



**HAL**  
open science

## The challenge of repowering from the energy yield assessment point of view

Paul Mazoyer, Georges Kariniotakis, Duc Thomas, Andreas Bechmann

### ► To cite this version:

Paul Mazoyer, Georges Kariniotakis, Duc Thomas, Andreas Bechmann. The challenge of repowering from the energy yield assessment point of view. WIND EUROPE ANNUAL EVENT, Apr 2022, BILBAO, Spain. hal-04693896

**HAL Id: hal-04693896**

**<https://hal.science/hal-04693896v1>**

Submitted on 11 Sep 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# The challenge of repowering from the energy yield assessment point of view

Paul Mazoyer<sup>1,2</sup>, Thomas Duc<sup>1</sup>, Georges Kariniotakis<sup>2</sup>, Andreas Bechmann<sup>3</sup>  
<sup>1</sup>ENGIE Green, <sup>2</sup>Centre PERSEE, MINES Paris PSL University, <sup>3</sup>DTU Wind Energy



## Abstract

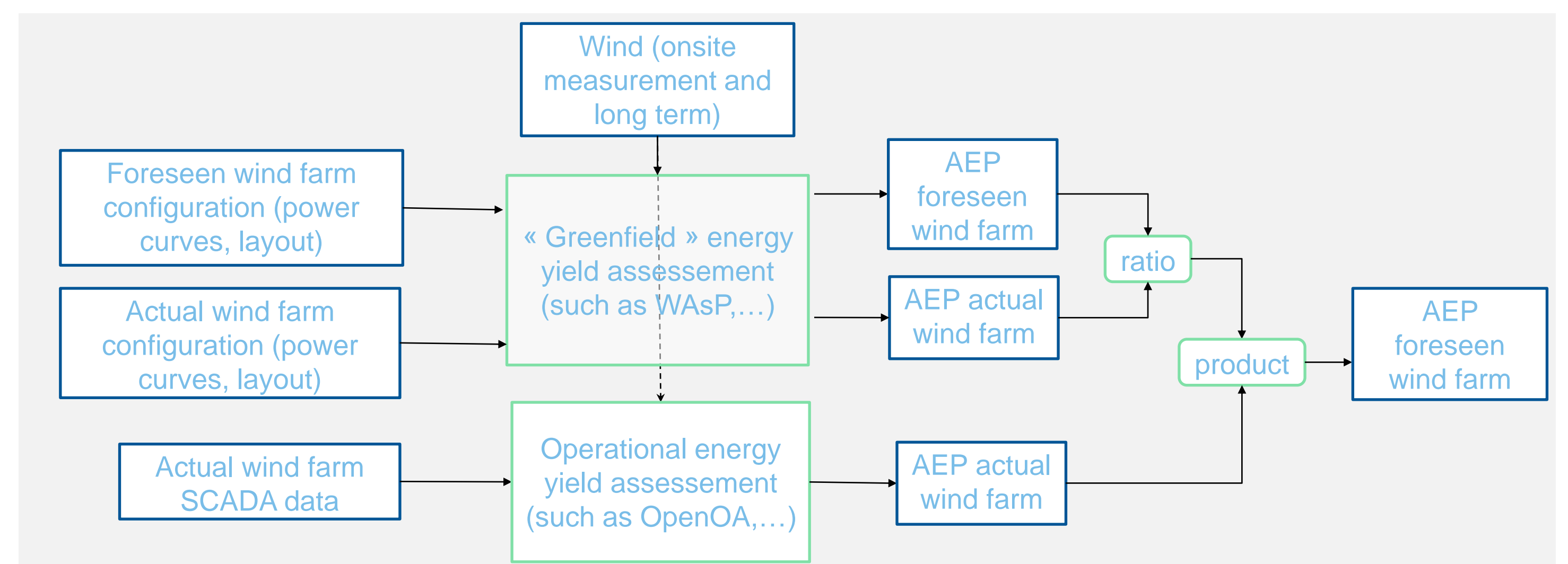
- By 2030, a total of wind power installed capacity between 40 GW and 80 GW will have reached its useful lifetime in Europe [1]. The decommissioning of these assets may compromise the EU effort to reach 451 GW of wind power capacity by 2030.
- Repowering** offers a convenient way to maintain, or even increase, this installed capacity. It basically consists of replacing older power stations with newer ones that either have a greater nameplate capacity or more efficiency which results into a net increase of power generated. WindEurope envisions that about 50% of turbines reaching end of life are to be repowered, i.e. 8 GW per year of capacity by 2030 [2]).
- Repowering has **several benefits**. It significantly improves the capacity factor. When the rated power remains constant, a repowered wind farm is expected to generate less noise, to have lower visual impact and to have lower impact for birds and bats [3]. The CO2 cost of repowering is offset by the benefits [1]. Repowering projects come with lower capital investments compared to greenfield projects since a part of the infrastructure can be reused. However, the net present value can still be negative. **The evaluation of the project profitability requires an energy yield assessment.**
- MINES Paris (PSL), DTU and Engie Green recently started a Ph.D. to define the best methods for energy yield assessment for repowering. This poster presents preliminary results from the Ph.D.

