Wind Energ. Sci. Discuss.,
https://doi.org/10.5194/wes-2019-82-RC1, 2020

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Interactive comment on "Are Uncertainty Categories in a Wind Farm Annual Energy Production Estimate Actually Uncorrelated?" *by* Nicola Bodini and Mike Optis

Anonymous Referee #1

Received and published: 10 February 2020

General comments

This work examines the combination of 5 uncertainty components inherent in operational-based windfarm AEP uncertainty estimation, where the estimation is based on production data and a particular type of long-term correction (linear regression on monthly means).
There is some relevant stuff here, and information from production data of > 400 wind farms which can be of use. However, unfortunately the draft does not (yet) appear to be sufficiently clear, rigorous, or complete; it offers a somewhat *qualitative* (incomplete) description of *quantitative* methods/analysis/results and subsequent conclusions.

Hopefully with some thought and revision, it can become useful to a number of readers.

The title is not honestly representative (nor scientifically accurate), as it connotes/implies consideration of all (or even typical) uncertainty components in production estimates—i.e., it overstates the scope and results of the work. But this draft only considers the LTC and observed/reference data aspects, i.e. operational AEP. The emerging IEC 61400-15 standard includes a much longer list of uncertainty components (and subcomponents), including different modelling uncertainties and plant-performance aspects, among others (as you mention in the final sentence of the conclusion). Further, the emerging standard does allow for correlated uncertainty components.

An appropriate title would be something more like "*Operational-based AEP uncertainty: are its components actually uncorrelated?"*. Or it could resemble "*correlations between uncertainties in operational-based* (or alternately *long-term correction of) wind farm annual energy estimates"*.

The terminology is a bit problematic, in a number of ways: e.g. the definition of *'windiness correction'* is unclear (is direction involved as well?); its relationship with the 'regression' uncertainty component is unclear; the classification 'regression' refers to only certain type of long-term correction (linear).

Yet more problematic is the lack of mathematical or specific definitions for the individual calculations/processes, to which the 5 uncertainty components are ascribed.
The total uncertainty calculation is missing, or rather mathematical description of the model for total operationally-based uncertainty estimation—along with mathematical description of all components; e.g. per the latter, the IAV 'incorporation' is not clear.

The paper first shows the correlations between uncertainty components in § 3.2. But these correlations are used to describe the uncertainty contributions in section 3.1, and presumably these correlations have already been used to prescribe/run the Monte Carlo simulations which were described in section 2.3.

But there is no description of the use of the covariance matrix in the MC calculations, or how these correlations were incorporated in the MC analysis.

The idea (and Fig.11a) about 'spread' and variance can be stated succinctly mathematically, and in a less confusing manner—instead of with only semi-qualitative demonstration.

Again, as mentioned just above, the MC method itself does not show correlations between components; rather, you _assign_ these from having calculated the correlation matrix.

The conclusions also include some overstatement, e.g. labelling Monte Carlo simulations as "our technique".
MC methods have become more commonly used in UQ within the wind industry (e.g. from Williams et al 2008 for economic analysis, to Takeshi+Yamaguchi 2015 for extremes with MCP, to Müller+Cheng 2018 for probabilistic design), and also in some standard references (e.g. GUM); this should have been mentioned and referenced.

Specific comments

1. Abstract/l.3: replace 'standard' with 'a popular', since the uncorrelated assumption is not necessarily standard.

2. l.4 and many places: replace 'categories' with 'components'; one does not add up categories, but calculates using component uncertanties.

3. l.97: include a reference on complex terrain/challenging for RA products

4. l.106 [point 2]: regarding *'between monthly energy production and average wind speeds'* — be explicit: a linear relationship is assumed for a presumably nonlinear P(U) dependence? Or derived wind to long-term wind data? Which "average wind speeds"?

5. l.108 [point 3]: perhaps this step should be noted differently because you don't perform it in your analysis. Or, you could indicate clearly the steps that you do calculate.

