Integrated Research Programme on Wind Energy

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Collaborative project
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Author(s) information (alphabetical):		
Name	Organisation	Email
Claudia Roberta Calidonna	CNR	cr.calidonna@isac.cnr.it
Anna Maria Sempreviva	DTU	anse@dtu.dk

Acknowledgements/Contributions:		
Name	**Name**	**Name**
Kira Toft Smith	**Mariafrancesca De Pino**	**Daniel Gullì**

Document Information

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			Prepared by	**Reviewed by**	**Approved by**
1	24/02/2016	**Name WP5 Deliverable 5.3**	Claudia R. Calidonna	Anna Maria Sempreviva, DTU	
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1. Executive Summary

In this document, we describe and evaluate the activity within WP5 "Mobility of Researchers" for the second year 1/03/2015-28/02/2016.

The document contains:
- The description of the activities within the mobility work package during second year,
- New issues with respect to the 1st year;
- Remarks and future actions; and
- An appendix with the collection of the final reports submitted by the beneficiaries of the grants and their evaluations.

The mobility programme has the following objectives:

1. To ensure an efficient implementation of the CPs and in general of the research activity in EERA;
2. To facilitate the cooperation between EERA research organizations and the broad scientific community to fill gaps in the ERA in the wind energy sector;
3. To connect relevant National projects/Initiatives to the IRPWind core projects and generally to the EERA JP Wind Energy Joint Sub Programmes, keeping an eye to future emerging technologies and scientific topics; and
4. To conduct actions oriented to promote the concept of mobility of researchers as brain gain and foresight schemes to enable effective mobility.

The innovative aspect of this programme is that the mobility scheme is not meant for high training purposes but rather for established scientists in order to enforce cooperation within the IRPWind Partners.

According the starting hypothesis, the Mobility of Researchers funding programme consisted of 39 Grants for a period length of 1 month; 18 Grants for a 3-month period and 16 grants for a 6-month period. And a lump sum covers travel expenses from/ to home institution.

Two calls have been launched during the second year, which makes a total of 4 calls during the two-year period. A total of 11 applications were received, 4 were submitted to the 3rd call and 7 to the 4th call. However, one application was rejected because the host institution was not an IRP Partner.
At the end of the second year, all projects granted during the first call were completed and evaluated; this included a three-month grant postponed due to health reasons. Dr. Doron Callies from IWES to DUT started in December 2015 for a period of three months. The 3- and 1-month periods are the most popular, while none of the applicants has chosen the 6-month option.

During this second year, a request for Clause 42 for third parties was issued to include the EERA partners and was approved by EC.
According to several requests, received also during Mobility session at IRPWIND 2015 Conference, a more flexible programme was adopted starting from the fourth call with the following schemes

1. A mobility scheme of 2 to 4 weeks for IRP Wind and EERA Managers.
   This scheme aims at stimulating the mobility of managers in the EERA organizations to meet and discuss for laying down strategic action plans and other collaborative efforts.

2. A mobility scheme from 4 to 26 weeks for all scientists.

This scheme aims at increasing mobility buy introducing flexibility in the choice of the grant duration.

2. Introduction

Differences in National programmes and policies across Europe are still a barrier for an effective short-term mobility of established researchers; therefore, the WP5 “Mobility of researchers” was designed to contribute to reach the following objectives:

1. To ensure an efficient implementation of the CPs and in general of the research activity in EERA;
2. To facilitate the cooperation between EERA research organizations and the broad scientific community to fill gaps in the ERA in the wind energy sector;
3. To connect relevant National projects/Initiatives to the IRPWind core projects and generally to the EERA JP Wind Energy Joint Sub Programmes, keeping an eye to future emerging technologies and scientific topics; and
4. To conduct actions oriented to promote the concept of mobility of researchers as brain gain and foresight schemes to enable effective mobility.

The overall KPI for this WP relates to the overall objective i.e. stimulate mobility. The number of granted mobility period over the number of applications classified according to the different proposed mobility schemes was identified as main KPI. This indicator will enable the evaluation of each scheme and outline the best practice for enhancing mobility for know-how transfer finalized to building trust amongst partners.

3. Main activities during year 2.

During this year, tasks of the whole mobility process were jointly performed by CNR and DTU.

Activities summary:

- The web page was continuously updated during 2015, (DTU)
- Two calls were launched with deadline 31 August 2015 and 31 January 2016, (CNR-DTU)
- Two contributions to the IRPWind Newsletter were published. (DTU-CNR)
- A second video with the interview of and applicant was prepared by DTU and posted on the IRPWind Web page. http://www.irpwind.eu/Mobility (DTU)
- Participation to Management Board eetings in Brussels and to the yearly conference in Amsterdam. (CNR-DTU)
- A special session for Mobility was organised in Amsterdam (IRPWIND Conference) (DTU-CNR)
- Database on past calls and all documents, was set-up with a cloud system and and regularly updated at CNR and duplicated at the IRPWind Website at DTU (CNR-DTU)
- FAQ on website have been updated (DTU-CNR)

A first evaluation of the effectiveness of the mobility scheme has been completed. By analysing the applications and the outcome of questionnaires and reports, it emerged that the three-month scheme is the most successful while no one has chosen the six-month scheme. Questionnaires gave a satisfactory evaluation of the programme and workflow.

However, we received comments by email, by talking to prospective candidates during meetings and talking to beneficiaries of the grants. All agreed that the programme is a great opportunity but not flexible thus not responding to actual needs. Needs are most to conciliate family life with work opportunities.

At the same time, Clause 42 was approved by the Commission allowing third parties, i.e. all EERA members, to participate to the programme. Therefore, changes were introduced in the mobility schemes. The IRPWind Management Board discussed together the Commission scientific officer and approved the adoption of different schemes, starting from the 4th call for application:

1. A mobility scheme of 2 to 4 weeks for IRP Wind and EERA Managers.
   The purpose of this scheme is to stimulate the mobility of managers in the EERA organizations to meet and discuss for laying down strategic action plans and other collaborative efforts.

2. Mobility scheme of 4 to 26 weeks for all scientists.
   The purpose of this scheme is to increase flexibility in the choice of the grant duration as requested by EERA researchers during discussions during the IRPWind general assemblies.

Table 1 shows the previous adopted funding schemes number of available grants per category and financial rules. The Rules for the mobility call text, the Frequent Asked Questions (FAQs) and rules of the Mobility programme are shown in Appendix.

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
FUNDING SCHEME	39	18	16
Daily Allowance	164 EU	105 EU	105 EU
Travel expenses	Lump sum 600 Euro		

Table 1 Precedent Funding schemes

At the end of second year, considering received application the hypothetic situation could be considered as in the table 2

Grant Period	1-4 weeks 1 month	4- 26 weeks 3-6 months
Year 1	4	7
Year 2	2	9
Year 3	12	11
Year 4	12	11
Funding Scheme	30	36
Daily Allowance	161 EU	105 EU
Travel Expenses	Lump sum 600 Euro	

Table 2 New funding scheme

On 1st of February, adopting more flexibility, we decided to propose scheme in terms of weeks. New mobility scheme are 1-4 weeks and 4-27 weeks. Table 2 describes the new correspondence between new two scheme in terms of week and previous scheme in terms of months.

4. Summary of the 2nd year calls

4.1.1 Third call

DEADLINE: 31st August 2015

RECEIVED APPLICATIONS: 4, Concluded: 1, active: 2, Rejected: 1 (red in Table 3)

FIRST GRANT START: 11 January 2016,

Applicant	Title of Research	Home Institution	Host Institution	Length of Grant	Core Project
FRÖLÉN RIBEIRO	SAFE STEPS FOR OPEN ACCESS, E--SCIENCE AND E--LEARNING WINDSCANNER PLATFORM	INSTITUTO DE BRAGANÇA POLITÉCNICO DE BRAGANÇA	DTU	1	Wind Integration
ROSEMEIER	VALIDATION AND IMPROVEMENT OF COMPONENT TEST DESIGN MODELS (VALDEMOD)	FRAUNHOFER IWES NORTHWEST	DTU	3	Wind Integration
DOMÍNGUEZ-GARCÍA	ANCILLARY SERVICES PROVISION FROM WIND POWER PLANTS	IREC	UNIVERSITY OF STRATHCLYDE (UOS)	3	Offshore
RAMOS GARCÍA	RESEARCH COLLABORATION ON THE DEVELOPMENT AND VALIDATION OF TWO-DIMENSIONAL PANEL METHODS FOR STALL SIMULATIONS	DTU	CENER	1	Wind Integration

Table 3. Summary of the Applications in the third call (the reject application in red).

All application described in Table 3, the first was rejected, as Home institution is not in EERA.

4.1.2 Fourth call

DEADLINE 31st January 2016

RECEIVED APPLICATIONS: 4, plus 3 (7 total)
The call was further extended following specific requests of three applicants.

STATUS: partially closed review

Foreseen first start: 07 April

Applicant	Title of Research	Home Institution	Host Institution	Lenght of Grant	Core Project
HOLTINNEN	USE OF FORECASTING TOOLS FOR WIND POWER IN ELECTRICITY MARKETS	VTT	LNEG	7 weeks	Wind Integration
HAERTEL	VALIDATION AND IMPROVEMENT OF COMPONENT TEST DESIGN MODELS (VALDEMOD)	IWES	SINTEF	13 weeks	Wind Integration
FRERE	ANCILLARY SERVICES PROVISION FROM WIND POWER PLANTS	BERA	DTU	13 weeks	Aerodynamics
DE PRADA	RESEARCH COLLABORATION ON THE DEVELOPMENT AND VALIDATION OF TWO-DIMENSIONAL PANEL METHODS FOR STALL SIMULATIONS	IREC	DTU	12 weeks	Wind integration
LO FEUDO	RESEARCH COLLABORATION ON USE OF LIDARS IN COASTAL AREAS	CNR	DTU	4 weeks	Wind conditions
GANCARSKI	STRATEGY TOWARDS A COMMON IT INFRASTRUCTURE FOR RESEARCH IN WIND ENERGY	CENER	DTU	7 weeks	Infrastructures
VRANA	VALIDATION AND GRID CODE COMPLIANCE OF MT-HVDC CONTROL FOR WIND POWER INTEGRATION	SINTEF	IREC	13 weeks	Wind Integration

Table 4. Summary of the Applications in the Fourth call.

GRADES	VALUE
0	***Out of scope***
1	***Sufficient***
2	***Good***
3	***Excellent***

Table 5 Evaluation grading

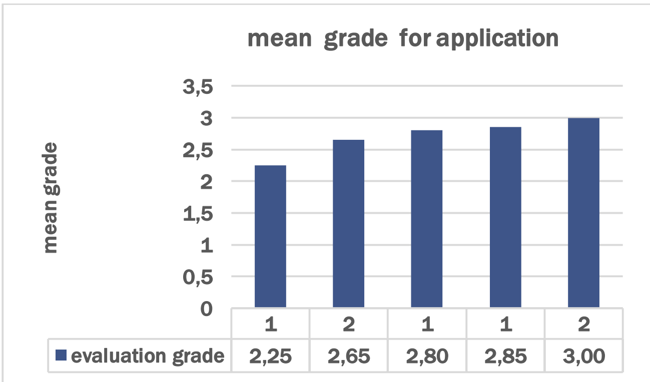

Figure 1 Mean grade for each criterion in the third and fourth call. The missing evaluations are ongoing.

Due to the low number of the applications, we also accepted three more submissions within February after the request of perspective applicants.

The evaluation process for last three applications in Table 4 is still ongoing.

4.2 Statistics

The statistics from the third and fourth call is shown in Figure 2 – 4.

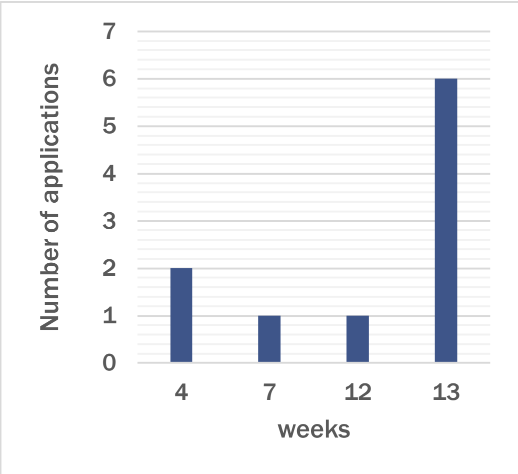

Figure 2 Preference of the length of the grant

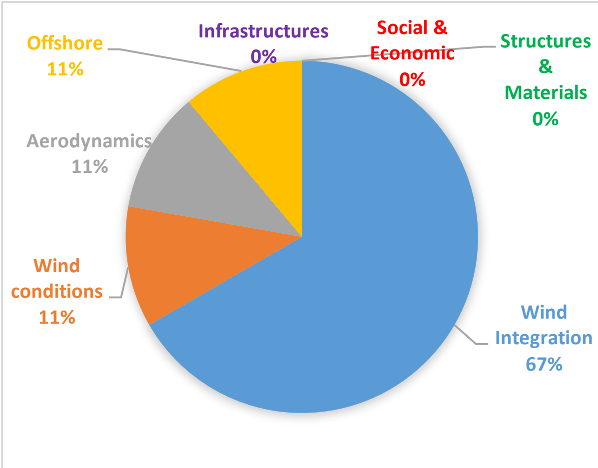

Figure 3 EERA JP Wind subprogram preference

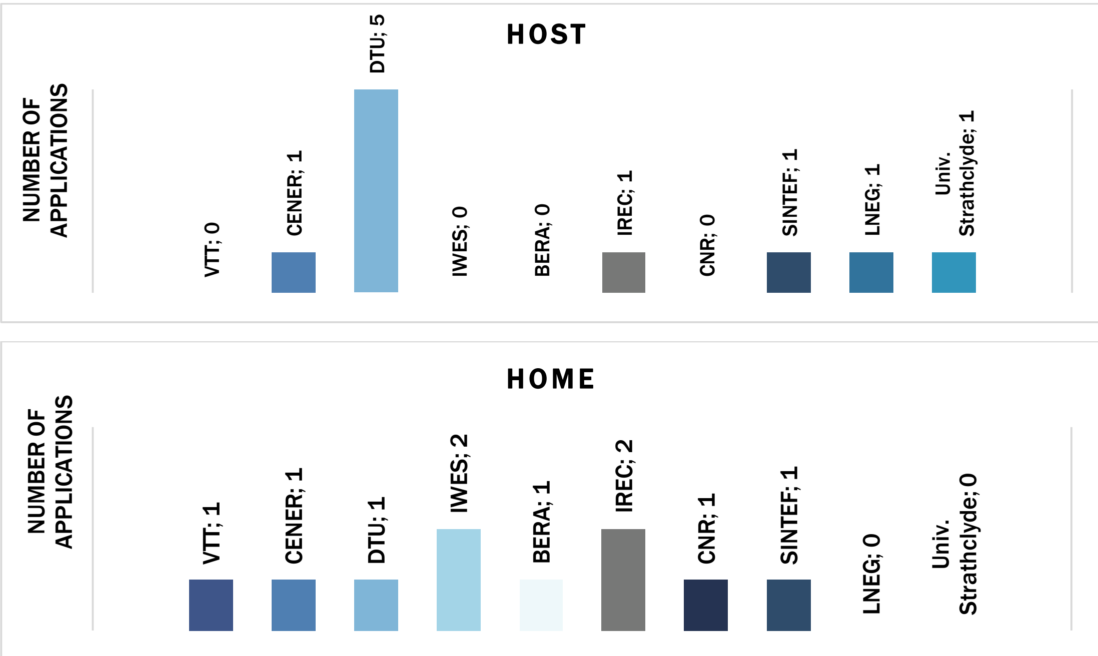

Figure 4. Role of IRPWind partner institutions that have been active in the third and fourth calls either as Home or as Host. Note that, in this figure, statistics does not include the rejected application.

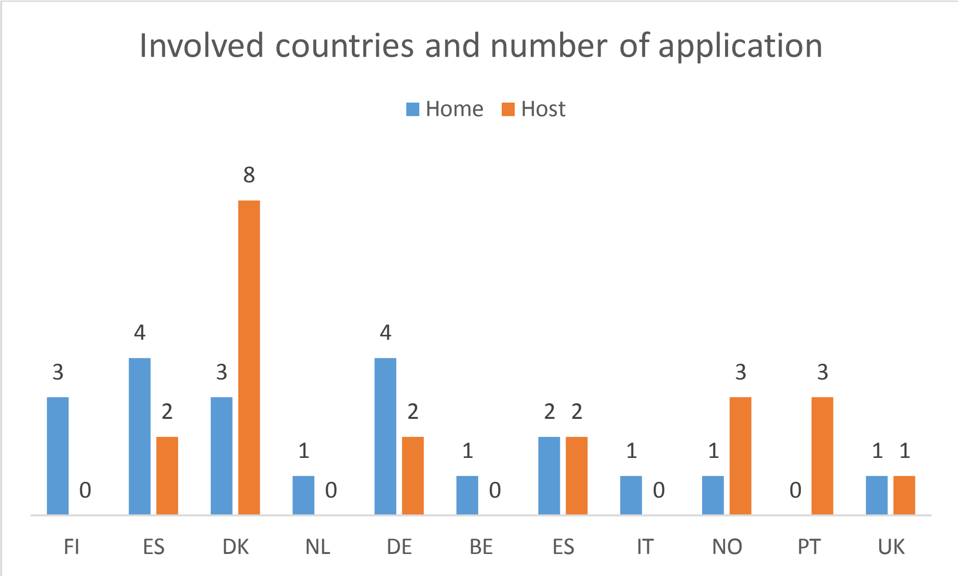

Figure 5 Countries involved as host and home

5. Conclusive remarks and future perspectives

At the end of second year, the IRPWind mobility programme is stationary but the flexibility introduced for the second call and the opening to the EERA partners has given a sensible increase of the number of applications. This support the positive effect of the flexibility.
The interaction with researchers interested on mobility application is good and there are several increasing number of questions about rules and procedures.
The questionnaires reveal still a satisfactory overall evaluation of the mobility programme and workflow.

Since the 6-month scheme has never been chosen, the Management Board decided to adopt a new more flexible programme, agreed with the IRPWind Scientific Officer:

Mobility scheme of 1 to 4 weeks for Managers, including the IRP Coordinator and sub-programme Managers, the IRP Management board members and EERA JPWind Energy Steering Committee members. This scheme is finalized to stimulate the mobility of top managers in the EERA organizations to meet and discuss for laying down strategic action plans. This will translate in an effective cooperation and partnerships.

Mobility scheme between 4 to 26 weeks for all scientists. As mentioned above, this scheme answers the request of flexibility in choosing the grant duration, solicited by EERA researchers during discussions in the first year and a half trail.

Reports appear non-homogenous due to different scheme adopted by applicants: the three-month reports are more detailed and contain proposal for joint articles with respect to the reports for the one-month grants.

It is an ongoing task to circulate the information on the IRPWind mobility programme amongst researchers in the EERA wind energy community consortium.

A new IRPWind session will be organized during 2016 in connection to the annual meeting in Amsterdam. Claudia Calidonna, CNR, and Anna Maria Sempreviva, DTU, will be in charge of the organization. This session will address the following questions:

- Which are the factors that limit the mobility or researchers?
- What is the expected added value for the home and host institutions?
- How would you define a successful mobility experience?

A LinkedIn discussion on the above issues will be launched during the third year in collaboration with EWEA and ECN, responsible of the IRPWind dissemination through the IRPWind LinkedIn account.
A more complete questionnaire will be designed to collect suggestions on the best scheme and rules for a successful mobility.

6. APPENDIX 1

CALL FOR APPLICATIONS FOR MOBILITY GRANTS WITHIN THE

Integrated Research Programme on Wind Energy (IRPWind)

A call for application is open in the frame of the Integrated Research Programme on Wind Energy (IRPWind) Mobility Programme and the European Energy Research Alliance, Joint Programme on Wind Energy (EERA JP Wind Energy)

The mobility scheme within the IRPWind) has the following objectives:

1) To ensure an **efficient implementation** of

- The Core Projects in the IRPWind;
- The research activity of other EERA Joint Sub Programmes (EERA JSP); and
- The EERA strategic action plan.

2) To **enhance the cooperation** between research organizations involved in the IRPWind and the broad scientific community of the EERA JP Wind Energy established to fill gaps in the European Research Area in the wind energy sector;
3) To **connect relevant National projects/Initiatives** to the IRP Wind Energy core projects and generally to the EERA JP Wind Energy Joint Sub Programmes, keeping an eye to future emerging technologies and scientific topics; and
4) To conduct actions oriented **to promote the concept of mobility** of researchers as brain gain and to foresight and implement best practice schemes for enabling effective mobility within the European Research Area.

1. ELEGIBILITY CRITERIA

The applicant must be an employee of an EERA JP Wind Energy member, hereafter called Home (Sending) organization, and have at least 5 years' experience as a researcher.

The mobility scheme is open for all EERA JP Wind Energy members; however either the sending or the receiving (Host) organization must be an IRPWind partner. As a general rule, the sending Organization will receive the funding of the grant from the IRPWind Coordinator.

The applications should follow a template, downloadable from the IRPWind Home page and be submitted online

2. FINANCIAL RULES

Applications are open for mobility grants of different duration: 1, 3 and 6 months according to Table 1

The grant includes travel expenses and daily allowance (see Funding Model).

Table 6 shows the initial number of available grants for each scheme compared to the actual numbers of granted applications.

Grant Period	1 month	1-3 months	6 months
Year 1	12	6	4
Year 2	9	4	0
Year 3	9	4	4
Year 4	9	4	3

Grant Period	1 month	1-3 months	6 months
Year 1	4	7	0
Year 2	2	8	0
Year 3	-	-	-
Year 4	-	-	-

Table 6 Left table: Available number of grant for each scheme at the start of the project. Right table: actual situation after year 2.

3. FUNDING MODEL FOR THE FIRST 3 CALLS

- **Grants for periods of (a) 1 month: 161 Euro/day**

Travel expenses and an advanced payment of 70% of the total grant will be issued immediately,

The remainder of the grant will be issued after the approval of the final report.

- **Grants for periods of (b) 3 months and (c) 6 months: 105 Euro/day**

Travel expenses and an advanced payment of 70% of the total grant will be issued immediately,

The sum remainder of the grant will be issued after the approval of the final report.

- **Travel expenses from/ to home Organization: lump sum of 600 Euros**

Financial scheme is summarized in Table 7

Funding scheme	1 month	3 months	6 months
Euros/day	161 Max 4991	105 Max 3150	105 Max 3150
Travel expenses from/ to home Organization: lump sum of 600 Euros			

Table 7 Daily allowance for each funding scheme

Daily allowance is granted in the following cases:

- Weekends during the grant period
- During National holydays in the host country

Daily allowance will NOT be granted in the following cases:

- Vacation hold during the grant period
- For National holydays in the home country of the recipient.

3. FUNDING MODEL FOR THE 4TH CALL DEADLINE JANUARY 2016, AFTER CLAUSE 42

1. Eligibility criteria - now open to all EERA Participant organizations

The call is open to researchers employed at all EERA participant organizations.

The application should follow a form, downloadable from the IRPWind home page and be submitted online.

2. Mobility scheme

There will be only two mobility schemes in the new call.

2.1. Mobility scheme of 2 to 4 weeks for IRP Wind and EERA Managers. The purpose of this scheme is to stimulate the mobility of managers in the EERA organizations to meet and discuss for laying down strategic action plans and other collaborative efforts.

2.2 Mobility scheme of 4 to 26 weeks for all scientists. The purpose of this scheme is to increase flexibility in the choice of the grant duration as requested by EERA researchers during discussions during the IRPWind general assemblies.

3. Funding Model

Grants for periods from 2 to 4 weeks: A sum of 161 Euro/day will be granted to successful applicants

Grants for periods between 4 and 26 weeks: An amount of 105 Euro/day will be granted to successful applicants

For both schemes the financial rules remain unchanged.

4. EVALUATION PROCEDURE OF THE APPLICATIONS

Each application will be evaluated by a panel of 2 reviewers;

The panel will assess the application and score it according to fixed criteria and a given grading scale;

The applications will be ranked and the highest scores will be granted according to the criteria identified in Table 3.

The grading score is shown in Table 4.

CRITERIA

EXCELLENCE	IMPACT	IMPLEMENTATION
Quality, innovative aspects and credibility of the research.	Enhancing research- and innovation-related human resources, skills and working conditions.	Overall coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources.
Clarity and quality of knowledge sharing among the participants in light of the research and innovation objectives.	To develop new and lasting research collaborations, to achieve transfer of knowledge between research institutions and to improve research and innovation potential at the European and global levels	Appropriateness of the management structures and procedures, including quality management and risk management
Quality of the interaction between the participating organizations	Effectiveness of the proposed measures for communication and results dissemination	Competences, experience and complementarity of the participating organizations and institutional commitment
Weight: 50%, 1st priority at ex equo	Weight: 30%, 2nd priority at ex equo	Weight: 20%, 3rd priority at ex equo
Grade 0-3	**Grade 0-3**	**Grade 0-3**

TABLE 3. Evaluation criteria

GRADES	VALUE
0	Out of scope
1	Sufficient
2	Good
3	Excellent

Table 4. Grading score for each proposal.

5. TIME SCHEDULE OF THE EVALUATION PROCEDURE

- Application deadline: four weeks after the call;
- Results of the evaluation: within two weeks from the application deadline;
- Start of the grant: within two months from the approval.

6. APPLICATION TEMPLATE (MAX 3 Pages)

The application template must be downloaded from www.irpwind.eu\ Mobility and submitted online.

7. Updated FAQs

Who is going to apply, the researcher (natural persons) or the organizations?

The researcher should apply in agreement with the home and host organization. The application should also contain a letter of intent between host and home organization.

What will the grant cover?

Funding will cover:

- A lump sum for travel expenses and
- A daily allowance depending on the duration of the period.

The longer the period, the smaller is the daily allowance because a long-term accommodation would cost less than a short-term one.

Who will be reimbursed? The researcher (natural persons) or the research organisations?

The IRPWIND Coordinator has allocated the funding for the mobility work package and will forward funding to the sending organization against invoice before the start of the grant.

Funding will be transferred to the sending organization for practical reasons e.g. to optimize funding avoiding monetary lost by international fund transfer fees;

In case the sending organization is not an IRPWIND participant, the coordinator will transfer funding to the host organization, against invoice, before the start of the grant.

