On the influences of icing on regional forecast errors

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KJELLER VINDTEKNIKK

Outline

- Icing forecasts
- Regional forecasts – Sweden and Finland, Kjeller data
- More detailed analyses on light icing case Riutunkari, Finland – Foreca/VTT data
- Main take aways and suggestions for the future work

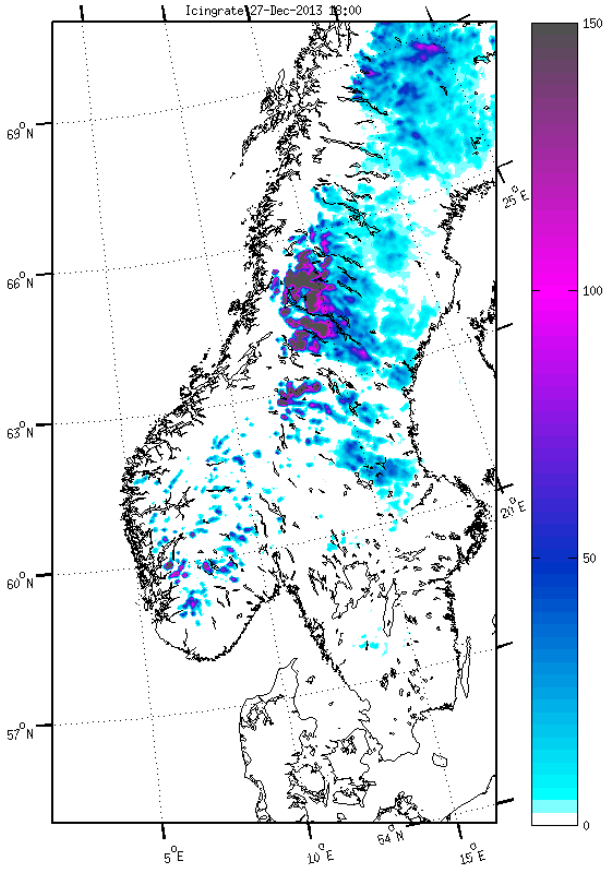
Icing forecasts

- Icing can cause significant production losses to the producer
  - Producers must place their bids to the Nordic power market
  - Differences between contracted and realized power can cause monetary losses
- Large forecast errors due to icing might cause regional level up regulation need
  - Low pressure fronts with low cloud heights can cause regional icing phenomena
  - This can happen when the wind power plants are concentrated on small geographical area

Regional forecast errors

- Power forecasts and icing forecasts in regional and local scale were analysed for two winters
- Focus on day-ahead forecasting
- Studied areas:
  - North Sweden
  - South Sweden
  - North-West coastal Finland
- Main research question: are there situations when icing is causing significant power losses at regional scale
- Turbines are without Ice Prevention Systems, IPS

Icing on a regional scale – Icing rate



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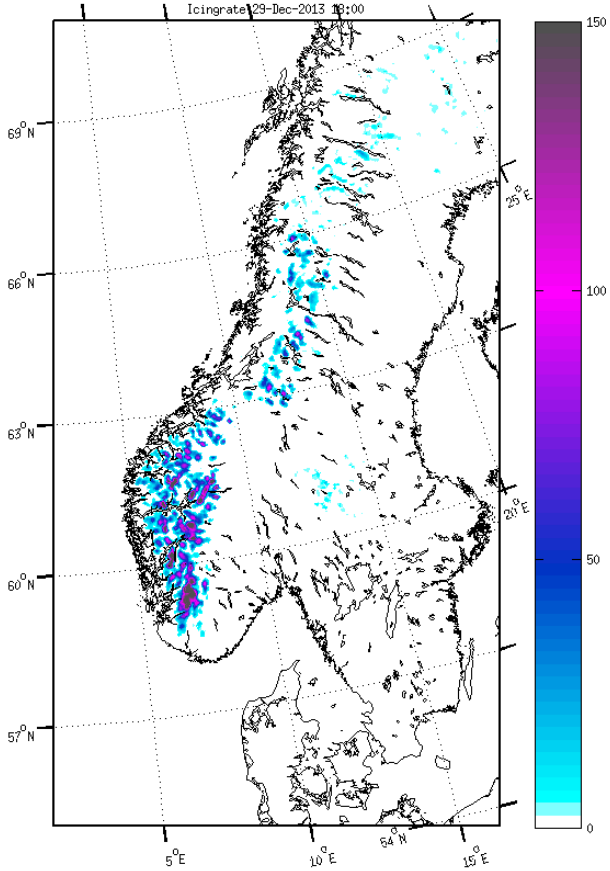

