ClassNK

University of Strathclyde Engineering

Research and Development Activities in Offshore Renewable Energy in the UK

Atilla Incecik
Department of Naval Architecture, Ocean and Marine Engineering
University of Strathclyde, Glasgow
UK
Email: (atilla.incecik@strath.ac.uk)

International Workshop on Marine Renewable Energy (IWS-MARE)
Tokyo, Japan
Monday, 4th August, 2014

THE AWARDS
UK University of the Year

Content

1. A summary of Offshore Renewable Energy Research in the UK

2. **SUPERGEN UK Marine Energy** (Wave and Tidal) Research

3. **SUPERGEN UK Wind Energy** Research

4. **UK Government Technology Strategy Board (TSB)** funded research

5. **Energy Technologies Institute (ETI)** funded research

6. **European Marine Energy Centre (EMEC)**

7. Industrial Doctoral Centre in Offshore Renewable Energy: **IDCORE**

8. Offshore Renewable Activity in **Kelvin Hydrodynamics Laboratory**

9. Other UK initiatives in Offshore Renewable Energy

10. Marine Renewables Infrastructure Network: **MARINET**

A summary Offshore Renewable Energy Research in the UK

Key Components are:

Investment in University Research:
e.g. Supergen Marine and Supergen Wind Programmes, funded by UK Government *Engineering & Physical Science Research Council (EPSRC)*

Investment in Industry, and Industry / University Research: via UK Government funded *Technology Strategy Board* (TSB) via Energy Technologies Institute (ETI)

Investment in novel facilities: e.g. EMEC (European Marine Energy Centre) via wide variety of public bodies including Scottish Government, Carbon Trust

European Union funded Research

SUPERGEN UK MARINE ENERGY RESEARCH

The EPSRC funded SUPERGEN UK Marine Energy Research Consortium has been tackling a wide range of challenges associated with wave and tidal power. Prototype devices exist for generating marine energy, but there is still a lot to learn about marine energy resources and ways to efficiently harness them and feed energy into networks.

SUPERGEN UK Marine Research Energy Partners are aiming to provide solutions to ensure marine energy can make a significant contribution to the sustainable energy mix to meet the challenges in accelerating deployment towards 2020 targets as well as to expand and operate an inclusive marine network of academic researchers, industry partners and international collaborators, and to continue to provide the highest quality of doctoral training and knowledge transfer in partnership with industry to build intellectual and human capacity for the sector

SUPERGEN UK MARINE ENERGY RESEARCH

Partner Universities:

University of Edinburgh
University of Strathclyde, Glasgow
Queen's University Belfast
University of Exeter

Associate Universities :

University of Cambridge
Cardiff University
University of Dundee
Heriot-Watt University
Imperial College, London
Lancaster University
University of Manchester
Plymouth University
Swansea University
University of Oxford
University Southampton

SUPERGEN UK MARINE ENERGY RESEARCH
PHASE: 1 (2003-2007)

WP1: Resource and Interactions
WP2: Evaluation and Optimisation
WP3: Engineering Guidance
WP4: Offshore Energy Conversion
WP5: Chemical Conversion
WP6: Network Interaction
WP7: Lifetime Economics
WP8: Moorings and Foundations
WP9: Novel Control Systems
WP10: Full-scale Field Validation
WP11: Testing of Tidal Devices
WP12: Economic, Environmental and Social Impact
WP13: Dissemination and Outreach

SUPERGEN UK MARINE ENERGY RESEARCH
PHASE: 2 (2007-2011)

WS1: Numerical and Physical Convergence
WS2: Optimisation
WS3: Combined Wave and Tidal Effects
WS4: Arrays, Wakes and Near Field Effects
WS5: Power Take-Off and Conditioning
WS6: Moorings and Positioning
WS7: Advanced Control
WS8: Reliability
WS9: Economic Analysis
WS10: Ecological Consequences
WS11: Doctoral Training Programme
WS12: Dissemination of Results

SUPERGEN UK MARINE ENERGY RESEARCH
PHASE: 3 (2011-2016)

1. SMARTY- Bridging the gap between the hydrodynamic loads that actually occur on real devices and what can be predicted using current engineering best practice.
2. Effects of Realistic Tidal Flows on Tidal Stream Turbines
3. Designing for Survivability
4. Increasing the life of Marine Turbines
5. Interactions Under Combined Waves and Tidal Conditions
6. Extreme Loading of Marine Energy Devices Due to Waves, Currents, Flotsam and Mammal Impact (X-MED)
7. TeraWatt
8. Environmental Impacts of Marine Energy Farms
9. Optimal Design of Large Tidal Farms
10. Reducing the Costs of Marine Renewables via Advanced Structural Materials

SUPERGEN UK Wind Energy Research

The EPSRC supports consortium of seven academic partners to undertake research to improve the cost-effective reliability and availability of existing and future large-scale wind turbine systems in the UK.

