Clir Renewables: Enhancing icing datasets

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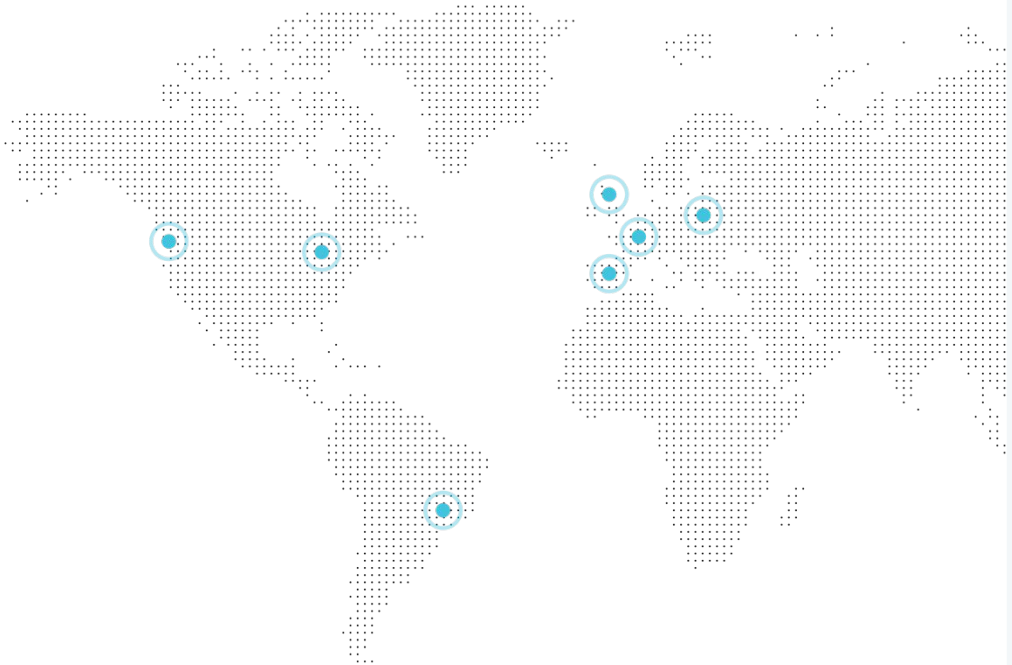
Agenda

- About Clir
- Improving icing loss quantification through power curve modelling.
- Cleaning and enriching of icing alarm data.
- Icing Analysis 1: Upgrade justification and validation.
- Icing Analysis 2: Texas Ice Storm 2021, increasing transparency on icing events.

clir

The market intelligence platform for wind and solar

Clir is an industry leading Cleantech company



Our reach

Our Values

Inclusion

Sustainability

Innovation

Communication

Impact

EQUAL by 30

Truth and Reconciliation Commission of Canada

17+
Countries

40+
Clients

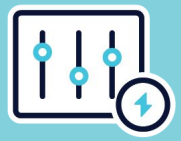
120+
Staff

Clean power curves allow for accurate estimation of icing losses

Enriched turbine datasets allow for more accurate insight into icing losses.

Gaussian Process models are used to clean power curves and flag suspected periods of underperformance.

Automate detectors flag periods of turbine underperformance, which are further classified as icing, depending on environmental conditions.

