Integrated Research Programme on Wind Energy

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Definitions

EERA	European Energy Research Alliance	SP	Sub programme
JP	Joint Programme	SAP	Strategic Action Plan
EERA JP Wind	EERA Joint Programme on Wind Energy	SR	Strategy and Roadmap
IRP	Integrated Research Programme	EWI	European Wind Initiative
TP	Technology Platform		
WP	Work Package		

Contents

Executive Summary

This document presents the Yearly Action Plan (YAP) for the EERA Joint Programme on Wind Energy (EERA JP Wind) as well as the IRPWIND project funded by the European Commission under FP7.

The present YAP presents the planned activities for the EERA JP Wind and IRPWIND for the period 2016-2017. The activities are based on the EERA JP Wind Medium to Long Term Research Strategy and Roadmap (SR). Together, the YAP and the SR guides the activities of the EERA JP Wind and the IRPWIND.

EERA JP Wind and IRPWIND aims to increase alignment and coordination of national and European activities. The overview of the sub-programme deliverables on sub-sequent pages shows that EU projects provide the majority of deliverables to each sub-programme, but national proejcts now make up 20-30%. The combination of national and EU project is an important contribution to the knowledge sharing in EERA JP WIND.

The mobility scheme and the programme for joint experiments under IRPWIND Work Package 3 5 contribute to link together the national and EU activities further. For the mobility scheme, IRPWIND has agreed with the European Commission to adjust the scheme so that it now offers continuous mobility calls without fixed deadlines.

This year, IRPWind also launched the first call for joint experiments for research infrastructures. Moving into the 3rd year of IRPWind it is therefore expected that we will see a strong increase in the number of coordination activities to help strengthen the EERA Joint Programme for Wind Energy.

For this period 2016-17, IRPWind also has a number of important foreseen activities especially within international cooperation and the development of the IRPWIND business plan to enable a viable EERA JP WIND after the end of the IRPWIND project.

This YAP still show some discrepancy in terms of how the EERA JP WIND Sub-programmes describe their activities. This reflects the modus operandi in EERA JP WIND which has allowed extensive self-governance within the individual SPs as they operate outside of IRPWIND as well.

Sub-Programme 1 *Wind Conditions*

Many offshore and complex terrain wind farm projects are hampered by unforeseen wind conditions leading to lower than predicted production and/or higher loads not taken into consideration in the design. Furthermore, uncertainties will also have consequence in the risk analysis for building, operation, maintenance and dismantling phases of the wind farm. The goal of the Wind Condition Sub-Programme within (EERA) is to align medium- and long-term research activities in order to lay a scientific foundation for a more cost effective wind energy reducing the uncertainties in models.

SP1 has defined 5 research themes and identified 10 deliverables

Research Themes for *Wind Conditions*

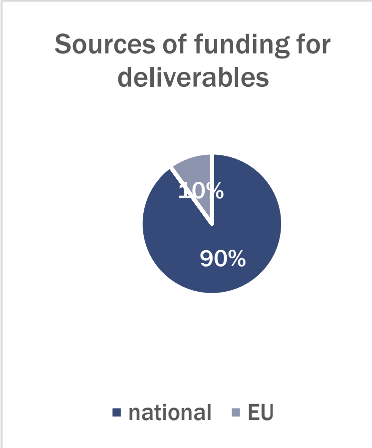
RT1 Improvement of the applicability of the models of wind conditions in the atmospheric boundary layer.

RT2 Establish an experimental basis for uncertainty assessment and evaluation of model uncertainties

RT3 Evaluating and improve the numerical weather models for short- and medium- term forecasting.

RT4 Future climate: resource trends, variability and predictability; and

RT5 Developing and implementing in experimental activities innovative measurement techniques.



Sub-programme 2 *Aerodynamics*

The EERA research activity Aerodynamics aims to align medium- and long-term research activities so that the knowledge of fundamental aerodynamics is raised to the level that the required high quality design tools can be developed. These tools will improve the elaborate, expensive and time consuming development of prototype wind turbines and decrease time to market, thus providing the European industry a competitive advantage.

SP2 has defined 5 research themes and 25 Deliverables.

Research Themes for *Aerodynamics*

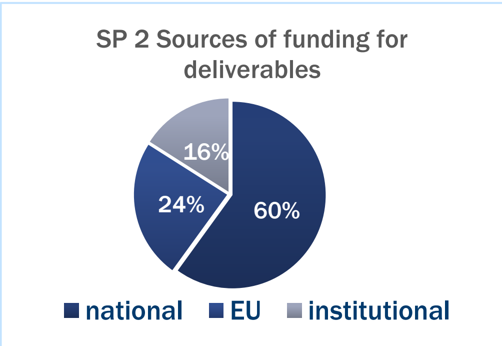
RT1. The inflow wind field at the rotor.

RT2. Aerodynamic design models that are used in aero-elastic calculations

RT3. Wake modelling.

RT4. Aero-hydro-elastic coupling

RT5. Innovative aerodynamic concepts and



Sub-programme 3 *Structures and Materials*

The sub-programme on Structures and Materials aims to reduce the uncertainty in the design of structural load carrying components, such as the blades, the support structure, the nacelle bed and the hub, in order to increase cost efficiency and reliability and allow for optimization, innovations and upscaling of future wind turbines.

SP3 has defined 5 research themes and 15 deliverables.

Research Themes for *Structures and Materials*

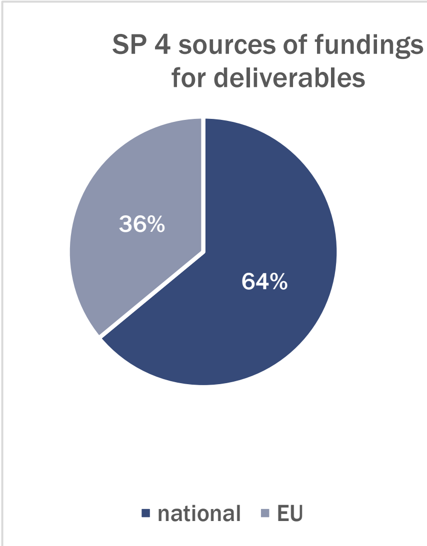
RT1. Structural analysis models and design methodologies for wind turbine blades

RT2. Structural reliability methods for wind turbine structural components

RT3. Material models and life prediction methods for structural components

RT4. Design processes, concepts and tools for wind turbine structural components

RT5. New concepts and features such as coatings, structural health monitoring and predictive maintenance and repair solutions for the structural components



Sub-programme 4 *Wind Energy Integration*

Under the guiding principle "Manage wind power as an integral part of the inter-connected European electricity supply system" the objectives of the SP on wind energy integration have been developed and formulated. The overall objective is to prepare pre-competitive research to lay the scientific foundation for cost effective wind power production and integration.

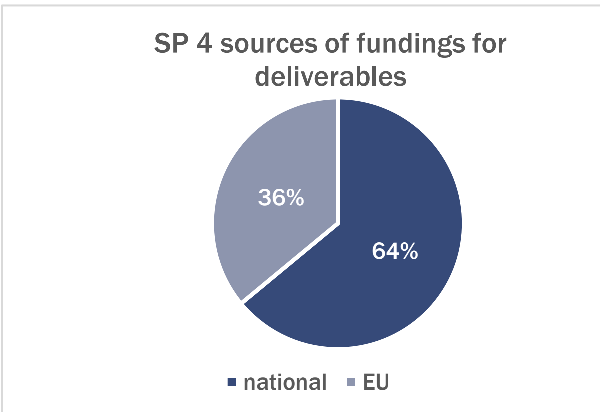
SP4 has defined 3 research themes and 25 deliverables

Research Themes for *Wind Energy Integration*

RT1. Wind power plant capabilities

RT2. Grid planning and operation

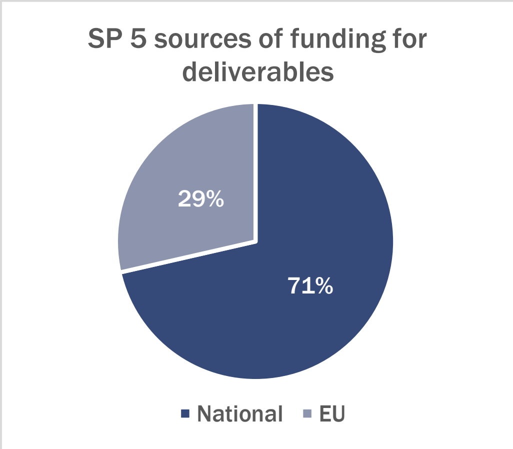
RT3. Wind energy and power management



Sub-programme 5 *Offshore Wind Energy*

The EERA sub-programme on offshore wind has an overall objective to prepare pre-competitive research laying a scientific foundation for the industrial development of more cost effective offshore wind farms and enabling large scale deployment at any seas.

SP5 has defined 5 research themes and 28 Deliverables



Research Themes for *Offshore Wind Energy*

RT1 Integrated numerical design tools for offshore wind turbines and wind farms.
RT2 Characterization and interaction of wind, wave and current
RT3 Numerical tools for offshore grid and wind farm electric design
RT4 Control, operation and maintenance of offshore wind farms
RT5 Development of novel wind turbine and wind farm concepts for deep sea

Sub-programme 6 *Research Infrastructure*

The Research Infrastructures sub-programme identifies the trends and needs of the sector in relation to tests, measurements, experiments and validation activities so to prioritize the most relevant topics to be supported by the actions of this sub-programme. In this regard, the objectives are set to promote joint experiments to be carried out by multiple European institutions, at facilities all over Europe. Consequently, this Sub-programmes defines objectives rather than research themes.

SP6 has defined 6 objectives and 2 deliverables

Objectives for *Research Infrastructure*

O1 Implement the actions to align and coordinate European institutions with research facilities to perform high value joint experiments
O2 Create the framework to develop and perform the experiments
O3 Dissemination of the data obtained on the experiments
O4 Identify needs for different type of testing that requires specific Research Infrastructures, considering the possibility of having demand for new type of testing facilities.
O5 Implement the actions required by the EERA Wind Strategy for the period (Strategy),
O6 Integrate the following projects into the RI Strategy & SAP:

i. Windscanner.eu – Preparatory Phase
ii. Windbench
iii. NEWA

SP6 Deliverables

2 deliverables from large European projects developing the wind community's research infrastructure:

- IRPWIND
- New European Wind Atlas (NEWA)

Sub-Programme 7 *Economic and Social Aspects*

This sub-programme will deal with a range of research areas, from cost developments of components and different turbine types to questions of how to best integrate wind energy into the energy systems – including social aspects - and how power markets should be adapted so that wind power can provide most benefits to the system.

SP7 has identified 10 Deliverables. All deliverables are directly related to get the Sub-programme operational and are consequently funded in-kind by SP members.

Research Themes for *Economic and Social Aspects*

RT1 Component and system costs of wind energy
RT2 Economic incentives and support mechanisms for wind energy
RT3 Integration of wind into energy systems
RT4 Adapting power markets for wind energy
RT5 Environmental issues of wind energy including Life Cycle Assessment (LCA)
RT6 Public engagement strategies for wind energy

1.1 EERA JP Wind and IRPWIND

The vision of the EERA Joint Programme for Wind Energy (EERA JP Wind) is to move from a voluntary network of research organisations towards a "virtual research centre" running an Integrated Research Programme and help develop a common European Research Area for wind energy research in Europe.

The European Energy Research Alliance (EERA) is the public research pillar of the European Commission's Strategic Energy Technology Plan (SET-Plan). Organised in Joint Programmes (JP), EERA complements the European Technology and Innovation Platforms (ETIPs) led by industry but including participation from EERA Joint Programmes.

EERA JP Wind started in 2010 on a voluntary basis. Since then activities and the number of members have grown substantially. In March 2014 an unprecedented project scheme co-funded by the European Commission called IRPWIND was started. IRPWIND contributes to the EERA JP Wind by establishing an IRPWIND secretariat, and support several coordinating activities within mobility, research infrastructures and international collaboration as well as to fund 3 core research projects.

The research activities in the EERA JP Wind are guided by two documents:

The Medium to Long Term Research Strategy and Roadmap (SR) defines the medium to long term research priorities based on gap-analysis and industry priorities.

The Yearly Action Plan (YAP) outlines the work which members of the EERA JP Wind plan to undertake in the coming year to achieve the targets and address the research themes outlined in the SR.

These two documents reflect the ongoing work among the EERA JP Wind partners including European Projects, the long term priorities defined by European Industry in the TPWind Strategic Research Agenda as well as planned activities in EERA JP Wind[1].

These activities were started before the launch of the IRPWIND. However, the IRPWIND has made it possible to *strengthen the management* of EERA JP Wind, to *greatly increase coordination activities* in EERA JP Wind and to *further deepen research efforts* in EERA JP Wind. In this way, IRPWIND enables EERA JP Wind to take an important step forward towards becoming a European Virtual Research Centre for Wind Energy.

The ability of EERA JP Wind and IRPWIND participants to deliver on the research targets outlined in this YAP depends on the function of the EERA JP Wind/IRPWIND secretariat and the coordinating activities undertaken within the IRPWIND. The coordination activities in EERA JP Wind and IRPWIND are described briefly in chapter 2 of this YAP[2].

About this document
The YAP is divided into three parts: an introduction to EERA JP Wind and IRPWIND and the background for how the priorities in this YAP are developed (Ch.1); the YAP itself described for each EERA JP Wind Sub-programme (Ch 2-8); and finally the background information about EERA JP Wind and IRPWIND (Ch 9).

1.2 IRPWIND: A new approach to combine national and European activities

Now that wind energy is a substantial part of the electrical generation mix, it is more important than ever to support the growing wind market with carefully targeted research in order to sustain European competitiveness. It will require improved understanding of technology, resources, environmental impact and social issues to achieve these ambitious goals.

The bulk of public research funding is still at national level. National wind energy research programmes have focused on meteorology, wind modeling, resource assessments, aerodynamics etc. Research organisations have also – together with industry – worked on standardisation and modeling to support the evolution of the wind energy market. With the growing importance of wind energy issues of social acceptance, siting offshore and in complex terrain has led to other research topics.

For industry, the main driver the last 10 years has been upscaling. This is also where joint European projects have made important contributions. For instance the UpWind project focuses on the design of very large wind turbines (8-10 MW), where new concepts looked into floating wind turbines etc.

[1] In 2016 the ETIP Wind, which replaces TPWind will publish an updated SRA.

[2] A description of the EERA JP Wind and IRPWIND organization and management can be found in chapter 9 of this document.

With the new SET-Plan (Towards and Integrated SET-Plan) and especially the document "Towards an Integrated Roadmap" we are starting to see a convergence between national and EU-targets for wind energy.

The basic mechanism in EERA JP Wind to do so has been to develop a research portfolio combining national and EU projects within a single framework.

The aim of IRPWIND is to accelerate the integration efforts in EERA JP Wind by supporting essential coordination and support actions (CSA) and providing key core research activities that complete the overall European programme portfolio.

In the IRPWIND, three core RTD projects (CPs) have been defined as self-contained institutional research programmes, the implementation of which will to a large extent be based on the different national projects already funded by research councils, ministries, etc. In this way, the partners will seek to align, optimize and develop R&D in these gap areas by conducting the research activities. Figure 6 shows how the IRPWIND contributes substantially to EERA JP Wind research portfolio.

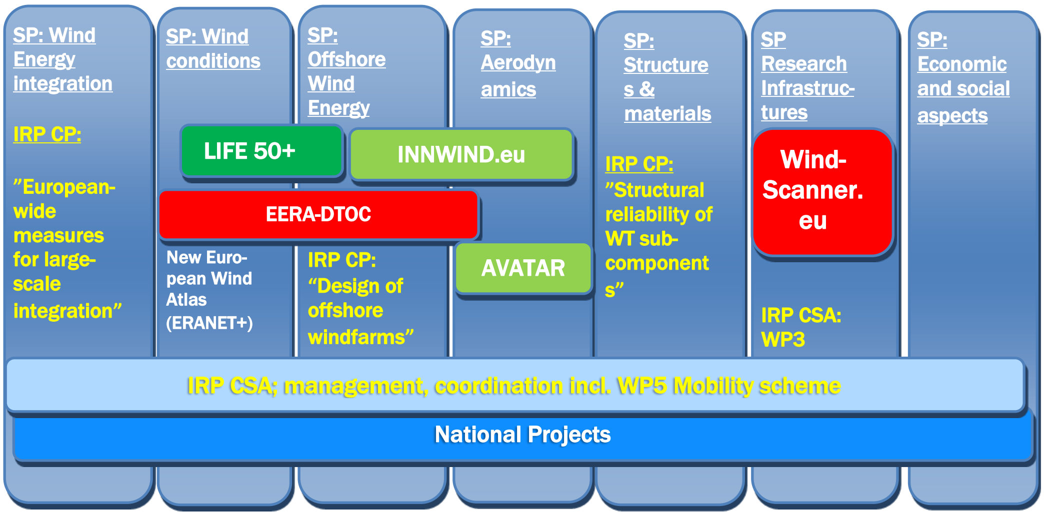


Figure 6 – EERA JP Wind portfolio with the IRPWIND (yellow text indicate IRPWind funded activities) Color code of boxes; light green = FP7; dark green H2020; red=finished FP7 projects; yellow= IRPWind

It is important to notice that finalized projects continue their life within JPWind, either by leading to new projects or drawing on the learnings and outcome of the projects. This is an important part of the increased efficiency and leverage effect of the JPWind project portfolio approach.
The three technical IRPWIND core projects (IRP CP) are described in the specific sub-programme chapters. The overall approach in EERA JP Wind and IRPWIND is described below.

1.3 Alignment and integration

The EERA JP Wind is about aligning and accelerating the research efforts done by the research organizations. The above process developing the project portfolio is just one way in which EERA JP Wind strives to achieve alignment and integration of national and

European projects. The overall ambitions for alignment and integration are stressed in the following.

There are several vehicles to obtain this. It is an aim in itself to make sure that the reporting included in the Yearly Action Plan will gradually reflect an increase in integrated activities. The result of this will be reported on a yearly basis both in a written format and at the yearly IRPWIND conference[3]. It is also important to mention that within the IRPWIND, a dedicated mobility scheme has been set up as a concrete way to link different existing national and European projects, by giving researchers the possibility to visit another European institution working on the same scientific issue. Furthermore the IRPWIND has a work package addressing better use and planning of research infrastructures including new joint activities and projects initiated at national level, but involving partners in several countries. As part of the KPIs reported on the project, data will be collected for mobility, infrastructures and EU project publications.

1.4 About the Yearly Action Plan 2014-17

In the previous sections of this chapter, the framework for and the modus operandi of the EERA JP Wind and the IRPWIND have been outlined. Based on this framework of policy targets, industry needs and research gaps and opportunities, each EERA JP Wind SP has developed a strategic action plan. Each SP has identified important knowledge gaps in their research domain. Based on the knowledge gaps, a set of objectives are outlined and from these a shortlist of Research Themes are identified. For each research theme a set of deliverables are identified.

A Total of 131 deliverables are defined in Sub-programmes 1-6. Of these, 52 are from EU projects, 65 are from national projects while 15 are not identified as either EU or national.

In addition to the deliverables, the SAP is used to define future research projects and priorities both nationally and at EU level. Together with the EERA JP Wind Medium to Long Term Research Strategy and Roadmap, the YAP provides important strategic guidance for EERA JP Wind members.

1.5 Key Performance Indicators

Measuring the progress of programmatic efforts such as IRPWIND is both difficult and important. Difficult, because many of the advances in building a virtual research programme are intangible and only show their effect over time. Important because we need to ensure that the efforts are moving in the right direction. A common set of Key Performance Indicators (KPIs) was therefore agreed between the European Commission and all 4 IRP-projects coordinated by EERA Joint Programmes. This section provides an overview of the indicators starting value and targets for 24 and 48 month for the IRPWIND the project. Updated KPI figures will be collected for 2014-15 by June 2016.

[3] Next IRPWind conference will take place 20-21 September 2016 in Amsterdam

Developing common KPIs for projects covering 4 different technologies poses a challenge as not all indicators will be relevant for all IRPs. In the list of KPIs it is therefore indicated "x" for those KPIs where no activities are done in relation to IRPWIND. For other KPIs we have indicated the same value for starting, 24 and 48 month targets as the Indicators refers to figures that can be collected, but are not influenced by the activities for IRPWIND. For the remaining KPIs we have collected first figures to estimate start and target values. But also here, we are facing challenges due to definition issues of some KPIs.

	IRPWIND KPIs	**Number #**	**Number #**	**Number #**
#	**NAME OF METRIC**	**TARGET Initial value**	**TARGET First 24 months**	**TARGET Total 48 months**
A)	**INTEGRATION**			
A1	Number of nation research programmes contributing to the long-term R&D strategy defined at European level	13	13	13
A2	Total budget from national research programmes contributing to the long-term R&D strategy defined at European level	30	30	30
B)	**QUALITY OF RESEARCH**			
B1	Number of joint publications by IRP participants supported by EU funding accepted/published in peer-reviewed journals	17*	>40	>100
B2	Number of joint publications by IRP participants supported by national funding accepted/published in peer reviewed journals	>20	>25	>60
C)	**RESEARCH FACILITIES**			
C1	Number of tests carried out at the facilities of each IRP participant	2	3	6
C2	Number of Round-robin sessions carried out at the facilities of each IRP participant	0	2	4
C3	Number of joint tests carried out by two or more IRP participants	2	3	6
C4	Total duration of joint tests carried out by two or more IRP participants	36	36	48
C5**	Number of cross tests carried out by two or more IRP participants	x	x	X
C6	Total duration of cross tests carried out by two or more IRP participants	x	x	X
C7	Number of jointly planned new research facilities at national level	0	0	0
C8	Number of jointly planned new research facilities at international level	0	1	1
C9	Number of Memoranda of Understanding (MoU) and agreements on the joint use and development of research facilities	2	3	6
D)	**EXCHANGE OF RESEARCHERS**			

D1	Number of researchers involved in mobility and exchange programmes	0	18	>36
D2	Number of reports from researchers involved in mobility and exchange programmes	0	18	>36
D3	Number of days of mobility and exchange	0	900	1800
D4	Number of joint publications related to the participation in the exchange programmes	0	>5	>25
D5	Number of dissemination events related to the participation in the exchange programmes	0	2	3
E)	**INNOVATION**			
E1	Number of agreements in the past two years between IRP participants and industry (among others: contract research, license agreements, cooperation agreements, etc.)	>700	>1000	>1500
E2	Number of agreements in the past two years between at least two IRP participants and industry (among others: contract research, license agreements, cooperation agreements, etc.)	>20	>40	>60
E3	Number of patent applications submitted in the past 2 years	14	14	>14
E4	Number of patent applications by at least two IRP participants submitted in the past 2 years	0	0	0
E5	Number of IP assets entered into the web-based IP show case, maintained by the EERA Secretariat	0	>100	>100
E6	Number of industry stakeholders involved in IRP R&D, or accessing IRP research facilities, or licenses of the IP generated within the IRP, or partners in the mobility programme	>10	>40	>50

*Publications from EU funded projects are counted only for projects by JPWind consortia

**Cross tests are not performed in relation to the IRPWIND and are therefore not included in the calculations.

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

<u>SUB-PROGRAMME: Wind Conditions</u>

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work 2016

January 2016

Sub-programme on Wind Conditions

The Levelized Cost of Energy LCOE) is strongly dependent on the ability to accurately calculate the wind resource and the design wind conditions. Many offshore and complex terrain wind farm projects are hampered by unforeseen wind conditions leading to lower than predicted production and/or higher loads not taken into consideration in the design. Furthermore, uncertainties will also have consequence in the risk analysis for building, operation, maintenance and dismantling phases of the wind farm. It is therefore crucial to provide the uncertainties linked to the environmental condition modeling for any given wind farm lifetime phase.

