



Ice Protection Systems: Performance Assessment Methodology

Matthew Wadham-Gagnon

Åre
2018-02-06

1

Wind farm
optimisation



2

Solar farm
optimisation



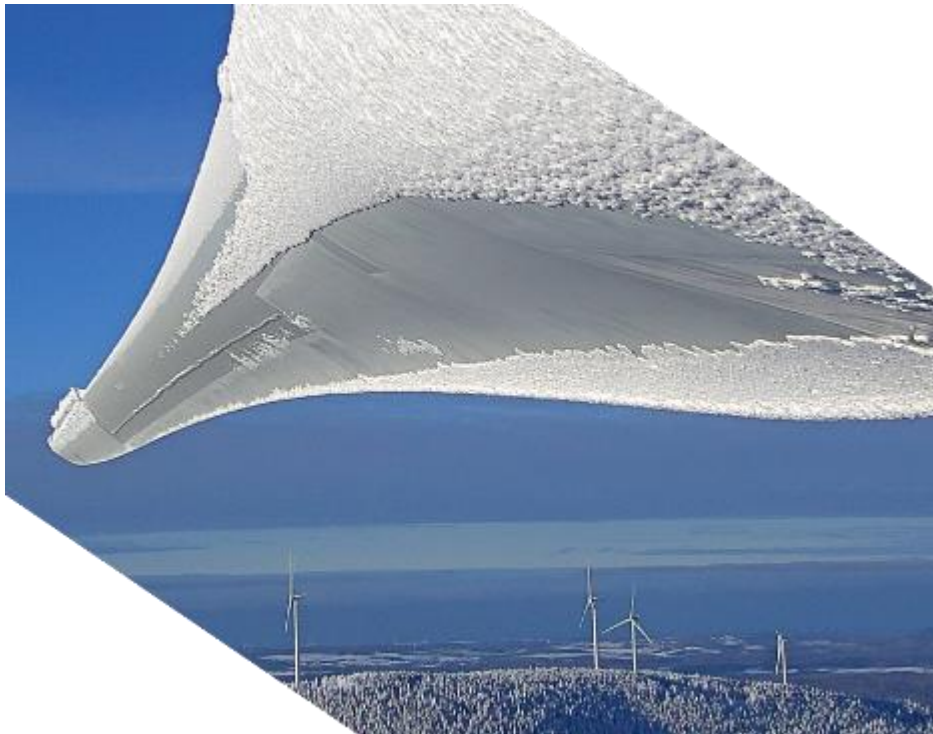
3

Integration of
renewables



Context

Ice Protection System retrofit



Context

instrumental icing 90% of measurement period



Screening of Operational Data

SCADA and met mast data

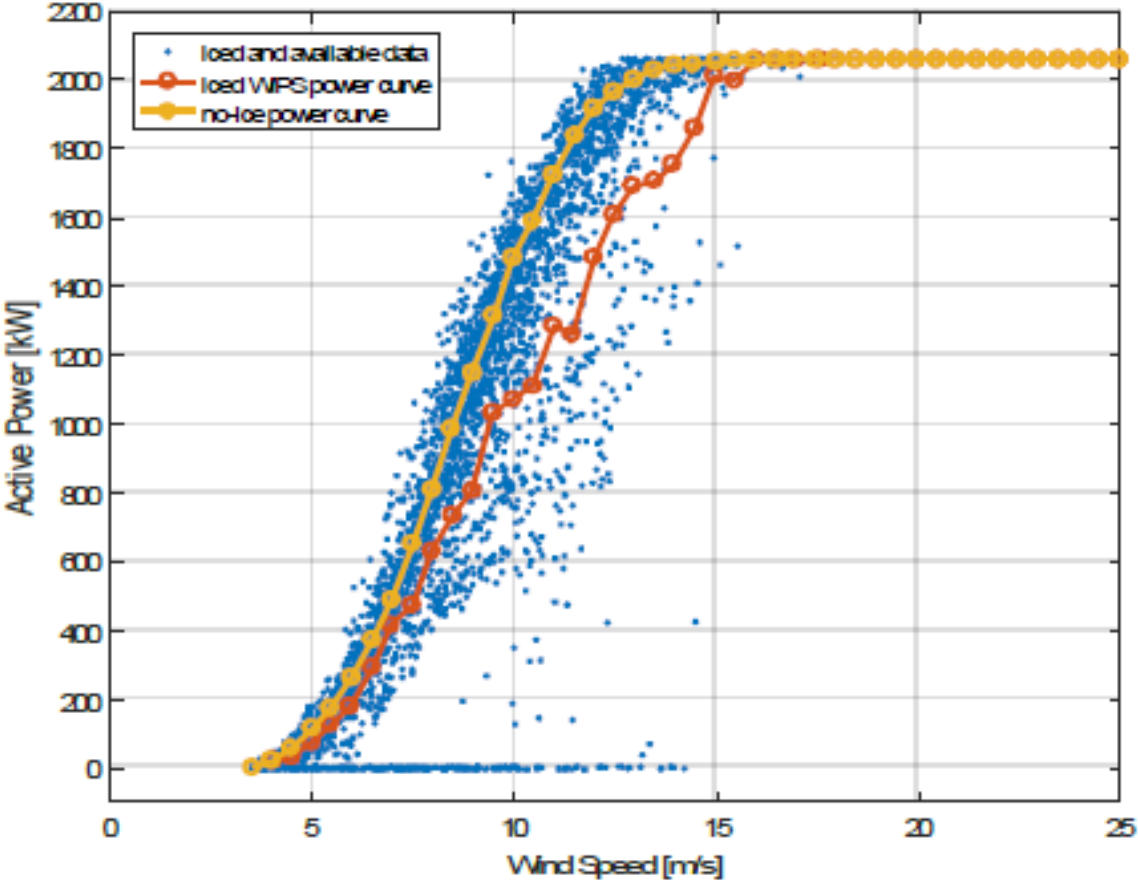
- Quality control of data
- Air density adjustments

