Record of the UKERC-supported Wind Energy Research Road Mapping meeting

2-3 March 2009
Ross Priory, University of Strathclyde

Commentary by Professor David Infield, University of Strathclyde

UKERC/WP/RA/2013/001
January 2013

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The meeting was organised by the wind group at the University of Strathclyde and involved David Infield, Bill Leithead, and Olimpo Anaya-Lara, supported by Julian Feuchtwang and Nand Singh.

External experts attending were:
Jos Beurskens – ECN Wind Power Systems, The Netherlands
Helge Madsen – DTU (previously Risø) , Denmark
Bob Thresher – NREL , USA
Martin Hansen – DTU, Denmark
Henrik Bindner – DTU (previously Risø), Denmark
Stephen Wilson
Charles Gamble – Nordic Wind Power
Bruce Valpy – ETI/DBERR/Carbon Trust adviser
Peter Poon – Romax
Henry Jeffrey – UKERC & Edinburgh University
Jim Halliday – STFC Rutherford Appleton Laboratory (RAL)
David Sharpe – NOVA project team
Leon Freris
Mike Graham – Imperial College
Peter Clive – Sgurr Energy
Peter Jamieson – Garrad Hassan and Partners Ltd

Attendees at Ross Priory with Loch Lomond at their back, March 3rd 2009

Preface – comments written in December 2012

At the time of the meeting in March 2009, the plan was to produce a research road map to inform Government research spending in the wind field. A formal report was never produced due to lack of time and resources, and in many ways events have moved on since then, in that substantial research is presently underway now in the UK, after a long period when little publicly funded wind energy research was carried out. This change was driven by a combination of immediate and medium term needs and concerns of the growing UK commercial sector in the context of a Government commitment to meet much of the UK's planned clean energy generation from wind. In parallel some UK companies and a number of overseas companies based in the UK are strengthening their wind research teams. Much of this effort, both in Industry and Universities is concentrated on the considerable and diverse challenges of offshore wind energy.

In this context, it was considered useful to reflect on the deliberations of the experts who were encouraged to take a very open approach to where wind energy was, and should be, going. Many of the ideas noted are equally valid 3 years later and might provide inspiration to funding agencies like TSB, DECC, ETI, and Carbon Trust, which are all increasingly involved in wind energy, as well of course as EPSRC who continues to support the Wind Supergen programme. Although it is worth noting that, despite the enormous (multi-billion) UK investment expected in on- and off-shore wind in the next decade or so, and the major science and engineering challenges that must be overcome before the UK's Offshore Round 3 sites can be exploited, EPSRC has chosen not to plan further increases in the direct research support for wind which is presently modest. This is not because wind technology is demonstrably fully mature as I hope these notes will demonstrate. In fact wind energy is poised at a critical juncture where radically different designs are being proposed by manufacturers for large scale offshore application, and attempt to sidestep reliability problems with aspects of existing technology. These new designs are almost completely unproven and the engineering tools to design these with confidence do not exist. This can be seen in the intensive research activity at the Danish Technical University (DTU) (now incorporating the Risø National Laboratory) which has focused on the combined challenges of : 1) scaling up the technology and 2) applying it offshore, and also their leadership role in EERA Wind, the wind part of the European Energy Research Alliance which seeks to deliver much of the EU's R&D activity in this sector.

Background to the 2009 meeting

In 2009 it was believed that there was a genuine need to debate in an open and uninhibited way, the role that wind energy can, and separately should, play over the decades ahead. For this reason funding agencies were not invited to the entire event itself, but just the final summary session. Once the realistic potential for the different forms that commercial wind might take over the next twenty years had been agreed, the meeting turned its attention to the question of how to get there, and in particular, but not exclusively, what research is needed. This last element is essential input to any wind research road mapping exercise, and took up most of the discussion time available.

The meeting brought together selected representatives of UK wind research, consultants and industry with a number of leading international figures from the major universities, laboratories and companies involved in wind research and technology development.

The conclusions of the deliberations are summarised in the tables below, drawing mainly on areas of common agreement where those could be established. A succinct evidence-based policy statement outlining future UK research priorities and proposed delivery mechanisms was at the time the main outcome sought by the UKERC, who were supporting the meeting. (The meeting plan is attached as Appendix 1).

The results of the meeting have been summarised in Tables 1 to 5 dealing with the key topics of: environmental/external conditions; wind turbine systems; wind energy integration (into power systems); policy; social context and environmental concern. In addition it was considered crucial to address the issue of experimental facilities as these are essential if technology risks are to be adequately controlled and the evolving design tools to be suitably validated. Table 6 summarises the perceived requirements for test facilities.

