Strategic Research Agenda
Market Deployment Strategy
From 2008 to 2030

SYNOPSIS

Preliminary discussion document

European Wind Energy
Technology Platform

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This synopsis provides an overview of TPWind Strategic Research Agenda and Market Deployment Strategy documents, currently under development. The final documents will be released during the first half of 2008.

This extract is based on the results of two General Assemblies held in Brussels in November 2007 and February 2008, and contributions from TPWind members.

www.windplatform.eu

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A 2030 Vision for the Wind Energy Sector

The wind energy deployment is expected to follow the following three phases:

- **Phase 1: Short-term (2020)**
  The market matures in the Western part of Europe and develops in Central and Eastern Europe. Large-scale deployment of offshore wind energy begins. The capacity installed reaches 180 GW, including 40 GW offshore;
- **Phase 2: Medium-term (2020-2030)**
  Wind energy becomes mature in all its applications both onshore and offshore. The main developments are further cost reductions and high technology penetration. Deep offshore technology develops on an industrial scale. Exports from Europe grow. Competition with low labour cost countries increases. The capacity installed reaches 300 GW in 2030, when annual installations reach 20 GW of which half is offshore and 7.5 GW is re-powering;
- **Phase 3: Long-term (2030-2050)**
  The main markets are in offshore and re-powering and exports outside Europe remain strong.

In 2030, wind energy will be a major modern energy source, reliable and cost competitive, in terms of cost per kWh. The market context will be driven by concerns over the impacts of climate change, oil and gas depletion, high costs and unpredictable availability of fuel (security of supply), CO_2 allowance prices and sustainability. Development will occur within the current context of decarbonisation and globalisation.

The European industry will continue to lead the global market. Depending on future electricity demand, 21-28% of the EU electricity consumption, or a total of 300 GW, will be provided by wind, corresponding to 575 millions of tons of CO_2 savings annually. It will be supported by an optimal industrial expansion in Europe. The European power markets will be much better integrated with full separation in ownership of transmission and production activities, larger inter-connectors and effective wholesale and balancing markets.

As a consequence, by 2030:

- Wind power will no longer be an incentive-driven energy source. On the contrary, as a result of its volume and value, it will reduce price variability and the cost of electricity;
- The European wind sector will be a global centre of excellence, driving innovation and creating large numbers of attractive jobs;
- The public will support wind energy developments strongly. Wind energy will be regarded as an element of European identity;
- Administrative procedures will no longer present obstacles to development, as they will be more coordinated, stream-lined and efficient;
- Wind power will be integrated optimally into the natural environment and informed decisions and planning will ensure minimal impact on the local environment.

Realising this vision requires the manufacture, delivery, implementation and operation of approximately 14 GW per year of additional capacity, which includes decommissioning. This is equivalent to more than 20 turbines being installed per working day.

Investments in resources such as technology, financing and knowledge will be needed to achieve this volume in a changing market and to ensure that wind energy is competitive, sustainable and effectively managed. It will also require robust technological development, adapted markets and supportive human resources and financing policies.

Realising the 2030 Vision: Research Priorities

Wind energy has entered a phase of technological maturity. The priority of the wind sector is to install and connect large amounts of wind power to the grid both quickly, safely and cost effectively, whilst simultaneously addressing concerns about the reliability, availability and accessibility of the turbines.

Four thematic areas have been identified: wind conditions; wind turbine technology; wind energy integration; and offshore deployment and operation. These thematic areas reflect the overall objective of the sector, which is to produce reductions in costs.

Wind conditions: a 3% vision

Optimising large-scale wind energy systems in complex environments needs in-depth understanding and advanced modelling of the physical phenomena involved. Whether the geographical location of the wind farm installation is flat terrain, complex terrain or offshore and whether there are plenty of wind measurements or absolutely none, current techniques must still be improved to provide predictions of:

- Annual mean power production with an uncertainty of less than 3%;
- Design wind characteristics with an uncertainty of less than 3%;
- A short-term forecasting scheme for power production and wind conditions with an uncertainty of less than 3%.