Status codes

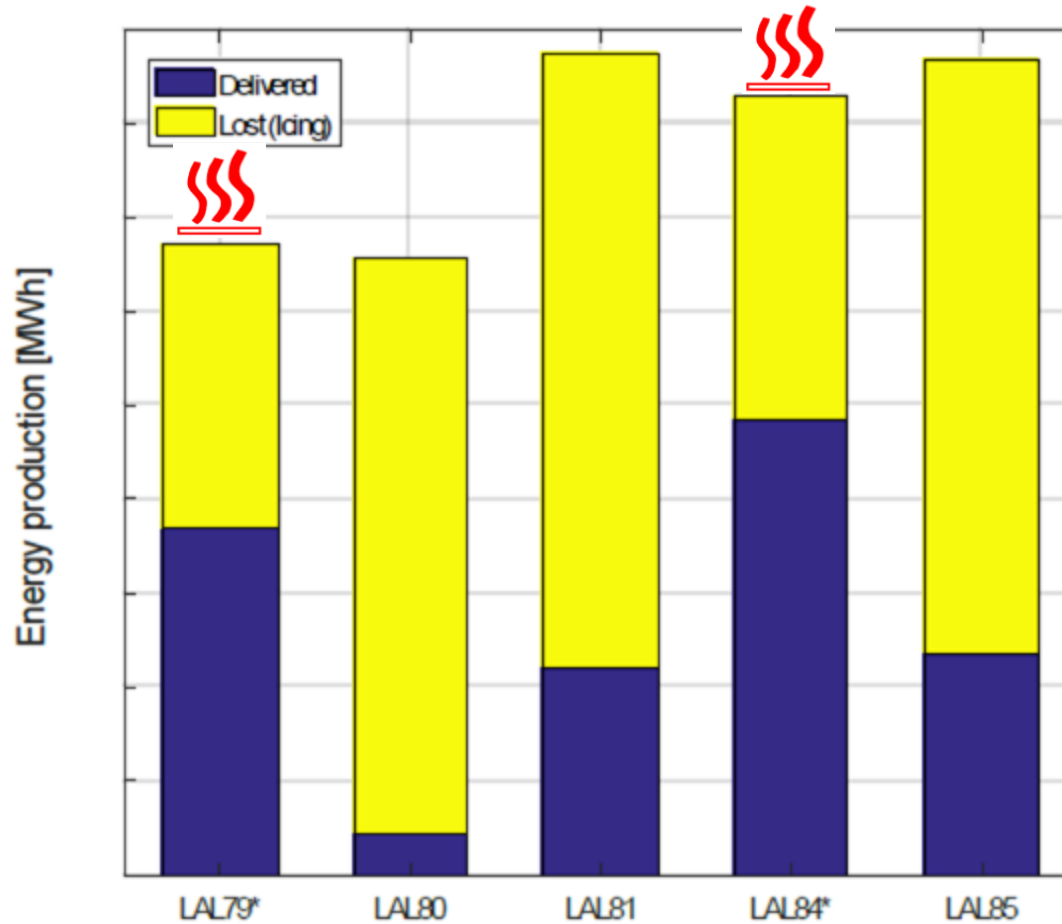
- Maintenances and faults (non ice related)
- Icing status codes
- Technical availability vs group availability