The goal of the Wind Condition Sub-Programme within (EERA) is to align medium- and long-term research activities in order to lay a scientific foundation for a more cost effective wind energy reducing the uncertainties in models.

The foreseen activities within EERA JP Wind Energy will burst the cooperation between the European research institutes as promoted by the European Commission through the Framework programs to a commitment of planning and implementing joint research programs including sharing and optimizing the use of human resources and research infrastructure.

The main research areas in the Wind Condition Sub Programme follow this line and are linked to gaps envisaged for the short- and medium-term in the EERA strategic plan and will address the following objectives:

RT1. Improvement of the applicability of the models of wind conditions in the atmospheric boundary layer.

RT2. Establish an experimental basis for uncertainty assessment and evaluation of model uncertainties

RT3. Evaluating and improve the numerical weather models for short- and medium- term forecasting.

RT4. Future climate: resource trends, variability and predictability; and

RT5. Developing and implementing in experimental activities innovative measurement techniques.

The SP Wind Conditions is closely linked to all sub-programmes providing the environmental models and data needed for the implementation of weather related activities. Required data and models will be secured through a cooperative effort between the participating institutes as far as possible.

2.7 Background

The present knowledge gaps in wind energy are inherently connected with the increasing size of wind turbines and wind farms and their interaction with environmental conditions. Furthermore, inland, turbines are going to be placed in forested and complex terrain that are still challenging to model for both resource assessment and for power forecast. Because the development of models for wind and load conditions over the wide range of topographies and climates of interest for wind energy deployment particularly at heights up to 300 meters are based on observations performed (and theories developed) close to the Earth's surface, their uncertainties are very large and accuracies might be inadequate. What seriously is halting the possibility of accelerating the model improvements is the lack of high-quality datasets necessary for progress. Immediate actions required – agreed by both the industry and research community - are the acquisition of data from mast and proven remote sensing technologies well above 100 meters at land and sea and subsequent model improvements. For offshore wind-wave coupling is required particularly with turbines moving to deep waters.

Knowledge gaps to be filled on a short-term scale:

- Knowledge on wind above 100 meters is limited over all types of terrain including offshore, mainly due to the lack of datasets for evaluating and proper modeling techniques.
- How different scales in models interact, i.e. what can different types of model offer and how can be coupled? (Global climate, meso-scale, micro-scale).
- How can the ocean wind and wave conditions be characterized and modeled through coupled ocean/meteorological models on different time and space scales?
- Impact of extreme wind and waves on the life cycle of a wind farm.
- Understanding and accurate characterizing the atmospheric turbulence on large and small scales over all types of surfaces and climates.
- Interaction of the very large turbines and wind farms with the atmospheric flow on turbine and wind farm scales.
- Understanding the impact of transition between different regimes at different atmospheric timescales as well as length scales on turbulence, e.g. transition during the diurnal cycle on land due to the properties of the atmospheric response to radiation or offshore due to the change in wind direction.
- How atmospheric and wind turbine data can be utilized in data assimilation to improve short-term wind forecast and wind resource assessment?
- What are the minimum requirements of the input data with respect to resolution and area coverage and type of input to obtain a reduction of uncertainty of the wind flow modelling?
- Understanding the causes of wind shear and changes of wind direction with height and their effect on power production and loading of wind turbines
- Quantifying the impact of the meteorological uncertainties on the risk analysis for any given wind farm lifetime phase.
- Consistency of modeling techniques for wind forecast for the wind power integration in the energy system. i.e. from short-term forecast over monthly to seasonal and inter-annual to decadal time scales, and from local to regional spatial scales
- Understanding of the interaction of the wakes behind a turbine with the environment turbulence.
- Influence from climate variability on the wind resources on timescales from months to the lifetimes of the wind farms (approximately 30 years).

Short-term activities are directed to understand and quantify the uncertainty inherent to state-of the art models and methods.

Long-term activities are directed to reduce these uncertainties through dedicated experiments and fundamental and tailored model building, i.e. with a seamless model tailored for wind energy specific purposes.

2.8 Objectives

The overall objective of the Sub-Programme Wind Conditions in 2016 is to perform pre-competitive research into the fundamental understanding on how atmospheric motions affect the use of wind energy: from the siting, design and operation of the turbines to the spatially integrated renewable energy systems, say, from dynamic inflow to regional resource assessments and forecast.

At present, most of the strategic objectives are directed towards the "New European Wind Atlas" (NEWA) and ensure that it will appear as an absolute reference for all aspects concerning wind turbines and wind conditions.
The NEWA consortium includes ten EERA members, DTU, BERA, CENER, CIEMAT, IREC, IWES, ForWind, LNEG, UniPorto, TÜBİTAK.
Due to the constraints of the ERANet + call, only countries that have committed co-funding to the project can be a partner within the consortium. However, EERA members not partners in "NEWA" have expressed the interest in contributing to the project through the man/months committed to EERA within SP Wind Conditions supplied by National parallel projects. A workshop is planned to gather the interested external EERA participant to SP wind condition where they can assert their interest and level of commitment.

In this view, a number of questions constitute some basic institutional knowledge gaps and will have to be answered/solved rigorously to fulfill all the scientific/technical objectives set in the New European Wind Atlas project.

The Research Themes R1 to RT5 will address the specific objectives.

RT1. Improvement of the applicability of the models of wind conditions in the atmospheric boundary layer.

RT2. Establish an experimental basis for uncertainty assessment and evaluation of model uncertainties

RT3. Evaluating and improve the numerical weather models for short- and medium- term forecasting.

RT4. Future climate: resource trends, variability and predictability; and

RT5. Developing and implementing in experimental activities innovative measurement techniques.

Research Themes

RT1: Applicability of wind conditions modelling in the atmospheric boundary layer.
Main Topics

- Establish the architecture for the Model Chain[4] from "Global to Local"
- To tailor selected meso-scale models to the Model Chain and determine the optimal solution through a concept, which is to the largest extent possible open source.
- Tailor the Global datasets, the "Reanalysis" high resolution datasets, to the Model Chain and determine their limitations and associated uncertainties.
- Establish the protocol/methodology for transferring information from meso-scale models to micro-scale models and determine the associated propagation of uncertainties.
- Investigate the applicability of contemporary coupled wind and wave models; model evaluation towards measurements of wind, waves and turbine response and possible model improvements.
- Establish a standard for site assessment based on a systematically validated model chain

RT2: Establish an experimental basis for uncertainty assessment and evaluation of model uncertainties. (Experimental Matrix)

Main Topics

- Establish a protocol for selection and implementation of the experimental setups

[4] Model chain: The transition from large scale meteorological models and the local conditions at a particular wind turbine site.

- Upgrades selected existing experimental sites with additional instruments and perform experiments to validate the model chain.
- Identify underway projects that include experiments which can be upgraded to provide essential data for model evaluation
- Establish a understandable and logic way to present uncertainty measures for regional to very local wind assessments
- Together with model developers, define procedures for the design of experiments and for post-processing to define strong sense benchmarks. These are engineering standards that define a comprehensive framework for model testing, the requirements for model inter-comparison and a set of acceptance criteria considering the intended use of the models.
- Design additional high-quality experimental campaigns on ideal sites, specially chosen to evaluate specific parts of the different atmospheric models (e.g. Forest parameterization, turbulence closures, terra incognita etc.)

RT3: Numerical weather models for short- and medium-term forecasting
Main Topics

- Ensure that the short term prediction models that currently are in use for wind energy take advantage of the continuous improvements on the meteorological forecast models created in the large meteorological centers (ECMWF, NCEP, NCAR etc.).
- Prepare for the increasing spatial and temporal resolution of numerical weather models, e.g. by adapted physical parameterizations and post-processing schemes.
- Improve the data assimilation system which is used today in Europe to be of optimal use for short-term predictions. This will be achieved in cooperation with the Meteorological institutions and organizations.

RT4: Future climate: resource trends, variability and predictability.

Main Topics

- Undertake a full assessment for the predictability of wind resource variability over future climate timescales of one month, season(s), year(s) or decade(s), using state-of-the-art climate forecast systems.
- Development of a fully seamless approach to the forecast methodology and the assessment of forecast uncertainty, reliability.
- Development of regional climate downscaling, to assess the impact of climate simulations at scales representative for wind energy analyses.
- Investigate methodologies to apply climate forecasts in wind planning and operational decision-making-processes.

RT5: Innovative measurement techniques.
Main Topics

- Develop measurement strategies for utilizing the windscanner lidars in large experiments onshore as well as offshore. Together with the WindScanner.eu ESFRI preparatory phase project.
- Develop new concepts of measurement devices to obtain data with a high spatial and temporal resolution for validation wind and temperature measurements applicable to the validation of models.
- Design a possible network of remote sensing instruments with the aim of improving models for wind forecasting.
- Better understanding of the behavior of the atmosphere with respect to the application wind energy by measurements with advanced remote sensing techniques.
- To support, enhance, and extend the capabilities of the university community and the broader scientific community, nationally and internationally in understanding the methods of remote sensing.

- To foster the transfer of knowledge and technology of wind scanners from research to industry.

2.9 Description of foreseen activities

2.9.1 Sub Programme Joint Activities

Developing a Content Management System (CMS) for the EERA Wind Condition Sub Programme

The wiki at www.EuropeanWindProjects.eu has been implemented in November 2015. The wiki will host information on wind energy research projects related to the SP Wind Conditions being undertaken across Europe at both at International and National level. The wiki was initially thought for serving the purpose of the SP Wind Conditions, e.g. to easily retrieve information, organizing activities, follow up of the SP and SP reporting. At present, the wiki host a sample of European and National funded projects in Denmark and Spain. Information can be found by the wiki searching engine. Users can add own projects using the provided template and instructions at EUWindProjects.

In 2016, the plan is to further populated and developed the wiki to expand the search capability by developing a Content Management System (CMS) that would allow a more flexible extraction of information with respect to the actual wiki. A step forward will be to **harmonize in a joint database the information already available at each EERA institutions. A further development under discussion is extending the** CMS including information on projects related to all EERA JPWind Sub Programmes.

Beneficiaries of the CMS span a broad range from individual researchers who become informed by up-to-date information on projects across Europe, to the EERA Management Board or EERA secretariat who can extract the information at hand for e.g. reporting progress in the JP. Finally the European Commission might use the CMS to be informed on the ongoing National projects and funding allignment to the H2020 agenda.

Expert Workshop on Lidar technology and Boundary Layer Research and modelling.
Added value of lidar technology in modelling the Atmospheric Boundary layer processes.

Foreseen format:
Over two days: Foreseen dates 24 May – 25 May
Call for extended abstracts
For each Topic: 1 invited speaker for 30 minutes - 20-minute talk on highlights, gaps and challenges and 10 minutes discussion on future perspectives
3 speakers for each topic for 10-minute talks.
Topics:

- Wind Scanner and lidars in Complex terrain, Coastal, Offshore, gaps, challenges and perspectives
- Review of Wind Scanner experiments
- Monitoring activities with lidars
- Integrating wind scanners and models, from microscale (LES, CFD) to mesoscale gaps, challenges and perspectives
- Review of modelling efforts along wind lidar measurements
- Wind Lidars and scanners and wind tunnels

A poster session will be organized in the afternoon of the first day with short presentations.

Developing the Sub Programme Wind Conditions session at IRPWind General conference, September 2016.

As done in the past years, a “Wind Condition” session will be developed at the IRPWing Conference . Key note speakers will be invited to give highlights on the ongoing activity.
A summary of the workshop on lidar technology will be presented by the sub programme chair.

Meso-scale benchmarking analysis and final report (DTU, ForWind-Oldenburg, CENER, CNR, and NKUA)
This benchmarking exercise, related to RT1, was co-organized and launched with the European Wind Energy Association (EWEA) in 2015. The exercise is a milestone in the medium- to long- term Strategic Plan and in the Roadmap of EERAJP Wind Energy, SP Wind Conditions. http://www.ewea.org/events/workshops/resource-assessment-2015/mesoscale-benchmarking-exercise/
The purpose is to evaluate the capabilities of mesoscale models used in wind energy for estimating of site wind conditions, with a tailored benchmarking, providing one year of time series from three sites in Europe with different characteristics: inland, coastal and offshore. There are two objectives:

- To highlight common issues on mesoscale modelling of wind conditions on sites with different characteristics i.e. offshore, coastal, onshore, providing a common understanding on differences; and
- To identify gaps and strengths of models and understand the root conditions for further evaluating uncertainties.

The analysis of the time series from twenty-four entries from 16 International groups including EERA partners has shown to be an invaluable source of information about state of the art in wind modelling with mesoscale models and the results have been shown at the IRPWind Annual Conference and at the EWEA annual Conference in Paris in November 2015. Following the EWEA presentation, three more entries were submitted by three other European teams. The activity in the first quarter of 2016 will be to merge the latest entries and finalize the analyses for developing the next phase of uncertainty evaluation and submit a paper.

Following, we describe Milestones and Deliverables for 2016, listed in Table 1 and in Table 2 respectively and we summarize the National projects supporting the partners activities in the SP.

Mile-stone	Title	Nature[5]	Delivery date (MM-YYYY)	Lead partner	Comment
M1	IEA-Wind Task 36. Forecasting models starts. RT1, RT3	O	01-2016	DTU	Oldenburg, CENER,
M2	Rune project: experimental campaign at Høvsøre concluded. RT1 and RT2	O	02-2016	DTU	National Funding
M3	1st NEWA Experiment, Østerild, Horizontal scanning of coastal flow. RT1 and RT2 and RT5	O	03-2016	DTU	NEWA
M4	Benchmarking Exercise article Submitted. RT1	R	04-2016	DTU	National Funding
M5	Workshop on the Wind Scanner Perdegao Experiment in Portugal,	O	05-2016	University of Porto	NEWA
M6	Workshop for the Sub Programme	O	05-2016	DTU	EERA
M7	Description of MOBI buoy and database of measurements ready. RT2	O	06-2016	RSE	National Funding

[5] R = Report, P = Prototype, D = Demonstrator, O = Other

M8	MYNN planetary boundary layer scheme adapted to the offshore environment. RT1	0	08-2016	Forwind Oldenburg	National Funding
M9	2nd NEWA experiment Horanmoseen (SE). Forested environment. RT2 and RT5	O	08-2016	University of Uppsala Non-EERA DTU	EU/National
M10	Three full years of experimental profiles from a wind lidar at the South Italy Tyrrhenian coast completed. RT2	O	08-2016	CNR	National Funding
M11	All meteorological sensors for the DFWind test site installed. RT2	O	09-2016	Forwind Oldenburg	National Funding
M12	Finalization of OBLEX-F1 offshore campaign. RT2, RT5		09-2016	CMR, UoB	National Funding
M13	End of simulations of storms affecting the Danish coastal extreme winds finished, X-WIWA Project, RT1	O	09-2016	DTU	National Funding
M14	Presentation and discussion of the updated final results of the benchmarking exercise at the 3rd IRPWind Conference, RT1	O	09-2016	DTU	DTU, UniOld, CENER, UoA, CNR
M15	Three measurement stations in Dutch North Sea using Lidars, RT2, RT5	O	12-2016	ECN	National Funding
M16	3rd NEWA Experiment Kassel (GE). RT2, RT5 Start. 08-2016	O	12-2016	IWES	DTU ForWind
M17	EuropeanWindProject.eu active	O	12-2016	DTU	EERA
M18	IEA-Wind Task 36. List of available databases available, RT2	R	12-2016	DTU	DTU, UniOld,
M19	Concept of assimilating measurements in the model chain consisting of WRF, PALM and FAST completed, RT3	R	12-2016	Forwind Oldenburg	National

Table 1 Foreseen Milestones for 2016.

Deliverable	Title	Na-ture[6]	Delivery date (MM-YYYY)	Lead partner	Source of Funding	Project
D1	Final Report of the Rune project on offshore coastal wind from the coast, RT1, RT3	R	06-2016	DTU	N	RUNE
D2	Database of measurements of Rune project. RT1, RT3	O	06-2016	DTU	N	RUNE Limited access

[6] R = Report, P = Prototype, D = Demonstrator, O = Other

Deliverable	Title	Na-ture[6]	Delivery date (MM-YYYY)	Lead partner	Source of Funding	Project
D3	Database report on simulated storms from the X-WiWa project. RT1	R	09-2016	DTU	N	X-WiWa
D4	EuropeanWindProject.eu WIKI	D	12-2016	DTU	O	EERA
D5	Final report on instrument deployment and data availability during the OBLEX-F1 campaign. RT2, RT5	R	12-2016	CMR UoB	N	NORCOWE
D6	Dutch offshore wind data made available through WindOpZee.net , RT2, RT5	D	12-2016	ECN	N	LAWINE
D7	Final reports LAWINE (Lidar) project, RT2, RT5	R	12-2016	ECN	N	LAWINE
D8	Report of the analysis of three years of experimental profiles from a wind lidar at the South Italy Tyrrenian coast. RT2, RT5	R	12-2016	CNR	N	I-AMICA
D9	Three years of wind profiles at coastal areas conditional available, RT2, RT5.	O	12-2016	CNR	N	I-AMICA Limited Access
D10	Description of MOBI buoy and database of measurements ready. RT2	O	12-2016	RSE	N	Wind Mapping of Sicily Channel

Table 2a. Foreseen Deliverables for 2016 and related information

Deliverable	Description	Source of funding[7]	PM/Y
D1	Final Report of the Rune project on offshore coastal wind from the coast, RT1, RT3	N	40
D2	Database of measurements of Rune project. RT1, RT3	N	30
D3	Database report on simulated storms from the X-WiWa project. RT1	N	18
D4	EuropeanWindProject.eu WIKI	O	2
D5	Final report on instrument deployment and data availability during the OBLEX-F1 campaign. RT2, RT5	N	84
D6	Dutch offshore wind data made available through WindOpZee.net , RT2, RT5	N	4

[7] National = N; European = EU; Other = O

Deliverable	Description	Source of funding[7]	PM/Y
D7	Final reports LAWINE (Lidar) project, RT2, RT5	N	4
D8	Report of the analysis of three years of experimental profiles from a wind lidar at the South Italy Tyrrenian coast. RT2, RT5	N	12
D9	Three years of wind profiles at coastal areas conditional available, RT2, RT5.	N	12
D10	Description of MOBI buoy and database of measurements ready. RT2	N	?? New Associated

Table 2b. Foreseen Deliverables for 2016 and related information

The list of milestones and deliverables above shall be understood as indicative only and to be completed in continued dialogue with SP partners during fall 2016, and adjusted according to success with starting new projects now in an application phase, both at national and EU level.

2.10 EERA Participants, Contributions/Engagement and Human Resources

The table below gives the contributions of the partners participating to Wind Conditions during 2016.

PARTICIPANTS

Partner	Country	Role[8]	Contribution / Engagement in Research Themes RT	PM/Y
BERA	BE	Full	RT1, NEWA	60
CMR	NO	Ass.	RT2, RT5, NORCOWE	42
CENER	ES	Full	RT1, RT2, RT3, RT5, NEWA	60
CIEMAT	ES	Ass.	RT2, NEWA	36
CIRCE	ES	Ass.	RT2, NEWA	18
CNR-ISAC	IT	Full	RT1, RT2, RT3, I-AMICA	88
CTC	ES	Ass.	N/A,	
CRES	GR	Full	N/A	37
DLR	GE	Ass.	RT1, NEWA, DF-Wind	3
DTU Wind	DK	CO	RT1, RT2, RT3, RT5, NEWA, RUNE, XWiWa, FarmOpt	120
ECN	NL	Full	RT1, RT2, RT5, LAWINE	8
Fraunhofer IWES	GE	Full	RT1, RT2, RT3, RT5	60
IREC	ES	Ass.	N/A	6
LNEG	PT	Ass.	RT2	60
METUWIND	TU	Ass.	N/A	48
RSE	IT	Ass.	RT1, RT5	??

8 Full = Full participant; Ass. = Associate participant; CO = Coordinator

Partner	Country	Roles8	Contribution / Engagement in Research Themes RT	PM/Y
SINTEF	NO	Full	N/A	
TECNALIA	ES	Ass.	N/A	12
Tubitak Usay	TU	Full	N/A	
University of Stuttgart	GE	Ass	RT3	15
University of Athens (NKUA)	GR	Ass.	RT1, RT2	24
University of Bergen (UoB)	NO	Ass.	RT2, RT5	48
University of Delft (UoD)	NL	Ass.	N/A	
University of Oldenburg (Uni-Ol)	GE	Ass.	R1, R2, R3, R5	36
University of Porto (UoP)	PT	Ass.	RT1, RT2, RT3	36
VTT	FI	Ass.	N/A	18

Table 3. Table 3 List of the participants in the SP and they engagement.