In this field, the priorities are:

- **A set of full scale measurement campaigns, Askervein II**, to enhance the current knowledge of the wind flow in complex terrains, forested areas and offshore/ nearshore. The data analysis will enable the development and fine tuning of advanced and new flow models, which are needed to move the three research objectives towards the delivery of the 3% vision;
- **New measurement techniques** to acquire data with sufficient spatial and temporal resolution both for onshore and offshore;
- **Advanced models,** developed in parallel, involving the use of Computational Fluid Dynamics software and, in the long-term, the integration of all aspects into a comprehensive numerical wind atlas;
- **Short-term forecasting** for market integration and grid operation providing improved accuracy and integration with meteorological models, improved uncertainty assessment and more effective integration with Energy Management Systems;
- **Standards** for siting, and new measurement techniques, in the medium-term.

Wind turbine technology:

meeting the challenge of both maximising reliability and making the technological breakthrough that will enable European industry to fulfill the ambitious wind energy objectives

In order to establish large production volumes, several pressing demands have to be met in terms of securing supplies of materials, technical reliability, manufacturing technology, cost control and expertise. This can only be realised if R&D is focused on producing continuous, incremental improvements in the current basic concepts of wind turbine systems. On the one hand, this requires fundamental analyses of some specific shortcomings of these concepts, such as transmissions, to arrive at cost effective solutions and, on the other hand, the incorporation of technical innovations such as intelligent materials and compact low speed generators into the concepts. Besides this strategy of incremental improvement, offshore project designers and operators are requesting the development of completely new concepts. The chance to make significant reductions in the cost of energy (COE) by developing 'disruptive' new technologies is another reason to develop a parallel strategy focused on concept innovation.

All innovative ideas and R&D proposals should have the same single objective of decreasing COE and reducing uncertainties. This is why all proposals need to be assessed in terms of their potential impact on COE and this includes all cost elements, specifically initial investments, operations and maintenance costs, energy efficiency of the entire wind energy system, availability in terms of reliability and accessibility and life time. Environmental issues such as decommissioning costs should also be part of this equation.

Research priorities are categorised according to the technical disciplines and cross cutting aspects on which the integral design and operation of wind energy systems is based. Not all future research needs new models. Therefore applying existing proven theories, models and tools to existing and new concepts is explicitly included in future R&D activities.

- **The wind turbine as a flow device** – with the increasing size and complexity of wind turbines, a full understanding of the aerodynamic phenomena is needed, including the external conditions. The corresponding design and analytical tools to enable the development of advanced rotor (control) concepts need significant improvements.
- **The wind turbine as a mechanical structure / materials** – basic knowledge is available to estimate operation loads. However, the level of uncertainty has to be lower if manufacturers are to be provided with appropriate design and production specifications. In combination with accurate operating loads, continued characterisation of both existing and new materials is needed to reduce design safety factors and cost. Fewer uncertainties in materials characterisation also call for improved methods of measurement and evaluation. Also, new materials are required for many components such as blades and towers. Condition monitoring and system control could be improved considerably by incorporating sensors into the materials. Recycling of materials should be investigated so that the quality of the materials can be maintained at their original levels.

- **The wind turbine as an electricity plant** – improved high voltage electronics could increase efficiency and decrease costs. Improved power converters could maximise system efficiency and improve controllability and power quality. New, light weight, low speed and low maintenance generators are needed that might include high temperature super conductors.
- **The wind turbine as a controlled system** – the development of sensors and computers could provide opportunities to realise multi-parameter, adaptive control strategies that can optimise the turbine's operation. This means that the entire range of critical parameters that influence efficiency, capacity factor, safety, power quality, structural and electric stability are continuously controlled, whilst external conditions and turbine properties may vary. Implementing these strategies would guarantee low operation and maintenance (O&M) costs during the specified life time.

- **Operation and Maintenance, Condition Monitoring, Installation** – in order to maximise availability, system reliability and accessibility (offshore) need to be improved to the maximum extent. Improving reliability implies improving wind farm management, the reliability of wind turbine components and the standardisation of these components. In addition, maintenance has to be minimised through the introduction of preventive maintenance strategies and tools that have been developed on the basis of low cost and extremely reliable condition monitoring methods.
- **Concepts and Integration** – design methods should comprise, for example, sub-design routines such as those for blades, power electronic systems, mechanical transmission, support structures and transport and installation loads. Fully integrated methods do not, as yet, exist but during their development they should be thoroughly verified and introduced into the standard design and certification processes.