Partner Universities:

1. **University of Strathclyde,Glasgow**
2. **University of Durham**
3. **Rutherford Appleton Laboratory**
4. **Loughborough University**
5. **University of Manchester**
6. **Manchester Metropolitan University**
7. **Surrey University**

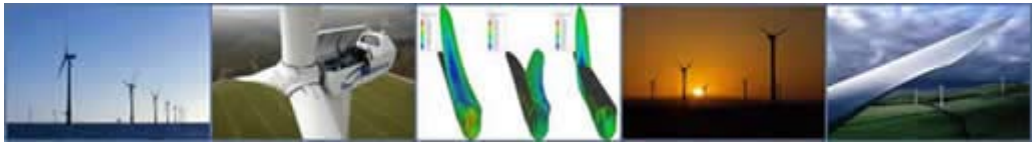
Engineering and Physical Sciences Research Council

UK University of the Year

SUPERGEN UK Wind Energy Research Phase-1 (2006-2010)

Research Themes:

1. Baselining Wind Turbine Performance
   - Reliability and Availability
   - Wind Turbine Configuration
   - Wind Characteristics
2. Drive-train Loads & Monitoring
   - Turbine Characterisation
   - Condition Monitoring
3. Structural Loads & Materials
   - Wind Turbine Component Design
   - Aerodynamic Estimation for Operational Control
   - Active Load Reduction
   - Engineering Large Wind Turbines
4. Environmental Issues
   - Foundation Scour
   - Radar Cross Section (RCS)
   - Lightning Protection

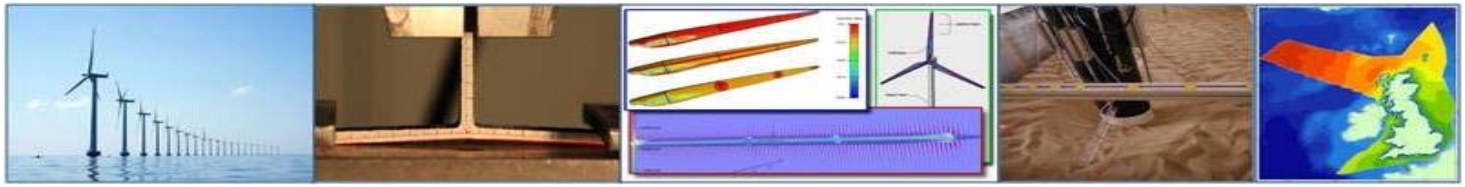


THE AWARDS
UK University of the Year

SUPERGEN UK Wind Energy Research Phase-2 (2010-2014)

Research Themes:

1. The Farm
    - Offshore wind resource
    - Wakes and aerodynamics
    - Radar and the environment
    - Optimisation of farm performance
    - Multiple wake impacts on machines
2. The Turbine
    - Drive train dynamics
    - Rotor-wind field interaction
    - Turbine blade and tower materials
    - Fault detection for a greater range of future wind turbine drive train configurations



THE AWARDS
UK University of the Year

SUPERGEN UK Wind Energy Research Phase-2 (2010-2014)

Research Themes (continued)

3. The Connection
    - New offshore nacelle and sub-statin equipment arrangements
    - Offshore control schemes
    - Connection to shore
    - Integration of energy storage
4. The wind farm as a power station
    - Offshore Connection
    - Economics and Performance
    - Asset Management
    - Dynamic Loading and Structures

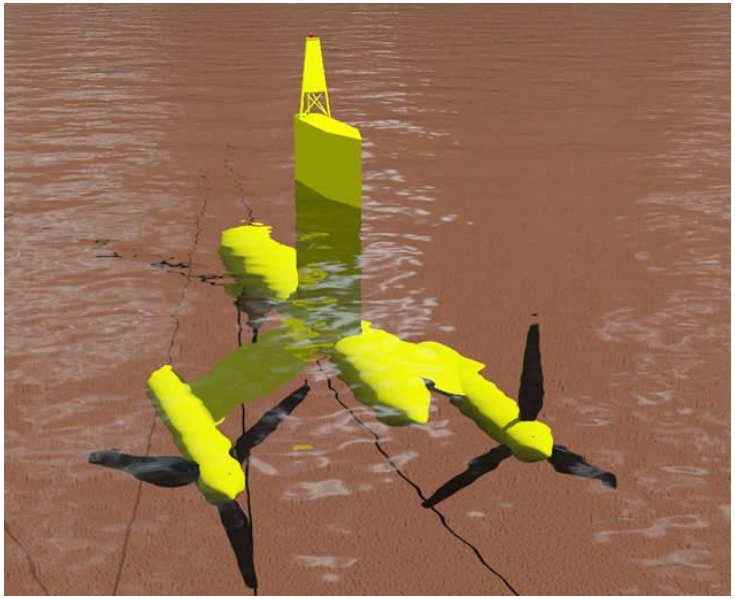
THE AWARDS
UK University of the Year

UK Government Technology Strategy Board (TSB)

TSB supports industry-led collaborative research

Recent programmes support deployment and operation of wave and tidal device arrays (2012):

1. **Developing electrical connection architectures for large-scale tidal arrays**



2. **Developing novel vessels for installation and maintenance of tidal devices**
3. **Developing novel systems for preventing biofouling**

UK Government Technology Strategy Board (TSB)

TSB recently announced an investment of about £7.5m in collaborative R&D projects to accelerate the development of innovative infrastructure technologies for the offshore wind, wave and tidal stream industries, to help reduce the cost of electricity generation.