2.11 Time schedule

The time schedule below outlines activities on a quarterly basis starting January 2016. The time schedule shall show activities outlined in 2.3 and milestones as defined in 2.4.

Activity	Q1	Q2	Q3	Q4
RT1	MS1, MS3	W, MS6	MS07, MS10, MS12, MS13	-
RT2	MS3	MS4	MS8, M9	MS14, MS15, MS17
RT3	MS1		MSS	MS18
RT4	-	-	-	-
RT5	MS2, MS3	W	MS8	MS15

Table 4. Time schedule of the activities in the research themes.

A: application; M: meeting; R: report; S: status report; W: workshop; MS: Milestone

Overall coordination between the SPs and the JP wind in general comes in addition, adding some one meeting between coordinators per month.

2.12 List of national research projects with links to the SP

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Country
1	RUNE, RT2, http://www.vindenergi.dtu.dk/english/News/2014/12/The-RUNE-project-Reducing-the-Uncertainty-of-Near-shore-Energy-estimates	0.5	2015-2016	DTU	DK
2	X-WiWa, RT1, http://uni.no/en/uni-computing/efg/x-wiwa-dtu/	0.8	2014-2017	DTU	DK
3	FarmOpt, RT1, RT2, http://energiforskning.dk/da/project/optimerede-layouts-vindmoelleparker-i-komplekst-terraen-farmopt	1.46	2014-2017	DTU	DK
4	NORCOWE/OBLEX-F1, RT2, http://norcowe.no/index.cfm?id=428599	0.5	2015-2017	CMR/UiB	NO
5	Dutch offshore wind measurement, RT2	5	2010-2015	ECN	NL
6	Dutch offshore wind measurement, RT2	0.8	2016	ECN	NL
7	LAWINE, Lidar Applications for Wind farm Efficiency, RT2, http://www.tki-windopzee.nl/project/lawine	2	2012-2016	ECN	NL
8	CNR Coastal Wind Lidar, RT1, RT2, http://www.i-amica.it/	In-kind funding	2013-2016	CNR	IT
9	RSE MOBI BUOY, RT2	In-kind funding	2016	RSE	IT
10	DFWind, RT3, http://www.dlr.de/ft/en/desktopdefault.aspx/tabid-10349/17736_read-42141/	2.84	2015-2017	DLR, IWES, Forwind	GE
11	Ventus efficiens, RT1, https://www.uni-hannover.de/de/aktuell/online-aktuell/details/news/1128/	5.0	2014-2019	ForWind	GE
12	OWEA-LOADS, RT3, http://rave.iwes.fraunhofer.de/rave/pages/raveLoads	1.01	2012-2016	Universität Stuttgart	GE
13	From atmospheric circulation to electrons RT1, RT2 http://www.kuleuven.be/research/researchdatabase/project/3E12/3E120223.htm	N/A	2012-2016	BERA/CENAERO	BE

Table 5. List of National projects.

2.13 Contact Point for the sub-programme on Wind Conditions

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

SUB-PROGRAMME: Aerodynamics

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work
2016

January 2016

Sub-programme on Aerodynamics

The design risks increase significantly for future large 10-20MW wind turbines, in particular for offshore applications. The larger the turbines become, the more optimised and thus flexible the structure becomes and materials are utilised to their limite. In particular, loads and fluctuating loads must be handled more carefully. Modelling of the flow-structure interaction of the long blades in the complex wind inflow field gets more and more challenging. For this reason even more advanced and accurate design tools are required. These models should include issues as large blade deflections, more extreme inflow wind conditions, wave loading of (floating) support structures, applied to steadily more cost-effective and possibly new designs.

The EERA research activity Aerodynamics aims to align medium- and long-term research activities so that the knowledge of fundamental aerodynamics is raised to the level that the required high quality design tools can be developed. These tools will improve the elaborate, expensive and time consuming development of prototype wind turbines and decrease time to market, thus providing the European industry a competitive advantage. Several validation projects, have shown that the modelling of a wind turbine response (i.e. the power or the loads) is associated with large uncertainties. The potential to reduce the uncertainties mainly find their origin in the aerodynamic modelling and inflow field modelling. The research aim of the sub programme Aerodynamics is to reduce this uncertainty for future large wind turbines and to invent innovations which improve the aerodynamic performance of a wind turbine. The areas of research are:

- ✓ *The inflow wind field at the rotor.*
- ✓ *Aerodynamic design models that are used in aero-elastic calculations*
- ✓ *Wake modelling.*
- ✓ *Aero-hydro-elastic coupling*
- ✓ *Innovative aerodynamic concepts and features*

The research ranges from development of advanced theories and innovative models to experimental validation and design of innovative applications. The data required for validations is obtained by 1. Combining existing resources at the various institutes, 2. Sharing experiments at the various experimental facilities, 3. Defining and executing new collaborative research including experiments.

2.2 Background

Today's largest wind turbine under development is a 10 MW turbine where the stock average wind turbine is approximately 3 MW. For offshore wind turbines today, the costs related to O&M and retrofitting contribute 25-50% to the total cost of energy (€/MWh). In order to significantly reduce the future cost of energy, this drives the development of very large and reliable turbines. With the increasing size and complexity of wind turbines, rotor design models must include physical aspects that were not relevant for smaller turbines. In order to design these large rotors, a full understanding of aerodynamic phenomena is required. This must include the external conditions, such as the wind speed and direction distribution on the rotor plane for different wind turbine configurations and sites.

This objective has also been identified in the Wind Technology Platform TPWind Strategic Research Agenda (SRA) and the major challenge of EERA *Aerodynamics* is the longer term fundamental research to obtain knowledge to accurately model physical aspects relevant for the future large turbines and to develop and validate aero-elastic design tools which are accurate, efficient and fast enough. To verify these design tools, highly resolved expensive modelling is needed for large parameter studies.

In the so-called SET plan the development of very large wind turbines is a central objective. Likewise, in the European Wind Initiative (EWI) the target is to develop very large and reliable offshore wind turbines and in the EWI and in the SRA from TPWind the elements are outlined to achieve large scale deployment of offshore wind turbines. The described activities in this sub-programme are in line with the proposed initiatives in the EWI and the Strategic Research Agenda, however, taking it to a long-term perspective.

2.3 Objectives

The overall objective is to align pre-competitive research activities at European Energy research institutes to lay a scientific foundation for the long-term industrial development of more cost effective wind energy. The research aims at reducing the uncertainty in aero-elastic design calculations of future large wind turbines and to provide the theoretical basis for innovative steps in turbine technology for the European Industry. The strategic goals are:

- ✓ *Improved engineering inflow wind field modelling including vertical and directional shear, coherence, extremes, consistency with conservation laws, to be used as input for aerodynamic design and aero-elastic simulations.*

- ✓ *Improved aerodynamic design modelling including rotational effects, dynamic inflow, transition, turbulence structures, unsteadiness and dynamic stall, distributed control, variable geometries etc. effects on the rotor that can be used in aero-elastic code calculations.*

- ✓ *Improved unsteady wake modelling including wake meandering, overlapping wake, ground effects, and interaction with the boundary layer that can be used in wind farm modelling.*

- ✓ *Improving the design process of (floating) offshore wind turbines by developing new, improved models, concepts and tools for the aerodynamic interaction with respect to the integrated system design. This includes interaction through aero-elastics, wind turbine control, aero-hydro-dynamic damping, acoustics, etc.*

- ✓ *Development and evaluation of new aerodynamic concepts and features with particular emphasis on large offshore turbines– new airfoils, new planforms, optimization routines including costs, downwind, two bladed, high-speed rotors, vertical axis, variable geometries.*

2.4 Description of foreseen activities

The work is structured around the following research themes covering a) development of theory, models and codes, b) data from experiments and c) validation.

Research Theme (RT1): Inflow wind field modelling
This research theme aims at improved modelling of the inflow wind field for the rotor. Although large overlap with the wind conditions sub-programme exists, the inflow wind field modelling is crucially important to accurately model the wind turbine aerodynamics. The activities will be coordinated with sub-programme wind conditions. Activities aim to include vertical and directional shear, coherence, extremes, consistency with conservation laws, etc. The improved engineering inflow wind field modelling is to be used in aero-elastic simulations.

Activities are:

1. Intercomparison of existing wind models;
2. Exchange of information on field experiments and common definition of new experiments;
3. Increase knowledge by long-term research, f.i. development and validation of CFD codes to more accurately model inflow wind fields taking into account for instance temperature gradients etc.
4. Research and development of intermittent inflow field models that for instance are based on wavelet or other descriptions instead of the usual Fourier based functions.

RT2: Aerodynamic design models
Understanding the underlying physics and determining the underlying parameters of aerodynamic design models. For this purpose detailed measurements and CFD techniques are used. The long-term research will lead to the development of new advanced aerodynamics models. To better model the acoustic emission of wind turbines, computational aero-acoustics (CAA) is further developed.

Activities are:

1. Analysis of existing experimental data (Mexico, Nasa-Ames, Danaero, etc) aiming to understand the physics phenomena of rotating rotor blades. This is coordinated in the IEA Annex Mexnext.
2. Large scale parallel computations based on CFD methods of entire turbines including inflow conditions, wake and ground effects. For the use of CAA techniques in wind energy, higher-order schemes are developed.
3. Design tools (including BEM-type models) are improved, especially regarding non-uniform inflow conditions.
4. Developments in numerical mathematics to further enhance CFD techniques for the modelling of wind turbine rotors and wind farms.
5. Fundamental research on turbulence models and closure relations – also under rotating conditions.
6. Comparisons and validations of models and codes based on experimental data of full-scale and wind tunnel measurements.
7. Experimental validation requires 1. Full scale field testing of rotors with an extensive number of sensors on the blades. 2. Improved and extended measurements with a rotating scale model (Mexico) in a large wind tunnel that include Aero-acoustic experiments. 3. the development of new measuring techniques.

RT3: Wake modelling.

Understanding wake formation (near wake), wake breakdown (vortex roll-up and breakdown) and expansion (turbulence creation, interaction with atmospheric turbulence and ground/ wave/complex terrain effects). The wake modelling partly overlaps with the offshore subprogramme, the key issue here is wake modelling to accurately describe the inflow conditions at the next rotor. Accurate and detailed wake models are developed, and for integration in wind farm design codes, engineering wake models are developed.

Activities are:

1. Study wake characteristics, velocity reduction, length scales, turbulence conditions etc. Study turbulent mixing with the outer atmospheric flow and recovery of velocity deficit.
2. Topology optimisation of wind farms including aspects of turbine control, farm control, wake modelling and aero-elastic calculations, aiming at the optimisation of the farm output and the reduction of mechanical loads.

RT4: Aero-hydro-elastic modelling

A key challenge in the development of accurate design tools for large wind turbines is to understand and model aero-elastic phenomena. The integrated design tools are extended by adding the effects of hydrodynamic loading of the turbine and adding low frequency cyclic motion. Damping mechanisms are investigated. The models are able to model the integral wind turbine, including aero-elastics, control, foundation (also floating), etc. so that the cost of energy can be estimated. The activities are coordinated with the sub-programme offshore wind energy.

Activities are:

1. Improving models to analyse the aero-elastic behaviour of turbines

2. improving the aero-acoustic modelling of large rotating rotors including validation.
3. Improving the wind turbine control algorithms by adding loops for load reduction in blades/tower/drive train, as well as fault tolerant control functionality for dealing with component failures, and extreme event control for handling severe operating conditions. Integration of the controller in the overall iterative wind turbine design process will enable to attain an optimal design in terms of cost of energy.
4. Validation of the integrated design tools by means of experimental data of modern large wind turbines.

RT5: Development and evaluation of innovative concepts and features

Development and evaluation of new aerodynamic concepts and features with emphasis on large offshore turbines– new airfoils, new planforms, optimization routines including costs, downwind, two bladed, high-speed rotors, vertical axis, variable geometries, etc. This RT will be carried out in coordination with the sub-programme on offshore wind energy.

Activities are:

1. Innovative concepts and features are modelled and evaluated. Through demonstration by wind tunnel tests and computational modelling.
2. Local blade control, through flaps, MEMS like structures, synthetic jets, plasma actuators or others is an ongoing activity in UPWIND. For the application of distributed control sensors, actuators and control algorithms must be developed.
3. Definition and execution of experimental testing of new concepts of for instance vortex generators, accessories, flaps or blunt airfoils.

2.5 Deliverables

The tables below describe the deliverables for 2016.

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D11	Theoretical and experimental assessment of the impact of inflow turbulence on rotor aerodynamics. (Deliverable from AVATAR)	Report	01-11-16	Ustutt	Experiments amongst other come from Forwind wind tunnel measurements under controlled conditions, Simulations of the reference wind turbine in turbulent inflow
D12	Mutual comparison of AVATAR CFD results. Explanation on differences (Deliverable from AVATAR)	Report	01-03-16	DTU	Until now CFD results in AVATAR show an unacceptable spread by which they cannot be used to calibrate engineering models
D13	Guidelines for the application of flow devices (vortex generators, dynamic flaps) based on experimental and theoretical results (Deliverable from AVATAR)	Report	01-04-16	CENER	Parametric evaluation of geometry, distribution on the blade and actuation modes of the flow devices
D14	Web based validation platform (Deliverable from AVATAR)	Data-base	01-04-06	ECN / CENER	(Wind tunnel) measurements on airfoil performance with and without flow devices, including measurements at Re=15 M are placed on the WindBench portal a
D15	First improvements of rotor engineering models based on experiments and CFD results. (Deliverable from AVATAR)	Report	31-12-16	DTU	The AVATAR deliverable on engineering models is due in September 2017. This is an intermediate deliverable
D16	Experimental validation of root spoilers (Deliverable from AVATAR)	Report	30-10-16	ECN	First tests on root spoilers in TUDelft wind tunnel showed potential but suffered from malfunctioning equipment. The test will be redone and analysis takes place
D17	Comparison between calculations and New Mexico measurements. (Deliverable from Mexnext)	Report	30-10-16	ECN	Many Mexnext participants sent in calculations to be compared with New Mexico measurements
D18	Full scale field experiments with new aerodynamic tip shapes	Report	31-12-16	ECN	

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D19	Large-Eddy Simulations and oil flow measurement of low Reynolds airfoils	Article	30-06-16	BERA	(Cenaero)
D20	Comparison of various CFD methodologies for Large-eddy simulations of wind turbines	Article	30-06-16	BERA	(Cenaero)
D21	Small wind turbines	Report	30-09-16	BERA	(UCL,UMons) Full characterization of the conversion chain on a small wind turbine, from the wind, to the grid
D22	Improvement of VAWT kinematics	Article	31-12-2016	BERA	(ULg) Wind tunnel studies
D23	Unsteady measurements of an airfoil with oscillating flap (Deliverable form Avatar)	Report	1-02-15	TUDelft	Experiments in TUDelft wind tunnel od the DU95W180 wit active flap
D24	Task 3.2 - Development of aerodynamic codes for modelling of flow devices on aerofoils and rotors	Report	16-11-15	TUDelft	Validation and benchmark of aerodynamic codes
D25	Unsteady measurements of an airfoil with oscillating flap (Deliverable form Avatar)	Report	1-02-15	TUDelft	Experiments in TUDelft wind tunnel od the DU95W180 wit active flap
D26	Closed-loop axial induction control using the TUM scaled experimental facility in the boundary layer wind tunnel at POLIMI		1-1-2016	TUM	Experiments in a wide range of conditions of axial induction control for power maximization. Characterization of wake recovery behaviour under with and without power curtailment. In collaboration with PoliMI.
D27	Closed-loop wake redirection control using the TUM scaled wind farm facility in the boundary layer wind tunnel at POLIMI		1-3-2016		Experiments in a wide range of conditions of wake redirection control for power maximization. Characterization of wake deflection by active misalignment and active pitching. In collaboration with PoliMI
D28	Validation of wake observer from rotor loads using the TUM scaled wind farm facility in the boundary layer wind tunnel at POLIMI		1-6-2016		Validation of the ability of the observer to detect partial wake interference from an upstream wind turbine.

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
					In collaboration with PoliMI
D29	Selected quality controlled met-ocean data from OBLEX-F1 measurement campaign made available together with a description of the data.	O	30-11-16	CMR	NORCOWE
D30	Results of codes validation with wave tank tests (Deliverable from Innwind.EU)	Report	31-08-16	USTUT	Aerodynamic validation of a floating model wind turbine by measurements
D31	Comparison between calculations and New Mexico measurements for near wake and aeroacoustics. (Deliverable from Mexnext)	Report	30-10-16	USTUTT	USTUTT is task leader for near wake aerodynamics
D32	ice accretion and ice sublimation model development and model validation at VTT's icing wind tunnel	Report	31-12-16	VTT	Internal funded project
D33	VAWT rotor design for urban areas (WINDUR)	Report	31-04-16	CENER	Design and manufacturing of a VAWT prototype
D34	VAWT rotor and aerofoil wind tunnel test (WINDUR)	Report	31-04-2016	CENER	Wind Tunnel test of the VAWT
D35	Theoretical and experimental assessment of the impact of inflow turbulence on 2D airfoil aerodynamics. (Deliverable from AVATAR)	Report	01-11-16	CENER	Experiments amongst other come from Forwind wind tunnel measurements under controlled conditions, CFD Simulations of the airfoil in turbulent inflow
D36	Effects of flaps on performance and loads of the AVATAR wind turbine (Deliverable from AVATAR)	Report	01-10-16	CENER	Use of different fidelity aero-elastic simulations codes to evaluate a new design of the Avatar rotor with flaps
D37	Design of specifications of a 3MW, a 10MW and a wind plant (Deliverable from IEA Task 37: Wind Energy Systems Engineering: Integrated RD&D)	Report	01-06-16	CENER	Define the general geometry and performance parameters that will serve as the basis for the two references wind turbines and the plant.
D38	Results of aeroelastic wind tunnel testing	Report	31-08-16	PoliMI	Experiments within INNWIND.EU
D39	Short Range LIDAR measurements in a boundary layer wind tunnel	Article	01-10-16	PoliMI	Experiments in collaboration with TUM, ForWind, DTU
D40	Evaluation of the importance of cross flow instabilities for modern wind turbines	Report	01-06-16	DTU	Part of DSF Flowcentre

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D41	Parametric study of wake/wake interaction between two or more turbines	Report	31-12-16	DTU	Part of DSF Flowcentre

Deliverable	Description	Source of funding[9]	PM per Year[10]
D1	Theoretical and experimental assessment of the impact of inflow turbulence on rotor aerodynamics. (Deliverable from AVATAR)	EU	10
D2		EU	
D3		EU	
D4		EU	
D5		EU	
D6	Experimental validation of root spoilers (Deliverable from AVATAR)	EU	6
D7	Comparison between calculations and New Mexico measurements. (Deliverable from Mexnext)	National	6
D8	Full scale field experiments with new aerodynamic tip shapes	National	12
D9	Large-Eddy Simulations and oil flow measurement of low Reynolds airfoils	Regional	12
D10	Comparison of various CFD methodologies for Large-eddy simulations of wind turbines	Regional	6
D11	Small wind turbines	Private sponsor: ENGIE	6
D12	Improvement of VAWT kinematics	BERA-ULg	3
D13	Noise source modelling and propagation and exp. validation	DTU	20
D14	Smart trailing edge flap tests on rotating test rig	DTU	6
D15			
D16	Data on wake, loads and performance for closed-loop axial induction control	National	8
D17	Data on wake, loads and performance for closed-loop wake redirection control	National	8
D18	Validation data for wake observer	National	12
D19			
D20	Results of codes validation with wave tank tests (Deliverable from Innwind.EU)	EU	8
D21	Comparison between calculations and New Mexico measurements for near wake and aeroacoustics. (Deliverable from Mexnext)	none	10
D22	ice accretion and ice sublimation model development and model validation at VTT's icing wind tunnel	National	
D23	VAWT rotor design for urban areas (WINDUR)	National	
D24	VAWT rotor and aerofoil wind tunnel test (WINDUR)	National	
D25	Theoretical and experimental assessment of the impact of inflow turbulence on 2D airfoil aerodynamics. (Deliverable from AVATAR)	EU	

9 National = N; European = EU; Other = O
10 Indicative only

Deliverable	Description	Source of funding[9]	PM per Year[10]
D26	Effects of flaps on performance and loads of the AVATAR wind turbine (Deliverable from AVATAR)	EU	
D27	Design of specifications of a 3MW, a 10MW and a wind plant (Deliverable from IEA Task 37: Wind Energy Systems Engineering: Integrated RD&D)	National	
D28	Wind tunnel testing of aero- elastically scaled wind turbine model with rotor equipped with integrated passive and active control systems in partial wake of a second model. Testing within INNWINND.EU project, WP2	EU	6
D29	Wake and flow measurements in the boundary layer test section of the PoliMI's wind tunnel	National	2
D30	Evaluation based on CFD and aeroelastic simulations	National	3
D31	Parametric study based on CFD simulations	National	5

The list of milestones and deliverables above shall be understood as indicative only and to be completed in continued dialogue with SP partners by start of 2016, and adjusted according to success with starting new projects now in an application phase, both national and EU projects.

2.6 Participants, Contributions/Engagement and Human Resources

The table below gives the participants, contributions and human resources for 2016. The stated committed resources are research person-months (PM) per year that are spent on activities that can be shared within EERA.