How will the funding for the grant be paid?

The sending Organization will issue the payment to the grant recipient according to the following procedure: travel expenses and 70 % of the total amount will be paid immediately. The balance will be paid at the end of the grant period after the approval of the reports.

The sending organizations will issue a declaration of conformity that the refunded sum conforms to the financial rules.

What if the home (sending) Organization is not a participant in IRPWIND?

In case the sending organization is not an IRPWIND participant, the grant recipient will receive funding from the host organization. In this case, host organization will issue a declaration of conformity that the refunded sum conforms to the financial rules

Will the visits be only to research organizations inside the consortium or outside as well?

At least one of the partners should be an IRPWind partner.
All organizations members of the EERA JP Wind Energy can enter the funding scheme. This will likely (i) increase the cohesion in the EERA JP Wind Energy group including associated partners and (ii) give the possibility to integrate new innovative ideas that might come from the "outsiders".

Is the mobility scheme aimed to educational purpose?

The mobility scheme is not for educational purposes but for strengthening the research in Europe. To be eligible, a scientist must be employed by one on the EERA Wind Energy Participants and have at least 5 years' experience as a researcher.

Can all EERA JP Wind Energy participants apply for a mobility grant?

The mobility schemes are open for all EERA Wind Members; however, either the sending or the receiving organization must be an IRPWind partner (for administrative reasons). As a general rule, the sending Organization will receive the funding of the grant from the IRPWind Coordinator.

If the sending Organization is not an IRPWind partner, funding will be forwarded to the host organization.

Can the grant period be split in shorter periods?

The grant periods must be carried out continuously and the reports should be presented within 2 months from the end of the grant.

8. Appendix: Final mobility reports and their evaluation

In this section are collected final reports and their evaluations together with applications (in evaluation) received during second year.

Outline of the application template:

Introduction

- Research topics, originality;
- Technological Readiness Level (TRL) of the proposed concept;
- Definition of Key Performance Indicators (KPIs); and
- Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP).

Description of national projects aligned to the proposed activities in both the sending and the receiving institution, including milestones, funding services, research activity (demonstration, applied research, basic research etc.) Please consider that at least one of the partners should have a national project relevant to the proposal

- Description of national project from receiving institution (please erase if not actual);
- Description of national project from sending institution (please erase if not actual); and
- Foreseen European added value of national alignment.

Work Plan

- Deliverables, milestones etc.

Benefits to EERA objective advancement

- Contribution to the advancement of the EERA strategy goals, gaps addressed,

Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

- Explain ToK or dissemination strategies and plan of future collaboration with other IRP/EERA partners

Expected results

- Methodologies and/or databases and/or best practices functional to the activities of the IRP and EERA strategic agenda objectives.
- Assessment of the advancement of the TRL
- Assessment of the KPIs

Application must be supplemented by

- A Curriculum Vitae
- A letter of interest from the host organization.

PROCEDURE AFTER THE COMPLETION OF THE GRANT

- A final report will be due within one month of the completion of the grant. The report must be filled and submitted online;
- A questionnaire about the evaluation of the schemes must be filled online by the recipient, the host and the sending institution referents;
- The final report will be reviewed by the panel that evaluated the proposal (The coordinator of the most relevant sub-programme and two chosen from the pool of reviewers);
- The evaluation of the panel approval will be within 2 weeks of receiving the report; and
- The sum remainder of the grant will be issued after the approval of the final report and the submission of the questionnaire.

FINAL REPORT TEMPLATE (MAX 3 Pages)
The Final Report must be filled online at www.irpwind.eu\Mobility and submitted online.

OUTLINE OF THE FINAL REPORT TEMPLATE:

- Description of the work and major results;
- Compliance to the expected results, Key Performance Indicators KPIs and the advancement of Technological Readiness Level according to the application;
- Description of the benefit for host, home and IRP programme; and

Future perspectives. (Future research, availability of databases to other parties, expected publications, and dissemination a

Final reports evaluations and applications

Supported by:

Final report for the IRPWind mobility program

Nikola Vasiljević, DTU Wind Energy

September 23, 2015

1 Introduction

The IRPWind mobility program, second call, with the deadline February 28, 2015, provided an opportunity to setup, execute and monitor the Perdigão experiment. Also the program provided means to perform related tasks such as the organization of a relevant seminar and meeting, the dissemination of knowledge and building the foundations of the future WindScanner infrastructure. The program started on the 3rd of May and ended on the 27th of June. It was hosted by Laboratório Nacional de Energia e Geologia (LNEG) in Portugal.

The Perdigão experiment was a large flow field experiment done with two multi-lidar systems in the heavy complex and forested terrain of Serra do Perdigão in Portugal during the months of May and June 2015 (Figure 1). It was a collaborative action among several European partners, namely Technical University of Denmark – Department for Wind Energy (DTU Wind Energy), Faculdade de Engenharia da Universidade do Porto (UPORTO), LNEG, Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial (INEGI) and Instituto Politécnico de Bragança (IPB).

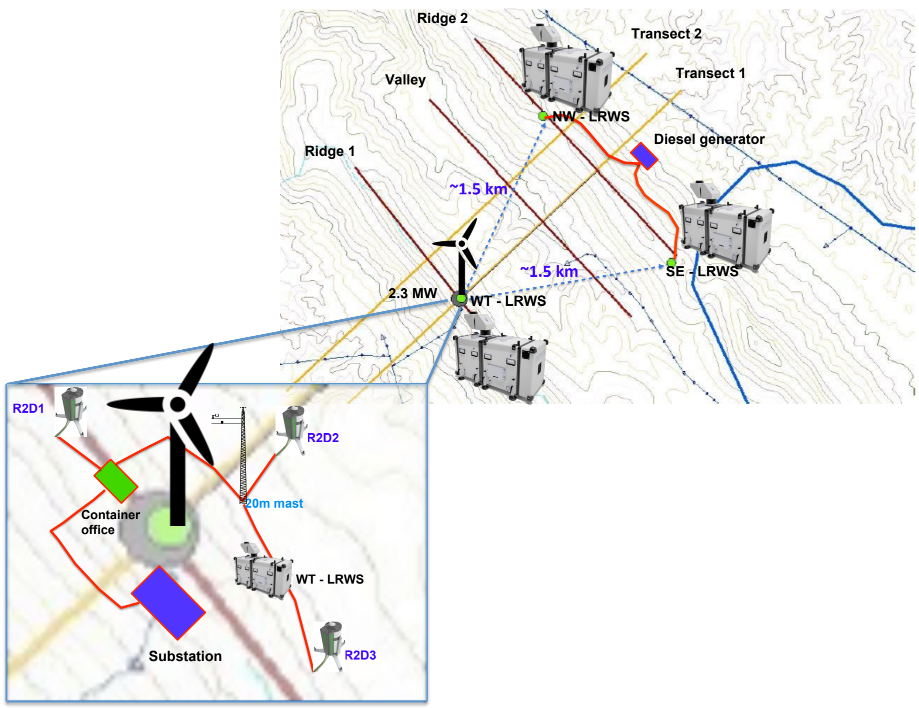

Figure 1: Experimental setup

During the experiment, "Dia Global do Vento" seminar and WindScanner.EU meeting took place where the Perdigao experiment, WindScanner technology and future WindScanner infrastructure were introduced to the broader audience.

Fundamentals of the WindScanner infrastructure and accompanying action plan were lay down during the last two weeks of the mobility program.

2 Description of the work

In the proposed outline of the work it has been indicated that the work will be divided to the task subsets that fall under the educational, scientific, technological and technical tracks. The work that has been done related to these tracks will be described in the following subsections.

2.1 Educational track

During the installation of the equipment I was instructing partners how to install and configure the WindScanners. In later stages of the experiment I taught the partners how to monitor WindScanner's measurement process, and how to analyze the data.

Apart from the knowledge dissemination specifically related to the installation and operation of the WindScanners I also gave lectures regarding the first results from the Perdigao experiment, background of the WindScanner technology and future WindScanner infrastructure at two events. These events were the seminar "Dia Global do Vento" in Vila Velha de Ródão on the 15th of June and WindScanner.EU meeting in Proença-a-Nova on the 16th and 17th of June. Beside participating as the lecturer I was also involved in the events orgranization.

2.2 Technical track

It was envisage that I will conduct the installation of the long-range WindScanner system and monitor and report the entire experiment. All of these tasks were accomplished. Due to the limited resources for the experiment, during the 80% of the entire period I was a single person at the experimental site taking care of all the equipment, which beside the three long-range WindScanners included three short-range WindScanners, meteorological mast, network and power infrastructure.

2.3 Scientific track

I performed coupling of the long-range and short-range WindScanner measurements by optimizing one set of scanning trajectories for the wake and inflow measurements of the long-range WindScanner system. Beside this scanning strategy two additional sets of the scanning trajectories are developed that address the wind resource along the ridge, where the wind turbine is installed, and recirculation zone and hill wake. Due to the extensive work on the technical track and delayed activities in the setup of the flow models the tasks related to the model validation are going to be addressed in the last quarter of this year.

2.4 Technological track

As mentioned above three new scanning trajectories are developed for the long-range WindScanner system, and implemented during the experiment. A new network architecture for communication between the master computer and WindScanners has been developed and implemented during the experiment.

3 Major results

The experiment was the first real-life test of the two multi-lidar instrumentation, namely long-range and short-range WindScanner systems, in the rough environment of the heavy complex and forested terrain of Serra do Perdigão in Portugal. Since both systems successfully passed the deployment and operation in this environment, we can argue that the WindScanner technology achieved the operational readiness suitable to be the backbone for the future measurement campaigns particularly related to New European Wind Atlas (NEWA).

Also, the Perdigão experiment was the first time we have operated simultaneously both WindScanner systems, and thus, by the knowledge of the author of this text, up to this date the experiment has been the most technologically advanced measurement campaign related to the wind energy research. Furthermore, due to the configuration and simultaneous operation of the WindScanner systems we have achieved an anticipated milestone that is the realization of the hybrid WindScanner system.

Using the dedicated blog `http://windscanner.tumblr.com` the experiment status was reported typically on a daily basis (Figure 2). This approach brought an extensive visibility of the Perdigão experiment in the wind energy community. Moreover, the blog served as the on-line log book of the experiment, where also some preliminary results were published.

The preliminary data analysis indicates acquisition of about 600 hours of high quality measurements in great many points of interest that will be further used for in depth analysis and model validation. We managed to capture the inflow and wake of the wind turbine (Figure 3), wind resources along 2 km long transect along the ridge (Figure 4), and recirculation zone in the valley between two ridges (Figure 5). The first database of measurements has been made and it is hosted at DTU Wind Energy. I made a layout of the catalogue of measurements, which will help future users of database to select the most interesting time series for further studies.

At the end of my stay I presented my vision of the WindScanner infrastructure (Figure 6) that has been accepted by the WindScanner.EU partners.

4 Compliance to the expected results

In the application the following Key Performance Indicators (KPIs) have been formulated:

- Development of the measurements database

Figure 2: Perdigão blog, `http://windscanner.tumblr.com`

- Development of the WindScanner e-Science and user platforms
- Reporting the experiment and scientific publications
- Addressing the question "How to compare the flow measurements with the numerical flow models prediction?"

During the stay the initial database of measurements has been made, which was the most important KPI defined in the mobility application. A public database, which will comprise a subset of the initial database, is planned to be available by March 2016.

The KPI related to the development of the WindScanner e-Science and user platforms has been addressed by developing the concept of the platforms which has been accepted by the WindScanner.EU partners. Moreover, the developed concept of the platforms is now central part of the WindScanner.EU business plan. The concept was partially demonstrated through the aforementioned blog.

Regarding the KPI related to scientific publishing and reporting the experiment, three papers have been planned and arranged, while a few additional papers expected to come. At the moment the report on the experiment is in a draft version.

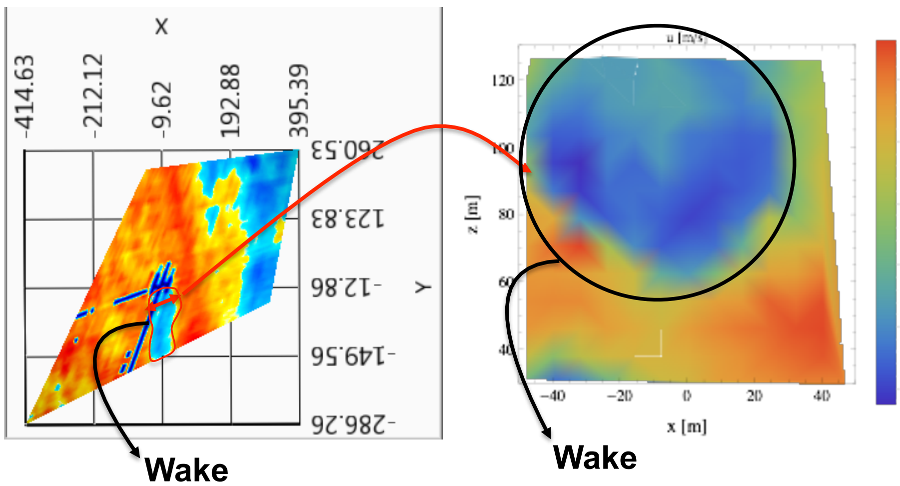

Figure 3: Left plot - the wind field around the wind turbine in horizontal plane captured by the long-range WindScanner system, Right plot - the vertical crossection of the wake captured by the short-range WindScanner system

The KPI related to formulating the answer how to compare the flow measurements with the numerical flow models predictions has not been met since the work regarding the maintenance and building of the entire infrastructure for the experiment was taking substantial amount of time (for more clarifications consider the blog).

In the mobility application it has been proposed that a hybrid WindScanner system will be achieved by combining and coupling the long- and short- range WindScanner systems. The Perdigão experiment allowed the assessment of the Technological Readiness Level (TRL) of this proposal. During the lifetime of the experiment the two WindScanner systems were configured to simultaneously and in a coordinated fashion acquire the same wind fields. We successfully observed both the mean wind regimes (long-range WindScanner) and associated turbulence fields (short-range WindScanner). Up to this date the existing literature does not report about the operation of two different multi-lidar instruments at the same time, neither there are indications that somebody simultaneously monitored the mean and turbulence wind fields with multi-lidar instruments. This lead us to the conclusion that during the mobility stay a fairly high TRL has been achieved.

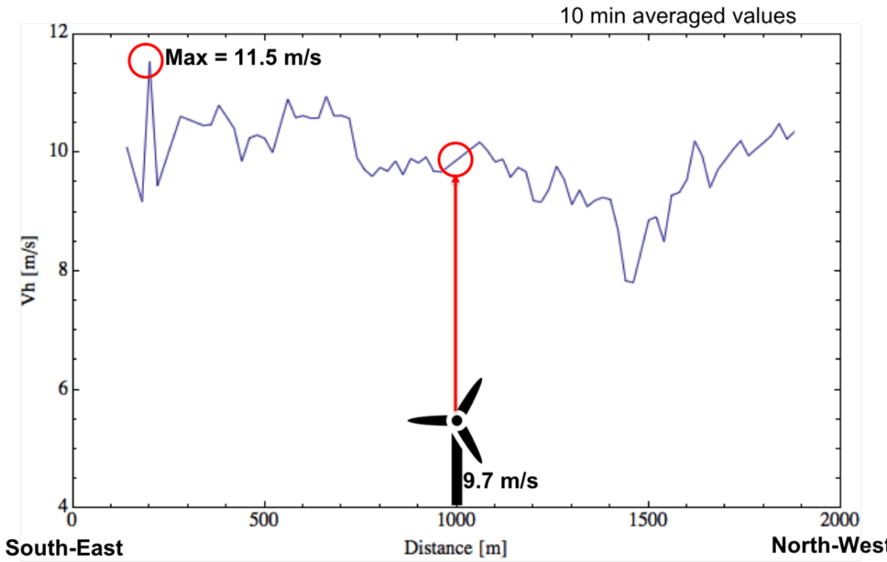

Figure 4: Mean wind speed along the ridge

5 Benefit for the researcher, host and home organization and IRP programme

The mobility program provided me an opportunity to stay over the lifetime of the experiment. It is important to mention that I acquired an exceptional know-how in performing large field experiments. Related to the benefit of IRP program, my stay in Portugal allowed me to collaborate with people from the local universities, research laboratories and institutes. I have extensively enlarged my network of acquaintances and exchange ideas for future collaborations and projects in which DTU Wind Energy, LNEG and other Portuguese parties will be involved. LNEG had a chance to acquire knowledge about the WindScanner technology and how to run the large field experiments with multi-lidar instrumentation. DTU Wind Energy benefited from the mobility program since the mobility funding provided means to have one of DTU's employees located at the experiment site during the entire measurement campaign.

6 Future perspectives

The future work will be focused on building the proposed WindScanner infrastructure and continuation of the development and application of here presented measurement technique with the hybrid WindScanner system.

The entire database of measurements will be accessible to the three projects

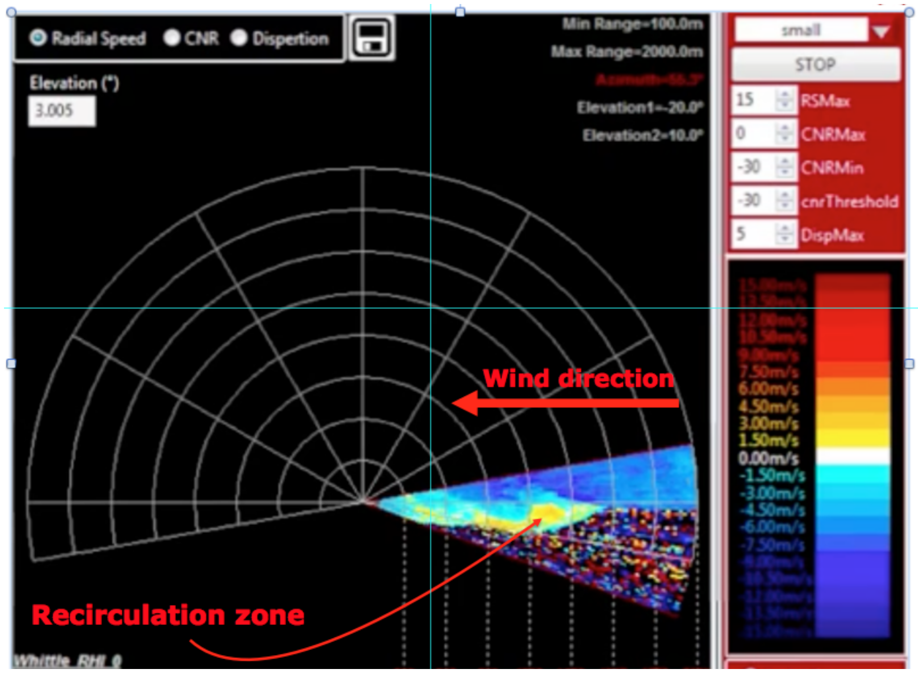

Figure 5: Flow field in the vertical plane perpendicular to the two ridges

that funded the experiment. As mentioned earlier a subset of this database will be public.

Currently we have an agreement on publishing three papers. One will address the entire experiment, explaining the measurement techniques and showing the highlights of the campaign. This paper will be submitted to the Atmospheric Measurement Techniques (AMT) journal during January 2016. Two other papers are related to the models validation of which one will address the validation of the results from the coupling of the forecast model with CFD, and second the validation of the results from the coupling of the re-analysis data with CFD. These two paper are intended to be submitted to the Boundary Layer Meteorology (BLM) journal by the mid of March 2016. We do expect at least two additional papers which will address topics of the inflow conditions in complex terrain of the wind turbine and the according wake.

A workshop related to the Perdigao experiment is planned to take place in March 2016 which will focus on lessons learned from the experiment, available measurements for model validation, and planning of the 2017th edition of the Perdigão experiment.

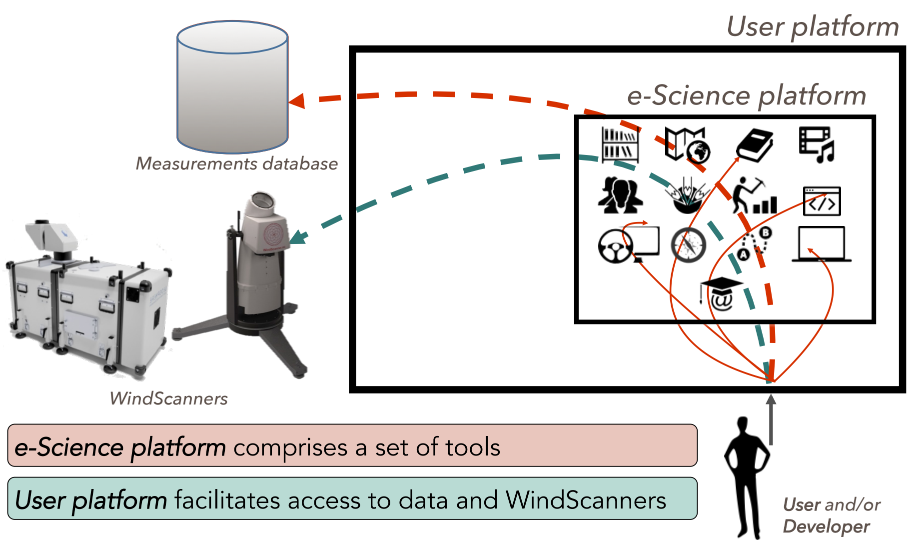

Figure 6: Vision of the WindScanner infrastructure

Mobility Call N°: **Mobility scheme:** **Granter Name/Hosting Institution:**	II III months **Vasiljevic/DTU**

Evaluation of the final report [1]

Were the goals described in the proposal reached? Please comments if NO	X yes ☐ No
Does the report include major results? i.e. **highlights and new insight** and advancement of the state of the art? The results are interesting showing new results in Windscanner experiment	☐ yes X No
Was the used methodology effective? Please comments if NO	X yes ☐ No
Are future perspectives clear? (Future research, availability of databases to other parties, expected publications and dissemination activities). Please comments if NO	X yes ☐ No
Has the work been a benefit for the researcher, the host and home organization and IRP programme? Please comments if NO	X yes ☐ No
How do you evaluate the report?	**4**
Is any missing information in the report? Please comments if yes	☐ yes X No
Rate the overall experience as described in the final report.	**4**

Other Suggestions?
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………
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………

[1] 1 (negative) - 2(Poor) - 3 (Sufficient) - 4 (Good) -5 (Excellent)

APPLICANT **XABIER MUNDUATE**

HOME INSTITUTION **CENER**

IRPWIND FINAL REPORT

1. Description of the work and major results

Description

The work presented at this document has been developed in the context of a collaborative project between CENER and DTU Wind through the IRPwind mobility programme grant for a 3 months stay of Xabier Munduate (CENER) at DTU Wind Energy. The applicant is Head of Section Aerodynamics and Aeroelasticity at the Department of Wind Energy, in Cener, Spain, and has since 1995 been working with different aspects of wind rotor aerodynamics, both theoretical and experimental. The stay at DTU Wind has taken place in the period from 11th June to 11th October, 2015, 3 months, as July is vacaccional time at the Technical University of Denmark.

In this context, the main activity during the first month has been the revision of the so called tip loss within the BEM, Blade Element Momentum, theory, which forms the backbone in most of the aerodynamic codes for the design of wind turbine rotors. In particular, the focus of the work, during the second month, has been the development of a new method to calculate the tip loss that may show to be important in new designs of wind turbines, leading to better and more real design of rotors. The study of the tip loss impact during the last month through the circulation (the tangential induction) , has been carry out all along the span of the blade, from root to tip, and the effect the finite number of blades has been tackle and take into account. This has been accomplished with a simple vortex model, that follows the Joukowsky concept of rotor with rectilinear filaments of circulation at the tip and the root of each blade.

Results

The tip loss in the tangential induction just behind the rotor, that appears for a finite number of blades on a 1 blade rotor, 2 blades rotor and a 3 blades rotor, has been obtained. In addition, following the same technique the result of the tangential induction for the case of an infinite number of blades has been obtained. The main result is the appearance of the non axisymmetry of the flow, azimuthal variation of the tangential induction over a rotation from root to the tip for the finite number of blades rotor. A second important result is the axisymmetry of the flow, no variation in azimuth of the induction, for the infinite number of blades case. Comparing the first results to the infinite number of blades case the difference on the azimuthal values of the tangential induction for a finite number of blades rotor compare to the solution for infinite number of blades can be detected.

Here, there is a difference between the infinite number of blades concept and the one from BEM theory. In the former, infinite number of blades means that there are discretely put a high enough number of discrete blades (100) that the effect of getting a constant value of the induction for the whole 360 deg azimuth is really calculated over the 360 degrees, since steams from the same method and theory that the 1 bladed result where the induction varies over the azimuthal rotation of the blade. This is not the case in the later, BEM theory, where only one mean value is calculated and them copy out over the 360 deg azimuth.

Result 1: Azimuthal variation of the tangential induction over a rotation from root to the tip for a finite number of blades rotor.

All the cases computed are for rotor radius R=1 (m) and circulation Γ=1 (m^2/s).

The first and main result is the appearance of the azimuthal variation of the tangential induction just after the rotor, over a rotation from root to the tip for the finite number of blades rotor. Instead of having a unique and constant value for the induced velocity over the azimuth positions of the blade as it turns 360 degrees as it is obtained if the BEM technique, or general momentum theory are applied, here the induced velocity changes its values over a rotation. This can be seen on Figure 1 where for 1 Blade rotor, the induced velocity over the azimuthal rotation is showed for 9 blade span locations ranging from r/R=0.10 near the root at the botton of the figure, to r/R=0.90 near the tip at the top of the figure.