- **New concepts** – these will arise from innovations in materials and components and from the needs of the offshore project operators/owners. Given the huge challenges in the current and medium-term markets that are caused by the gap between demand and supply, the first priority is to improve the existing wind turbine concepts. This should not be hindered by the exploration of 'disruptive' technologies.
- **Standards** – standardisation is considered to be the final stage of a development trajectory and, in a way, it freezes the state-of-the-art knowledge in methods or evaluation criteria. To avoid standards becoming a barrier to technical innovation, they should be subject to an updating process into which all the aspects of technology development that have been mentioned earlier would have an input.
- **R&D facilities** – as wind turbines are big structures most of the research infrastructure is correspondingly large and costly. This applies particularly to wind tunnels, blade fatigue testing facilities, drive train testing, wind turbine test stations and facilities to evaluate wind farm control. Joint efforts are required to establish such facilities and to make them accessible to the international R&D community and to wind turbine and component manufacturers. Apart from using these facilities for research, there is also a need for the operational verification or demonstration of new high risk concepts such as those related to new installation and transport. Also full scale, comparative testing of wind turbines, under extreme climate conditions, provides extra security for financiers who are planning to make a large investment in the sector. This need would be fulfilled by a jointly operated test site at a location where the climate is extreme.

Wind energy integration:

adapt the supply and demand system to large amounts of variable supply of electricity

Here the objective is to enable the large-scale integration of wind power with high penetration levels, whilst maintaining system reliability, with low or reduced integration costs.

Priority areas are:

- **Wind power plant capabilities** – this should involve investigating the options of operating wind farms as much like conventional power plants as possible, meeting adapted grid codes requirements and providing ancillary services. In addition, there is a need to develop and verify wind power plant capabilities and to assess the extent of requirements at different wind penetration levels.
- **Grid planning and operation** – a more efficient use of existing grid capacity is needed, which would require advanced control of wind farms and probability management tools for grid operation. The needs in grid infrastructure and inter-connection capacity improvements should be studied to manage a low capacity factor resource. Transmission technologies for both onshore and offshore should be further investigated.
- **Energy and power management** – there should be an assessment and demonstration of the benefits and costs of several options to provide ancillary services and power balancing in higher wind penetrations. To handle variable production capacity, existing flexibility in power systems should be explored and quantified. Additional flexibility should also be explored both by generation and demand side management, together with the development of storage with a view to future, high penetration levels of wind.

- **Energy markets** – wind power should become an adapted market product, tradable, exchangeable, and transparent like other forms of energy. Research will be needed on market rules and design development for international and local market places to accommodate wind power, market access for small producers and wind power impacts on market prices. Markets should make use of all possible flexibility in the power system to keep the imbalance costs low. Bringing virtual power plants to the market may demonstrate more predictable and controllable demand and generation profiles.

Offshore deployment and operation:

10% electricity demand from offshore wind

The objective of offshore wind research should be to deliver:

- More than 10% of Europe's electricity demand from offshore wind by 2030;
- Offshore generating costs that are competitive with other sources of generation;
- Technology for sites of water depth up to 50m, at any distance from shore which is commercially mature;
- Technology for sites in deeper water, proven through full-scale demonstration.

The key priority areas are:

- **Substructures** – the prerequisites for substructures are efficient, fabrication-friendly designs combined with more efficient manufacturing processes and improved fabrication technologies.
- **Assembly, installation, and decommissioning** – the transporting of equipment from suppliers across Europe to the wind farm site and the installation of each turbine in a hostile offshore environment are key challenges. Both involve complex and repetitive processes, which, in turn, require efficient transport links, large lay down areas, good harbours and purpose-designed vessels and specialist equipment.
- **Electrical infrastructure** – two major challenges face the electrical infra-structure in delivering Europe's offshore wind targets. These are integrating the offshore wind capacity into the power system and the manufacture and installation of the equipment and cables.
- **Turbines** – the offshore environment needs larger turbines that have been adapted to the hostile environment and are fully marinised, robust and reliable. This will require a substantial modification of onshore machines in the short-term and the development of specific offshore designs in the medium and long-term.
- **Operations and Maintenance** – safe, efficient access systems are essential for the operation of the offshore facilities and for transferring personnel and equipment safely to the turbine.
- In addition to these five priority areas, there are three common themes which underpin each and are critical to the delivery of a world-leading offshore wind industry in Europe. **These are safety, environment and education.**

Realising the 2030 vision: Market and Policy recommendations

Market recommendations

The overall objective is for wind energy to become a major, modern, energy source that is reliable and competitive in terms of cost per kWh within a market that is driven by concerns about the impacts of climate change, oil and gas depletion and the modern focus on sustainability. This development will also occur within the current context of decarbonisation and globalisation. Another important goal is to ensure that European industry continues to lead the global market.