No.	Partner	Country	Role[11]	Contribution / Engagement	PM/Y
1.	AAU	GER		Not partner in SP Aerodynamics	--
2.	BERA	BE		Collaboration DTU-BERA on LES (UCL,Cenaero), Wind tunnel tests (at VKI, ULg)	30
3.	CENER	ESP		Management Board of the EERA IRPWind. Task 2.3 Leader and WP3 Leader in Avatar. Task 4.2 Leader in InnWind. WP3 leader in Windur.	54
4.	CENERG			Not partner in SP Aerodynamics	--
5.	CIEMAT			Not partner in SP Aerodynamics	--
6.	CIRCE	ESP		Not partner in SP Aerodynamics	--
7.	CMR	NO			4
8.	CNR				
9.	CRES	GR			
10.	CTC			Not partner in SP Aerodynamics	--
11.	DHI	DK		Not partner in SP Aerodynamics	--
12.	DLR	GER			
13.	DTU	DK		Coordinator and work package leader in INNWIND.EU and WP leader in AVATAR. Management of IRPWIND	54
14.	DUT	NL		Co-coordinator EERA SP Aerodynamics Task leader and partner in the Avatar and InWind projects, and other national and EU projects	240

[11] Full = Full participant; Ass. = Associate participant

15.	ECN	NL		Coordinator EERA SP Aerodynamics Coordniator EU AVATAR project	48
16.	FhG IWES	GER			
17.	ForWind	GER			
18.	IC3			Not partner in SP Aerodynamics	--
19.	IFE	NOR		Not partner in SP Aerodynamics	--
20.	IK4 Alliance	ESP		Not partner in SP Aerodynamics	--
21.	IREC	ESP		Not partner in SP Aerodynamics	--
22.	LNEG	POR		Not partner in SP Aerodynamics	--
23.	METUWIND				
24.	NTNU	NOR			
25.	Politecnico di Milano	ITA		Collaboration with TUM in D16,D17 and D18	12
26.	RWTH Aachen University	GER		Not partner in SP Aerodynamics	--
27.	SINTEF	NON			
28.	TECNALIA	ESP		Not partner in SP Aerodynamics	--
29.	TU München				28
30.	Tubitak			Not partner in SP Aerodynamics	--
31.	University College of Dublin	IR		Not partner in SP Aerodynamics	--
32.	University of Athens (NKUA)	GRE			
33.	University of Bergen	NOR		Not partner in SP Aerodynamics	--
34.	University of Stuttgart	GER			20
35.	UoP			Not partner in SP Aerodynamics	--
36.	UoS	UK		Not partner in SP Aerodynamics	--
37.	VTT	FIN			4
38.	WMC	NL		Not partner in SP Aerodynamics	--

2.7 Time schedule

The time schedule below outlines activities on a quarterly basis starting January 2016.
The time schedule shall show activities outlined in 3.3 and milestones as defined in 3.4.

Activity	Q1	Q2	Q3	Q4
EERA DeepWind R&D Offshore Wind Conference	M			
Benchmarks scheduled and launched	MS			
Data in database for benchmark exercise			MS	
Euromech VAWT colloquium				W
IEA special topic meeting on smart blades				M
TORQUE 2016 (The Science of Making Torque from Wind, TUM, Munich, Oct. 2016)				W, MS

A: application; M: meeting; R: report; S: status report; W: workshop; MS: Milestone

Overall coordination between the SPs and the JP wind in general comes in addition, adding some one meeting between coordinators per month.

2.8 List of national research projects with links to the SP

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Country
1	TKI Innotip	0,9	2015-2017	ECN	NL
2	IEA Mexnext coordination	0,5		ECN	NL
3	APPLES	0.35	2013-2017	BERA	BE
4	Small Wind Turbines	0.15	2015-2016	BERA	BE
5	L1 wind tunnel studies at VKI	0.4		BERA	BE
6	CompactWind	0.5	2015-2016	TUM	DE
7	ActiQuieter		2016-2017	USTUTT	GER
8	Integrated Blade Design Tool	0.4	2015-2016	CENER	ES
9	INDUFLAP2	2.0	2015-2018	DTU	DK
10	Stretched rotor	0.5	2015-2016	DTU	DK

2.9 Contact Point for the sub-programme on aerodynamics

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

SUB-PROGRAMME: Structures & materials

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work
2016

January 2016

Sub-programme on Structures & Materials

The envisioned large deployment of both on- and off-shore wind energy encompassing future wind turbines of 10-20 MW sizes requires the optimized design of wind turbine structural components. In turn this implies a full understanding of structural response and increased knowledge of material behaviour in order to develop the appropriate tools for design of such large structures undertaking very high loads with increased reliability and reduced maintenance needs.
The European Energy Research Alliance (EERA) JP-Wind sub-programme on Structures and Materials aims to align medium- and long-term research activities in order to lay a scientific foundation for the industrial development of more cost effective wind energy. The research aims to reduce the uncertainty in the design of structural load carrying components, such as the blades, the support structure, the nacelle bed and the hub, in order to increase cost efficiency and reliability and allow for optimization, innovations and upscaling of future wind turbines.
The EERA participants have agreed to form a common research program in the field of Wind Energy. The agreement signifies a step forward from the well proven research project cooperation between the European research institutes as promoted by the European Commission through the Framework programs to a commitment of planning and implementing joint research programs including sharing and optimizing the use of human resources and research infrastructure. The main research areas are:

- ✓ *Structural analysis models and design methodologies for wind turbine blades*
- ✓ *Structural reliability methods for wind turbine structural components (blades, tower, substructure, hub, nacelle frame)*
- ✓ *Material models and life prediction methods for structural components*
- ✓ *Design processes, concepts and tools for wind turbine structural components (tower, substructure, hub, nacelle frame)*
- ✓ *New concepts and features such as coatings, structural health monitoring and predictive maintenance and repair solutions for the structural components*

The research ranges from development of advanced theories and appropriate models to experimental validation and specific design for innovative applications. Data required in both the development and verification phase will be obtained through a close cooperation between the participating institutes: BERA, CENER, CNR, CRES, DTU Wind Energy, ECN, EPFL, the universities of ForWind, IWES, Sintef, Aalborg University, CTC, IK4, METUWIND, NTNU, Politecnico di Milano, RWTH Aachen University, TUD (DUWind), TECNALIA, and WMC, all joining forces to align research on structural design and materials.
As a horizontal sub-programme of the joint EERA programme on wind energy, the sub-programme on structures and materials will link closely to the EERA JP-Wind vertical sub-programme on offshore wind technology, while the extensive foreseen verification of the developed models, features and design (at a later stage) will require also collaboration with other parallel sub-programmes, i.e. mainly the sub-programmes on research facilities and aerodynamics and aeroelastics.

2.1 Background

In the SET plan and the European Wind Industrial Initiative (EWI) the development of very large and reliable wind turbines is a central objective. In the EWI and in the newly updated Wind Technology platform Strategic Research Agenda (TPWind SRA, 2014) the elements are outlined to achieve large scale deployment of offshore wind turbines. The wind turbine size envisioned for 2020 is 15-20MW and plans are set for reduction of cost of wind energy beyond 2030; while today's largest wind turbine under development is a 10 MW turbine with the average wind turbine capacity installed offshore being 3.8 MW.

Yet, increasing the wind turbine size does not entail a straight forward procedure of structural upscaling. Structural design challenges are posed instead, since the load carrying components need to overcome the "upscaled" wind and wave loading in addition to gravitational loads and physical aspects that are not relevant for smaller turbines, as well as manufacturing constraints of increasing affect. The significant reduction of the future cost of energy, to enable the target wind energy development, requires the optimized design of wind turbine components, implying a full understanding of structural response and increased knowledge of material behaviour.

In TPWind SRA the need for a wider base of material properties as well as the need of improved understanding of the material properties interaction with design and manufacturing is recognized and highlights the need of developing methods for verification of structural strength and reliability of components. At the same time, both TPWind SRA and EWI point to the requirement of technology improvements in wind turbine design, which will lead to the enhancement of weight to power ratio, in addition to the requirement of improvement of the lifetime capacity factor relating to the wind turbine reliability and efficiency (including maintenance procedures) for the acceleration of wind energy kWh cost reduction.

The described activities in EERA Structures & Materials are in line with the relevant proposed initiatives in the EWI and the TPWind SRA, however, taking it to a long-term perspective. The major objective of this sub-programme is the longer-term fundamental research to obtain knowledge to accurately model physical aspects relevant for the future large turbines and to build up and validate structural design tools which are accurate, efficient and fast enough to allow the development of wind turbine massive components. To verify these design tools, highly resolved expensive modelling is needed for large parameter studies.

2.2 Objectives

The overall objective of the sub-programme Structures and Materials is to align pre-competitive research activities at the European Energy research institutes to lay a scientific foundation for the industrial development of more cost effective wind energy. The research aims to reduce the uncertainty in the design of structural load carrying components, such as the blades, the support structures, the nacelle frame and the hub, in order to increase cost efficiency and reliability and allow for optimization, innovations and upscaling of future wind turbines. The specific objectives are:

- ✓ *Develop more efficient blade structures (lighter, stronger, stiffer, more sustainable, economical) by improving and validating structural analysis models, developing design methodologies and virtual test beds for blade joints, introducing innovative features and investigating alternative structural solutions.*
- ✓ *Develop structural reliability methods that include uncertainties associated with inherent material and loading variability as well as model, statistical and manufacturing induced uncertainties and allow design of optimized structural components in combination with appropriate operation and maintenance strategies*
- ✓ *Develop new material models and life prediction methods for materials used in the structural components of the wind turbine, that include environmental effects, material and manufacturing imperfections, multiaxial stresses, etc. that strongly influence the property degradation during the lifetime of the components.*
- ✓ *Improve the design process of wind turbines by developing new, improved structural models, concepts and tools for wind turbine components affecting the overall behaviour of the system, such as the tower, the substructure, the nacelle frame and the hub.*
- ✓ *Develop and evaluate new concepts and features such as blade and steel (tower and substructure) coatings, material state monitoring for structural components and repair solutions for blades to increase wind turbine availability.*

2.3 Description of foreseen activities

The tables below describe the milestones and deliverables for the years 2016-2017.

Mile-stone	Title	Nature[12]	Delivery date (MM-YYYY)	Lead partner	Comment
M1	RT2: Platform for validation of stochastic methodologies for reliability assessment of wind turbine blades	O	12- 2015	CRES	+5 contributing EERA partners; AAU, DTU, CENER, WMC, Forwind-H
M2	RT2: Assessment of current reliability level for support structures	O	02-2016	AAU	+3 Contributing partners; IWES, Forwind-H, WMC
M3	RT5: Review of structural health monitoring methodologies for wind turbine blades and methodology for NDT/SHM testing	R	04-2016	IWES	+5 Contributing partners: CRES, CENER, CNR, WMC, SINTEF
M4	Aeroelastic Analysis of Large and Flexible Blades	R	5-2017	NTUA	+ 8 contributing partners: CRES, DTU WIND, ECN, GE, IWES, POLIMI, FORWIND
M5	INNWIND wind tunnel testing	R	8-2016	PoliMI	+ 1 contributing partner: DTU

Mile-stone	Description
M1	Platform for validation of stochastic methodologies for reliability assessment of wind turbine blades; Input data for probabilistic analysis required for performing reliability analysis of blades, including data from the reference blade (geometry, lamination lay-out, material properties, loads, etc.) used for the deterministic analysis (InnWind.EU)
M2	Assessment of current reliability level for support structures, connected to IRPWIND milestone M28, Lead Partner AAU, other contributing partners WMC, Forwind-H, IWES-Kassel
M3	Review of structural health monitoring methodologies for wind turbine blades and methodology for NDT/SHM testing; Connected to IRPWIND Milestone M29, Lead partner IWES, other contributing partners CRES, CENER, CNR, WMC, SINTEF
M4	Re-design of the reference blade and analysis of the effects of blade flexibility and structural tailoring on loads within AVATAR project, WP4
M5	Wind tunnel testing of aeroelastically scaled models with rotor equipped with integrated passive and active control systems within INNWINND.EU project, WP2

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D1	RT1: Test report on blade subcomponents	R	07- 2017	IWES	IRPWIND Deliverable D71.2
D2	RT1: Report on validation and improvement of blade design tools	R	11-2017	DTU	IRPWIND Deliverable D71.3
D3	RT2: Assessment of current reliability level for blades, based on performed	R	02-2016	DTU	IRPWIND Milestone M28

[12] R = Report, P = Prototype, D = Demonstrator, O = Other

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
	reliability analysis on platform blade				
D4	RT3: Report on material models for blades (IRPWIND deliverables D73.1 and D73.2)	R	02-2017	WMC	IRPWIND deliverable D73.1
D5	RT3: Report on material models for support structures	R	02-2017	CTC	IRPWIND deliverable D73.2
D6	RT4: Report on validation of grouted joints	R	05-2017	DTU	IRPWIND deliverable D72.1
D7	RT5: Predictive Maintenance state of art, for the support of WTs	R	12-2016	BERA (ULG)	
D8	RT3: Round robin on white etching cracks	R	12-2016	DTU	RWTH Aachen, BERA (UGhent, Laborelec)
D9	RT2: An integrated model for probabilistic design of offshore wind monopiles	R	10-2016	ECN	Dutch D4REL project
D10	RT1: Development of models for progressive damage of adhesively bonded composite joints	R	12-2016	EPFL	
D11	RT1: development of models for the creep-fatigue interaction in composite materials and the effect of interrupted fatigue loading on the structural integrity of composite materials and structures	R	12-2016	EPFL	
D12	RT3: Investigation of the material behavior of thin-ply composites for structural elements of wind turbine rotor blades	R	10-2016	EPFL	
D13	RT4: development of CFRP anchors	R	10-2016	EPFL	
D14	RT5: Investigation of the mechanical performance of composite materials of wind turbine rotor blades under experimentally-derived lightning waveforms	R	5-2017	EPFL	
D15	RT5: Reference metrics for erosion environmental load characterisation	N	12-2017	ORE Catapult	Demowind XL-Blade project

Deliverable	Description	Source of funding[13]	PM[14]
D1	Test report on blade subcomponents. IRPWIND deliverable D71.2, Lead Partner IWES, other contributing partners CRES, DTU, CENER, WMC	EU	30
D2	Report on validation and improvement of blade structural design tools, IRPWIND deliverable D71.3, Lead Partner DTU, other contributing partners CRES, IWES, WMC, CENER	EU	27
D3	Report on the assessment of current reliability level for blades, based on performed reliability analysis on platform blade, connected to IRPWIND milestone M6, Lead partner DTU, other contributing partners AAU, CRES, CENER, IWES, Forwind-H, WMC	EU, N	10
D4	Report on material models for blades, connect to IRPWIND deliverable D73.1, Lead partner WMC, other contributing partners CRES, IWES, CENER	EU	20
D5	Report on material models for support structures, connected to IRPWIND deliverable D73.2, Lead partner CTC	EU	10
D6	Report on validation of grouted joints, connected to IRPWIND deliverable D72.1, Lead partner DTU, other contributing partners CTC, AAU	EU	
D7	Predictive Maintenance state of art, for the support of WTs, Connected to Belgian national project, Contributing partners BERA (ULG and ULB)	N	27
D8	Collaborative paper on the round robin results of white etching cracks on fatigued wind turbine roller bearings	N	
D9	An integrated model for probabilistic design of offshore wind monopiles	N	5
D10	Paper submitted relevant to the work on the development of progressive damage models for adhesively bonded composite joints under static and fatigue loading conditions	N	4
D11	Experimental report on development of models for the creep-fatigue interaction in composite materials and the effect of interrupted fatigue loading on the structural integrity of composite materials and structures	N	8
D12	Report on the Investigation of the material behavior of thin-ply composites for structural elements of wind turbine rotor blades	N	6
D13	Experimental and numerical report on the development of CFRP anchors	N	6
D14	Experimental results and modelling of the material behaviour reIevant to the investigation of the mechanical performance of composite materials of wind turbine rotor blades under experimentally-derived lightning waveforms	N	3
D15	RT5: Report on the erosion environmental data modelling for the measurement campaign at the offshore met mast NOAH performed in the Demowind XL-Blade project	N	4

2.4 Participants, Contributions/Engagement and Human resources

The table below gives the participants, contributions and human resources. The stated committed resources for 2016 are research person-months (PM) per year that are spent on activities that can be shared within EERA.

[13] National = N; European = EU; Other = O
[14] Indicative only

No.	Partner	Country	Role [15]	Contribution/Engagement	PM/Y
39.	Aalborg University	DK	Ass.	RT Leader for RT2, Contributes to M1, D3 and D6	12
40.	BERA	BE	Full	Leads in preparing deliverable D7. Contributes to D9	27
41.	CENER	ES	Full	Contributes to M1, M3, D1, D2, D3, and D4	15
42.	CENERG			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
43.	CIEMAT			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
44.	CIRCE			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
45.	CMR			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
46.	CNR	IT	Full	Contributes to M3	9
47.	CRES	GR	Full	SP coordinator. RT Leader for RT1. Leads milestone M1. Contributes to D1, D2, D3 and D4	30
48.	CTC	ES	Ass.	Leads in preparing deliverables D5. Contributes to D6	21
49.	DHI			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
50.	DLR	DE	Ass.		
51.	DTU	DK	Full	RT Leader for RT2, Leads in preparing Deliverables D2, D3, D6 and D9. Contributes to M1 and D1	30
52.	DUT	NL	Ass.		10
53.	ECN	NL	Full	Leading D9	5
54.	EPFL	CH	Full	Leading D10, D11, D12, D13, D14	27
55.	FhG IWES	DE	Full	RT Leader for RT5. Leads in M3 and in preparing deliverable D1. Contributes to M2, D2, D3, and D4	12
56.	ForWind	DE	Full	RT Leader for RT4. Contributes to M1, M2 and D3	22
57.	IC3			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
58.	IFE			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
59.	IK4 Alliance	ES	Ass.		20
60.	IREC			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
61.	LNEG			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
62.	METUWIND	TR	Ass.		
63.	NTNU	NO	Ass.		12
64.	ORE Catapult	UK	Ass.	Contributes to D15	4
65.	Politecnico di Milano	IT	Ass.	Contributes to M4 and M5	12
66.	RWTH Aachen Univ.	DE	Ass.		
67.	SINTEF	NO	Ass.	Contributes to M3	27
68.	TECNALIA	ES	Ass.		
69.	TU München	DE	Ass.		
70.	TUBITAK			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
71.	University College of Dublin			NOT PARTNER in SP "STRUCTURES & MATERIALS"	

15 Full = Full participant; Ass. = Associate participant

No.	Partner	Country	Role [15]	Contribution/Engagement	PM/Y
72.	University of Athens (NKUA)			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
73.	University of Bergen			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
74.	University of Stuttgart			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
75.	UOP			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
76.	UOS			NOT PARTNER in SP "STRUCTURES & MATERIALS"	
77.	VTT	FI	Full		
78.	WMC	NL	Ass.	RT Leader for RT3. Leads in preparing Deliverable D4. Contributes to M1, M2, M3, D1, and D2	31

2.5 Time schedule

The time schedule below outlines activities on a quarterly basis starting January 2016. The time schedule shows activities outlined and milestones/deliverables defined in section 2.3.

Activity	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
RT1: Structural design of blades & blade joints			M_5		M_4		D_1	D_2
RT2: Reliability assessment of blades	M_1, M_2 D_3							
RT3: Metallic material models incl. extreme conditions					D_5			
RT3: Material models for composites				D_8	D_4			
RT4: Design methods for tower joints				D_9		D_6		
RT4: Analysis of pitch bearings								
RT5: Coatings for blades & towers								D_{15}
RT5: SHM, CMS & NDT		M_3		D_7				
RT5: Blade Repair methodologies								
SP coordination			W				W	

A: application; R: report; S: status report; W: workshop/meeting; F: Web/Form; P: Pre-Proposal; M_x = milestone nr. X; D_x: Deliverable nr. X

2.6 List of national research projects

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Country
1	AEROS: Autonomous Inspection of wind turbines in operation. Funded by Ministry of Economy and Competitiveness, 2014 RETOS Call- file number RTC-2014-1977-3	1,88	2014-2016	DIAGNOSTIQA CONSULTORIA TECNICA SL	ES

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Countr y
2	D4REL http://www.d4rel.nl/		2013-2016	ECN	NL
3	Project number: 200021_156647 Progressive fatigue damage modeling of FRP structural assemblies	0.34	2015-2018	EPFL	CH
4	Project number: 200021_156207 Multiscale characterization and modeling of thin-ply composite size effects	0.12	2014-2016	EPFL	CH
5	Project number: IZLRZ2_163907 Impact of experimentally-derived lightning waveforms on mechanical performance of composite structures	0.22	2015-2019	EPFL	CH
6	CTI project – Co-funding between the Swiss government (Commission of Technology and Innovation) and companies: Development of a pre-stressed permanent soil / rock anchors from noncorrosive CFRP fiber composites		2012-2016	EPFL	CH
7	Demowind XL-Blade (Contract negotiation)	13.2	2016-2018	(Contract negotiation)	

2.7 Contact Point for the sub-programme on Structures & Materials

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

SUB-PROGRAMME: Wind Energy Integration

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work 2016

January 2016

Sub-programme on Wind Energy Integration

The power supply system is in a phase of the radical change and the transformation to a system, based on renewable energy sources. In this system, wind energy will play the predominant role in the energy generation. The necessary innovations concerning technology, infrastructure and markets for the transformation of the power supply system with a dominating role of wind energy are to be created only by common and coordinated R&D. The most important objectives of the transformation are:

- A remaining alike supply security and power quality by wind power plant capabilities
- A sustainable grid planning and expansion as well as a reliable grid operation
- A European-wide energy and power market with major contribution of renewable energies.

Within this decade, the most important measures for the transformation of the energy supply systems must be initiated or finalized to a large extent since otherwise the necessary development of the wind energy and other RES will stagnate.

2.8 Background

The SET-plan, EWI and TP Wind strongly support the need for R&D on wind energy integration. EWI suggests R&D on wind assessment, turbine technology and grid integration both for on- and offshore. TP Wind suggests grid integration R&D within grid connection and power transmission, system dynamics, and balancing.

One of the main barriers to large-scale deployment of the wind energy technology is the limited capacity of the transmission grids. Large-scale fluctuating wind power production can be smoothed due wide area balancing by energy transmission over long distances and will increase the capacity credit. In addition to new transmission lines and interconnections, a better utilisation of existing infrastructure will avoid wasting of large amounts of renewable energy by curtailment of wind power production.

Enhanced pan-European electricity network capacity has been argued in a number of studies to be extremely cost-effective relative to alternatives such as large scale storage for maximizing the utilisation of available renewable energy resources and minimising the costs of system operation when managing the variability of wind. The cost-effective and sustainable enlargement of the transmission capacity and the enhancement of the utilisation of the grids is mainly the task of the European Transmission System Operators and the concerning organisation, the ENTSO-E. This planning and design needs joint actions of grid operators, generators, traders and consumers and depends on realistic representations of the variability and diversity of available wind power. To be practical for use by network planners, such a representation should be succinct and portable.

