ORE Supergen Challenge Workshops:

TRANSFORMATION OF THE ORE SYSTEM - RESEARCH CHALLENGES

Minimising human intervention (safety)

Autonomy
Condition monitoring; Remote monitoring and fault diagnosis; Remote sensing and condition monitoring (digital twin); intelligent wind turbines and AI / machine learning with remote resets and repairs
AUV access for inspection/maintenance; Autonomous vessels/Robotics, i.e. for monitoring of turbine and structure, environmental monitoring; flexible/autonomous ships; complete autonomous vessels with a range of auto units for separate tasks
Automated/remote sensing/data collection tech / tools - for environmental interactions, integration with devices/infrastructure
Engage existing offshore service providers to ensure they understand the purpose of autonomous / remote systems offshore (displaced employment opportunities
Environmental monitoring technologies fully integrated in blades / infrastructure e.g. birds
Fully autonomous farms with logistics solutions
Active learning with regard to autonomous motion and positioning subsea; path planning in mid water
Data transmission through water; no Doppler signal from seabed
Regulations and legislation of UAV systems
Smart sensors – smart, robust, cheap, underwater

Control
Wind farm control and feedback
Frequency control and power oscillation damping
Integrated system dynamics of floating wind turbines
Intelligent and smart control to displace structure
Improve grid interaction with reactive power control, voltage regulation and other ancillary services; address issue of sudden outages (when wind turbines are generating at high power and a fault takes place for example)

Improving communication/resolving conflicts

Data/information/knowledge sharing/exchange
Affordable data collections systems – archiving – data mining; BIM/GIS equivalent for ORE; common data formats e.g. AGS
Early engagement/Integration of environmental issues to facilitate designing out of environmental issues
Uncertainty; difficult conditions, use established knowledge understanding
Interaction with other marine users - tech/skills synergies, conflicts (planning, insurance), co-location
'Soft' infrastructure – local knowledge/ capability
Raise awareness/sharing of performance and failure for whole life cycle
Data anonymity and building trust
Providing access, increasing availability (public)
OEMs/Developers/Academia/regulators (e.g. consenting mammals/benthic impacts)
Improved analysis tools and treatment of big data, smarter benchmarking
Software sharing and curation
Share lessons learnt, e.g. structural responses
G+ (global offshore wind health and safety organisation)
Regulators, OWA, ORECAT, EU, Networks etc., H2020, European academy of wind energy
Data and digital cyber security

Providing reassurance / informing / educating
Public acceptability issues - communicate progress on collision risks to de risk public perceptions
Environmental considerations early to avoid conflict in consenting process
Commonality in systems, share progress
Run events specifically for politicians to educate at level of non-scientist
Ocean literacy – communication to politicians and public, education, improved understanding public engagement;
Ecological impact/perception of harm - communications re for e.g. noise impacts on mammals
Ensuring societal acceptance/addressing public perception
Consistent language
Informing government better

Reducing uncertainty/risk

Better data/ understanding
Detailed measurement of the ocean over time (velocity, waves, turbulence); resource variations, extreme events; site specific
Risk – reliability/survival
Standardised approaches to environmental monitoring across sectors with national data sets
Resolve environmental impact uncertainties
Better measurement/forecasting/characterisation of resource/MetOcean, i.e. wind @ 100m, influence of land, accessibility forecasting, extreme event prediction etc.
Marine system carrying capacity - Limit of UK coastal waters to accommodate offshore wind; environmental limits
Cumulative/in combination effects - better prediction and detailed monitoring overtime; Industrialisation of offshore - far field and cumulative effects - 'in-combination' effects
Evidence for collision risk - further develop tech. ; Improve collision risk models (for birds/moving wind)
Cyclic loads on foundations/soils
Operational limits of devices, i.e. size limitations of turbines, fatigue damage
Biological impact: birds, mammals, benthic (cabling)
O&M uncertainties: risk based approaches to minimise risk
Dynamics/system stiffness of moored systems
Better understanding of wakes (wind and tidal)

Reducing policy uncertainty
Route to market (tidal), needs policy framework, gov't and public support
Political will – 'need a political champion' who is open to learning the opportunities presented by the offshore industry (learn from wind)
Clear vision and policies for 2050, endorsed by gov't, informing policy and public