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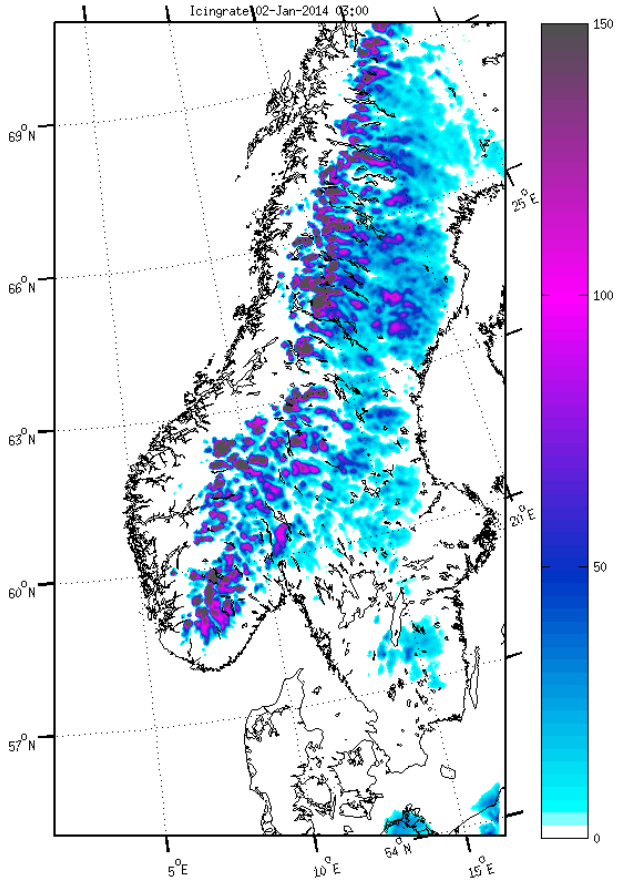