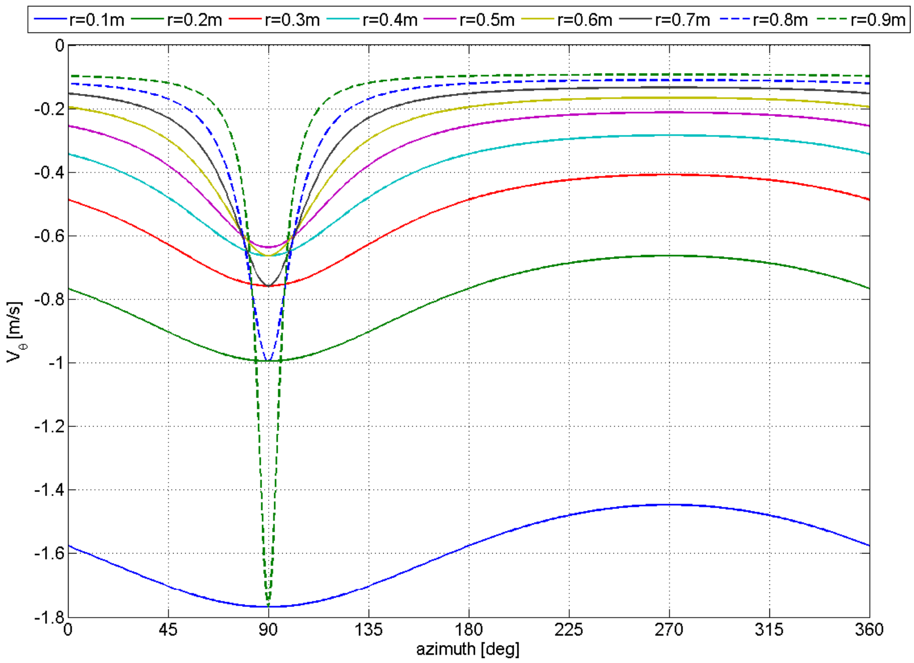

Figure 1. The tangential induced velocity over the azimuth for 9 blade span locations. 1 Blade rotor.

The 0 deg azitmuth is the 12 o'clock of the rotor and 90 deg is 3 o'clock, looking from the upwind, for a blade that rotates clockwise. In this case where the rotor has 1 blade, the results are when the blade is at Azimuth=90 degrees. The interesting result here is that we have obtained how the circulation or the tangential induction changes in azimuth, with a maximum effect on the change of the induction when we are just on the blade location at 90 degrees. The variation of the induction can be seen all around the rotor disc, and affects strongly the tip of the blade but its effects can be see reaching the root sections as well. For example at the r/R=0.10 there is still a variation of about 10% of the value of the induction. At the the r/R=0.90 the effect is very important.

Figure 2 illustrates the2 Blades rotor, the induced velocity over the azimuthal rotation is showed for the same 9 blade span locations from near the root at the bottom of the figure, to near the tip at the top of the figure. The result is obtained with the 2 blades at the 90 and 180 degrees position. Now the variation of the velocity has become smoother and the high peaks are also reduced. Still the effect of the finite number of blades (tip loss) is important, about 20%, up to r/R=30, at the inner part of the rotor.

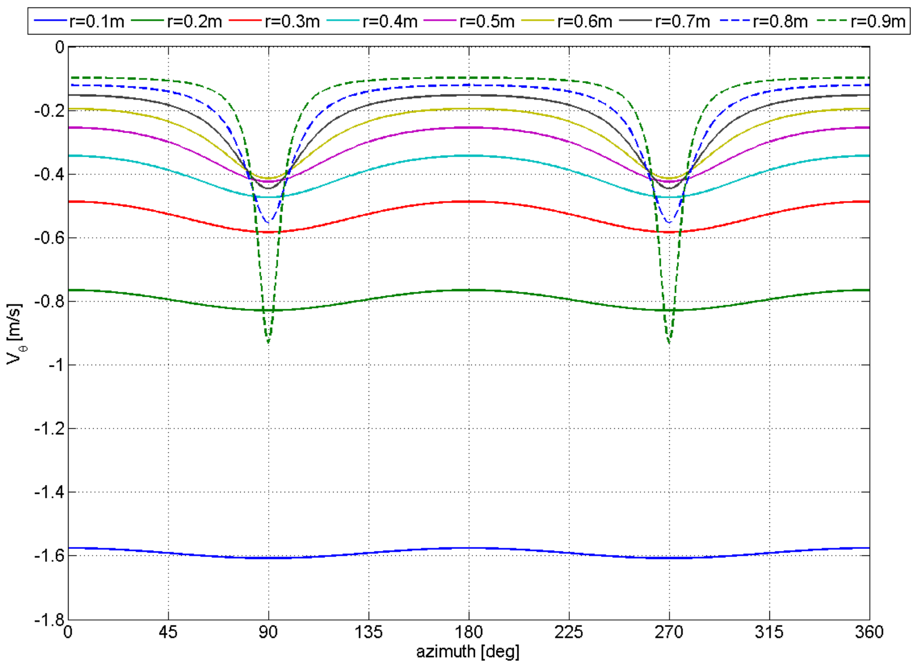

Figure 2. The tangential induced velocity over the azimuth for 9 blade span locations. 2 Blade rotor.

In Figure 3 for the 4 Blade rotor, with blades at 0-90-180 and 270 degrees, the induced velocity over the azimuthal rotation is showed. Now the variation of the velocity has become smooth up to r/R=50, the middle part of the rotor.

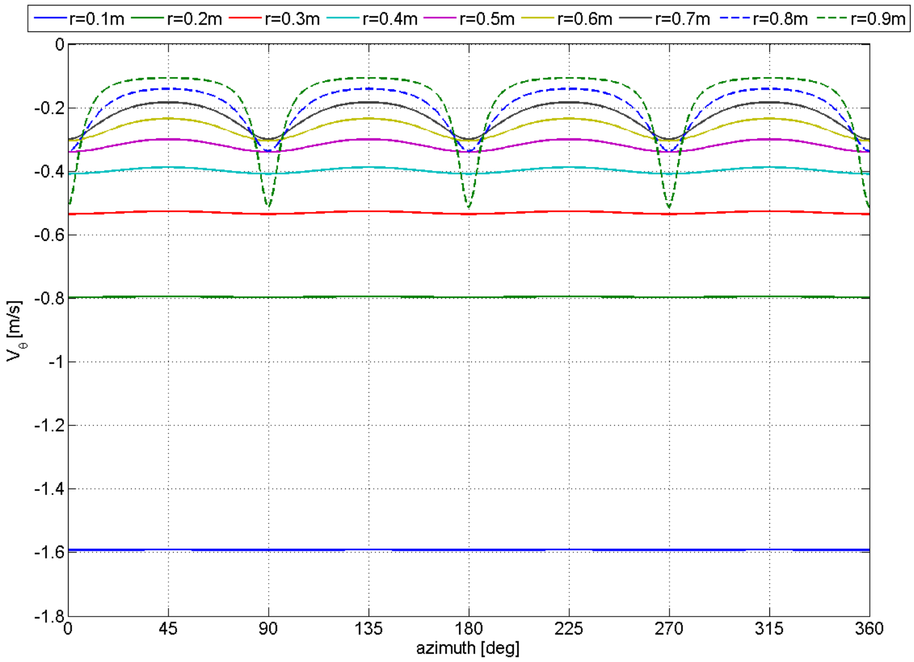

Figure 3. The tangential induced velocity over the azimuth for 9 blade span locations. 4 Blade rotor.

Result 2: A second important result is the no variation in azimuth of the induction for the infinite number of blades case

As in the previous cases, the same method has been applied now for 100 blades, emulating the infinite blades. It appears that this result has already reached the convergence of the velocity since the inducted velocity plotted in Figure 4 obtain constant values of the velocity all around the azimuth and for all the blade span locations, even at the most inner ones.

What has relevance here is that an averaged value at each section of the blade has been obtained, demonstrating that for a infinite number of blades the induce velocity is constant all over the azimuthal positions. We can see the axisymmetry or the rotational symmetry of the flow.

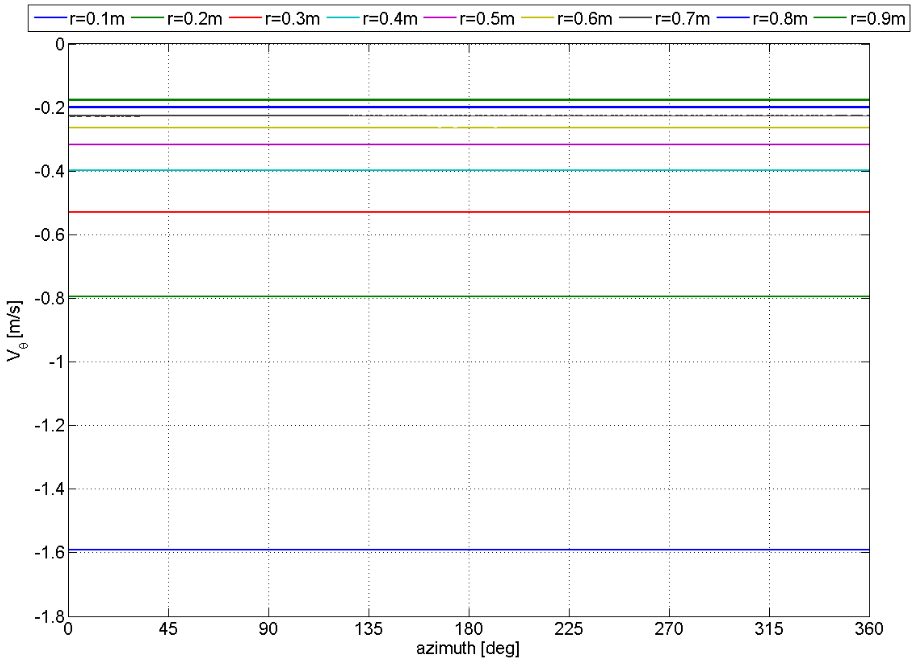

Figure 4. The tangential induced velocity over the azimuth for 9 blade span locations. Infinite Blade rotor (100 blades).

Conclusion

Further work could be done in order to achieve a more in depth understanding, but at this point, the tip loss effect (number of blades effect, more strictly talking) has been showed and the non axisymmetry of the tangential velocity induction has been obtained.

2. Compliance to the expected results, key performance indicators KPIs and the advancement of technological readiness level according to the application

The obtained results have been:

- Research lines and Collaborative projects have been set up.

- Development of a model for tip blade correction. A model to calculate tip loss (finite and infinite number of blades) has been accomplished.

- Preparation for a paper on the new tip correction. Accomplished. With these results we are now prepare to start writing a paper on a journal/conference with some further work.

The Tip correction model has moved from conceptual stage defined as (TRL 2), to a more analytical stage (TRL 3). The advancement of TRL from 2 to 3 has been accomplished since a code has been built and results of the tipoi loss has been already presented. Furthermore, will be proved by the presentation of the work through the European project AVATAR and through the publication of the work on a Journal. Key Performance Index for the project is that the above-mentioned paper and the presentation will be published in 2016.

3. Description of the benefit for the researcher, the host and home organization and IRP programme

The programme has enhance the cooperation between CENER and DTU Wind Energy. The results of the project will lead to improve the development of wind energy technologies, and respond to current wind turbine sector's needs. It will feel the gap of the cooperation and transfer of knowledge in theoretical research among Research Centers in a European context. It will promote future synergies with other European Research Centers willing to share knowledge.

4. Future perspectives (future research, availability of databases to other parties, expected publications and dissemination activities).

There are some further tasks that that would be very interesting to continue

- To validate with CFD or experimental data

The dissemination of the project developed will be done by:

- Presentation of the results on the Work Package Meeting of the AVATAR project, 2016
- Publication of the work report on the IRPWIND bi-annual newsletter, on 2016.
- Writing of a conference or journal paper, 2016.

Mobility Call N°: **Mobility scheme:** **Granter Name/Hosting Institution:**	IRPWIND **DTU**

Evaluation of the final report [1]

Were the goals described in the proposal reached? Please comments if NO	X yes
Does the report include major results? i.e. **highlights and new insight** and advancement of the state of the art? Please comments if NO: Result of the new tip loss model in terms of tangential induced velocity components with the new model are presented, but what difference this makes to blade design is not presented, nor is a comparison with existing methods made. So the benefit of the research cannot be ascertained from the report.	X No
Was the used methodology effective ? Please comments if NO	X yes
Are future perspectives clear? (Future research, availability of databases to other parties, expected publications and dissemination activities). Please comments if NO	X yes
Has the work been a benefit for the researcher, the host and home organization and IRP programme? Please comments if NO	X yes
How do you evaluate the report?	3
Is any missing information in the report? Please comments if yes – A comparison of the results with those obtained using existing methods and inferred impact on blade design	X yes
Rate the overall experience as described in the final report.	3

[1] 1 (negative) - 2(Poor) - 3 (Sufficient) - 4 (Good) -5 (Excellent)

Other Suggestions?
A few spelling corrections and English language correction should be made.
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Funded by EU

Application form for Mobility grants within IRPWIND

A) Applicant details

Applicant Name	Hannele
Applicant Surname	Holttinen
Home Institution	VTT
IRP Partner? (yes/no)	yes
Home Institution Postal address	P.O.Box 1000; 02044 VTT; Finland
E-mail	hannele.holttinen@vtt.fi

B) Host institution details

Institute name	IREC
IRP PARTNER?	yes
Contact person	Jose Luis Dominguez
Country	Spain
E-mail	jldominguez@irec.cat

C) Relevant Programme and scheme

CORE PROJECT? YES/NO *(Please erase the non-relevant)*	(B) Wind Integration	RELEVANT EERA SUB-PROGRAMME Max 2 (Please erase the non-relevant)	(B) Wind Integration
Length of the grant scheme *(Please erase the non-relevant length)*	(03) 3 months	Start date:	1st September, 2015

D. Project description and outcomes

Wind Power Plant Control for Ancillary Services

Integrating wind power to European power systems and electricity markets involves changes in how wind power plants contribute to managing the system balancing and system security. Control and market mechanisms for wind power plant Ancillary Services is one core element of future changes.This mobility aimed at a fruitful collaboration of a senior researcher from VTT visiting a group actively involved in IRPwind WP8 opening new possibilities through cross-feeding ideas and the identification of synergies between VTT and IREC long-term objectives aligned with IRPWind main goals. This will contribute to Task 8.1.2 Control Strategies for Integrating and Operating Future International Clusters of Wind Farms and have a link to Task 8.3.1 Market design for high wind power penetration.

1. Work during mobility period at IREC

As anticipated, Hannele Holttinen had the opportunity to widen her knowledge on control strategies of wind turbines as well as smart/microgrids and PV storage systems. On top of that the work at IREC relating to eV storage second life, and the cost optimising software for offshore wind and PV proved to be interesting. There were fruitful discussions on the Nordic project OffshoreDC and IREC's work on offshore wind power plant grid connection research, as well as between IEA Wind activities on offshore wind power costs and EU H2020 LIFES50+. She contributed to IREC widening know how on market mechanisms and higher level integration issues – this was concretely organised as a joint supervision of Hannele Holttinen from VTT and Jose Luis Dominguez and Cristina Corchero from IREC for a student work (Anzelika Ivanova) on ancillary services markets in Europe. An abstract of this work was accepted to EEM2016 conference, the paper deadline is mid February.

Meetings with other Spanish actors were organised to TSO REE, Iberdrola and wind turbine manufacturer Gamesa. These were both as general interviews/interaction regarding future changes in energy systems and more concretely to discuss and disseminate the mobility task. In addition there was a possibility to visit SmartCity Expo Barcelona.

IREC and VTT were not successful in the spring 2015 LCE6 proposal AnSer2RES as EERA consortium, but future collaborative projects are actively searched for. Currently, different joint proposals are being prepared such as LCE7 and ERANET-LAC. Opportunities for KIC Innovation projects were explored, too, resulting hopefully in a common proposal later.

2. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

Dissemination and communication were made through a couple of workshops in Barcelona (one internally in IREC and other open to students and anyone interested in UPC) as well as through joint publications (a conference and a journal paper). The publications will be part of IRP and EERA Wind articles.

The general findings of changes in future business models and market mechanisms for energy sector reported to the Finnish national projects Neocarbon and FLEXe will be disseminated also to IRPWIND and EERA JP WIND subprogramme Grid integration. The 3 month visits planned for Portugal, Spain and Ireland will give an opportunity to link new knowledge to several countries.

A presentation of the total 3 mobility periods will be given at the Irp.Wind workshop on business models for ancillary service provision in Helsinki (or Trondheim) summer 2016 as agreed with Kurt Rohrig.

3. Results

At the end of the mobility period, we have organised a public workshop in the UPC, we have pursued new ideas for joint project proposal between VTT and IREC and are in the process of writing joint publications (one for the conference EEM 2016 and another for a journal).

The interviews of Spanish actors (system operator Red Electrica REE; large power producer Iberdrola and wind power manufacturer Gamesa) have been made with following main observations:

- Consumer mistrust for larger energy companies partly stems from tariffs, regulations and taxes. The uninterrupted electricity supply is not valued as high as what is its value – for example cell phones have higher tariffs. Cost of interruption and energy not served is high and it will be more expensive to reach same reliability with PV and storages and leaving the grid. Large companies are also needed for making large investments to renewables and that is not appreciated.
- There is a strong need for capacity payments seen in the power producer sector
- Ancillary services markets/Cross-Border balancing services: a pilot phase between Spain, Portugal and France has started, but so far this pilot is sharing extra reserves, not sharing the actual balancing task – however this already shows cost benefits even if it is still way to go to reach the same level of collaboration than in Nordic countries
- Ancillary services markets/wind participation: Information communication system (CERCE) for aggregating information from small scale power producers and communicating with system operator has proved useful could in future be used for ancillary services trading as well. Tertiary reserve is seen as the first easier service from wind power to bid, but secondary could be tried out as well. The TSO has already used the information from the system for some DSO collaboration in congestion management.

General findings of changes in future business models and market mechanisms for energy sector will be reported to both the Finnish national projects Neocarbon and FLEXe and to IRPWIND and EERA JP WIND subprogramme Grid integration, after the following mobility periods to LNEG Portugal (currently ongoing) and UCD Ireland (currently applied for).

The KPI's of IRPWIND have the following additions:

- Number of (existing and new) projects that cooperate actively with IRPWIND and that exchange knowledge (and data) with IRPWIND +2 (Finland national project FLEXe and Nordic project Offshore DC).
- Number of joint publications by IRP participants supported by national funding accepted/published in peer reviewed journals +1 (to be submitted in February to review paper conference EEM and the review paper to the RSER from Elsevier)
- Number of researchers involved in mobility and exchange programmes +1
- Number of reports from researchers involved in mobility and exchange programmes +1
- Number of days of mobility and exchange +89
- Number of joint publications related to the participation in the exchange programmes +2
- Number of dissemination events related to the participation in the exchange programmes +1 (1 public at UPC + 1 internal at IREC, and the meetings with industry).

Mobility Call N°:	**2**
Mobility scheme:	**3**
Home Institution:	**VTT**

Evaluation[1]

S1. EXCELLENCE	0 1 **2** 3
Observations: The proposed research is multi-disciplinary, combining market operations with control capabilities.	
S2. IMPACT	0 1 **2** 3
Observations: the proposed work is addressing the need for more cross-disciplinary interactions.	
S3. IMPLEMENTATION	0 1 **2** 3
Observations: Reasonable implementation	
S4. OVERALL EVALUATION	0 1 **2** 3

Suggestion?
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Internal note

Petten, 22 April 2015

[Resource Identifier]

Department Wind Energy

From Wiggelinkhuizen, E.J.

To Philipp Härtl, Mirjam Stappel, Thomas Schoeb

Subject **NSON scenario data**

This note summarizes national RES plans, existing and planned offshore wind farms in NL an Belgium and some recent projects that can provide data for the NSON scenarios..

National plans Netherlands

The report ”Netherlands National Energy Outlook 2014” (Hekkenberg, 2014) provides an overview of the energy sector as a whole withan outlook towards 2020 and 2030.

Targets (pages 33-34)

- 2020 14% RES share
- 2023 16% RES share
- 2023 6000 MW onshore Wind + 4500 MW onshore Wind
- 2030 no RES share targets defined, only emission reduction targets
- 2050 no RES share targets defined, only emission reduction targets

Actual and estimated renewables share (page 11, also on page 53. Fig. 3.7, page 64 shows all RES)

- 2013 current share: 4,5%, of 2145 PJ
- 2020 based on existing policy measures: 10.6%, (9.1-11.1% bandwidth), of 2163 PJ
- 2020 also including intended policy measures: 12.4%, (10.5-13.0% bandwidth), of 2131PJ
- 2030 20%, of which 50% RES produced in NL

Actual and estimated CO2 emissions: (page 53)

- 2013 213 Mtonnes
- 2020 realistic estimate, based on existing policy measures: 183 Mtonnes
- 2020 estimate also including intended policy measures: 176 Mtonnes

Both estiates contain a large uncertainty linked to the realisation of offshore wind (from 1 GW to 4.5GW in 2023) and onshore wind from 2.5 to 6GW in 2023. For offshore the uncertinty has to do with the meeting binding 40% cost reduction target (translated into gradually decreasing subsidy levels), as for onshore the lengthy permitting process and social acceptance are risks. (page 61)

On pages 54 and 56 the share of the consumption per sector is given, might be useful for Demand Response (DR) potential estimation.

In the report table-annex (Hekkenberg, 2014) the energy production until 2030 is given on page 23 (assuming that the fixed and intended policy measured are realised)

Offshore wind energy in the Netherlands

The map below sows the existing and planned offshore wind farms as part of the national Energy agraament (Energieakkoord) from 2013. Please note that consents for all other planned offshore wind farms have been cancelled by the Dutch government.

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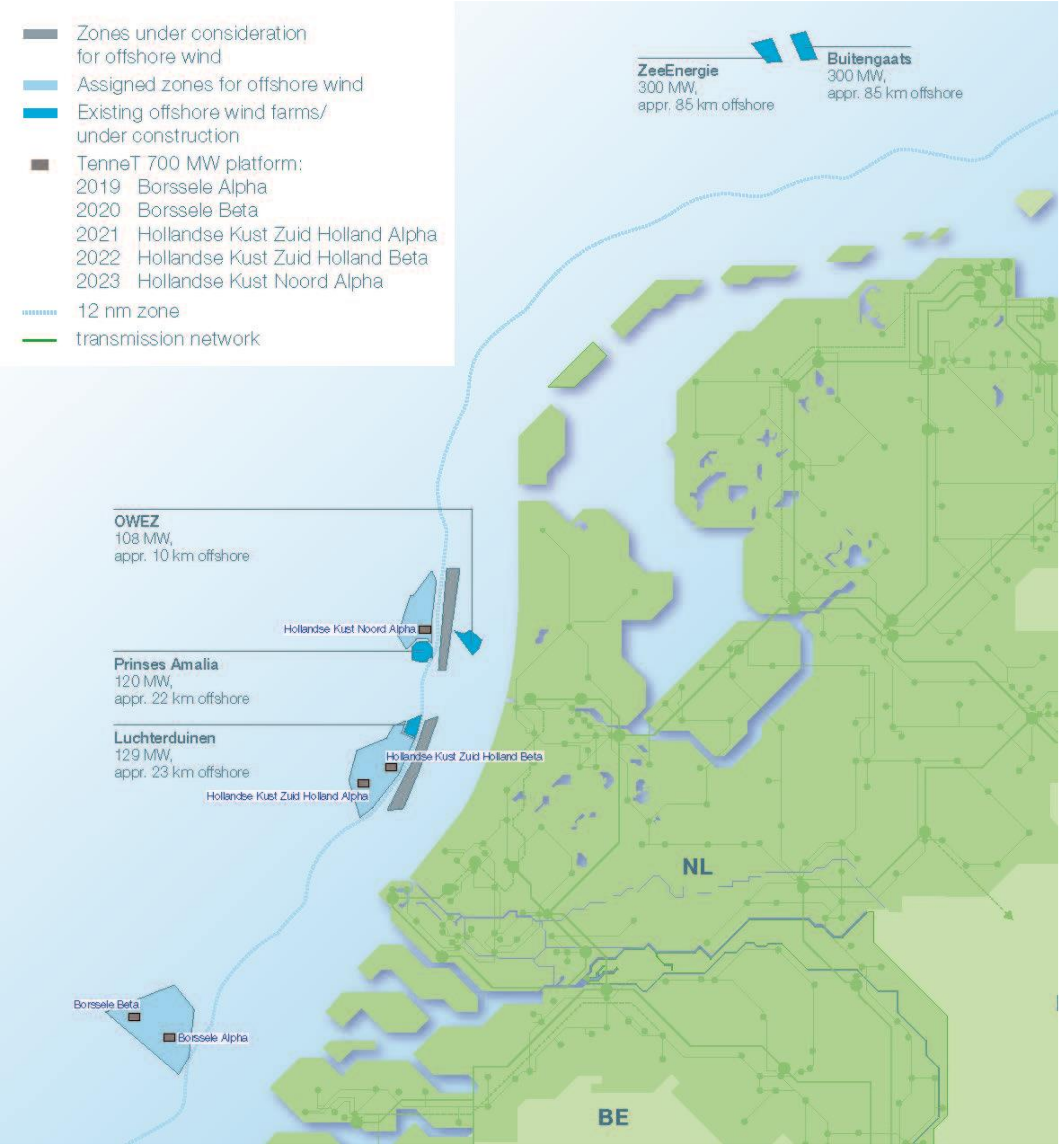

Figure 1: Map of existing and plnned ofshore wind farms

Existing offshore wind farms:

OWEZ (Offshore Wind Farm Egmond aan Zee), Noordzeewind, Operational
Located between 10 and 18km offshore,
36*Vestas V90-3MW = 108MW
Feed-in at 33kV level (three strings) at Velsen substation, North Holland
www.noordzeewind.nl
http://www.4coffshore.com/windfarms/egmond-aan-zee-netherlands-nl02.html

Princes Amalia Windpark, Eneco Energie, Operational
Located 25km offshore (Q7)
Operational (60 x V80-2MW = 120MW)
Feed-in at 150kV level (26km offshore + 7km onshore) at Velsen substation North-Holland
http://projecten.eneco.nl/prinses-amaliawindpark
http://projecten.eneco.nl/prinses-amaliawindpark/projectgegevens/feiten-en-cijfers/

Luchterduinen, Eneco Energie, under construction
Located 24 km offshore (Q10)
43 x Vestas V112-3MW = 129MW
Feed-in at 150kV (2 circuits) at Sassenheim, Zuid-Holland substation
http://projecten.eneco.nl/eneco-luchterduinen/
http://www.4coffshore.com/windfarms/eneco-luchterduinen-netherlands-nl32.html

Gemini, under construction
Located North (Buitengaats, ZeeEnergie, NL1,64, 85 km offshore)
2 x 75 x Siemens SWT-4.0-130 (4MW) = 600MW
Feed-in at 220kV (2 circuits of 105km, on average) at Eemshaven substation, Groningen
http://geminiwindpark.nl/
http://www.4coffshore.com/windfarms/gemini-netherlands-nl18.html

Planned wind farms:

Five tenders of 700MW each, according to the table under Figure 1, connected through 700MW HVAC platforms, developed and operated by TenneT.
Each platform is connected to shore through 2 circuits of 220kV. The option is considered to make the platforms suitable for mid-point reactive power compensation for future far-ofshore wind farms, also by 2 circuits of 220kV.
Another option is to directly interconnect the TenneT platforms, either to sav costs, e.g. on auxiliary power provisions, or to increase the reliability.
Currently a public consultation process is ongoing on the techncal, planing and legal conditions.
http://www.tennet.eu/nl/news/article/tennet-appointed-as-offshore-grid-operator-in-the-netherlands.html

National plans Belgium

Targets Belgium:
source: http://economie.fgov.be/nl/consument/Energie/hernieuwbare_energieen/
2020 13% RES share (realistic),
2020 proactive scenario 18.9% RES share, including 5% onshore wind, 6% offshore wind (ource : ODE Vlaanderen vzw)
2020 1500 MW onshore wind

2020 4320MW, 10474 MWh (National Action Plan Renewable Energy, Nov. 2010):
http://economie.fgov.be/nl/binaries/NREAP-BE-v25-NL_tcm325-112992.pdf

Renewables share Belgium
source: http://www.indicators.be/nl/indicator/hernieuwbare-energie-elektriciteitsverbruik?detail=#gegevens
2011 9.0% RES share
2012 1.0 GW onshore + 380 MWoffshore, together producing 840 GWh

Source: http://www.kennisplatformeconomie.be/downloads/WestVlaanderenWerkt/2014-03/2014_03_DeBelgischeOffshoreWindsector_EenNuttigeNoodzaak.pdf
2014 712 MW offshore operational,
2020 2200MW offshore (expected from projects in planning/development phase)
Here 6.8% RES share in 2012 is mentioned (maybe more strict definition of RES is used here)

Offshore wind energy in Belgium

As the potential for offshore wind in Belgium is limited. Besides the data as available at 4C-offshore on existing and planned wind farms, not other aditional informtion is available: http://www.4coffshore.com/windfarms/belwind--belgium-be03.html

Note that the available onshore connection capacity is insufficient to connect the planned offshore wind farms of 1300MW. http://www.belgianoffshoreplatform.be/files/2014-11/memorandum-2014%20(1).pdf
The current STEVIN project of the Belgian TSO ELIA foresees to create additional capacity (two 380kV circuits at Zeebrugge substation, currently 150kV) to be able to connect 2300MW (which is the total amount of all concessions) source: http://www.elia.be/~/media/files/Elia/Grid-data/Investment-plans/Federal/Federaal-Ontwikkelingsplan_2015-2025-Ontwerp-NL-2015-02-03.pdf
No other offshore feed-in points with signifcant cpacity are (and will be) available.