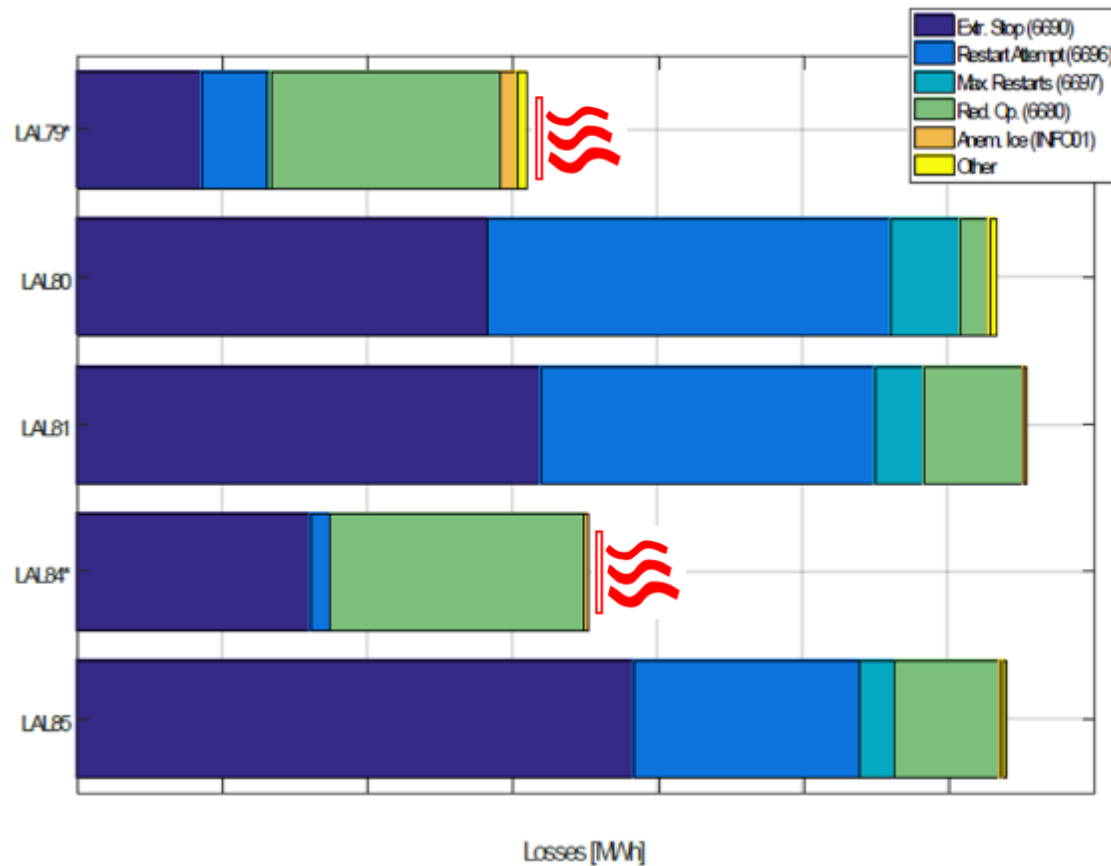
Power curves



Expected vs Actual Energy



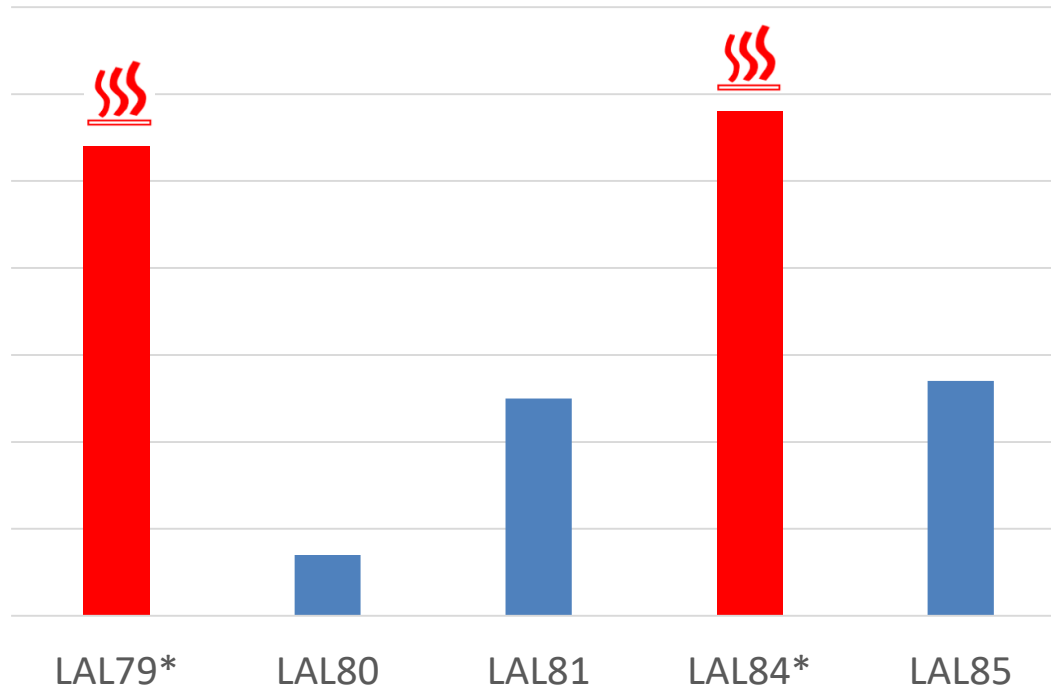
Icing loss breakdown by status code



Production Ratio