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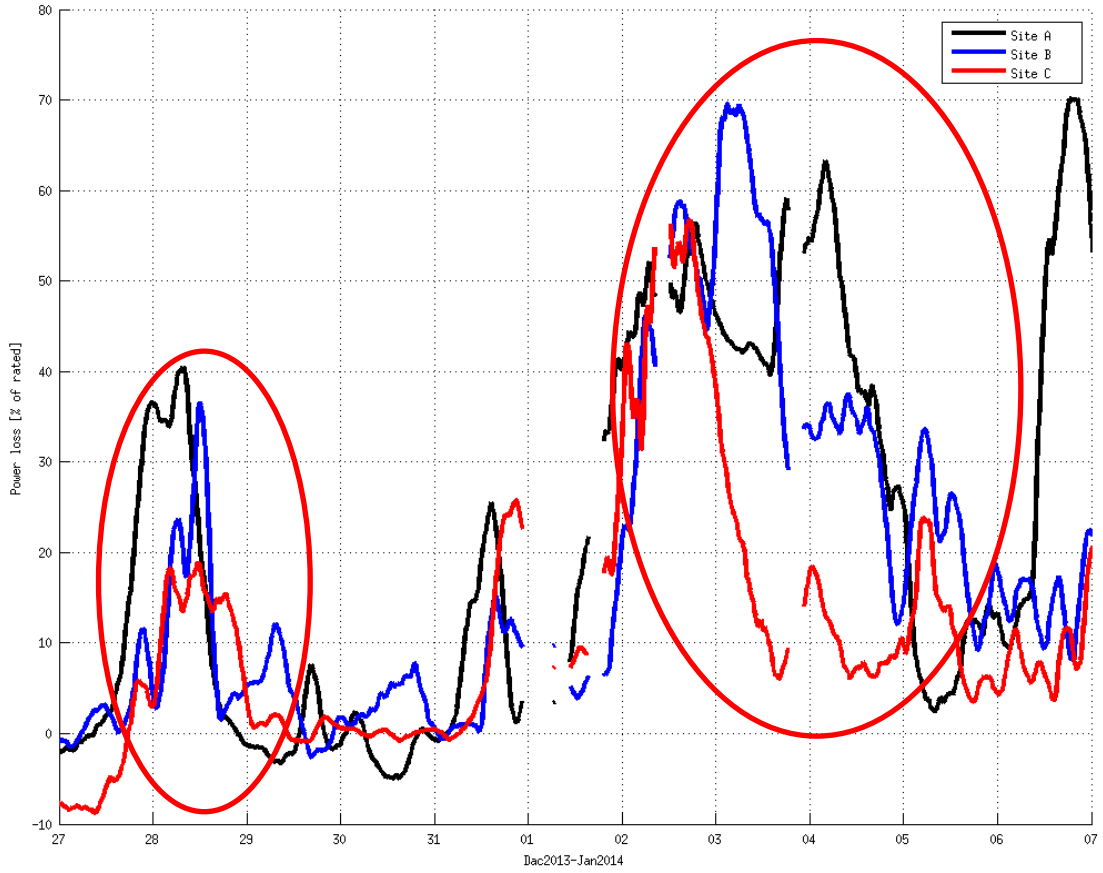
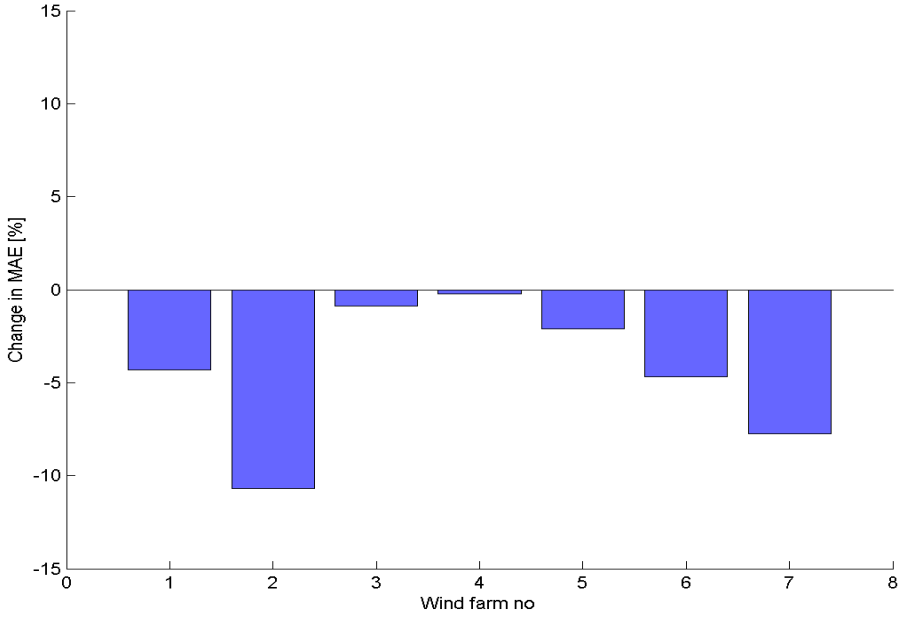
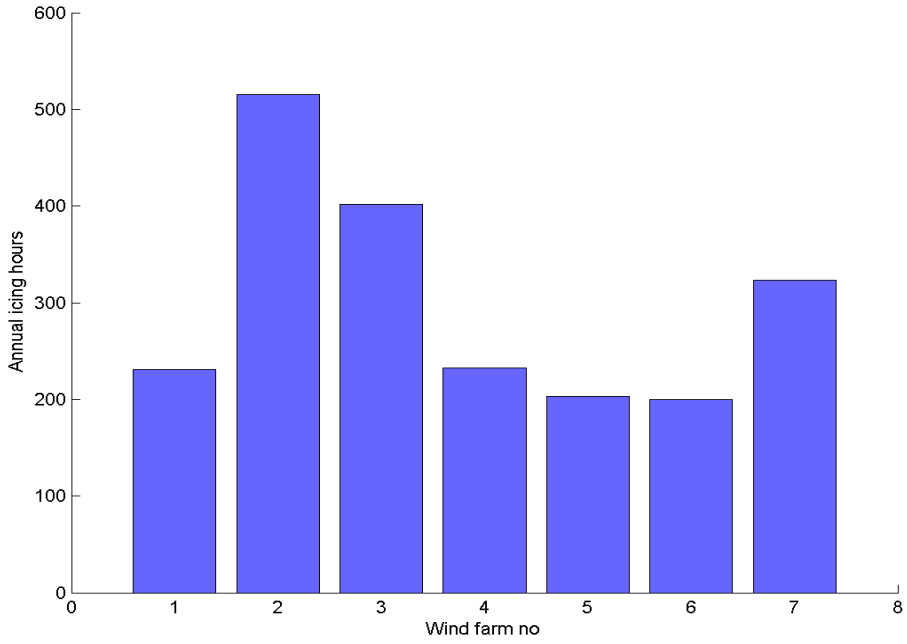
Power loss for 3 wind farms



