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WHEN TRUST MATTERS

Modelled icing losses with WICE: A blind test in France

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Winterwind 2021, online

21 April 2021

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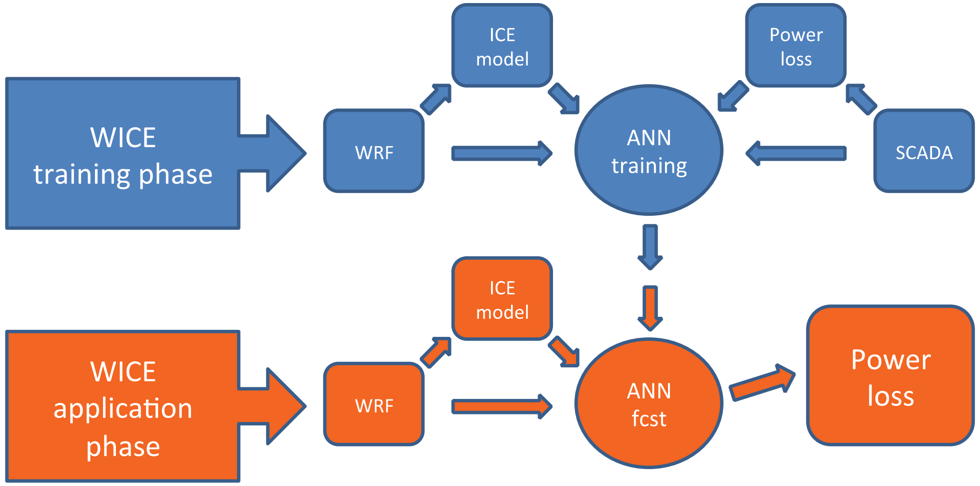
Part 1: Introduction and Methodology