These projects include:

1. **Development and Demonstration of an intelligent active mooring load-management system (IAMS)**
2. **Reducing the Cost of HVDC Offshore Platforms**
3. **TLPWIND UK: "Driving the cost down of offshore wind in UK Waters"**
4. **Development of a new integrated approach for Structural health monitoring and lifecycle management of offshore wind turbine foundations and transition pieces. (Acronym: Pile-Monitor)**
5. **Rationalising offshore wind-turbine pile design and assurance in difficult ground**
6. **Steered LIDAR Resource Performance and Condition Monitoring For Optimising Offshore Wind Infrastructure**
7. **PLAT-0 2 - Proving a Low Cost, Composite, Buoyant, Mid-Stream Tidal Turbine Platform at Full-Scale**
8. **Offshore Foundation Condition Monitoring Systems (OFCMS)**
9. **Design, build and testing of a 50 kVA SiC BJT inverter as a building block for high-power HVDC inverters**

UK Government Technology Strategy Board (TSB)

TSB recently launched ***Offshore Renewable Energy Catapult*** (based in Glasgow)

The ORE Catapult focusses on technologies for offshore wind, wave and tidal energy
It aims at the identification, development and rapid commercialisation of innovative technology to deliver affordable, offshore renewable energy.
The ORE works in collaboration with policy makers, industry large and small, utilities, owners and the UK's research organisations and will provide RE&D support to SMEs.

Transferring knowledge from established industries (e.g. oil & gas)

Started in Spring 2013

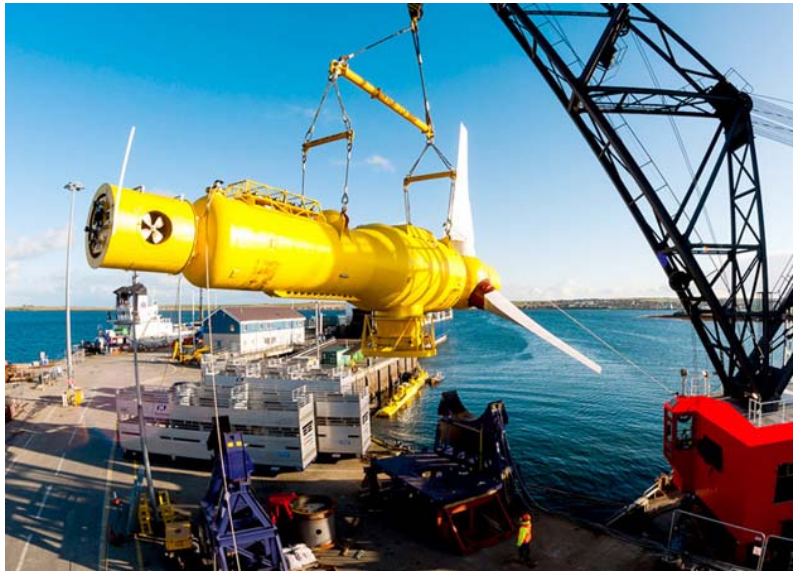
Energy Technologies Institute (ETI)

Public-private partnership between the UK Government and global energy and engineering companies (BP, EDF, Shell, Caterpillar, E-ON and Rolls-Royce)

ETI aims:

to bring together engineering projects to accelerate development of affordable, secure and sustainable technologies (including offshore wind & Marine Energy)

to help the UK address its long term emissions reductions targets as well as delivering nearer term benefit



THE AWARDS
UK University of the Year

European Marine Energy Centre (EMEC)

Funded by Scottish /UK public bodies

EMEC provides device developers with:

purpose-built, open-sea testing facilities

performance assessments

14 full-scale test berths plus two scale sites

THE AWARDS
UK University of the Year

IDCORE Industrial Doctoral Centre in Offshore Renewable Energy

University of Strathclyde Engineering

Industrial Doctoral Centre for Offshore Renewable Energy

THE AWARDS
UK University of the Year

IDCORE Consortium

Universities of Edinburgh, Exeter and Strathclyde

will jointly award the degree of Doctor of Engineering (EngD)

Summer school courses are also delivered by HR-Wallingford and Scottish Association for Marine Science (SAMS).

IDCORE is funded by
Energy Technology Institute (ETI)
UK Engineering & Physical Sciences Research Council (EPSRC)

IDCORE Vision

- *To attract the very best graduate students into a vibrant learning environment*
- *To train them in partnership with industry to deliver Eng.D graduates*
- *To deliver world-class industrially-focussed research outcomes that will accelerate the deployment of offshore wind, wave and tidal-current technologies,*
- *To help to position the UK to meet its 2020 & 2050 targets for renewable energy generating capacity,*
- *To expand and sustain a community of high-quality post-doctoral staff for the UK offshore renewable energy industry.*

Engineering Doctorate (Eng.D)

- EngD programmes provide an industrially-oriented, professional, doctorate requiring the same level of academic rigour as a PhD
- ***Research Engineers*** complete a comprehensive taught programme and pursue a three year project in industry
- EngD is designed to
  - Meet the needs of industry and enhance its knowledge base.
  - Provide graduates with challenging research in an industrial context.
  - Prepare graduates for leadership positions in industry.
  - Produce exploitable outcomes from research.
  - Generate partnerships between academia and industry.