North Sweden regional forecasts

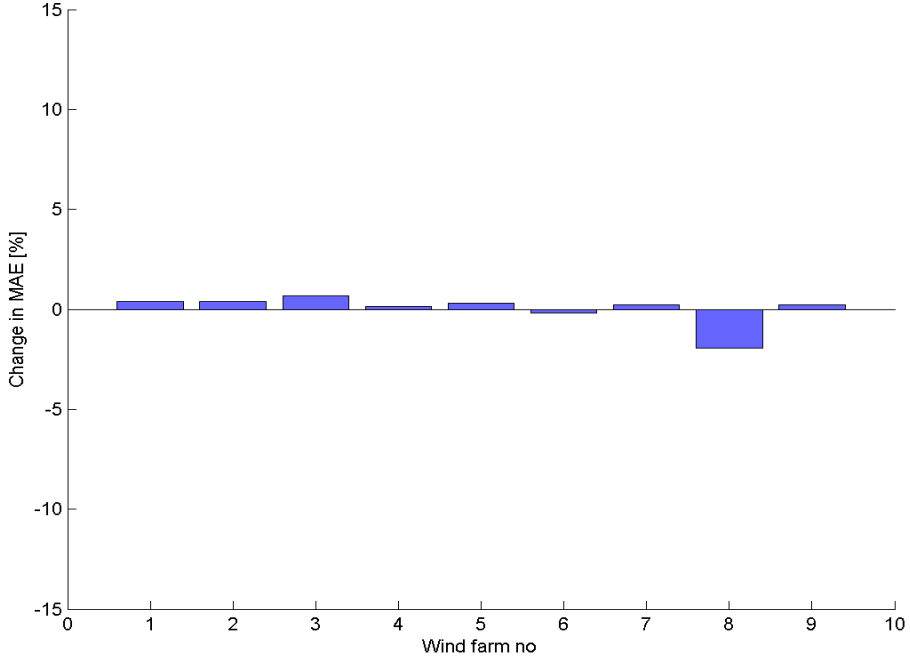
- Left figure: Change in Mean Absolute Errors in forecasts for 7 wind farms in Northern Sweden (Price area SE01 and SE02)
- Right figure: Annual number of icing hours for the 7 wind farms

