



future Wind & Marine 2019

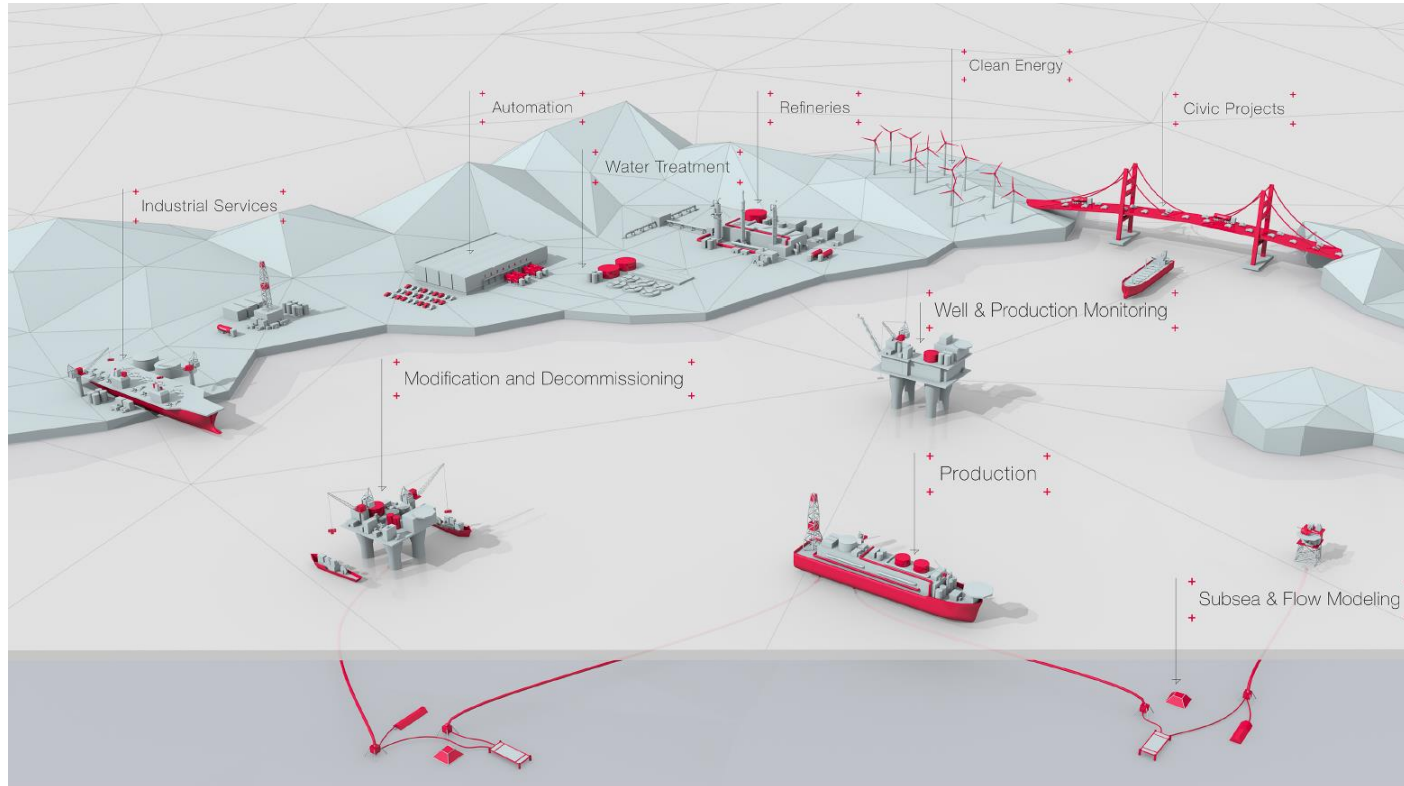
Industry-Academia Collaboration

Challenges & Opportunities

Alan Mortimer

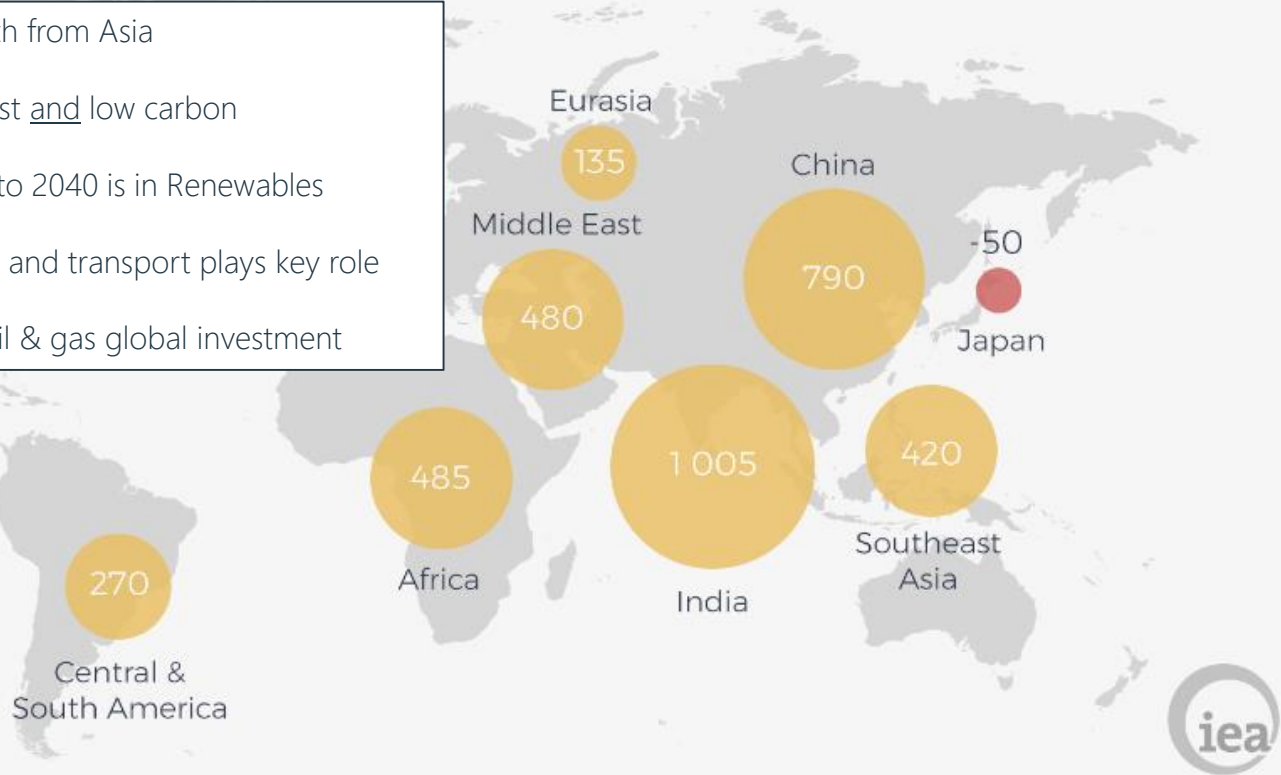
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Wood activities



Energy demand is growing, whilst also decarbonising

- Two thirds of demand growth from Asia
- New energy must be low cost and low carbon
- Two thirds of all investment to 2040 is in Renewables
- Electrification of power, heat and transport plays key role
- Electricity already exceeds oil & gas global investment



Renewables can decarbonise all energy...