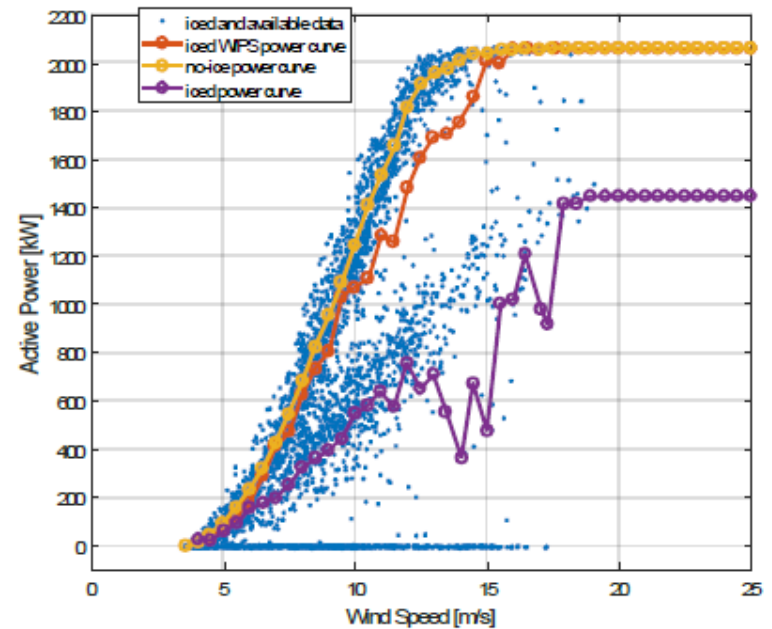
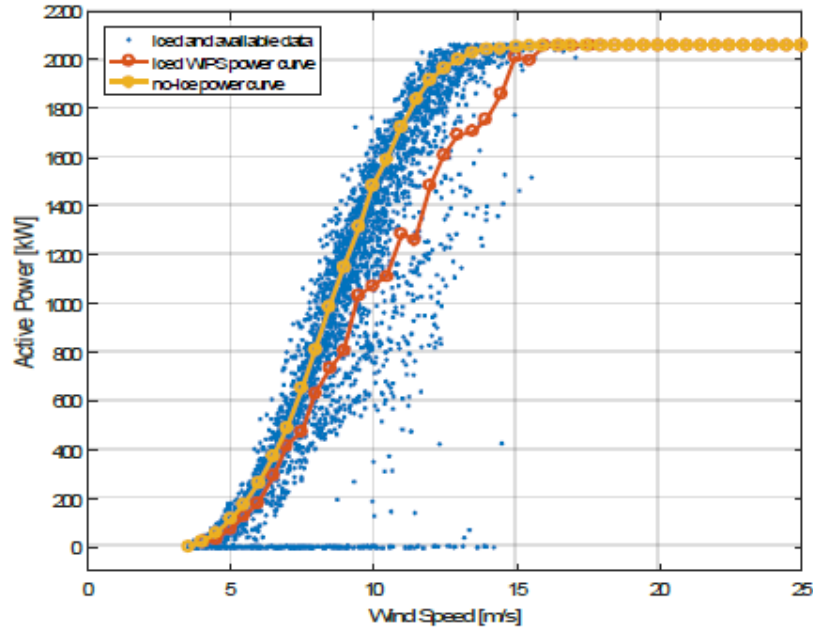
Text

$$\text{Production Ratio} = \frac{\text{Total Energy Produced}}{\text{Total Energy Expected}}$$



