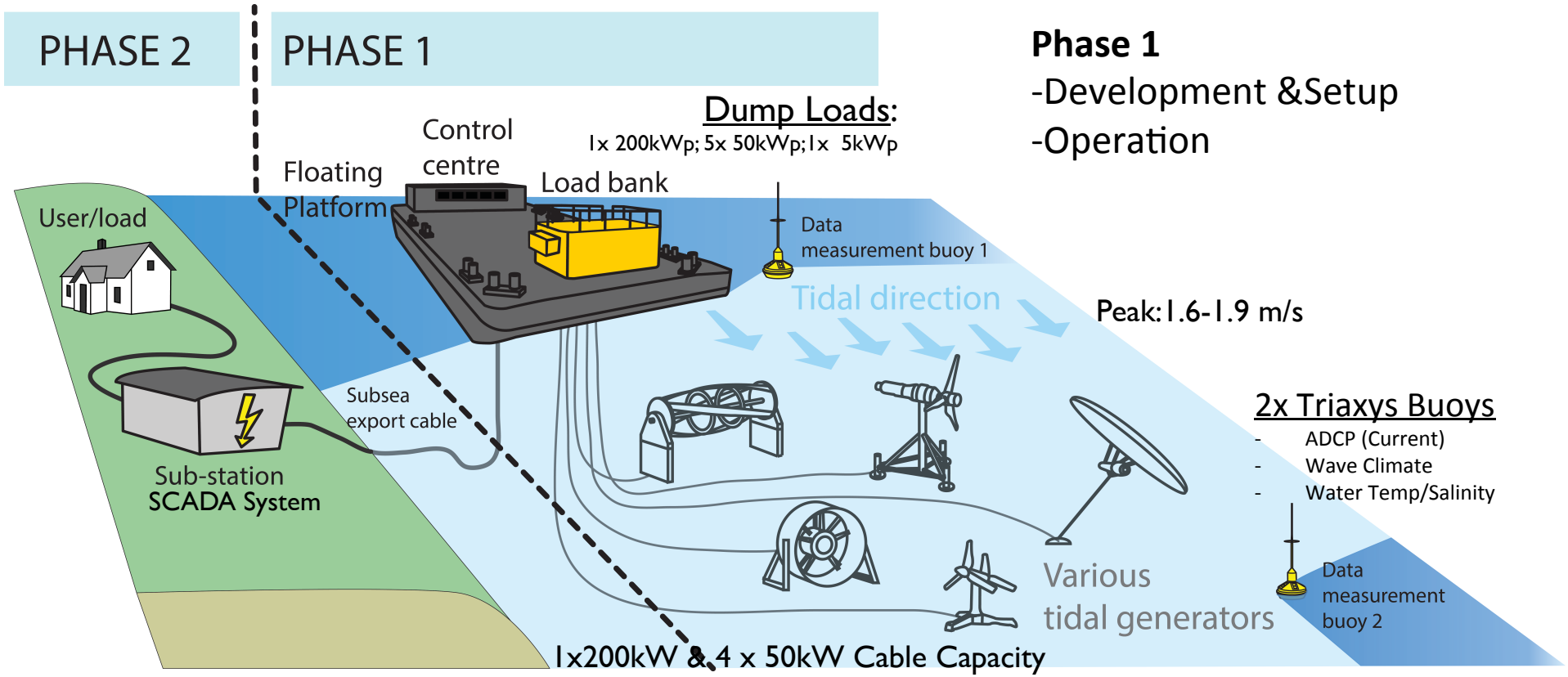
REIDS Offshore
Marine Renewable Energy Scale-Up Test Sites



REIDS Off-shore test facility layout



Phase 1
-Development &Setup
-Operation

Phase 2
- Connecting to substation

Feasibility Study on Proposed Sites

Duration: 18 months

- A feasibility study is crucial to the planning and development of a marine test site
- ERI@N working together with EMEC and relevant companies experience with handling the FS scope of work
- Overall feasibility study grouped into 4 major studies;
  - Site & Resource Assessment
  - Impact Studies & Risk Assessment
  - Tidal In-Stream Site-Device Studies
  - Over-all Project Feasibility Study

Collaboration Partner:

ClassNK

EMEC ORKNEY
THE EUROPEAN MARINE ENERGY CENTRE LTD

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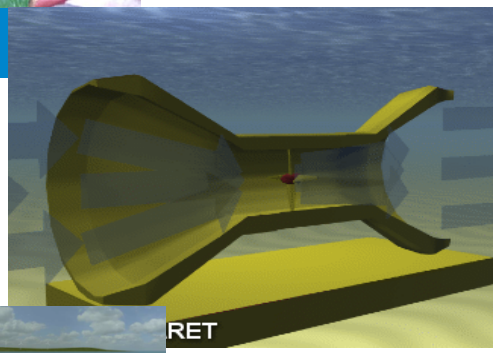
Marine RE Applied Research