Heat



Electricity



Marine & Hydro Bio/Geo Energy

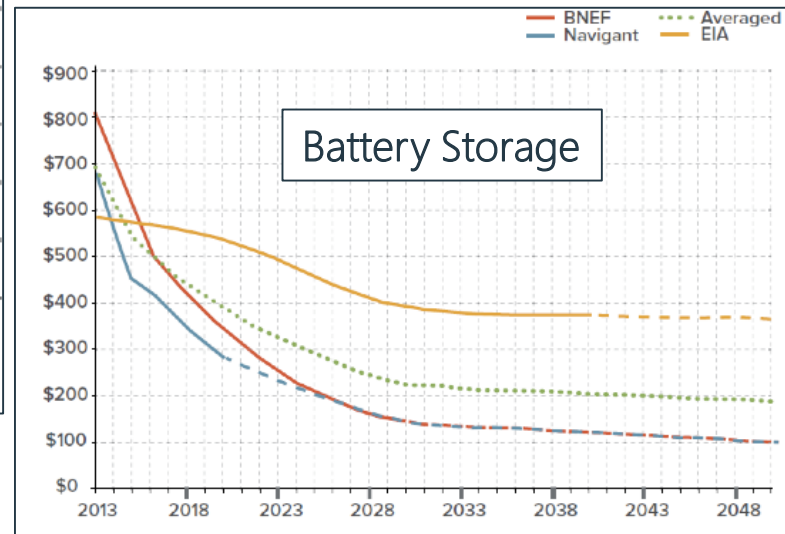
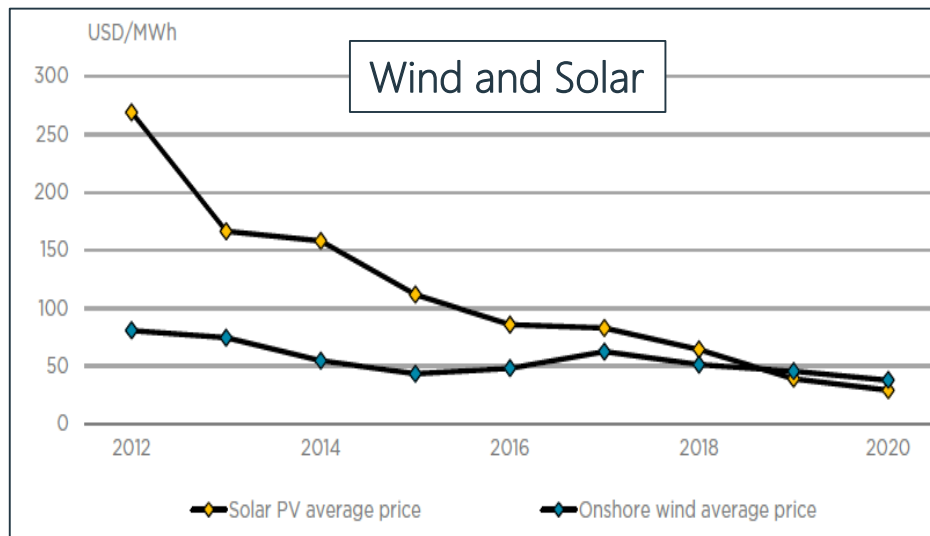
Transport



Heat & Transport

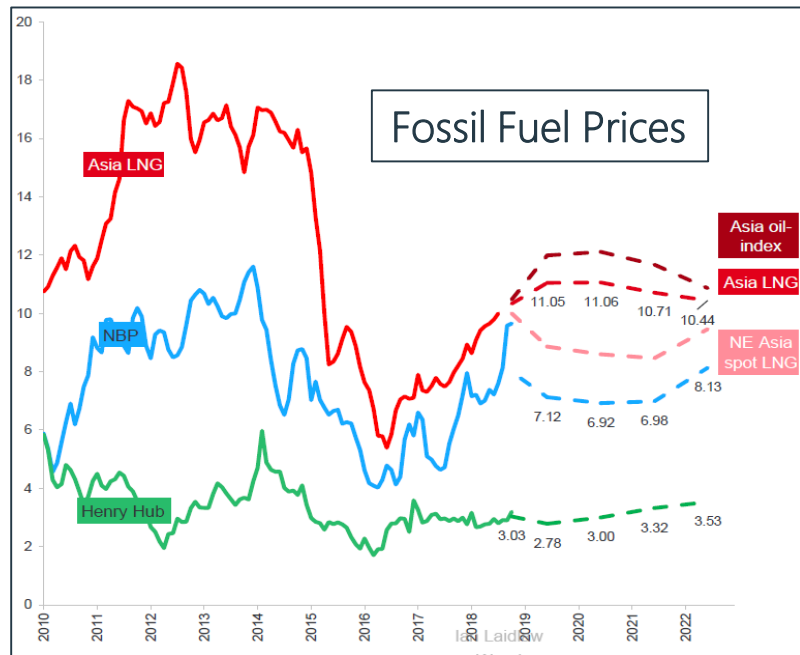
- Now key focus of decarbonisation policy
- Three times more energy than electricity
- Solutions will require large scale infrastructure
- Broad range of technical expertise needed (e.g. gas handling)
- New challenges will emerge
- Research will be needed