The wind community, mainly the R&D organisations TP Wind and EERA JP Wind enhance this change by the development and provision of concepts, planning tools, information and data for a better understanding of the characteristics of wind power and the utilisation of advanced wind power plant capabilities.

2.9 Objectives

The RES directive and the SET Plan enforce a high rate of deployment of wind energy, on- and offshore for the European Union's member states leading to a high challenge for research in the two priority areas: Integration and Offshore. The grid integration of wind power implies two major challenges:

- **Transformation of the electrical supply system to allow large scale deployment of wind energy**

- **To enable wind power plants to be managed as an integral part of the interconnected European electricity supply system**

Under the guiding principle "**Manage wind power as an integral part of the inter-connected European electricity supply system**" the objectives of the SP have been developed and formulated. The overall objective is preparing pre-competitive research laying a scientific foundation for cost effective wind power production and integration. The specific objectives are:

- ✓ **Wind power plant capabilities.** Since large scale integration of wind power and other RES technologies will force out conventional power stations, the system stability must be maintained from other sources, including wind power plants. The objective of the SP is to enable wind power plants to offer characteristics, similar to conventional power plants for a secure and economical power system operation with less conventional power plants. This includes the ability of wind power plants to supply ancillary services such as support of frequency and voltage control including contribution to power system inertia and the power quality. This requires R&D to further develop electric design and control of wind power plants that can provide these services and to develop simulation models and demonstrations to validate these characteristics.

- ✓ **Grid planning and operation.** The sustainable grid planning and reliable operation can only be met by jointly actions of the concerning parties – the TSOs, the wind community, the traders and customers. The SP will support the sustainable enlargement of the transmission capacity and the enhancement of the utilisation of the grids by the development of tools for planning and operating energy supply systems with large amounts of wind power and the investigation of the impact of different high wind penetration levels on the European grid. This implies the assessment of the future grid structure requirements considering the design of multi-terminal operated and controlled trans-national offshore grids as well as future capabilities of wind power plants.

- ✓ **Wind energy and power management.** For a cost-effective and sustainable energy system transformation, the competitiveness of wind power on power and ancillary service markets is essential. The SP supports this objective by the development of tools for energy and power management taking into account the characteristics of wind power (in different time scales) to support the interaction between wind power, other RES, storage and demand side management. Furthermore, the development and utilisation of wind power aggregation techniques; the improvement of wind power forecast and the development of business models and market mechanisms to establish wind energy in European energy markets is in focus of the SP work.

2.10 Description of foreseen activities

The research is structured around system analysis and assessment, tool and model development and simulation, demonstration and validation. The planned activities in 2016 are:

RT1: Wind power plant capabilities

The Sub-Program Grid Integration of EERA JP Wind Energy organized a workshop in 09/2015 to present and discuss latest developments of frequency and voltage support by WPP as well as the requirements on system stability support by RES including new ideas for system services and dedicated grid support. The results of this workshop were integrated in the proposal preparation for H2020 LCE7-2016/2017: “Enhanced system support services for a 100% RES power system”.

The utilisation of enhanced Wind Power Plant Capabilities requires new approaches and software-tools. A focus of the RT was the development of such Tools in the EERA DTOC project. Further, the work of this RT formed the major input of IRPWIND WP81 and the team in SP Wind Energy Integration delivered input to the project. The WPP capabilities are developed from two perspectives; 1- the fulfilment of grid code obligations and 2- the provision of ancillary services including balancing reserve and primary and secondary frequency responses. The first aspect was covered in a paper that was recently presented in EERA DeepWind’16 conference[16] that investigated the performance of large offshore wind power clusters that are constructed at far distances from onshore grids and connected via HVDC corridors.
The second aspect was investigated in IRPWIND-D81.1 where the provision of balancing power and different methods of frequency support from WPPs that are connected via HVDC links were studied. Three different frequency support methods were compared; continuous de-loading, battery storage banks and a mix between the two previous methods. A simplified method was applied to estimate the de-loading ratios and battery bank rated power. Presently, further research is conducted in the frame of IRWPIND D81.3 to estimate the inertia contribution from a WPP with individual wind turbine representation (e.g. 5 to 15 wind turbines) to assess the overall contribution with turbines operating under different conditions. In addition, the role of enhanced controllers for hybrid AC-MTDC grids to provide frequency support to power system operation is being developed[17].

RT2: Grid planning and operation

Several meetings and discussions with ENTSO-E – regarding the H2020 2015 Call LCE5 “Meshed offshore grids” dominated the work to this RT. To improve the co-operation with ENTSO-E, a joint workshop with EERA JP Smart Grids, EERA JP Wind Energy and ENTSO-E is planned in 2016.

The structured linking of the wind farms in the North Sea is major focus of the NSON initiative; a group of national funded projects, funded by the Berlin Model and established in this SP. Results of NSON were presented at the DeepWind Conference in Trondheim in 2015. In 2016, the planning for ongoing work is focussed on the proposal preparation in frame of H2020 LCE33 2016.

The main planned activities in 2016 are:
Joint workshop with EERA JP Smart Grids, EERA JP Wind Energy and ENTSO-E; the main goal of this workshop will be to improve the co-operation with ENTSO-E and to share experiences and knowledge on models, tools and services to support grid operators in grid planning and operation.

NSON.EU workshop hosted by UCD. The workshop focus remains to be determined, but the main objective of those periodical workshops is to bring together a group of national funded projects, funded by the Berlin Model and established in this SP.

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[16] A. B. Attya, O. Anaya-Lara, P. Ledesma and H. Svendsen, Fulfilment of grid code obligations by large offshore wind farms clusters connected via HVDC corridors, in proc. of EERA 13th Deep Sea Offshore Wind R&D Conference, Trondheim, 2016 (to be published in Energy Procedia in Aug 2016).
[17] F.D. Bianchi and J.L. Domínguez-García, Coordinated frequency control using MT-HVDC grids with wind power plants, IEEE Transactions on Sustainable Energy, vol. 7, no. 1, 2016

Develop and submit a proposal for an ECRIA action for NSON.EU to be submitted in the frame of H2020 LCE33 2016.

Develop and submit a proposal for H2020 LCE7 2016 focusing on technology development for grid integration of RES. The proposal is called “Ancillary Services from RES” and it includes several members of SP Wind Energy Integration, as well as partners from JP Smart Grids and industry partners.

RT3: Wind energy and power management

The needed improvement of forecast-tools is one focus of this RT and was elaborated and discussed in joined workshops. The adaptation for the different applications, such as new market mechanisms, new business models and the assessment of the value of forecast systems were discussed and further developed and used as input for IRPWIND WP83.

Mechanisms for a better procurement of ancillary services were discussed at the workshop on ancillary services in December 2014 and provided input for the proposal development for the H2020 2015 LCE6 Call.
This research theme, related to tools and business models (markets) to allow economic wind power utilization, is pursued as part of IRPWIND WP83, with work in 2016 centered on three related deliverables in 2016 and three in early 2017.
Additionally, a workshop, previously postponed, will be arranged in Helsinki in Q2/Q3 addressing markets and business models for ancillary services.

2.11 Milestones and deliverables

The tables below describe the milestones and deliverables for the year.

Mile-stone	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
M1	EERA DeepWind R&D Offshore Wind Conference	O	01- 2016	SINTEF Energy Research	Results on RT1 and RT2 were presented
M2	NSON ECRIA Proposal preparation	O	04-2016	SINTEF/IWES	Applying for Support to intensify the NSON activities and to enable a better collaboration
M3	Mid-Term Workshop: Results and ongoing R&D of IRPWIND WP8	O	03-2016	IWES	Presentation of Deliverables and Milestones of WP8
M4	EERA JP Wind and JP Smart Grids – Workshop on ENTSO-E R&D roadmap revision	O	04-2016	IWES	Discussion of ENTSO-E revised R&D roadmap
M5	Proposal preparation “Ancillary Services from RES”	O	03-2016	DTU, SINTEF, VTT	Joint proposal with EERA Smart Grids
M6	Workshop on Models, Tools and Services to Support Grid	O	06-2016	IWES, SINTEF	Joint workshop of JP Wind and JP Smart

	Operators in Grid Planning and Operation				Grids in co-opeation with ENTSO-E
M7	Workshop on business models for ancillary service provision	O	06-2016	IWES, VTT	Joint workshop with SP Socio Economics

Mile-stone	Description
M1	EERA DeepWind R&D Offshore Wind Conference: EERA partners will contribute in total to about 50 oral and 50 posters, and approx. 30 papers from the conference will go through peer-review and be published in Energy Procedia
M2	Proposal preparation for H2020 LCE 33 – ECRIA call to get EC funding for NSON activities
M3	Mid-Term Workshop: Results, deliverables, Milestones and ongoing R&D of IRPWIND WP8
M4	Joint workshop of EERA JP Wind and JP Smart Grids –ENTSO-E R&D roadmap revision
M5	Proposal preparation for H2020 LCE 7 call to get EC funding for "Ancillary Services from RES" project
M6	Joint Workshop of JP Wind Energy (Grids) and JP Smart Grids (Transmission) on Models, Tools and Services to Support Grid Operators in Grid Planning and Operation – in co-operation with ENTSO-E
M7	Workshop on business models for ancillary service and first discussion for proposal preparation for H2020-Calls

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D42	Towards a meshed North Sea Grid. Policy challenges and potential solutions from a Norwegian perspective	R	01-2016	SINTEF ER	NSON
D43	Technology Perspectives of North Sea Offshore Networks	R	01-2016	SINTEF ER	NSON
D44	Cost-benefits sharing models	R	06-2016	SINTEF ER	NSON
D45	Intelligent control mechanisms for provision of virtual inertia and voltage support	R	09-2016	CIRCE, UoS	IRPWIND D81.3
D46	Novel coupled high resolution Marine Boundary layer models	R	03-2016	IWES/NKUA DTU, CENER	IRPWIND D82.1
D47	Forecast scenarios for market algorithms	R	02-2016	IWES/DTU Comp	IRPWIND D82.4
D48	Market design with multi-agent systems	R	02-2016	LNEG	IRPWIND D83.1
D49	Strategies for congestion alleviations through dynamic determination of NTC	R	02-2106	IWES	IRPWIND D83.4
D50	Nordic hydro storage for balancing of wind power	R	02-2016	SINTEF	IRPWIND D83.5
D51	Wind power forecasts for grid nodes to support grid operation	O	06-2016	IWES	EWELINE
D52	Technical evaluation and replicability assessment of distributed intelligence solutions on MV and LV networks	R	04-2016	CIRCE	DISCERN project
D53	Full probabilistic forecasts of wind power generation using SDEs	N	11-2016	DTU Comp.	CITIES
D54	New sensors and methods for blade manufacturing	N	12-2016	DTU Comp.	MADE

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D55	A new extended high resolution wind/wave data base for the offshore areas of Europe	O	12-2016	NKUA	
D56	Upscaling: Algorithms for transforms, reference and data selection	R	08-2016	ForWind-OL	IRPWIND D82.2
D57	Multivariate forecast scenarios for markets (Iberian Case Study)	R	12-2016	DTU/LNEG	IRPWIND D82.4
D58	Optimal Bidding Strategies for Aggregated WPP in a Pool Environment	R	10-2016	LNEG	LNEG/MIT Port.
D59	On the use of Wavelets and other Decomposition Techniques to Assess the Wind Power Balance	R	09-2016	LNEG	4WeatherRamps
D60	Role of wind power forecast in the electricity market	R	10-2016	LNEG	4WeatherRamps
D61	Impact Assessment: Predictability vs Data Sharing	R	04-2016	ECN/IWES	IRPWIND WP82.6
D62	Specifications for ReGen plant model and control architecture	R	01-2016	DTU	RePlan
D63	A review on Optimal dispatch methods for ReGen plants	R	01-2016	DTU	RePlan
D64	Detailed functional requirements to WPPs connected via DR-HVDC	R	12-2016	DTU	EU PROMOTiON
D65	Report on voltage control support and coordination between ReGen plants in transmission and distribution level.	R	09-2016	DTU	RePlan
D66	Wind forecasts at some pilot Italian Coastal Sites	O	11-2016	CNR	(INKIND CNR costs)
D67	Solar and Wind resource integration, validate form satellite data, to support grid integration at some South Italian Ports	O	9-2016	CNR	(INKIND CNR costs)

Deliverable	Description	Source of funding[18]	PM per Year[19]
D30	Political, regulatory and societal drivers and barriers for the realization of a meshed off-shore grid between North Sea countries is here assessed.	N	1
D31	Overview over the most relevant technologies for realising an offshore power system in the North Sea.	N	1
D32	A SW tool - NetOp - is applied for transmission system investment planning with the goal to establish optimal offshore grid layouts for different future scenarios. The scenarios are built based on ENTSO-E four visions for 2030	N	2
D33	D81.3) Development and validation of intelligent control mechanisms for provision of virtual inertia and voltage support	EU	6
D34	D82.1) Development and adaptation of Marine Boundary layer models for improved forecast systems.	EU	8
D35	D82.4) Elaboration of forecast scenarios for market algorithms in different European market regions	EU	8

18 National = N; European = EU; Other = O
19 Indicative only

Deliverable	Description	Source of funding[18]	PM per Year[19]
D36	D83.1) Elaboration of market design with multi-agent systems	EU	6
D37	D83.4) Strategies for congestion alleviations through dynamic determination of NTC	EU	4
D38	D83.5) Nordic hydro storage for balancing of wind power	EU	6
D39	Wind power forecasts for grid nodes to support grid operation	N	72
D40	Technical evaluation and replicability assessment of distributed intelligence solutions on MV and LV networks	N	
D41	Full probabilistic forecasts of wind power generation using SDEs	N	
D42	Development of new sensors and methods for blade manufacturing	N	
D43	A new extended high resolution wind/wave data base for the offshore areas of Europe	N	
D44	D82.2) Improvement of upscaling: Algorithms for transforms, reference and data selection	EU	6
D45	D82.4) Multivariate forecast scenarios for markets (Iberian Case Study)	EU	6
D46	Optimal Bidding Strategies for Aggregated WPP in a Pool Environment	N	
D47	On the use of Wavelets and other Decomposition Techniques to Assess the Wind Power Balance	N	
D48	Role of wind power forecast in the electricity market	N	
D49	Impact Assessment: Predictability vs Data Sharing	EU	
D50	Specifications for ReGen plant model and control architecture	N	
D51	A review on Optimal dispatch methods for ReGen plants	N	
D52	Detailed functional requirements to WPPs connected via DR-HVDC	EU	
D53	Report on voltage control support and coordination between ReGen plants in transmission and distribution level.	N	
D54	Wind forecasts at some pilot Italy Coastal Sites	N	6
D55	Solar and Wind resource integration form satellite data to support grid integration at some pilot Italy Coastal Sites	N	6

The list of milestones and deliverables above shall be understood as indicative only and to be completed in continued dialogue with SP partners by start of 2016, and adjusted according to success with starting new projects now in an application phase, both national and EU projects.

2.12 Participants, Contributions/Engagement and Human Resources

The table below gives the participants, contributions and human resources for 2016. The stated committed resources are research person-months (PM) per year that are spent on activities that can be shared within EERA.
(Table to be completed)

No.	Partner	Country	Role[20]	Contribution / Engagement	PM/Y
79.	FhG IWES	GER	Full	EERA JPW SP Coordinator, IRPWIND WP8 Coordinatior, Contributes to RT1, RT2, RT3, and to D4, D5, D7, D9	64
80.	DTU	DK	Full	RT2 Coordinator Contributes to. RT1, RT2, and to D5, D8, D13, D16, D21, D22, D23 and D24	36

20 Full = Full participant; Ass. = Associate participant

81.	ECN	NL	Full	Contributes to RT1, RT2, RT3, and to D20	28
82.	CENER	ESP	Full	Contributes to RT1, RT2, RT3	34
83.	UoS	UK	Full	RT1 Coordinator, contributes to RT1, RT2, and D4	30
84.	CRES	GR	Full	Contributes to RT1, RT2	24
85.	IREC	ESP	Ass	Contributes to RT1, RT2 and RT3	14
86.	SINTEF	NO	Full	RT3 coordinator, contributes to D1, D2, D3 and D8	30
87.	VTT	FIN	Full	Contributes to RT1, RT2, RT3	50
88.	LNEG	POR	Full	Contributes to D6, D16, D17 D18 and D19.	35
89.	ForWind	GER	Full	Contributes to RT2, RT3, D15	30
90.	CIRCE	ESP	Ass	Contributes to RT1, RT2, RT3 and to D4 and D11	10
91.	CNR	IT	Full	Contributes to RT1,RT2, RT3 and to D25,D26	12
92.	NKUA	GRE	Ass	Contributes to RT2, RT3, D5, D14	24
	SUM				421

2.13 Time schedule

The time schedule below outlines activities on a quarterly basis starting January 2016. The time schedule shall show activities outlined in 2.3 and milestones as defined in 2.4.

Activity	Q1	Q2	Q3	Q4
EERA DeepWind R&D Offshore Wind Conference	W			
NSON ECRIA Proposal preparation	A			
Mid-Term Workshop: Results and ongoing R&D of IRPWIND WP8	W			
EERA JP Wind and JP Smart Grids Workshop on ENTSO-E R&D roadmap revision		W		
Proposal preparation “Ancillary Services from RES”	A			
Workshop on Models, Tools and Services to Support Grid Operators in Grid Planning and Operation		W		
Workshop on business models for ancillary service provision		W		

A: application; M: meeting; R: report; S: status report; W: workshop; MS: Milestone

Overall coordination between the SPs and the JP wind in general comes in addition, adding some one meeting between coordinators per month.

2.14 List of national research projects with links to the SP

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Country
1	IRPWind (http://www.irpwind.eu/)	12	2014-18	DTU-Wind	DK
2	NOWITECH, www.nowitech.no	40	2009-2017	SINTEF Energy	NO
2	NORCOWE, www.norcowe.no	30	2009-2017	CMR	NO
3	EWELINE, http://www.projekt-eweline.de/en/index.html	10	2013-2017	IWES	GER
4	NSON-DE, http://www.energiesystemtechnik.iwes.fraunhofer.de/de/projekte/suche/laufende/nson.html	1	2014-2017	IWES	GER

5	IMOWEN http://forschung-stromnetze.info/projekte/windpark-cluster-sicher-ins-netz-integrieren/	0,8	2014-2017	IWES	GER
6	DEA-Stabil, http://www.energiesystemtechnik.iwes.fraunhofer.de/de/projekte/suche/laufende/dea-stabil.html	4	2013-2016	IWES	GER
7	NETZ:KRAFT, http://www.energiesystemtechnik.iwes.fraunhofer.de/de/projekte/suche/laufende/Netzkraft.html	12	2015-2018	IWES	GER
8	REDACTIVA	4	2015-2018	CIRCE	ES
9	Synergies at Sea	1.2 (*)	2013-2016	ECN	NL
10	Offshore wind integration with the stand-alone electric grid	0.7	2016-2018	SINTEF ER	NO
11	FLEXe, http://clicinnovation.fi/activity/flexe/		2014–2016	CLIC Innovation	FI
12	EL-TRAN, http://el-tran.fi/		2015–2021	Uni. Tampere	FI
13	NeoCarbon Energy, http://www.neocarbonenergy.fi/		2014–2019	VTT	FI
14	RealValue, http://www.realvalueproject.com/	15.5	2015–2018	Glen Dimplex	EU
15	VaGe, http://www.aka.fi/en/research-and-science-policy/academy-programmes/current-programmes/new-energy/	1.5	2015–2018	VTT	FI
16	CITIES	10	2014-2020	DTU Compute	DK
17	MADE	22	2014-2018	DTU Compute	DK
18	Project Title: VRPP - Dynamic model of Virtual Power Plant able to account for Ancillary Services (n.a.)	0,2	2013-2016	LNEG	PT
19	4WeatherRamps (n.a.)	0,16	2013-2017	LNEG	PT
20	MAN-REM Negociação Multi-agente e Gestão de Risco em Mercados de Energia Elétrica. (http://www.lneg.pt/iedt/projectos/473/)	0,11	2013-2016	LNEG	PT
21	MODEOL (http://www.lneg.pt/iedt/projectos/216/)	0,16	2015-2017	LNEG	PT
22	NSON.DK	1.2	2016-2019	DTU	DK
23	RePlan	0.8	2015-2019	DTU	DK
24	CONCERT	1.12	2016-2019	DTU	DK
25	NetVind	0.5	2016-2018	EnergiMidt	DK
26	Security Assessment of Renewable Power Systems	1,5	2016-2019	DTU	DK
27	SUPERGEN: Wind Hub		2014-2019	UoS	UK
28	INTERNAL PROJECT (IN-KIND-Activity)	0,1	2016-2017	CNR	IT

2.15 Contact Point for the sub-programme on wind energy integration

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

SUB-PROGRAMME: Offshore Wind Energy

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work 2016

January 2016

Sub-programme on Offshore Wind Energy

The high targets for deployment of offshore wind farms (150 GW in Europe by 2030) are only viable provided that costs per kWh from offshore wind farms can be reduced to a competitive level. This requires long-term efforts to develop offshore specific turbine technology, sub-structures, grid connection/integration and O&M schemes. To this end, the EERA sub-programme on offshore wind has an overall objective to prepare pre-competitive research laying a scientific foundation for the industrial development of more cost effective offshore wind farms and enabling large scale deployment at any seas. The specific objectives are:

- ✓ *Design optimization through validation studies offshore, including development of integrated numerical design tools and establishing an open database with measurements for validation of tools.*
- ✓ *Characterization and interaction of wind, wave and current as input for developing standard design load cases.*
- ✓ *Innovative wind farm internal grids for offshore applications, and connection to HVDC transmission.*
- ✓ *Control, operation and maintenance of offshore wind farms.*
- ✓ *Development of novel concepts for deep sea, including multi-use of wind farm areas giving step-changes in technology for reducing cost of energy from offshore wind farms.*

As a vertical sub-programme of the EERA JP Wind, this sub-programme will link closely to the EERA JP Wind horizontal sub-programmes, i.e. wind conditions, aerodynamics, grid integration etc.

