Portfolio effect on long-term energy yield assessments

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Considering mixed assets into portfolios can increase their aggregate value by 2.0%

THE BASIS: WHY SUMMING P90s IS WRONG

Most uncertainties in a long-term energy yield assessment are assumed to follow analytical distributions and combined by root-sum-squaring. However, because assessments are produced at single-asset level, portfolio P90s are often simply summed, implying **perfect correlation between assets.** This assumption is conservative and results in a **poor approximation of physical reality**.

DIVERSIFICATION IS KEY

In practice, uncertainties are decorrelated due to three main diversification routes:

- **Geographically** spreading assets reduces exposure to correlated interannual climate variability;
- **Technological:** combining PV and wind assets removes most correlating uncertainty factors. Varying turbine types limits common-mode errors;
- **Methodological:** making use of independent measurement campaigns, different modelling approaches, different consultants;

To quantify the effect correlation between uncertainty components on the combined uncertainty on the energy yield estimate of a portfolio containing two assets, the following equation (**Eq. 1)** is used, where:

- μ_x: mean of the distribution (i.e. our P50)
- σ_x: spread of the distribution (the uncertainty on P50)
- ρ_{xy}: correlation between two uncertainties

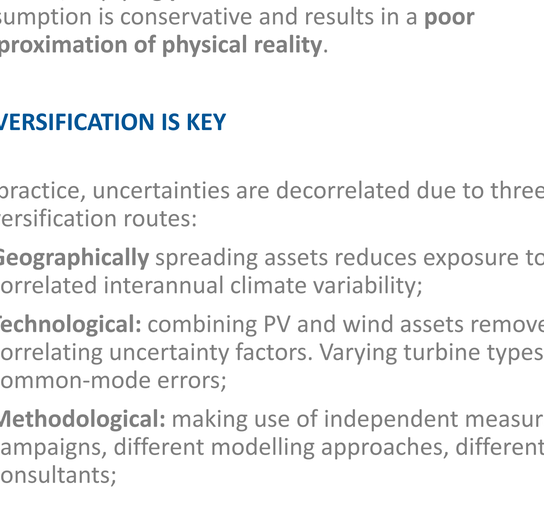

***Fig. 1**: Illustration of the increased P90 of a portfolio of two assets, with fully positively correlated uncertainties (red) and decorrelated uncertainties (green).*

Variance of each plant

$$\underbrace{\mu_c^2\sigma_c^2}_{\text{Variance of the portfolio}} = \mu_1^2\,\sigma_1^2 + \mu_2^2\sigma_2^2 + \underbrace{2\rho_{12}\mu_1\mu_2\sigma_1\sigma_2}_{\text{Covariance of the uncertainties of both farms = diversifiable!}} \quad \textbf{(Eq. 1)}$$

FROM TWO-ASSET THEORY TO N-ASSET PORTFOLIOS

This generalises to a portfolio of n assets with a P50 of w_x, where each uncertainty component is combined. The uncertainty of the portfolio is assessed as usual by root-sum-squaring the uncertainty components σ_p assuming independence between components.

$$\sigma_p^2 = \begin{pmatrix} w_1 & \dots & w_n \end{pmatrix} \underbrace{\begin{pmatrix} \sigma_1^2 & \rho_{12}\sigma_1\sigma_2 & \dots & \rho_{1,n-1}\sigma_1\sigma_{n-1} & \rho_{1n}\sigma_1\sigma_n \\ \rho_{12}\sigma_1\sigma_2 & \sigma_2^2 & \dots & \rho_{2,n-1}\sigma_2\sigma_{n-1} & \rho_{1n}\sigma_2\sigma_n \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \rho_{1,n-1}\sigma_1\sigma_{n-1} & \rho_{2,n-1}\sigma_2\sigma_{n-1} & \dots & \sigma_{n-1}^2 & \rho_{1,n-1}\sigma_{n-1}\sigma_n \\ \rho_{1n}\sigma_1\sigma_n & \rho_{1n}\sigma_2\sigma_n & \dots & \rho_{1,n-1}\sigma_{n-1}\sigma_n & \sigma_n^2 \end{pmatrix}}_{\text{Variance-covariance matrix}} \begin{pmatrix} w_1 \\ \vdots \\ w_n \end{pmatrix}$$

QUANTIFYING DECORRELATION

The level of decorrelation is judgement-dependent, except for two tractable cases: **climate variability** and **technology-driven decorrelation**. The former can be estimated from reanalysis data: Fig. 2 shows the correlation of inter-annual wind speed variability between Copenhagen and ERA5 grid points across Western Europe, illustrating the **strong decorrelation from the Iberian climate** and the resulting potential for portfolio P90 improvement. The latter justifies assuming **near-full decorrelation** of most uncertainty components when combining fundamentally different technologies, such as wind and solar.

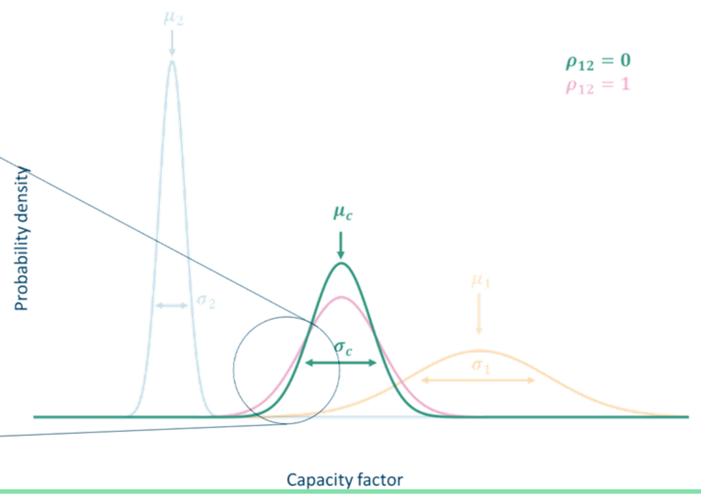

***Fig. 2**: Correlation in annual average wind speeds between Copenhagen and Western Europe. Negative correlation is highlighted in **blue**.*

SIMULATED AND REAL-WORLD PORTFOLIO GAINS

To evaluate the potential for the portfolio-benefit from combining multiple technologies, and geographically distant assets, we simulated various fictitious cases for portfolios of two assets with decreasing levels of similarity:

Portfolio composition	Portfolio gain
Two twin and adjacent wind farms	0.1%
Two dissimilar wind farms, geographically separated	2.1%
One PV and one wind farm, geographically close	3.7%

In a real-world example, applying the same methodology as part of a due diligence on a portfolio of 350 MW combining wind and solar assets across France yielded a gain of 3.5%, with most of the contribution arising from the PV assets which representing less than 10% of the portfolio AEP.

OUTLOOK

Summing single-asset P90s is a structural conservative bias. Accounting for actual inter-asset correlations, even within apparently homogeneous portfolios, consistently unlocks **P90 improvements of 2-4%,** with larger gains where wind and solar are combined.

The key remaining challenge is the robust, defensible estimation of correlation coefficients. As portfolio-level yield assessment becomes more common in project financing, **standardised approaches to this estimation will therefore be essential to the industry.**

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