Belgium is considering to create an offshore island close to shore, which will be decided upon this year: http://www.offshorewind.biz/2014/12/17/belgium-to-decide-on-wind-energy-storing-island-in-2015/. The porpose is pumped storage of exess energy (2 GWh) combined with the HV station.

Demand Side Response Netherlands

Quantifying flexibility markets, ECN study 2014 (van Hout, 2014)

This study provides dat of the genertion mix and electricity market in 2023. Demand Side Response is dscussed at pages 36-37 mentioning 1730MW, 300-500Euro/kWh, while peak shifting has a potential of 3-25% of the peak demand, including commercial and industrial customers.

Demand repsonse actual use in NL, see slide 27:
https://www.kivi.nl/media/Techniekpromotie/Thema_sKIVINIRIA/Energie/lezingenreeks_geotechniek/20130516_DemandResponse_Kamphuis.pdf

Triple E, april 2015
http://www.tripleeconsulting.com/sites/default/files/The%20Balance%20of%20Power%20%E2%80%93%20Flexibility%20Options%20for%20the%20Dutch%20Electricity%20Market%20(final%20report).pdf

Domestic sector, aug. 2014, concl. See page 55
http://dspace.library.uu.nl/bitstream/handle/1874/296740/Thesis%20-%202014-08-01%20Final.pdf?sequence=2

Paper, focusing on domestic sector:
http://www.e-price-project.eu/website/files/Final%20-%20Abdisalaam%20et%20al.%202012.pdf

Overviews per EU-country CEPA, Imperial College, 2014, see from page 42
http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/References/DSF_Final_Report.pdf
http://sedc-coalition.eu/wp-content/uploads/2014/04/SEDC-Mapping_DR_In_Europe-2014-04111.pdf

Recent projects relvant for NSON scenarios in general

Below relevant information is listed from several recent projects for the NSON scenario development .

NorthSeaGrid EU-FP7, 2013-2015 http://www.northseagrid.info/publications
NorthSeaGrid carried out an in-depth analysis of three concrete case studies, resulting in:

- A detailed cost inventory for each case study project, for different scenarios of each case study
- A calculation of the benefits of the interconnection analysed in each case study and scenario
- Different models for cost and benefit allocation to different countries and stakeholders, such as project developer, TSO, etc.
- Identification of risk and the financial effects of this risk, for each stakeholder
- Evaluation of the compatibility of support schemes and regulatory frameworks in the different countries, with the proposed interconnection design
- Discussion surrounding the political barriers present and how to overcome them
- Specific recommendations for European and regional policy

SUSPLAN (PLANning for SUStainability) EU 7FP, 2008-2011 (DG-ENER). www.susplan.eu
SUSPLAN focused on developing strategies, recommendations, and benchmarks for the integration of renewable energy sources (RES) by 2030-2050 within an Europe-wide context. Against this background, SUSPLAN performed a multi-dimensional approach by assembling legislative, policy, business, economic, environmental, and energy professionals together towards addressing the following objectives.

- Develop grid-based renewable energy sources integrated scenarios for national, regional and European levels;
- Compare results from each scenario to identify the optimal path for RES integration, in consideration of security issues and economic competitiveness;
- Establish implementation strategies for decisioin makers; and Publish SUSPLAN work for decision-makers and related professionals on national and European levels via workshops, reports, and online resources.

The scenario setup (WP1) was conducted by SINTEF as well as (WP4) to ensure the comparability of results and conclusions. The benefits of transnational networks (WP3) were compared to individual regional networks for a maximum possible share of RES. IN this WP also a long-term plan for grid expansion in electricity and gas for Europe was developed until 2050

NSTG, national project NL, 2009-2014 http://www.nstg-project.nl/project/publications/
This project compared the an offshore grid in the North Sea, connecting all future offshore wind farms in 2030 with individual wind farm connections and interconnectors. The costs and socio-economic benefits of a stepwise development have been assessed, as well as the consequences for onshore grid planning and stability, and the power flow control of the of the DC offshore grid.
The scenarios were defined in 2010 (WP1), and are therefore not completely up-to-date.

Synergies at Sea, national project NL, 2013-2016 studies a specific case of an interconnection between NL and UK grid via two planned offshore wind farms in the NorthSea. Both the economic, regulatory and technical aspects have been asessed in a feasibility study, followed by in-depth R&D (ongoing) on design of a modified legal framework and novel technical solutions.

RealiseGrid http://realisegrid.rse-web.it/Publications-and-results.asp
Comparison of AC and DC technlogy (Univ. of Dortmund)., cost benefots of grid technologies (Technofi), and model adopted for scenario analysis (univ. Torino)

References

Hekkenberg. (2014). *Netherlands National Energy Outlook 2014.* ECN (Summary: ECN-E--15-005, Full report in Dutch: ECN-E--014-036).

Hekkenberg. (2014). *Netherlands National Energy Outlook 2014 - Tables.* ECN (in Dutch: ECN-E--04-052).

van Hout. (2014). *Quantifying Flexibility Markets.* ECN (ECN-E--14-039).

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Application form for Mobility grants within IRPWIND

A) Applicant details

Applicant Name	**Néstor**
Applicant Surname	**Ramos García**
Home Institution	**DTU Wind Energy**
IRP Partner? *(yes/no)*	**Yes**
Home Institution Postal address	**Nils Koppels Alle, Building 403, 2800 Lyngby, Denmark**
E-mail	**nerga@dtu.dk**

B) Host institution details

Institute name	**CENER**
IRP PARTNER?	**Yes**
Contact person	**Alvaro González Salcedo**
Country	**Spain**
E-mail	**agonzalez@cener.com**

C) Relevant Programme and scheme

CORE PROJECT? YES/NO	**(A) Offshore Wind Energy**	**RELEVANT EERA SUB-PROGRAMME**	**(A) Offshore Wind Energy** **(E) Aerodynamics**
Length of the grant scheme	**(01) 1 month**	**Start date:**	**25th January**

D) *Project description*

RESEARCH COLLABORATION ON THE DEVELOPMENT AND VALIDATION OF TWO-DIMENSIONAL PANEL METHODS FOR STALL SIMULATIONS

1. Introduction

The applicant for the IRPWind mobility programme is a researcher at the Fluid Mechanics section of the Wind Energy department, Technical University of Denmark (DTU Wind Energy), and has been working within the field of wind energy since 2007. More specifically his background relies on his experience in the development of viscous-inviscid solvers for aerodynamic simulations of wind turbine airfoils and rotors. Despite this application concerning a one month grant, the anticipated stay at CENER will take place in the period from January 25th to March 24th 2016. The second month of the stay will be at the expense of the applicant or, if possible, the total grant amount would be stretched over the two month duration of the stay.

The proposed collaboration project between CENER and DTU Wind Energy is mainly based on the development and validation of state of the art aerodynamic solvers conceived independently by both partners. CENER has since 2010 worked in the development of AdaptFoil2D [1,2,3], an unsteady free-wake panel method capable of performing unsteady airfoil simulations at high angles of attack, accurately modelling dynamic stall effects, see Figure 1 (a) and (b). In parallel, DTU Wind Energy has upgraded its steady double wake model, DWM [4,5], into an unsteady version coupled to an integral boundary layer solver, the USDWM [6,7]. As shown in Figure 1 (d), the upgraded version of the code is capable of capturing the vortex shedding dynamics behind two-dimensional bodies. The USDWM has been successfully used to simulate the static stall characteristics of airfoils at high angles of attack, see Figure 1 (c).

Vortex methods are a level of aerodynamic tools which lie between engineering codes and CFD in terms of computational effort and accuracy. Therefore, these methods can offer an added value in wind turbine design and evaluation applications when combined with the rest of the modelling tools. However, the use of panel codes and vortex methods is not so widespread and validated in the wind energy community as it would be desired. This is one of the main reasons behind the research activities at DTU and CENER on the development of this type of aerodynamic solvers.

Both codes, AdaptFoil2D and USDWM, are based in the idea that the flow past a solid body can be modelled by a distribution of flow singularities around the body's contour. Considering the flow around a body with a free stream velocity, U_∞, at a point in the flow domain the velocity can be defined as the sum of the free stream velocity and the induced velocity, u, which can be seen as the influence of the body on its surroundings. If the flow is considered to be incompressible, inviscid and irrotational, u can be expressed as the gradient of the potential field, $\nabla\Phi$, with Φ satisfying the Laplace equation. As sketched in Figure 2, the general solution to the Laplace equation can be obtained through a distribution of singularities around the body contour, which can be of sources, vortices, or a combination of them like dipoles or doublets. Moreover, the wake shed behind the solid body can be modelled in a free-manner with a set of downstream converging vortices. Following the superposition principle the velocity induced at any point in the domain can therefore be written as the sum of the inductions from the body and wake singularities:

$$u = u_\sigma + u_\gamma + u_{\gamma w\,TE} + u_{\gamma w\,SEP} + u_{\Gamma\,TE} + u_{\Gamma\,SEP} \qquad (1)$$

u_σ and u_γ are the velocities induced by the body's source and vortex distribution respectively. $u_{\gamma w\,TE}$ and $u_{\gamma w\,SEP}$ are the velocities induced by the first wake panel of the trailing edge and separation wakes. $u_{\Gamma\,TE}$ and $u_{\Gamma\,SEP}$ are the velocities induced by the point vortices of the trailing edge and separation wakes.

However, in the process of implementation CENER and DTU followed different fundamental approaches. While AdaptFoil2D uses a Dirichlet boundary condition of zero internal potential, USDWM implements a Neumann condition of zero normal velocity at the airfoil surface. The way these boundary conditions are treated and solved forms the core of the panel methods, being the main characteristic that differentiates the codes from each other, and making very interesting a detailed comparison and validation of the solvers. Furthermore, different implementation strategies have been taken: Kutta condition, vortex modelling, wake-body interaction and the treatment of the separation region.

In the scope of this project we would like to interchange the knowledge obtained by both partners in the subject, studying the possibility to overcome some of the limitations of this type of methods for the modelling of separated flow, i.e. accumulation of vorticity in the body's vicinity, numerical problems with the wake roll up, over-estimation of the suction peak in the deep stall region and treatment of the pressure plateau region. In parallel we would like to perform a thorough verification of the codes, identifying best practices, and an initial validation against existing experimental data available and/or high fidelity Navier-Stokes simulations.

The flow past a circular cylinder is an excellent validation case for vortex-type methods, presenting very interesting vortex shedding behaviors that have been extensively studied and reported in detail by several researchers in the fluid mechanics community. It is our objective to perform a comprehensive validation of the codes for this specific case as well as for a group of selected airfoil profiles. Moreover is our interest to look into the possibility to extend the codes with the capability to perform multibody simulations, making possible the study of the change in shedding frequencies for a set of cylinders in a row as a function of the distance between them.

During the last months, effort has been put to equip DTUs USDWM with an integrated boundary layer solver. In a first attempt a direct viscous-inviscid coupling has been successfully implemented. Further on, a more complex quasi-simultaneous coupling is to be ready in the coming months. As a part of this collaboration project, the applicant's knowledge on viscous-inviscid solvers can be used to implement a direct viscous-inviscid coupling into CENERs AdaptFoil2D potential code. With the new coupling, AdaptFoil2D will be able to simulate the viscous flow over attached boundary layers, and therefore account for the viscous effects that modify the inviscid aerodynamic behavior in the so-called linear lift region, accounting at the same time for viscous drag.

The proposed KPI's for the collaboration project will be one publication that will be made publically available and the validation of both aerodynamic solvers. Additionally, a report with the development and improvements applied in the codes will also be a clear KPI. The TRL of the codes is at the moment a 4, since the concept has already been implemented and partially validated against wind tunnel experiments.

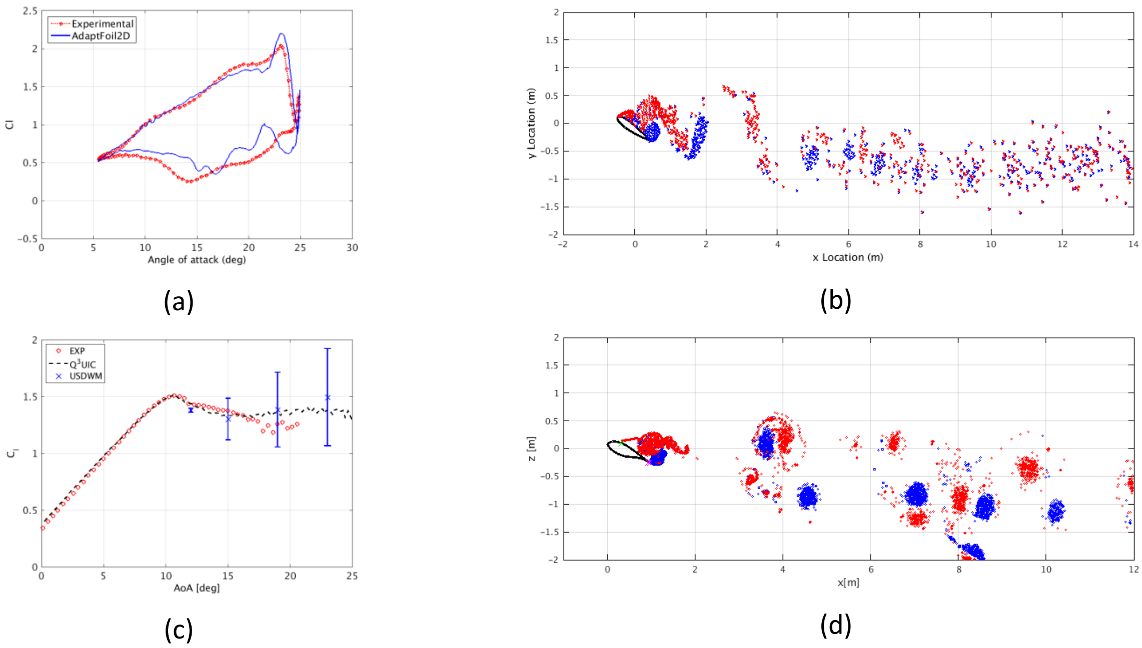

Figure 1 – (a) AdaptFoil2D simulation of the Cl of a dynamic stall cycle for a pitching NACA0015 (b) Dynamic stall vortex development for a pitching NACA0015 (c) DTUs USDWM calculation from [5] of the lift force

coefficient for flows past the FFA-W3-211 airfoil at a Reynolds number of $1.8 \cdot 10^6$. (d) Instantaneous flow visualization at t = 50 s of the flow past the FFA-W3-211 airfoil at an angle of attack of 19 deg.

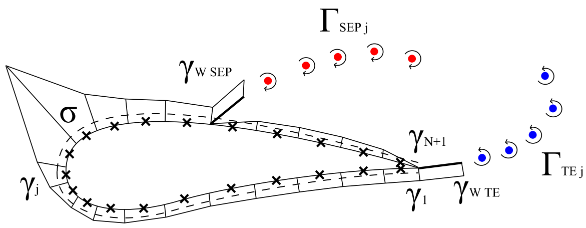

Figure 2 – Sketch of the singularity distribution in the USDWM solver.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Relevant national project at DTU Wind Energy

At DTU Wind Energy, the research is conducted in 9 research programmes, focused on three main topics: Wind energy systems, Wind turbine technology and Wind energy basics, and is organized in 8 sections. The research takes its lead in critical challenges and needs for development and application of the technology, rather than in possible applications of more generic technical-scientific disciplines. The present application deals mainly with aerodynamics.

The applicant is part of the national research project “Center for Computational Wind Turbine Aerodynamics and Atmospheric Turbulence”. The objective of this project, which is sponsored by the Danish Strategic Research Council in the period 2010-2016 with a total amount of 32Mdkr (approx. 4.2 M€), is to develop computational methodologies and physical models capable of coping with multiple scales an apply them to combined wind turbine aerodynamics and atmospheric physics problems. The project is divided into the following tasks:

- Rotor/ABL Aerodynamics.
- Wind Turbine Wakes and Clusters.
- Wind Farms.
- Siting in Complex Terrain.
- Atmospheric boundary layers.

The first two tasks are of clear relevance for the present collaboration project.

Relevant national projects at CENER

CENER is and has been involved in projects where vortex methods are or can be of large relevance. Some of them are listed below as an example:

- AdaptFoil (2010 – 2016). Development of aeroelastic codes to improve the modelling of airfoils and blades including attached flow, separated flow and dynamic stall, and with the possibility to simulate deformable geometries. The development is mainly related to panel codes and vortex methods.
- Sea-Mar (2013 – 2014). Design of an 8MW wind turbine, with main focus on rotor design, to calculate reference loads of a wind turbine of such dimensions. Project funded by Acciona Energía, Spanish company.
- Azimut (2010-2013). Investigation on Force and Moment coefficients of large Offshore wind turbines. Funded by the Centre for Industrial Technological Development of Spain (CDTI).

Into these projects, CENER has gained experience on the main characteristics of panel codes and vortex methods, with a deep comprehension of the advantages and deficiencies. This experience can be directed to overcome the limitations of panel methods in terms of airfoil and rotor modelling for wind turbine applications.

3. Work plan

	Feb.				Mar.			
Task / Week	1	2	3	4	1	2	3	4
A								
B								
C								
D								
E								

The tasks distributed in the above diagram are described in what follows:

A Identify and select a variety of cases showing the limitations of panel methods, i.e. accumulation of vorticity in the body's vicinity, numerical problems with the wake roll up, over-estimation of the suction peak in the deep stall region and treatment of the pressure plateau region.

B Study previously proposed and new solutions for the above described panel methods limitations.

C Development and improvement of the codes to overcome some of the previously identified limitations.

D Verification and validation of AdaptFoil2D and USDWM for airfoil and cylinder cases against experimental and/or CFD simulations. It will include an analysis of the calculated aerodynamic forces as well as the wake characteristics.

E Write a report on the collaboration project. The report will include the verification and validation as well as a detailed description of the newly implemented capabilities.

4. Benefits to EERA objective advancement

The main benefit for the EERA Corporation will be accomplished as the research and dissemination activity during the researcher stay at CENER will be directly related to the EERA Joint Sub Programme in Aerodynamics and Offshore Wind Energy. The present application is in direct alignment with the European collaboration project "AdVanced Aerodynamic Tools for lArge Rotors" (AVATAR), which is carried out by a consortium from the subprogram aerodynamics of the EERA Joint Program Wind. The main objective of the project is to evaluate, validate and improve aerodynamic and aero-elastic tools to ensure applicability in the next generation of large wind turbines, ranging from 10 to 20 MW. Due to, mainly, structural reasons, the new blade designs demand longer and more slender blades which require thick and innovative airfoils designs, relatively new for the wind energy sector. Thick airfoil design has become one of the main obstacles that aerodynamicists face nowadays. Panel method based solvers have the potential to become an important tool in the analysis and design of this new generation of airfoils.

The validation and development of AdaptFoil2D and USDWM is part of several European projects being a key element in AVATAR. CENER and DTU would like to use this opportunity to extend the collaboration in the execution of tasks 3.2 and 3.3, part of work package 3 (WP3) in the AVATAR project. WP3 deals with the modeling of flow devices and flow control on airfoils and rotors, including parametric study of geometry, positions and actuations, as well as a study of control strategies. The development of USDWM is also key part of the national research project "Center for Computational Wind Turbine Aerodynamics and Atmospheric Turbulence'.

The Aerodynamics Section at CENER and the Fluid Section ad DTU Wind Energy have a long history of collaboration, which has recently been revitalized by Jens Sørensen seven week stay at CENER in 2014 and Xabier Munduate three months stay at DTU in 2015. It is by this application that we would like to give a further continuity to the already productive collaboration between both institutions. Enhancing the integration of some of the research activities carried out by both institutions. In addition, the collaboration can be a step forward in the development, improvement and validation of panel/vortex methods in the wind energy community.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

During the stay at CENER, the applicant will give one or more presentations on the development of aerodynamic codes for rotor as well as airfoil simulations. Furthermore, both CENER and DTU Wind Energy are partners in the EU-sponsored project AVATAR, and the stay will make possible a direct transfer knowledge of relevance for this project between the two partners.

The dissemination can be effective with the presence or contribution in some of the following channels:

- Yearly EERA Wind Event.
- EWEA 2016 Annual Event.
- AVATAR meeting, Glasgow June 2016.
- TORQUE, October 2016, Munich.
- DTU Fluid Mechanics section mini-seminar 2016.
- Distribution of documents generated among EERA Aerodynamics group participants.

6. Expected results

- List of improvements in the codes to overcome some of the limitations of vortex methods, making them more competitive tools for the simulation and design of the next generation of wind turbine airfoils.
- Report on the verification and validation of both AdaptFoil2D and USDWM against a variety of experimental and/or CFD simulations.
- Advancement of the TRL to a level 8, the solution to the previously described limitations of the panel methods will be implemented and the codes will be verified/validated against relevant data.
- The assessment of the KPIs will be accomplished through the above-mentioned document, which will be publicly available in 2016.

References

[1] A. González, "Aeroelastic modelling of wind turbine deformable airfoils" PhD Transfer Report, June 2011.

[2] A. González, X. Munduate, R. Palacios, J.M.R. Graham "Aeroelastic panel code for airfoils with variable geometry" Proceedings of 8th PhD Seminar on Wind Energy in Europe, September 2012.

[3] A. González, "Description, application, development and validation of AdaptFoil2D", AVATAR Deliverable 3.2, Section 4.13.

[4] N. Ramos-García, Unsteady Viscous-Inviscid Interaction Technique for Wind Turbine Airfoils. Phd thesis. DTU, Department of Mechanical Engineering. ISBN 978-87-90416-53-9. April 2011.

[5] L. Marion, N. Ramos-García and J.N. Sørensen "Inviscid Double Wake Model for Stalled Airfoils" The Science of Making Torque from Wind. IOP Publishing. Journal of Physics: Conference Series 524 (2014) 012132. August 2014. http://iopscience.iop.org/1742-6596/524/1/012132.

[6] N. Ramos-García and A. Cayron and J. N. Sørensen. Unsteady Double Wake Model for the Simulation of Stalled Airfoils. Journal of Power and Energy Engineering, Proceedings of the 5th Conference on New Energy and Sustainable Development, July 2015. http://www.scirp.org/Journal/PaperInformation.aspx?PaperID=58091.

[7] N. Ramos-García, J.N. Sørensen and W.Z. Shen, "A Strong Viscous-Inviscid Interaction Model for Rotating Airfoils" Wind Energy. Vol. 17, Issue 12, pp. 1957–1984, December 2014. http://onlinelibrary.wiley.com/doi/10.1002/we.1677/abstract.

IRPWind

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Application form for Mobility grants within IRPWIND

NOTE

- **All documents must be named as follows:**

Sub Programme letter, Scheme no., Surname, Document type. Ex: A_2_Smidt_cv
See Table C) below.