The attainment of these objectives is supported by six priorities:

- **Securing revenues in a long-term perspective** by improving the reliability of technology, minimising uncertainty about the pricing of wind energy, harnessing the potential of providing ancillary services, and reducing utility costs by improving forecasting techniques.
- **Reducing investment costs** through solving supply chain bottlenecks and decreasing the uncertainties about the future cost of raw materials and their impact on the cost of wind energy. Technology should be adapted to challenging environments as the market expands.
- **Reducing operational costs** by improving the cost/benefit ratio of operating costs, increasing access to maintenance and services companies, and reducing offshore O&M costs through technological improvements.
- **Reducing the cost of capital** by boosting the confidence of the financial sector in the technology, future revenue and market sustainability.
- **Adapting the grid infrastructure** access and management and making wind as manageable as possible for the network operators. This should involve adapting the grid networks to the distributed nature of wind energy, investing to modernise the infrastructure at the necessary pace and adapting grid codes, because they are so diverse and change so often that they present unnecessary obstacles.
- **Adapting trading mechanisms** to high wind penetration levels, by assessing the impact of a large penetration of wind energy on current markets, developing wind power forecasting, and adapting market regulations such as gate-closure time and imbalance pricing.

Policy recommendations

Following the adoption of the 20% binding target on the use of renewable energy sources, long-term legally binding electricity, heating/cooling and transport renewable energy targets should be established at national level, for heat, power and transport.

In parallel, corresponding policies should be developed to provide a stable and predictable environment in which the targets can be met. Stable and long-term support schemes have been proven to deliver long-term investment. This point is essential and could provide a significant signal to promote the confidence of investors.

Clear, transparent and simplified planning and administrative procedures should be established to increase efficiency in terms of the time and costs spent on development.

A fully functioning internal European electricity market should be created to enable efficient trading in electricity production. As a complement, a new network infrastructure should be designed to facilitate large-scale wind deployment and enable physical trading. This development should also be supported through regional policies and investment. Access to the grid must be fair and the process simplified through policy and regulation. At project scale, cost reductions should be achieved through grid access harmonisation, where appropriate.

On the remuneration side, there should be fair and efficient economic regulation in favour of wind power, which takes account of its positive externalities, contribution to energy independence and industrial development. In line with EU legislation, this would be a clear recognition, at EU and national level, that wind energy is a technology which is contributing effectively to sustainable development and deserves to be categorised as a public interest investment.

In relation to the integration of wind energy into the natural environment, the potential overlaps between the Habitats Directive and the Renewables Directive should be addressed.

Realising the 2030 Vision: Human Resources

The wind energy sector is currently facing a shortage of human resources. This is a critical issue because of the scale of wind energy developments that are required to meet the 2020 targets and TPWind 2030 vision. The needs range from skilled workers who can manufacture, build and operate the facilities to graduates, who understand the technical, commercial and social context of the industry and are equipped to provide the technology, drive and direction to maintain European leadership in wind energy.

The current shortage of human resources should be solved. With the support of the European Commission and Member States, the whole sector must design and implement initiatives to attract people at all levels. The promotion of environmental aspects such as CO_2 reduction and the opportunities that exist for career development are strong arguments that can be used to attract skilled individuals to the sector.

Realising the 2030 Vision: Financing of Research

To comply with the decision of the Barcelona European Council, the Research and Development efforts of the sector should be financed at a level of at least 3% of annual turnover. Based on the expected Wind Energy deployment scenarios, European turnover is used to calculate the R&D figures indicated below.

This assumption produces minimal R&D investment levels, for three reasons: a) world technological leadership is not guaranteed by “advisable” Lisbon levels; b) export sales and manufacturing outside Europe based on European technology figures have not been incorporated; and c) the figures might be improved for strategic technologies, with a clear impact on fossil fuel independency and climate change mitigation.

A very gross approximation indicates that the average Member State contribution is currently in line with the 3% objective at €50 million per year for the period 2000-2005 and €55 million per year for the period 1995-2005. However, while some Member States are making appropriate contributions, others with large companies operating in the wind sector are not committing enough resources to R&D. In the future, the overall spending on R&D may have to increase but it is likely that many Member States would not be in a position to provide a larger contribution.

A sub-optimal element in the financial equation is the EC contribution through its Framework Programmes (FP). If the Barcelona objectives and the 20% renewables target are to be achieved and the EC maintains its previous financing trends during 2006-2020, then the cumulative gap in total R&D financing is estimated at €1 billion. Also, for the FP7 financing period (2007-2013), this gap is estimated to be €450 million. However, early FP7 is showing signs of a greater sensitivity to Wind Energy R&D.