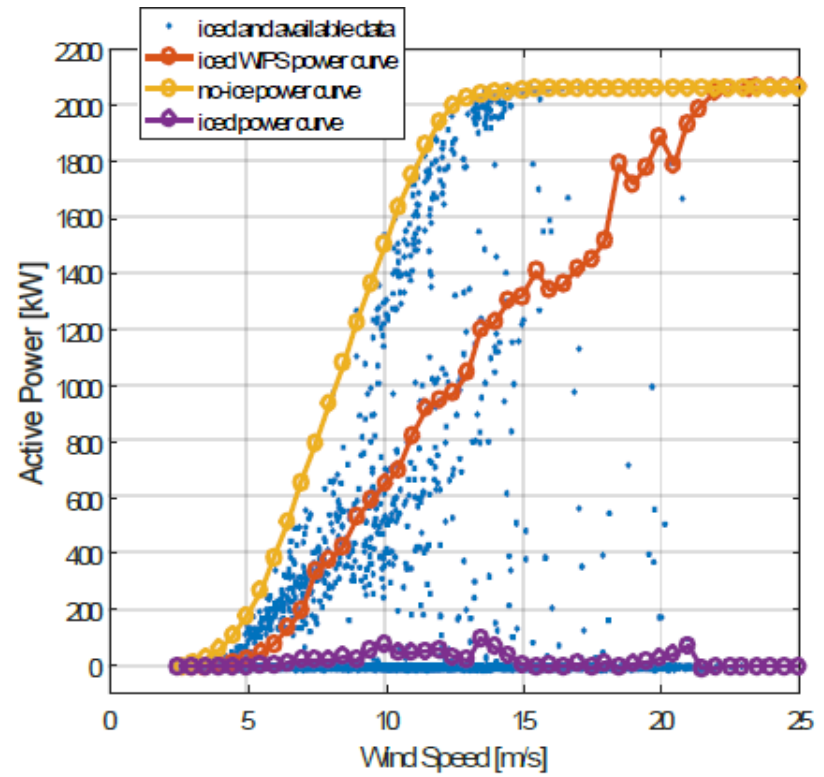
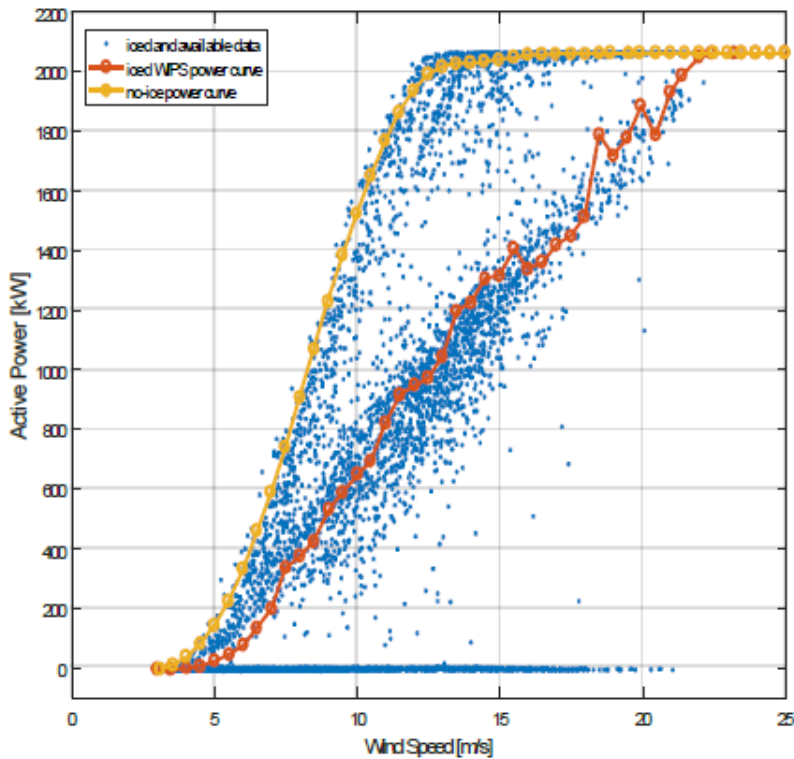
Simulated efficiency gain

