NeWindEERA

A New Research Programme for the European Wind Energy Sector

March 2024

EERA
European Energy Research Alliance
Wind Energy

Photo: EnBW

INTRODUCTION

Wind energy is indisputably a key part of the current European energy system and will continue to play a hugely important role as the energy sector strives towards the ultimate goal of Net Zero by 2050.

Whilst wind energy has made huge strides over the last few decades, there is still much to do in the research and innovation arena to future-proof wind energy technology; technology that must continue to play its part as an essential contributor to key sector targets in 2035 and 2050.

The European Wind Power Package launched in September 2023 highlighted several challenges facing the European wind energy industry including the REPowerEU target of 420GW by 2030. The resulting EU Wind Power Action Plan identified 15 actions to strengthen Europe's wind energy industry, and this was closely followed by the launch of the ETIPWind Strategic Research and Innovation Agenda (SRIA) in December 2023. With 2030 in mind, the SRIA defines 23 R&I priorities that need to be urgently addressed in the 2025-2027 period. However, these priorities focus on short-term must-haves and if you delve deeper into the SRIA content, you find several references to key longer-term research topics. Welcome to the NeWindEERA project!

NeWindEERA defines a research vision for our route to 2050. It defines a programme and roadmap for the European wind energy research community whilst staying strongly aligned with the ETIPWind SRIA industry-led priorities. The programme provides clear and simple messaging for key stakeholders and includes non-technical cross-cutting topics as well as the more traditional technical research priorities. The NeWindEERA project has produced a comprehensive report which will be available on the EERA JP Wind website from April 2024 (www.eera-wind.eu). This brochure provides a visual summary of the research programme developed as part of the NeWindEERA project.

In addition to the Cross-cutting theme mentioned earlier, the research programme has identified several research topics under the five R&I priority themes of Industrialisation, Operations & Maintenance, Wind Energy System Integration, Sustainability & Circularity, and Skills & Coexistence. These are illustrated in this brochure across six pages along with the associated research programme timelines in the centrefold. The timelines provide a forecast for the expected duration and milestones of the key research activities across the six research themes identified.

The penultimate page of the brochure highlights another important feature of NeWindEERA, in that it builds upon the well-founded research activity of the EERA JP Wind research community; previously summarised in the 2020 EERA JP Wind R&I Strategy publication. This is represented via a table to indicate how the ongoing research activities map against the newly established NeWindEERA research programme. Finally, the back cover illustrates how the NeWindEERA research programme represents one of the three pillars of European wind energy research and innovation. It stands alongside the ETIPWind SRIA and the emerging European Wind Energy Centre of Excellence (EuCoE4Wind); the vehicle that will carry us on the journey in delivering the NeWindEERA programme over the coming decades. So, happy reading and looking forward to sharing the journey with you!

Paul McKeever

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NeWindEERA – A New Research Programme for the European Wind Energy Sector

3.1 R&I PRIORITY THEME 1
Industrialisation, Scale-up and Competitiveness

This R&I priority theme is guided by the IEA's Grand Challenges in Wind Energy Science and the R&I priorities from ETIPWind's Strategic Research and Innovation Agenda. Research topics take note of the current State of the Art and future challenges and also recognise the need to continuously improve the underlying design and modelling tools.

Mass Production supported by automation and reliable supply chain
- Manufacturing capacities for mass production
- Serial manufacturing of components
- Automation and optimisation of manufacturing processes
- Environmental Impacts
- Social Impacts

3.1.1.1 Research Topic – Manufacturing for mass production

3.1.1.2 Research Topic – Environmental impacts of mass production

3.1.1.3 Research Topic – Social impacts of mass production

Design for large volume manufacturing and deployment
- Next generation wind turbine technology and economic optimization
- Combination with other generation technologies
- Industrialisation of floating offshore wind

3.1.2.1 Research Topic – Next generation wind turbine technology and economic optimization

3.1.2.2 Research Topic – Combination with other generation technologies

3.1.2.3 Research Topic – Industrialisation of floating offshore wind

Design for reliable and lasting products
- Holistic, accelerated turbine design
- Probabilistic design
- Virtual and scaled testing
- Small and Off-Grid Wind