6. l.111–113 [point 5]: how the values are applied needs to be made explicit/clear to the reader (without assumptions or ambiguity): which "long-term resource data" is operated upon (i.e. scaled and shifted)? One could assume e.g. that measured or production-derived monthly speeds are corrected...

7. l.114 [point 6]: how are the gross energies 'denormalized', and what is meant by 'normal' number of days?

8. l.119–122: include references for Monte-Carlo approach; e.g. GUM has some guidance, others (e.g. Dimitrov *et al.*, 2018 WES) outline use in our field.

9. Table 2 [p.7]: There is no description explaining/defending your choices of 'incorporation in Monte Carlo approach.
a. How did you arrive at 0.5% for meter accuracy? b. How can one justify that a random choice from 3 RA products is equivalent to the uncertainty in that long-term reference dataset or 'wind measurement accuracy'? For example, there are places where all 3 have a similar bias; further, the uncertainty in each (as being representative of speeds at a place) can be similar for a number of locations, but the variability amongst the 3 sources can then be significantly smaller. c. How is sampling the number of years for the 'windiness correction' accounting for the uncertainty in using a linear adjustment? The latter may likely dominate this uncertainty component.

10. Fig.5 / p.10: caption should refer to eqn.7, so the reader knows that these are % differences of uncertainties (which are also in %, Fig.5a).

11. l.186: need reference and short mention/description of p-test.

12. Fig.9/l.210-212: is this randomly-sampled months, or an increasing sample size

building consecutively/sequentially from some given time?

Technical corrections

There are many English usage/grammatical corrections and suggestions, which are included in the attached annotated PDF-file. I thus only include a sample of them here in this list.

- l.4: need comma after 'uncorrelated'; replace 'through a sum of squares approach' with 'as the sum of their squares'.
- l.5: remove 'In this analysis'; replace 'rigor' with 'practical validity', add ' for operationally-based uncertainty, which is comprised of components associated with long-term correction and measurements,' after 'assumption'.
- l.6: replace 'standard uncertainty assumption' with 'uncorrelated sum-of-squares method'; replace 'to uncertainty quantification' with a comma.
- l.7: replace first instance of 'categories' with 'components'; replaces second instance with 'component pairs'.
- l.8: replace 'do, in fact, show' with 'exhibit'; remove *', namely'*; replace 'windiness' with a more accepted term like *'linearized long-term correction'*.
- l.9: replace comma after '(positive correlation)' with a semicolon; delete *'wind resource'*; replace comma after 'negative)' with a semicolon.
- l.12: replace 'industry standard approach' with 'simple approach which neglects correlations between uncertainty components'.
- l.34/p.2: is there not a DNV-GL report on this?

- l.58–59: rewrite 'the more simple AEP calculation relative to the preconstruction method' as 'that the operationally-driven calculation is much simpler than the calculation needed for preconstruction estimates'.
- l.60: replace 'equally' with 'also'
- l.75,77: need 'dataset' after 'interim)' and 'NCEP-2)'.
- l.104/p.5 [point 1]: remove 'Analysis is performed on a monthly timescale (i.e.,'; replace end parens with 'are calculated'.
- l.130–136: cite GUM / textbook(s).
- l.165–166: remove 'uncertainty calculated with the current usual industry standard, which assumes uncorrelated components and calculates the'.
- l.167: replace 'with' with 'using'.
- l.169: replace *'472 considered wind farms, both in terms of a scatterplot and'* with *'472 wind farms considered, as a scatterplot and also as'*.
- l.170: remove ', Δ_σ,'; change ', calculated as' to a colon.
- l.172: add comma after 'observed'.

Please also note the supplement to this comment:
https://www.wind-energ-sci-discuss.net/wes-2019-82/wes-2019-82-RC1-supplement.pdf

Interactive comment on Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2019-82, 2019.