This sub-programme includes close to all partners in EERA JP Wind and all are joining forces to align research on offshore wind energy. The work will align with on-going research in EU projects, but also seek to attract and align national projects providing added value, developing new joint projects for collaboration, sharing knowledge in a series of workshops and disseminate results through publications and conferences. There is already established a dedicated offshore R&D conference prepared first time as an EERA event in January 2014, and this will be repeated also in the years to come. The EERA sub-programme on offshore wind energy will continue to develop towards joint European long-term pre-competitive research giving a basis for cost-effective large scale deployment of offshore wind at any seas.

2.16 Background

Targets are set for a massive installation of offshore wind. EWI suggests 40 GW by 2020 and 150 GW by 2030 as viable. The development is ongoing, but in an early stage. Only about 2 GW of offshore wind have so far been installed in Europe, and all relatively close to shore using what can be called on-shore wind technology.

The experience so far indicates that technical challenges related to offshore installation, operation, maintenance and repairs have been underestimated. This is now being addressed by the industry and applied research including EERA JP Wind.

The SET-plan, EWI and TPWind strongly support the need for R&D on offshore wind energy. EWI suggests R&D on wind assessment, turbine technology and grid integration both for on- and offshore, and specific offshore focus on support structures for large wind turbines in deep waters (+ 30 m). Bottom-fixed wind farms, and mainly at shallow waters, are expected to dominate the near term development, whereas the development of Hywind 30 MW floating wind farm scheduled for 2017 demonstrate the viability of future industry-scale deployment of deep offshore (floating) wind farms after 2020.

The high targets for offshore wind (150 GW by 2030) are only viable provided that costs can be reduced to a competitive level. The cost targets provided in the "SET-Plan – Declaration on Strategic Targets in the context of an Initiative for Global Leadership in Offshore Wind", see Figure 1, are ambitious and require long-term efforts to develop offshore specific turbine technology, sub-structures, grid connection/integration and O&M schemes.

Agreed strategic targets for offshore wind energy

1. **Reduce the levelised cost of energy (LCoE)** at final investment decision (FID) for fixed offshore wind* by improvement of the performances of the entire value chain to
   - **less than 10 ct€/kWh by 2020** and to
   - **less than 7ct€/kWh by 2030**;
2. Develop cost competitive **integrated wind energy systems** including substructures which can be used in **deeper waters (>50m) at a maximum distance of 50 km from shore with a LCoE* of**
   - **less than 12 ct€/kWh by 2025** and to
   - **less than 9 ct€/kWh by 2030**

** the costs for delivering the electricity to onshore substations are taken into account within the LCoE*

Figure 1: Targets for offshore wind set out by the between representatives of the European Commission services, the SET-Plan Steering Group and stakeholders as detailed in https://setis.ec.europa.eu/system/files/declaration_of_intent_offshore_wind.pdf.

2.17 Objectives

The overall objective of the sub-programme is to prepare pre-competitive research laying a scientific foundation for the industrial development of more cost effective offshore wind farms and enabling large scale deployment at any seas. The specific objectives are:

- ✓ *Design optimization through validation studies offshore, including development of integrated numerical design tools and establishing an open database with measurements for validation of tools.*
- ✓ *Characterization and interaction of wind, wave and current as input for developing standard design load cases.*
- ✓ *Innovative wind farm internal grids for offshore applications, and connection to HVDC transmission.*

- ✓ *Control, operation and maintenance of offshore wind farms.*
- ✓ *Development of novel concepts for deep sea, including multi-use of wind farm areas giving step-changes in technology for reducing cost of energy from offshore wind farms.*

As a vertical sub-programme it will link closely to the horizontal sub-programmes, i.e. wind conditions, aerodynamics, grid integration, structural design and materials, etc.

2.18 Description of foreseen activities

The research is structured around a) development of theory and models, b) data from experiments and c) validation. Five long term *research themes (RTs)* are addressed:

RT 1: Integrated numerical design tools for offshore wind turbines and wind farms. The goal of this RT is to develop a set of proven tools for integrated design of large deep offshore wind turbines by accounting for wind and sea environment, hydrodynamic and aerodynamic loads, structure dynamics and elasticity, generator behaviour and automated control systems. Emphasis is on turbines for deep sea including various designs for up- or downwind rotor, mechanical and hydraulic transmission, gearbox, generator, tower and support structure, floater and anchoring. Time domain as well as frequency domain approaches will be addressed.

The research will focus on features not yet covered in existing software, especially relating to wind turbine concepts for deep sea. The novel features will as far as possible be integrated in existing, robust and internationally leading software.

The total suite of tools will span a wide range of applications. This includes user-friendly and fast tools for conceptual studies and preliminary design, tools for real time automatic control applications and state-of-the art computational tools enabling detailed and highly accurate analysis to validate particular features.

The research has long-term goals, but has also immediate relevance. Examples are modelling of hydrodynamic forces on coned structures, coupling of standard wind turbine models with sub-structure models (e.g. jackets) and indeed, experimental validation. For instance, there is there is a fundamental lack of measurements on the hydrodynamic loading on wind turbines.

A database will be established with data from experiments (e.g. “in-house” labs) and full scale tests (e.g. HyWind and Alpha Ventus, pending on availability and permission to share data).

The database will be used for validation of tools.

Selected novel wind turbine concepts will be assessed by application of the tools developed, hereunder to demonstrate the usability of the tools.

RT 2: Characterization and interaction of wind, wave and current
The goal of this RT is to gain an improved understanding of micro-scale wind, wave and ocean current as input for developing standard design load cases for large deep offshore wind turbines.

Reliable offshore wind measurements are available from Denmark and Germany (FINO 1, 2 and 3 platforms). In addition some wind information is available for selected sectors with marine characteristics from Frøya (Mid-Norway). The meteorological observations from oil rigs in the North

Sea and the Norwegian Sea are of limited use for offshore wind energy analysis since the data often are significantly affected by the oil rig itself. New measurements are however planned to be initiated applying dedicated wind, wave and current measurement facilities at selected locations in Norwegian offshore seas. These and other relevant met-ocean measurement data that may be available will be shared (pending on permissions) and used for relevant analyses. Key elements to be considered are:

- ✓ wind turbulence and profile
- ✓ wave and current characteristics
- ✓ co-variance of wind, waves and current, both in terms of strength and direction
- ✓ extreme values
- ✓ modelling of non-linear irregular waves, wind and current

This RT is closely linked to the numerical tool development (RT 1).

RT 3: Numerical tools for offshore grid and wind farm electric design

This RT aims to develop numerical tools for assisting decisions on a) offshore grid development and b) wind farm electric design, in particular considering connection to HVDC transmission. Case studies will be carried out to demonstrate the usability of the tools.

Future offshore wind farms are expected to constitute a significant part of the European power system (150 GW by 2030); hereunder large wind farms may be located far from shore with the need for long subsea power cables to the onshore power system. To ensure an optimal development of the power grid in Europe it is necessary to coordinate the grid connection of new wind farms with one another and with the building of new interconnectors between countries. Also, the transmission system will affect the overall power system operation, and this effect should be taken into account when planning the offshore transmission grid. To assist this development a set of new tools are required:

- ✓ Planning an offshore transmission grid involves making choices of from where to where the lines shall go, what capacity these shall have and what technology to apply (HVAC or HVDC). Existing tools used to investigate such transmission expansion planning problems are inadequate for systems with large amounts of wind power distributed over large geographical areas. There is also a need to further develop the transmission expansion planning methods to determine the optimal timing of investments in response to the development of offshore wind power. A suitably developed tool can be a valuable decision support when planning a new offshore grid and may help to identify potential for cost savings. Case studies of offshore grid development in the North-Sea and surrounding areas will be conducted in concert with the development of the tool.

- ✓ The foreseen transmission expansion planning tool can only offer a simplified description of the onshore power grid due to computational limits. It is therefore necessary to combine it with detailed load flow and power market models to validate the results. The work will therefore aim to establish a procedure to integrate the transmission expansion planning tool with existing detailed power market models (PSST) to offer robust analysis and results.

Offshore grids include the internal grid of the wind farms, the connection to the individual wind turbines, transformer stations and the main transmission to an onshore power grid. The grid connection could simply be radial from the individual offshore wind farms to the nearest or best located onshore nodes, or it could be part of a more extensive offshore grid solution. The choice of technology for the grid implementation is dependent on the overall grid planning and results from the grid design. However, when the overall solution is determined, the next challenge is related to monitoring, operation, protection and control of the offshore grid and the offshore wind farms. The following issues require development of numerical tool for proper analysis and design:

- ✓ Internal wind farm grids: Appropriate design tools for electric grids must be assessed and adapted to analyse the specific challenges of connection and protection of offshore wind turbines. This also includes the choice of technology for the internal grids, converters and transformer stations.

- ✓ Grid codes are established to provide firm requirements regarding grid connection and control of wind farms and their performance and capabilities during fault situations. Existing grid codes differs from country to country depending on specific needs and grid characteristics, and it is not obvious how the grid codes should be adapted to the characteristics of an offshore grid, in particular for an offshore HVDC grid it may be relevant to consider other requirements to the wind farms.

- ✓ Security and control of offshore grid systems. Whether offshore wind farms are connected by radials or through a meshed offshore grid, the increasing amount of offshore wind will impact the integrity and security of power system operation. Tools must be adapted for security and stability analysis of more complex grid topologies and control solutions. In particular there is a need for new models to integrate multi-terminal dc grids in simulation tools for large-scale power systems. The goal must be to establish sufficiently accurate and simple-to-use models of offshore grids that include representation of primary and secondary controls with the same level of details as for conventional generation and grid components.

Case studies shall be carried out to test the model developments and to demonstrate the analysis and design of proposed grid design solutions. It is proposed to develop a joint multi-terminal, multi-area power system model for testing and benchmarking studies. Studies should be carried out to analyse the ultimate challenges of coordinated control in a multi-terminal offshore grid as well as the more local and immediate challenges of connecting offshore wind farms.

RT 4: Control, operation and maintenance of offshore wind farms

The aim of this RT is to develop control concepts and numerical tools for reducing O&M costs. Particular emphasis is put on the following topics all being critical for offshore wind farms:

- ✓ wind turbine and wind farm control

- ✓ tools for selecting more robust design of components and need for redundancy

- ✓ tools for doing predictive maintenance, hereunder models of component degradation

- ✓ establish a database with operational and failure data for validation of tools

Maintenance of offshore wind farms consists of three parts: preventive, corrective, and condition based maintenance. At present, the O&M costs are dominated by corrective maintenance. To reduce the O&M costs it is necessary to lower the amount of corrective maintenance by shifting some parts to preventive maintenance and some parts to condition based maintenance. To minimise the O&M costs the following topics are foreseen.

- ✓ The conceptual basis for predictive O&M should be based on a rational theoretical basis. A Bayesian approach and application of risk analysis tools have proven efficient in other industries and could be further developed for application for offshore wind energy. Application of predictive methods requires that damage development can be modelled and reliability estimated. Application of risk based methods implies that both cost and reliability aspects are combined and therefore data and models for these are needed – see topics below. Robustness of design in the sense that 'the wind turbine (system) is designed, fabricated, installed and operated in such a way that it will not be damaged due to accidental, unforeseen incidents and consequences of human errors to an extent disproportionate to the original cause' require. A risk based approach can be used to develop guidelines for robust design using information on reliability of components and systems, system redundancy and consequences of component failures.

- ✓ Numerical tools for quantifying the O&M aspects need to be further developed to estimate the different contributions of the three maintenance types to the total O&M costs and to assess the impact of different components with each a different reliability and maintainability on the overall O&M costs.

- ✓ The most important data to be used as input for the quantification of corrective maintenance with the O&M costs models are failure rates and reliability data of wind turbine (and balance of plant) components. Such data, especially reliability data, are hard to obtain. Databases with operational and failure data should become available and the industry should exchange such data. Parties involved should collect in a similar and structured way. Next, information about local weather conditions, capabilities of vessels, and logistic aspects are needed as input and should be collected centrally and exchanged. This RT could focus on structuring the format for data collection, setting up procedures for analysis and reporting, and developing a central database that can be accessed by industrial parties, keeping in mind the confidentiality aspects.

- ✓ To move from corrective maintenance to condition based maintenance, the diagnostics should be strongly improved. The R&D institutes can commonly develop (1) methods for low cost load monitoring (sensors, measurement equipment, and data reduction and analysis software) like the Flight Leader concept, (2) develop methods to relate mechanical (fatigue and ultimate) loads with component degradation and assess the remaining lifetime (e.g. for composite materials, bearings, gearboxes, sub-structures, and connections), and (3) develop methods to measure component degradation and remaining lifetime directly through improved condition monitoring systems. Once the remaining lifetime can be measured, estimates can be made with the O&M cost models of the expected amount of condition based maintenance.

- ✓ If the diagnostics function correctly, operators can intervene manually or automate the decisions making process. For both situations the large amount of data should be reduced first. The turbines should be equipped with redundant sensors and actuators to some extent. In case the decision making process is automated, developments should focus in implementing it in the turbine and wind farm controllers. This RT could focus on developing methods for data processing, the use of redundant sensors and actuators and development of fault tolerant control.

New control concepts should be considered, both for wind turbines and wind farms. On turbine level These should address possibilities of more simple designs (e.g. without pitch control, but variable speed only), more advanced controls (e.g. using lidar technology for measuring the incoming wind over the turbine area and applying individual pitching), means to reducing tower vibrations on bottom-fixed turbines, and angular motions for floating turbines. Tower vibrations may also be reduced by increasing the passive damping, e.g. viscous mass dampers as already used by the industry. The general aim shall be efficient operation and load mitigation, in overall reducing the cost of energy.

RT 5: Development of novel wind turbine and wind farm concepts for deep sea
The aim of this RT is to assess various possible novel designs of turbine and sub-structure for deep sea, and wind farm concepts, bottom-fixed and floating, and giving step-changes in technology for reducing cost of energy from offshore wind farms. Aspects of consideration are larger wind turbines (10-20 MW), lower top mass for large turbines, more robust design, more easy installation, wind farm design including multi-use of wind farm areas giving step-changes in technology for reducing cost of energy from offshore wind farms. Example concepts for research are listed below:

- ✓ Simple up-scaling of present wind turbines to sizes of 10-20 MW may mean an increase of top mass from 2-500 tonnes (3-5 MW) to maybe about 1000 tonnes. This would put excessive loading on the tower (and lifting equipment) and likely not economic. Reduction of the top mass is thus paramount for cost reductions, and possibilities should be investigated. Applying a down-wind concept with slender and light-weight blades is one option, alternative and more light-weight generator and drive-train solutions are another, hereunder (development and) use of new strong and lightweight materials.

Novel wind turbine concepts should be considered, e.g. the concept of a floating vertical axis turbine with a sub-sea generator should be investigated. Topics of research are aero-and hydrodynamics related to the stability of the turbine, mooring system taking up the turbine torque, turbine-generator swings, and control issues, e.g. speed control of the generator for smoothing torque variations and limiting the stress on the mooring system.

2.19 Milestones and deliverables

The tables below describe the milestones and deliverables for the year.

Mile-stone	Title	Nature[21]	Delivery date (MM-YYYY)	Lead partner	Comment
M1	EERA DeepWind R&D Offshore Wind Conference	O	02- 2016	SINTEF Energy Research	+30 peer-review journal papers by EERA partners
M2	Benchmarks scheduled and launched	O	03-2016	CENER	IRPwind MS22
M3	Data in database for benchmark exercise	O	09-2016	Hannover	IRPwind MS20

Mile-stone	Description
M1	EERA DeepWind R&D Offshore Wind Conference: EERA partners will contribute in total to about 50 oral and 50 posters, and approx. 30 papers from the conference will go through peer-review and be published in Energy Procedia
M2	Benchmarks scheduled and launched; IRPwind milestone MS22
M3	Data in database for benchmark exercise; IRPwind milestone MS20

[21] R = Report, P = Prototype, D = Demonstrator, O = Other

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D1	Towards a meshed North Sea Grid. Policy challenges and potential solutions from a Norwegian perspective	R	06-2016	SINTEF ER	NSON
D2	Technology Perspectives of North Sea Offshore Networks	R	06-2016	SINTEF ER	NSON
D3	Cost-benefits sharing models	R	06-2016	SINTEF ER	NSON
D4	Installation of a database	O	03-2016	FORWIND	IRPWIND D61.2
D5	Upload of the formatted data to the database (fixed)	O	09-2016	FORWIND	IRPWIND D61.3
D6	Upload of the formatted data to the database (floating)	O	09-2016	FORWIND	IRPWIND D61.4
D7	Benchmark reports 1	R	03-2016	CENER	IRPWIND D62.5
D8	Benchmark reports 2	R	09-2016	CENER	IRPWIND D62.6
D9	Models for offshore wind turbines	R	09-2016	UoS	IRPWIND D63.1
D10	Wideband modelling of 33 kV and 66 kV collection grid	R	02-2016	SINTEF ER	NOWITECH
D11	Wind turbine control	R	12-2016	NTNU	NOWITECH
D12	Simplified tool for long distance HVAC transmission	O	12-2006	SINTEF ER	NOWITECH
D13	STAS v2	R	09-2016	SINTEF ER	NOWITECH
D14	Vessel fleet optimization	R	10-2016	MARINTEK	NOWITECH
D15	Substructures - Estimate the impact of using a probabilistic method for the design of support structures compared to the conventional approach	R	12-2016	ECN	
D16	Substructures - Analysis of wave loads on large (10MW) wind turbines	R	12-2016	ECN	
D17	Substructures - Preliminary (first iteration) design of a semi-submersible floater for a vertical axis wind turbine	Model	12-2016	ECN	
D18	Substructures - Identify the technology barriers (and other limitations) for support structure design for the future very large (20MW) wind turbines	R	12-2016	ECN	
D19	IRPWind - Forecasting Tools for Wind Power Plant Operation	R	12-2016	ECN	
D20	Upscaling procedure	R	10-2016	TECNALIA	LIFES50+ D1.6
D21	Contribution to IEA Wind OC5	R		NA (NREL)	IEA Wind OC5
D22	Roadmap for O&M – How can research contribute to bringing down O&M costs	Report	12-2016	DTU	
D23	Maintenance polar and marine traffic analysis on an existing wind farm	Paper	04-2016	DTU	
D24	XL monopiles design for 10 MW turbines at 50m water depth	Paper	12-2016	DTU	
D25	Design of Semi floater concept	Paper	11-2016	DTU	
D26	Jacket design for longer fatigue life	Paper	11-2016	DTU	

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D27	Variation of Loads on Offshore Wind Turbine Drivetrains during Measured Shut-Down Events	Paper	05-2016	DTU	
D28	Models for fatigue optimization and fracture mechanics in jacket support structures.	Report	11-2016	DTU	
D29	Tractable problem formulations for optimal design of jacket support structures	Report	11-2016	DTU	
D30	Numerical optimization algorithms for jacket support structures	Paper	11-2016	DTU	
D31	Optimal wind turbine rotor design under offshore wind conditions in China	Report	12-2016	DTU	
D32	EUDP IEA Task 30 OC5	Report	12-2016	DTU	
D33	Design of 10MW floating wind turbine system	Report	12-2016	DTU	
D34	A wind-wave coupled forecasting model system for offshore wind and waves	Model	12-2016	DTU	
D35	A report of this model system	Report	12-2016	DTU	
D36	A report on the investigation on the uncertainties in current methodologies in providing statistics for offshore O&M	Report	12-2016	DTU	
D37	Supergen Wind Energy Technologies: Wind Turbine Control	O	05-2016	UoS	Supergen Wind
D38	Adjustment of wind farm power output through flexible turbine operation using wind farm control	O	05-2016	UoS	Supergen Wind
D39	Power adjusting controller	R	09-2016	UoS	Supergen Wind + Industry
D40	Strathclyde wind farm model	R	11-2016	UoS	CDT+MAX FARM+ IRPWIND D6.3.4
D41	Fulfilment of grid-code obligations by large offshore wind farm clusters connected via HVDC corridors	O	05-2016	UoS	DTOC WP5 + Supergen + IRPWind
D42	Optioneering analysis for connection Dogger Bank offshore wind farms to the GB electricity network	O	02-2016	UoS	ETP + industry + UoS
D43	Dynamic time-domain finite element model for Offshore structures	O	10-2016	UPC	
D44	Selcted met-ocean data from OBLEX-F1 measurement campaign made availabe	O	11-2016	CMR	
D45	Innovative design of a hybrid-type jacket for 10ME turbines	R	08-2016	FORWIND-Hannover	INNWIND D4.3.5
D46	Report for the Project “System for early damage and ice detection for rotor blades	R	12-2017	FORWIND-Hannover	

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
	of offshore wind turbines" (SHM.Rotorblatt)				
D47	GIGAWIND life: Interim Report	R	02-2016	FORWIND-Hannover	GIGAWIND life
D48	Monitoring Suction Bucket Jacket: Interim Report	R	03-2016	FORWIND-Hannover	Monitoring SBJ
D49	Substructures – Report on model tests for the installation procedure of a floating jacket type structure	R	12-2016	FORWIND-Hannover	
D50	INNWIND.EU – Deliverable 4.15 "Innovations on component level for coming 20MW turbines"	R	08-2016	FORWIND-Hannover	INNWIND 4.15
D51	INNWIND.EU – deliverable 4.25 "Results of codes validation with wave tank tests (incl. #2 series)"	R	09-2016	CENER	INNWIND 4.25

Deliverable	Description	Source of funding[22]	PM per Year[23]
D1	Political, regulatory and societal drivers and barriers for the realization of a meshed off-shore grid between North Sea countries are assessed.	N	1
D2	Overview over the most relevant technologies for realising an offshore power system in the North Sea.	N	1
D3	A SW tool – NetOp – is applied for transmission system investment planning with the goal to establish optimal offshore grid layouts for different future scenarios. The scenarios are built based on ENTSO-E four visions for 2030	N	2
D4			
D5			
D6			
D7	D62.5) Benchmark reports 1: The benchmark reports are for users of offshore design tools to see the results of the executed benchmark tests. The purpose is for giving performance indicators and range of application for the models tested.	EU	6
D8	D62.6) Benchmark reports 2: The benchmark reports are for users of offshore design tools to see the results of the executed benchmark tests. The purpose is for giving performance indicators and range of application for the models tested.	EU	4
D9			
D10	Journal paper describing 33 and 66 kV voltage systems for offshore wind farms	N	1
D11	Journal paper describing new turbine control concepts	N	1
D12	Model to describe High Voltage AC current based transmission	N	2
D13	State space based model tool for turbine control	N	4
D14		N	
D15			
D16			
D17			

22 National = N; European = EU; Other = O

23 Indicative only

Deliverable	Description	Source of funding[22]	PM per Year[23]
D18			
D19			
D20	LIFES50+ D1.6 Upscaling procedure. Four concept developers (Olav Olsen, Iberdrola Ingenieria, NAUTILUS and IDEOL) will upscale their 5MW floating structures to a 10MW wind turbine and three different locations. The report will collect design experiences during the upscaling process.	EU	4
D21	Codes simulation, comparison and correlation to experimental results for a semisubmersible floating structure.	N	12
D22			
D23			
D37	Design of controllers for large wind turbines	N	6
38	Design of wind farm controllers with a hierarchical decentralised and scalable structure	N	6
D39	Dynamic adjustment of the set-points of wind turbine controllers	N+O	12
D40	Control design and analysis model and simulation of arrays with 100+ turbines	N+EU	24
D41	Use of the electrical elements of the EERA-DTOC tools to test grid code compliance of different clusters connections	N+EU	12
D42	Identification of most suitable options for connection of large wind power plants both from the stability and reliability point of view	N+O	4
D43	Description of the model, including main hypothesis, mapping of loads and validation with benchmark examples.	N	12
D44	Selected data from the NORCOWE OBLEX-F1 measurement campaign at FINO1 will be made available together with a description of the data.	N	
D45	The Deliverable D4.3.5. will conclude the development within hybrid materials within a structural design solution. This means that the design will include the developed innovations on the component level from deliverables 4.1.2 and 4.1.3.	EU	4
D46	The report of the SHM.Rotorblatt Project should include the works performed during the project, i.e. the development of algorithms for SHM of rotor blades by means of vibration based approaches, the experimental work performed (rotor blade fatigue test and measurements in operation), as well as the results. Aim of the project is to finally combine the results with the partner's airborne sound based approach for damage detection.	N	12
D47	Validation methods and structural models for integrated and economical design of OWEC support structures. Measuring data based condition assessment.	N	33
D48	Measuring data based validation of present calculation methods to design suction bucket foundations.	N	25
D49	Report on model tests for the installation procedure of a floating jacket type structure	N	1
D50	Report on the applicability of the sandwich tubes (two relatively thin steel tubes with core made of Ultra-High Performance Concrete or Elastomer) on an innovative hybrid jacket support structure for coming 20MW turbine. The emphasis will be put on the main challenges that may be encountered. Recommendations for future research will be given.	EU	3
D51	Task 4.2 of the INNWIND.EU project on design methods for floating offshore wind turbines, deliverable "4.25 Results of codes	EU	3

Deliverable	Description	Source of funding[22]	PM per Year[23]
	validation with wave tank tests (incl. #2 series)" on the validation of simulation codes against wave tank tests.		