There is a serious and urgent need to reprioritise energy R&D financing, in the light of the recently changed energy, socio-political, social concern and environmental paradigm. Current instruments should be revised to take account of the new situation. Those that are compatible should be adapted and, where appropriate, new instruments should be developed.

The forthcoming European Wind Initiative, which is outlined in the Strategic Energy Technology Plan, is a key opportunity to reinforce European world leadership in R&D financing and execution frameworks.

The European Wind Energy Technology Platform

In 2006, the European wind energy sector, through the European Wind Energy Association, launched the European Wind Energy Technology Platform (TPWind). The main objective of TPWind is to identify areas for increased innovation, new and existing research and development tasks, and to prioritise them - the primary objective being overall cost reductions comprising social, environmental and technological aspects.

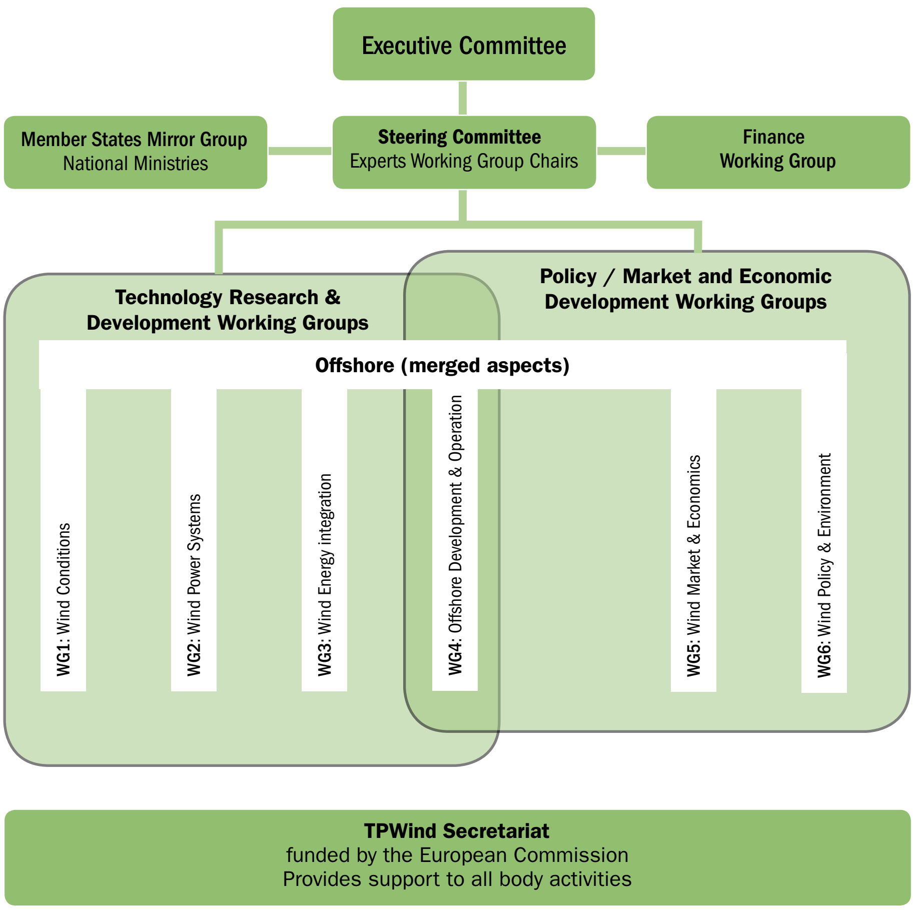
TPWind objectives will be met through incremental or radical technological improvements and large-scale deployment of technology. Historically, the principal drivers of wind energy cost reductions have been R&D and economies of scale. The scope of TPWind mirrors this duality. TPWind not only focuses on short- to long-term technological R&D, but also on market deployment issues and potential "show stoppers."

TPWind develops a Strategic Research Agenda, addressing technology development issues and a Market Deployment Strategy, addressing issues affecting the large-scale deployment of the technology.