Icing study model chain

Icing study model chain – production loss

A combination of physical and statistical modelling

ANN – Artificial Neural Network

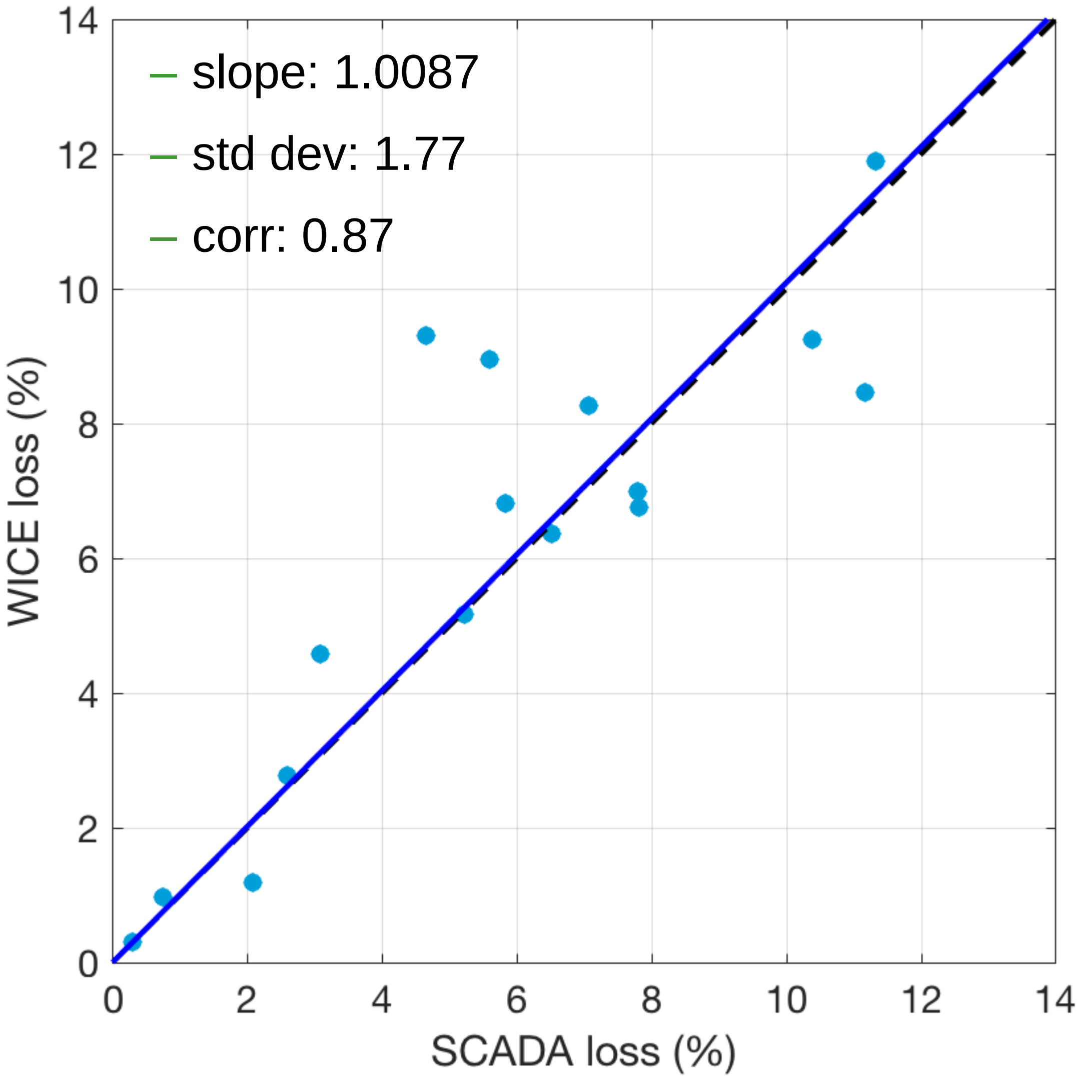


Training data set from operational wind farms in Sweden.

Previous validations

- Internal validation with 10 wind farms located in Scandinavia (Winterwind 2019, Umeå)
- Blind test for RES, 5 wind farms in Sweden (Winterwind 2020, Åre)

- All wind farms in the validations located in the same region as the training dataset.
- **How well can WICE perform in other regions?**



