Supergen 3
UK Centre for Marine Energy Research

Themes
- Arrays and farms
- Extreme loadings and durability
- Novel marine energy systems and components
- Environmental interaction
- Fatigue loadings and reliability

Grand Challenge Projects
- EcoWatt 2050
  Supergen Marine Technology Challenge (SMARTY)
  Increasing the life of Marine Turbines by Design and Innovation
- Modelling Marine Renewable Energy Devices - Designing for Survivability (EloWEC)
- Optimal Design of Very Large Tidal Stream Farms for Shallow Estuarine Applications
- LS interactive coupled modelling of environmental impacts of marine RE farms (LINC)
- The Effects of Realistic Tidal Flows on the Performance and Structural Integrity of TSTs
- The hydrodynamics of deformable flexible fabric structures for wave energy conversion
- Reducing the Costs of Marine Renewables via Advanced Structural Materials (ReC-ASM)
- Interactions of Flow, TSTs, Local Sediment Bed under Combined Waves&Tides (INSTRON)
- LS-Interactive Coupled 3D Modelling for Wave & Tidal Energy Res&Env Impact (Terawatt)
- Extreme Loading of MEDs due to Waves, Currents, Flotsam and Mammal Impact (XMED)
- Step Change for WEC through Floating Multi-Body Multi-Mode Systems in Swell (STEPWEC)
Supergen 4
UK Centre for Marine Energy Research

Themes
- Control and Performance
- Risk and Reliability
- Extreme loads and survivability
- Array Interaction
- Materials and Structural Integrity

Grand Challenge Projects
- Dynamic Loadings on Turbines in a Tidal Array (DyLoTTA)
- Survivability of Floating Tidal Energy Converters (SURFTEC)
- All Electric Drive Train for Marine Energy Converters (EDRIVE)
- Response of Tidal Energy Converters to Combined Tidal Flow, Waves, & Turbulence (FloWTurb)
Overarching Aims

UKCMER has always aimed to

**Conduct** world-class *fundamental and applied research* that assists the wave, tidal and offshore wind energy sector to accelerate deployment and ensure growth in generating capacity towards 2030 and 2050 targets.

**Expand** and operate an inclusive *marine network* of academic researchers, industry and policy partners and international collaborators.

**Provide** the highest quality of *industry partnership* and *policy engagement* and *knowledge transfer* to sustain progress, sense of purpose and momentum in the sector.
Networking and engagement

**Policy** UKCMER has worked closely with key UK policy stakeholders, including: Renewable UK Marine Strategy Group; ETI Advisory Board; South West Marine Energy Park; Scottish Renewables Marine Working Group; Scottish Government Marine Energy Group; Northern Ireland Environmental Agency; Marine Management Organisation; Scottish Government (Marine Scotland Science); Natural Resources Wales; Welsh Government and The Crown Estate.

**Industry** Direct collaborators: Nautricity Ltd; Nova Innovations; Tidal Energy Ltd; Sustainable Marine Energy; Lloyds Register; Sgurr Energy; RES Ltd; Marine Power Systems Ltd; Marine Energy Pembrokeshire; Oceanflow Energy; EMEC; Black and Veatch; DNV GL (UK); Partrac Ltd; Scotrenewables Tidal Power Ltd; AlbaTern; Carnegie Wave Energy Ltd (UK); Columbia Power Technologies Inc; LABEIN tecnalia; Turbopowersystems; NIOT Chennai; Airborne Composites BV; ANSYS; Arup Group Ltd; Bosch Rexroth Corporation; Lloyd's Register; National instruments; SKF Group.

Offshore Wind Structural Lifecycle Industry Collaboration (SLIC) Joint Industry Project (JIP) brings: Centrica Renewables; DONG Energy; EDF-Energy; Energie Baden-Württemberg (EnBW); E.ON UK; RWE; SSE; Statkraft; Statoil; Vattenfall; Siemens; DECC and The Crown Estate.