Engineering Doctorate

- EngD programmes provide an industrially-oriented, professional, doctorate requiring the same level of academic rigour as a PhD
- ***Research Engineers*** complete a comprehensive taught programme and pursue a three year project in industry
- Output can be in the form of a thesis (like a PhD) or can be a portfolio of work on a chosen topic

Research Engineers

IDCORE will recruit 50 Research Engineers over five years.

- First intake: five Research Engineers in January 2012
- Second intake: seven Research engineers in September 2012
- Third intake : 15 engineers in 2013
- Further intakes September 2014 and 2015.
- Total programme will run to 2019

Research Engineers Resources

Research Engineers

- Receive a scholarship of £15,000-17,000 per year
- have access to state of the art experimental facilities across the consortium (both for taught modules and research)
- Are issued with a laptop computer with industry standard modelling software installed.

Sponsoring Companies

- contribute £10,000 per year for four years for their student (Except ETI companies)
- provide workplace accommodation and supervision,
- assist in the student recruitment process, and
- Can contribute guest lectures and real world exercises to the taught programme.

Foundation Programme

- Research Engineers study a customised six-month foundation programme
- Programme includes customised element designed to fill gaps in each student's knowledge
- Programme covers Mechanical, Electrical and Ocean Engineering, Hydrodynamics, Structural Analysis
- Programme also covers Economics, Environmental Impact, and Project Management
- Education continues through research programme via summer schools

Industrial Doctoral Centre for Offshore Renewable Energy

Taught Programme

University of Strathclyde Engineering

Term 1	Introduction to Offshore Renewable Technologies Cross-disciplinary Engineering Science Foundations Hydrodynamics of Offshore Renewable Energy Devices Electromechanical & Electronic Energy Conversion Systems Marine Renewable Resource Assessment Economics Tools for Offshore Renewables
Term 2	Marine Operations, Condition Monitoring and Reliability Physical Model Testing for Offshore Renewables Structural Behavior of Offshore Renewable Energy Devices Electricity Network Interaction, Integration and Control Marine Energy Systems Design Interdisciplinary Group Project Marine Renewables and the Environment
Summer Schools	Marine Renewables and Society Offshore and Near-shore Renewables - the Maritime Realities Moorings and Reliability
Distance Learning	Innovation Design and Manufacturing Management Management of the Project Life-cycle Regulation in the Offshore Renewable Sector

Research Project

THE UNIVERSITY OF EDINBURGH · UNIVERSITY OF EXETER · University of Strathclyde Glasgow · HR Wallingford Working with water · SCOTTISH ASSOCIATION for MARINE SCIENCE · Research Councils UK Energy For a Low Carbon Future · energy technologies institute

Research Programme

Students are based in Industry for three years

Each student has an Industry Supervisor

Each Student has a lead academic supervisor

Students also have support from second supervisors from the other two Universities

Students attend summer schools and continue with distance learning

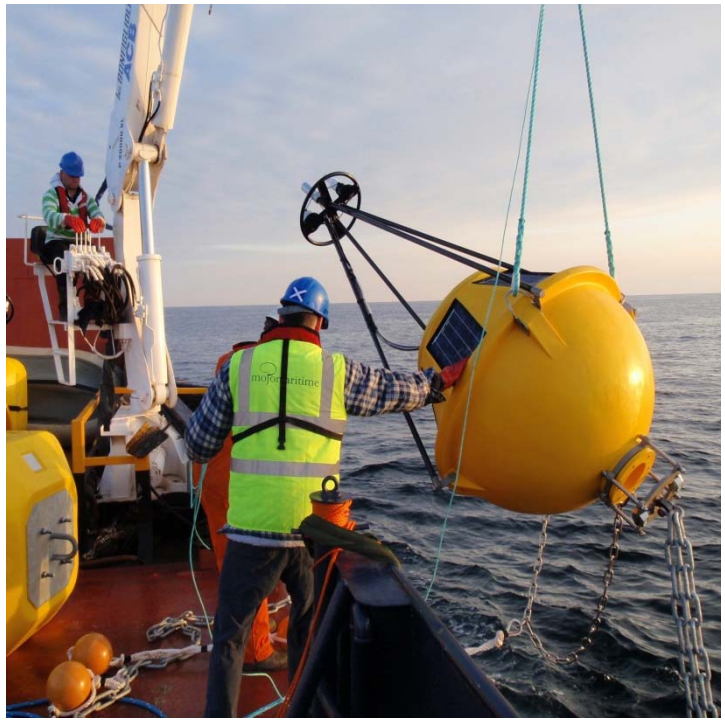
Industrial Projects

Students are based in Industry for 75% of their project

Intellectual Property arising from their work will normally be shared between the student and the sponsor

Except in cases where significant background IP has been licensed from the University.

Research Project Selection



After four months, industry partners present project ideas to students on “Industry Day”

Students choose which projects they wish to apply for; Industry interview and choose students.

Academic supervisors ensure that the students work meets EngD standards

Non Disclosure Agreement set up between the Centre and the sponsoring company.