Clean Energy costs are falling

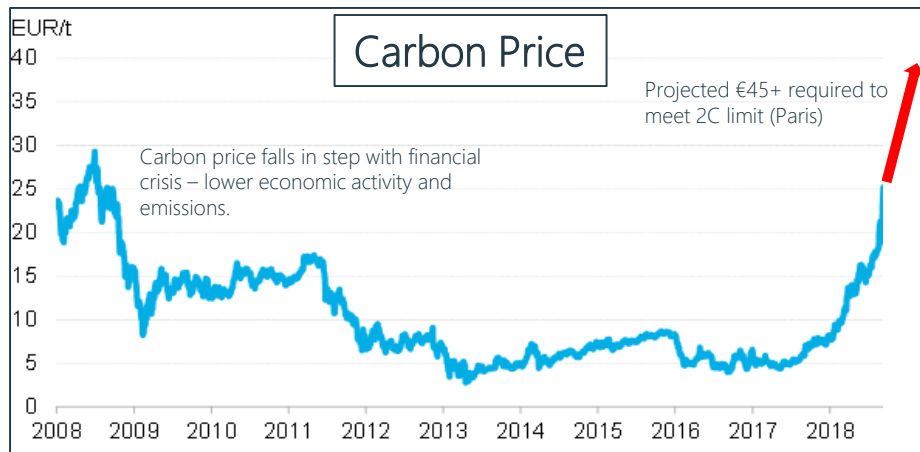


Source: Rocky Mountain Institute

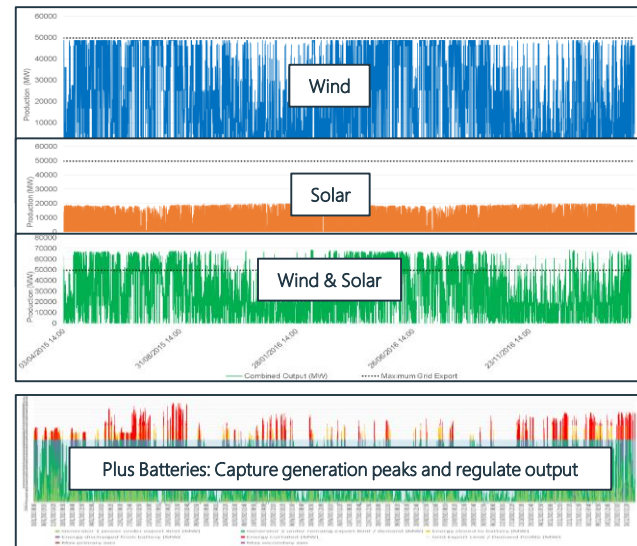
Whilst Fossil Fuel & Carbon Prices are rising



Source: Rystad Energy 2018

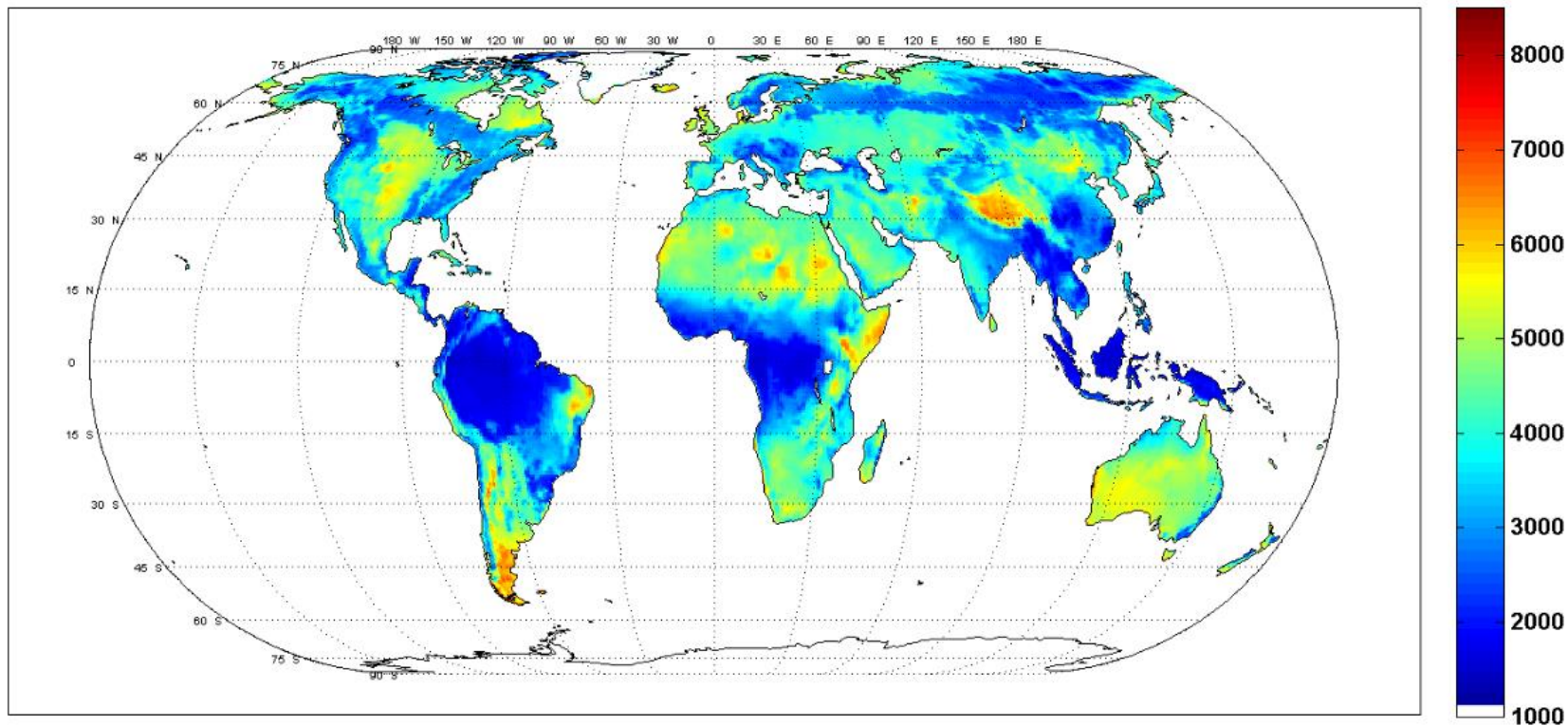


Wind, Solar & Batteries – can be lowest cost option



'...renewables can drive down energy costs by up to 25% in existing operations and 50% in new mines through an effective energy management program, of which renewables are a major component.'
Deloitte, 2018