Discussion of findings (with minor updates made in 2012)

The meeting, as might have been expected given the expertise assembled, anticipated a number of present research concerns, including:

1) The need for improved offshore resource modelling and wake models. In fact this is now understood to require much more detailed understanding of the interaction between very large offshore wind farms and the lower boundary layer itself and the impact of atmospheric stability on this interaction;
2) Seabed modelling and improved understanding of scour was highlighted and now commands considerable attention;
3) The technology and modelling issues identified remain current and in most cases under-resourced;
4) The integration issues identified are receiving considerable attention from both academic research and the Electricity Supply Industry, often in close collaboration. The relevant topics are often picked up in research programmes classified rather unhelpfully under the broad heading of smart grids, but at least this research is being funded.

The other main focus of the group was the need for appropriate UK experimental facilities. Progress is being made in some areas but no national test sites for full size turbines, on or offshore, have been seriously progressed, although industry is now starting to plan such facilities. In particular, key companies within the Electricity Supply Industry (ESI) with major commitments to offshore wind development, are taking steps to avert risk through access to test machines, in the UK and overseas. Scottish and Southern Electricity (SSE) who are at the forefront of offshore wind and now well advanced with their plans for onshore testing, at Hunterston, of large turbines designed for offshore. This site, adjacent to their nuclear power station south west of Glasgow is ideal in being exposed to strong westerly winds directly off the sea, whilst benefitting from easy access to the grid and close to appropriate engineering facilities. However this development is commercial and to an extent isolated from other activities and research in the UK. Another positive development is the ETI's commitment to funding a drive train test rig for large turbines at NaREC.

However, overall progress has been slow compared to other countries and is not well coordinated across the UK, in part possibly due to the number of involved funding bodies and possibly difficulties in achieving effective coordination between them: DECC, TSB, EPSRC, ETI and Carbon Trust to mention the main protagonists in the UK as a whole, and ETP and Enterprise Scotland north of the border. No one body is recognised as responsible for, nor exercises, national leadership. This contrasts with our overseas competitors, now including China and other fast developing economies, which seem much better organised and benefit also from a national research infrastructure outside Universities. The UK now has no such facilities or infrastructure, having closed almost all central research laboratories for science or technology during the 1980s. Much of the research community believes this puts the UK at a technical and commercial disadvantage, and also inhibits our ability to gain from EU research funding in wind, where, as mentioned above, DTU dominates.

Conclusion

The most recent Government commitment on wind is to achieve 15 GW of onshore capacity, and 13 GW onshore, by 2020 in order to achieve its binding European contribution to renewable power generation. Although this total installed capacity of 28 GW is less than earlier targets, it remains highly challenging. Investments of many billions will be required just for the turbines themselves and alongside these comparable amounts for infrastructure, both on and offshore. The UK's R&D spend to mitigate the significant risks associated with these investments appears disproportionately restricted and has scope for improved coordination.

Road Map Table 1: Environmental / External Conditions

1 Understanding the Wind

1.1. Resource assessment
- 1.1.1. new data analysis methods
- 1.1.2. reducing costs of collecting data, particularly off-shore
- 1.1.3. use of satellite images for wind and wave condition assessment

1.2. Profiles and measurements
- 1.2.1. development and application of remote sensing and measurement technology (eg LIDAR)
- 1.2.2. improved models of flow up to at least 100m including turbulence
- 1.2.3. improved CFD modelling of lower boundary layer (lbl)

1.3. Complex Terrain
- 1.3.1. changes of roughness, for example at forest margins
- 1.3.2. onshore/offshore transition
- 1.3.3. flow over forest canopies

1.4. Extreme conditions particularly offshore

1.5. Spatial turbulence structure

1.6. Wakes
- 1.6.1. better modelling including turbulence
- 1.6.2. measurement
- 1.6.3. complex large offshore farms
- 1.6.4. interaction between farms
- 1.6.5. power decay effects in offshore wind farms

2 Waves

2.1. Measurements: conventional methods and new techniques, for example over the horizon radar

2.2. Understanding wave climate – normal and extreme

2.3. Wave / wind interaction

2.4. Breaking wave loading

2.5. Storm surges

3 Fouling of Blades - ice, dirt, salt – corrosion, erosion altered loading

4 Seabed conditions

4.1. scouring

4.2. seabed movement

4.3. characterisation of seabed

4.4. tidal currents

4.5. geo-technical methods - reducing cost of surveying through development of new technologies

5 Lightning

5.1. Frequency, intensity, impact of farm on frequency

6 Shipping Impact

6.1. Standards for design for ship impact

Road Map Table 2: Wind Turbine Systems

1 Aeroelastic Analysis, Materials and Control

1.1. Tailored aerofoil design
1.2. Improved aeroelastic modelling
1.3. New materials including carbon and high strength hybrids
1.4. Smart materials
1.5. Wind turbine control
  1.5.1. Advanced multivariable control
  1.5.2. Distributed active control flaps etc.
  1.5.3. Individual pitch control for blade and system loads
  1.5.4. Blade control surfaces (flaps, tabs etc)
  1.5.5. Innovative actuators and sensors
  1.5.6. Inflow sensors
1.6. Improved aeroelastic blade design
1.7. High speed rotors (downwind)