These documents are drafted by four Technology Research and Development Working Groups and two Policy and Market Development Working Groups. The TPWind structure also comprises:

- a transversal Offshore Deployment Working Group, covering offshore-specific issues;
- a Finance Working Group considering the assessment and procurement of sufficient funds to finance the innovation and R&D tasks;
- a Steering Committee, which is the decision-making body and executive arm of the Technology Platform. It comprises five Executive Committee Members, as primary link with the Secretariat;
- a Mirror Group, comprising the relevant ministries and energy agencies of Member States, which advises the Steering Committee;
- a Secretariat coordinating the activities of the Platform, which is supported by the European Commission.

Figure 1: Structure of TPWind



Realising the 2030 Vision: Research Action Plan

GLOBAL VISION: 300 GW – 21% to 28% of EU electricity consumption

	Thematic priority to achieve the global vision	2030 vision in the thematic priority
STRATEGIC RESEARCH AGENDA	WIND CONDITIONS	3% vision
	WIND TURBINE TECHNOLOGY	Maximising reliability and realising technology breakthrough to meet ambitious objectives
	WIND ENERGY INTEGRATION	High penetration levels ensuring system reliability, reduced integration costs
	OFFSHORE DEPLOYMENT AND OPERATION	10% of EU electricity
MARKET DEPLOYMENT STRATEGY	MARKET RECOMMENDATIONS	A major modern energy source, reliable and cost competitive
	POLICY RECOMMENDATIONS	A vision for the wind energy sector

WIND CONDITIONS

Thematic priority to achieve the global vision	WIND CONDITIONS											
Priority topics to achieve the 2030 vision	Siting in complex terrain and forested areas		Wakes		Offshore		Extreme wind speeds		Wind profiles at greater heights		Short-term Forecasting	
Implementation of priority topics: research priorities	Askervein II	1	Data analysis	2	Design conditions for offshore sites	1	Data analysis	1	Data Analysis	1	Data Analysis	1
	New measurement techniques	1	Advanced Models	6	Improvement of meteorological models	1	Advanced models	3	Advanced Models	4	New Measurement Techniques	1
	Standards	3			Dedicated offshore short-term forecasting models	2	Extreme Wind Atlas	5	New Measurement Techniques	6	Advanced Models	6
	Advanced models	6			Fully integrated wind-wave-current interaction models	2						
					Basic knowledge of marine atmosphere	2						
					Standard models for resource assessment	4						
					Ground-based remote sensing techniques	6						
					Satellite-based remote sensing techniques	6						

WIND TURBINE TECHNOLOGY

Thematic priority to achieve the global vision	WIND TURBINE TECHNOLOGY								
Priority topics to achieve the 2030 vision	Wind turbine as a flow device	Wind turbine as a mechanical structure / materials	Wind turbine as an electricity plant	Wind turbine as a controlled system	Operation and Maintenance, Condition Monitoring, Installation	Concepts and Integration	New concepts	Standards	R&D facilities
Implementation of priority topics: research priorities	Final strategy under development								

WIND ENERGY INTEGRATION

Thematic priority to achieve the global vision	WIND ENERGY INTEGRATION							
Priority topics to achieve the 2030 vision	Wind power plant capabilities		Grid planning and operation		Energy and power management		Energy markets	
Implementation of priority topics: research priorities	Grid code requirements	2	Improved operation, interoperability	2	Long term planning	4	Market modelling	1
	Means of verification	2	Models, simulation tools	2	System Operation	6	Market rules	3
	Opportunities for meeting requirements	4	Accelerated extension and reinforcement	3			Market access	6
			Transmission studies for offshore	5				

OFFSHORE DEPLOYMENT AND OPERATION

Thematic priority to achieve the global vision	OFFSHORE DEPLOYMENT AND OPERATION			
Priority topics to achieve the 2030 vision	Market deployment actions		Research actions	
Implementation of priority topics: research priorities	Installation, Assembly, Decommissioning	1	Environment	5
	Environment	1	Electrical infrastructure	5
	Safety	6	Safety	6
	Education	6	Substructure	6
	Substructure	6	Installation, Assembly, Decommissioning	6
	Electrical infrastructure	6	Turbines	6
	Turbines	6	Operation and Maintenance	6
	Operation and Maintenance	6		

Legend

1	Short term
2	Short and medium term
3	Medium term
4	Medium and long term
5	Long term
6	Including short to long term

About TPWind

The European Technology Platform for Wind Energy (TPWind) is the indispensable forum for the crystallisation of policy and technology research and development pathways for the wind energy sector; as well as a new opportunity for informal collaboration among Member States, including those less developed in wind energy terms.

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SIXTH FRAMEWORK PROGRAMME

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