Low cost requires high load factors



Source: International Energy Agency

Priorities for Industry-Academic Collaboration

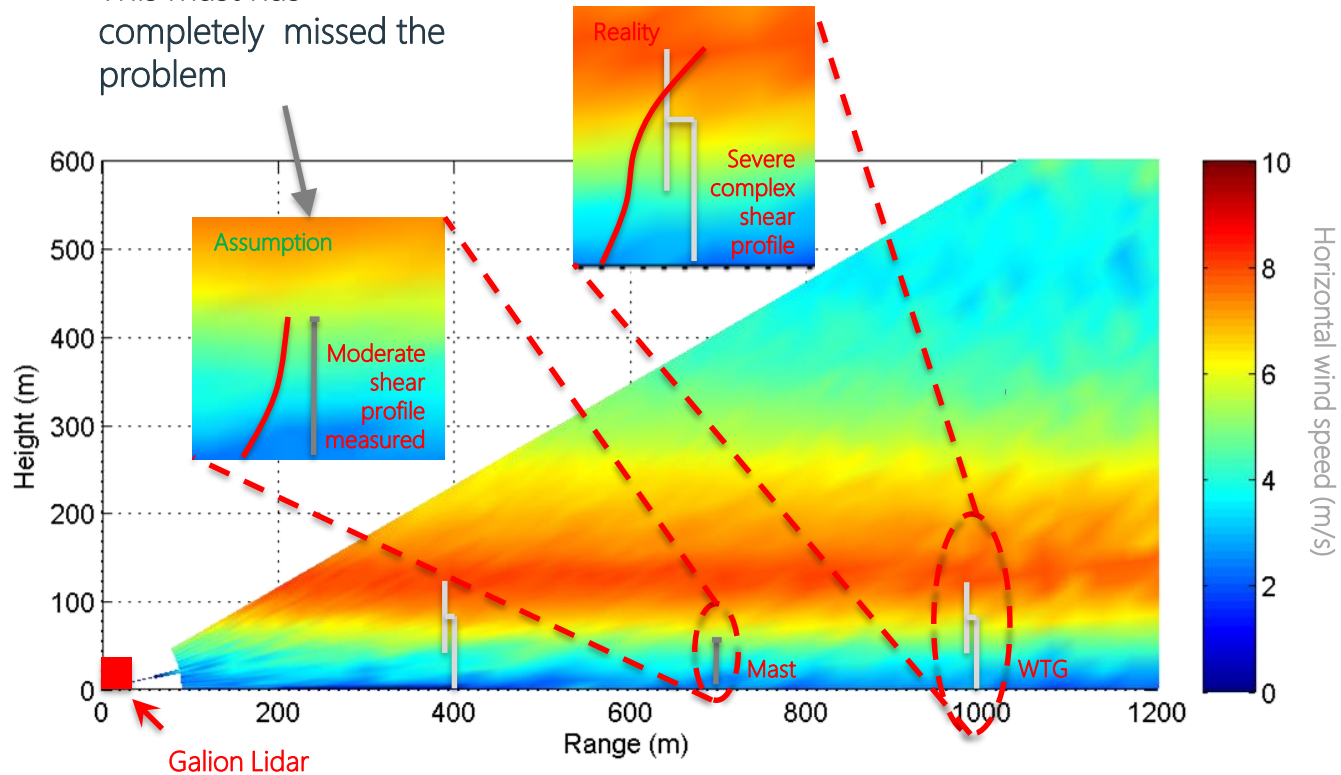
| Issue | Onshore Wind | Offshore Wind | Tidal | Wave |
|---------------------------|--------------|---------------|-------|------|
| Resource Measurement | ✓ | ✓ | ✓ | ✓ |
| Resource Characterisation | | ✓ | ✓ | ✓ |
| Performance Prediction | | | ✓ | ✓ |
| Design | ✓ | ✓ | ✓ | ✓ |
| Installation | | ✓ | ✓ | ✓ |
| Accessibility | | ✓ | ✓ | ✓ |
| Performance Optimisation | ✓ | ✓ | | |
| Asset Integrity | ✓ | ✓ | | |

Resource Measurement

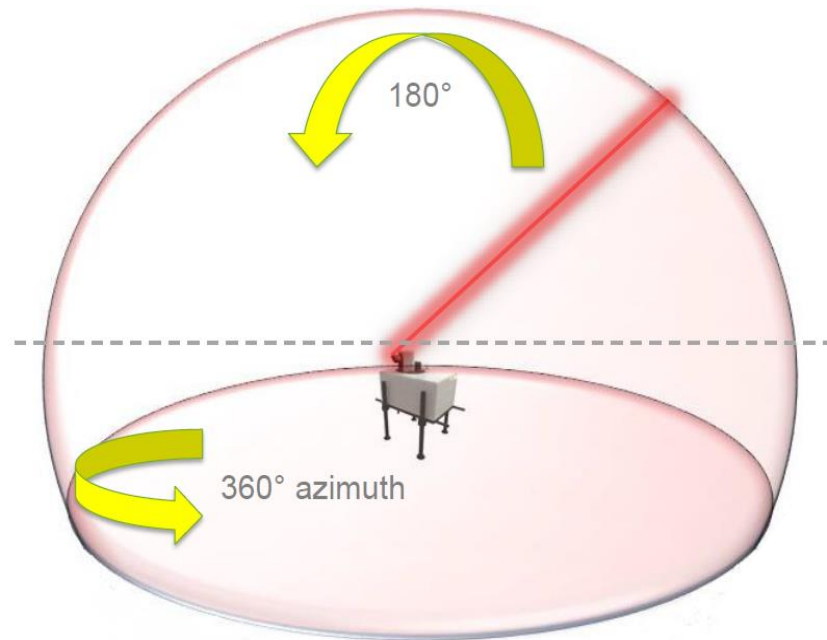
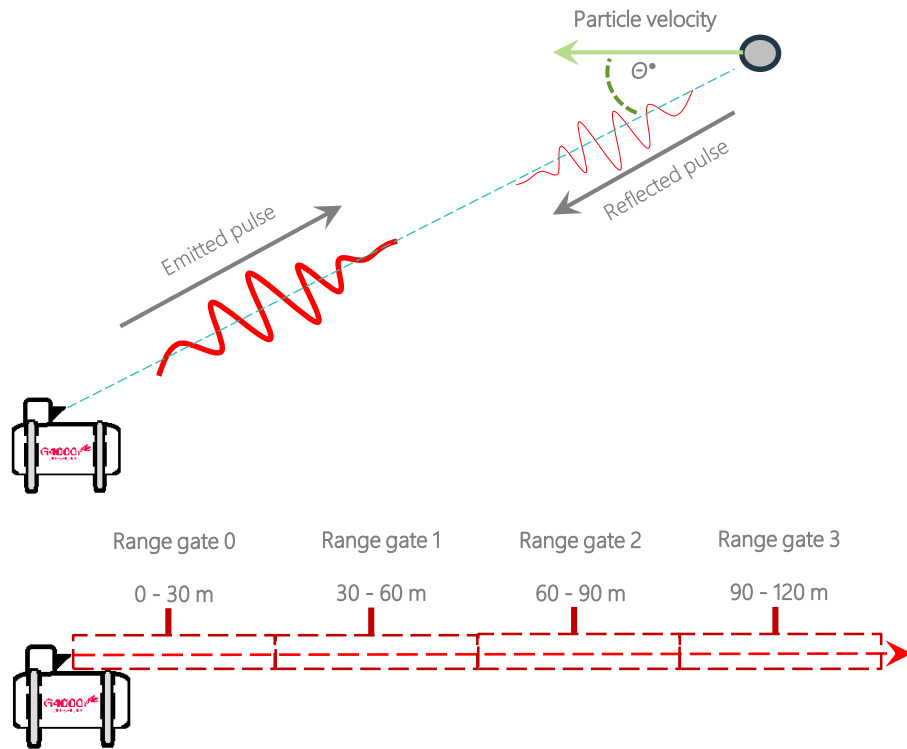