## Objectives

The estimation of the **annual energy production (AEP)** for a greenfield project is a two-step process that relies on onsite wind measurements and long-term weather data [4]. For rather simple terrains, the uncertainty ranges between 6.2% and 11% [5], [6], [7] and arises mainly from the estimation of losses (including sub-optimal performances) and the long-term correlation of wind speed [5]. **The aim of this work is to show how these uncertainties can be reduced when AEP is estimated in a repowering project using the existing wind farm data (at least 20 years).** This data can be used either to calibrate the wind resource [8] or as a baseline for a repowering coefficient method [9]. In this work we focus on *the repowering coefficient method*.

## Method: the repowering coefficient method

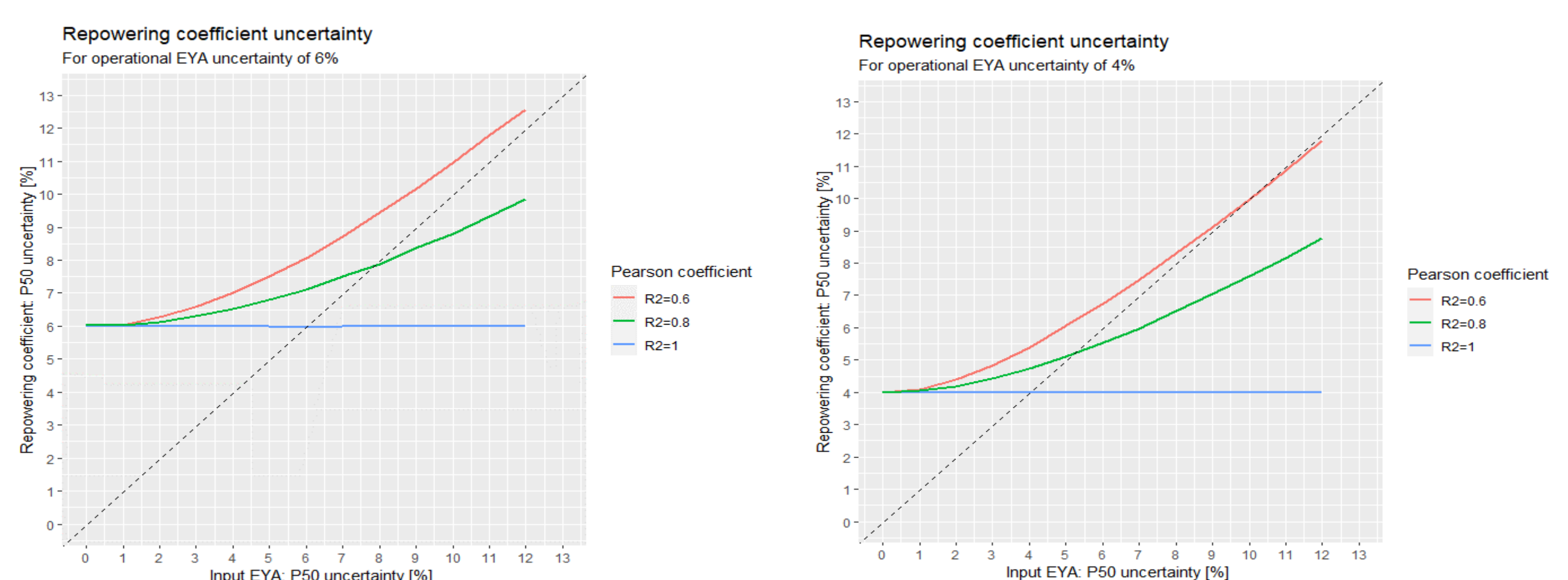
The repowering coefficient method consists of multiplying the AEP estimated from observed production by a ratio that reflects the modification of power production between the actual (or old) wind farm and the foreseen new wind farm. The AEP from observed production is obtained from cleaned production data that is long term extrapolated (so called “operational Energy Yield Assessment (EYA)”). The uncertainties of such methods range between 4% and 8% [10], [11]. As repowering coefficient uses similar input (such as wind speed), some “errors” contributors of the two terms of the ratio may cancel out. This translates into a low variance of the ratio estimation (low uncertainty).