Reducing financial risk
Impact of failures on investor confidence
Valley of death – no support to commercialise
Reduce uncertainty of LCOE prediction; £/kWh – overall system models; economic analysis
Return on investment - expectations of investors
Confidence in returns on investments
Providing reassurance to investors/confidence in returns

Public acceptance / perception
Environmental considerations early to avoid conflict/consenting issues
Impact of poor ocean literacy on perception
Lack of confidence – in tech, public perception and awareness, impact on investors
Aesthetic impacts of turbines close to shore - consenting risk and impact on schedule

Innovation (in design/methods)

Improved design (cost effective)
Novel concepts for wave and tidal devices
Novel PTO & control system for wave - control systems for wave to improve yield & survival
Design for through-life performance with reliable components, balance among device properties, control strategies and PTO properties
Yield optimisation; blocking and efficient arrays in real channels
Moorings & foundations; coupling mooring analysis and hydrodynamics for OW / W devices; multi devices per foundation
Structured innovation for wave technology
Structural design/structure of wind turbines
Improve reliability of electrical power conversion systems (all components)
Cable life
Multi-device in one system (MPP)
Mooring systems and cost reduction of mooring components
Reduce cost of all components (i.e. some from O&G - over engineered)
Floating wind - safe, economic, reliable, how to build/get energy out? Spar vs. TLP
Multi-rotor design for wind turbines
Larger wind turbines (20MW+)
Hybrid systems/Multi-purpose platforms (MPPs)
Vertical axis wind turbines (VAWTs),Fault tolerant modular designs, Airborne wind & PTO
Innovative subsystems and components
Power transmission alternatives, e.g. HVDC, and connection to shore - cost effective/reliable
Design for different service lives than 25 years
Design for decommissioning (whole life)
Validated design and fatigue models for composite tidal blades (cross sectoral in wind)
Accelerated fatigue testing of tidal turbine blades
Improved industry participation in design code development and optimisation
Risk based design
AI into control to reduce weight and costs
Consider redundant systems to reduce time off for maintenance and human intervention
Optimal control under network constraint
Remove future decommissioning cost – establish case for triple bottom line benefit of in situ decommissioning of structure/foundation
Combined aero, hydro, mech. response analysis → RT control for optimal response and FSI

Better design methods
Modularisation / streamline manufacture to minimise (high risk) offshore activities; reducing cost of deployment); new concept to combine device into one system
Technology convergence to follow markets/opportunities; convergence of components/ whole systems; component consolidation for wave
Probabilistic design
Wind farm analysis and design tools
Similar design philosophy for monopiles/towers
Unpack existing practices inherited from O+G – padded due to people/hydrocarbon risk. Instead develop rational, coupled structures & foundations with the right target reliability
We spend too much on site surveys and inspections, use smart survey tech (autonomous geotechnics and geophysics) and smart inspection methods (remote vision/intervention)
Cables should not be design on same basis inherited from large O+G pipelines; revisit fundamentals of exposure and support to unlock more cost effective designs

Numerical modelling
Hydrodynamic interaction for support platforms of devices; aerodynamics FSI
Arrays - Efficient numerical models for optimisation; optimal control; understanding device conditions; hydrodynamic interaction; uncertainty quantification
Numerical models – understanding of best practice, error, assumptions (better use, reduced risk, reduce LCOE); system based numerical modelling
CFD - Fully coupled FSI/ 3 phase flow (air, water, solid)
Extreme loads vs. operation behaviour; lifetime loadings / fatigue; understanding localised environment conditions to inform aggregated effects (e.g. on fatigue); modelling/prediction of extreme/'strange' environmental loads
Understanding scaling effects – move towards larger scale modelling or field experiments
Fully integrated/coupled design tools, i.e. wind, wave, current, structure
Cheaper methods for resource assessment (virtual MET mast)
Improved geo-tech modelling
Wake modelling (wind)
Integrated design tools for floating structures. Most need for development
Array optimisation: maximisation of extracted energy while minimising environmental impact
Hydro –wave – sediments – biogeochemical – coupled numerical models to assess positive/negative environmental impacts
Modelling of large deformation geotech./installation problems and validation