3.1.3.1 Research Topic – Holistic and accelerated turbine design

3.1.3.2 Research Topic – Probabilistic design

3.1.3.3 Research Topic – Virtual, scaled and full-scale testing

3.1.3.4 Research Topic – Small and Off-Grid Wind

Improve construction and installation methods
- Scaling up installation
- Assembly and heavy maintenance solutions

3.1.4.1 Research Topic – Scaling up installation

3.1.4.2 Research Topic – Assembly and heavy maintenance solutions

Adequate economic and financial conditions
- Market design
- Accounting for environmental cost

3.1.5.1 Research Topic – Adequate support policies

3.1.5.2 Research Topic – Market design

3.1.5.3 Research Topic – Impact assessment for value creation

3.2 R&I PRIORITY THEME 2

Optimisation and further digitalisation of Operations & Maintenance

R&I Priority Theme 2 creates four sub-themes focusing on improving operational efficiency through digitalisation; the need to automate a significant amount of O&M; the opportunity to embrace a digital ecosystem; and the need to cater for the replacement and transport of major components as the size of offshore wind turbines continues to grow.

Digitalisation of maintenance and optimisation tools for operational effficiency

- Innovative training for technicians using AR, VR and/or AI
- AI-driven predictive maintenance for key components & report analysis
- AI-driven resource assessment and forecasting tools

3.2.1.1 Research Topic
Innovative training for technicians using AR, VR, and/or AI

3.2.1.2 Research Topic
AI-driven predictive maintenance for key components & report analysis

3.2.1.3 Research Topic
AI-driven resource assessment and forecasting tools

Autonomous Operations and Maintenance

- Enhanced robotics for blade servicing & semi-automated inspection
- Advanced offshore repair methodologies and autonomous vehices for maine operations
- Autonomous wind installation, O&M and decommissioning

3.2.2.1 Research Topic
Enhanced robotics for blade servicing & semi-automated inspection

3.2.2.2 Research Topic
Advanced offshore repair methodologies and autonomous vehicles for marine operations

3.2.2.3 Research Topic
Autonomous wind installation, O&M and decommissioning

Digital Ecosystem(s)

- Data exchange across sub-systems
- Sensor technologies
- Industrial IoT, cloud analytics, cybersecurity
- Optimisation & Decision-making
- Hollistic understanding of natural systems (physical, social, biological)

3.2.3.1 Research Topic
Data exchange across sub-systems

3.2.3.2 Research Topic
Sensor technologies

3.2.3.3 Research Topic
Industrial IoT, cloud analytics, cybersecurity

3.2.3.4 Research Topic
Optimisation & Decision-making

3.2.3.5 Research Topic
Holistic understanding of natural systems (physical, social, biological)

Replacement and transport of major components

- Component replacement solutions onshore & offshore
- Quick connect/disconnect systems for mooring lines & inter-array cables
- In-situ repairs and craneless exchange
- Autonomy & digitalization for port operations
- Novel fuel alternatives in ports (e.g. hydrogen fuelling)

3.2.4.1 Research Topic
Component replacement solutions onshore & offshore

3.2.4.2 Research Topic
Quick connect/ disconnect systems for mooring lines & inter-array cables

3.2.4.3 Research Topic
Autonomy & digitalization for port operations with novel fuel alternatives

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3.3 R&I PRIORITY THEME 3

Wind Energy System Integration

The integration of large scale wind energy remains one of the biggest challenges facing the sector. This priority theme identifies six sub-themes including plant level control and grid forming hybrid plants that were highlighted in the IEA's Grand Challenges in Wind Energy Science.