Sample projects

Projects from first cohort include:

EDF: Numerical study of a real floating wind turbine

E-ON: Assessment of next generation offshore wind turbine foundations installation methodologies

Tidal Generation Limited: Tidal Resource Modelling

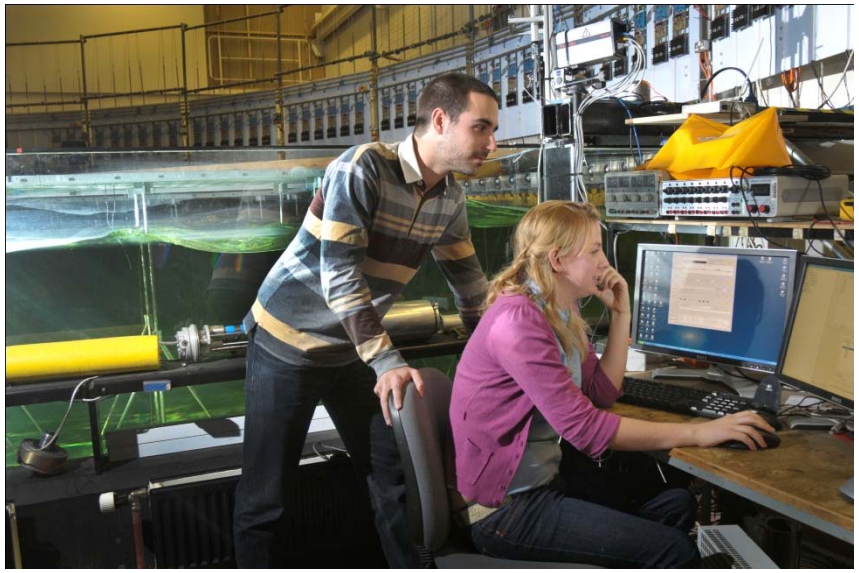
NAREC: Development and Validation of full Scale Lab Based Tidal Turbine Drive Train Test Facility

Sample projects

- Scotrenewables: Tidal turbine rotor study
- Aquamarine: study of compliant wave energy devices
- EDF: Offshore Wind Farm Layout Optimisation
- Sgurr Energy : Tidal Resource Assessment
- Pelamis Wave Power: Design and manufacture of post-tensioned concrete tubes

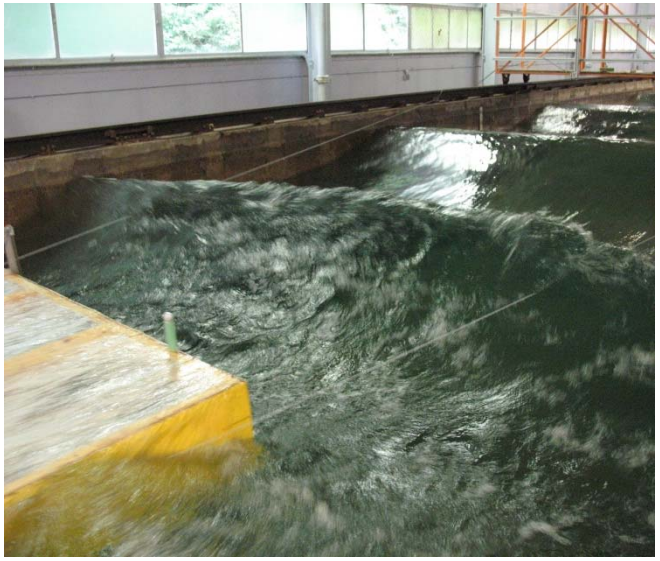
Continuing Professional Development

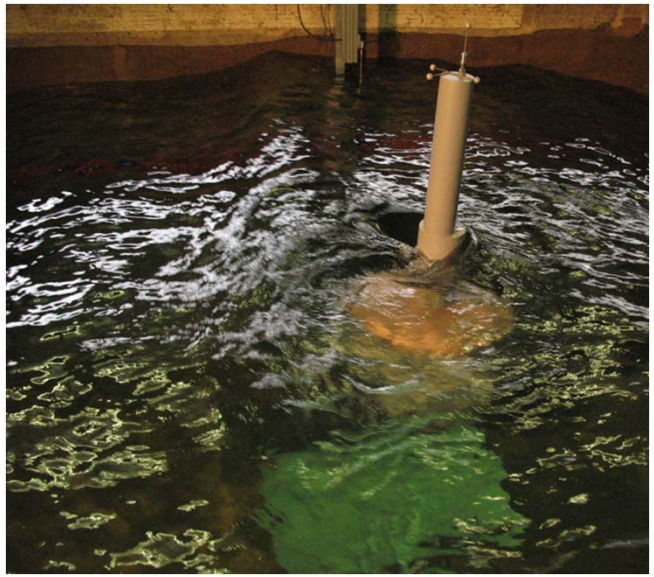
Additional places on the taught programme are made available for company employees wishing to undertake Professional Development (CPD) in offshore renewable energy.