- **The application must be max. 6 pages, ex tables, figures and references.**

A) Applicant details

Applicant Name	**Mikel**
Applicant Surname	**De Prada Gil**
Home Institution	**Catalonia Institute for Energy Research (IREC)**
EERA/IRP Partner? *(yes/no)*	**YES**
Home Institution Postal address	**Jardins de les dones de negre, 1, 2nd floor.** **08930 Sant Adrià de Besòs, Barcelona, Spain.**
E-mail	**mdeprada@irec.cat**

B) Host institution details

Institute name	**DTU Wind Energy Department** **Technical University of Denmark (DTU)**
EERA/IRP PARTNER?	**YES**
Contact person	**Anca Daniela Hansen**
Country	**Denmark**
E-mail	**anca@dtu.dk**

Relevant Programme and scheme

CORE PROJECT? ***YES/NO*** ***(Please erase the non-relevant)***	**(B) Wind Integration**	**RELEVANT EERA SUB-PROGRAMME** **Max 2** **(Please erase the non-relevant)**	**(A) Offshore Wind Energy** **(B) Wind Integration**
Length of the grant scheme ***(Please erase the non-relevant length)***	**Scheme:** **(02) 4-26 weeks**	**Number of weeks:** **Start date:**	**12** **23th May 2016**

D. Project description

Control of DFIG wind turbines with reduced power electronic converters connected to a VSC-HVDC converter

1. Introduction

Research topics, originality:

The main objective of the work expected to be done during this mobility period is to develop new knowledge for offshore wind power plants and wind turbines that move the development towards more cost-competitive offshore wind solutions.

This project investigates a new variable frequency wind power plant configuration which combines DFIG wind turbines with reduced size power converters (approx. 5 % instead of 25-35% of the rated power) in order to provide control capability for the wind power plant at a reduced cost. Specifically, this project is focus on determining how much the size of the power converter can be reduced and on the control strategy for such reduced converter for both normal and fault operations in order to maximize the energy production and partially/totally compensate for the wind speed difference inside a wind farm due to the wake effect.

This proposal is based on the existence of VSC-HVDC transmission systems and the opportunity to modify the frequency of the offshore collection grid, allowing rethinking the way the offshore wind power plants are designed. Currently, the wind turbine and wind power plant can be designed independently. This has some interesting advantages related to flexibility but the overall system is not optimized. The present proposal will require an overall optimized design of the whole wind power plants considering the wind turbines together with the collection grid where they are connected.

Specific challenges related to the design, optimization, modeling, operation and control of the new technologies will be considered during this mobility stay.

Technological Readiness Level (TRL) of the proposed concept:

This mobility is aimed to develop basic research and to increase and share know how among IRPWind partners. Thus, at this moment, the Technology Readiness Level of the proposed concept is 1-2 (basic research and technology concept formulated) aiming to bring it to higher TRLs in possible further projects/collaborations.

Definition of Key Performance Indicators (KPIs):

This mobility aims to contribute to following IRPWIND KPIs:

- Number of (existing and new) projects that cooperate actively with IRPWIND and that exchange knowledge with IRPWIND.
- Number of joint publications by IRP participants.
- Number of researchers and reports from these researchers involved in mobility and exchange programmes.
- Number of days of mobility and exchange.
- Number of dissemination events related to the participation in the exchange programmes.
- Cost of energy reduction in the wind turbine and the wind power plant.

Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP):

The proposed project is aligned with the scope of IRPWind Core Projects (WP6 and WP8) and EERA JP Wind of Offshore Wind Energy and Grid Integration. It deals with basic research on novel approaches for offshore wind turbines and wind power plants, which are more cost-competitive and more efficient than the existing technologies. It combines multidisciplinary academic scientific expertise, through the development of new technical knowledge, and it is expected to accelerate the development of offshore wind power technology, toward the achievement of a more flexible and reliable energy system in Europe or worldwide. The project seeks to provide a better scientific understanding and guidance to achieve overall system cost reductions for offshore wind technologies. Particular emphasis will be on challenges related to develop of a coordinated control strategy between reduced power electronic converters inside DFIG wind turbines and a common large VSC-HVDC located in the offshore substation for both normal and fault operations in order to maximize the energy production and partially/totally compensate for the wind speed difference within a wind power plant due to the wake effect. This will contribute to WP81 in IRPWind based on grid integration issues such as grid codes and controllability. In fact, the key concepts of the proposal are based on the existence of VSC-HVDC transmission systems and the opportunity to modify the frequency offshore collection grids.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Description of national projects at DTU Wind Energy Department (receiving institution):

- **Integrated analysis of wind turbine design:** The project aimed to develop procedures for the design and control of wind power systems taking into account the interactions between the mechanical, structural and electrical aspects of wind turbines

- **Stability and Control of Wind Farms in Power Systems:** The objective of the project has been to analyse and assess the possibilities for control of different types of wind turbines and different wind farm concepts.
- **Electrical design and control - Simulation Platform to Model, Optimize and Design Wind Turbines:** the project had the main goal to create a model database in different simulation tools for a system optimization of the wind turbine systems.
- **Grid fault and design-basis for wind turbines:** The goal is to investigate into the consequences of the new grid connection requirements for the fatigue and extreme loads of wind turbines and to clarify and define possible new directions in the certification process of wind turbines.
- **Simulation and verification of transient events in large wind power installations:** The objective of this work was to develop and verify tools, which can be used to study and improve the dynamic interaction between large wind farms and the power system to which they are connected.
- **EASEWIND:** The aim of this project is investigate and develop new primary control features for ancillary services provided by wind power plants, like inertial response, synchronizing power and on power system damping (PSS like functionality)

Description of national projects/industrial contracts from the sending institution:

- **Emerge Spanish Government - INNPACTO** (MICINN). The study and development of electrical engineering associated with deep water offshore wind power: generation, generator design and transmission, AC-DC line types, connection to the coast, etc
- **Vendaval**. Alstom Wind SLU. The aim of this project is to analyze, to model and to simulate possible configurations of offshore wind farms and different offshore wind farms power system connection.
- **Roadmap and Design of DC wind power plants (Vendaval 2)**. Alstom Wind SLU. The scope of this project is to define a roadmap and the first steps to develop the future DC wind power plants (WPP) for offshore applications.
- **Design of a Modular Power Converter for AC and DC wind power plants (Vendaval 3)** Alstom Wind SLU. This project relies on providing conceptual designs of modular and adaptable power converters for their use in both AC and DC wind power plants; carrying out studies to evaluate their performance and comparison determining the best power converter option. Finally, a detailed technical specification of the most advantageous power converter design that enables further studies on the construction of a prototype will be produced.
- **HAL150 6MW connected with HVDC.** Alstom Wind SLU. This project deals with the study of the HAL150 6MW wind turbines connected with HVDC in terms of two different approaches: to check the feasibility of the current electrical protections to detect internal faults and to assess parallel resonances in WTs and to check high harmonic voltages due to transformer energization.

Foreseen European added value of national alignment:

As it is previously stated, national projects from both the receiving and sending institution face specific challenges related to the design, optimization, modeling, operation and/or control of new technologies and wind power plant configurations with the aim of increasing the competitiveness of the European wind industry and contributing to ease wind power integration while ensuring a stable and secure power systems.

It is foreseen an European added value of this national alignment by taking advantage of DTU Wind Energy Department as a coordinator of EERA JP Wind Sub-Programme 1 on Wind Conditions and its large expertise in wind energy and its integration to the grid, together with IREC's experience and knowledge acquired by the participation of the aforementioned national projects related with wind energy and power systems.

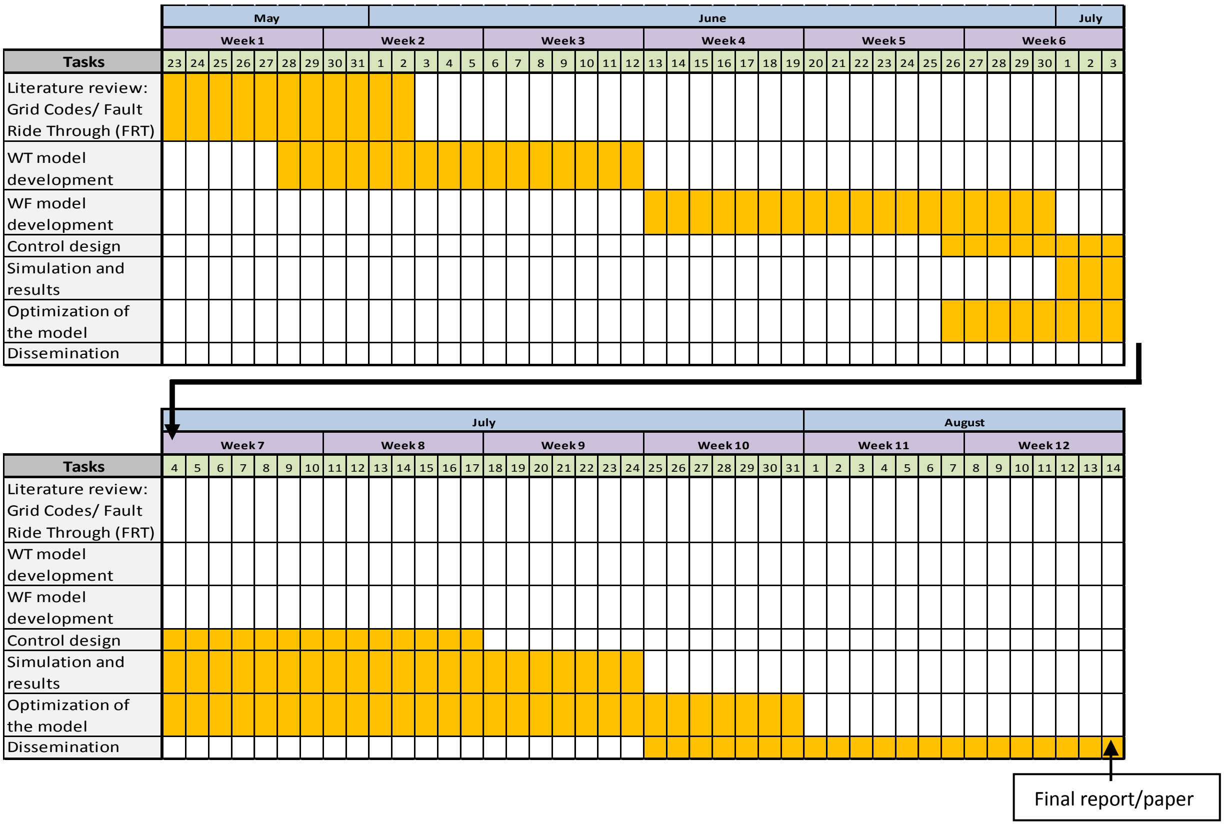
During the stay of the researcher Mikel de Prada in DTU Wind Energy department, he will have access to DTU's CorWind simulation software to generate stochastic wind speeds time series. CorWind model can simulate multiple wind power time series taking into account the spatial and temporal correlation of those, without including dynamic phenomena as meandering wakes.

<u>Description of the host institute: e.g. infrastructure, experience etc:</u>

DTU Wind Energy has a long tradition in wind energy research, being the continuator of the former Risø National Laboratory, a worldwide pioneer in wind power research and development. The objective of DTU Wind Energy research is to provide industry and society with new solutions, with due consideration to the demands for significant reductions in the consumption of resources and environmental impact worldwide. DTU Wind Energy participates in Danish and international research programs and conducts research and consulting activities for industry and governmental authorities. DTU Wind Energy has extensive expertise on modeling, control and integration of wind energy into power systems, which supports the development of new wind power technology solutions to the energy challenge in Europe or worldwide. The key competence of DTU Wind Energy of relevance to the tasks in the present project is on modeling, operation, control and grid compatibility of wind turbines and wind power plants.

3. Work plan

In the following, the proposed work plan for the 3 months period is presented.



4. Benefits to EERA objective advancement

The work expected to be done during this mobility period will contribute to the advancement of the EERA strategy goals by integrating European research activities in the field of wind energy aimed at accelerating the transition towards a low-carbon economy and maintain and increase European competitiveness by investigating new appealing wind farm configurations more cost-effective than the existing ones. The experience of both the hosting group and the researcher will help in achieving good advancement in the relatively short period of 3 months. Moreover, after the mobility period, continuous interaction among the centers for further developing joint research will ensure further advancement on reaching such goals.

The research to be developed during the mobility stage is well aligned with several research objectives within EERA Wind. The work deals with the Research Themes RT1: Wind power plant capabilities and RT3: Wind energy and power management from EERA JP Wind Grid Integration sub-programme, as well as, RT5: Control, operation and maintenance of offshore wind farms from EERA JP Wind Sub-programme on Offshore Wind Energy.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

Dissemination and transfer of knowledge are planned through joint publications between DTU Wind Energy and IREC as well as a workshop in Copenhagen. The publication/s will be part of IRP and EERA Wind articles and it is expected than other IRP and EERA JP Wind SP Grid Integration partners will collaborate preparing a future joint project proposal.

6. Expected results

At the end of the mobility period we aim to have joint publications, to have organized a public workshop and ideas for joint project proposals between IREC and DTU Wind Energy.

Moreover, it is expected that the results of the activities will provide better scientific understanding and guidance which will be available to all the research community to continue advancing on the design of more cost-competitive offshore wind power plant concepts.

Funded by EU

Application form for Mobility grants within IRPWIND

*****NOTE*****

- All documents must be named as follows:

Sub Programme letter, Scheme no., Surname, Document type. Ex: A_2_Smidt_cv
See Table C) below.

- The application must be max. 6 pages, ex tables, figures and references.

A) *Applicant details*

Applicant Name	Hannele
Applicant Surname	Holttinen
Home Institution	VTT
EERA/IRP Partner? *(yes/no)*	yes/yes
Home Institution Postal address	P.O.Box 1000; 02044 VTT; Finland
E-mail	hannele.holttinen@vtt.fi

B) *Host institution details*

Institute name	LNEG
EERA/IRP PARTNER?	yes/yes
Contact person	Ana Estanqueiro
Country	Portugal
E-mail	ana.estanqueiro@lneg.pt

C) Relevant Programme and scheme

CORE PROJECT? YES/NO *(Please erase the non-relevant)*	(B) Wind Integration	RELEVANT EERA SUB-PROGRAMME Max 2 (Please erase the non-relevant)	(B) Wind Integration
Length of the grant scheme *(Please erase the non-relevant length)*	Scheme: (02) 4-26 weeks	Number of weeks: Start date:	7 28th March, 2016

D. Project description

Use of forecasting tools for wind power in electricity markets

1. Introduction

This is an application to continue a 3 month long mobility (Dec2015-Feb2016) with 7 weeks in April-May. The topic has been updated to focus more on use of forecasting tools, from general electricity market issues with wind power.

Research topics, originality. Integrating wind power to European power systems and electricity markets involves changes in use of forecast tools for wind power operators participating in the different markets.

Technological Readiness Level (TRL) of the proposed concept. Not really applicable to this mobility aiming to increase know how on a more general level, combining and linking specific know how for integration related issues. The models that are used at LNEG are at level 7-8.

Definition of Key Performance Indicators (KPIs). This mobility will contribute to following IRPWIND KPIs:

- Number of (existing and new) projects that cooperate actively with IRPWIND and that exchange knowledge (and data) with IRPWIND. (the same as for 3 month mobility)
- Number of joint publications by IRP participants supported by national funding accepted/published in peer reviewed journals (new publication after 3 month mobility)
- Number of researchers involved in mobility and exchange programmes (the same as for 3 month mobility)
- Number of reports from researchers involved in mobility and exchange programmes (new publication after 3 month mobility)
- Number of days of mobility and exchange (additional after 3 month mobility)
- Number of joint publications related to the participation in the exchange programmes (new publication after 3 month mobility)
- Number of dissemination events related to the participation in the exchange programmes (new event after 3 month mobility)

Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP):

This mobility is a continuation of currently ongoing mobility that aims at a fruitful collaboration of a senior researcher from VTT visiting a group actively involved in Irpwind WP8 opening new possibilities through cross-feeding ideas and the identification of synergies between VTT and LNEG R&D long-term objectives aligned with IRPWind main goals.

The main contribution will be for Task 8.3.1 Market design for high wind power penetration and Task 8.3.2 Mitigation of the impact of wind power variability (Deliverables D8.12 Market design with multi-agent systems; D8.13 New market products; D8.14 Role of forecasting in the power system).

Other tasks where this collaboration has the potential to be fruitful are: Task 8.1.1 Management and Control of Large European-Scale Clusters of Wind Farms (ramps and fluctuations) ;Task 8.2.2 Upscaling: Minimum reference and data selection, and decomposition and Task 8.2.3 Probabilistic forecasts for grid control and Task 8.2.4 Multivariate forecast scenarios for markets (D8.10 Predictability Guarantees vs. Data Sharing: Impact assessment).

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Description of national projects from the receiving institution LNEG:

The mobility is building on national project funding from several sources, to support IRPWIND WP8 work.

- MAN-REM – Multi-Agent Negotiation and Risk Management in Electricity Markets;
- Fluct.Wind: Wind power fluctuation characterization and categorization by time-spectra analysis;
- VRPP - Dynamic model of Virtual Power Plant able to account for Ancillary Services;
- OptGrids- Optimization Tools for Industry to Actively Engage in Smart Grids;
- OptEnergy - This project aims at a more rational use of energy in industries through the development of operational processes that are capable of including the main alternatives for energy integration;
- IEA Wind Task 25 international collaboration on wind integration involving 16 countries (both VTT and LNEG participating) – one of the targets is a database for wind forecast time series relevant for wind integration;

Description of national projects from the sending institution VTT:

The mobility is building on national project funding from several sources, to support IRPWIND WP8 work.

- VaGe project –Academy of Finland funded basic research project aims at improved forecasting of all weather related generation (and demand) for improved integration of wind and solar;
- FLEXe research programme – national TEKES funded programme of future flexible energy systems, including work for market designs;
- Neocarbon project – National Tekes funded project aims at studying new flexibility for power systems from future power to gas options;
- IEA Wind coordinating Task 25 international collaboration on wind integration involving 16 countries (LNEG participating): integration collaboration project – one of the targets is a database for wind forecast time series relevant for wind integration.

Foreseen European added value of national alignment.

Energy sector is in the middle of profound changes with increasing variable renewable generation as well as changing roles of consumers towards producer-consumers and active prosumers. This will impact the generation business, the network business and market mechanisms as well as future business models. The mobility period willThe mobility period will be used, in addition to work related directly to IRPWIND WP 8, to interviews of Portuguese energy sector actors regarding the changes in market mechanisms resulting from potential changes in energy systems. The aim is to contribute to aligning the work on market mechanisms in Finland and Portugal, which is a start. Through EERA Wind Grid integration and IEA Wind collaboration on wind integration where 10 European countries participate these results can help aligning for also in a wider European context. Hannele Holttinen has visited also Spain and these consequent visits will have a larger impact.

Description of the host institute: e.g. infrastructure, experience etc.

Relevant LNEG's Facilities, Models and Tools:

A cluster computing system based on a SGI Altrix system, formed with a head node and eight servers linked together via IB at 40Gbits. The system has a total hard disk space of 16TBytes and share 144 Intel Xeon E52680 cores and 320GBytes RAM. The cluster runs Linux CentOS 6.0 and has available libraries for MPI and OpenMPI applications and different C and C++ and Fortran Compilers. The system is configured to run many atmospheric mesoscale models such as the MM5, WRF, ARPS and RAMS. It is also expected in the near future the implementation of the oceanic model WW3. Four other workstations with specialized software tools (GAMS, Matlab/Simulink and PSSE) are at the disposal of LNEG's researchers.

Other Tools:

- The INPark and INGrid models are dynamic detailed wind generation models that characterize the electric power delivered by a wind turbine as well as the dynamic voltage fluctuations induced at its terminals by the variable and time-dependent energy resource thus particularly adequate for power quality assessment and identification of the capability of wind turbines (and parks) to provide ancillary systems. These models started to be developed in the mid-1990s, mainly focused on the power quality assessment of wind turbines. Within the activities of International Energy Agency Wind Tasks 21 and 25 research tasks, the model has been developed in order to address a wider range of phenomena, and sub-models have been added to include the common smart-grid configurations (e.g. EVs, MG, prosumers, active loads and sources, etc…). The models also enable to assess the inertial contribution of a wind turbine for the FRT support under transient events.
- LNEG developed and maintain an agent based market simulator enabling its participants to: i) Negotiate the terms of forward bilateral contracts, considering dynamic pricing tariffs (efficient management of Demand Response), reaching (near) Pareto-optimal agreements, and unilaterally de-commit from contracts by paying de-commitment penalties; ii) Ally into beneficial coalitions - notably coalitions involving end-use customers - to achieve more powerful negotiation positions, and thus negotiate better tariffs; ii) Manage a portfolio of customers/producers, taking into account trade-offs between the risk and return of bilateral contracts - notably contracts involving traders and customers.
- Additional tools are also under development specifically within IRP.Wind, e.g. an alert system for severe wind ramping based on climatic phenomena and optimal wind turbine aggregation model among others.

3. Work plan

Hannele Holttinen is currently visiting LNEG and has started a joint article regarding wind power producers' at energy markets. There are interesting other opportunities for joint article, for example looking more in detail in intra-day and real time markets, that would be possible to pursue more with a continuation to the mobility. In LNEG there is the opportunity to continue widening her knowledge on agent based market designs, and general wind/PV/energy system research at LNEG. She will contribute to LNEG widening know how on market mechanisms and future energy system integration issues.

Meetings with other Portuguese actors are currently planned mostly in February, in the longer 3 month period (InescTec, EDP, ERS), but a continuation gives further possibilities to that as well (TSO REN ,...). These are both as general interviews/interaction regarding future changes in energy systems and more concretely to discuss and disseminate the LNEG/VTT joint mobility task. LNEG and VTT future collaborative projects will also be searched for.

Mobility task 1 – Wind forecasting and electricty markets (weeks1-4)

1.1 - Short-term forecasting and intra-day/ancillary system markets
1.2 - Market design for high wind power penetration using multi-agent systems
1.3 - Identification of 'wind products' for electricity markets

Mobility task 2 – Joint publication (weeks 4-7)

A final joint publication will be a concrete aim of the mobility period. This will be written on market mechanisms with a focus on intra day markets.

4. Benefits to EERA objective advancement

The mobility period of the senior researcher will contribute to the advancement of the EERA strategy goals on aligning European research on wind integration and on performing coordinated research. The experience gained on the international collaboration in Nordic, EU and IEA Wind Task 25 activities will help in acheiving advancement in the relatively short period of 7 weeks, as well as the previous mobility visits to Spain and Portugal. The mobility will also contribute to progress of EERA JP-Wind workplan in the development of models and tools for large integration of wind generation. This work aligns with the Research Themes RT1: Wind power plant capabilities and RT3: Wind energy and power management.

LNEG is participating also in PV, biogas and CSP IRP and EERA Sub-programmes which makes the unique opportunity to grab/spread information of the grid integration of variable renewables and/or the need for flexibility in all these areas.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

Dissemination is planned through a joint publication that will be part of IRP and EERA Wind articles, and a visit/seminar.

The general findings of changes in future business models and market mechanisms for energy sector reported to the Finnish national projects Neocarbon and FLEXe will be disseminated also to IRPWIND and EERA JP WIND subprogramme Grid integration – in the workshop organised summer 2016, as agreed with Kurt Rohrig.

6. Expected results

Assessment of the advancement of the TRL: this short 7 week mobility does not have the potential to advance the tools significantly. The most relevant expected positive impacts will be the contribution to a common international approach - both european through EERA-SP Wind (IRP.Wind) and international through IEA Wind Task 25 - of the main challenges of wind generation when asked to participate in electricity markets.

Assessment of the KPIs:

- Number of (existing and new) projects that cooperate actively with IRPWIND and that exchange knowledge (and data) with IRPWIND: +2 (IEA Wind Task 25+ NEOCARBON project – the same as for 3 month mobiity before)
- Number of joint publications by IRP participants supported by national funding accepted/published in peer reviewed journals: +1
- Number of researchers involved in mobility and exchange programmes: +1 (the same as for 3 month mobility before)
- Number of days of mobility and exchange:+49
- Number of joint publications related to the participation in the exchange programmes:+1
- Number of dissemination events related to the participation in the exchange programmes:+1

At the end of the mobility period we aim to have a second joint publication (on top of the one from the 3 month period earlier), to have organised an extra visit or dissemination seminar and ideas for joint project proposal between VTT and LNEG.

The general findings of changes in future business models and market mechanisms for the wind and renewable energy sector will be reported to both the Finnish national projects Neocarbon and FLEXe and to IRPWIND and EERA JP WIND subprogramme Grid integration (summer workshop of Irpwind).

Funded by EU

Application form for mobility grants within IRPWIND

A) Applicant details

Applicant Name	**Til Kristian**
Applicant Surname	**Vrana**
Home Institution	**Sintef Energi**
EERA/IRP Partner?	**Yes**
Home Institution Postal address	**Sintef Energi, Postboks 4761 Sluppen 7465 Trondheim, Norway**
E-mail	**vrana@sintef.no**

B) Host institution details

Institute name	**IREC**
EERA/IRP PARTNER?	**Yes**
Contact person	**Jose Luis Dominguez-Garcia**
Country	**Spain (Catalunya)**
E-mail	**jldominguez@irec.cat**

C) Relevant Programme and scheme

CORE PROJECT? ***YES***	**(B) Wind Integration**	**RELEVANT EERA SUB-PROGRAMME**	**(A) Offshore Wind Energy** **(B) Wind Integration**
Length of the grant scheme	**Scheme:** **(02) 4-26 weeks**	**Number of weeks:** **Start date:**	**17** **2016-09-01**

D. Project description

Validation and Grid Code Compliance of MT-HVDC Control for Wind Power Integration

1. Introduction

Research topics, originality

The integration of large amounts of wind power into the electric power systems leads to challenges for system operation. Wind power plants are therefore more and more required to contribute to systems stability and security instead of only focussing on maximum power tracking and minimum cost of energy. Moreover, the interconnection among countries and offshore wind by means of a MT-HVDC system is lately attracting interest, and some proposals are being done for the North Sea. These systems also need to be operated in a stable way. Offshore WPP therefore need to behave in a determined way, to address stability concern offshore and onshore, in the AC and in the DC systems. Future grid codes will define the specific requirements for WPPC controls, regarding stability of the HVDC transmission systems and exporting services through HVDC to the onshore AC grids.

Technological Readiness Level (TRL) of the proposed concept

The proposed activities focus on concepts that are on TRL2 aiming at TRL3. However, TRL scale is difficult to apply here, because the main goal of the activity is to increase and share know how among IRPWind partners on a more general level.