Wind Resource Measurement

This mast has completely missed the problem

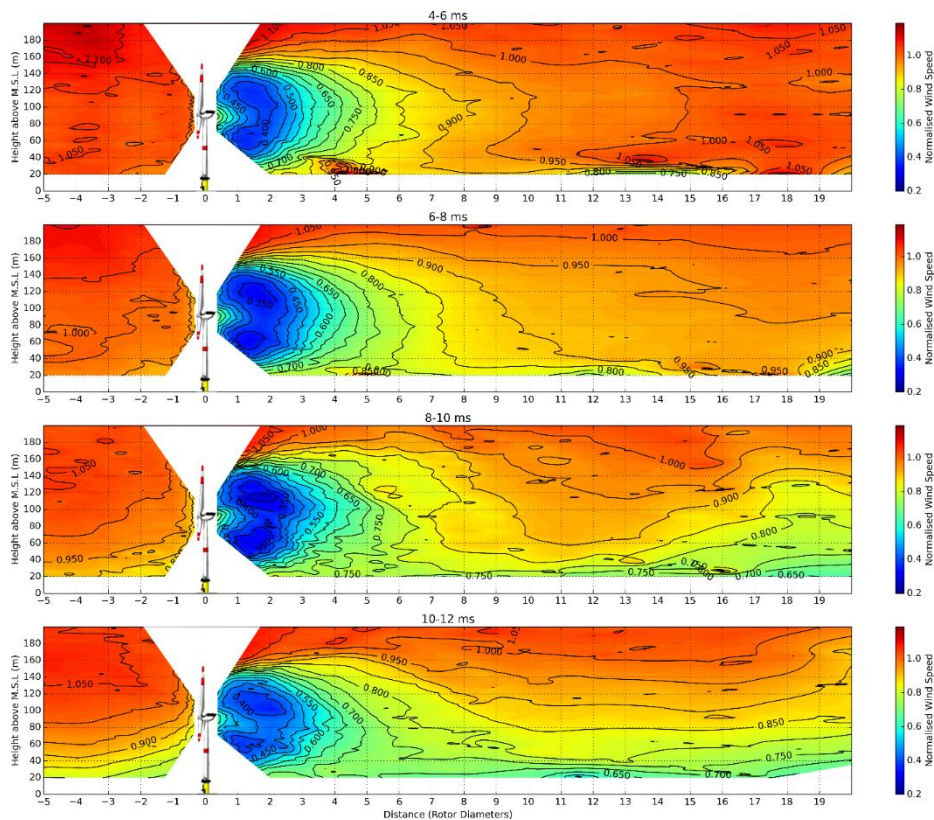


Wind Measurement - Lidar



New opportunity – turbine mounted lidar for active control

Lidar is uncovering new findings...



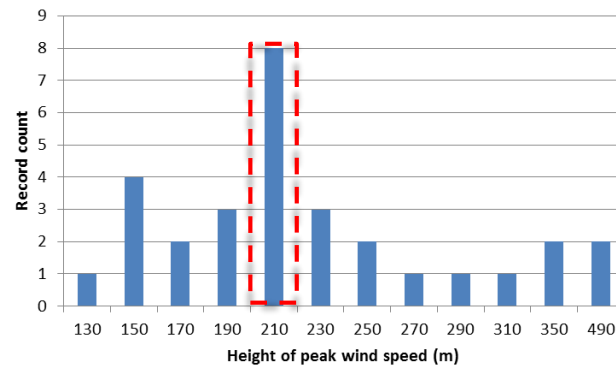
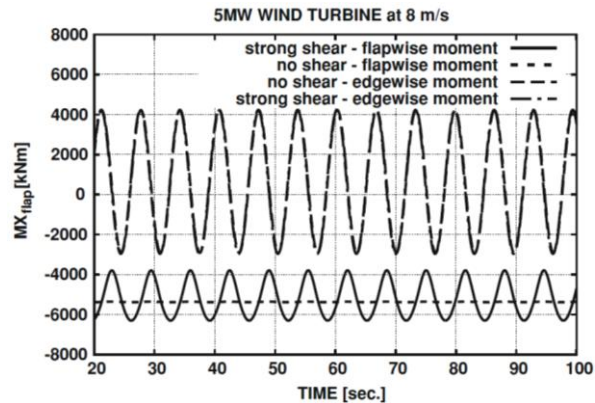
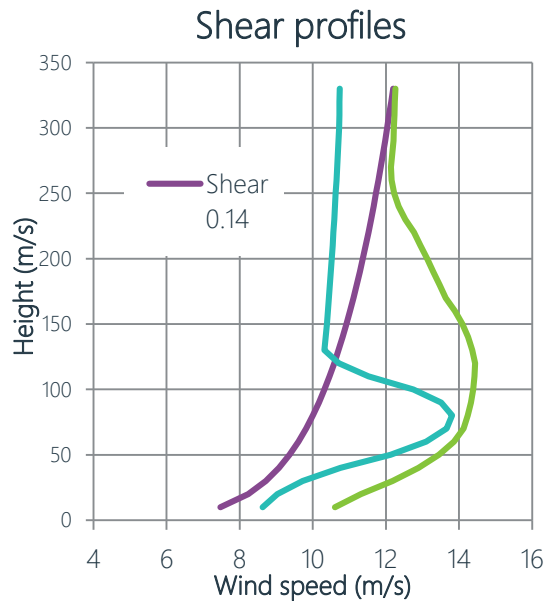
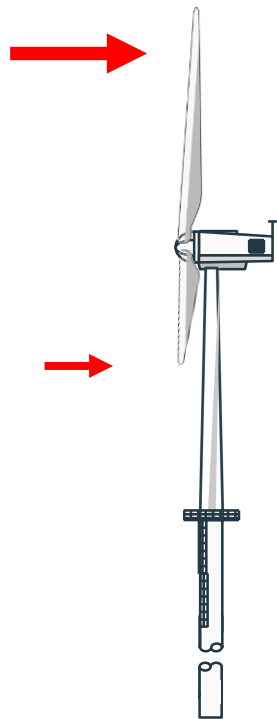
- Inflow deflection
- Compression zone
- Wake structure
- Wake recovery
- Extreme shear prevalence