Idcore
Industrial Doctoral Centre for Offshore Renewable Energy
www.idcore.ac.uk

Kelvin Hydrodynamics Laboratory





Kelvin Hydrodynamics Laboratory houses a moderate scale towing tank with high-performance wave-maker well suited for moderate scale renewable energy testing

Tank Dimensions:
76m L x 4.6m W x 2.5m D

Maximal Wave Height:
0.7m (single frequency)

Maximal Carriage Speed:
4.5m/s

Kelvin Hydrodynamics Laboratory: Research Areas

Research is diverse, including

Ship Hydrodynamics
Ship Safety and Survivability
Wave Loads Offshore Structures
Vortex Induced Vibration (VIV)
Sports Hydrodynamics

and
Offshore Renewable Energy

University of Strathclyde Engineering

THE AWARDS
UK University of the Year

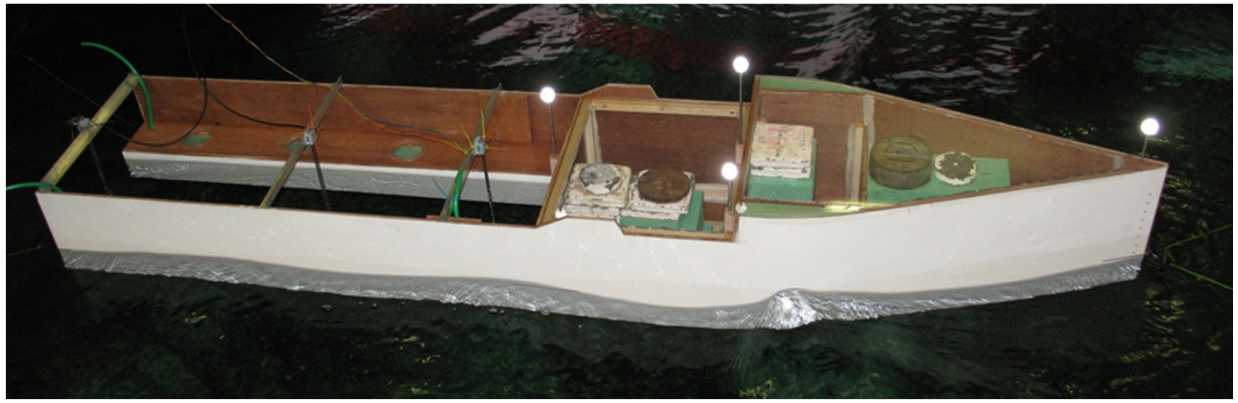
Kelvin Hydrodynamics Laboratory: Renewable Energy

Offshore Renewable Energy activities include research and commercial testing for:

1. Wave Energy Converter performance / survivability / installation

2. Tidal Energy Device Unsteady Performance & Survivability

3. Offshore Wind Maintenance Access Vessels & Systems



THE AWARDS
UK University of the Year

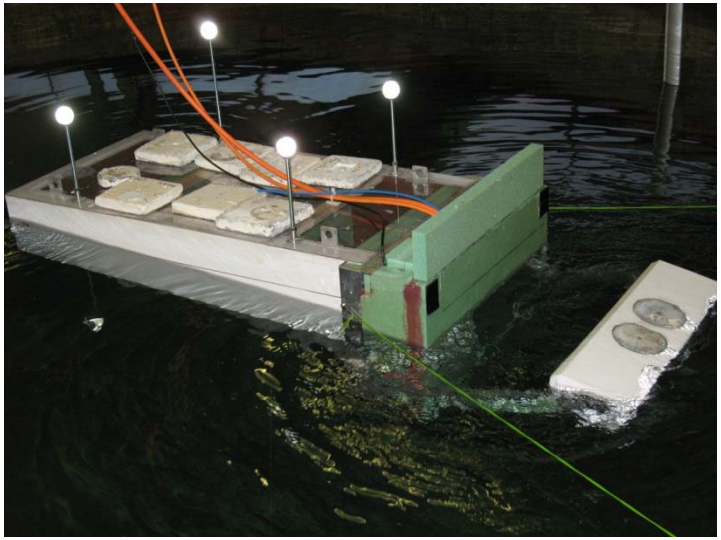
Kelvin Hydrodynamics Laboratory: Renewable Energy

Commercial projects include:

Wave Energy : Checkmate SeaEnergy (Anaconda), Pure Marine, AWS Ocean Energy, Aker Solutions, Sea Energy, Sea Power, Aquamarine (Oyster) Neptune Energy, Green Ocean Energy…

Tidal Energy: Scotrenewables, Oceanflow, Nautricity, Nova Innovation, Tidal Stream…

Offshore Wind: Z-technologies, Divex, Solid Sea Transfer…



THE AWARDS
UK University of the Year

Other UK initiatives in Offshore Renewable Energy

The Saltire Prize: a prize of £10 million was funded by Scottish Government, to accelerate the commercial development of wave and tidal energy technology

The Prize is open to any team from across the world who believes they have wave or tidal technology capable of fulfilling the Challenge.

The winner will be the team that achieves the greatest volume of electrical output over the set minimum hurdle of 100GWh over a continuous two year period, using only the power of the sea.

The ***Junior Saltire Prize*** was launched in 2011 and is specifically aimed to inspire the next generation of innovators and entrepreneurs in Scotland's schools.

