上海理工大學
UNIVERSITY OF SHANGHAI FOR SCIENCE AND TECHNOLOGY

Presentation for: 2022 WindSim User Meeting

Wind Turbine Wake Effects on Wind Resource Assessments by Using WindSim

– A Case Study

Jia Yi Jin

Lecturer

University of Shanghai for Science and Technology

School of Energy and Power Engineering

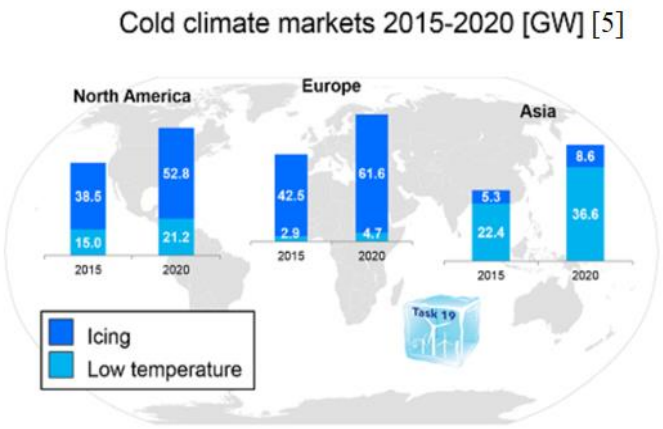
21.06.2022

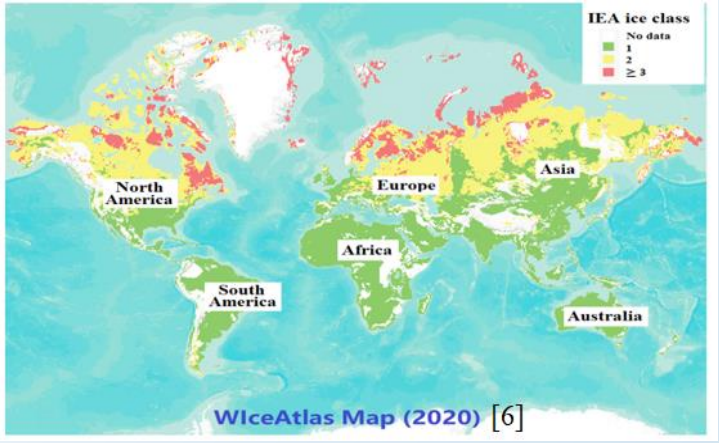
Content

Global Energy Statement

- From the first standard adopted by United States in 1970s, renewable energy has steadily emerged as an important mechanism to set national and regional economies on the path towards the medium and the long-term expectations of the envisioned sustainability goals in the global energy deployment. [1]
  - 2021 -- Wind energy is likely to account for 14 – 17% of the EU's electricity, European Wind Energy Association (EWEA). [2]
  - 2030 -- Sustainable Development Goal 7 (SDG 7), United Nations (UN). [3]
  - 2050 -- The World's Roadmap to Net Zero by 2050 (NZE2050), International Energy Agency (IEA). [4]

- Cold climate regions have good resources of wind energy, which can help to achieve these goals.



