



Closed Loop Wind Farm Control

DELIVERABLE REPORT

Training sessions

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LIST OF ABBREVIATIONS

Abbreviation	Description
ACC	American Control Conference
LCOE	Levelized Cost of Energy
WESC	Wind Energy Science Conference

EXECUTIVE SUMMARY

One of the key actions within the dissemination activities is to perform knowledge transfer in order to show the benefits of the proposed technologies to potential users. With this aim, two training sessions have been organized in the frame of two outstanding international conferences.

The first one was held as a mini-symposium called “Wind Farm Control” during the Wind Energy Science Conference (WESC 2019, held at Cork on 17th to 20th June 2019). This mini-symposium was co-chaired with the EU H2020 funded project ‘Total Control’ in order to complement outputs from both projects and serving as a clustering activity.

A second training session was organized during the American Control Conference (ACC 2019, held at Philadelphia on 10th to 12th July 2019) as a Tutorial Session called “Closed-Loop Wind Farm Control”.

These conferences have been selected as they are among most relevant scientific conferences about Wind Energy and Control Applications respectively.

1 INTRODUCTION

CL-Windcon project works on the development of tools and techniques focused on wind farm control to optimize the LCOE. In order to disseminate the results, it is very important to widely explain the technical work performed during the project. In this way, the technical and industrial community will be aware of the progresses achieved and the potential use of the project outcomes.

Two training sessions have been organized with this objective at the latest stage of the project. This deliverable report is presenting an overview of these training sessions, explaining the main contents, results and conclusions.

2 FIRST TRAINING SESSION

2.1 Description

The first training session was organized as a mini-symposium during the Wind Energy Science Conference (WESC 2019). The WESC is a biennial conference organized by the European Academy of Wind Energy (EAWE) that takes place every odd year. The purpose of this conference is to gather leading scientists and researchers in the field of wind energy to present their latest findings in oral presentations and several parallel sessions, covering all scientific topics in wind energy.



Figure 1. WESC 2019 logo

WESC 2019 took place at Cork (Ireland) from 17th to 19th of June 2019. The training session was organized as a one and a half day mini-symposium called “Wind Farm Control”. The event was co-chaired with the EU Horizon 2020 funded project Total Control. CL-Windcon and Total Control projects share different research areas on wind farm control and the joint organization of the mini-symposium was a good opportunity for clustering activity.

The sessions were co-chaired by Prof. Jan-Willem van Wingerden (CL-Windcon) and Dr. Gregor Gibel (Total Control).

2.2 Content

The session included 25 presentations (listed in Table 1) dealing from general overviews of wind farm control concepts and applications to particular presentations of different tools and techniques developed during the project.

Table 1: Mini-Symposium Wind Farm Control presentations

Speaker	Organization	Presentation title
Dr. Irene Eguinoa	CENER	CL-Windcon EU-Project. A control problem approach
Mr. Thomas Duc	Engie Green	Experimental analysis of wind turbine blade loading when applying wind farm control strategies: results from SMARTEOLE field tests
Dr. Mads Pedersen	DTU	The influence of wind farm control on optimal wind farm layout
Dr. James Sinfield	Carbon Trust	Offshore Wind Accelerator Wind Farm Control Trial Project
Dr. Gunner Larsen	DTU Wind Energy	TotalControl – Advanced integrated control of large-scale wind power plants and wind turbines
Mr. Stefan Loew	TU Munich, Siemens AG	Offline Economic Active-Power Dispatch for Wind Farms Taking Fatigue into Account
Dr. Irene Eguinoa	CENER	Estimation of partial wake loads for wind farm control design
Mr. Matthias Kretschmer	University Of Stuttgart	Validation of FAST.Farm considering structural loads at alpha ventus
Dr. Jonas Kazda	DTU Wind Energy	Reducing Turbine Mechanical Loads Using Model-optimized Power Control of Waked Wind Farms
Dr. Wouter Engels	ECN Part Of TNO	Wind farm control including grid support and load minimisation and (re)distribution
Mr. Şafak Burak Altun	Siemens Gamesa Renewable Energy	Improving wake steering engineering models with wake deflection coupling effects
Dr. Paul Fleming	National Renewable Energy Laboratory	Investigation into wake steering performance at rated power
Dr. Filippo Campagnolo	Wind Energy Institute	Wind tunnel testing of open-loop wake deflection under dynamic wind direction changes
Mr. Bastian Salbert	Technical University of Munich	Validation and calibration of a wake model in complex terrain