MARINET Marine Renewables Infrastructure Network for Emerging Energy Technologies

Ocean Basin: Ecole Centrale de Nantes

MARINET Background

MARINET (*Marine Renewables Infrastructure Network*) is an €11m EC-funded infrastructure initiative running from 2012-2015

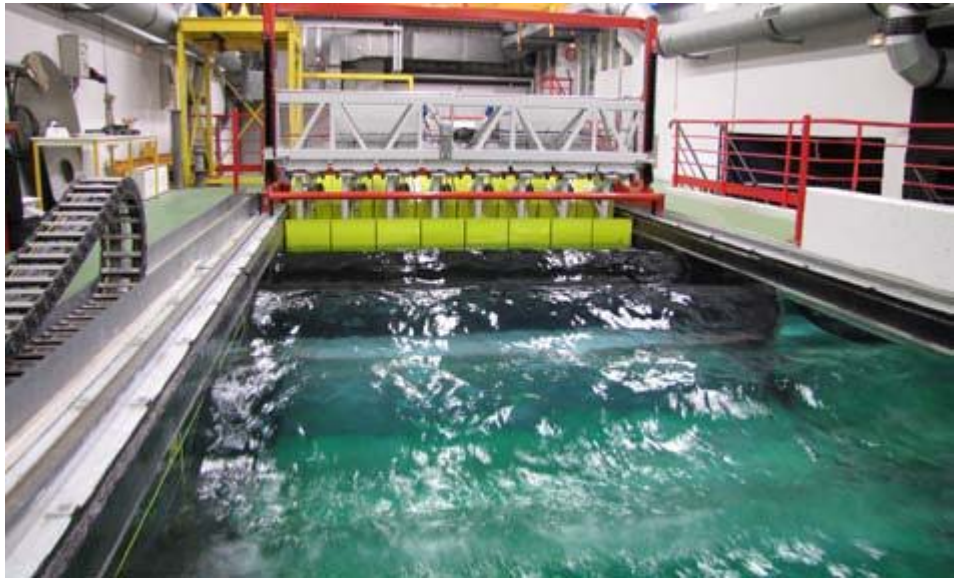
MARINET is a network of research centres and organisations working together to accelerate the development and commercial deployment of marine renewable energy technologies.

New Test Facility at University of Edinburgh: FloWave TT

MARINET Aims

- **MARINET** aims to facilitate testing for the renewable energy industry by offering periods of free-of-charge access to world-class test facilities including laboratory and field trial sites

- **MARINET** is also developing joint approaches to testing standards, research and industry networking & training.



Wave-Current Circulation Tank: IFREMER France

MARINET Partners

The MARINET network consists of 29 partners

With 42 specialist marine research facilities

Spread across 11 EU countries

And 1 FP7 partner-country, Brazil.

Transnational Access

Companies and research groups can apply for periods of free-of-charge access to facilities -

to test devices at any scale in applications areas such as wave energy, tidal energy, offshore-wind energy and environmental analysis

Facilities must be located in EU countries other than that of the company: "***Transnational Access***"

EMEC Test Support Buoy,
Scapa Flow Wave Test Site

Transnational Access

Companies can also conduct tests in cross-cutting common areas such as power take-off systems, grid integration, materials or moorings.

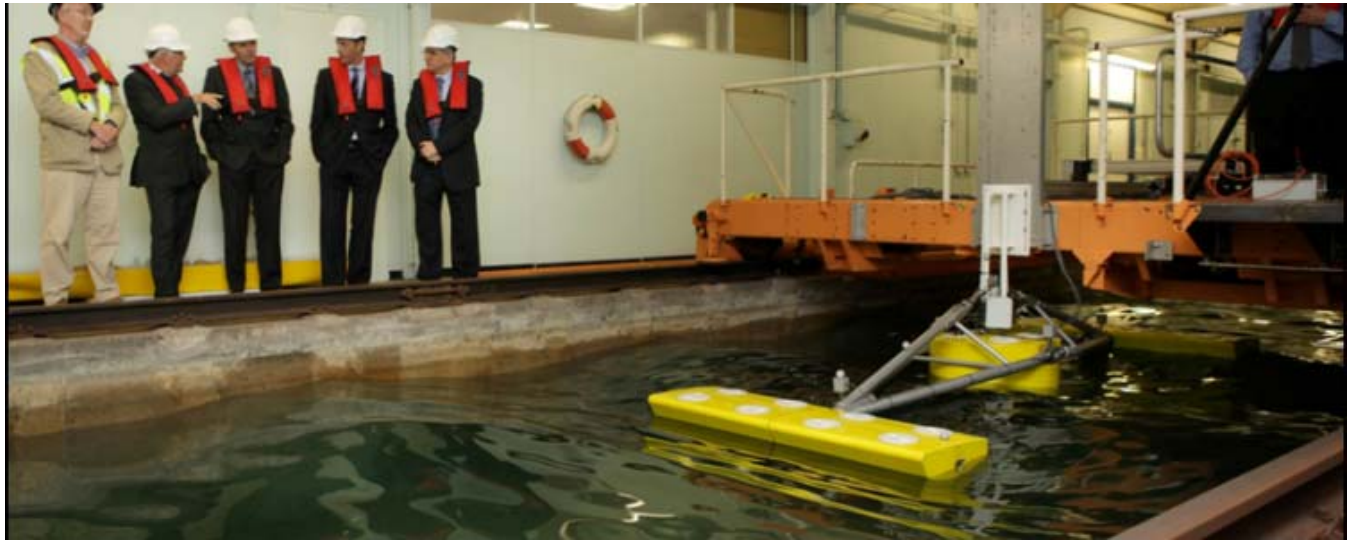
In total, over 700 weeks of access is available to an estimated 300 projects and 800 external users, with at least four calls for access applications over the 4-year initiative.