Simplified flow chart of the repowering coefficient method

## Results : Monte Carlo method is used to propagate the variance

The uncertainty of the repowering coefficient method is simulated and represented here. It uses normal distributed random variables that represent the “greenfield” EYA of a typical repowering project. If the operational AEP assessment is very precise (i.e. uncertainty of 4%), then one should prefer the repowering coefficient method over the “greenfield” method if the latter comes with an uncertainty higher than 5% (very likely) and if the correlation between the two terms of the ratio is moderate (green line). This value goes up to 8% in the case the operational AEP assessment is less precise (uncertainty of 6%).



The uncertainty of the P50 estimation with the repowering coefficient method for a strong correlation between the two terms or the ratio (blue line), a moderate correlation (green line) and a weak correlation (red line) is compared to the uncertainty of the “greenfield” process (dash line). It is the “greenfield” method estimated AEP that are used for the ratio thus the uncertainty of repowering coefficient method depends on this value (x-axis).

## Conclusions

- Repowering coefficient method is promising to achieve low uncertainty AEP estimation compared to typical “greenfield” energy yield assessment methods.
- The uncertainty model will be further developed to include the various prevailing uncertainty contributors and their correlations. It will be validated against data from repowered wind farm.
- With a validated uncertainty simulation model, one can determine if the repowering coefficient method should be preferred over other methods.

## References

- Martínez, E., Latorre-Biel, J. I., Jiménez, E., Sanz, F., & Blanco, J. (2018). Life cycle assessment of a wind farm repowering process. *Renewable and Sustainable Energy Reviews*, 93, 260–271. <https://doi.org/10.1016/j.rser.2018.05.044>
- WindEurope-*Repowering-and-Lifetime-Extension*. (n.d.).
- Lacal-Arántegui, R., Uihlein, A., & Yusta, J. M. (2020). Technology effects in repowering wind turbines. *Wind Energy*, 23(3), 660–675. <https://doi.org/10.1002/we.2450>
- Landberg, L. Myllerup, O. Rathmann, EL Petersen, BH Jørgensen, JBadger, and NG Mortensen. “Wind resource estimation—an overview”. In: *Wind Energy* 6.3 (2003), pp. 261–271. doi:10.1002/we.94 (cit. onp.36)
- Lee, J. C. Y., & Jason Fields, M. (2021). An overview of wind-energy-production prediction bias, losses, and uncertainties. *Wind Energy Science*, 6(2), 311–365. <https://doi.org/10.5194/wes-6-311-2021>
- Gylling, N., Jørgensen, E., Mortensen, N. G., Nielsen, M., & Jørgensen, H. E. (2015). Comparison of Resource and Energy Yield Assessment Procedures 2011-2015: What have we learned and what needs to be done? In *Proceedings of the EWEA Annual Event and Exhibition*.
- Kwon, S. D. (2010). Uncertainty analysis of wind energy potential assessment. *Applied Energy*, 87(3), 856–865. <https://doi.org/10.1016/j.apenergy.2009.08.038>
- Bezbradica, M., Kerkvliet, H., Borbolla, I. M., & Lehtimäki, P. (2016, November 16). Introducing multi-criteria decision analysis for wind farm repowering: A case study on Gotland. 1st International Conference on Multidisciplinary Engineering Design Optimization, MEDO 2016. <https://doi.org/10.1109/MEDO.2016.7746546>
- Bullard, M. H. (2019). Getting back in the game, uncertainty in Wind Speed Dating in the Repower world. AWEA WRA.
- Lindvall, J., Hansson, J., Undheim, O., & Vindteknikk, K. (2016). Post-construction production assessment of wind farms Assessment and optimization of the energy production of operational wind farms: Part 1. [www.energiforsk.se](http://www.energiforsk.se)
- Bodini, N., Optis, M., Perr-Sauer, J., Simley, E., & Fields, M. J. (2021). Lowering post-construction yield assessment uncertainty through better wind plant power curves. *Wind Energy*. <https://doi.org/10.1002/we.2645>

Watch this presentation

Download the poster

Replace with QR code

Replace with QR code