Speaker	Organization	Presentation title
Mr. Steffen Raach	University Of Stuttgart	Prospects of combined feedforward-feedback wake redirection control
Mr. Joeri Frederik	Delft University of Technology	Wind tunnel experiments exploring the possibilities of dynamic induction control
Mr. Daan van der Hoek	Delft University of Technology	Improving wind farm power performance through Gaussian process optimization – A high-fidelity simulation study
Mr. Søren Andersen	Technical University Of Denmark	A Comparative Study of the Wake Dynamics during Yaw and Derating
Dr. Paolo Schito	Dipartimento Di Meccanica - Politecnico Di Milano	SOWFA modelling for wind farm control strategies
Prof Johan Meyers	KU Leuven	Set-up of a reference wind-farm simulation database for testing of turbine and farm control strategies and load scenarios
Prof Ervin Bossanyi	DNV GL	Wind farm controller design and simulation testing
Dr. Mario Rotea	The University Of Texas At Dallas	Wind Power Maximization using Log-of-Power Extremum Seeking
Dr. Jennifer King	National Renewable Energy Laboratory	Real-time Consensus Wind Farm Control
Dr. Leif Erik Andersson	Norwegian University of Science And Technology (ntnu)	Real-time optimization of wind farms using modifier adaptation and machine learning
Mr. Johannes Schreiber	Technical University of Munich	Augmentation and calibration of a wind farm model

2.3 Outcome

A variety of presentations have been performed during the Mini-symposium delivering to the wind energy community a broad description of CL-Windcon project and its outcomes, from a general description to particular technical aspects. Attendees from industry and the research community have been able to learn and discuss about the project outcomes and their potential applications.

Equally, dissemination was performed intensively during the conference through CL-Windcon social media profiles, in particular LinkedIn profile as the one with higher impact, with 264 followers at the time of writing this deliverable. See Figure 3 as an example of publication. In total, 13 publications were performed during the conference, with an accumulated value of 5703 impressions and 127 recommendations.



Figure 2. Photos from different presentations at WESC Wind Farm Control Mini-Symposium



Figure 3. Example of dissemination performed in LinkedIn

3 SECOND TRAINING SESSION

3.1 Description

A Tutorial Session was organized during the American Control Conference (ACC 2019). The ACC is an annual meeting held under the auspices of American Automatic Control Council (AACC), the US National Member Organization of the International Federation of Automatic Control (IFAC). It brings together an international community of researchers and practitioners in all areas related to the engineering and science of control systems. It features presentations and discussions on the latest scientific developments as well as application successes and lessons learned. Participants convene to discuss the latest advances in the discipline, to shape its future directions, to provide training and educational opportunities for attendees, and to develop and maintain scientific and professional networks.

ACC2019 was held at Philadelphia during July 2019, 10th to 12th. A half-day Tutorial Session named: “Closed-Loop Wind Farm Control” was chaired by Bart Doekemeijer (TU-Delft). The session was also Co-chaired by the National Renewable Energy Laboratory (NREL), the reference technical institute in the US for Wind Energy development, and also advisor of the CL-Windcon project. It has also counted with the collaboration of US wind energy control community.

3.2 Content

During the session, 4 papers were presented explaining the latest advances in techniques oriented to the closed-loop control of wind farms. Different control topics were covered, from explanation about scientific ways to treat the closed-loop solution to wind farm control, to network sharing information technics to facilitate advanced control methods, as well as improvement of wake prediction engineering tools with additional wake effects. Table 2 shows the papers presented during the session.