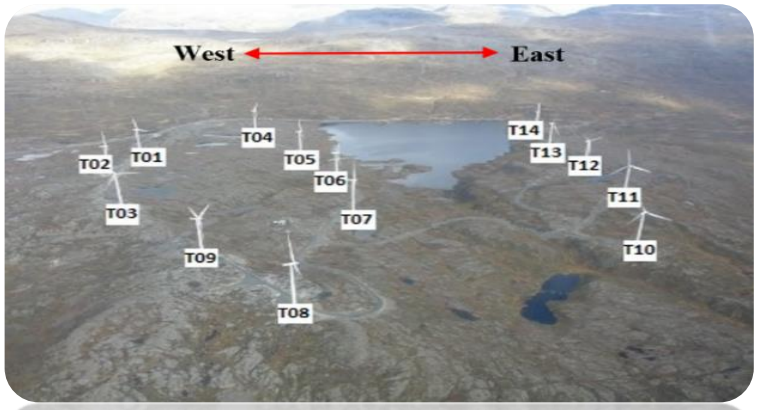


[1]-Renewable Energy Target Setting, International Renewable Energy Agency, 2015.
[2]-European Wind Energy Association, http://www.ewea.org/.
[3]- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all, United Nations General Assembly, 2015.
[4]- IEA to produce world's first comprehensive roadmap to net-zero emissions by 2050, https://www.iea.org/news/iea-to-produce-world-s-first-comprehensive-roadmap-to-net-zero-emissions-by-2050.
[5]- IEA Wind Task 19: Wind Energy in Cold Climates, https://community.ieawind.org/task19/home.
[6]- IEA: Data and Statistics, http://www.iea.org/statistics/.

Introduction

- The ***assessment of wind resources*** at cold regions are challenging, but important, as wind energy project development decisions are based on these estimated results.
- Three wake loss models are includes :
  - ***Jensen Model:*** is based on momentum deficit theory. This model gives a simple linear expansion of the wake.
  - ***Larsen Model:*** is derived from the turbulent boundary layer equations. It considers the axial velocity into consideration to increase the order of magnitudes of terms in the equation of motion neglected by first order equations.
  - ***Ishihara model:*** takes into account the effect of turbulence on the wake recovery, which is not constant and depends on the distance from the wind turbine, and the turbulence generated by the rotor and the atmospheric turbulence.

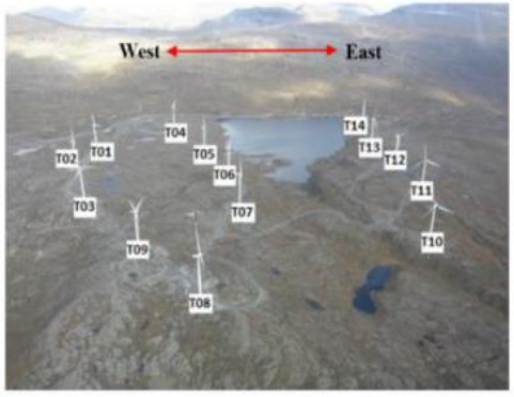
Wind Park Site

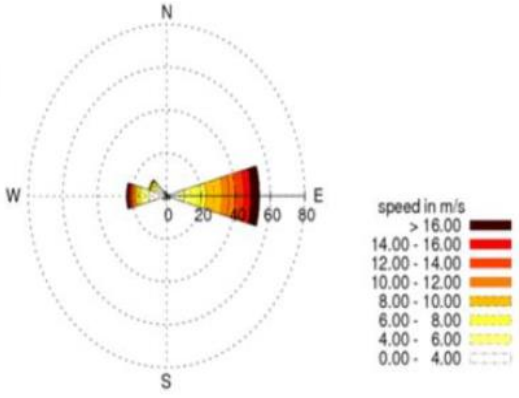


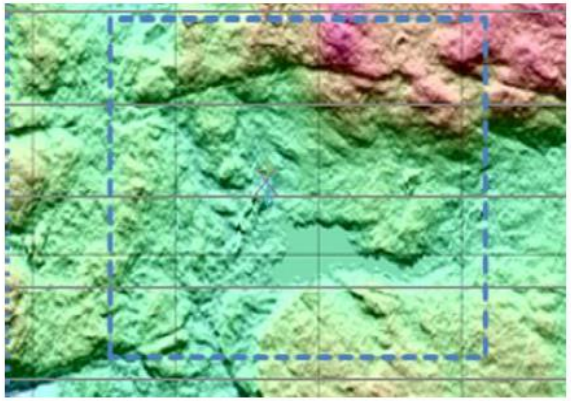
The wind park is located beside E10 near Norwegian and Swedish border.