The list of milestones and deliverables above shall be understood as indicative only and to be completed in continued dialogue with SP partners, and adjusted according to success with starting new projects now in an application phase, both national and EU projects.

2.20 Participants, Contributions/Engagement and Human Resources

The table below gives the participants, contributions and human resources for 2016. The stated committed resources are research person-months (PM) per year that are spent on activities that can be shared within EERA.

No.	Partner	Country	Role [24]	Contribution / Engagement	PM/Y
1	AAU	DK	Ass	-	36
2	BERA	BE	Full	-	60
3	CENER	ES	Full	See list of deliverables	30
4	CENERG	ES	Ass	Not partner in SP offshore	
5	CIEMAT	ES	Ass	Not partner in SP offshore	
6	CIRCE	ES	Ass	-	12
7	CMR	NO	Ass	NORCOWE; Mainly in SP1, SP2 and offshore with met/ocean measurements	6
8	CNR	IT	Full	-	32
9	CRES	GR	Full	-	32
10	CTC	ES	Ass	-	12
11	DHI	DK	Ass	-	60
12	DLR	DE	Ass	-	3
13	DTU	DK	Full	EERA JP wind and IRPwind coordinator.	52
14	DUT	NL	Ass	-	12
15	ECN	NL	Full	See list of deliverables	30
16	FhG IWES	DE	Full	Offshore grids and asset management	73
17	ForWind	DE	Full	See list of deliverables	84
18	IC3	ES	Ass	Not partner in SP offshore	
19	IFE	NO	Ass	NOWITECH	12
20	IK4 Alliance	ES	Ass	-	1,8
21	IREC	ES	Ass	-	12
22	LNEG	PT	Full	-	22
23	METUWIND	TR	Ass	Not partner in SP offshore	
24	NTNU	NO	Ass	See list of deliverables	36
25	Pol. di Milano	IT	Ass	Lifes50+	3,6
26	RWTH Aachen	DE	Ass	Not partner in SP offshore	
27	SINTEF[25]	NO	Full	SINTEF Energy Research is heading SP offshore and is lead on M1, D1, D2, D3	42

[24] Full = Full participant; Ass. = Associate participant
[25] SINTEF = SINTEF Energy Research + SINTEF Foundation + MARINTEK.

28	TECNALIA	ES	Ass	TECNALIA will contribute to IRPWIND deliverables D62.5, D62.6 and D63.1; LIFES50+ public deliverable D1.6; IEA WIND OC5 activities. TECNALIA will also present a poster related to NAUTILUS floating structure wave tank testing at EERA Deep Wind 2016.	24
29	TU München	DE	Ass	Not partner in SP offshore	
30	Tubitak	TR	Full	Not partner in SP offshore	
31	University College of Dublin	IR	Ass	Not partner in SP offshore	
32	University of Athens (NKUA)	GR	Ass	-	12
33	University of Bergen	NO	Ass	Not partner in SP offshore	
34	University of Stuttgart	DE	Ass	-	4
35	UoP	PT	Ass	Not partner in SP offshore	
36	UoS	UK	Full	UoS is lead on IRPWIND D63.1	36
37	VTT	FI	Full	-	12
38	WMC	NL	Ass	Not partner in SP offshore	
39	UPC-BarcelonaTech	ES	Ass		
	SUM				617,8

2.21 Time schedule

The time schedule below outlines activities on a quarterly basis starting January 2016.

The time schedule shall show activities outlined in 2.3 and milestones as defined in 2.4.

Activity	Q1	Q2	Q3	Q4
EERA DeepWind R&D Offshore Wind Conference	M			
Benchmarks scheduled and launched	MS			
Data in database for benchmark exercise			MS	
IRPwind conference			M	

A: application; M: meeting; R: report; S: status report; W: workshop; MS: Milestone

Overall coordination between the SPs and the JP wind in general comes in addition, adding some one meeting between coordinators per month.

2.22 List of national research projects with links to the SP

(to be completed)

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Country
1	NOWITECH, www.nowitech.no	40	2009-2017	SINTEF Energy	NO
2	NORCOWE, www.norcowe.no	30	2009-2017	CMR	NO
3	NSON				

2.23 Contact Point for the sub-programme on offshore wind energy

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

<u>SUB-PROGRAMME: Research Infrastructures</u>

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work
2016

January 2016

Sub-programme on Research Infrastructures

A major motivation for the creation of this sub-programme is the need to align European efforts in obtaining relevant data from experiments to enhance development in the wind energy sector. The results from a survey done at European level showed at the time an emphasis on short to medium term research and demonstration, mostly driven individually at national level and single institutions. However, IRPWIND clearly focuses on the medium to long term research and it will provide a European added value by promoting collaborative projects with joint experiments and overall reinforcement of research excellence to boost development in the wind energy sector.

The Research Infrastructures sub-programme identified the trends and needs of the sector in relation to tests, measurements, experiments and validation activities so to prioritize the most relevant topics to be supported by the actions of this sub-programme. In this regard, the objectives were set to promote joint experiments to be carried out by multiple European institutions, at facilities all over Europe. This approach will lead to a more effective use of their capabilities and a more useful European investment effort than possible. In addition, complementary virtual Research Facilities are developed to match identified technological gaps, being the most representative WindScanner.eu.

The ultimate goal of IRPWIND is to accelerate the route to market for breakthrough innovations, and eventually to contribute to reaching the ambitious European objectives for wind energy generation towards 2050. This sub-programme has the general objective of promoting alignment plus focusing of national research activities through joint experiments carried out in European research facilities.

2.24 Background

The design and deployment of new large wind turbines requires prototype testing to obtain essential data. The motivation for having a sub-programme on Research Infrastructures is based on the importance of achieving as much synergy as possible and enough critical mass among the EERA partners, to improve their ability to perform very large and advanced experiments as well as pre-commercial testing of prototypes from where obtaining such significant and essential data.

The synergy and alignment will be gained by means of:

1. Generate awareness among EERA partners about the existing operative research facilities with their specific characteristics that are willing to join this initiative.
2. Create a framework with adequate rules and conditions that enable the procedures to use the research facilities and the guidelines to set up and perform joint experiments.
3. Select the topics most urgent and relevant to focus the target of the experiments and to promote cooperation and alignment to match experiments with the most appropriate European research facilities.
4. Implementation of a technical committee to select the experiments that will benefit from funding.

5. Funding of selected strategic joint experiments, including infrastructure use, at chosen national facilities.
6. Perform joint experiments and share valuable date within the European Wind Energy community.

By doing this, the joint use of European research facilities shall be carried out in a strategically focused and coordinated way, in which selected nationally operated facilities are employed to run specific high value experiments. This will lead to a more effective use of assets and better support of national R&D efforts, aligned with European objectives.

2.25 Objectives

The general objectives of the sub-programme are:

1. To mobilize and coordinate EU research and investment on infrastructures in the field of Wind Energy,
2. To optimize the use of the facilities making the most of their output,
3. To create the conditions for the long-term development and enlargement of the wind energy research facilities,
4. To create synergies between the partners of the EERA common research program in the field of Wind Energy.

The specific objectives for the period 2016 are:

5. Implement the actions to align and coordinate European institutions with research facilities to perform high value joint experiments
6. Create the framework to develop and perform the experiments
7. Dissemination of the data obtained on the experiments
8. Identify needs for different type of testing that requires specific Research Infrastructures, considering the possibility of having demand for new type of testing facilities.
9. Implement the actions required by the EERA Wind Strategy for the period (Strategy),
10. Integrate the following projects into the RI Strategy & SAP:
    i. Windscanner.eu – Preparatory Phase
    ii. Windbench
    iii. NEWA

2.26 Description of foreseen activities

Reliability issues are a main concern for wind technology development and it is becoming a critical aspect for the ongoing offshore deployment. Testing wind turbine components, full wind turbines, offshore support structures and even wind farms is becoming a growing common practice to obtain useful data that will feedback design models and procedures. This loop of activities brings reliability into the industrial development towards a more competitive market.

New testing facilities are built at different European countries without a common framework and without aligned objectives. Overall, it is ignored the possibility to work in a coordinated way at European level optimizing the financial resources provided by the EU and as well as the once provided by their own countries.

As previously mentioned, there are many types of tests for most of the wind turbine components and some of them are more mature than others. Therefore, standards, tests and codes are largely developed in some cases (i.e blades). In contrast, some others have never been properly tested (i.e. wind power offshore substructures) and other ones are now being developed (i.e. drive train). It is foreseen large effort before reaching knowledge in the relation among tests, components and codes; and therefore, here it is propose to work intensively among industry, test laboratories and code developers.

Now it is proposed a list of test categories for which it is recommended to set up working programs for further knowledge development; and ultimately, for adapting and transforming the Research Infrastructures:

- ✓ **Blades** – multiaxial testing looking for coupled actions more representatives of real behaviour while on the wind turbine
- ✓ **Drive train** – to determine the dynamics to be tested and how it should be performed by the test actuators. Simulation software validation with test results. Determining parameters to be monitored and sensoring technology
- ✓ **Offshore substructure** – Test definition / Scaling limitations / simulation software development and test validation
- ✓ **Wind Turbine** – correlation between accurate inflow measurements and aerodynamic-aerolastic codes / to determine real aerodynamic performance
- ✓ **Wind farm** – define grid integration tests / wind farm control vs overall production

Actions are taken to rich coordination among European institutions with research and testing infrastructures to join IRPWind initiative. Three initial Networks were created on wind tunnels, research wind turbines and grid integration. These Networks will have the ability to define and establish the state of the art in testing; and therefore, to set up the research and development programmes.

At the moment, there are already three established networks but more are to be created as Windscanner is now. Experiments about the topics from the networks will be performed in a jointly manner coordinating two or more IRPWind and EERA institutions. Further Networks on different topics will be created to coordinate efforts in defining the specific needs in their field of expertize and then perform a new round of joint experiments.

<u>Integrated existing Research Infrastructure projects:</u>

Windscanner – this infrastructure has the particularity of being integrated by several EERA partners and it will have the mobile capacity to perform measurements all around European countries. The procedures to use this infrastructure have been already defined at the Windscanner Preparatory Phase project. In this period an implementation process will follow so all interested countries will know how to use it and how to provide specific services to all industries interested in it.

Windbench – is a virtual infrastructure accessible to anyone interested in comparing and benchmarking any kind of data. This platform will facilitate unified references about simulation codes performance. At the moment implementing actions are in progress to create and operate a stable tool by extending some existing developments. Windbench is being developed and used now in the IRPWind Offshore sub-progarmme.

NEWA - the European project "New European Wind Atlas" (NEWA) officially started in March 2015.this project is included in the ERA-Net Plus on wind resource where Spain takes part through MINECO. The final deliverable is meant to be a new European Wind Atlas developed with high resolution meteorological models and validated by several extensive measurement campaigns. It will have duration of 5 years and a Budget of 13 M €. NEWA is articulated through national nodes that represent all the ERA-Net signing countries. Nine Funding Agencies representing eight countries constitute the Consortium headed by DTU (Danish Technical University). The Spanish participation consists of five organisms led by CENER with active participation in all the project´s Work Packages.

The tables below describe the milestones and deliverables for the year.

2.27 Milestones and deliverables

Mile-stone	Title	Nature[26]	Delivery date (MM-YYYY)	Lead partner	Comment
M1	Publishing data from joint experiments	O	12- 2016	CENER	Workshop with EERA members
M2	MS9 - Call for Access and Granting of Access (joint experiments)	O	12-2016	CENER	IRPwind MS9
M3	Creation of New Networks	O	05-2016	CENER	RI Sub-programme
M4	Start running Windbench	0	09-2016	CENER	IRPWind
M5	Roadmap for the implementation phase of the European Windscanner.eu	0	09-2016	DTU	Windscanner.eu implementation phase

[26] R = Report, P = Prototype, D = Demonstrator, O = Other

M6	Windbench.eu validation	0	11-2016	CENER	IRPWind

Mile-stone	Description
M1	After the first round of joint experiments, it will be organized a workshop for EERA members where the relevant information and results from the joint experiments will be explained.
M2	The 2cd call for joint experiments will be issued
M3	New networks will be created to prepare next round of joint experiments
M4	Windbench platform will be operational in IRPWind project
M5	Windscanner Implementation Phase project will be defined as a proposal for the H2020
M6	It will be demonstrated that Windbench platform is operational and with satisfactory results in IRPWind project.

Deliverable	Title	Nature	Delivery date (MM-YYYY)	Lead partner	Comment
D1	D3.6 - Report on working networks, including recommendations on future research infrastructure and selected joint experiments	R	03-2016	CENER	IRPWIND D3.6
D2	NEWA: Perdigao Measurements	0	12-2016	DTU	To be followed as the project progresses

Deliverable	Description	Source of funding[27]	PM per Year[28]
D1	First report informing about the experience of Network creation and operation, plus describing the process for the first round of experiments	EU	2
D2	Completion of the measurement campaign in Perdiago, Portugal.	EU	6

2.28 Participants and Human resources

The Research Infrastructures sub-programme has the particular characteristic to have only the coordinator as the only participant with assigned resources men/month.

No.	Partner	Country	Role[29]	Contribution / Engagement	PM/Y
1	CENER	ESP	full	To develop all the activities foreseen in the sub-programme	3

2.29 Time Schedule

The time schedule below outlines activities on a quarterly basis starting January 2016.

Activity	Q1	Q2	Q3	Q4
Creation of New Networks		MS		

27 National = N; European = EU; Other = O
28 Indicative only
29 Full = Full participant; Ass. = Associate participant

Start running Windbench			MS	
Roadmap for the implementation phase of the European Windscanner.eu			MS	
Windbench.eu validation				S
2sc Call for Access and Granting of Access (joint experiments)				MS
Publishing data from joint experiments				W
Report on working networks, including recommendations on future research infrastructure and selected joint experiments	R			
NEWA: Perdigao Measurements				S

A: application; M: meeting; R: report; S: status report; W: workshop; MS: Milestone

2.30 List of national research projects with links to the SP

#	Project title and web address	Total budget (MEUR)	Start-End Year	Coordinator	Country
1	MEDAP-ADITECH (no web)	0,05	2016	CENER	ESP
2	WINDTRUST – FP7 - http://windtrust.eu/	11.5	2013-2016	GAMESA	EU
3	NUEVAS SOLUCIONES DE TRENES DE POTENCIA Y CONTROL AVANZADO PARA AEROGENERADORES EFICIENTES – RETOS (no web)	4	2014-2017	MToi	ESP
4	FLOCAN 5 – CIEN (no web)	3.5	2015-2017	ACS COBRA	ESP

2.31 Contact Point

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EERA
EUROPEAN ENERGY RESEARCH ALLIANCE

<u>SUB-PROGRAMME: Economic and social aspects</u>

A sub-programme within the:
Joint Research Programme on Wind Energy

Description of Work
2016

January 2016

Sub-programme on Economic and social aspects of wind integration

2.32 Background

With the increasing shares of wind energy in the energy systems, economic and social aspects become more and more challenging. It is thus of utmost importance to understand and incorporate political and social aspects in the research, so that wind energy can continue to be a success story.
This sub-programme will explore the major economic and social challenges for wind energy now and in the future and will investigate how they can be addressed and mitigated.
This sub-programme will deal with a range of research areas, from cost developments of components and different turbine types to questions of how to best integrate wind energy into the energy systems and how power markets should be adapted so that wind power can provide most benefits to the system. Moreover, social aspects are decisive for the future deployment of wind energy: A better understanding of mechanisms and processes related to effective local siting of wind power and lessons learned from other areas may avoid conflicts and possibly reduce uncertainties in project lead times and development costs. At the same time, how can support mechanisms be designed in a cost-efficient way, so that they strengthen public trust at both national and supranational levels?
This sub-programme supports the other sub-programmes within the joint programme on wind energy by adding an economic and social perspective into the analysis. This includes aspects relating to society, technology, environmental and economic challenges of wind integration. Moreover, independent research activities will be undertaken within the sub-programme. The main research areas are:

- ✓ Component and system costs of wind energy
- ✓ Economic incentives and support mechanisms for wind energy
- ✓ Integration of wind into energy systems
- ✓ Adapting power markets for wind energy
- ✓ Environmental issues of wind energy including Life Cycle Assessment (LCA)
- ✓ Public engagement strategies for wind energy

It is the intention that the sub-programme will also be dealing with research areas such as *resource efficiency, macroeconomics* and *innovation processes*. Macroeconomics includes e.g. the employment effects of wind energy in a country. However these issues will be addressed at a later stage.
This sub-programme will be highly interlinked with the other sub-programmes within the joint research programme on wind energy, and will also collaborate with the EERA Joint Programme “Economic, environmental and social impacts of energy policies and technologies” (e3s).
While the cost of energy from wind farms is still often higher than from conventional electricity generation options, they provide significant environmental and other benefits, so that policy makers all over the world have implemented support mechanisms to promote the deployment of wind energy. This is however closely related to the expectation that in the long term, wind energy will be able to compete on the market without support. For this, significant cost reductions in components and system cost are necessary. Also, for the long term success of wind energy, their integration into the energy systems needs to be ensured. Currently, energy systems are often challenged by high shares of wind energy due to its variability of production and its clustering at high wind locations. This sub-programme explores component and system cost reduction potentials, system integration options and new market designs to ensure the success of wind energy.
This sub-programme addresses two priority research areas of the Wind Technology platform Strategic Research Agenda (TPWind SRA): grid integration and market deployment strategy. Amongst the issues mentioned in the TPWind SRA are the need for assessing the impact of high wind energy

penetration on power system planning and operations, and the need to investigate new market designs and business models. This sub-programme will use energy system analysis as an important element to address these issues. Additionally, the TPWind SRA describes a lack of coordination and holistic perspective in the economic assessment of wind power generation versus other generation technologies, including all costs and benefits and effects. Adapting policies and ensuring public acceptance of wind power are mentioned as important areas within the field of market deployment strategy. This sub-programme will research on innovative policy design for wind technology development and wind integration. Focus will be placed on the economic assessment of environmental effects of wind energy, so that these can be integrated into a holistic technology assessment. Also social aspects will be addressed, which can have significant impact on the success of wind, with special focus on public engagement options, including participatory approaches.

2.33 Objectives

The overall objective of the sub-programme is to align research activities in the area of economic and social aspects of wind integration to lay a scientific foundation for the long term cost-effective development of wind energy and its successful deployment in energy systems. This will be done in two ways: 1) by involvement in research activities in other sub-programmes and aligning the approaches and methods taken there when assessing and analysing economic and social aspects. This creates synergies and may enhance the comparability and quality of economic analysis. 2) by initiating and undertaking separate research activities in the area of economic and social aspects of wind integration. The strategic research objectives are:

- ✓ Provide the theoretical basis for assessing economic and social aspects of wind integration, including a comprehensive assessment of environmental effects
- ✓ Understand technological learning processes for wind energy and assess overall cost reduction potentials, including all elements of a wind park and its development process in order to justify the further promotion of wind, to identify the necessary support needs for the future; and to identify priority areas in technical development and optimisation of business activities.
- ✓ Explore and assess options to enhance the integration of wind into energy systems
- ✓ Identify the best financial support mechanisms for promotion of wind in future energy systems
- ✓ Optimise the design of energy markets for the participation of wind energy, incl. ancillary services
- ✓ Make comprehensive assessments of wind energy options in comparison to other technologies by adopting a holistic perspective including environmental, social and economic effects
- ✓ Reduce uncertainties about successful wind deployment by establishing a better understanding of public views, engaging the public, and identifying ways to dealing with barriers and issues related to public acceptance.