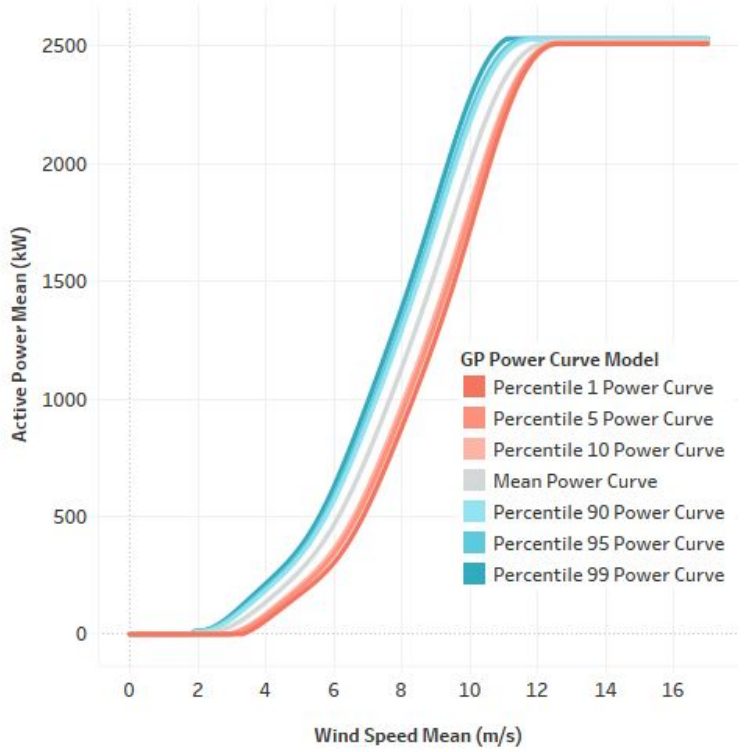


Hierarchy of potential energy models are used to calculate lost energy for each 10-minute period, depending on data available for each data point.

Gaussian process power curve models

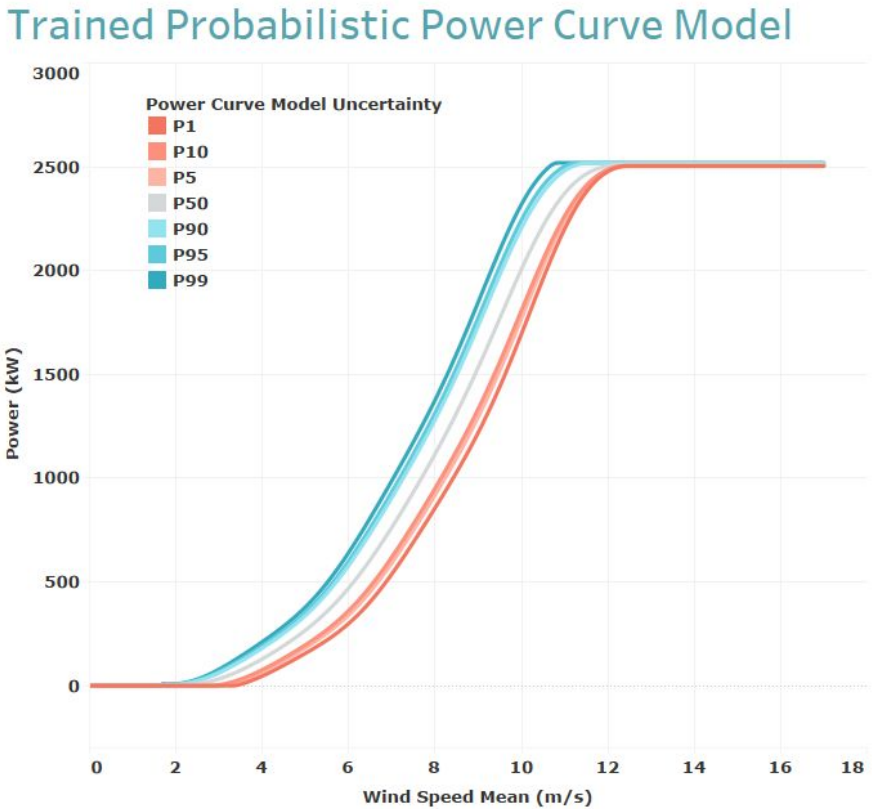
Accurate models of turbine performance enable automatic identification of turbine underperformance.

Detectors can be set up at different confidence intervals depending on the level of scatter at a given turbine.