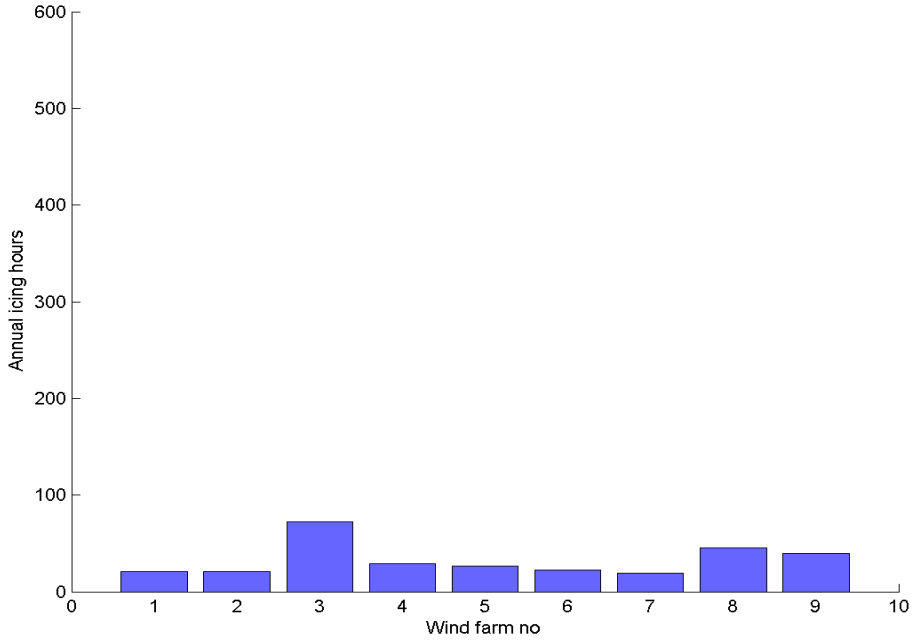




South Sweden regional forecasts

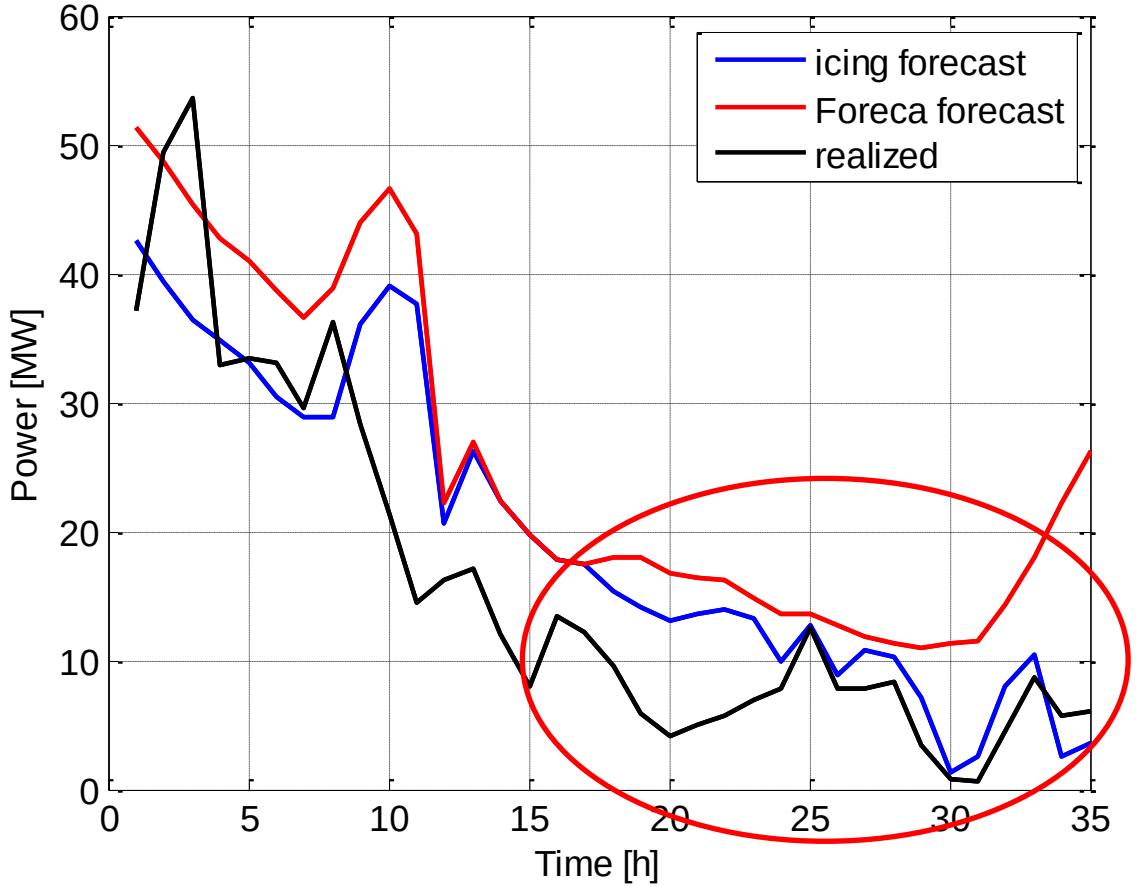
- Left figure: Change in Mean Absolute Errors in forecasts for 9 wind farms in Northern Sweden (Price area SE03 and SE04)
- Right figure: Annual number of icing hours for the 9 wind farms





Regional forecasts North-West coastal Finland

- Production losses on average 27 % of the time from the winter hours



site	MAE [%]	MAE icing [%]
1	12.2	12.0
2	13.2	13.5
3	13.7	14.5
4	14.9	15.2
5	15.3	16.4
sum	**10.7**	**11.4**

