University of Perugia
Department of Engineering

ROYAL INSTITUTE OF
TECHNOLOGY

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Numerical and experimental analysis of the operation of small and large scale Wind Turbines

Erasmus+ Staff mobility for Teaching

Stockholm
KTH June 2^{nd}, 3^{rd} and 7^{th} 2016

Module A
Small Wind Turbine Wind Tunnel testing

June 2^{nd} 2016 - from 14:00 to 18:00

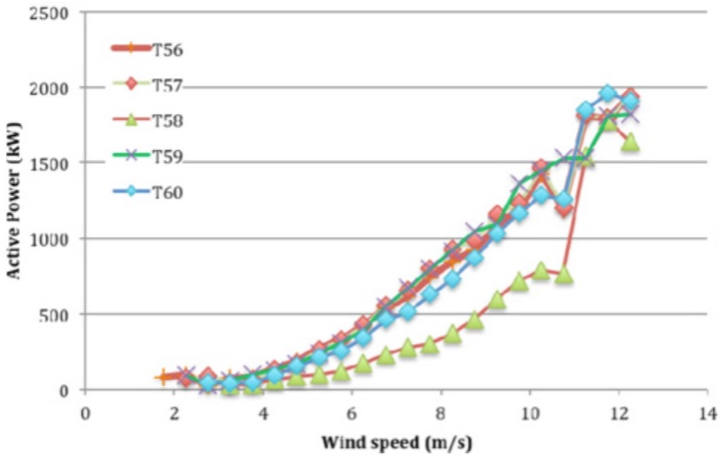
Module Introduction	30 minutes
Sub-module 1: Wind Tunnel flow characterization	1 hour
Sub-module 2: Rotor performance testing	1 hour
Break	10 minutes
Sub-module 3: Energy conversion system testing	1 hour
Final discussion - Q&A	20 minutes

This module describes the activities in the study and development of Small Wind Turbines. Details in wind tunnel test procedures as well as control and electrical interface characterization will be presented.

REFERENCES

- Bartolini N.,Castellani F.,Garinei A.,Pignattini R., "Experimental Methods for the Optimal Design of Small Wind Turbines", Conference proceeding 10^{th} EAWE PhD Seminar on Wind Energy in Europe, October 28-31 2014, Orleans, France, pp. 105-108.
- Lorenzo Bastianelli, Francesco Castellani, Valentina Morettini, Michele Pompei, Enrico Raschi, Francesco Tissi 2014. "Permanent Magnet Synchronous Generator Coupled to Variable Speed Small Wind Turbine: Modeling and Experimental Testing." In AEIT Annual Conference-From Research to Industry. The Need for a More Effective Technology Transfer (AEIT), 2014, .

Module B
Wind Turbine operation on complex flow



June 3^{rd} 2016 - from 09:00 to 13:00

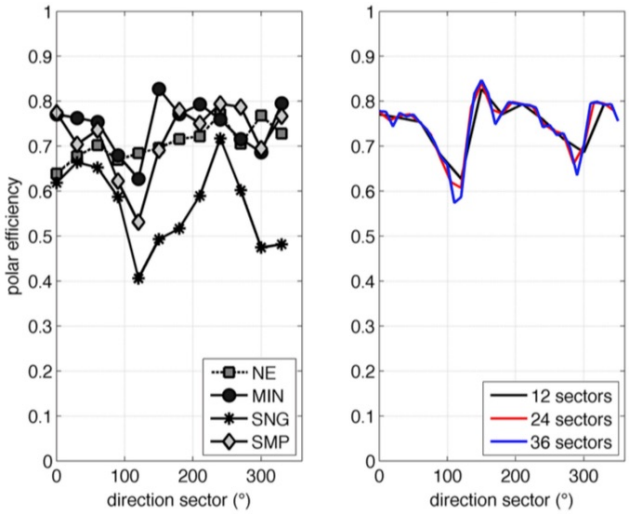
Module Introduction	30 minutes
Sub-module 1: Small Wind Turbine Operation	1 hour
Sub-module 2: Multi-Megawatt Wind turbine and complex terrains	1 hour
Break	10 minutes
Sub-module 3: Operating in Wakes	1 hour
Final discussion - Q&A	20 minutes

This module is focused on the analysis of the operation of small and large wind turbine in complex flow. Some interesting experimental data and results from numerical analysis will be discussed in order to assess how complex flows can affect the reliability of operation.