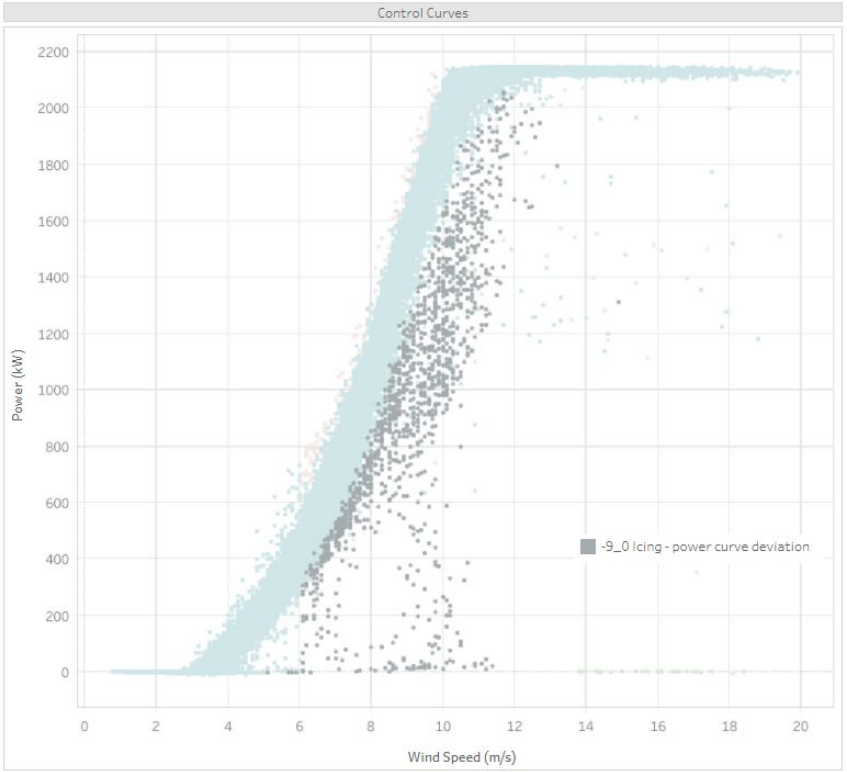
Trained probabilistic power curve model

Iterative gaussian process modelling used to clean power curves



Iterative Gaussian process-based power curve modelling

Icing detector flags periods of suspected icing, not identified by OEM alarms



Clir's icing detector showing data points being flagged as icing

Automated cleaning of alarm data

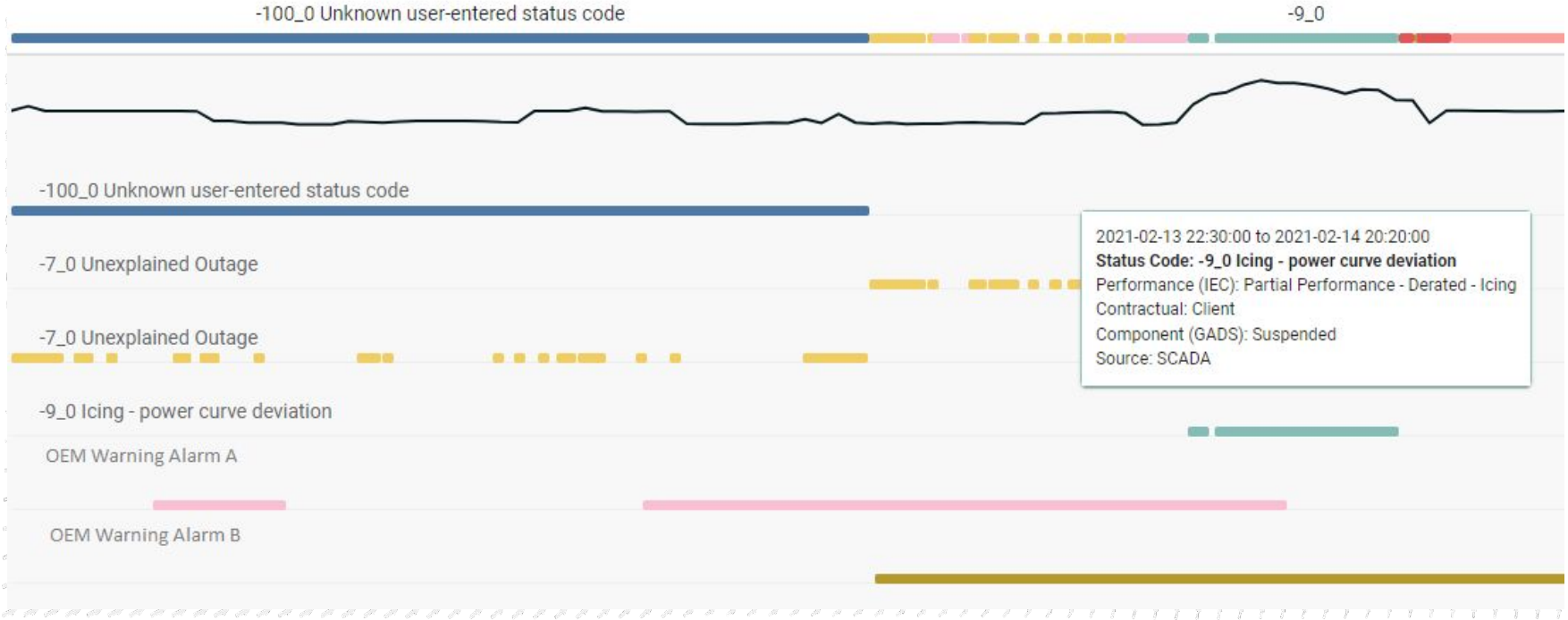
Synthetic events, correction of erroneous alarm data and user amendments combine to provide clear history of turbine operation during large icing events.