Source: International Energy Agency

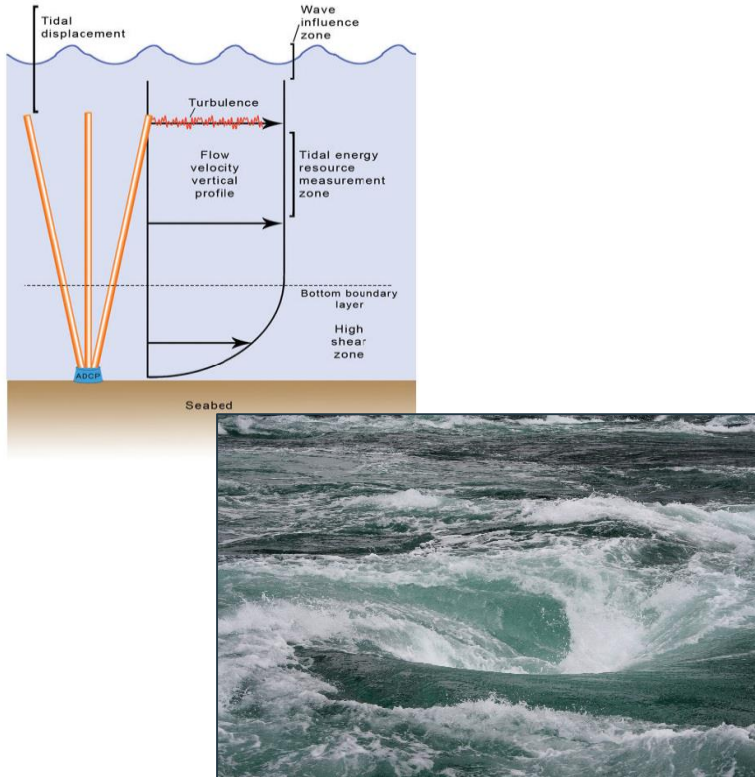
Resource Characterisation



Extreme Shear - Wind

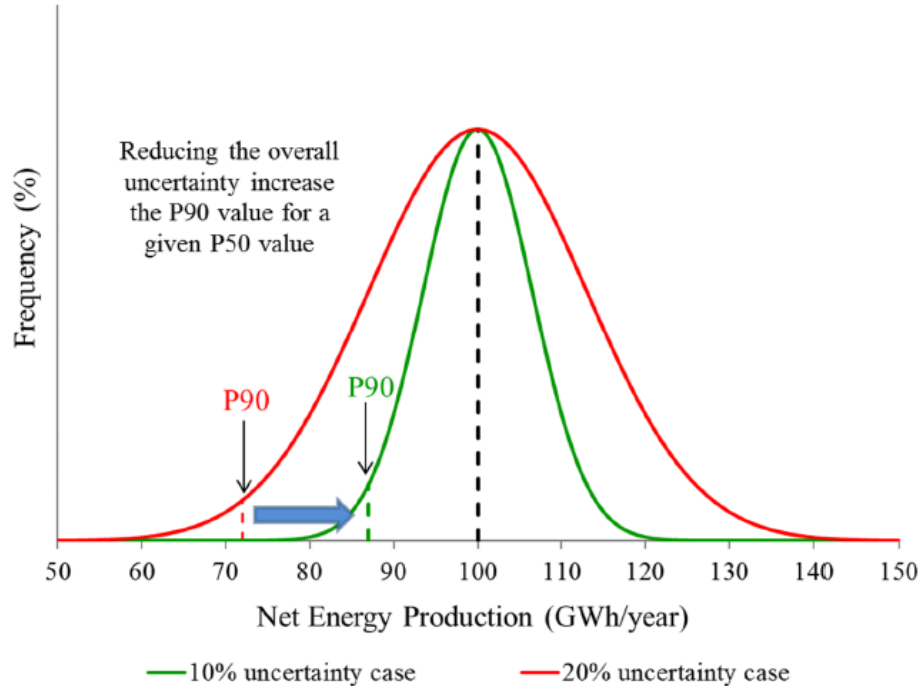


Resource Behaviour - Tidal



- Highest shear is at bottom of column
- Waves impact top of column – cyclic
- Boundary layer is complex
- Turbulence behaviour is complex
- Blockage is particularly relevant to tidal
- Water behaves differently from air!

Uncertainty costs money....