The research is structured around a) development of theory and models, b) historical data analysis, c) data collection through industry cooperation, interviews and simulation; and d) forecasts based on models. Six Research Themes (RTs) are addressed:

RT1: Component and system costs of wind energy

RT2: Economic incentives and support mechanisms for wind energy

RT3: Economic integration of wind into energy systems

RT4: Adapting power markets for wind energy

RT5: Environmental issues of wind energy including Life Cycle Assessment (LCA)

RT6: Public engagement strategies for wind energy

2.34 Description of foreseen activities

The tables below describe the milestones and deliverables for 2016.

	Title	Deliverable date, MM-YY	Lead partner
	RT6: Publish final version of white book on social science approaches of wind energy deployment	*01-16*	*DTU Wind*
	RT6: Input to newsletter and website	*02-16*	*DTU WIND*
	Preparing 1-2 calls of interest for joint EERA H2020 project proposals (for Jan '17)	*08-16*	
M6	*RT3: Workshop on economic integration options and how to model effects in energy systems models for high wind energy scenarios*	*09-16*	
	Subprogramme meeting in connection to IRP annual conference	*09-16*	*DTU Man*
	Kick-off in RT4: Economic integration of wind into energy systems	*09-16*	*??*
M5	*RT2: Report on future policy support options for offshore wind energy in Europe*	*10-16*	*DTU MAN / ECN*
	RT1: Publish final version of state of the art of existing tools for wind energy economic assessment	*11-16*	*IREC*
M7	*RT4: Report on merit-order effects of wind power on spot markets*	*11-16*	
M8	*RT5: Report on a comparison and assessment of different methods to evaluate environmental impacts on wind energy*		

2.35 Participants, Contributions/Engagement and Human Resources

Name	Country	Role	Active in Research Themes	Human Resource committed
DTU Management Engineering	*Denmark*	SP Coordinator (Lead)	*1,2,3,4,6*	
ECN Policy	Netherlands	Participant		[min. contribution 5 py/y]
IREC	Spain	Participant		[min. contribution 5 py/y]
METU/TUBITAK	Turkey	Participant	*5*	[min. contribution 5 py/y]
SINTEF	Norway	Participant		[min. contribution 5 py/y]

University of Strathclyde	United Kingdom	Participant		[min. contribution 5 py/y]
University College Dublin	Ireland	Participant		[min. contribution 5 py/y]
TU Delft (esp. RT2, RT3)	Netherland s	Participant		[min. contribution 5 py/y]
VTT (esp. RT3, RT4, also RT2 and RT5)	Finland	Participant		[min. contribution 5 py/y]
IWES, Fraunhofer	Germany	Participant		[min. contribution 5 py/y]
University of Delaware [Bonnie at DTU Wind now]	USA	Participant		[min. contribution 5 py/y]

2.36 Contact Point for the sub-programme on Economic and social aspects of wind integration

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The organisation and management of EERA JP Wind and the IRPWIND

This chapter provides an overview of the organization and management of EERA JP Wind and the IRPWIND project.

The EERA JP Wind is an ambitious and complex programme with many partners and various types of interrelated activities. The IRPWIND has included several of the EERA members directly as partners. The remaining participants and future members will benefit from the Coordination and Support Action (CSAs) activities setup in the IRPWIND.
Together this requires an efficient management structure. From the beginning, EERA JP Wind designed an organisation where management, tasks and responsibility are well defined as well as the decision-making and financial procedures. With the IRPWIND this is further strengthened to ensure that the organisation can handle the increased complexity and responsibilities.

2.37 EERA JP Wind Participants and human resources

The Joint Programme is based on openness and generic pre-competitive research. Participation is open to all European research organizations. Public research organizations can join as either Participants or Associate Participants. The latter are linked to a Participant and contribute to the volume and scope of this Participants activity and effort. Participants must commit a significant effort in the order of 5 Professional Person Years (PPY) per year. This effort does not include temporary staff such as guest researchers or PhDstudents.

Participants in the EERA JPWind are also obliged to be associate or full members of the legal entity of the European Energy Research Alliance – EERA AISBL[30].

In order to promote efficiency in the planning, management and coordination, the programme is organised with national nodes. Full Participants have the responsibility to act as a node with Associate Participants. These Associate Participants may be other research institutes, university groups or similar with attractive research competencies, resources and/or facilities. Full Participants must have significant and comprehensive activities in wind energy research and be active in most of the sub-programmes. Participants shall organise and coordinate the contribution and participation on national or regional level. The national coordination is a very important part of the EERA JP Wind and in the IRPWIND specific tasks address this by means of i.e. setting up national coordination mechanisms involving all EERA JP Wind members and relevant MS funding bodies. A report on this is due in spring 2015[31].

Full Participants in the Joint Programme are also members of the JP's steering committee. This implies direct contact to the management board and a vital role in the joint programme planning and follow-up specifically towards Associated Participants.

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30 For more information about the EERA AISBL membership criteria see http://www.eera-set.eu/welcome-to-eera/from-eera-to-eera-aisbl/

31 This is IRPWIND deliverable D.2.5 submitted July 2015 and resubmitted with corrections August 31 2015.

While the effort of the participants in the joint research projects will be dynamic and also include non-EERA Wind members, below is a list of the present members (July 2014):

Full Participants: DTU (DK), ECN (NL), CRES (GR), CENER (ES), FhG IWES (DE), LNEG/INETI (PO), SINTEF (NO), VTT (FIN), University of Strathclyde (UK), Forwind/University of Oldenburg (DE), Tubitak Uzay (TU), CNR (IT), BERA (B)

Associate Participants: Forwind/Univeristy of Hannover (DE), Forwind/University of Bremen (DE), University of Porto (PO), NTNU (NO), IFE(NO), MARINTEK (NO), DHI (DK), University of Aalborg (DK), IEN (PO), UCD (IR), WMC (NL), DUT (NL), CTC (ES), IREC (ES), ENEA (IT), NKUA (GR), CIEMAT (ES), CIRCE (ES), Tecnalia (ES), IK4 Alliance (ES), POLIMI (IT), UoB (NO), CMR (NO), Middle East Technical University – Center for Wind Energy (TU), MARINTEK (NO) and NAREC (UK), University of Stuttgart (DE), SINTEF MC (NO) and DLR (DE)

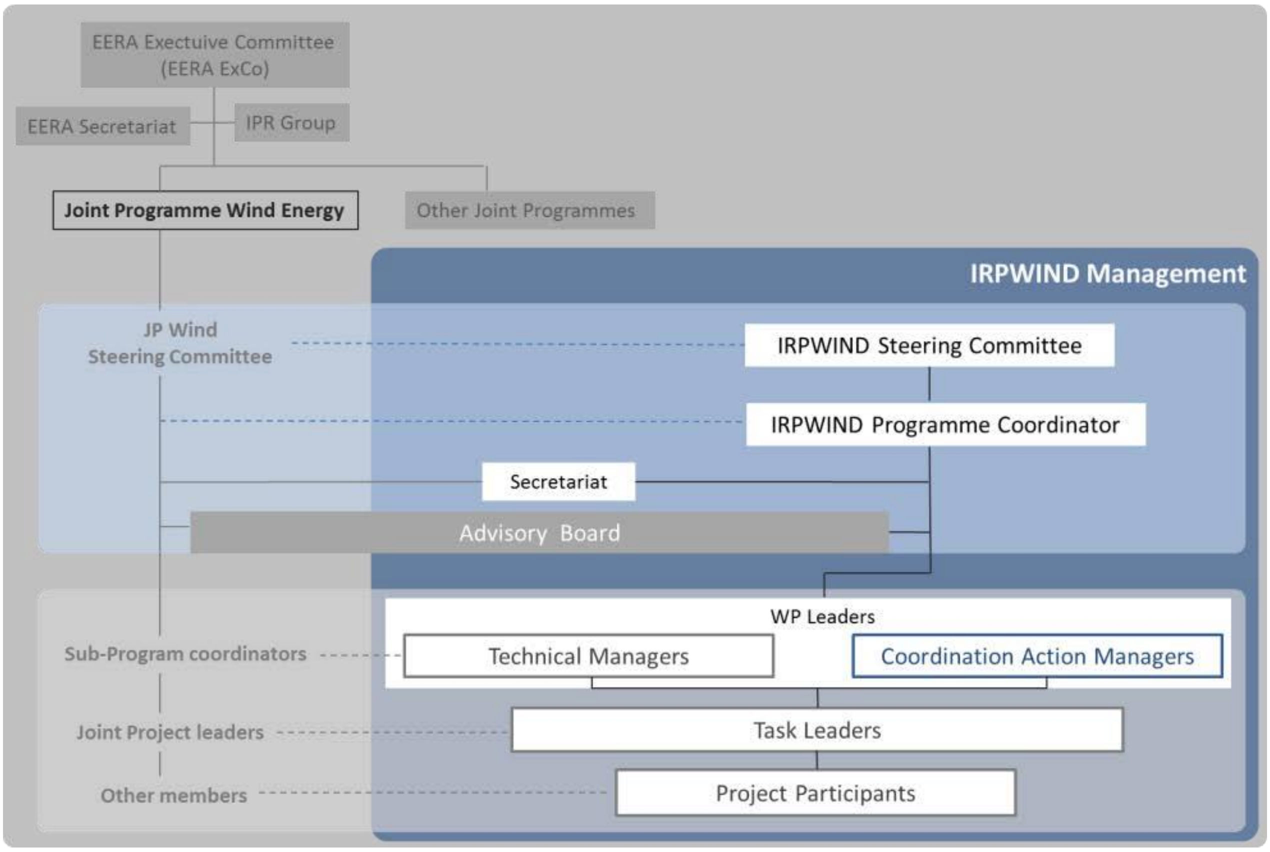
Each member of the EERA JP Wind has committed between 3 and 30 PPYs per year to the programme with a total of more than 300 PPYs. The PPYs are not covering the total effort of the partners, but only the effort with a potential for alignment in the joint programme (activities were results can be openly shared).

Since the start of the IRPWIND in March 2014 a revision of all planned and future activities has started and detailed list for 2015 has been developed on the basis of this document. In the section of each of the sub-programmes the planned research activities and the partners involved are listed. The milestones, indication of partners and the corresponding Person Months for the specific activities will we discuss and further developed in the coming months.

2.38 Management

EERA JP Wind is organised in scientific sub-programmes with separate research goals and milestones. The sub-programmes are the scientific and strategic cornerstones for the operation of the programme. The overall planning of the programme's activities and future strategy is developed at sub programme level and sanctioned by the Steering Committee and Management Board. The Management Board consists of the Joint Programme Coordinator and the Sub-programme leaders.

The governance structure for EERA JP Wind and the IRPWIND, designed to ensure a transparent and accountable structure for all the partners, is outlined below. The illustration also includes the management of the general EERA level.



The following levels of management are defined:

- EERA Executive Committee (ExCo)
- JP Steering Committee (SC)
- JP Programme Management Board (PMB)
- Joint Programme Coordinator (JPC) and Sub-Programme Coordinator (SPC) • Project Leader (PL)

The management groups are assisted by the Advisory Board.

EERA Executive Committee (EERA ExCo)
The EERA ExCo is the highest decision making body of the EERA. The EERA ExCo approves and monitors the progress of the EERA joint programmes, including ensuring that the right players are participating as well as establishing and monitoring links with other initiatives etc. The EERA ExCo also approves the Joint Programme Coordinator.

JP Steering Committee (SC)
Persons in this committee are nominated by the respective EERA Full Participants and act as the contact persons between the Management Board and the participating organisations. The Joint Programme Coordinator and the Sub-programme Coordinators are chosen by the SC. The SC provides recommendations to the Management Board in order to ensure that the programme activities will meet the highest scientific standards and that the competences and facilities within the EERA parties are utilised in an optimal manner. Plans for the Joint Programme for the coming planning period as well as progress reports are presented to the SC for discussion and approval.

The Steering Committee comprises a member from each Full Participant. The Steering Committee convenes twice a year and is chaired by the JPC. The IRPWIND has a General Assembly which convenes once a year.

JP Management Board (MB)
The MB is responsible for all managerial aspects of the Joint Programme. The MB comprises the Joint Programme Coordinator and the Sub-Programme Coordinators. The MB is assisted by the IPR Group, which drafts confidentiality agreements and provides advice concerning protection of intellectual property of project partners, based on interaction with the ExCo. The MB is up for election at the next Steering Committee meeting in September 2014, however, the JPC was re-elected at the SC meeting in January 2014.

Joint Programme Coordinator (JPC)
The joint programme is organised in scientific sub-programmes with separate research goals and milestones for the planning period and comprises a number of joint projects or activities. A Joint Programme Coordinator (JPC) manages the MB for the joint programme and has the responsibility to report to the ExCo on plans, results, findings and progress within the running joint programme.

Sub-Programme Coordinator (SPC)
The Joint Wind Energy Programme is organised in scientific sub-programmes with separate research goals and milestones for the planning period and encompassing a number of joint projects and activities. A Sub-Programme Coordinator (SPC) manages the sub-programme.

Project Leader (PL)
The projects are the organisational units where the R&D activities are being carried out. The projects may involve several scientific sub-programmes. The actual work takes place at various EERA and affiliated organizations. A Project Leader (PL) is managing the activities on a day-to-day basis. The Project may be divided into several tasks, managed by task leaders.

Advisory Board (AB)
Persons assigned to the AB are being selected for their relevant technological, industrial and scientific know-how. The AB consists of 2 members appointed by TPWind, 2 Members from EAWE and 1 member from KIC-InnoEnergy. ENTSO-E will also have one member of the AB. Further members will be invited. The AB will provide recommendations to the MB in order to ensure that the project's activities will meet the highest scientific standards, that the activities are properly targeted to industrial needs and that the project's activities can match the industrial needs in terms of content and form.

The AB convenes once a year. On a yearly cycle meeting agendas must contain the following items: Joint programme strategy and objectives, sub-programme plans and milestones, evaluation of the results achieved so far and possible modifications of the joint programme priorities.

2.39 Networking, coordination and planning - IRPWIND Integrating Activities

The IRPWIND project includes a specific Work Package on “Integrating Activities”. These activities aim to facilitate and ensure a formalized approach to coordinate and align existing and planned national and European activities along the same European strategy, realizing the ambition of IRPWIND to move from a collaboration model based on ad-hoc participation in projects to collectively plan and implement a joint strategy. This is already the aim of EERA JP Wind - but the IRPWIND should imply that we take the next steps.

EERA JP Wind full Participants have a more active role in the national coordination. Full participants are expected to actively enforce links to associated participants (planning and reporting in connection to EERA JP Wind and IRPWIND) and ensure adequate information about EERA and IRPWIND issues of general interests (SC decisions, future Horizon 2020 proposal preparation). It is also important that full participants more proactively take contact to national SET-Plan stakeholders.

The yearly planning and reporting of the activities (including the national activities contributing to the IRPWIND and the milestones in the EERA Wind Strategic Action Plan (DoW) will be strengthened. This will imply that in the upcoming revision of the EERA Wind Strategic Action Plan all members will be asked to specify more accurately how many Person Months they commit to which specific deliverable. Each sub-programme coordinator will coordinate this. The details are described in the IRPWIND DOW.

The key activities and deliverables as formulated in the IRPWIND DoW can be summarized as follows:

- Strategic Action Plan
  Every year the planning and actions for the coming year will be put in to a Strategic Action Plan. This document is the first version, which will be further refined in the coming 6 month and in future editions.
- Yearly Report on IRPWIND and EERA JP Wind
  A yearly report on the national and European projects contributing to the IRPWIND and EERA JP Wind. The reporting will not just be in a written format as a yearly IRPWIND Conference will take place. The Yearly Report will be based on what has been put into the Strategic Action Plan. First report is due in spring 2015.
- Medium to long term Research Strategy and Roadmap
  Every second year an EERA JP Wind Research Strategy and Roadmap will be published. The first edition will be finalized in autumn 2014
- Report describing the national structure for funding wind energy research and decision-making regarding implementation of implementing the SET Plan Plans and instruments for jointly developing and implementing projects will be described in the report. The report will be ready in spring 2015. In the following years this work will be included in the Yearly Reports. The report will analyse and outline mechanisms for ensuring integration of national efforts in the 13 Member countries in the IRPWIND. All Full Participants of the EERA JP Wind will be responsible for this.
- Strategy on openness and access to data
  Regarding data collection and data sharing the IRPWIND will develop a strategy on how to ensure better openness and access to data also for partners not having been previously involved in the specific projects. A workshop with industry will take place in the autumn of 2014 and a report will be finalized in spring 2015.
- InCo Strategy
  International Cooperation with 3rd countries will be investigated during the first 2 years via expert workshops with targeted countries. This work will be compiled in an

IRPWIND InCo strategy identifying 2-3 targeted countries, areas of collaboration and also outline possible schemes for the collaboration. The strategy should be a living document and facilitate a continuous strategic discussion on how and with who to collaborate based on an assessment of the mutual benefits and reciprocity. A report will be done in M26 of the IPRWIND (autumn 2016)

- Business Plan for future steps of EERA IRP on Wind Energy
  The Mid-Term review of the RIWPWIND will feed into this plan, which will be based on the input from the review process and an assessment of the various funding instruments used to obtain other seed and glue funding for activities to support and further develop the IRP and the envisaged long term research activities. A report is due in M 30 of the IRPWIND (autumn 2016).

9.3.1 Collaboration with industry and dissemination

The IRPWIND includes a specific work package dedicated to this issue. The objective is to organize and integrate dissemination and exploitation activities. The latter will optimise the delivery and impact of the EERA JP Wind to the European industry in order to maximise the programme's impact on the realisation of the EU's 2020 Climate and Energy objectives. A large number of dissemination activities will be performed to raise awareness of the programme within the various target groups, and in particular the European wind industry. The main actors in the target group are wind turbine and component manufacturers, wind farm developers, power utilities, standardisation committees, certification bodies and consultants.

The industry partners that are selected will be invited to specific events that are linked to IRPWIND. Furthermore, presentations and publications will be held at major specialised conferences. Through an IRPWIND-initiated mailing list, the selected industry partners will also be informed on progress within the IRPWIND project and the initiatives that are developed. To increase efficiency of this process, a network of technology transfer experts will be set up.

The tasks in this WP are divided between tasks to extend dissemination activities to create further synergies from the IRP, and tasks to consolidate on-going integrative transfer of knowledge activities in the EERA Wind context. Within the project the following dissemination activities are undertaken:

- Annual IRPWIND conference
  The first one was organised 25-26 September 2014 in Amsterdam. The Second conference will be held 28-29 September 2015, also in Amsterdam.
- Website (www.irpwind.eu) Launched.
- Bi-annual newsletter
  First edition distributed. Second edition to be launched end 2014/early 2015. • 4 scientific publications per work package

2.40 Mobility

Increasing the mobility of researchers is a cornerstone of plans to complete the development of the European Research Area (ERA). For the individual scientist as well as for his or her institution, strongly embedded in both the institutional and international network is an important condition for developing an international perspective of his work and ensure a proper knowledge of the global state of the art in his field of expertise.

Nevertheless, there are obstacles to researchers' mobility. This is particularly evident at the level of experienced researchers, where the volume of mobility is rather low. While especially younger researchers benefit from the Marie S. Curie scheme under Horizon2020, institutions often view the mobility of a senior employee as a brain drain rather than a brain gain. In addition, the current mobility schemes, such as the Marie S Curie programme, does not allow for flexible short term exchange of researchers.

9.4.1 Objectives

The IRPWIND mobility scheme aims to address this particular short coming of existing mobility programmes. Importantly, the scheme is also open to all EERA partners and industrial actors that are not partners in the IRPWIND.

The IRPWIND Mobility scheme has three main objectives:

1) To ensure an efficient implementation of the IRPWIND project and the research activity of EERA JP Wind Sub-Programmes;

2) To facilitate the mobility of experienced researchers between the EERA JP Wind research organizations to fill gaps in the European Research Area in the wind energy sector; and

3) To conduct actions to promote the concept that the mobility of researchers is a brain gain as well as foresight schemes to enable effective mobility.

The planned actions will be conducted partly bottom up to enable all interested researchers to participate in the scheme and partly top down targeting the managements to communicate the idea that mobility is an opportunity and not a threat to the efficiency of an organization.

9.4.2 Implementation

Mobility calls are announced on the web page www.IRPWind.eu\mobility where the detailed mobility activity and rules for applications can be found. The pilot mobility scheme structure has been designed with three options: grants for periods of one month, three months, and six months and is summarized in Table 1.

GRANT SCHEMES	One month	Three months	Six months	Total
Number of persons	39	18	16	73.0
Number of months	39	54	96	189.0
Man/years				15.8

Table 1. Total number of individual grants and number of man-months allocated to the mobility activity within the 4 year duration of IRP Wind Energy

Grant Period	1 month	3 months	6 months
Year 1	12	6	5
Year 2	9	4	4
Year 3	9	4	4
Year 4	9	4	3

Table 2. Number of individual grants per year divided per scheme.

In total there will be 79 individual grants. Table 2 shows the distribution of the available number of grants during the 4 years of the project for each scheme.

After the results of the first call, the scheme will be evaluated and possibly revised according to IRPWIND KPIs. One of the KPIs set for the Mobility activity is the number of granted periods over the number of applications classified according to the different schemes. Based on this indicator we will be able to evaluate each scheme and outline the best practice for enhancing mobility.

At the end of each year there will be reports about the evaluation of the proposed pilot schemes in terms of its success based on a series of questionnaires. Guidelines for best practice of mobility schemes amongst R&D public institutions, private organizations and scientific communities at national, European and international level will be one of the final outputs of the mobility activity.

2.41 Conclusions

The organization of EERA JP Wind has developed based on a solid foundation of a well-structured management. As more participants have joined, the programme led by the management board has adopted procedures and rules based on continuous discussions with the Joint Programme Steering Committee and the general development in EERA as decided by the EERA Executive Committee. With the IRPWIND, EERA JP Wind is expected to further consolidate its activities over the common years to build a stronger base for European public research and its collaboration with industry.