Synthetic events (i.e. underperformance, icing, overperformance) are automatically created based on output of GPs to supplement the OEM dataset.

Erroneous alarm data is automatically flagged and corrected (i.e. run-on alarms and periods of no generation labelled as being operational).

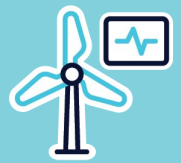
Data input system and UI allow for easy manual amendment and integration of supplementary events if necessary.

Automated cleaning of alarm data



Clir's Event Timeline showing a combination of OEM events and Clir synthetic events

Icing Analysis 1: Upgrade justification and validation



Significant losses were quantified from Clir icing analysis.
Investment in icing package was recommended.

Client trialled pilot project at three turbines to validate the effectiveness and value of the icing package.

Clir conducted upgrade validation analysis to quantify impact of icing package.
Seasonal icing losses reduced by 66 per cent at pilot turbines.

Based on Clir's findings, the client implemented this package on all turbines.
A further validation was completed by Clir.

Icing Analysis 1: Upgrade justification and validation

Problem:

- Owner wanted to gain greater insight into impact of icing and the potential uplift of installing an icing package.
- Dataset available to owner did not accurately flag and quantify icing losses.

Solution:

- Icing detector flagged an additional 18 per cent of icing losses compared to losses accrued during OEM icing events.

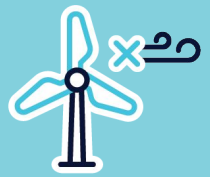
Outcome:

- Investment in icing package justified as a result of more accurate icing loss estimation.
- Clir validated the site-wide installation of the icing package to have reduced seasonal icing losses and increased generation significantly (as shown in table).

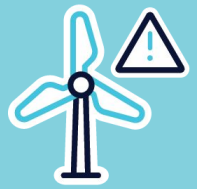
2020-07-01 to 2020-04-03	Icing Package Installed		No Icing Package Installed	
	Total Lost Energy (MWh)	Generated Energy (MWh)	Total Lost Energy (MWh)	Generated Energy (MWh)
Farm Total	1203.2	1027.9	284.2	73.0
Avg. per Turbine	27.3	23.4	25.8	6.6

Breakdown of the lost energy and generated energy values seen at turbines with and without an icing package

Icing Analysis 2: Texas winter storm data



Unprecedented winter storm and low winds hit Texas and the Central States.