Definition and Modelling of future system needs

- Transmission and generation flexibility
- Optimisation of transmission infrastructure
- Grid digitalisation

3.3.1.1 Research Topic
Transmission and generation flexibility

3.3.1.2 Research Topic
Optimisation of transmission infrastructure

3.3.1.3 Research Topic
Grid digitalisation

Advanced grid capabilities

- Ancillary service provision
- Development of new converter capabilities and systems
- Short term balancing

3.3.2.1 Research Topic
Ancillary service provision

3.3.2.2 Research Topic
Development of new converter capabilities and systems

3.3.2.3 Research Topic
Short term balancing

Interoperability

- Digital twin technologies
- Plant level control

3.3.3.1 Research Topic
Digital twin technologies

3.3.3.2 Research Topic
Plant level control

Solutions to effectively manage curtailment

- Long duration energy storage
- Offshore wind and hydrogen production

3.3.4.1 Research Topic
Long duration energy storage

3.3.4.2 Research Topic
Offshore wind and hydrogen production

Power to X and hybrid plants

- Power to X technologies
- Hydrogen market integration
- Hybrid plants

3.3.5.1 Research Topic
Power to X technologies

3.3.5.2 Research Topic
Hydrogen market integration

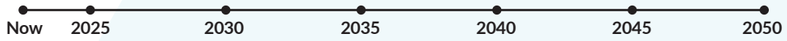
3.3.5.3 Research Topic
Hybrid plants

DC grid solutions

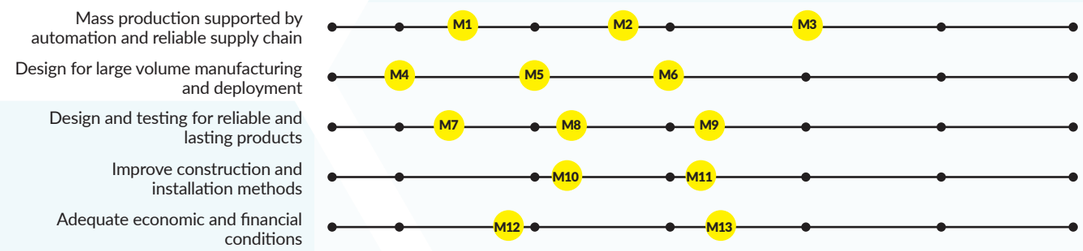
- Offshore grid infrastructure

3.3.6.1 Research Topic
Offshore grid infrastructure

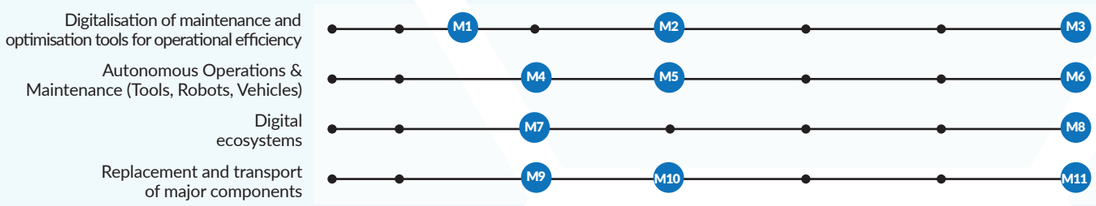
TIMELINE



Theme 1 – Industrialisation, Scale-up and Competitiveness



Theme 2 – Optimisation and further digitalisation of Operations & Maintenance



Theme 3 – Wind Energy System Integration

Theme 4 – Sustainability and Circularity

Theme 5 – Skills, Acceptability & Coexistence

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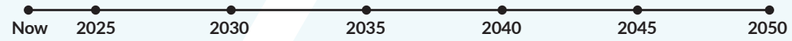
TIMELINE



Theme 6 – Cross-cutting Research Themes

MILESTONES – KEY

Theme 1 – Industrialisation, Scale-up and Competitiveness

- **M1** European certification standard for robust supply chains
- **M2** Pilot implementations of innovative factories for future serial manufacturing
- **M3** Full scale commercial deployment
- **M4** Ideal balance between turbine power and quantity
- **M5** Economically and technically feasible Hybrid Projects
- **M6** Standardized design and large series production of floating offshore wind
- **M7** Scaling method for complete components
- **M8** Standardized holistic design approaches
- **M9** Standardized test methods based on scaled, virtual and full scale tests
- **M10** Implementation of new construction strategies and contracts with different suppliers
- **M11** Infrastructure ready for large scale deployment
- **M12** Robust policy framework
- **M13** Full integration of environmental costs for decision-making