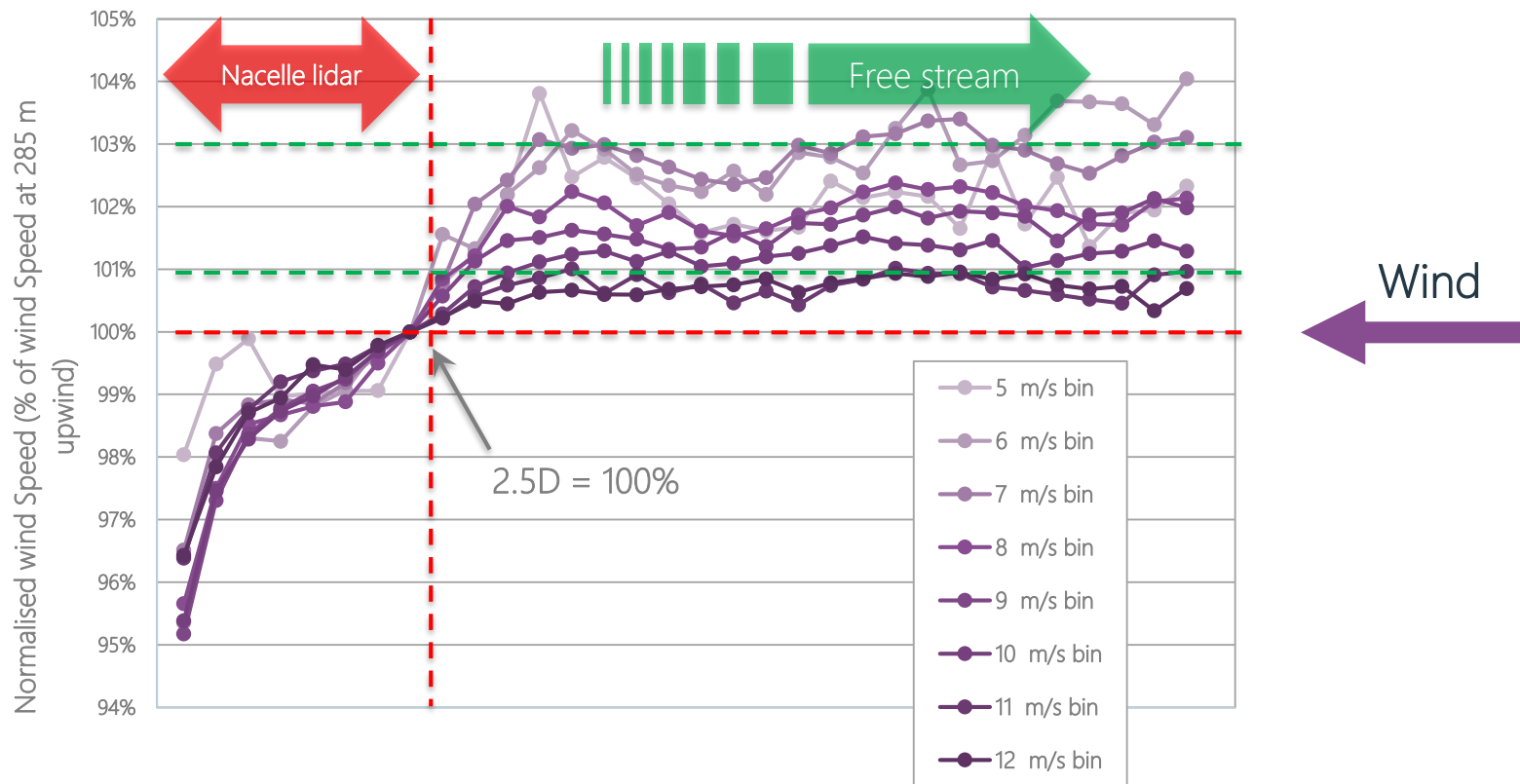


- Banks evaluate debt on P90 yield
- Uncertainty reduction is technical challenge:
 - Measurement
 - Analysis
 - Design
 - Validation
- Average error is 7%
- There is scope for improvement!