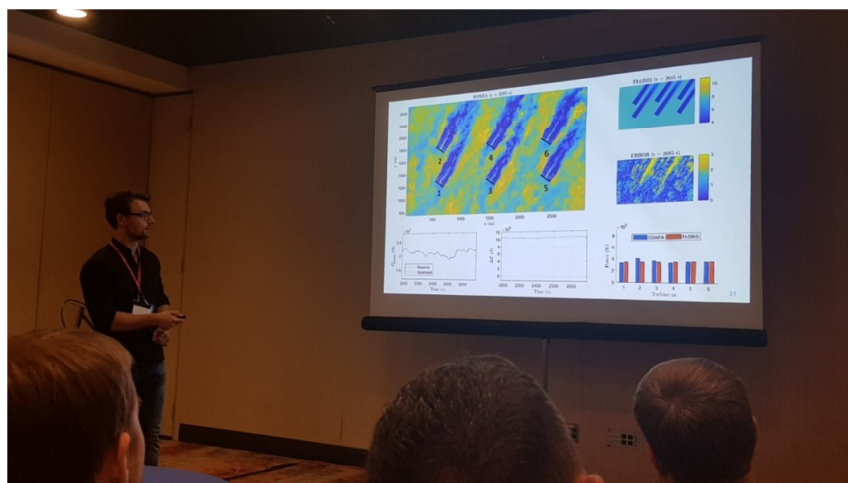


Figure 4. Bart Doekemeijer (TU-Delft) presenting during ACC Tutorial Session

Table 2: ACC Tutorial Session presented papers

<i>A Tutorial on the Synthesis and Validation of a Closed-Loop Wind Farm Controller Using a Steady-State Surrogate Model (I)</i>	
Doekemeijer, Bart Matthijs	Delft University of Technology
Fleming, Paul	National Renewable Energy Laboratory
van Wingerden, Jan-Willem	Delft University of Technology
<i>Short-Term Forecasting across a Network for the Autonomous Wind Farm (I)</i>	
Annoni, Jennifer	National Renewable Energy Laboratory
Bay, Christopher	National Renewable Energy Laboratory
Fleming, Paul	National Renewable Energy Laboratory
Johnson, Kathryn	Colorado School of Mines
<i>Flow Control Leveraging Downwind Rotors for Improved Wind Farm Operation (I)</i>	
Bay, Christopher	National Renewable Energy Laboratory
Annoni, Jennifer	National Renewable Energy Laboratory
Martinez-Tossas, Luis	National Renewable Energy Laboratory
Pao, Lucy Y.	University of Colorado Boulder
Johnson, Kathryn	Colorado School of Mines
<i>Development of a Surrogate Model for Wind Farm Control (I)</i>	
Ciri, Umberto	The University of Texas at Dallas
Santoni, Christian	The University of Texas at Dallas
Bernardoni, Federico	The University of Texas at Dallas
Savetti, Maria Vittoria	Universita' Di Pisa
Leonardi, Stefano	The University of Texas at Dallas

3.3 Outcome

Different aspects and techniques applied to wind farm control have been explained and discussed. The attendees have been able to learn about different technical approaches to optimize the behaviour of wind farms as a whole. Therefore this has been a very educational opportunity to introduce and enhance knowledge to an international forum about the technical outputs that CL-Windcon project cover.

4 CONCLUSIONS

Towards the project completion, CL-Windcon has organized two educational and training sessions in order to show at international forums the project development, outputs and potential applications.

The sessions have been performed as special events within two international conferences, the Wind Energy Science Conference and the American Control Conference, which are two of the most outstanding events in the Wind Energy and Control Science areas respectively. This allowed a broad diffusion of the sessions and the presence of a wide variety audience from industry, academia and research areas.

During the sessions, the general view of the project as well as particular technical aspects have been explained and discussed, giving the audience the opportunity to learn about the project objectives, outcomes and possible applications.