Theme 2 – Optimisation and further digitalisation of Operations & Maintenance

- **M1** Advanced AR/VR and AI tools are developed & validated for several aspects of O&M
- **M2** Advanced digital tools are fully implemented into O&M workflow for better performance overall
- **M3** Climate (Change) resilience and advanced energy control systems are validated
- **M4** Enhanced robotics for blade servicing and semi-automated inspections are in use
- **M5** Offshore repair methodologies and autonomous vehicles for marine operations are advanced
- **M6** Autonomous wind installation, O&M and decommissioning
- **M7** Integration of Industrial IoT, cloud analytics, advanced communication technologies, and cybersecurity measures into safe operation
- **M8** Holistic analysis of natural systems through advanced sensors and digitalization, and environmental data-driven spatial planning for human and ecological needs
- **M9** Demonstration and qualification of major component replacement solutions onshore and offshore, including floating wind
- **M10** Quick connect/disconnect systems for mooring lines and inter-array cables are in place
- **M11** Autonomous and digitalized port operations with novel fuel alternatives

Theme 3 – Wind Energy System Integration

- **M1** Next generation modelling tools developed
- **M2** Grid digitalisation widely implemented
- **M3** Transmission infrastructure fully optimised
- **M4** Refined ancillary service provision achieved
- **M5** New converter capabilities implemented
- **M6** Robust enhanced grid services established
- **M7** Plant level control demonstrated
- **M8** Digital twin technologies fully established
- **M9** Offshore wind/hydrogen production demonstrated
- **M10** Long duration energy storage implemented
- **M11** Early power to X technologies demonstrated
- **M12** Hydrogen market integration established
- **M13** Hybrid plants fully realised
- **M14** Planning & optimisation tools developed
- **M15** Energy hub/island demonstrators established
- **M16** DC grid network fully implemented

Theme 4 – Sustainability and Circularity

- **M1** Validation of blades with new materials and more circular coatings
- **M2** Validation of new concept of WT with new materials
- **M3** Maximize the benefits of material at the end of life
- **M4** 100% wind turbine recyclability with the lowest CO2 footprint
- **M5** LCA of all the influences among WT and environmental processes
- **M6** Quasi-Zero environmental co-design WT procedure
- **M7** LCA methodology
- **M8** Digital twinning and use of AI fully established
- **M9** New methods and tools for offshore wind
- **M10** Economic model for full decommissioning project
- **M11** New technologies for effective and environmentally friendly decommissioning

Theme 5 – Skills, Acceptability & Coexistence

- **M1** Establish a robust interdisciplinary wind energy education framework
- **M2** Achieve industry-wide continuous learning, fostering adaptability and sustainable expertise
- **M3** Establish comprehensive wind energy skilling programs for diverse competences.
- **M4** Majority of professionals in the sector have received ongoing skilling, re-skilling, and upskilling
- **M5** Pilot projects with enhanced community involvement established
- **M6** All European wind project developments follow good practices of community involvement
- **M7** Governance models developed
- **M8** Implementation and assessment of governance models in wind energy projects
- **M9** Systematic method to identify relevant stakeholders and their (competing) interests in specific projects
- **M10** Assessment criteria of balanced coexistence

Theme 6 – Cross-cutting Research Themes

- **M1** Accurate validated models of wind farm cluster wake effects
- **M2** Comprehensive operational collaboration with weather and climate centres
- **M3** "Watch-list" established on most promising disruptive technologies
- **M4** Disruptive technology innovation validated
- **M5** Experimental assessment of novel approaches
- **M6** New engagement and assessment methods verified in different contexts
- **M7** Regulatory implementation across Europe
- **M8** Approaches for creating tangible benefits identified
- **M9** New governance models assessed and developed
- **M10** Regulatory implementation in all wind energy projects
- **M11** Risk factors impacting financing costs understood
- **M12** Updated finance and cost models fully implemented

3.4 R&I PRIORITY THEME 4
Sustainability and Circularity

Inspired by IEA Wind and ETIPWind activity, this R&I priority theme focuses on several topics including environmental co-design, social aspects of wind energy development, sustainable materials, and reuse and recycling. It also identifies the need to research end-of-life management, life cycle assessment, and new business models for reusing materials.