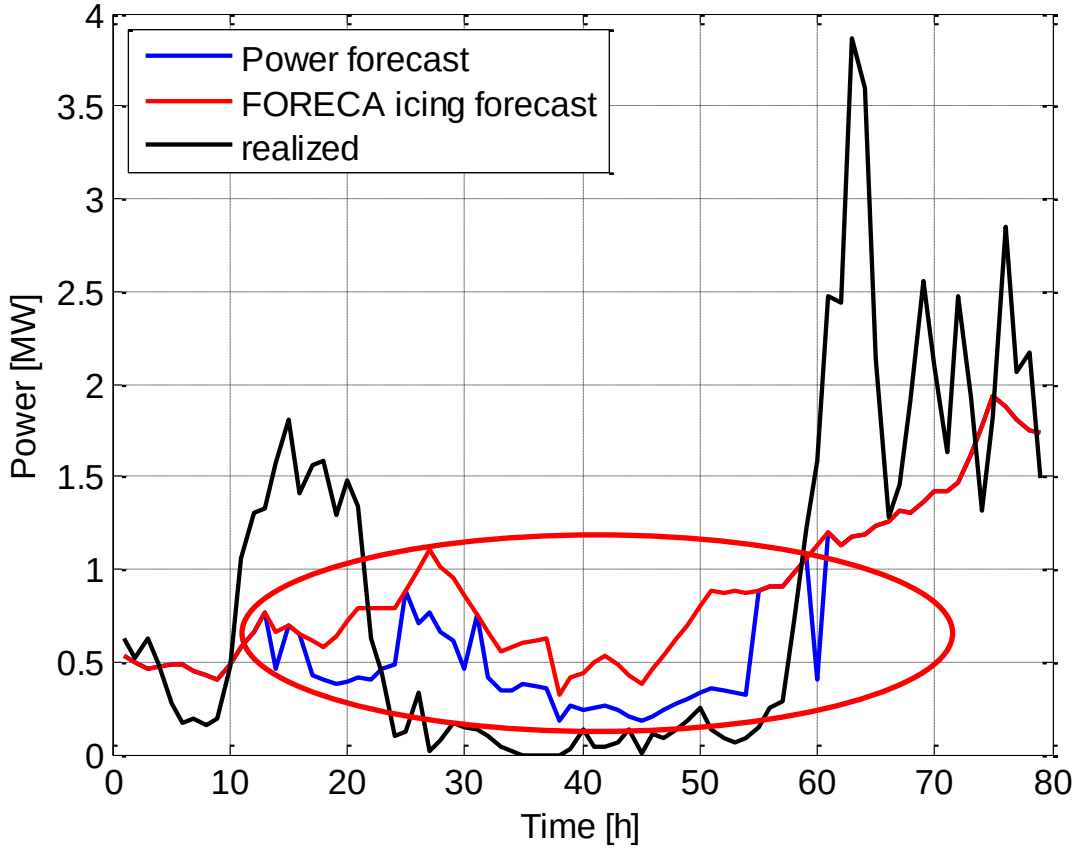
Riutunkari icing forecasts

Riutunkari

- 7.5MW wind power site in Northern Finland
- Site included in Finland regional case (Kjeller data)
- Another data set with different power loss model and duration of power losses
  - Foreca day-ahead icing forecasts, calibrated based on Labkotec icing detector mounted to the top of the wind power plant
  - Icing forecasts were transformed to power losses with VTT power loss module
  - Icing events over 70% probability was chosen (icing is observed 5% of the winter months)
  - One winter
- MAE was reduced by 1 percentage unit.