Jeffrey serves on Renewables UK Marine Strategy Group; Wallace chairs the ORE-Catapult Research Advisory Group; Jeffrey is seconded to Wave Energy Scotland.

**Academic** UKCMER has established relationships with comparator consortia and academic research groupings in Taiwan, China, USA, Canada, France, Norway, South Korea and Singapore. Past and present GC partners; Delft University of Technology; University of Chile; Pontificial University Catolica; Cape Breton University; UNAM Mexico; IIT Madras; IIT Bombay; IIT Kharagpur; Hiroshima University, Nagasaki University

**International** UKCMER (Jeffrey) chair of the IEA Ocean Energy Systems Implementing Agreement. UKCMER staff continue to: provide leadership of EERA Marine; chair the Executive of EWTEC; be Board Members of Ocean Energy Europe and AWTEC; be Members of IEC Technical Committee 114.

Staff continue to engage in key strategic collaborations in countries with emerging ocean energy research programmes such as Chile (MERIC), Mexico (CEMIE-Oceano), Japan (Nagasaki Marine Industry Cluster) and India (Min of Energy, UK SIN and FCO, West Bengal Renewable Energy Devt Agency and WWF - India)
Challenges are multi-faceted, programme needs to:

- Grow and make coherent UK research capacity and infrastructure, to develop materials, technologies, knowledge and practice.
- Evolve a transition pathway, from resource to end-use of energy, to develop affordable new low-carbon technologies;
- Help deliver resilience, security and economic and social acceptability;
- Ensure the world-leading outputs and delivery from research and innovation lead to intellectual and economic growth;
- Build human and physical capacity;
- Conjoin stakeholder, delivery and beneficiary communities;
- Define and deliver interventions that respond to the Global Challenges in energy.
Programme vision & mission

The vision is that the Supergen programme will continue to deliver excellent research, innovation and training and see the results of its efforts affordably transform the energy system to one of much lower carbon emissions with improved security of supply.

The mission is to conduct **use-inspired basic** and **applied** research in the key lower-carbon energy sources and technologies to drive disruptive change and innovation towards a more sustainable energy system that is more resilient and secure, and within which there lies greater economic and social wealth.
ORE context and importance

Offshore renewable energy technology and capacity development is a key opportunity.

• We lead the world in the research, innovation, development, demonstration and deployment.

• We have 35% and 50% of European wave and tidal current energy potential, have a greater installed capacity of tidal current technologies and have demonstrated more wave technologies than the rest of the world put together.

• Our innovation chain is better-developed and more continuous than anywhere else in the world. UKCMER, IDCORE and the CDTs is training more PhD students for the sector than any other country.

But….

• The world is catching up fast. IEA International Vision for Ocean Energy: 337 GW of capacity; 1.2 million jobs and CO₂ emissions reduced by 1 billion tonnes by 2050.

• Sustained effort from R&D to deployment must lead to demonstrable results to ensure the delivery and installation of enduring and reliable devices at scale in the sea.

• To retain our world-leading position we must nurture and grow an agile, credible, capable and properly equipped research community.

• Addressing fundamental to applied research challenges is critical if the UK is to engage in trans-continental alliances that will up-scale tidal energy, establish wave energy and address the evolution from on-shore to fixed and floating off-shore wind.
Sectoral Agreed Plans
• Predicting and delivering performance – **Numerical and physical closure**
• Manufacturability & installability of components, subsystems and technologies – **Right first time**
• Survival and durability under extreme loadings – **Avoid catastrophic failure**
• Increased reliability, operability and maintainability under fatigue loadings – **Remain available - Don’t wear out**
• Economic, social and environmental interaction and affordability – **Reduce risk to be acceptable**
Hub R&I Challenges

Design optimisation and tool development to predict & deliver performance

• Well beyond today we need to be able to understand the natural resource and predict the energy and economic yield from individual devices or arrays.

