Yaw misalignment is causing a significant loss of production; we have conducted measurements on around 250 different wind turbines and more than 50 showed significant static (average) yaw misalignment.

The Spinnaker Aneomotometer (Spinn) consists of three ultrasonic anemometers, mounted on the spinner of a wind turbine, basically turning the spinner of the turbine into a wind sensor. The measurements lead to a reanalysis of all yaw conditions and all yaw misalignments in the past. The majority of yaw misalignments have a good yaw control system with little benefit to be gained from further optimization, but a few could increase the yaw accuracy up to 4% if they improved their yaw system.

**Dynamic Yaw Misalignment**

Dynamic yaw misalignment is defined as the variation dynamic around the mean static yaw misalignment, in terms of standard wind measurement, the analysis of the yaw misalignment on the wind turbine's yaw moment. Additionally, we will show detailed studies of average power produced. In 10min wind speed time, as a function of degree of yaw misalignment compared with the theoretical losses according to the Cosine Cubed and Cosine Squared rules.

**Power losses due to Yaw Misalignment**

The component of the wind vector that comes in perpendicular to the rotor of the wind turbine produces a significant power loss. The scatter curve is further color coded as a function of the 10min average power measurements vs wind speed, with the measured vector in the angle range of the rotor axis.

**Theory:**

Above image illustrates a "lazy" turbine e.g. this type allow +/-20 degrees of dynamic yaw misalignment before it will start to turn into the wind.

Above to the right illustrates the measured average power from this wind turbine at 7.5m wind speed bin, and in 2 degrees yaw misalignment the average power normalized to the average power the turbine yields when its operated with zero degrees of yaw misalignment. The gray area marks the measured standard deviation of power for the same bin conditions.

So directly from measured power output from the turbine, it is visible that at extreme angles the turbine losses over 20% of the energy potential compared to a turbine which only allows 2-4 degrees yaw dynamic yaw misalignment.

**Conclusions**

Over 50% of all wind turbines in the 300 turbine sample have problems yawing into the incoming wind direction, resulting in severe losses of annual production.

The vast majority of turbine types have acceptable average yaw control, only allowing between 2-4 degrees on average before they start yawing after the changed wind direction, but a selected few from the same turbine design is showing a great opportunity for improving energy yield by as much as 1.2% annually.

Energy losses related to static yaw misalignment have been shown to follow a cosine relationship, on average for all turbines in ROMO's database the energy could be improved for all of these turbines combined by more than 1.7% annually. For most wind parks where we conduct yaw misalignment correction, the return on investment is from one to five years depending on the local energy tariff and turbine type.

Contact ROMO wind should you be interested on further information.

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**References**

2. Spinning Aneomotometer by means of spinning anemometer: Trifon F. Pedersen, Germain Demirbul, Julia Gottschall, Henrik Jeppstein, Jürgen Häuser, Wolfgang Christensen, Günther West, Andreas Schmor, Jürgen Rumpf-Knorrer.