Definition of Key Performance Indicators (KPIs)

The proposed exchange aims to contribute to following IRPWIND KPIs:

- Number of (existing and new) projects that cooperate actively with IRPWIND and that exchange knowledge with IRPWIND.
- Number of joint publications by IRP participants.
- Number of researchers and reports from these researchers involved in mobility and exchange programmes.
- Number of days of mobility and exchange.
- Number of dissemination events related to the participation in the exchange programmes.

Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP):

Sintef and IREC are partners in the IRPwind project. The activities planned during the research visit are based on the common Tasks of WP81. These are specifically Tasks 8.1.2 and 8.1.3 where both Sintef and IREC are involved. Foreseen activities are focusing on Subtask 8.1.2.1 and Task 8.1.3.

Subtask 8.1.2.1. DoW: Develop enhanced controllers for WPP/WPPC integrated via hybrid AC and MTDC networks in order to keep the DC grid stable and exploring capabilities for provision of ancillary services.

Task 8.1.3. DoW: Two case studies will be considered as examples of future grid configurations and technical analyses, one for an offshore wind farm relatively close to shore and one far from shore. Technical analyses will be undertaken for validating grid stability and implications on security of supply under current grid code requirements.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Description of national projects from the receiving institution

- Emerge Spanish Government - INNPACTO (MICINN). The study and development of electrical engineering associated with deep-water offshore wind power: generation, generator design and transmission, AC-DC line types, connection to the coast, etc.
- Vendaval. Alstom Wind SLU. The aim of this project is to analyse, to model and to simulate possible configurations of offshore wind farms and different offshore wind farms power system connection.
- Roadmap and Design of DC wind power plants (Vendaval 2). Alstom Wind SLU. The scope of this project is to define a roadmap and the first steps to develop the future DC wind power plants (WPP) for offshore applications.
- Design of a Modular Power Converter for AC and DC wind power plants (Vendaval 3) Alstom Wind SLU. This project relies on providing conceptual designs of modular and adaptable power converters for their use in both AC and DC wind power plants; carrying out studies to evaluate their performance and comparison determining the best power converter option. Finally, a detailed technical specification of the most advantageous power converter design that enables further studies on the construction of a prototype will be produced.
- Electrical configuration selection for competitive storage enabled PV building blocks Alstom Renewables SLU. This project deals with the development of technical and economic tool for determining the most cost-effective electrical configuration for a PV power plant considering the integration of energy storage systems for grid integration issues.

Description of national projects from the sending institution

- NOWITECH. The objective of NOWITECH is pre-competitive research laying a foundation for industrial value creation and cost-effective offshore wind farms. Emphasis is on “deep-sea” (+30 m) including bottom-fixed and floating wind turbines.
- NSON. The aim of this project is the analysis and evaluation of different market and network options for the North Sea with regard to their impact on the European electric power system. The cases considered include the connection of different synchronous areas, the planning and operation of meshed Multi-Terminal High Voltage Direct Current (HVDC) networks, the integration of new offshore storage concepts.

Foreseen European added value of national alignment.

The Norwegian hydropower based electricity system has good power balancing abilities. The large-scale implementation of wind power in Europe creates an increasing need for balancing resources. Norway has therefore often been considered as the future "green battery" of Europe. This European approach to power balancing offers significant advantages (e.g. highlighted by the e-Highway project). However, such a European approach requires good coordination and alignment on a European scale. Spain being a "wind power country" is therefore a natural partner for Norway.

The research visit will improve the coordination of activities within IRPWind WP81, leading to better and more natural collaboration than possibly only by email and telephone meetings. This will lead to more efficient and fruitful cooperation between Sintef and IREC regarding IRPwind activities. In addition to the direct benefits for the IRPwind work, the knowledge exchange will be generally valuable for both sides, have positive effects on related projects at both institutes.

Description of the host institute: e.g. infrastructure, experience etc.

The Electrical Engineering Research Area of IREC has been working in several research lines related to control, design and grid integration of wind power and other renewable sources (such as PV) in the last years. We have participated in several industrial projects mainly with Alstom Renewables and also in some competitive research projects.

Research infrastructures and test facilities in IREC

IREC's electrical lab is currently operating with a number of configurable units. The units can be configured to work as energy generators (for example wind power), energy storage nodes or energy consumption nodes. Also real storage systems (flywheel, super-capacitors and batteries), wind emulators (SCIG, DFIG, PMSG and multi-phase generators) and PEV charging point are integrated. Finally, there is a grid emulator allowing studying different grid perturbations and configurations.

3. Work plan

At IREC, Til Kristian Vrana will have the opportunity to increase his knowledge and experience on control strategies for wind power plants and ancillary services control for wind power grid integration. He will contribute to IREC providing know how on MT-HVDC control and the CIGRE HVDC test grid.

The plan is to address the following points:

- Exchanging ideas on
  - Frequency control contribution from offshore wind power plants.
  - DC voltage control contribution for MT-HVDC from offshore wind power plants.
  - Correlation between AC frequency and DC voltage control
- Developing of control systems for
  - Offshore wind power plants
  - MT-HVDC converters
- Implementing a testing environment in PowerFactory
- Testing the control concepts with regard to grid codes
- Preparing the testing environment for testing of other control aspects (involvement from University of Strathclyde
- Testing also these control aspects, if they will be available early enough.

4. Benefits to EERA objective advancement

The research visit of Til Kristian Vrana at IREC will contribute to the advancement of the EERA strategy goals on aligning European research on wind integration and on performing coordinated research. Moreover, after the mobility period, continuous interaction among the centres for further developing joint research will ensure further advancement on reaching such goals.

The research to be done during the research visit is well aligned with several research objectives within EERA Wind. The work deals with the Research Themes

- RT1: Wind power plant capabilities
- RT3: Wind energy and power management from EERA JP Wind Grid Integration sub-programme
- RT5: Control, operation and maintenance of offshore wind farms from EERA JP Wind Sub-programme on Offshore Wind Energy

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

The work developed will contribute to IRPWind project objectives, specifically WP81 where both Sintef and IREC are involved. The results will be disseminated in the deliverables of WP81. Specific results of special relevance are to be additionally disseminated in joint publications under the regime of IRP and EERA Wind.

A workshop will be organised at IREC to disseminate the outputs of the research visit and to discuss how to keep the link beyond the research visit. Further dissemination will be done within IRPWind and EERA JP Wind SP Grid Integration.

6. Expected results

The results expected are

- Specific results described in the DoW of IRPwind WP81
- At least one joint research article
- A workshop
- Ideas for future collaboration and joint project proposals

Funded by EU

Application form for Mobility grants within IRPWIND

NOTE

- **All documents must be named as follows:**

Sub Programme letter, Number of months, Surname, Document type. Ex: A_03_Smidt_cv See Table C) below.

- **The application must be max. 6 pages, ex tables, figures and references.**

A) Applicant details

Applicant Name	**Jose Luis**
Applicant Surname	**Domínguez-García**
Home Institution	**Catalonia Institute for Energy Research (IREC)**
IRP Partner? *(yes/no)*	**YES**
Home Institution Postal address	**Jardins de les dones de negre 1, 2nd floor.** **08930 Sant adrià de Besòs, Barcelona, Spain**
E-mail	**jldominguez@irec.cat**

B) Host institution details

Institute name	**University of Strathclyde (UoS)**
IRP PARTNER?	**YES**
Contact person	**Olimpo Anaya-Lara**
Country	**United Kingdom**
E-mail	**olimpo.anaya-lara@strath.ac.uk**

C) Relevant Programme and scheme

CORE PROJECT? YES/NO *(Please erase the non-relevant)*	**(B) Wind Integration**	**RELEVANT EERA SUB-PROGRAMME Max 2** **(Please erase the non-relevant)**	**(A) Offshore Wind Energy** **(B) Wind Integration**
Length of the grant scheme *(Please erase the non-relevant length)*	**(03) 3 months**	**Start date:**	**1st November 2015**

D. Project description

ANCILLARY SERVICES PROVISION FROM WIND POWER PLANTS

1. Introduction

Research topics, originality. The integration of wind power to power systems leads to a change on power systems dynamics and response. To overcome this, TSOs are asking wind power plants to contribute to ensure power systems stability and security with novel grid code requirements. How wind power may provide such requirements is a challenge.

Technological Readiness Level (TRL) of the proposed concept. Not really applicable to this mobility which aims to increase and share know how among IRPWind partners on a more general level.

Definition of Key Performance Indicators (KPIs). This mobility aims to contribute to following IRPWIND KPIs:

- Number of (existing and new) projects that cooperate actively with IRPWIND and that exchange knowledge with IRPWIND.
- Number of joint publications by IRP participants.
- Number of researchers and reports from these researchers involved in mobility and exchange programmes.
- Number of days of mobility and exchange.
- Number of dissemination events related to the participation in the exchange programmes.

Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP):

This mobility will allow a fruitful and deeper collaboration of a researcher from IREC visiting the leading group of WP81 in IRPWind. This mobility will allow the identification of synergies between IREC and UoS long-term objectives aligned with IRPWind and EERA JP Wind main goals.

The main contribution will be on designing different control schemes for providing ancillary services from wind power plants. This work also expects to consider not only AC connection but also HVDC and/or Multi-

terminal HVDC. This will contribute to Task 8.1.2 Control Strategies for Integrating and Operating Future International Clusters of Wind Farms.
Work to be developed deals with some topics to be treated by the project proposal AnSer2RES under review at the H2020 LCE 6 call.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Description of national projects from the receiving institution:

- **Centre for Doctoral Training in Wind Energy (CDT Wind).** The scope of the research is unrestricted. In particular, we are undertaking research into wind turbine and wind farm control, offshore networks and grid integration and offshore asset management.
- **Industrial Doctoral Centre for Offshore Renewable Energy.** The scope of the research is unrestricted. In particular, we are undertaking research into offshore networks and grid integration offshore asset management.
- **SuperGen Wind Energy Hub.** The scope of research is on wind farm and wind turbine control and offshore networks

Description of national projects from the sending institution

- **Emerge Spanish Government - INNPACTO** (MICINN). The study and development of electrical engineering associated with deep water offshore wind power: generation, generator design and transmission, AC-DC line types, connection to the coast, etc
- **Vendaval**. Alstom Wind SLU. The aim of this project is to analyze, to model and to simulate possible configurations of offshore wind farms and different offshore wind farms power system connection.
- **Roadmap and Design of DC wind power plants (Vendaval 2)**. Alstom Wind SLU. The scope of this project is to define a roadmap and the first steps to develop the future DC wind power plants (WPP) for offshore applications.
- **Design of a Modular Power Converter for AC and DC wind power plants (Vendaval 3)** Alstom Wind SLU. This project relies on providing conceptual designs of modular and adaptable power converters for their use in both AC and DC wind power plants; carrying out studies to evaluate their performance and comparison determining the best power converter option. Finally, a detailed technical specification of the most advantageous power converter design that enables further studies on the construction of a prototype will be produced.
- **Electrical configuration selection for competitive storage enabled PV building blocks** Alstom Renewables SLU. This project deals with the development of technical and economic tool for determining the most cost-effective electrical configuration for a PV power plant considering the integration of energy storage systems for grid integration issues.

Foreseen European added value of national alignment.

The rapid increase of wind power penetration on electricity generation share is leading to changes on power system behaviour. In 2050, such changes will be even harder since about 100% of renewable energy is expected to be generated. Due to this, how wind farms may provide ancillary services, which currently are being provided by thermal or other conventional-based generation, became a relevant challenge to be solved. This change is affecting especially to island (or sort of) power systems such as Unite Kingdom and Spain. Thus, it is expected that those electrical systems present stringent grid codes for wind power integration to ensure its security and stability. Moreover, the interconnection among countries and offshore wind by means of a MT-HVDC grid is lately attracting interest, and some proposals are being done for the North Sea. The mobility period will be used, in addition to work related directly to IRPWind Task 8.1, to have interviews with British actors on the sector for determining their interests and needs. The aim is to contribute to ease wind power integration while ensuring a stable and secure power systems. The works is aimed to align specific needs of ancillary services from UK and Spain, which can be expanded to the whole European grid. By means of EERA Wind SP Grid Integration and other collaborative associations, the work can help to obtain wider aligned all over Europe.

Description of the host institute: e.g. infrastructure, experience etc.

The University of Strathclyde is an international technological higher education institution, research-led, with a reputation for innovation and enterprise. The University is engaged in a large number of international collaborative projects, involving over 600 academic and industrial partners in over 80 EU FP7 projects.
The wind energy group at Strathclyde University has approximately 80 researchers and 10 academic staff. The research covers all aspects of wind energy with particular strengths in wind turbine control, grid-integration, offshore power networks, wind turbine condition monitoring, asset management, floating and fixed support structures and wind turbine design. The group, has a current portfolio exceeding £10M, including the EPSRC funded Centre for Doctoral Training in Wind Energy Systems.
Research is supported by EPSRC, DECC, the Scottish Government, EU and industry. It leads or co-leads many of the relevant EPSRC Supergen consortia including Wind Energy Technologies. In addition, it is a member of the Supergen Energy Infrastructure and Marine consortia. European research grants of relevance include DOWNVind (on offshore wind power), DISPOWER (distributed power systems), InnWind, DTOC, WindTrust and IRPWind.
Active research programmes exist with Gamesa, Rolls-Royce, Scottish Power, Scottish and Southern Energy, National Grid, EdF, E.On, ABB and British Energy.

3. Work plan

In University of Strathclyde, José Luis Domínguez-García will have the opportunity to increase his knowledge and experience on control strategies for wind turbines and wind farms. He will contribute to UoS providing know how and experience on ancillary services control for wind power grid integration as well as MT-HVDC technology and control knowledge. He will also create a link among North Sea projects from UoS and IREC's work on offshore wind power plants experience.

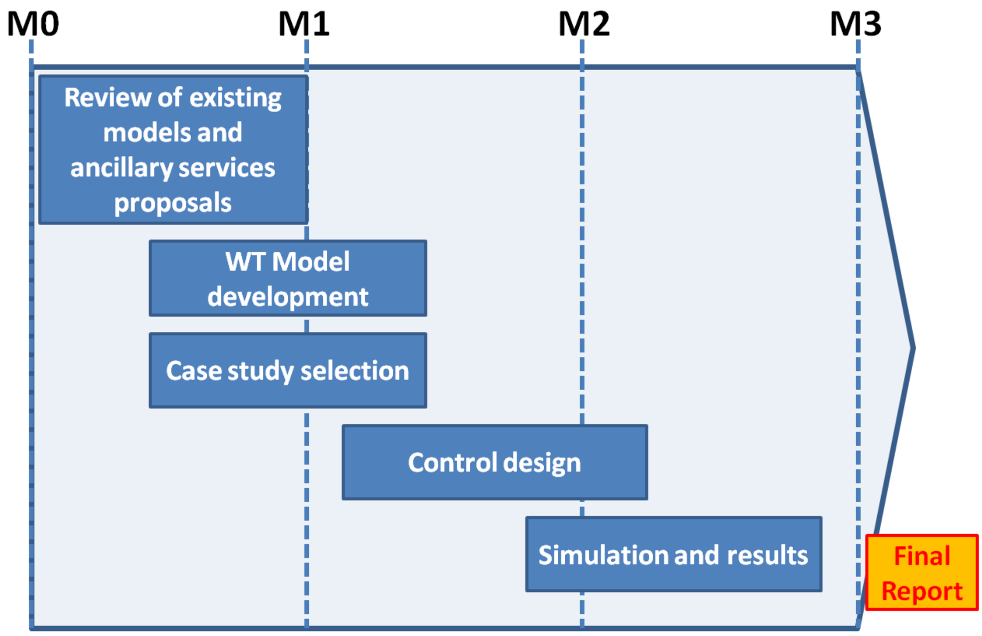
Meeting with other UK actors are expected to be organized such as Scottish Power, National Grid, among others, for providing and obtaining better knowledge among industry experience and needs regarding power systems changes and especially wind power penetration increase. Moreover, these meetings will allow wider dissemination of UoS/IREC joint mobility tasks and expected results. Moreover, currently UoS and IREC are in the EERA consortium for the LCE6 proposal ”AnSer2RES” and on the approved but not funded LCE2 2014 proposal ”SmartWind” developing such research lines, and future collaborative projects will be searched for.

During the mobility period some Special lectures for the Universtity of Strathclyde will be given on ancillary services provision and grid integration of wind power. For increasing interest of students on research topics related to wind power and specially grid integration.

Joint publications will be an objective of the mobility period. These will be written on the provision of ancillary services from wind turbines. The work developed will also contribute to IRPWind project objectives, concretelly in task 8.1 where both centers are working.

A workshops will be organised at University of Strathclyde to disseminate the outputs of the mobility stage.

The following schedule is expected aiming to reach the specific and challenging goals of the mobility programme during the 3 months.



Some potential Risks which can limit the objectives proposed can be the lack of data for model development, the not appropriate definition of study cases for Current and New Grid Code compliance and the usage of not adequate software. For that reason a risk management plan will be prepared for reducing such risks. The plan includes the selection of a well-known benchmark for testing, the selection of common software for modeling and control design and finally, the selection of well-known wind turbine models prepared for ancillary services validation.

4. Benefits to EERA objective advancement

The mobility period of a researcher will contribute to the advancement of the EERA strategy goals on aligning European research on wind integration and on performing coordinated research. The experience of both the hosting group and the researcher will help in achieving good advancement in the relatively short period of 3 months. Moreover, after the mobility period, continuous interaction among the centres for further developing joint research will ensure further advancement on reaching such goals.

The research to be developed during the mobility stage is well aligned with several research objectives within EERA Wind. The work deals with the Research Themes RT1: Wind power plant capabilities and RT3: Wind energy and power management from EERA JP Wind Grid Integration sub-programme. However, this work will also have an impact on RT5: Control, operation and maintenance of offshore wind farms from EERA JP Wind Sub-programme on Offshore Wind Energy.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

Dissemination is planned through joint publications as well as a workshop in Glasgow. The publication/publications will be part of IRP and EERA Wind articles.

The general findings on control development for ancillary services provision from wind power will be reported to national projects such as SuperGen, also further dissemination will be done within IRPWind and EERA JP Wind SP Grid Integration.

6. Expected results

At the end of the mobility period we aim to have joint publications, to have organised a public workshop and ideas for joint project proposals between IREC and UoS.

The general findings on control development for ancillary services provision from wind power will be reported to national projects such as SuperGen, also further dissemination will be done within IRPWind and EERA JP Wind SP Grid Integration.

Funded by EU

Application form for Mobility grants within IRPWIND

- **All documents must be named as follows:**

Sub Programme letter, Number of months, Surname, Document type. Ex: A_03_Smidt_cv See Table C) below.

A) Applicant details

Applicant Name	Philipp
Applicant Surname	Härtel
Home Institution	Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)
IRP Partner?	Yes
Home Institution Postal address	Königstor 59 34119 Kassel (Germany)
E-mail	philipp.haertel@iwes.fraunhofer.de

B) Host institution details

Institute name	SINTEF Energi AS
IRP Partner?	Yes
Contact person	Hans Christian Bolstad
Country	Norway
E-mail	hans.christian.bolstad@sintef.no

C) Relevant Programme and scheme

CORE PROJECT? YES/NO	**(B) Wind Integration**	**Relevant EERA SUB PROGRAMME** **Max 2**	**(B) Wind Integration**
Length of the grant scheme	**(02) 4-26 weeks**	**Number of weeks** **Start date:**	**13 weeks (April-June 2016)** **1 April 2016**

D) Project description

Impact of alternative flexibility options on offshore grids in the North Sea

1. Introduction

Research topics and originality

The ongoing generation shift from dispatchable hydro-thermal generation towards fluctuating renewable feed-in in the respective generation portfolios is a main driver of energy system evolution as it demands increased flexibility of the energy system and yields a new allocation of power flows at the same time. In an energy system dominated by renewable energy generation, the efficient utilization of spatial and temporal fluctuations induces increased energy transfer between market areas. Offshore transmission infrastructure in the North Sea Region, especially in the form of an integrated offshore grid, can provide additional flexibility to the system and avoid heavy curtailment of weather-dependent renewable energy generation.

Therefore, discussions about offshore grids serving the twofold purpose of integrating offshore generation into onshore energy systems and at the same time enabling cross-border electricity trade are intensifying. As offshore infrastructure is comparatively costly and has to compete with other flexibility options, accounting for the flexibility potential that already exists in the system or which is likely to be tapped in the future is critical. These alternative flexibility options among others include existing storage plants across Europe, demand-side management/ demand response options and more flexible fossil power plants (CHP flexibility by means of power-to-heat).

As a consequence of the above, the main focus and also the originality of this proposal lies on methods and modelling approaches for assessing the impact of alternative flexibility options on offshore grid designs in the North Sea. This involves finding and implementing suitable transmission expansion planning (TEP) models for offshore grid investments. As one part of this modelling process, building aggregated but adequate models of hydro power systems across Europe plays an important role as well as aligning cost data for offshore grid components for the investment decisions. Based on the need of evaluating the cost-benefit allocation on a single market area level, a commonly agreed upon cost-benefit evaluation methodology has to be found and will therefore also be part of work plan of this proposal.

Since 2012 the founding institutes *SINTEF*, *Fraunhofer IWES*, *University of Strathclyde* and newer members *DTU*, *ECN, NTNU* and *UCD* have been developing the *North Sea Offshore Network (NSON) Initiative* with national activities. It is closely linked to the *EERA Joint Programme Wind* and its *Sub Programme (SP) Wind Integration*. Integrating knowledge from nationally funded projects and gathering results on a collaborative level is at the core of the *NSON Initiative*.

Regarding the *IRPWind Mobility* project proposed here, *SINTEF Energy Research* brings in experience from several national projects in which offshore grid design concepts and scenarios have been defined and evaluated. Given Norway's energy system dominated by hydro power, *SINTEF* has substantial knowledge in building and operating hydro power models. This will be combined with the in-depth expertise of *Fraunhofer IWES* on energy economy, system analysis and grid planning. The possibility of discussing different approaches and comparing data assumptions in person holds great merits, both from a methodological and a result's point of view. Complex tasks such as the assessment of cost-benefit implications of offshore grids can be collaboratively investigated and evaluated. Moreover, an improved quality of published research can be expected on a daily basis of collaboration.

Technological Readiness Level (TRL) of the proposed concept

As the proposed concept primarily involves future energy system investigation with a mid- and long-term focus, the relevant *Technological Readiness Levels* are within the range of TRL 2 and 4.

Definition of Key Performance Indicators (KPIs)

For this *IRPWind Mobility* project the following KPIs can be defined:

- Applicability and usefulness of a consistent data set covering cost parameters for offshore grid transmission technology options,
- Availability and functionality of aggregated models for hydro power representation in unit commitment/ transmission expansion planning models,
- Completed comparison of two market-based offshore grid expansion planning models,
- Commonly agreed upon cost-benefit allocation evaluation methodology,
- Successful submission of a journal paper containing central results of this *IRPWind Mobility* project.

Description of links to relevant *EERA Sub Programmes (SP)* and/or *IRPWind Core Projects (CP)*

As to the *EERA Joint Programme on Wind Energy*, this *IRPWind Mobility* project is primarily linked to the *SP Wind Integration* as it aims to contribute to *SP*'s objective of laying a scientific foundation for cost-effective wind power production and integration. More specifically, the *SP*'s research theme *Grid planning and operation* covers the assessment of future European grid requirements with a particular focus on trans-national offshore grid infrastructures. Therefore, 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 are crucial. This exactly is the purpose of the *IRPWind Mobility* project proposed here, since sharing model experiences for investigating offshore grid designs and its cost-benefit implications as well as jointly discussing implemented methodologies and simulation results are central activities deduced from the general *SP* structure.

Regarding the *IRPWind Core Projects*, the most relevant link is established by the ongoing tasks in work package 8 and 8.3 in particular. Given its title *Power Market Design and Modelling for High Wind Penetration*, *IRPWind* work package 8.3 is in line with the proposed work content of this *IRPWind Mobility* project. As the main purpose is to work on new and refined offshore grid planning and optimization tools with a special focus on the interdependencies with existing and new system flexibility and its cost-benefit implications in the connected market areas, one of the work package's objectives of determining economically robust offshore grids is directly addressed.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Description of relevant national projects from the receiving institution *SINTEF*

- *National North Sea Offshore Network project in Norway (NSON-NO)*

  NSON-NO provides a framework of methods and tools for offshore grid investment decisions for alternative cost-benefit sharing models, reflecting the trade-off between the risks of stranded investments vs. the risk of building parallel infrastructure. This includes model development and analysis of case based point-to-point vs. common overall grid. The associated activity by NTNU is a PhD project on the optimization of onshore and offshore grid structures in the North Sea region, with a particular focus on the treatment of long-term uncertainty. From a policy perspective, national and EU policies driving or hindering the development of offshore grids are investigated.

- *NOWITECH – Research Centre for Offshore Wind Technology*

  Work package 3 of NOWITECH considers Grid Connection and System Integration of Offshore Wind Farms. Among other topics, this includes SINTEF's research activities and NTNU's PhD projects on the operation and design of meshed offshore grids in the North Sea.

- *CEDREN - Research Centre for Environmental Design of Renewable Energy*
  The CEDREN Hydrobalance project particularly investigates the utilization of Norwegian hydro power for balancing of European wind and solar power, facilitated by strengthening North Sea interconnectors.

- *EERA-DTOC (Work Package 2)*

  The overall objective is to develop a tool and procedure for the optimization of the electrical design of offshore wind farm clusters including the provision of power plant system services by the cluster. SINTEF's task is to analyse connections to the main grid and clustering of wind farms. To be able to find the optimal clustering of wind farms in an area, it is necessary to assess different alternatives for connection to the main grid; e.g. AC directly to shore, DC directly to shore, or connection to an offshore grid hub. The aim is further to determine how the wind farms can be connected into clusters, where the number, size and location of offshore substations must be found. The optimization of the connection to the main grid is conducted by using the Mixed-Integer LP model for offshore transmission planning NET-OP.

- *IRPWind (Work Package 8.3)*

  The overall objective of this work package is to study challenges and possibilities related to the electricity market in a situation with high penetration of wind power. SINTEF's task is to determine economically robust offshore grids taking into account markets and uncertainties in wind developments.

- *BestPaths*

  Task 13.6 of work package 13 contains socio-economic cost-benefit analyses of different offshore grid options. By incorporating the potential contribution of different configurations of offshore trans-border connections in the North Sea, research activities address socio-economic benefits, cost savings and gross consumer surplus of different offshore grid topologies in the northern European system (radial connection, clustering, possibly of T-connection with HVDC links between countries around the North Sea).