Moderate icing example

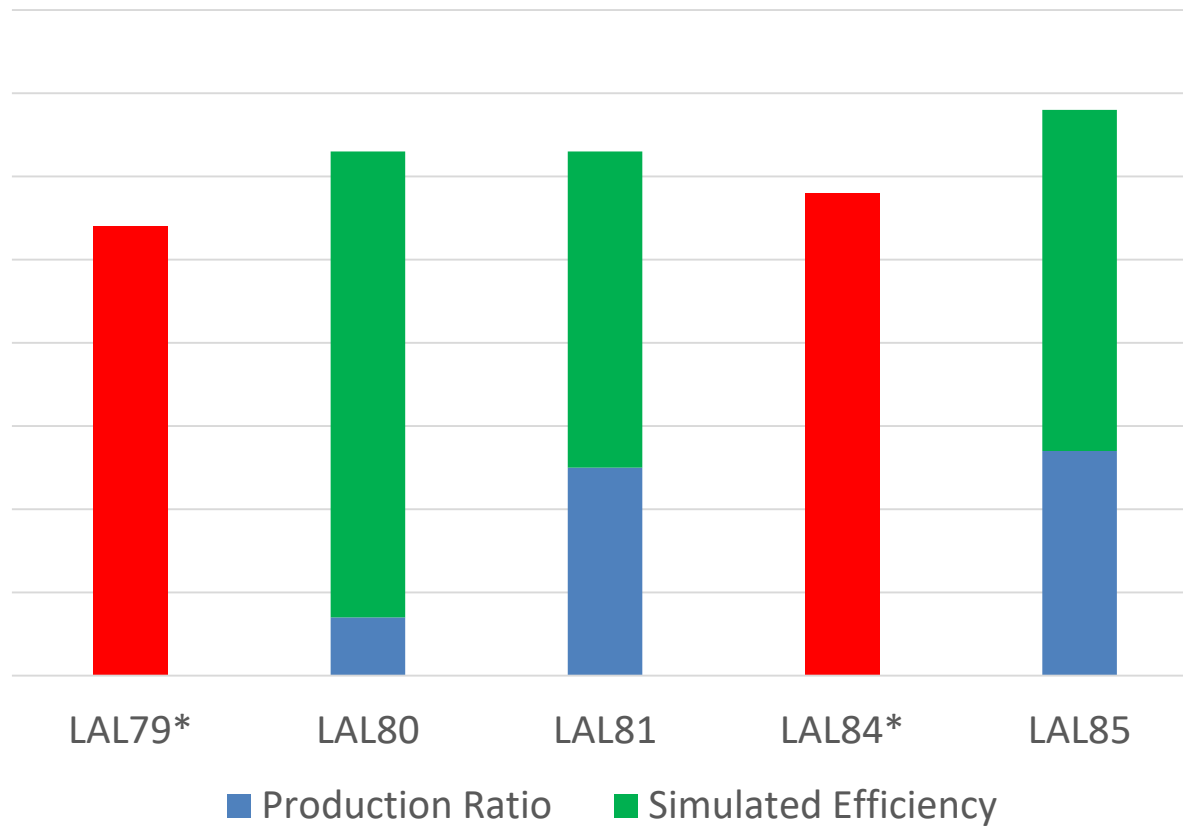


Simulated efficiency gain

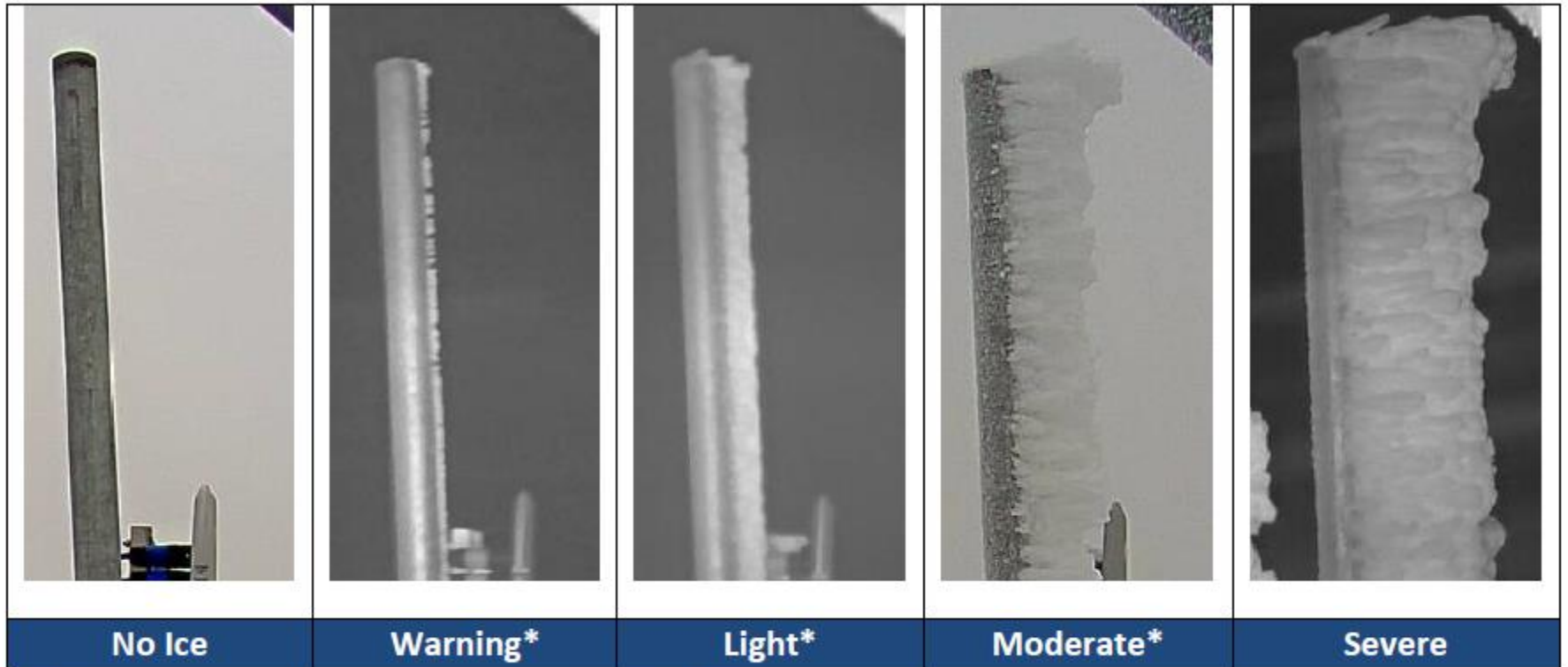
Example of severe icing



Production ratio and Simulated efficiency gain



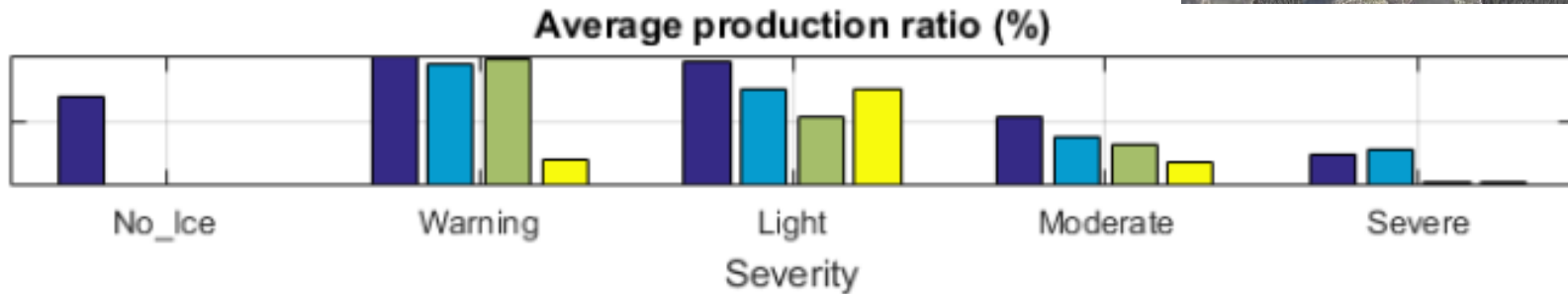
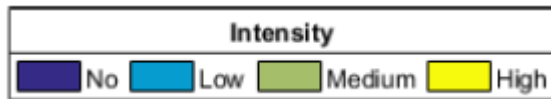
Nacelle icing classification



* Photo represents the maximum amount of ice for that category

Nacelle icing classification

Automated Image analysis algorithm