• Requires continuing development of design and optimisation tools, including non-linear, fully coupled, 3-D and time varying hydrodynamic, structural, electromechanical models both in numerical form and at tank scale.

• Scale and in-sea measurements must be used to drive numerical and physical closure between predicted and actual performance.

• Optimisation must maximise energy yield at minimum cost.

CAPEX reduction in manufacture and installation of components, subsystems and technologies

• Sub-systems or sub-components must be system-integrated and optimised individually and collectively to maximise capability, performance and reliability.

• Need to concurrently reduce capital cost and advance technology to be better fit for purpose in the ocean.

• Capex of installation and setting to work must also be reduced through applied research and innovation and increase in know-how gained during increasing deployment.
Hub R&I Challenges

Increased yield and reduced OPEX through survival, durability, operability and maintainability

- Components, subsystems, technologies and structures of devices must withstand the most extreme loadings in and outside normal operation lowest realistic cost.
- Lifetime energy production must be maximised by extending mean times between failure through greater resistance to wear and failure under repetitive and cyclic loadings and improving operating and maintenance regimes.

Economic, social and environmental interaction and affordability

- Lifetime costs of energy have to be demonstrated to be competitive with mainstream renewables and social and environmental interaction has to be understood, fairly measured and assessed for acceptability.

Networking and engagement

- UK, European and International networking and collaboration is essential among fundamental and applied research providers, industry partners and environmental stakeholders.
- Policy and innovation engagement is equally essential to maintain landscape.
### Specific R & I needs

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<tr>
<th>Design optimisation and tool development</th>
<th>Immediate</th>
<th>Short term (within 5 years)</th>
<th>Medium term (within 10 years)</th>
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<tr>
<td>Understanding large scale turbulence, and its effect on the tidal farm environment; Predicting effects of wave propagation through tidal farms. Predicting effects of flow misalignment on turbines; Modelling large scale wake interaction with tidal flows.</td>
<td>Non-linear models and tools; techno-economic optimisation tools; Fully-coupled array to network models; quantifying 3D and time-effects of wave and tidal resources on energy yield, durability and reliability; Standardisation of intra-array network layouts and transmission options for arrays and farms.</td>
<td>Development of spatially defined bed resistance models; comparison and validation with ocean scale models; Designing and dimensioning PTO systems for optimal control;</td>
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<td>CAPEX reduction in manufacture and installation</td>
<td>Improved foundations and moorings (dynamics/materials), fixings, station keeping; affordable offshore umbilicals and wet MV connectors;</td>
<td>Cost-effective design of integrated power-take-offs, power electronic converters and control systems; Cost effective device structures; Economic recovery &amp; installation methods.</td>
<td>Whole systems integrated design for cradle to grave lifetime needs.</td>
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<td>Increased yield and reduced OPEX</td>
<td>Mitigating extreme loads power capping and load shedding; demonstrating increased reliability at component and system level;</td>
<td>Design for maintenance; Intelligent predictive maintenance systems; Development of robust techniques for the estimation of extreme loads; Maximising performance while minimising loads; Device and technology performance data collection and analysis Increased reliability at array and farm scale;</td>
<td>Remote monitoring, optical and acoustic technologies; condition monitoring and control for arrays; Understanding the effects of sea water on degradation of composites; Hybrid and functionally graded structures to mitigate wear.</td>
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<td>Economic, policy &amp; environmental interaction</td>
<td>Improved Environmental Impact Assessment tools; Determination of acceptable means and monitoring for environmental compliance certification.</td>
<td>Model, quantify and validate marine animal/mammal impact on turbines; Understand, predict and mitigate effects of biofouling; More robust techno-economic analysis.</td>
<td>Understand model and mitigate large scale and long term impacts on ecology; Develop methods for estimating the far-field impacts of wave and tidal farms.</td>
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**Networking and engagement**