- **Tidal/Wind Turbine Device Research**
  - Novel Aero/hydrofoil shape & Rotor design
  - Low inertia drive train research
  - Light weight fatigue-resistant material research
  - Multi-functional coating research
  - Structural health monitoring Sensing system
- **Support Structure Research**
  - Turbine Wake Field Studies
  - Fluid-structure interaction research for Mooring / Supporting Structure
  - Floating platform Under Wind-Wave Interaction
- **Research Against Environmental Impact**
  - Effects on Marine Ecosystem
  - Seaweed / Debris Effect on Propeller Rotor
  - Anti Bio Fouling and Marine Corrosion coating
  - Underwater Acoustic noise
- **Grid integration studies**
  - Research for Weak Grids & Fault Ride-Through Systems
  - Distributed grid System Integration
  - Energy storage system research

Seaweed trapped around Rotor



Floating Platform Design

Surface Bio-Fouling

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Challenging site conditions

- Different Tropical Environmental Challenges such as
  - Prolific Marine Growth and different Bio-fouling Species
  - Different types of fauna
  - Seaweed Growth
  - Slime Formation
  - Warm Water

- One Possible Study: High Level of Turbidity and Sedimentation Effects on Tidal Stream Turbine Systems due to coastal development, land reclamations and regular dredging works

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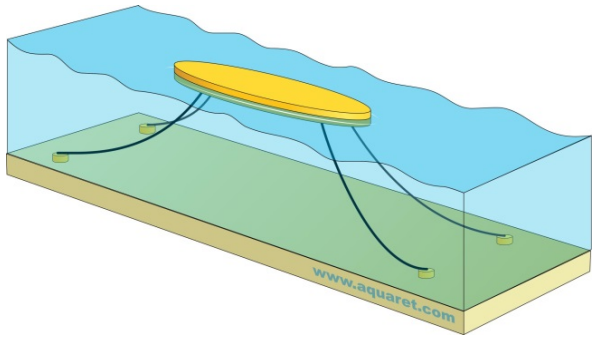
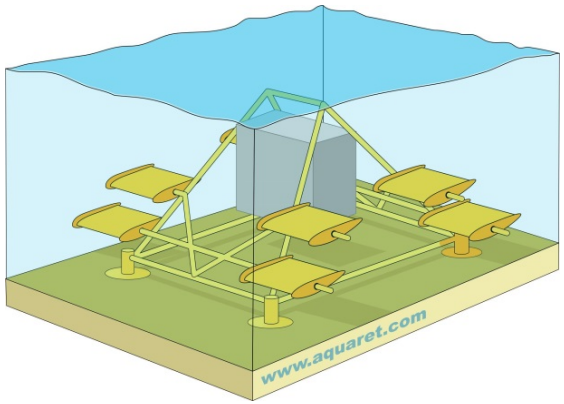
Potential types of technology that could be tested