REFERENCES

- Proietti Stefania, Sdringola Paolo, Castellani Francesco, Astolfi Davide and Vuillermoz Elisa (2015). "On the contribution of renewable energies for feeding a high altitude Smart Mini Grid." Applied Energy.
- Castellani Francesco, Astolfi Davide, Burlando Massimiliano and Terzi Ludovico (2015). "Numerical modelling for wind farm operational assessment in complex terrain." Journal of Wind Engineering and Industrial Aerodynamics, 147, 320-329.

Module C
Wind Farm Performance analysis



June 7^{th} 2016 - from 09:30 to 12:30

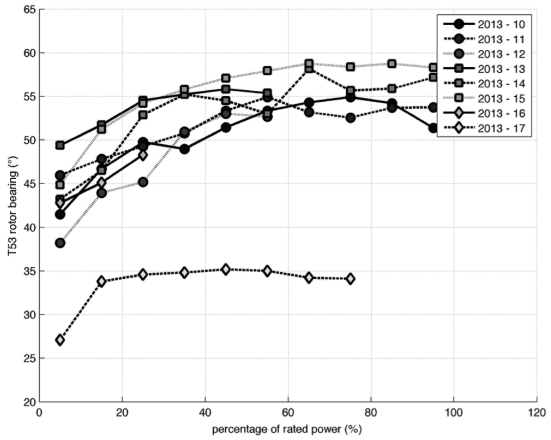
Module Introduction	30 minutes
Sub-module 1: Performance metrics	1 hour
Break	10 minutes
Sub-module 2: Wakes and terrain effects	1 hour
Final discussion - Q&A	20 minutes

The extensive use of wind technology has spawned the need to control and boost the performance of a huge numbers of turbines. Here different techniques to assess the performance a single turbine as well as the whole wind farm are discussed.

REFERENCES

- Astolfi, Davide, Francesco Castellani, Alberto Garinei, and Ludovico Terzi. 2015. "Data Mining Techniques for Performance Analysis of Onshore Wind Farms." Applied Energy.
- Castellani Francesco, Astolfi Davide, Sdringola Paolo, Proietti Stefania, and Terzi Ludovico (2015). "Analyzing wind turbine directional behavior: SCADA data mining techniques for efficiency and power assessment." Applied Energy.
- Castellani, Francesco, Davide Astolfi, et al. 2014. "Analysing Wind Farm Efficiency on Complex Terrains" Journal of Physics: Conference Series 524(1): 12142.

Module D
SCADA data analysis and Fault Diagnosis



June 7^{th} 2016 - from 14:00 to 17:00

Module Introduction	30 minutes
Sub-module 1: SCADA system and its use for fault diagnosis	1 hour
Break	10 minutes
Sub-module 2: Temperature and TCM data analysis for gearbox diagnosis	1 hour
Final discussion - Q&A	20 minutes

The financial feasibility of wind farms can be sometimes pushed to the limit; in this framework operational reliability can be fundamental for the investment competitiveness. In present modules some techniques for early fault diagnosis and maintenance managing are presented; all the discussed methods use the standard SCADA database that too often operators marginally consider.

REFERENCES

- Astolfi, Davide, F Castellani, and Ludovico Terzi. 2014. "Fault Prevention and Diagnosis through Scada Temperature Data Analysis of an Onshore Wind Farm." Diagnostyka, 15.
- Castellani, Francesco, Alberto Garinei, Ludovico Terzi, Daniele Astolfi, and Mario Gaudiosi. 2014. "Improving Windfarm Operation Practice through Numerical Modelling and Supervisory Control and Data Acquisition Data Analysis." Renewable Power Generation, IET.