Material substitution for decarbonisation
Sustainable materials in design and recyclability by design
New components and materials
Material durability and protection
Alternative design solutions

- 3.4.1.1 **Research Topic** — Sustainable materials in design and recyclability by design
- 3.4.1.2 **Research Topic** — New components and materials
- 3.4.1.3 **Research Topic** — Material durability and protection
- 3.4.1.4 **Research Topic** — Alternative design solutions

Recycling methods
Sustainable blade recycling
New recycling process
Reliability of secondary materials
Holistic life cycle assessment
New business models

- 3.4.2.1 **Research Topic** — Blade recycling, sustainability assessment and technologies to lower CO2 footprint
- 3.4.2.2 **Research Topic** — Reliability of secondary materials
- 3.4.2.3 **Research Topic** — New recycling process
- 3.4.2.4 **Research Topic** — Holistic life cycle assessment
- 3.4.2.5 **Research Topic** — New business models

Lifetime extension via re-using, refurbishing and re-purposing
Solutions for lifetime extension
End-of-life management
Assessment of the damage state of turbine properties

- 3.4.3.1 **Research Topic** — Solutions for lifetime extension
- 3.4.3.2 **Research Topic** — End-of-life management
- 3.4.3.3 **Research Topic** — Assessment of the damage state of turbine properties

New decommissioning tools and methods
Methods and tools for offshore wind
Technologies for environmentally friendly decommissioning
Processes and components to ease reuse and recycling
Economic model for full decommissioning project cycle

- 3.4.4.1 **Research Topic** — Decommissioning methods and tools for offshore wind
- 3.4.4.2 **Research Topic** — Technologies for environmentally friendly decommissioning
- 3.4.4.3 **Research Topic** — Processes and components to ease reuse and recycling
- 3.4.4.4 **Research Topic** — Economic model for full decommissioning project cycle

Biodiversity solutions
Environmental co-design
Impact on ecosystems and biodiversity
Noise reduction

- 3.4.5.1 **Research Topic** — Environmental co-design
- 3.4.5.2 **Research Topic** — Impact on ecosystems and biodiversity
- 3.4.5.3 **Research Topic** — Noise reduction

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3.5 R&I PRIORITY THEME 5
Skills, Acceptability & Coexistence

The large-scale expansion of wind energy demands a skilled workforce, cultivating both inter- and transdisciplinary collaboration, and nurturing a holistic understanding and acceptance. Coexistence with individuals, diverse industries, and the environment is crucial.

Education
Continue examine gaps in wind energy education
Assess measures/tools to increase number of study places and increase recruitment (e.g. long term campaigns)

- 3.5.1.1 **Research Topic** — Education and strategic workforce expansion for the wind energy sector
- 3.5.1.2 **Research Topic** — Innovative pedagogy for wind energy excellence
- 3.5.1.3 **Research Topic** — Cultivating diversity and sustained interest in wind energy

Skilling, re-skilling and upskilling activities
Programmes to skill, re-skill and upskill experts in related professions
Designing comprehensive programs covering entire value chain

- 3.5.2.1 **Research Topic** — Strategic workforce development across the wind energy value chain
- 3.5.2.2 **Research Topic** — Optimising cross-sector talent integration for wind energy sustainability