RES blind test in France

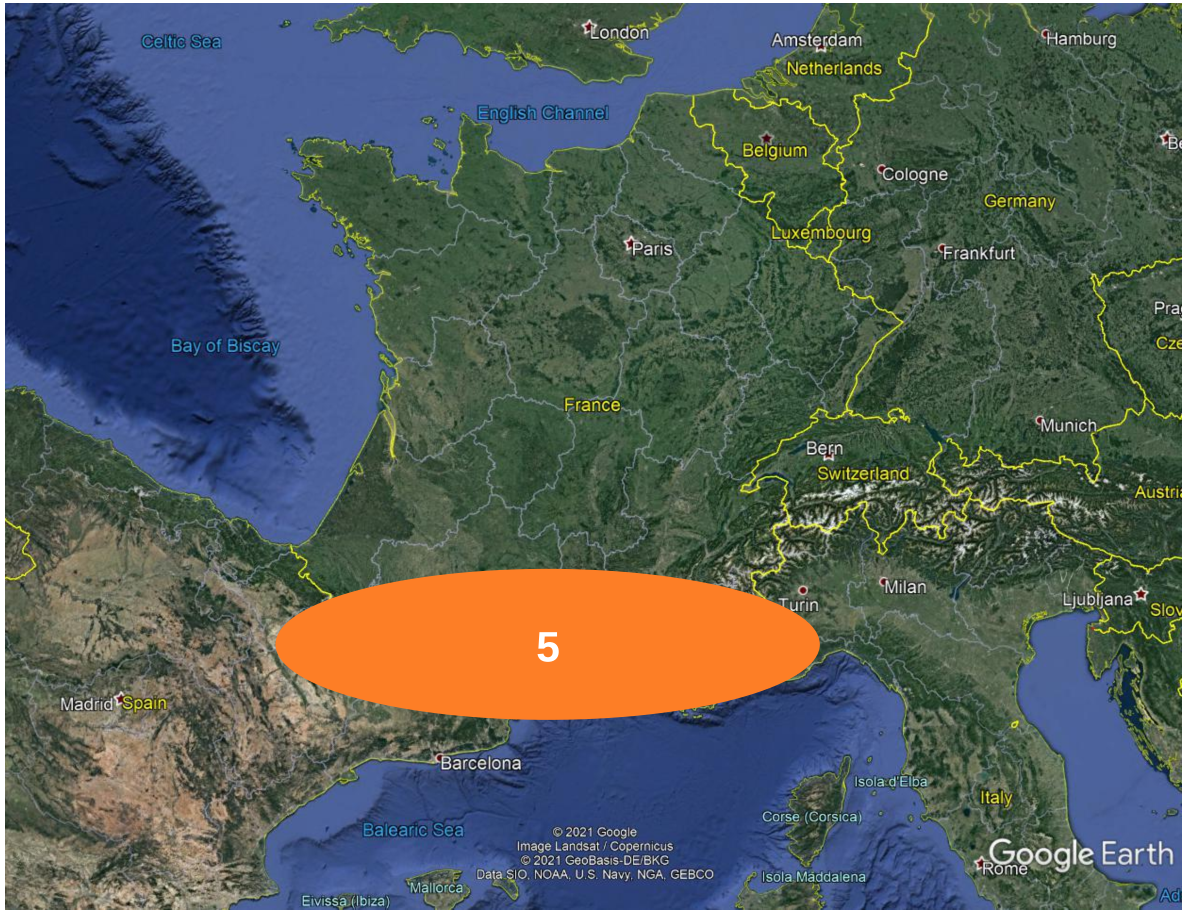
5 sites in southern France

SCADA

- 1 year per wind farm
- 78 turbines
- IEA Task 19 method used to estimate losses

Weather modelling

- WRF
- In-house setup
- 333m model grid resolution



Part 2: Validation results

Validation results

Observed and modelled ice losses

	WF 1	WF 2	WF 3	WF 4	WF 5
Observed loss	4.6%	6.3%	0.5%	2.5%	5.4%
WICE loss	4.0%	3.9%	2.5%	3.1%	3.4%
OEM	A	B	C	A	D
Shut down for ice risk	No	Yes	No	No	Yes

- Good agreement for WF 1 and WF 4
- Modelled losses underestimated for WF 2 and WF 5
- Modelled losses overestimated for WF 3

Questions addressed in detailed analysis:

Can we explain the under and over estimations?

Can WICE be updated to correctly predict these in future?

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Validation results

WF 2 analysis

- Good agreement for all but two turbines.
- Observed losses much higher than modelled for these two turbines.
- Ice shutdown procedure for these two turbines are more restrictive than for the other ones.

Validation results

WF 2 analysis – WICE modified to capture additional shutdown

- Modelling assumption: Ice detector on hub for measuring icing intensity. Turbine shut down when the modelled ice growth on an ISO standard cylinder at hub height exceeds a given limit.

Observed and modelled ice losses

10 g/hour	WF 2
Observed loss	6.3%
WICE loss	3.9%
WICE incl. shut down	6.1%

15 g/hour	WF 2
Observed loss	6.3%
WICE loss	3.9%
WICE incl. shut down	5.9%

20 g/hour	WF 2
Observed loss	6.3%
WICE loss	3.9%
WICE incl. shut down	5.6%

Best choice when considering losses on both turbine and wind farm level

Validation results

WF 3 analysis

- Gaps between SCADA data and WICE tool for WF 3 couldn’t be explained in RES analysis
- One possible explanation is that the turbine type in WF 3 is less sensitive to ice than the turbine types in neighbouring wind farms included in the analysis.

Validation results

WF 5 analysis

- Wind turbines are equipped with blade ice detection system
- Turbines are shut down when “too much ice on the blades” is detected
- A larger intra-farm variability in observations compared to model results

Validation results

WF 5 analysis – WICE modified to capture additional shutdown

- Assumption: Blade ice detector. Turbines are shut down when the modelled ice load on a simplified turbine blade exceeds a threshold (calculated for each individual turbine).