Better manufacturing methods
Innovative manufacturing process for modular systems
Additive manufacture with bespoke material (limitations to component size?)
Preparation for reduce cost/ high quality re-commissioning
Design and development of load limited systems/reuse of high cost infrastructure
Condition monitoring/appraisal (SHM) to enable re-use max value of high cost infrastructure
Reduction in composite manufacturing costs
Common fabrication of monopiles/towers
Standardisation of fabrication of substructures. Difficult to design for all options

Better/ alternative materials
Low carbon materials (whole life-cycle / fit for purpose in ocean environment – marinisation of components; resilience, corrosion, degradation, protection e.g. Fouling on joint sensors
Combined coatings / materials vs biofouling
Better materials for turbine blades, alternatives for floating e.g. concrete hulls, wave (composites, potential for WBRH learning → tidal devices (smaller) support structures
Anti-corrosion (protecting assets) (or replace corroded elements)
Design for high fatigue life/materials for this and control (above)
Modelling methods to enable evaluation of innovative solutions and of high fatigue life
Framework for evaluation/managing service life
Active coatings
Bio inspired materials and structures
Programmable materials EAPs etc.
Smart composites (anti-corrosion and SHM ;layers)- Wind, wave, tidal, cross sectional
Composite materials benefits as alternatives to steel as less biofouling, greater performance, lower mass, Res Q: recyclable/re-use
Biofouling integrated with design (very difficult to apply retrospectively) – Wind mainly/splash zone could be major LCOE gain
Control methods to enable the use of more flexible, lightweight materials, and/or stabilisation of dynamics response (wave control on floating wind)
Design of high tolerance drivetrains to enable large dynamic response – digital hydraulics/direct drive bearing

New management strategies
Joint / community ownership models (as on land)
Colocation of technologies/smoothing of power supply at large scale (interaction) – large scale/systems level
Hybrid devices (as for power supply and/or for stability)
Increased use of automation to reduce installation and operation (O&M)
Links - control systems repos farms drawing on big data/embedded sensors (SHM)
OF-HUB: collaboration across industry partners on modelling/field/site/data
Contracting strategy to allow optimised fabrication

New financial / commercial models
Innovative finance mechanisms; development grants for technology and challenges, generation subsidy
Finance/commercial management/models
Links – optimisation of service life of existing systems (structures for reuse/over several generations of device
Pathways to cost reduction without increase MW per support
Joint industry common testing platform for cross sector components
Improved confidence in industry leading to finance improvements
Reduce uncertainty of cost predictions – learning from offshore wind reliability methods

Identifying opportunities

Cost reduction
Structured plan to reach acceptable COE and lower risk (sector wide) – UK benefit, needs to be in global context, potential to reduce LCOE
Cost reduction - but gap between industry and academia because of REF and apps
Cost optimisation on both CAPEX and OPEX
Optimisation of O&M through integration of methods/tools

Identifying market opportunities
New markets (small scale, non-grid connected); scope for multi-purpose projects, to fill valley of death with gov't / policy support
Export opportunities – international markets -> GCRF/ODA

Socio-economic opportunities and benefits
Means to maximise the benefit for the UK (with Brexit uncertainty)
Development of social capital/well-being from employment, identity and cultural aspects i.e. benefits beyond low carbon electricity - analyse salient factors e.g. 'Orkney-story'
Need a route to market for wave and tidal - no policy framework need sustained support for industry and expectations managed
Awareness of markets
Community owned projects; integrated community ownership/joint ventures (JVs) with energy companies
Clear vision and policies for 2050, endorsed by government, informing policy and public to bring forward large installations which recognise wind as major contribution to system
Public engagement demonstrator -> "bloodhound" type initiative for ORE
Mapping social benefits -> valuation of benefits

Recycling / relifing
Decommissioning - recycle, reuse, repair, repower
Recyclable wind turbine blades
Recycle tidal turbine blades (cross-sectional)
Remove everything design vs. Design for decommissioning

Environmental benefits
Design in environmental benefits (e.g. de facto MPAs), decommissioning, reef effect - X-sectoral engagement; wider use of systems based modelling tools, GES;
Interaction with other marine users - technology / skills synergies, conflicts (planning, insurance), co-location
Strategic approach to design including cabling to reduce impact on environment or design in benefits - to minimise industrialisation of offshore - co location aquaculture / MPAs etc.
Quantify environmental benefits, i.e. restoration, feeding into CSR, carbon accounting