2 Support Structures

2.1. Taller towers
2.2. Platform concepts for floating wind turbine systems
2.3. Fixed bed foundation concepts
2.4. Optimised jacket design for manufacturability
2.5. Designs for integrated deployment strategies

3 Wind Farm Control, Reliability, Condition and Performance Monitoring

3.1. Intelligent use of SCADA data
3.2. Fast characterisation of machine performance
3.3. Innovative sensors
3.4. Data analysis for failure prediction
3.5. Fault diagnosis tools for operators
3.6. Wind Farm Control and Monitoring
  3.6.1. Use of remote wind sensing
  3.6.2. Optimised whole farm operation
  3.6.3. SCADA system development
3.7. Collect more data to improve failure statistics
3.8. Improved in depth understanding of failure modes
3.9. Assessment of impact of component design on reliability
3.10. Turbine control for load alleviation (including downwind machines)

4 Operation and Maintenance

4.1. Advanced O&M techniques such predictive maintenance
4.2. Offshore turbine access system design

5 Drive-Train and Bearing Design and Modelling

5.1. Improved drive train dynamics through analysis and design
5.2. Improved direct drive generator concepts with emphasis on weight reduction
5.3. Hybrid concept analysis including 1,2 gear stages, PMGs, multi-generators etc
5.4. Improved gear-box design with non-rigid structural assumptions
5.5. Scoping of potential of superconducting generators

Road Map Table 3: Wind Energy Integration

1 Wind power plant capabilities

1.1. Frequency response and cost of delivering this

1.2. Real power control

1.3. Power quality enhancement

2 Power system operation

2.1. Short term power prediction/forecasting

2.2. Congestion management

2.3. Demand side management

2.4. Electric Vehicle charging

3 Grid design and infrastructure

3.1. Offshore HVDC networks

- 3.1.1. Multi-terminal HVDC
- 3.1.2. DC networks protection

3.2. FACTS (Flexible AC Transmission Systems) and integrated power converter technologies

3.3. Advanced offshore connection arrangements including floating frequency wind farms

Road Map Table 4: Policy (important but not seen as research issues)

1 Supply chain

1.1. GDP

1.2. Jobs

1.3. Capability

1.4. Economic development

2 Incentives and tariffs, cost benefit analysis

3 Capacity building

3.1. Education and training and guidelines

4 Improve Knowledge Transfer

5 Planning

5.1. Public Attitude effects

Road Map Table 5: Social Context

1 Baseline of environmental data

1.1. Further improvements to the SEA process

1.2. Cumulative effects (arrays)

1.3. Visual impacts, attitudes and opinions

Road Map Table 6: Proposed and Existing UK Testing Facilities

2 Already in existence in the UK

2.1. Blade load test facilities (NaREC) Static/Dynamic, 1-axis, 2-axis, up to 70m

2.2. Lightning testing

2.2.1. Clothier at NaREC - 4MV a.c.

2.2.2. Culham Lab – High Current, High Voltage

2.3. Drive Train test facility (NaREC) 15MW

2.4. Scour + Support Structure Wave Loading HR, NaREC, Herriot-Watt, Manchester, Strathclyde flume

2.5. Wave and Wind Combined Loading, 1:100 scale, Newcastle U

2.6. Medium Voltage Power System - Strathclyde U, Scottish Power, Cumbernauld, 11kV

3 Facilities lacking

3.1. Field Test Site - for full scale wind turbines (up to 7 MW), onshore, coastal, high wind

3.2. Field Test Site - ideally near offshore (<100m from shore) including different foundation types[1]

3.3. Wind tunnels for aerofoil development and CFD validation

[1] This list should now be extended to include floating wind turbine test facilities at full scale as already installed of the Norwegian and Portuguese costs with many more presently planned overseas.

Appendix 1: Original Meeting Plan

Monday 2nd March 2009

9.00 am	Registration (tea, coffee etc)
9.50	Introduction to event – David Infield
10.00	Round table introductions
10.20	Brief presentation from UKERC (Jim Skea)
10.45	break for coffee
11.00	Overseas invited contributors (to be agreed)
12.30	lunch
2.00	Round table debate structured by professional facilitator (including expectations from wind over next 2 decades and the particular forms the technologies will take and be applied)
3.30	tea break
3.45	Round table discussion continues (to include research needs and priorities)
5.30	end for day one

Tuesday 3rd March 2009

9.00	Recap by facilitator on conclusions from day one
9.45	Specific challenges for UK research community
10.45	Coffee
11.00	Discussion of funding and infrastructural needs for UK wind research and testing
12.30	lunch
2.00pm	Outline of UK Wind Research Road Map (open to funding agencies)
3.30	tea break
3.45	Agreement of Draft Road Map
5.00	Concluding comments and thanks.