High Availability



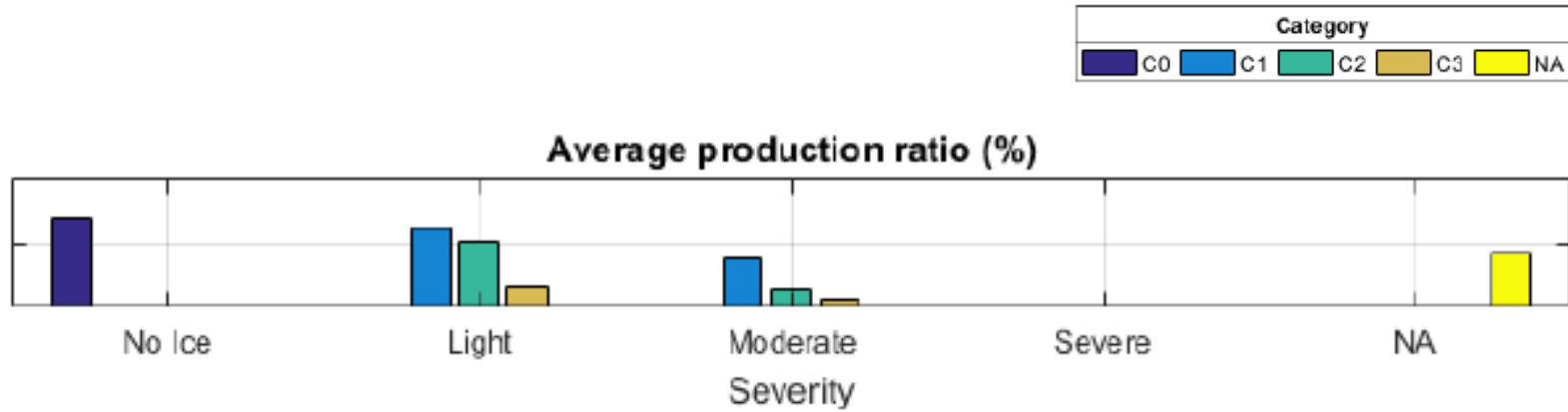
$$\text{Production Ratios} = \frac{\text{Total Energy Produced}}{\text{Total Energy Expected}}$$

Blade icing classification

| Hub Classification | Description |
|--------------------|---|
| C0 | Blade mostly free of ice |
| C1 | WIPS section mostly free of ice |
| C2 | WIPS section partially covered with ice |
| C3 | WIPS section mostly covered with ice |