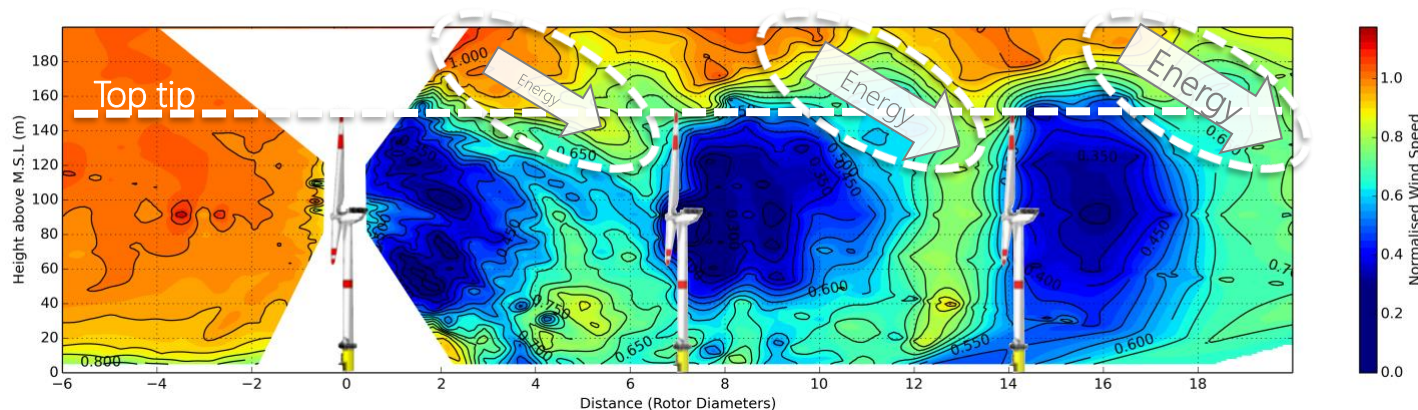
Performance Prediction



Compression Zone – new findings



Wake Behaviours are still not fully understood

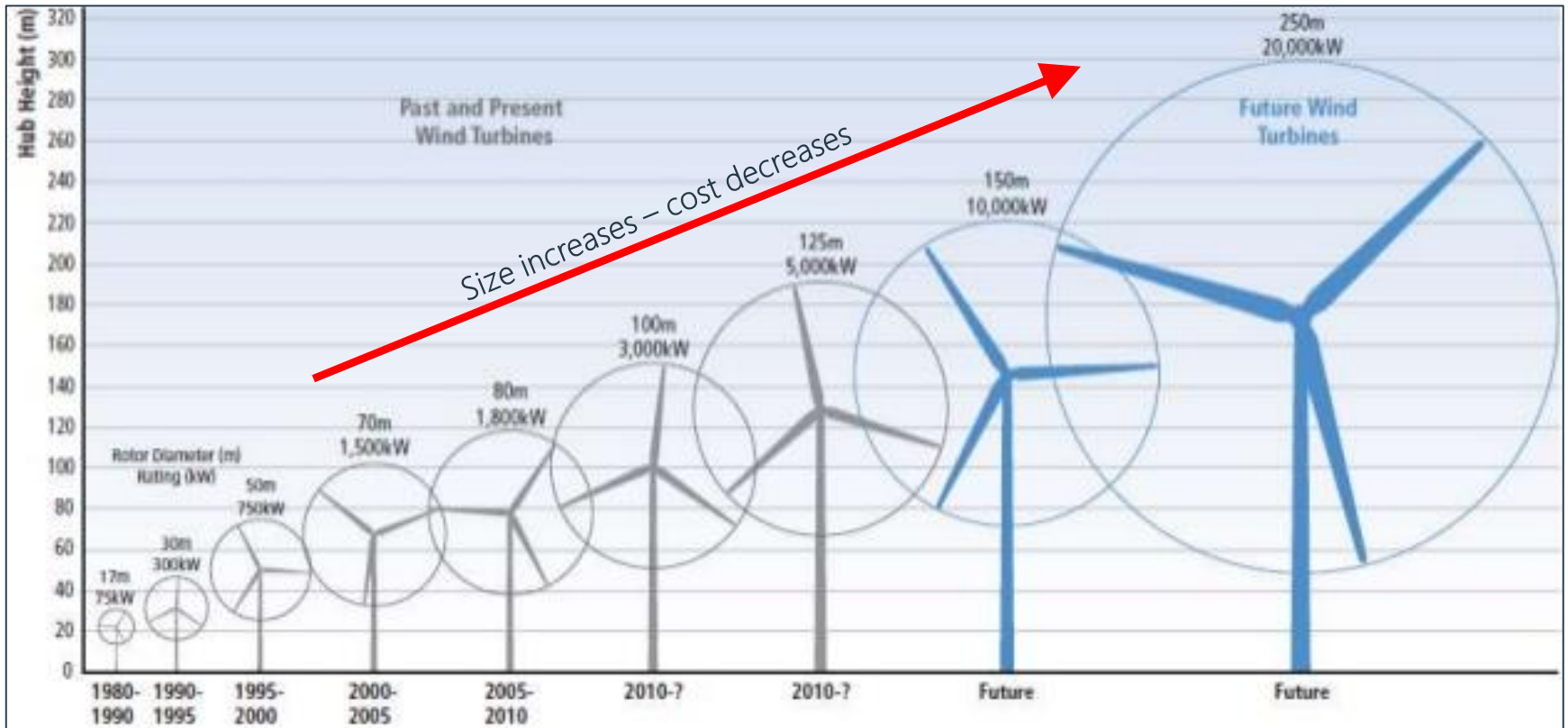


Tidal wake behaviours are even less understood!!

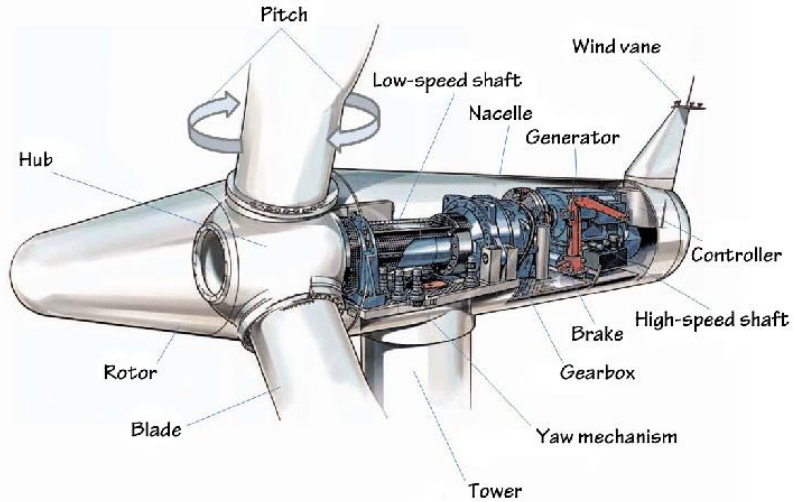
Design



Wind turbine size continues to grow



New materials are required



Carbon fibre blades

Concrete towers



Tidal concepts are still evolving



To yaw or not to yaw?

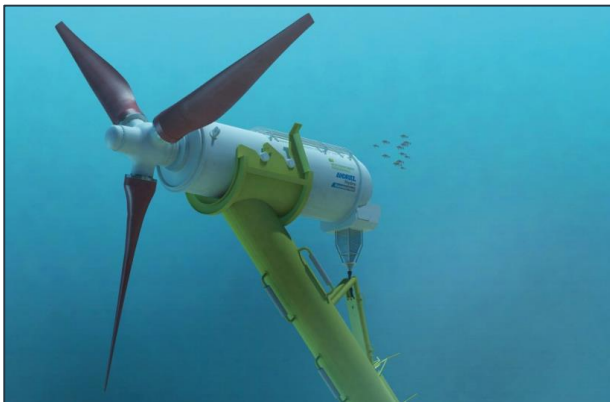
Pitchable blades?

Direct drive?

Optimum size?

Steel or GRP blades?

Support structure interface?



Performance Optimisation



Performance Optimisation



Forestry
Optimisation



Yaw Error
Correction

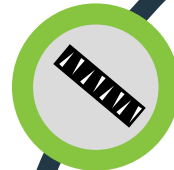


Advanced
Controls



Noise
Management

**There is always room
for improvement**



Aerodynamic
Enhancements



Life
Extension



Grid
Services



Battery Storage

Installation gets tougher as turbines get bigger



Modular installation?

Two part blades?

Self installation?

Assembly at port?



Integrity Management - Blades



Drone Benefits

- Reduce or eliminate working at height
- 4x faster than traditional methods
- Lower inspection cost per turbine
- Reduced downtime
- But – measurement is not the full solution!



Integrity Challenges

- Blades degrading faster than anticipated
- Repairs are costly and uncertain
- Erosion impacts performance
- Long-term mechanisms not understood

Additional Topics requiring Research

Offshore wind

- Develop understanding of interactions between floating structures through modelling of offshore dynamics:
 - local blade deformations
 - fully distributed loads on floating structure
 - disturbances in the wind field - turbulence
- Advanced control systems required for whole system approach (floating wind)
- Develop and testing of an advanced single point mooring for offshore devices
- Characterising resource using Lidar on floating platforms including mooring design and modelling

Tidal

- Characterising turbulence through measurement and modelling
- Wake modelling & measurement validation
- Impact of climate change and sea level rise on resource
- Biofouling and corrosion
- Battery storage and potential benefit to produce 'base load' power

Wave

- Wave convertor control
- Improved material design
- Improving performance and PTO efficiency
- Wave energy yield uncertainties

Wood's current academic collaborations

Academic relationships:

1. Uni Strathclyde TIC Low Carbon Programme, Tier 2 Member
2. Uni Strathclyde Centre of Doctoral Training Wind Power Research
3. Uni Herriot Watt Solar Research Programme
4. Uni Highlands & Islands Bryden Centre Marine Renewables Research
5. Uni Edinburgh IDCORE EngD Programme: Floating Wind Research
6. Uni Southampton Centre of Doctoral Training Energy Storage Research



Industry-Academic Collaborations

Some observations:

1. Mutual benefit required, meaning:
 - Alignment with industry drivers, usually commercial
 - Alignment with individual's interests, and academic programme
2. Time spent in the office is invaluable – cultural exchange!
3. Clear milestones and deliverables needed, but also flexibility
4. Industry sometimes needs to be more patient, and adopt long-term view
5. Student self-starter mentality helps a lot
6. There is scope for much more collaboration in the UK generally



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