Description of relevant national projects from the sending institution *Fraunhofer IWES*

- *National North Sea Offshore Network project in Germany (NSON-DE)*

  Fraunhofer IWES is the head of the national *NSON* project consortium in Germany and together with the *Institute of Mathematics* (*University of Kassel*) and the *Institute of Electric Power Systems* (*Leibniz University Hannover*) they have been granted funding within the call *Zukunftsfähige Stromnetze*. This joint call was published by the *Federal Ministry for the Environment, Nature Conversation and Nuclear Safety (BMU, now BMUB),* the *Federal Ministry for Economic Affairs and Energy (BMWi)* and the *Federal Ministry of Education and Research (BMBF)*. The *NSON-DE* project started in October 2014 and will run for three years until September 2017. The project consists of the seven following work packages:

  - WP 1: Project coordination
  - WP 2: Development of consistent scenarios
  - WP 3: Energy meteorology and requirement analysis of future power plants
  - WP 4: Technology analysis and evaluation
  - WP 5: Market simulation, grid planning and load flow calculations for a NSON reference concept
  - WP 6: Iterative cost-benefit analysis and evaluation of various NSON market and grid concepts regarding techno-economic aspects
  - WP 7: Framework conditions and analysis of external influencing factors

  In particular, WP 5 and 6 of the German *NSON-DE* project will greatly benefit from the collaboration and experience of *SINTEF* and *Fraunhofer IWES* colleagues.

- *IRPWind*
- *EERA-DTOC*

Foreseen European added value of national alignment

Regarding the idea of an offshore grid in the North Sea area, several studies support that a common undertaking, with shared costs among the different stakeholders over a long timeframe, will be considerably cheaper than a case by case approach. The overall cost will be minimized and future industrial initiatives in the region (e.g. more offshore wind and ocean energy) would see a relatively lower marginal integration cost.

All countries are making substantial efforts to address these issues at a national level. The national alignment already initiated by the *NSON Initiative* keeps the national starting point and enhances it with joint European planning. This includes sharing of work and results within the *NSON* research initiative and beyond, for example with *EERA* members.

The *IRPWind Mobility* project proposed here intends to build new, compare and refine existing offshore grid planning tools with a special focus on long-term developments of Europe's energy system. Therefore, it contributes to facing the main challenges of on- and offshore grid development in Europe, eventually touching upon the main pillars of the EU's energy strategy: strengthening the Internal Energy Market, integrating large amounts of renewable energy sources and guaranteeing security of supply.

Description of the host institute *SINTEF*

SINTEF Energy Research has a focus on finding solutions related to power production and conversion, transmission/distribution and the end use of energy both onshore and offshore/subsea. We cover all the key areas from the indoor climate and energy use in buildings to gas technology, combustion, CCS, bioenergy, refrigeration engineering and technology for the food and nutrition industry. Recent and ongoing research activities relevant for this proposal includes our contributions to the EU-projects *eHighWay2050*, *Twenties*, *OffshoreGrid* and *WindSpeed* as well as several nationally funded research projects, ranging from economic analysis of offshore grids to technical solutions for HVDC systems and components (see project list above).

3. Work plan

Month 1 (April)

- Developing suitable aggregated hydro power models for the application in transmission grid expansion planning/ unit commitment models

  Milestone: Aggregated hydro power models implemented and operational

Month 2 (May)

- Comparing cost models and parameters for offshore grid transmission technology options for the application in transmission grid expansion planning models

  Milestone: Consistent cost model and updated cost data set completed

- Undertaking model comparison of two market-based offshore grid expansion planning models (i.e. SINTEF's NetOp model and the TEP model developed at Fraunhofer IWES within the NSON-DE project)

  Milestone: Model comparison completed and results analysed

Month 3 (June)

- Discussing and aligning cost-benefit evaluation methodology for upcoming analyses in the NSON-DE project

  Milestone: Agreed-upon cost-benefit evaluation methodology for application in further NSON activities

As a general task during the *IRPWind Mobility* project, the submission of a journal paper focussing on the *Fraunhofer IWES* offshore transmission expansion planning model is planned, this particularly includes planned work results of month 1 and 2.

4. Benefits to EERA objective advancement

The objective and its related contents in the planned work layout of this proposal are directly linked to the *EERA* strategy goals, more specifically, to the following two research themes of the *EERA SP Wind Integration*:

- ***SP Wind Integration* research theme 2: *Grid planning and operation***
  This proposal will contribute to the sustainable enlargement of the transmission capacity and the enhancement of grid utilization levels by developing and providing planning tools taking into account large penetration and future capabilities of wind power. Refining and further developing transmission expansion planning models with a special focus on offshore grids in the North Sea will help to better

assess future grid structures of (far-) offshore wind power plants connected to multi-terminal operated and controlled trans-national offshore grids.

- ***SP Wind Integration* research theme 3: *Wind energy and power management***
  As the focus is put on alternative flexibility options and their interdependencies with offshore grid development, the tools being developed in this proposal will help to evaluate the interaction between offshore wind power, other RES, existing and new storage systems and demand-side management.

By addressing these research themes of the *SP Wind Integration*, this proposal can help in advancing grid infrastructure optimization tools and on top of that identify new research gaps in need of further investigation.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

The transfer of knowledge is intended by the following dissemination activities, but not necessarily limited to these:

- The results of this proposed project will be presented and discussed at a NSON/ EERA workshop which will also include a plan for following up on the model development and application,
- Central results of the *IRPWind Mobility* scheme will be publicly available after a successful submission of the planned journal paper,
- The *IRPWind Mobility* report will be distributed to a suitable group of interested persons,
- A summary of the collaboration at *SINTEF* highlighting the results will be issued in an *NSON* update within the *IRPWind* newsletter.

The activities presented above will also provide potential links for future collaboration with other *IRP/EERA* partners.

6. Expected results

Methodologies and/or databases and/or best practices functional to the activities of the *IRP* and *EERA* strategic agenda objectives

The *IRPWind Mobility* project report will contain the methodological results concerning the examined offshore grid expansion planning tools and the cost-benefit evaluation methodology which are to be applied in the ongoing national project(s). These outcomes can also have a functional value for *IRP* and *EERA* partners outside the *NSON Initiative*. The same goes for offshore component cost data as well as aggregated hydro power models.

Assessment of the advancement of the TRL

As this is a project in an early phase of a long process towards an offshore grid in the North Sea, the TRL level is expected to remain at the same level. However, as part of the KPI assessment by other *NSON* partners, the expected time and effort to reach the next TRL level can be reported.

Assessment of the KPIs

The KPIs will be measured by a review of two other partners within the *NSON Initiative*, who will evaluate the added value of the offshore grid planning tool comparison and critically assess cost-benefit allocation methodology.

Funded by EU

Application form for Mobility grants within IRPWIND

A) Applicant details

Applicant Name	**Malo**
Applicant Surname	**Rosemeier**
Home Institution	**Fraunhofer IWES Northwest**
IRP Partner? *(yes/no)*	**yes**
Home Institution Postal address	**Am Seedeich 45** **27572 Bremerhaven, GERMANY**
E-mail	**malo.rosemeier@iwes.fraunhofer.de**

B) Host institution details

Institute name	**DTU Wind Energy**
IRP PARTNER?	**yes**
Contact person	**Kim Branner**
Country	**Denmark**
E-mail	**kibr@dtu.dk**

C) Relevant Programme and scheme

CORE PROJECT? ***YES/NO*** *(Please erase the non-relevant)*	**(C) Structures and Materials**	**RELEVANT EERA SUB-PROGRAMME** **Max 2** (Please erase the non-relevant)	**(C) Structures and Materials**
Length of the grant scheme *(Please erase the non-relevant length)*	**(03) 3 months**	**Start date:**	**March 1, 2016**

D. Project description

Validation and Improvement of Component Test Design Models (VALDEMOD)

1. Introduction

- Research topics, originality:

The goal of this project is to develop and validate design models for an integrated process towards defining a trailing edge (TE) component test out of a full-scale rotor blade structure, i.e. definition of test loading, test configuration, and test validation. Current design models need to be improved in terms of material, geometry and structural detail modeling of the specimen, reinforcement of the test specimen, as well as load introduction and configuration of the test setup. Definition of measurement strategies are required to validate those design models with the experimental results.

The research focus of the TE component test is to mimic both static compressive and dynamic tension compression loading in the bond line and the panels as the component will be subjected to under full-scale conditions. Realistic loading conditions for e.g. the static test (pure compression) and simplified conditions (varying compressive strain at the edges of the specimen) are possible by a smart choice of load introduction. The challenge is to exclude the edge effects due to the boundary conditions in the component test. Thus, a proper design of reinforcements is required.

TE tests with scientific focus have been conducted at DTU Wind Energy for the ultimate limit state (static loading). Also, TE component tests for industry purposes have already been conducted at IWES for the fatigue limit state (dynamic loading). Experiences of both institutions, i.e. the type of testing (static/dynamic) and the testing purpose (scientific/industry relevance) are bundled in this project.

Within WP7.1 of IRPWind similar blade parts of five 34m blades, i.e. TE panels are shared and tested in both institutions IWES and DTU. Current models are used to design those tests. At the beginning of this project results of the first tests are available. IWES and DTU are aiming for different test setups of the same type of specimen, while initially using both their own design models. Experiences of both test setups and test results are gathered into improved models to design future tests of the same type of specimen.

Current research has shown that a rotor blade structure undergoes geometrically non-linear deformations and linear models are not sufficient to capture these effects [1]. Especially in a combined load case the trailing edge (TE) failure can be caused by these effects [2-3]. It is shown that current standards and guidelines for the design of rotor blades do not sufficiently cover those phenomena in the certification process. Future design guidelines such as the IEC61400-5 ”Rotor blades” and the DNVGL-ST-0376 ”Rotor blades for wind turbines” will encourage designers to use validated models and appropriate analysis methods. Component tests represent a relatively economic way for validation. Thus, the outcome of this project will support the industry with proposals for applicable methods and modeling strategies for component tests.

This project will provide the following deliverables:

- Proposals for current design model improvements to predict a more compliant test behavior based on the available measurement data from experiments.
- Proposal for a test setup using the improved design model for future component tests.

- Technological Readiness Level (TRL) of the proposed concept.

The Technological Readiness Level at the beginning of the project ”Validation and Improvement of Component Test Design Models” is 2-3: Simple models are available to design a component test and components are available for testing. On the one hand the models still lack of predicting the behavior observed in component tests. And on the other hand the testing boundary conditions are not properly modeled to design a component test that fails in the desired conditions.

- Definition of Key Performance Indicators (KPIs).

The key performance is indicated by the quality of the design models' prediction of the experimental behavior, i. e. capturing the structural response from experiments in a numerical model. Mathematically it is defined as deviation between the model's response and the experimental measurements (strains, deflections, damage, etc.).

- Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP).

This project links to the EERA SP6 “Structural design and materials” whose objective is to reduce the uncertainty in the design of structural load carrying components as well as machinery components in order to increase cost efficiency and reliability and allow for optimization, innovations and up scaling of future wind turbines.

Further, this project links to the IRPWind WP7.1 “Efficient blade structure” where the objective is to provide a basis for the validation of structural design methodologies through experiments on blade subcomponents: first tests on wind turbine blade subparts and model support structures are planned for the end of the year 2015. Due to the interconnecting structure of WP7, a strong interaction between the different work packages and the research teams involved is required; an IRPWind WP7 meeting in May 2015 formed a basis for the proceedings and interconnection between all partners.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

- Description of national projects from the receiving institution.

Danish Centre for Composite Structures and Materials for Wind Turbines (DCCSM) (2010 – 2017): Wind turbine blades are usually made from composite materials such as glass fiber and carbon fiber reinforced plastic and lightweight cores. These are during their lifespan exposed to fierce weather conditions. Furthermore, future wind turbines are becoming larger and are in increasing number sited offshore which makes servicing more expensive and challenging. This calls for very reliable wind turbines with as few stops as possible. The purpose of DCCSM is therefore to develop new experimental and modelling methods covering everything from micro scale defects to cracks that are several meters long with the purpose of improving our understanding of what make defects develop into major cracks which can cause wind turbine blades to fail. The methods have potential for the development of more damage tolerant composite materials resulting in more reliable wind turbine blade structures as well as prediction of the evolution of damages and cracks.

- Description of national projects from the sending institution.

Introduction of component tests as part of the development and certification of rotor blade for wind turbines (KompZert) (2014 -2016): The goal of the national KompZert project is to develop general concepts for component tests of rotor blades. These concepts will be assembled in a requirements catalogue, which is the basis for advancements of the international standard series IEC 61400. IWES and DNV GL introduce jointly the development and certification of component tests for wind turbine rotor blades, while IWES develops test designs and their implementation and DNV GL takes the part of certification and standardization in the project.

Increase of service life time and light weight structure optimization through nano modified and hybrid materials in the rotor blade (LENAH) (2015-2018): With focus on the improvement on fatigue behavior and a better application of light weight structures in rotor blades, the project aims for: (1) improvement of matrix dominated material properties of endless fiber reinforced laminates through nano particles, (2) improvement of mechanical properties of short fiber reinforced adhesives through nano particles, (3) material reinforcement in load introduction areas through the introduction of metal foils into the fiber reinforced plastics, and (4) efficient application of carbon reinforced plastics (CFRP) through hybrid glass and carbon reinforced plastics (GFRP/CFRP) materials. Within the project's consortium of IWES, DLR and ForWind, IWES is developing structural blade component models, which are based on appropriate models for the above mentioned materials. Those models are validated with component tests.

- Foreseen European added value of national alignment.

The above mentioned national projects connect directly to the IRPWind WP7.1 and to this project aiming for validated models for component testing. The European industry will benefit from the covered scientific topics and the developed methods. The cooperation between the partners will be enhanced and state a basis for future collaborations on a European level.

- Description of the host institute: e.g. infrastructure, experience etc.

DTU Wind Energy is a globally leading department for wind energy with scientific and engineering competences in the international front and with a unique integration of research, education, innovation and public/private sector consulting.

The hosting section "Wind turbine structures" operates a full-scale testing facility as well as component test rigs. Further DTU Wind Energy operates a strong computational cluster required for costly numerical calculations. Within the Danish project "Experimental blade research – phase 2" experiences has been gathered and analysis models were proposed with regard to combined ultimate full-scale testing and its response on the trailing edge bond line.

3. Work plan

- Deliverables, milestones etc.

Week 1 to 4	- Evaluation of the structural response predicted by test design models with respect to the gathered component test results. - Identification of relevant design model improvements, e.g. material model, load introduction, or geometry modeling. - Proposal for design model improvements to predict a more compliant test behavior (D1).
Week 5 to 12	- Implementation of proposed improvements into the design model. - Validation of test design model improvements with the gathered component test results. - Proposal for a test setup using the improved design model for further component tests (D2).

4. Benefits to EERA objective advancement

- Contribution to the advancement of the EERA strategy goals, gaps addressed.

The EERA strategy goals of better integration of European research activities, capacities and resources are addressed by this project. The joint development of design models enhances the cooperation between both organizations. Further, experiences gathered from national projects are bundled and exchanged on a European level. Resources, i. e. available testing setups are shared with European partners and offer a larger variety of research opportunities. Gaps in the wind energy sector of the European Research Area are addressed by supporting standardization and certification with validated models for rotor blade design, as well as better understanding the rotor blade’s failure mechanisms. Both gaps are also addressed by the above mentioned national projects forming a direct connection to the IPRWind research core project WP7 and the EERA JP Wind SP6. This helps to increase the European competiveness.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

- Explain ToK or dissemination strategies and plan of future collaboration with other IRP/EERA partners.

The project results will be shared with the IRP/EERA partners. Since other partners of IRPWind WP7.1 are also testing the same type of specimen, the results of this project will be even more beneficial for those institutes. Further, the results of this project are presented on specific wind conferences like the annual EWEA conference and EERA conferences including the joint submission of a paper.

6. Expected results

- Methodologies and/or databases and/or best practices functional to the activities of the IRP and EERA strategic agenda objectives.

The jointly developed methodologies and component test design model improvements based on experimental results are delivered and represent the main results of this project. The impact of validated design models is already addressed in Chapter 4.

- Assessment of the advancement of the TRL.

At the end of the project, the technological readiness level shall be 3-4: the test design model should be the basis for application on a laboratory level for industry project purposes.

- Assessment of the KPIs.

The first feedback will be foreseen from the evaluation of the structural response predicted by test design models with respect to the gathered component test results at the beginning of the project. Later the KPI can be again evaluated after the validation of test design model improvements with the gathered component test results.

7. References

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Funded by EU

Application form for Mobility grants within IRPWIND

A) Applicant details

Applicant Name	**Teresa**
Applicant Surname	**Lo Feudo**
Home Institution	**CNR-ISAC**
IRP Partner? *(yes/no)*	**Yes**
Home Institution Postal address	**Area Industriale Comp. 15-88046 Lamezia Terme (CZ) Italy**
E-mail	**t.lofeudo@isac.cnr.it; t.lofeudo@gmail.com**

B) Host institution details

Institute name	**DTU Wind Energy**
IRP PARTNER?	**Yes**
Contact person	**Anna Maria Sempreviva**
Country	**Denmark**
E-mail	**anse@dtu.dk**

C) Relevant Programme and scheme

CORE PROJECT? YES/NO *(Please erase the non-relevant)*	**(A) Wind Condition**	**RELEVANT EERA SUB-PROGRAMME Max 2** **(Please erase the non-relevant)**	**(A) Wind Condition**
Length of the grant scheme *(Please erase the non-relevant length)*	**(01) 4 weeks**	**Start date:**	**7 March – 7 April 2016**

D. Project description

The application should take into account the following structure. Further sub-heading might be added.

TITLE OF THE PROJECT

RESEARCH COLLABORATION ON USE OF LIDARS IN COASTAL AREAS

1. Introduction

Developing projects for wind farms needs high quality data under a wide range of atmospheric conditions and models at high spatial-temporal resolution for mapping wind resources or for forecasting energy production at different time horizons. To model coastal areas, both onshore and offshore, is a challenge due to the coastal discontinuity of the surface characteristics. In models, the position of the coastline is not well located due to the low horizontal resolution of the model. In this frame, suitable datasets have a two-fold purpose: for evaluating the accuracy of the model output at different resolutions and for improving existing parameterizing in coastal areas.

To study the dynamics of the coastal Atmospheric Planetary Boundary Layer, PBL, ground-based remote sensing devices such as lidars are nowadays used for monitoring the evolution of the vertical wind structure within the BL [1,2, 3,4,5].

The GAW Regional SUPERSITE of the Institute of Atmospheric Sciences and Climate of the National Council of Research of Italy (CNR-ISAC) section of Lamezia Terme in Italy is an unique site being located 600m from the west coast of the Italian Region Calabria in the central Mediterranean. As the coastline is North-South oriented, wind direction from 90 degrees represents offshore flows 270 degrees represents onshore flow. During summer, the site is characterized by both synoptic flow and sea-land breeze system oriented along west-east. Sea breeze always develops due to the solar heating modulating the synoptic wind with its daily cycle. The landscape inland is characterized as a suburban area with a mix of built environment and agricultural areas with high roughness and sparse houses.

A summer experiment was organized in collaboration with the Wind Energy Department of the Technical University of Denmark (DTU) from July 12 to August 5th 2009 to add new data on the vertical structure of the coastal flow at the coastal discontinuity. A lidar Doppler, WLS7-0012-LEOSPHERE, was used to obtain

time series of vertical profiles of wind speed and direction; the height of the Planetary Boundary Layer (PBL) was retrieved from a Vaisala CL31 ceilometer. The reflectivity of a sodar DSDPA90-24-METEK complemented the information from the lidar and characterizing the vertical thermal structures of the PBL.
A surface standard meteorological station provided measurement of wind speed and direction, temperature, relative humidity, and solar radiation. An ultrasonic anemometer provided turbulent fluxes for estimating atmospheric stability.
The integrated analyses of all these instruments helped in classifying the weather regimes in sea-land breeze, synoptic flow and a combination of the two. During the night, weak low level jets develop and the wind profile shows a daily variation. During synoptic flow, stability is near neutral and the wind vertical profile does not show a change in shape all day long.

Furthermore, since July 2013, a wind Lidar ZephIr has been monitoring vertical profiles between 10 m and 250 m supported by a meteorological ground station. (http://www.i-amica.it/i-amica/?page_id=1122)

Proposed work:

During the stay at DTU, the main activity will be to finalize a joint paper on the campaign of 2009 adding further analysis of the lidar database integrated with the other instruments.
Second activity is to explore similarity and differences between the site of Lamezia Terme and the site of Høvsøre at the west coast of Jutland.

The focus will be on the response of the wind lidar when the sea breeze is fully developed and the vertical layer is non homogeneous in terms of aerosol content due to the presence of the internal boundary layer with marine aerosols above.
This will be performed looking at the raw signal of the lidar in the different wind regimes. In particular starting from the 2009 summer campaign at Lamezia Terme experimental site, we will study the development of the vertical structure of the coastal flow under different meteorological conditions, using different instruments and the WRF model.
The presence of different source of data allows not only to study atmospheric processes in coastal areas but also to describe the vertical structure of the PBL and its spatial variation in different atmospheric conditions. Some of the results from the project are expected to be directly applied in deriving innovative integration analysis of data, leading to better and more clear wind condition.
The DTU Wind Energy department is the ideal partners because of the extensive experience in developing wind lidars and in advanced tools developed for the lidar signal analysis.

References:
[1] Wandinger U., Freudenthaler V., Baars H., Amodeo A., Engelmann R., Mattis I., Groß S., Pappalardo G., Giunta A., D'Amico G., Chaikovsky A., Osipenko F., Slesar A., Nicolae D., Belegante L., Talianu C., Serikov I., Linné H., Jansen, F., Apituley, A., Wilson K. M., de Graaf M., Trickl T., Giehl H., Adam M., Comerón A., Muñoz C., Rocadenbosch F., Sicard M., Tomás S., LangeD., Kumar D, Pujadas M., Molero F., Fernández A. J., Alados-Arboledas L., Bravo-Aranda J.A., Navas-Guzmán F., Guerrero-Rascado J.L., Granados-Muñoz M. J., Preißler J., Wagner F., Gausa M., Grigorov I., Stoyanov D., Iarlori M., Rizi V., Spinelli, N., Boselli A., Wang X., **Lo Feudo T.** Perrone M. R, De Tomasi F., and Burlizzi P." EARLINET instrument intercomparison campaigns: overview on strategy and results" (2016). Atmos. Meas. Tech: DOI: 10.5194/amt-2015-275

[2] T. Lo Feudo, C. Calidonna, M. Courtney, L. De Leo, S. Federico, A. M. Sempreviva, R. Wagner, and C. Bellecci, "Flow evolution at coastal site in the Central Mediterranean" in detailed program ISARS 2010.
[3] R. Wagner, M. Courtney, T. Lo Feudo, C. Calidonna, L. de Leo and A. M. Sempreviva, "Use of Doppler LIDAR for measuring the vertical profiles of wind speed at a coastal site." in detailed program ISARS 2010.
[4] Emeis, S., Schäfer K., and Münkel, C.: Surface based remote sensing of the mixing-layer height – a review, Meteorologische Zeitschrift, 17(5), 621–630, 2008.
[5]Eresmaa, N., Karppinen, A., Joffre, S. M., Rsnen, J., and Talvitie, H.: Mixing height determination by ceilometer, Atmos. Chem. Phys., 6, 1485–1493, 2006.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

The on-going joint project that involves both institutions, IRPWIND, focuses on the alignment of competencies and developing strategies in wind energy in Europe.
In this frame, the IRPWIND mobility program is considered an excellent framework to develop a further collaboration within the EERA SP Wind Condition.

Relevant national project at ISAC-CNR
At ISAC-CNR, Wind Energy research is conducted in different project:
Sinergreen-Res Novae "Smart Energy Master for the energetic government of the territory", Res Novae "Renewable energy e smart grid". PON04a2_E, PON 2007-2013 (MIUR),
I-AMICA "Infrastructure of High Technology for Integrated Climate and Environmental Monitoring" PONa3_0036, PON 2007-2013 (MIUR),

GREEN PORTS "Renewable energy in port area".–DDS 14225 14/10/2010; DDS 3329 05/03/2013, POR Calabria 2007-2013.
Furthermore, ISAC-CNR develops research in wind energy related arguments.

The above projects and in-kind funding address the following main subjects
- Wind profiles in Complex Terrain
- Characterization of turbulence in the Atmospheric Boundary Layer in different atmospheric conditions in coastal areas
- Analysis of the interplay between sea breeze and synoptic flow
- Exploring the use of integrated renewable systems in Mediterranean harbours.
- Exploring wind energy in built environment

Relevant national projects at DTU
There have been several National and International campaigns coordinated by DTU regarding wind lidars in coastal areas at the site of Høvsøre at the west coast of Jutland. The site of Høvsøre has the same coastal alignment as Lamezia with the main synoptic wind from west. However, the presence of the sea breeze is not so clear as in South Italy and the climatic conditions are different.

The latest project is **RUNE. Reducing the Uncertainty of Near-shore Energy.**

Objective: To reduce the uncertainty of near-shore wind resource estimates by using onshore scanning lidar technology combined with ocean and satellite information.

Expected outcome: To reduce the uncertainty of near-shore wind resource estimates by using onshore scanning lidar technology combined with ocean and satellite information.

3. Work plan

The application is for a period of 4 weeks, and the expected work plan is as follows:

- Day 1-4 Discussion on advanced wind lidar data
- Week 1-4 Analysis of the impact of the sea breeze on the lidar and sodar signals.
- Week 3-4 Finalization of the Joint paper on the campaign 2009 with an in depth analysis of the lidar signal.
- Week 4 outline of a paper on the comparison between development of coastal flows in Lamezia Terme and Høvsøre in Denmark.

4. Benefits to EERA objective advancement

The project will benefit the advancement of the following Research Themes within the SP *Wind Condition.*

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. Evaluate and improve numerical weather models for short- and medium- term forecasting.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

During the stay at DTU the applicant will have different discussion on liddata analysis and methodology.

Furthermore, both CNR and DTU Wind Energy are partners in the EU-sponsored project IRPWIND, and the stay will make it possible to transfer knowledge of relevance for this project directly between the two partners.