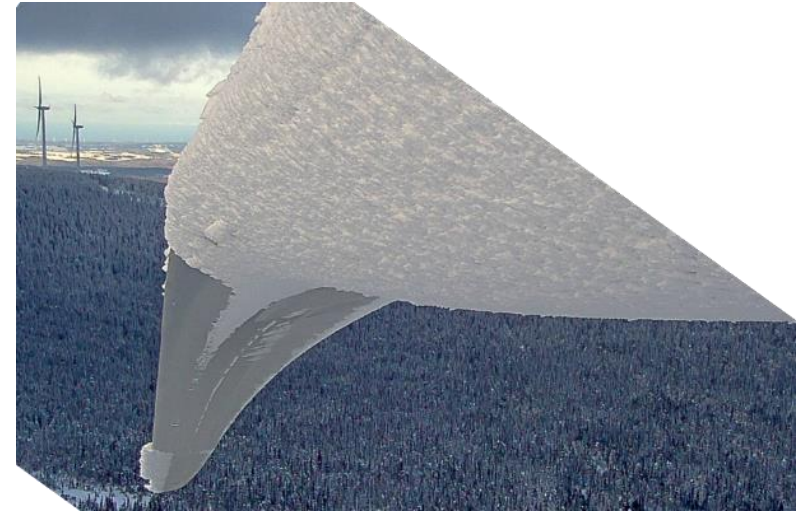
Blade icing classification



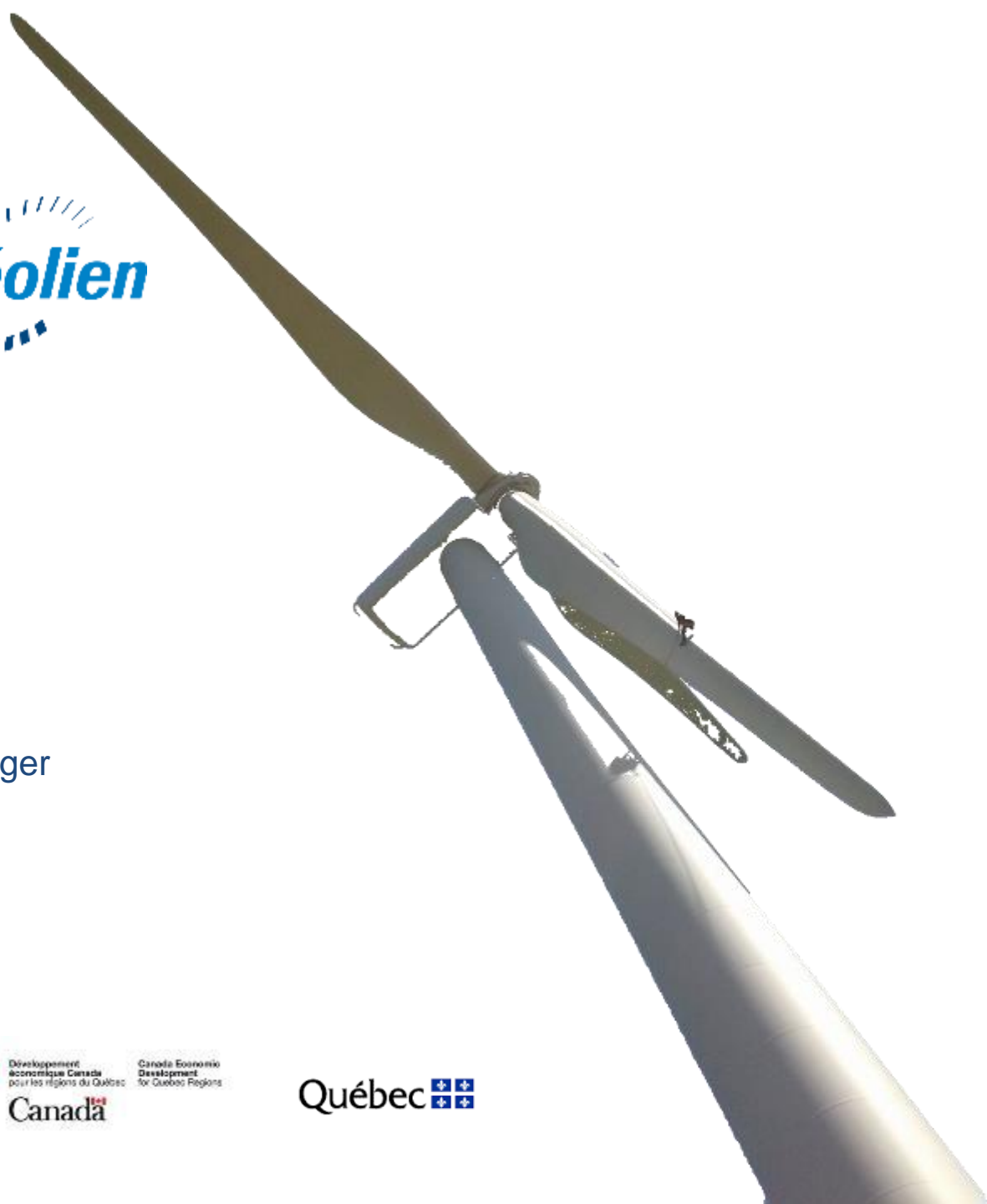
Conclusions

Critical to accurate analysis:

- QC, status codes, met mast data, availability groups, power curves



Icing severity classification (from cameras) enables in-depth understanding of WIPS performance



Matthew Wadham-Gagnon
Business Development Manager
mgagnon@eolien.qc.ca