Technical Specifications

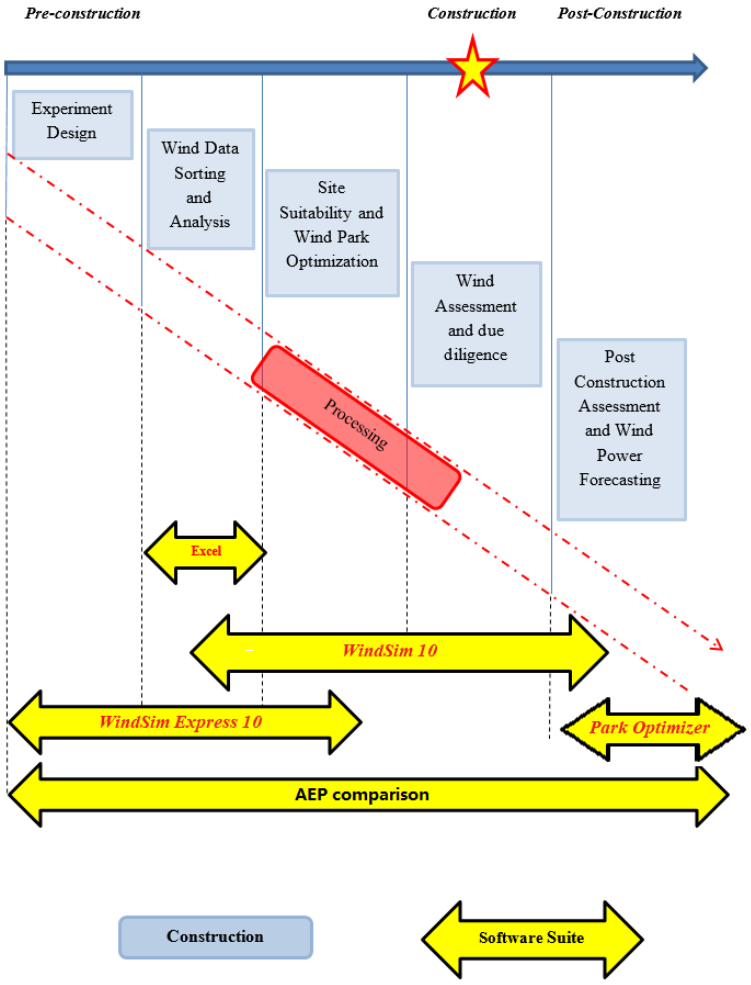
Turbine Manufacturer	Siemens_23_93VS	Max Production Capacity	104.2 GWh	Rotor Area	6361 m2
Tower Height	80 m	Nacelle Weight	83 tonn	High Wind Speed	20 ~ 25 m/s
Rotor Diameter	90 m	Tower Weight	158 tonn	Rotor Weight	60 tonn
Height of Boundary Layer	**500.0m**	**Speed Above Boundary Layer**	**10m/s**	**Boundary Condition at The Top**	**Fix pres.**