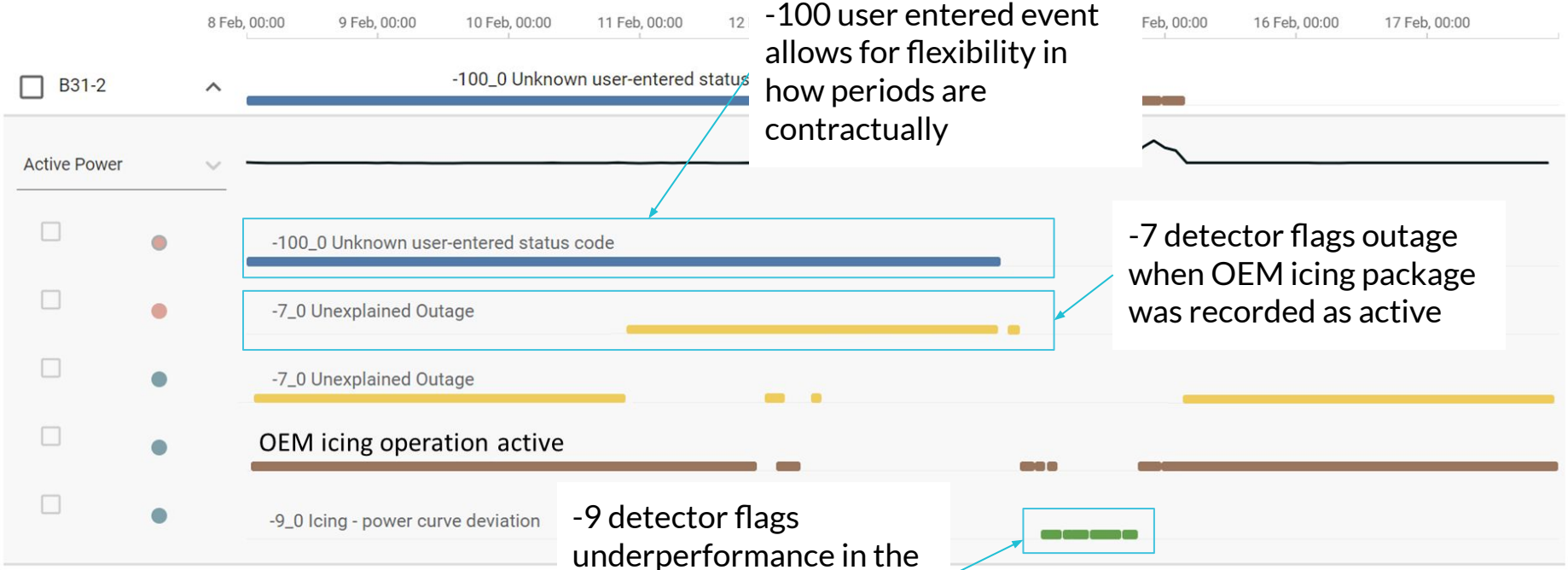
Clir users with and without icing packages struggle to interpret their raw data as alarms and events occurred at a greater volume than usual.

Synthetic events and automated data cleaning was used to overcome the noisy data and provide clear picture of icing events.