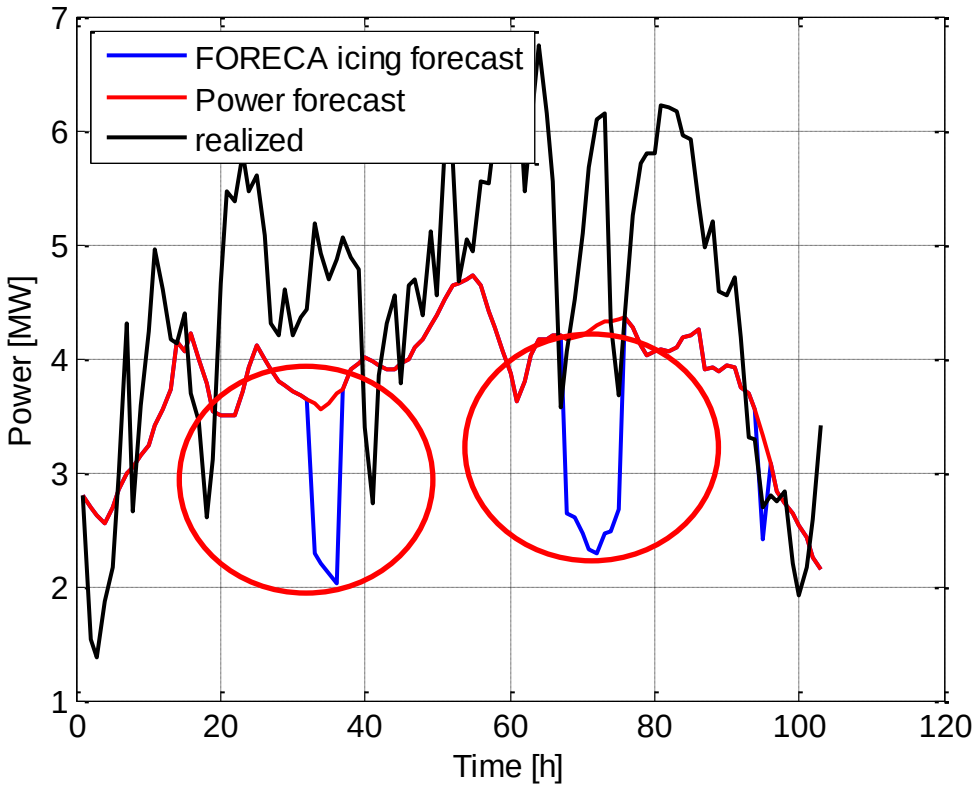
Riutunkari

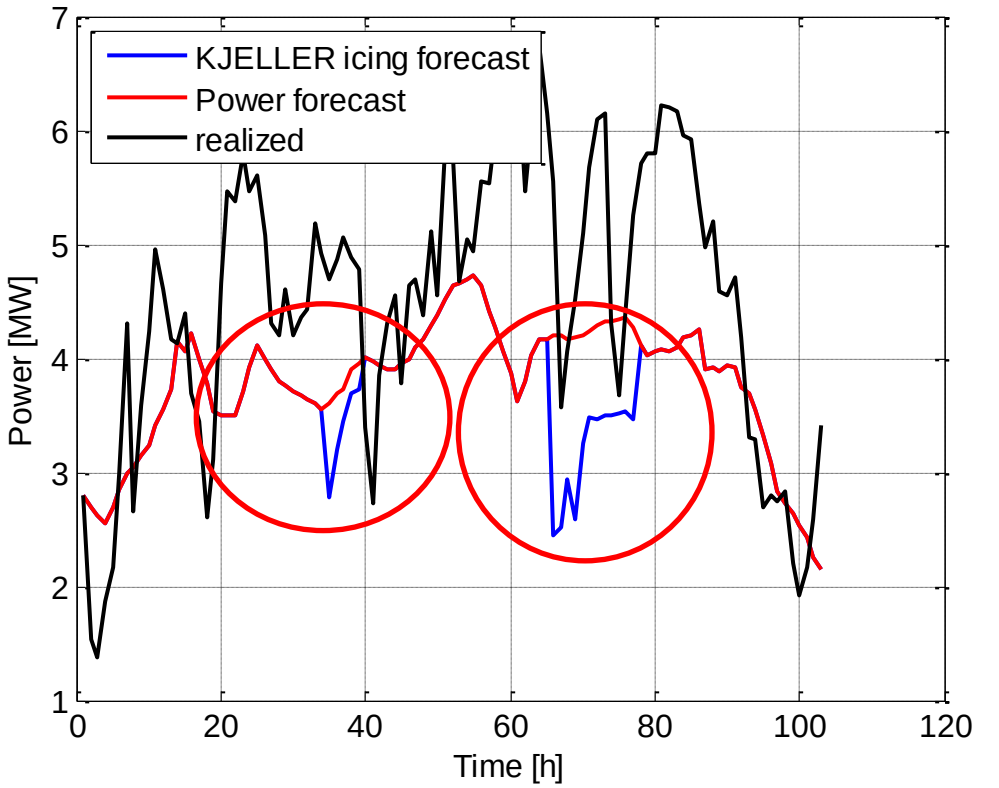
- An example of forecasted icing event



Riutunkari

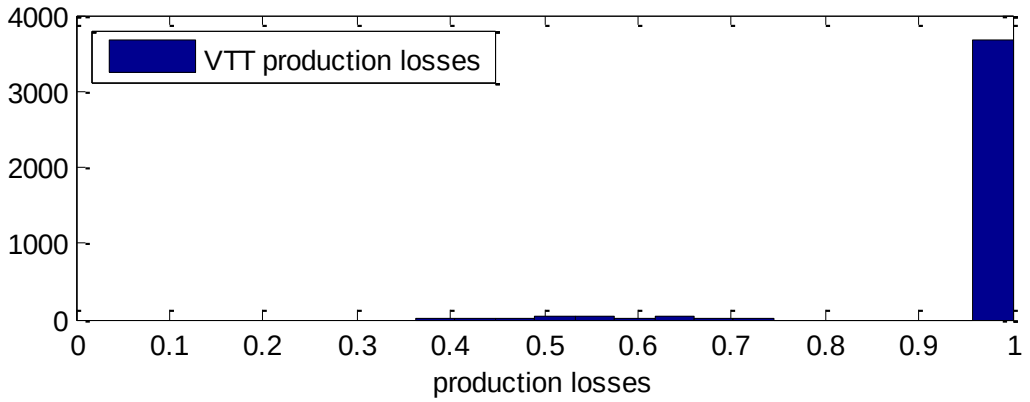
- Typical example of icing forecast when the icing event cannot be seen from power data