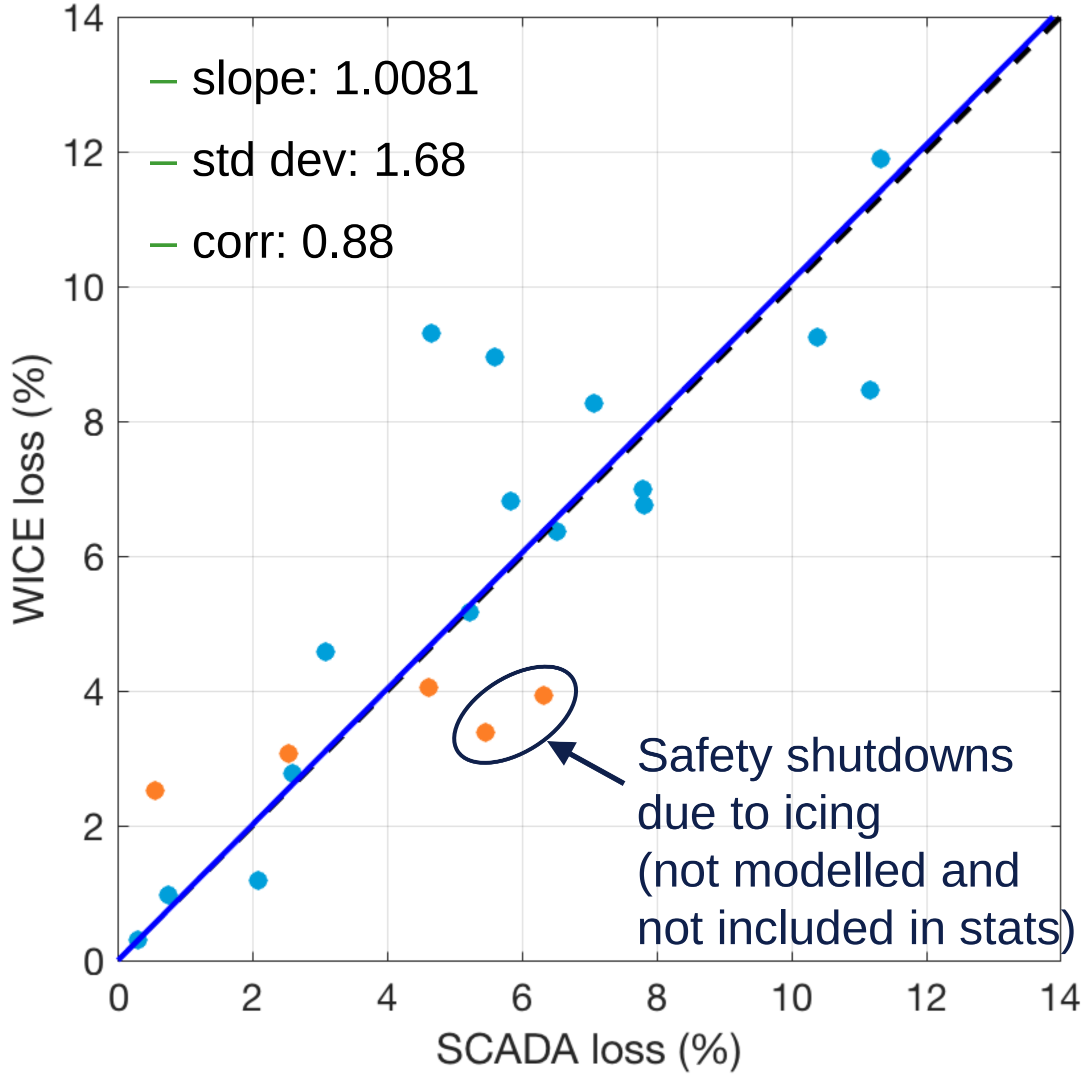
Observed and modelled ice losses

	WF 5
Observed loss	5.4
WICE loss	3.4
WICE incl. shut down	5.2

- Many uncertainties on the operational characteristics of the ice detection system.
- No access to time series from blade ice detection system.
- Same settings for all turbines?
- There is a potential for modelling the blade ice detection system but more data is required.

Internal validation and RES Blind Tests

- Internal validation, 10 wind farms located in Scandinavia (Winterwind 2019, Umeå)
- Blind test for RES, 5 wind farms in Sweden (Winterwind 2020, Åre)
- Blind test for RES, 5 wind farms in France



Part 3: Summary

Summary

- Modelled and observed losses agree well for 2 wind farms (WF 1 and WF 4)
- For one wind farm the agreement is good for all but two wind turbines (WF 2)
  - The differences can be explained by shut downs due to safety rules in icing conditions
- For one wind farm the modelled losses are underestimated (WF 5).
  Difference can be explained by:
  - Blade ice detection system installed
  - Turbines are shut down when “too much ice on the blades” is detected
- For one wind farm the modelled losses are overpredicted (WF 3)
  - Possible explanation is that the turbine type is less sensitive to ice than the turbine types in neighbouring wind farms

Conclusion

- Scatter plot shows that the modelled wind farms in France fall within the scatter from previous validations
- When assessing the icing model performance it is essential to understand the wind farm turbine operation strategy in order to make a fair comparison
- There is a potential for modelling turbine shut down due to ice detectors or blade ice detection systems, but more data is required

Thanks for listening

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