WavEC - Full-scale OWC for Real-Sea Testing of Air Turbines

NAREC - Nautilus Rotary Test Rig

Transnational Access: Process

- MARINET issues call for access – typically for a six-month period
- Device developers and Researchers apply to use MARINET facilities
- Applications are refereed by Infrastructure managers and MARINET Board
- Successful Applicants are granted time at facilities
- Facilities are funded (at cost) by MARINET at agreed rate
- Applicants are funded for travel and subsistence



University of Strathclyde Kelvin Hydrodynamics Lab

Parallel activities

- Testing Protocols developed in the EC FP7-funded project EquiMar and by the IEA-OES are being implemented and further refined at all MARINET infrastructures.
- Outcomes are feeding directly into on-going international standardisation exercises such as IEC TC114, and ITTC guidelines

CNR – INSEAN Circulating Water Channel

Parallel activities

- MARINET is conducting Comparative testing – a 'Round Robin' testing of a calibration model in MARINET facilities to characterise and verify the performance behaviour of the various test facilities.
- This is particularly relevant to tidal turbine testing due to availability of many types of facilities – towing tanks, circulating water channels, wave-current basins

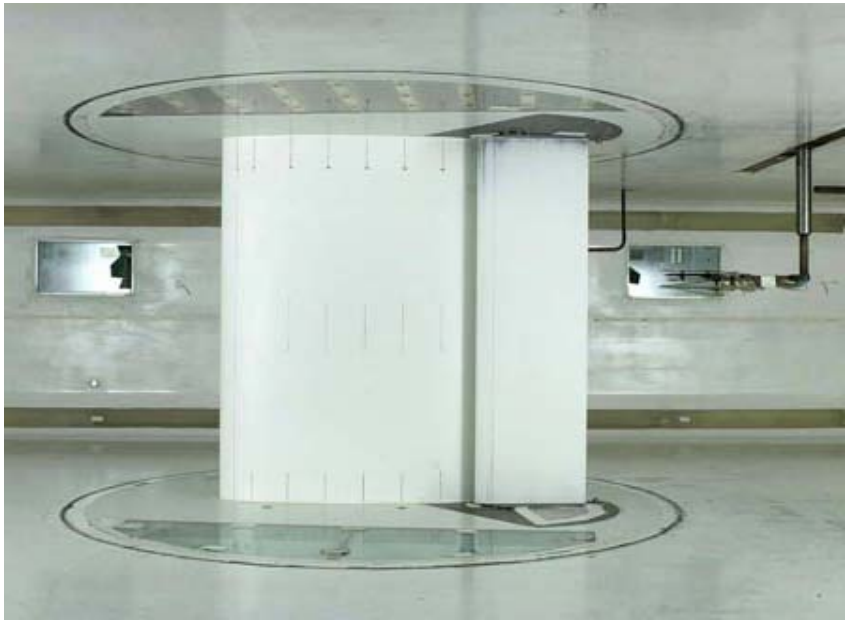
TTC Tidal Testing Centre Den Oever

Parallel activities

MARINET also offers a series of short free training courses aimed at researchers and postgraduate students, but open to companies, research groups & universities

Course include:

- Experimental Testing in Wave Tanks and Flumes
- Monitoring of Pilot Plant and Pilot Zones
- Instrumentation of Ocean Devices
- Experimental Modelling of Electrical Equipment
- Experimental Modelling of Air Turbines
- Offshore Wind Measurement Techniques
- Remote Sensing in the Offshore Environment
- Experimental Modelling of Wind Actions on Offshore Structures



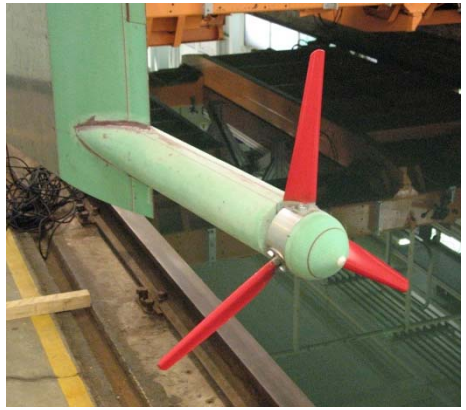
University of Stuttgart - Laminar Wind Tunnel

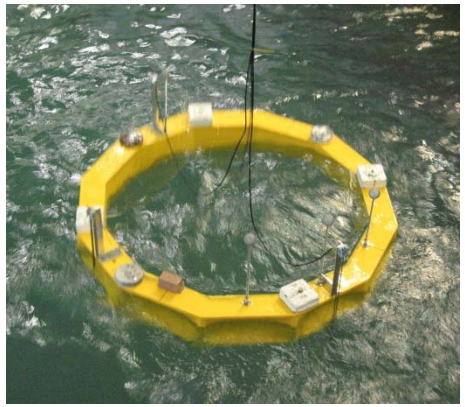
References:

1. *www.supergen-marine.org.uk*
2. *www.supergen-wind.org.uk*
3. *www.innoveteuk.org*
4. *www.eti.co.uk*
5. *www.emec.org.uk*
6. *www.idcore.ac.uk*
7. *www.fp7-marine.eu*
8. *www.strath.ac.uk/naome*

University of Strathclyde Engineering

Thank you very much for your attention





THE AWARDS
UK University of the Year