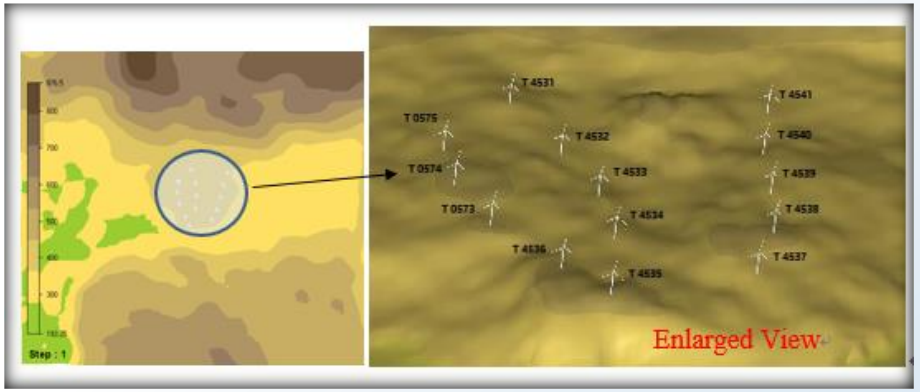


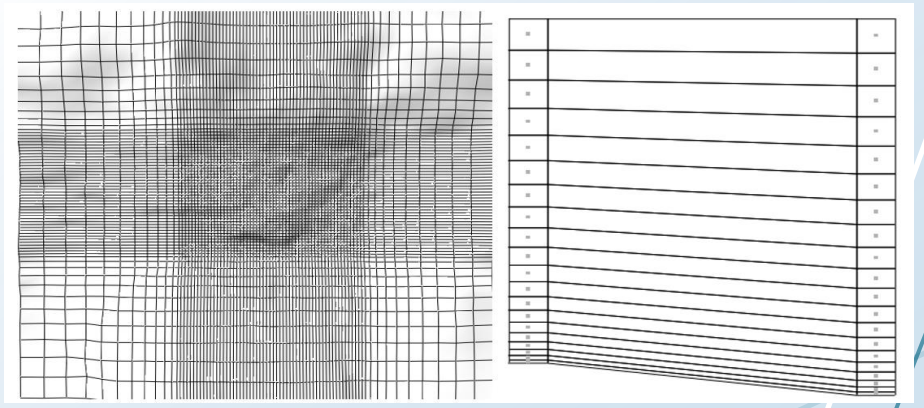




WindSim Setup

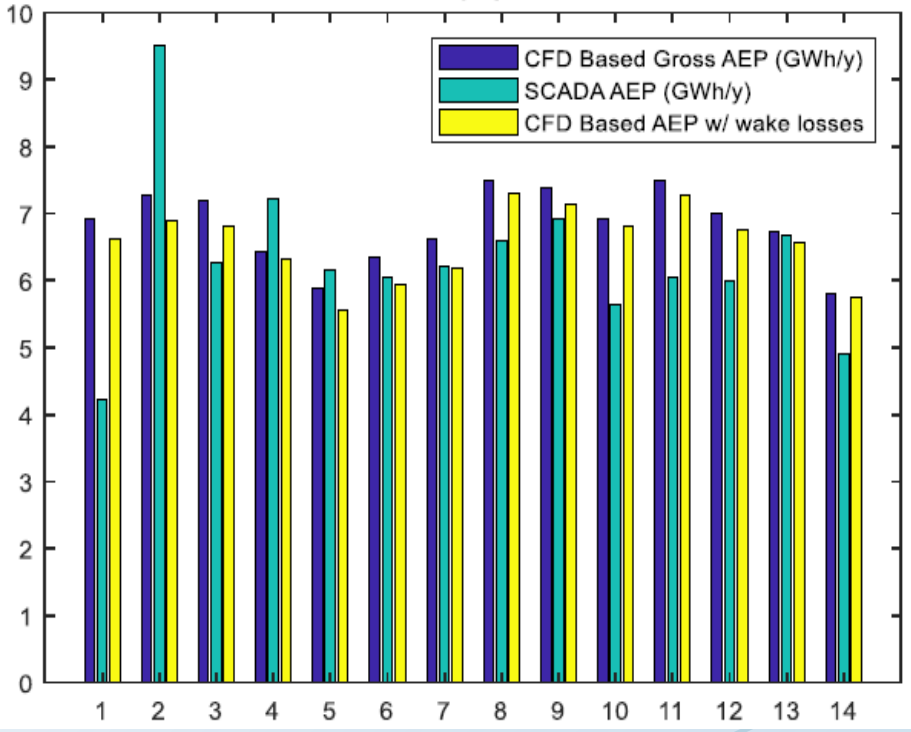




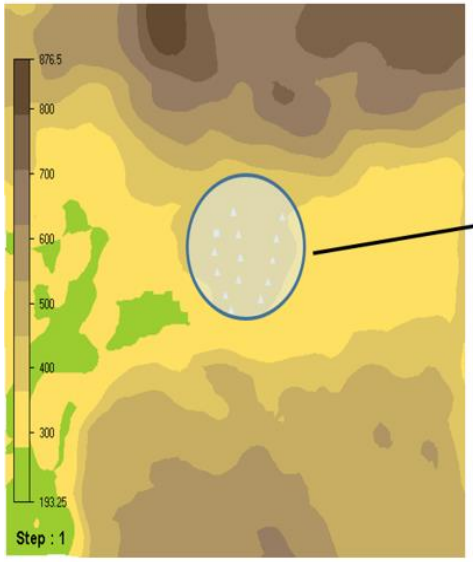


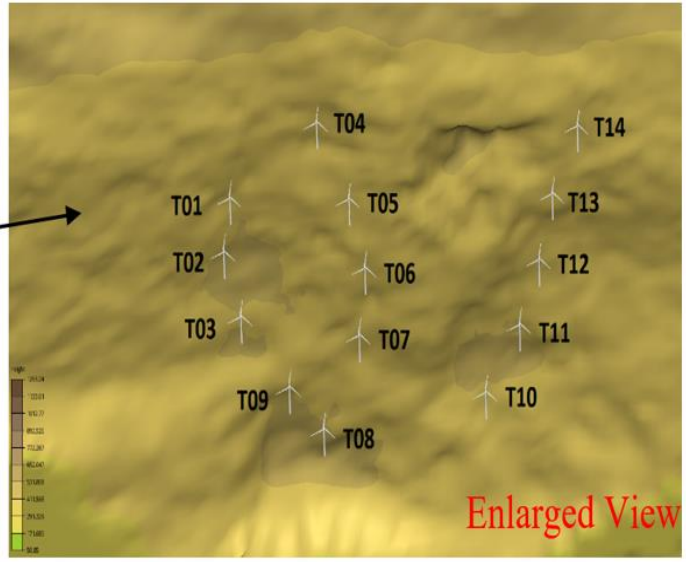
Wake Loss Model Study

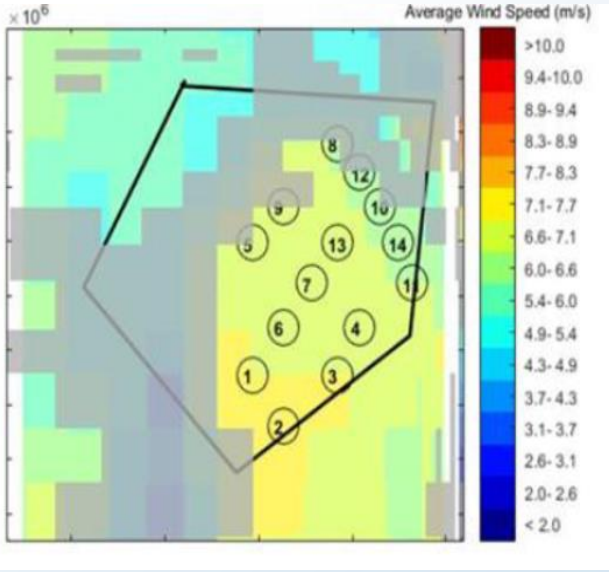
Wake loss model	Gross AEP from SCADA (GWh/y)	Gross AEP without wake loss using CFD (GWh/y)	Gross AEP with wake losses using CFD (GWh/y)
Jensen	88.49	95	87.7
Larsen			91.9
Ishihara			87.8



Wind Park Layout Optimization







Hub Height (m)	No. of turbines	Gross AEP (GWh/y) from SCADA with existing layout	AEP from CFD with wake losses (GWh/y) with existing layout	AEP from CFD with wake losses (GWh/y) after layout optimization
80.0	14	88.49	91.9	99.3

Conclusion

1. SCADA data AEP results are compared with CFD simulations where ***a good agreement*** is found.
2. To better understand the wake effects on AEP, three wake models were tested, where the results show that CFD results with the use of wake loss models are in ***good agreement*** with the SCADA data.
3. As an overall a ***good comparison*** is found between SCADA data and CFD simulations results.
4. A preliminary case study about wind park layout optimization shows that AEP can be optimized by optimizing the wind park layout and CFD simulations can be used as a tool in this regards.

Thank you !

Acknowledgement:

This research work collaborate with the Arctic Technology and Icing Research Group at UiT-The Arctic University of Norway.