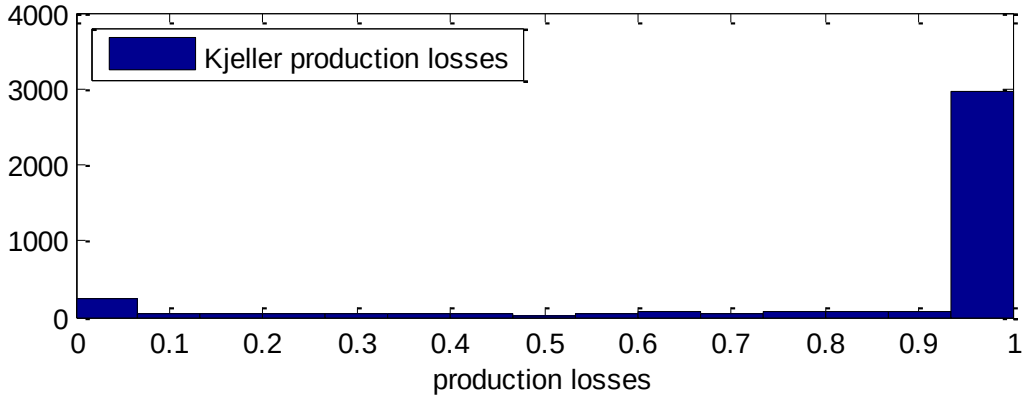




Number of hours with production losses during one winter

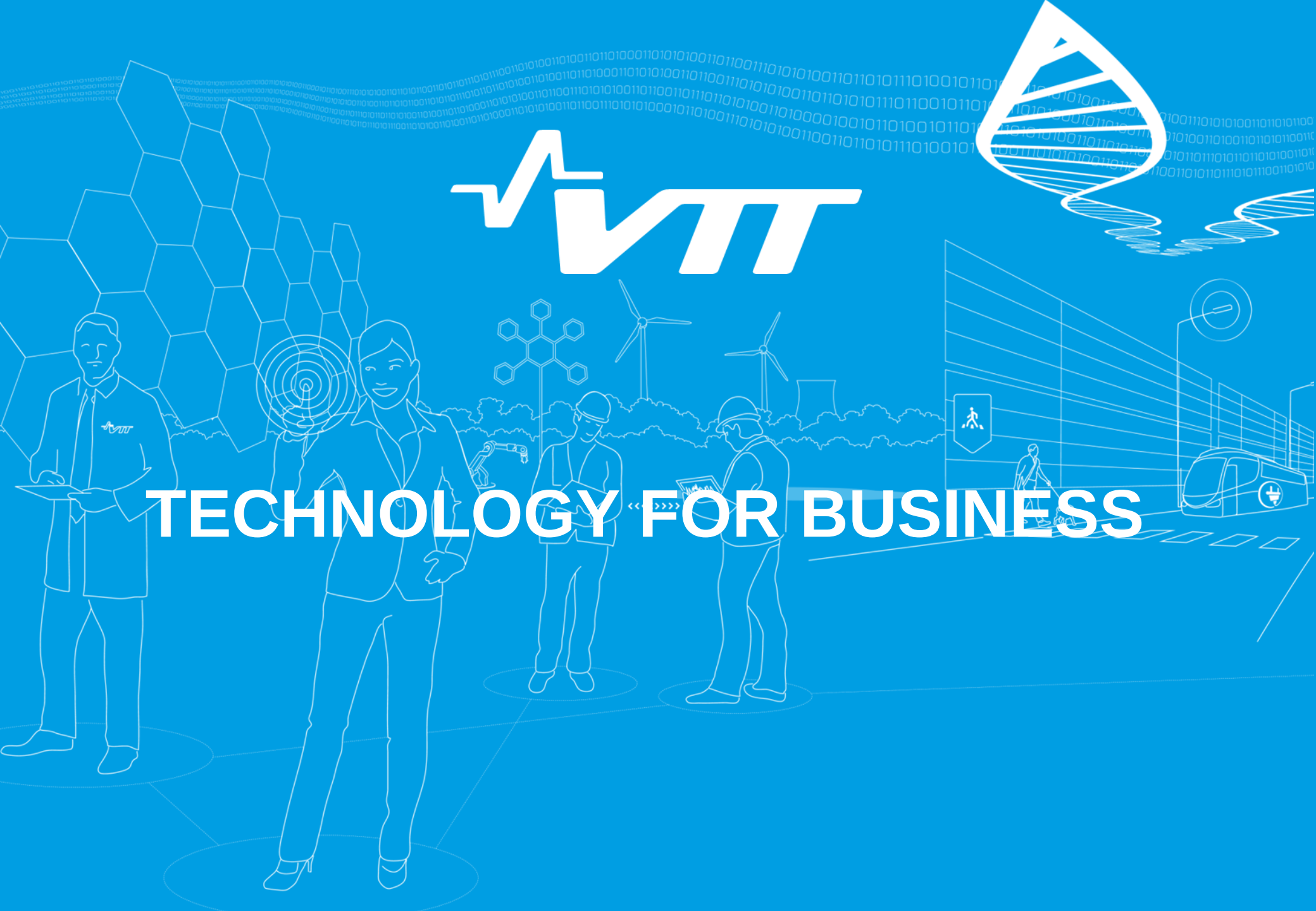
- Kjeller power loss module is more radical than VTT's
- Kjeller estimates icing events more frequently
- Based on the historical data there should be power losses due to icing ~5% of the time
- For light icing sites production loss model that has short duration after icing event seems to work better





Take aways and future research

- First attempts to analyse impacts of icing forecasting
- In heavy icing regions forecast errors due to icing are significant
  - can impact system balancing
- In light icing regions forecast methods need to be improved to capture the icing event impacts on production
  - some events were spotted with one model
- Model development and verification/calibration needed
  - Capturing icing event timing
  - Length of icing, duration of ice after events important, probably different models for heavy/light icing needed
  - Further research on models for duration of ice (erosion, sublimation)
- Difficult to assess how well the icing module operate
  - Icing forecasts added to sometimes incorrect wind forecasts…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