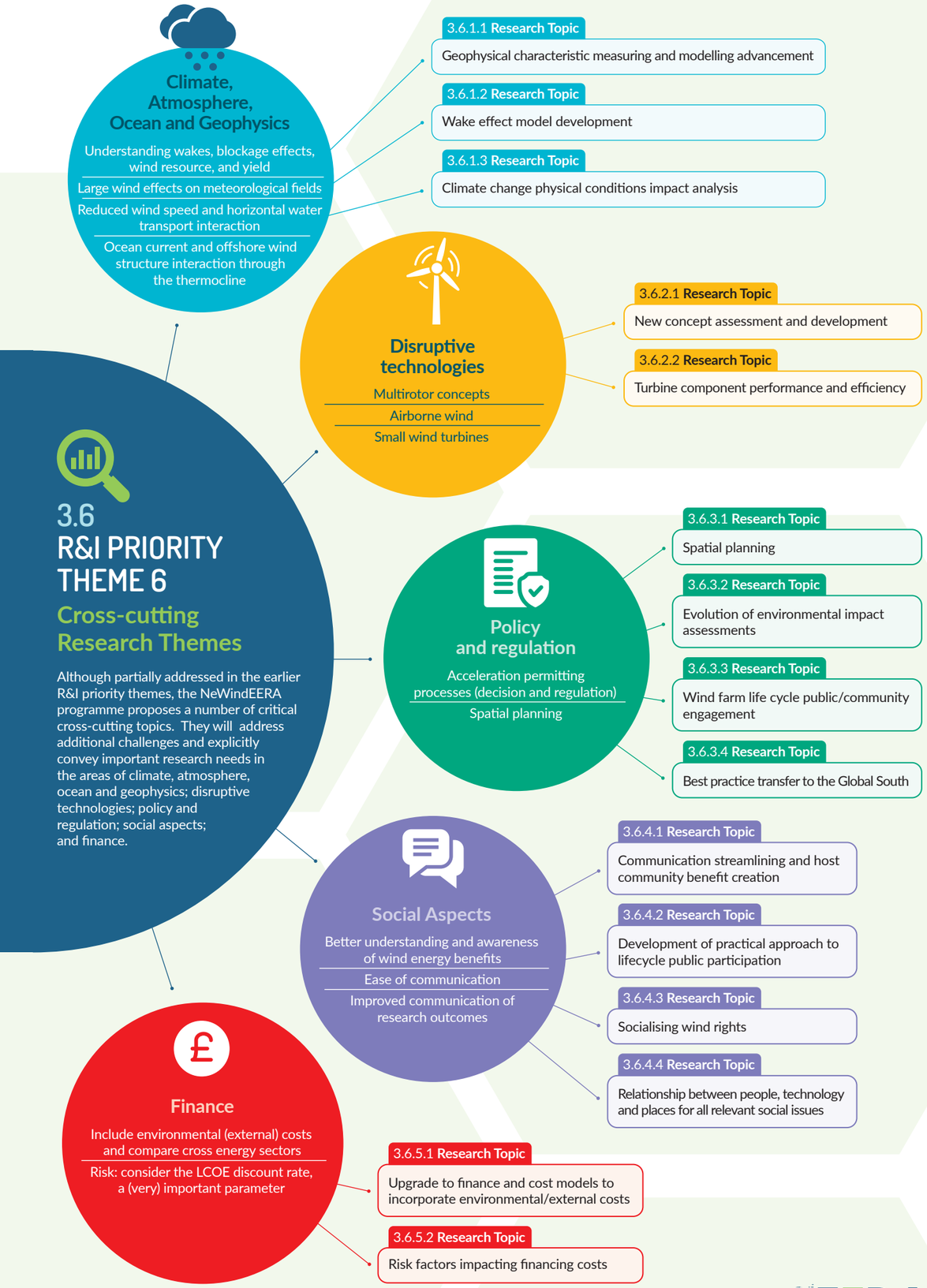
Increase public engagement of citizens
Provide guidelines for continuous community involvement throughout the whole project period, and implement in regulations
Demonstrate the benefits of wind energy for society as a whole and local communities

- 3.5.3.1 **Research Topic** — Community involvement modelling/ tool development
- 3.5.3.2 **Research Topic** — Wind energy societal benefits and impacts analysis

Fair transition, inclusiveness and stakeholder interests
Develop tools to identify stakeholders, improve the understanding and map stakeholder concerns
Develop novel governance and ownership models of wind farms

- 3.5.4.1 **Research Topic** — The good process
- 3.5.4.2 **Research Topic** — Tools to map stakeholder concerns
- 3.5.4.3 **Research Topic** — Technology-people-relations and public perception

Interdisciplinary and transdisciplinary relations with coexistence
Planning for positive co-existence: Identification and definition of relevant societal and environmental assessment criteria of site specific impacts
Evaluation of the consequences of intensified wind energy production and upscaling



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MAPPING THE EERA JP WIND RESEARCH DISCIPLINES

The NeWindEERA project builds on the EERA JP Wind R&I Strategy released in 2020 and recognises the strong heritage of research disciplines and technical excellence currently in existence amongst the EERA JP Wind membership.