Results will be presented at the IRPWind Conference in Amsterdam in September.

6. Expected results

- Analysis of the possible impact of the sea breeze on the lidar signal
- Plan for a comparative analysis between the sites of Høvsøre and Lamezia Terme.
- Key Performance Indicator one paper submission in 2016.

Funded by EU

Application form for Mobility grants within IRPWIND

A) Applicant details

Applicant Name	**Ariane**
Applicant Surname	**Frère**
Home Institution	**BERA (Cenaero)**
EERA/IRP Partner?	**Yes (EERA member but not IRP)**
Home Institution Postal address	**29 rue des Frères Wright 6041 Belgium**
E-mail	**ariane.frere@cenaero.be**

B) Host institution details

Institute name	**DTU Wind**
EERA/IRP PARTNER?	**Yes (both EERA and IRP)**
Contact person	**Torben Larsen**
Country	**Denmark**
E-mail	**tjul@dtu.dk**

C) Relevant Programme and scheme

CORE PROJECT? ***NO***		**RELEVANT EERA SUB-PROGRAMME**	**(E) Aerodynamics**
Length of the grant scheme	**Scheme:** **(02) 4-26 weeks**	**Number of weeks:** **Start date:**	**13 weeks** **02 / 05 / 2016**

D Project description

TITLE OF THE PROJECT: HiFi_LES_4_Wind

1. Introduction

- ***Research topics, originality:***

The collaboration proposed here aims at applying an innovative CFD methodology which already proved its worth on turbomachinery applications to airfoil and add-ons geometries critical for the Wind Industry.
The Argo group from BERA-Cenaero aims at providing high accuracy Large-Eddy Simulations (LES) to the industry. There are mainly two categories of LES methodologies. Firstly, the methodologies developed in the academia (Finite Difference) which are very accurate (low dispersion and low dissipation) and have high scalability capacity (run on thousands of processors in parallel) but are not efficient on complex geometries as they need a structured mesh. Secondly, the methodologies used in the industry (Finite Volume) which are robust on unstructured mesh but have low accuracy and low scalability. The methods available currently are hence not satisfying and LES is rarely used in the Wind industry although LES could improve drastically modeling accuracy of unsteady, separated or transitional flows.
The innovative Discontinuous Galerkin Method (DGM) permits to obtain high accuracy and low calculation time (high scalability) on unstructured mesh. Therefore the Argo group has develop ArgoDGM and has proven its high potential on DNS and LES of academic and industrial applications [1,2,3,4]. ArgoDGM has been originally developed and used for turbomachinery applications due to a strong interest in this methodology from the aircraft industry but its high strengths seem promising as well for the wind industry to model low Reynolds airfoils, high Reynolds thick airfoils or on add-ons (serration, VG...). Two applications are foreseen for the 3 months of collaboration:

1. LES of low Reynolds airfoils and add-ons
2. Wall-Modeled LES of high Reynolds airfoils

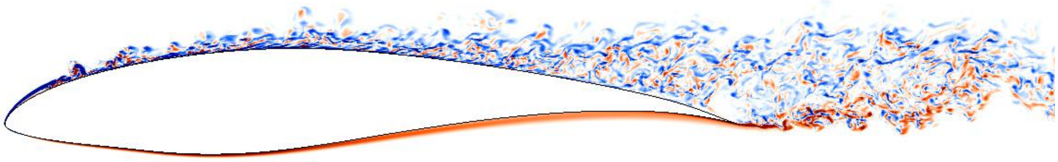

Figure 1: S826 airfoil: separation region visualized by the spanwise vorticity in the periodic plane at Re = 100,000 AoA=12°(small laminar separation bubble on the leading-edge)

The present collaboration will hence permit to use ArgoDGM on applications critical for the wind industry. The BERA-Cenaero team will gain from the deep expertise of the DTU “Aeroelastic Design” team in Wind Energy critical CFD and experimental test cases. The DTU team will gain from the knowledge transfer from the aircraft industry and the highly accurate LES results which could be used in the improvement of simpler and quicker models (e.g. the improvement of the source terms based VG models for RANS using highly resolved LES of VG).
As this collaboration is the first between BERA Wind and DTU Wind “Aeroelastic Design” team and as the researcher Ariane Frère is BERA Wind vice-president, this 3 months stay will also permit to develop a long term collaboration between DTU Wind and BERA by, among others, listing complementary activities in Aerodynamics.

- Technological Readiness Level (TRL) of the proposed concept.

The ArgoDGM code will be used to perform LES of low Reynolds number applications and Wall-Modeled LES of high Reynolds number applications. The LES approach has been largely validated [1,2,3,4] and is hence considered as TRL4 (technology validated in lab). Among others, the researcher Ariane Frère has already collaborated with DTU Wind on LES of low Reynolds airfoils. ArgoDGM and EllipSys were compared on the S826 airfoil case [5]. The Wall-Modeled LES approach (enabling the use of LES for high Reynolds cases by modeling the inner part of the boundary layer and hence limiting the CPU cost) has been validated only on academic cases (channel flow and periodic hill) and the methodology is hence considered as TRL2 (technology concept formulated).

- Definition of Key Performance Indicators (KPIs).

Improvement of the CFD models:

- prove feasibility of running WMLES at high Reynolds
- reduction of the error
- reduction of CPU cost by use of Wall-Modeled LES compared to LES

Improvement of the collaboration between BERA and DTU Wind:

- establish complementarities
- future collaborations

- Description of links to relevant EERA Sub Programmes (SP) and/or IRPWIND Core Projects (CP).

By developing and testing a new CFD methodology on airfoils and add-ons aerodynamics, by increasing the knowledge on numerical methods but above all on complex turbulent flow physics relevant for wind blade aerodynamics, the proposed collaboration will contribute to the EERA Wind sub-programme Aerodynamics in the following research themes:

- RT2: Aerodynamic design models:
  - (RT2-4) Developments in numerical mathematics to further enhance CFD techniques for the modeling of wind turbine rotors and wind farms.
  - (RT2-5) Fundamental research on turbulence models and closure relations.
  - (RT2-6) Comparisons and validations of models and codes based on experimental data of full-scale and wind tunnel measurements.
- RT5: Development and evaluation of innovative concepts and features:
  - (RT5-1) Innovative concepts and features are modeled and evaluated. Through demonstration by wind tunnel tests and computational modeling.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

Description of national projects from the receiving institution:

DTU Wind is currently working on four projects related to the proposed HiFi-LES-4-Wind project. The two first projects (AVATAR and INNWIND) are directly linked to the CFD modeling of airfoil and add-ons. The two following projects (COMWIND and NEWA) are more related to the wall modeling approach in LES and the use of it for rough walls (future development based on HiFi-LES-4-Wind project).
AVATAR is a project initiated by the EERA, carried out under the FP7 program of the European Union. Its main goal is the development and validation of advanced aerodynamic models, to be used in integral design codes for the next generation of large scale wind turbines. The overall objectives of the INNWIND.EU project are the high performance innovative design of a beyond-state-of-the-art 10-20MW offshore wind turbine and hardware demonstrators of some of the critical components.
COMWIND: Center for Computational Wind Turbine Aerodynamics and Atmospheric Turbulence. The objective of the project is to develop computational methodologies and physical models capable of coping with multiple scales and apply them to combined wind turbine aerodynamics and atmospheric physics problems. NEWA: New European Wind Atlas project aims at providing reliable wind resource data.

Description of national projects from the sending institution:

APPLES: Aerodynamic Performance Prediction using Large-Eddy Simulations (BERA-Cenaero) 2013-2017

4 years research project (PhD) funded by the Walloon Region under the FirstDoCA framework aiming at reducing LES cost drastically by implementing Wall Models in ArgoDGM.

NEWA: New European Wind Atlas (BERA-Cenaero and BERA-KUL) 2015-2020

5 years research project funded by the Walloon Region and the European commission under the ERANET+ framework aiming at providing reliable wind resource data as well as a reliable meso-micro model chain. ArgoDGM could be used to perform precise simulations (LES) to develop benchmarks for RANS models. Wall models considering rough surfaces need however first to be implemented. HiFi-LES-4-Wind would be a first good collaboration to attain this goal.

FRIA PhD (BERA-UcL) 2015-2017

2 years research project funded by the Walloon Region under the FRIA framework aiming at developing a highly accurate finite difference solver to perform LES of wind park wake interactions. The collaboration between BERA-UcL and BERA-Cenaero on the implementation of Wall-models in high-order LES is strong.

Foreseen European added value of national alignment.

The methodology developed at Cenaero, ArgoDGM, is very innovative, providing highly accurate and efficient LES of complex flows. Its strengths have been demonstrated on turbomachinery applications but not yet on Wind specific applications. DTU Wind large expertise on Wind Aerodynamics will permit to evaluate ArgoDGM on test cases critical to the Wind community. This collaboration will permit to bring a new methodology to the wind research community but also to provide very precise characterization of complex flows: transitional/separated airfoils and VG. These results could be used in the improvement of simpler models (e.g. Xfoil).

Furthermore, this first collaboration between BERA and DTU Wind will permit to increase the communication and the general research alignment of the two institutions by creating a strong long-lasting collaboration.

Description of the host institute: e.g. infrastructure, experience etc.

DTU Wind Energy is co-operating with world leading research institutions and universities. It is an active participant in TPWind (European Wind Energy Technology Platform) and coordinates the European Energy Research Alliance (EERA) joint programme on wind energy. It is thus a key player in implementing strategic, public research in the framework of the SET Plan. The substantial presence on the European stage is materializing in a number of concrete projects with industry and several universities. DTU Wind Energy is and has been participating in 31 FP7 projects and is coordinating 5 of them presently.

The research in the Aeroelastic Design Section is focused on the development of aero-servo-elastic simulation methods, computational fluid dynamics (CFD) codes and software design tools for analysis of airfoils, blades, and wind turbines, and application for design in interaction with the industry. The research is going hand in hand with experimental validation and is aiming at continuously extending the design basis for optimization and up-scaling of existing concepts as well as paving the way for new concepts and principles.

New dedicated airfoils like thick high lift- or multi-element airfoils are developed and designed by means of aerodynamic engineering models and the Numerical Wind Tunnel in combination with numerical optimization. They are verified by wind tunnel measurements and subsequently applied by the industry. The large experimental database on airfoil and add-ons as well as the possibility to perform new airfoil measurements in the wind tunnel in Lyngby are key elements for the project proposed here.

3. Work plan

The project presented here aims at working on four main tasks. These tasks are described below. Please note that these tasks will be performed in parallel and do not represent equivalent work force. The percentage of time planned for each task is given in brackets next to the task title.

- **Task 1: LES of low Reynolds airfoils (5%)**

DTU Wind and BERA-Cenaero collaborated already on the experimental and numerical evaluation of the S826 airfoil at low Reynolds numbers. The S826 airfoil is a 14% thick NREL airfoil which was used recently in a series of blind tests, the Nowitech-Norcowe tests. These blind tests were comparing different wind turbine wake models to wind tunnel measurements. The blind tests demonstrated that some errors in the wake modeling could be attributed to the incorrect capture of the low Reynolds airfoil polar. DTU Wind and BERA-Cenaero collaborated hence in trying to understand better the low Reynolds effects on this airfoil. Hamid Sarlak from DTU Wind (researcher in Jens Sorensen team) and Ariane Frère (applicant to this proposal) compared LES from ArgoDGM and EllipSys and performed oil flow visualization, demonstrating large 3D structures (stall cells). This collaboration (one week in June 2014) lead to one AIAA conference paper [5]. Hamid and Ariane are currently working on writing two journal papers on this work, the present collaboration would hence give the possibility to finalize this collaborative work.

Task 1 deliverable:

- one journal paper on the experiment
- one journal paper on low Reynolds airfoil LES (S826 and E387)
- technical report for EERA community with feedback on the experimentation (first oil flow performed in DTU Lab)

- **Task 2: LES of add-ons (20%)**

Add-ons (serrations, VG) are frequently used in the field but their aerodynamic characterization is still not satisfactory. They are so small compared to the blade length that to resolve them in a CFD simulations would be too computationally expensive. The most usual solution is to model them as source terms in order to observe their impact on a full blade CFD simulation. Precise simulation, even at low Reynolds, of add-ons could help to improve these models. It is hence proposed to use ArgoDGM to perform LES of add-ons in order to increase the understanding of this complex flow physics.

Task 2 deliverable:

- specification of a low Reynolds experiment with add-ons that will be used for the comparison with LES (there is already one experiment foreseen in DTU with the experimental study of low Reynolds flow over a bump with VG's in Jens Sorensen's team)
- wall-resolved LES of the previous chosen set-up
- technical report for EERA community with lessons learned from the comparison and advise for add-ons modeling

- **T3: WMLES of high Reynolds airfoils (60%)**

Large-Eddy Simulation (LES), when resolved up to the wall, require too important computational resources. This high cost is due to the high resolution required for resolving the inner part of the boundary layer. The mesh requirement scales as $Re^{1.9}$ [6,7], limiting LES of wall bounded flows to low Reynolds number applications.

In order to perform LES of wall bounded flows at high Reynolds numbers, the main approach consists in modeling the inner layer. There are mainly two classes of methods doing this modeling: the Hybrid (or DES) and Wall-Stress approaches. As it is more adapted to DGM methodology, the second option has been chosen for ArgoDGM. Note that the DES approach has been chosen for EllipSys.

WMLES approach of ArgoDGM has been tested against academic cases (channel flow and periodic hill) but not yet on airfoil geometry. The main task of the proposed project is to evaluate the WMLES on airfoils and to quantify the gain/loss in computational cost and accuracy compared to wall-resolved LES, DES, RANS, Xfoil and experiment.

Task 3 deliverable:

- wall-modeled LES of a wind turbine critical airfoil (thick, flat-back, stalled ...)
- presentation of the lessons learned to DTU Wind seminar
- conference paper on the comparison of the different tools (WMLES, LES, RANS, Xfoil)

- **T4: Collaboration strategy BERA and DTU Wind (15%)**

BERA Wind is since three years part of the EERA Wind JP. BERA has participated actively in the EERA meetings and workshops and has focused on defining BERA research area complementarity with the other EERA Wind partners. By hosting Ariane Frère (BERA Wind vice-president and ex-president), DTU Wind will permit to help BERA in the effort of strategy alignment and integration.

Task 4 deliverable:

- presentation of BERA's activities and research strategy to DTU Wind collaborators
- list of possible collaborations between BERA and DTU Wind or other EERA members

4. Benefits to EERA objective advancement

Contribution to the advancement of the EERA Wind sub-programme Aerodynamics strategy goals:

By proposing high fidelity CFD simulation of unsteady, transitional and/or, separated airfoils as well as study of vortex generators, the project contribute strongly to the second and fifth strategy goals of the sub-programme Aerodynamics copied below. The work on Wall-Modeled LES is also a strong step further in providing high fidelity CFD for an acceptable computational cost and will provide very interesting work on turbulence modeling.

<u>EERA Wind sub-programme Aerodynamics strategy goals:</u>

2/ Improved aerodynamic design modeling 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.

5/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.

Contribution to the advancement of the EERA strategy goals, gaps addressed.

Being the first participation of BERA in the Wind IRP and Mobility scheme, this project is clearly a step forward in the integration of Belgian activities at European level. With the BERA Wind vice-president as sent researcher, the project will permit to improve the coordination of BERA Wind, to align and prioritize BERA activities based on the strategy that will be discussed in DTU. There is also a clear complementarity and integration of innovative methodology from BERA and strong expertise from DTU Wind.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

As described in section 3, the proposed project will lead to 2 journal papers (exp. and LES of low Reynolds airfoils), one conference paper (WMLES airfoil), two technical reports (oil experiment and VG simulations), one presentation to DTU seminar (ArgoDGM in Wind applications) and one list of future possible projects between BERA and other EERA Wind members.

6. Expected results

Methodologies and/or databases and/or best practices functional to the activities of the IRP and EERA strategic agenda objectives.

1. Deployment and assessment of the use of DG methodology for Wind applications.
2. Discussion on WMLES validity, computational gain and interest compared to state-of-the-art models.
3. Results of low Reynolds airfoil and add-ons LES and WMLES of high Reynolds airfoils provided in database and discussed in a report available for the entire EERA Wind community.
4. List of complementarity activities between BERA and DTU Wind. Strategy for better collaboration, alignment and future steps.

Assessment of the advancement of the TRL.

By being validated on Wind Energy environment, ArgoDGM LES will during this project evolve from TRL4 to 5 (technology validated in relevant environment in the case of key enabling technologies). The WMLES will evolve from TRL2 to TRL5.

Assessment of the KPIs.

Improvement of the CFD models:

- prove feasibility of running WMLES at high Reynolds → at least one converged simulation of an airfoil at Re=1,000,000.
- reduction of the error → 10% improvement of airfoil lift and drag accuracy compared to state of the art codes (Xfoil, EllipSys RANS).
- reduction of CPU cost by use of Wall-Modeled LES compared to LES → 50% reduction of the mesh degree of freedoms for a case at Re=1,000,000.

Improvement of the collaboration between BERA and DTU Wind:

- establish complementarities → list of complementary activities/projects between BERA and DTU Wind in the Aerodynamic field
- future collaborations → at least one clearly defined following project between BERA and DTU Wind

7. References

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Application form for Mobility grants within IRPWIND

A) Applicant details

Applicant Name	**Pawel**
Applicant Surname	**Gancarski**
Home Institution	**CENER**
EERA/IRP Partner? *(yes/no)*	**yes**
Home Institution Postal address	**CENER, Ciudad de la Innovación, nº 7 31621 Sarriguren (Navarra) · Spain**
E-mail	**pgancarski@cener.com**

B) Host institution details

Institute name	**Technical University of Denmark**
EERA/IRP PARTNER?	**yes**
Contact person	**Merete Badger**
Country	**Denmark**
E-mail	**mebc@dtu.dk**

C) Relevant Programme and scheme

CORE PROJECT? ***NO*** *(Please erase the non-relevant)*		**RELEVANT EERA SUB-PROGRAMME** **Max 2** (Please erase the non-relevant)	**(F) Research Infrastructures**
Length of the grant scheme *(Please erase the non-relevant length)*	**Scheme:** **(02) 4-26 weeks**	**Number of weeks:** **Start date:**	**7** **16th May 2016**

D. Project description

Strategy towards a common IT infrastructure for research in wind energy

1. Introduction

In the past two decades the research community in the area of wind energy have achieved a great improvement in the amount and quality of physical infrastructures (laboratories, experimental parks), databases, and virtual services. With a growing number of projects, often restricted to a country, university or a project consortium, a problem of fragmentation of efforts and access is a growing issue.

The energy research community has not been blind to that, and a number of bottom-up initiatives have been implemented. At the same time, as the fragmentation of virtual research infrastructures is not unique to wind energy, the European Commission has begun to stress out the impotence of creation of the common pan-European infrastructure for researchers.

In 2015 a project proposal (OUVRE) have been submitted by (among others) DTU and CENER for the H2020 e-infrastructures program on joining specific virtual services within the wind community with the general European infrastructures. While the proposal received good reviews it was rejected for its limited scope and maturity. Unfortunately, because wind energy virtual services are in general incompatible with the European infrastructure, it is difficult to increase the scope of the proposed project without multiplying the number partners and the size of the project.

We believe, that there is a gap here which cannot be filled by a single project, but rather should be addressed by a centralized strategy coordinated by EERA, and that this project could serve as a starting point for its creation. The main question to be addressed is how the initiatives dealing with the research fragmentation within the wind energy community could be better synchronized with each other, as well as with the general efforts for the creation of the virtual infrastructures within the European Union.

The idea for this project is to analyze examples of attempts to unify research infrastructures within wind energy field, and investigate how they can be synchronized with each other and the general efforts of the European Commission in the creation of European infrastructures. The project will not try to create a complete repository of current research infrastructures, but rather focus on examples for each of the key aspects like:

- databases - NEWA, Windscanner
- services - CFD Cloud, FUSED-Wind, DTU Virtual lab, Windbench
- education - Virtual Campus Hub
- infrastructure - OpenConext
- EU infrastructures - GEANT, STORK, PRACE, EUDAT

It will then be described how the example projects could be joined, what is the best way for them to proceed and what are the general conclusions/guidelines for the new projects dealing with similar aspects.

The conclusions achieved here can be used for the definitions of strategy plans within WP2 Integrating activities and WP3 Infrastructures, in order to contribute to the EERA sub-programme on research infrastructures.

2. Description of national projects aligned to the proposed activities in both the sending and the receiving institution

CENER:

- **CFD Cloud -**

CFD Cloud is an online commercial service for modelling of atmospheric wind flow over complex terrain. The service is implemented using OpenFOAM CFD software and an in-house model for atmospheric flow CFDWind. To guarantee scalability and cost efficiency the CFD computations are being performed in a computing cloud.

- **Windbench -**

Windbench.net is a portal for the online management of benchmarking activities related to wind energy model development, verification and validation (V&V). It was first released in May 2013 as a prototype to manage the benchmarking activities of the IEA-Wind Task 31 "Wakebench" on wind farm (microscale) flow models. Since then Windbench was extended to host coupled offshore WT models (IRPWind WP6), and aerodynamic models (AVATAR).

- **Model validation environment -**

The goal of the project is to define a process for validation of atmospheric wind flow models, allowing their continuous improvements while reducing the risks of mistakes. The process will be defined by a set of best practice guides for cleaning and categorization of measurement data, definition of model benchmarks and for modeling results analysis. The best practice guides will be implemented by a number of tools for data processing, analysis and visualization.

DTU:

- **FUSED-Wind -**

FUSED-Wind is a modeling platform based on OpenMDAO, an open source platform for multidisciplinary design analysis and optimization developed in python. By having standardized definition of inputs, outputs and modelling parameters it allows use of different numerical solvers. Also, OpenMDAO libraries by analyzing the interaction of input parameters with the quality of outputs, leads to an automatic process of model optimization.

- **Virtual Campus Hub -**

The project have developed an e-learning platform for a Virtual Campus network. The platform makes use of the European infrastructures eduGAIN allowing single login access to the provided services and trust to the identity of both users and service providers. The project resulted in a creation of joint research infrastructure for four universities:

- The Technical University of Denmark (DTU) - coordinator
- The Royal Institute of Technology, Sweden (KTH)
- Politecnico di Torino, Italy (Polito)
- Eindhoven University of Technology, Netherlands (TU/e)

The use of European infrastructure as a backbone allows for the platform to be easily expanded in the future.

3. Work plan

Task 1: Review of existing and prospecting e-infra initiatives for wind energy.

The task will include interviewing the following:

- Merete Badger DTU - Virtual Campus Hub, OpenConext, MaRINET, OUVRE
- Pierre-Elouan Réthoré DTU - FUSED-Wind
- Nikola Vasiljevic DTU - Windscanner
- Javier Sanz Rodrigo CENER - Windbench, IEA Wakebench, Windscanner, NEWA, CFD Cloud

Task 2: Review of existing projects, H2020 calls and strategic plans of EC towards e-infrastructures.

Task 3: Concept statement for a Virtual Research Environment for Wind Energy (where we would like to be, who will benefit from this, what are the key features).

Apart from people interviewed for Task 1 comments of the following will be included:

- Antonio Ugarte Olarreaga CENER - EERA strategic actions plan for infrastructures - IRPWind WP3
- Charlotte Bay Hasager DTU - Infrastructure towards data access - IRPWind WP2

Task 4: High-level requirements: preliminary design (what do we need in technical terms)

Task 5: Feasibility analysis: how to reach TRL 4 (how do we demonstrate that it works, how do we measure success KPIs)

Task 6: Implementation strategy (how do we make this happen, what kind of financing would be suitable, who should be involved -including non-Europeans-, what is the plan in the short to medium term).

The project will be summarized with a document which will be passed to the coordinator of EERA JP Wind sub-programme on Research Infrastructures.

Deliverable 1. Strategy towards european wind energy Virtual Research Environment.

Milestone 1. Presentation of the strategy to the EERA-Wind.

4. Benefits to EERA objective advancement

We believe there is a gap between the efforts of the European Union to create a general solution for the Virtual Research Environments and EERA's efforts on creation of virtual services, labs and databases. While the commission is focused on general solution, EERA is only supporting specific and unconnected use cases.

While EU does support creation of sector specific infrastructures (H2020-EINFRA User-driven e-infrastructure innovation), attempts to apply for the funding in the past were unsuccessful. The "Orchestration of European Virtual Research Environments" - OEUVRE proposal while being positively reviewed, was rejected for not being based on a mature enough e-infrastructure and too small in scope. While the proposal can be improved, increasing the scope will greatly increase the budget necessary for the implementation. The reason for that is the lack of databases and services within the community which are already compatible with each other or the European infrastructure. This means that every existing service, in order to be connected to the new infrastructure needs to be included in the budget.
On the other hand EERA does not provide guidelines on IT standards/solutions for the newly developed projects which makes them incompatible with each other and difficult to connect to a common infrastructure in the future.

The proposed project will look at a possible solution for this gap - a strategy containing guidelines and standards for all new infrastructures (databases, labs) and services (online tools) to follow, allow them in the future to be enabled in a cost-effective way.

5. Dissemination and Transfer of Knowledge to other IRP and EERA Wind participants

Deliverable 1 will be submitted to EERA through the coordinator of EERA JP Wind sub-programme on Research Infrastructures. The results will also be presented during a forthcoming IRPWind conference where we will have a dedicated workshop on e-infrastructures to seek interest for potential contributions from the EERA-Wind community. At international level, there are good synergies with the IEA-Wind Task 31. The VRE strategy will be presented there in order to reach out to the international community, notably to the U.S. Department of Energy's Atmosphere to Electrons research program, which is also active in the development of a data archiving portal to provide open-access to research data.

DTU, KTH and CENER are providing a number of online services and have some experience in creating scientists communities. The key aspect of the project is to organise a number of meetings to allow exchange of past experiences and ideas for the future of VRE for wind energy. The exchange of ideas here is expected to result in a future collaboration in the VRE related projects.

6. Expected results

It is expected that the final results of the project will be used in defining a new strategic agenda objectives for the EERA infrastructure sub-program. In this aspect the success of the projects will be assessed by the influence it had on the EERA's objectives. Also the results will aid the future collaboration by providing examples of possible synergies between the national projects. If successful the examples will result in projects implementing them.