Liberating lidar – eliminating monitoring masts can reduce turbine performance assessment uncertainty

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<u>"Purpose" of lidar monitoring masts:</u>

Lidar drift monitoring (L.5.4):
- **0% of LMM-monitored lidars have violated consistency thresholds,** during modern DNV tests.
- Lidar technology not susceptible to anemometer-like mechanical drift.

Lidar uncertainty monitoring (L.5.3):
- **0% of LMM-monitored lidars have violated uncertainty thresholds** during DNV performance testing campaigns, when verifications performed at the project site.

Above-ground density measurements:
- More accurate to use hub-height mast signals on/near site than to use 60-m signals at test turbine.
- **Pressure:** IEC supports measuring anywhere within 5 km.
- **Relative humidity:** Low sensitivity; ignored in 12-1 Edition 1. Stronger vertical than lateral gradients.
- **Temperature:** Stronger vertical than lateral gradients.

Assess more turbines for less money at lower uncertainty

Lidar monitoring masts add negligible value to measurement accuracy and integrity.

- Zero cases of measurement consistency failure (L.5.4).
- Zero cases of LMM-derived monitoring uncertainty expansion (L.5.3) when lidars verified on site.
- LMM-based density characterization less accurate than hub-height-mast density characterization elsewhere on site.

Eliminating monitoring masts enables assessing 5x turbines for the cost of 1x.

- Sequentially test five turbines with one lidar for the cost of testing one turbine with a lidar w/ monitoring mast.

Assessing more turbines reduces aggregate performance uncertainty.

- Basic statistics say so.
- IEC 12-1 Annex R provides standardized methodology.
- Risk reduction for both buyers and sellers.

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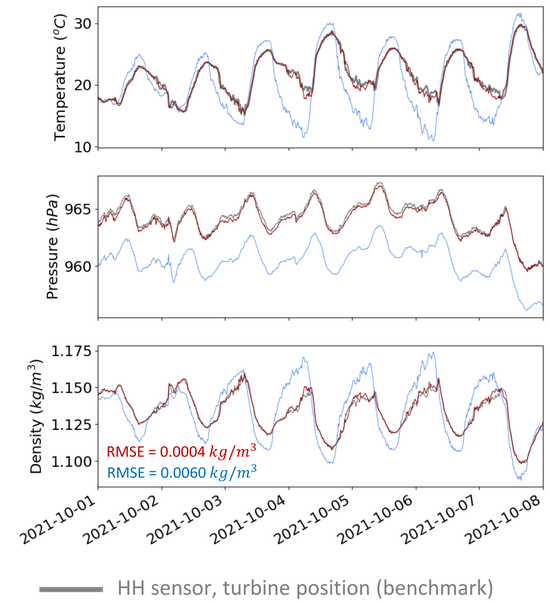
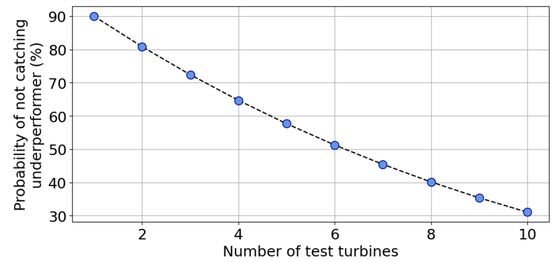
Air density characterization:
Hub-height mast 10 km away better than short mast at turbine position.



All signals adjusted to turbine hub elevation (m.s.l) per IEC

Testing more turbines:
- Decreases AEP uncertainty.
- Expands probability of identifying faulty turbines.
- Expands wind farm knowledge.



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