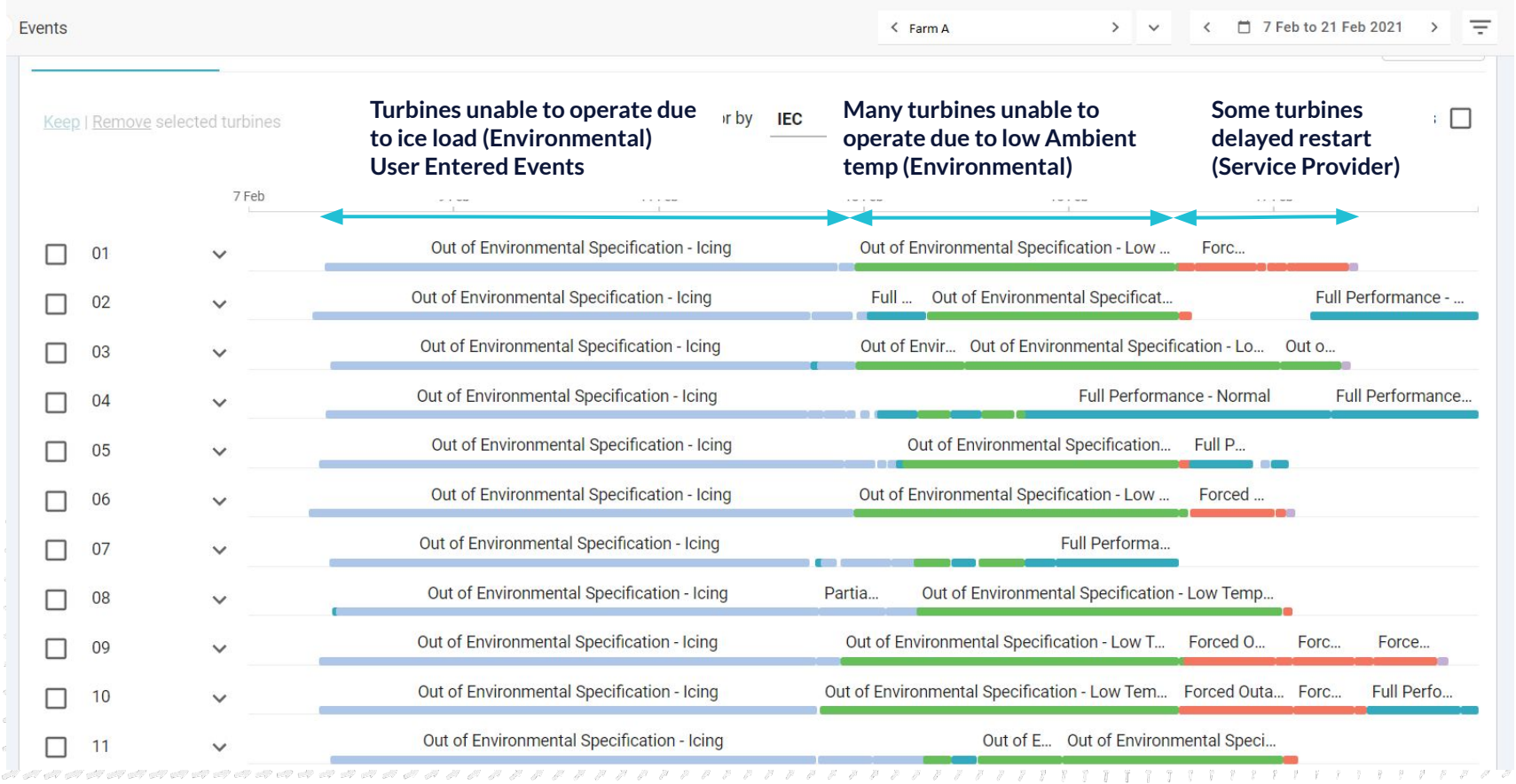
Accurate calculation of yield based availabilities and lost energies reflect and quantify the real impact of the storm.

OEM alarms and poor data quality resulted in turbines being incorrectly reported as online and operating.

Automatically and manually generated synthetic events combine to tell the true story.



Icing Analysis 2: Texas winter storm data



Icing Analysis 2: Texas winter storm data

Problem

- Lack of visibility into the impact of the winter ice storm due to poor data quality from OEM event data.
- Incorrect contractual categories for primary events leading to inaccurately reported availabilities.

Solution

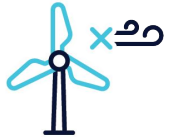
- Clirs detectors, synthetic events, Error Code Reconciliation (ECR) and user entered events were used to highlight periods of icing, low winds and when ambient conditions were out of turbine spec.

Outcome

- Owner and O&M provider were able to gain transparency around the availability and lost energy impact of the ice storm.
- Accurate contractual categorization to ensure the owner and service provider have clarity on who is accountable for downtime.

Summary

- Raw turbine data is not always reliable for reporting losses and analyzing turbine performance, extreme weather events exacerbate this problem.
- Advanced power curve modelling, automated detectors and data cleaning features combine to produce a more reliable and interpretable dataset.
- These methods have successfully been proven to be very useful in:
  - The justification and validation of icing upgrade packages, through more accurate quantification and insight into icing related losses.
  - Overcoming the challenges posed by poor reported data during extreme weather events, which misrepresents availability and contractual responsibilities.



Questions welcome!

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