Support Structures



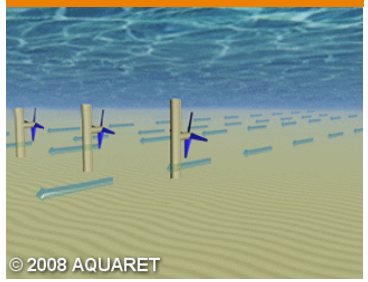
Floating Support Structure Designs



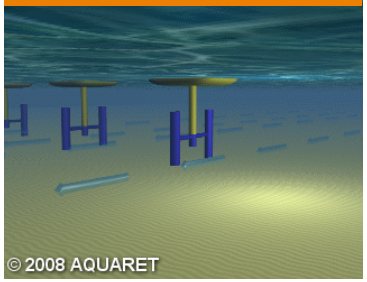
Non-Floating Support Structure Designs

Tidal Stream Turbine Designs

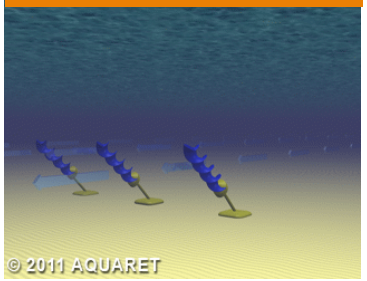
Axial Tidal Turbines



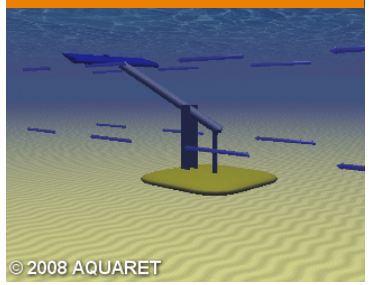
Cross Flow Tidal Turbines



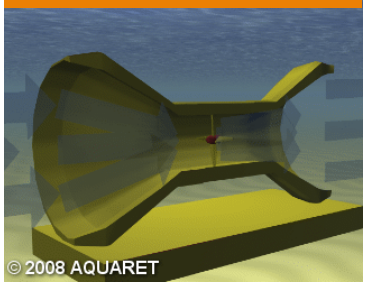
Screw Type Tidal Turbines



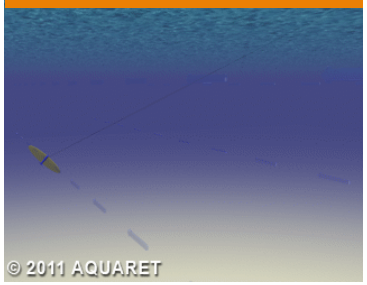
Reciprocating Tidal Energy Devices



Shrouded Tidal Turbines



Underwater Kite Tidal Turbines



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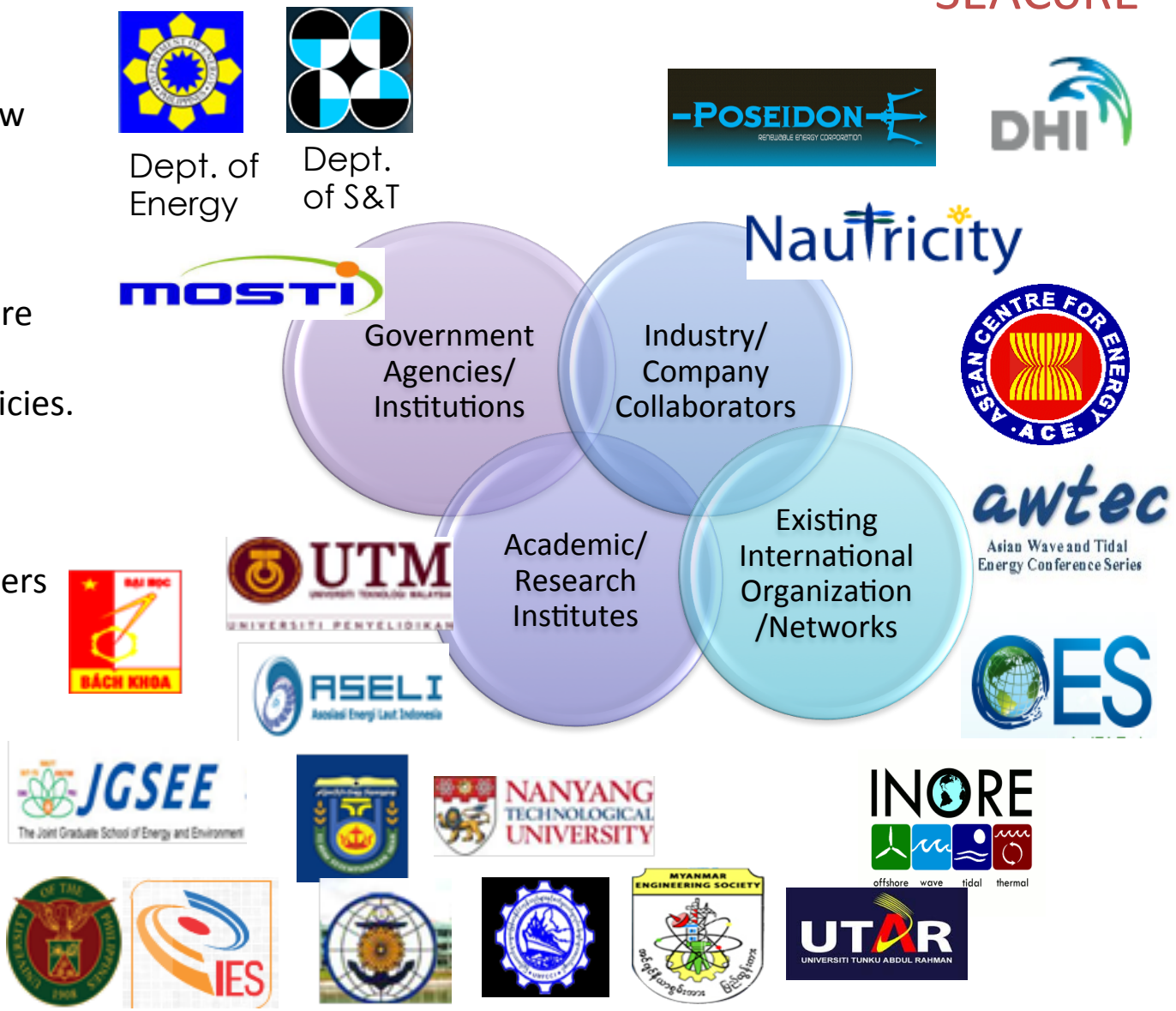
Regional Offshore Energy Research Collaboration SEACoRE

Objectives:

- Collaborative Research in Low flow tropical marine energy.
- To support SEA countries' Regional Energy Security.
- Knowledge sharing of offshore renewables: Technology, Innovation, Industry and policies.

Activities:

- Tropical Marine Energy Centers
- Marine Spatial Planning
- Environmental Impact Assessment
- Training Programs/R&D Collaborations
- Standards and Certification



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Thank you!