The table below maps how this existing capability and activity will continue to be utilised and developed in the six R&I priority themes identified in this brochure.

EERA JP Wind R&I Strategy Topic	NeWindEERA R&I Priority Theme					
	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6
Next generation wind turbine technology & disruptive concepts						
Implementation of 6000GW wind power worldwide	x		x	x		x
Unknowns in degradation mechanisms	x	x		x		
Interpretation and extrapolation of testing	x		x	x		
Multi-purpose platforms	x		x			x
Degradation and damage mechanisms	x	x		x		
Access to data	x	x	x	x		
Upscaling of wind	x	x	x	x	x	
Development of larger and larger turbines	x	x	x		x	x
Grid integration & energy systems						
Validated energy systems models			x			
System friendly wind power			x		x	x
Behaviour and control of large HVDC connected clusters			x		x	x
Dynamic performance of very large wind power clusters			x		x	
Failure mechanisms of cables, transformers, converters	x	x	x			
Advanced system services from wind power		x	x		x	
Sustainability, social acceptance & human resources						
Identifying higher societal value from wind energy				x	x	x
Assessing wind energy contribution to sustainable goals				x	x	x
Developing sustainable technologies and designs	x	x		x		x
Identifying skills and training needs					x	
Assessing R&I project economic and societal impact	x	x	x	x	x	x
Applying life cycle assessment		x		x	x	x
Social acceptance mechanism understanding	x			x	x	x
Offshore wind (bottom fixed + floating)						
Validation of integrated design models for floating wind	x	x				
Offshore physics (soil, waves, air, sea)	x	x				x
Efficient multi-disciplinary optimisation	x	x			x	x
Site specific conditions for electrical infrastructure		x	x			
Operation & Maintenance	x	x	x			
Accurate component reliability models	x	x	x	x		
Lifetime extension		x		x		x
Robotics	x	x				x
Degradation mechanisms of surfaces (wear, erosion..)	x	x		x		
Data analytics for O&M and condition monitoring	x	x	x	x	x	x
Fundamental wind energy science						
Climate change and extreme climate impact	x			x		x
Physics of large rotor aerodynamics (inflow, blade, wake)	x	x		x	x	
Better knowledge of materials (properties, degradation..)	x			x		x
Atmospheric multi-scale flow (mesoscale to wind farm)	x	x				x
High performance computing and digitalisation	x	x	x		x	
System engineering models (fluid, soil, electro-mech.)	x		x	x	x	x

ABOUT EERA JP WIND

The European Energy Research Alliance Joint Programme for Wind energy (EERA JP Wind) is a joint programme that brings together many of the major research and academic organisations from the European wind energy community. With circa 50 members in the joint programme, it provides strategic leadership for medium to long-term research activity in the field of wind energy and supports the European wind energy industry and societal stakeholders. The joint programme currently operates eight sub-programmes designed to identify and develop the solutions to the grand challenges facing the wind energy research community over the coming decades.

For more information, please visit the EERA JP Wind website (https://www.eera-wind.eu/) or follow us on social media:

LinkedIn: **www.linkedin.com/in/eera-jp-wind**

X: **@eera_jpwind**

THE THREE PILLARS OF EUROPEAN WIND ENERGY RESEARCH AND INNOVATION

We must have strong alignment with industry and a common set of research and innovation priorities with short, medium and longer term goals.

With this in mind, the new NeWindEERA research programme is one of three pillars that will enable a fully aligned delivery of the European wind energy research and innovation activity.

1

The first pillar is the ETIP Wind Strategic Research and Innovation Agenda
Shorter term R&I priorities for the next five years

2

The second pillar is the NeWindEERA research programme
Medium and longer-term R&I priorities for 2035 and 2050 targets

3

The third pillar is the European Wind Energy Centre of Excellence (EuCoE4Wind)
The emerging framework/ vehicle that will carry us on the journey

ACKNOWLEDGEMENTS

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DISCLAIMER

The NeWindEERA project is funded by the EERA JP Wind membership. However, the views and opinions expressed are those of the author(s) of the NeWindEERA consortium and do not necessarily reflect those of the wider EERA or EERA JP Wind membership.

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