



# A new energy yield assessment method for wind repowering projects

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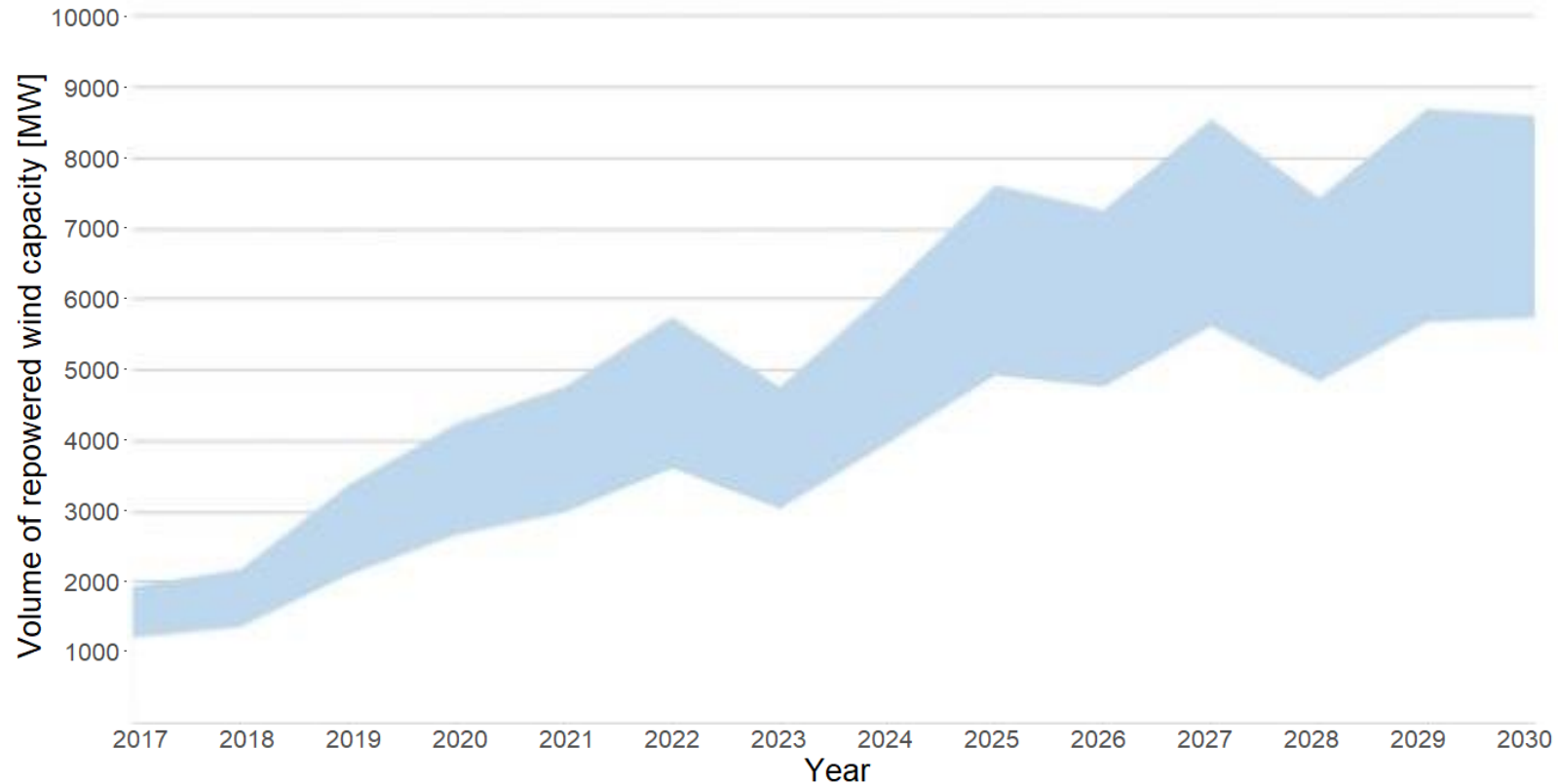
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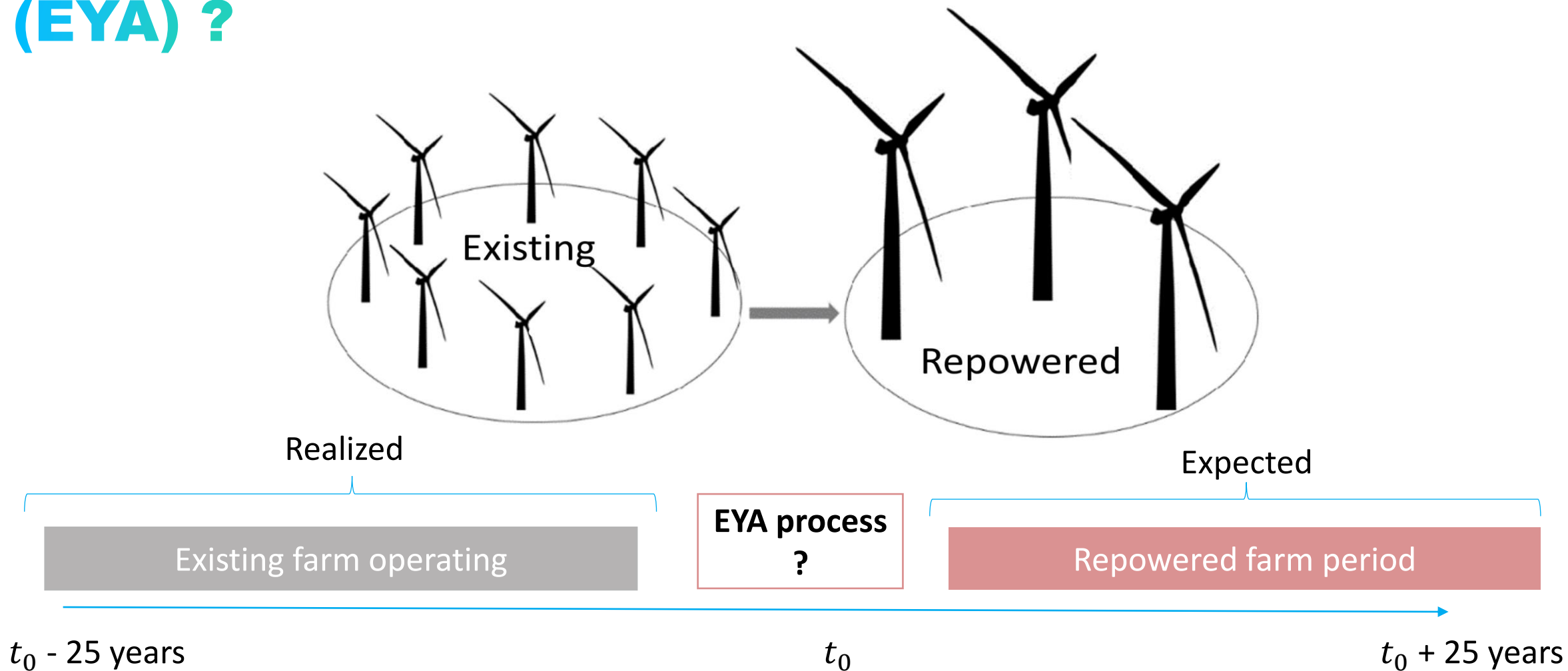
# Repowering at one glance

40GW to 80GW of repowering project in Europe Union by 2030



*Expected volume of repowered wind capacity in the European Union (WindEurope)*

# How to integrate operational data in the repowered farm energy yield assessment (EYA) ?



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graph LR; A[Review of state-of-the-art yield assessment methods] --> B[Test of the most promising method -> shortcomings identified]; B --> C[CONWEY: new method that overcomes the shortcomings];
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Review of  
state-of-the-art  
yield  
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Test of the  
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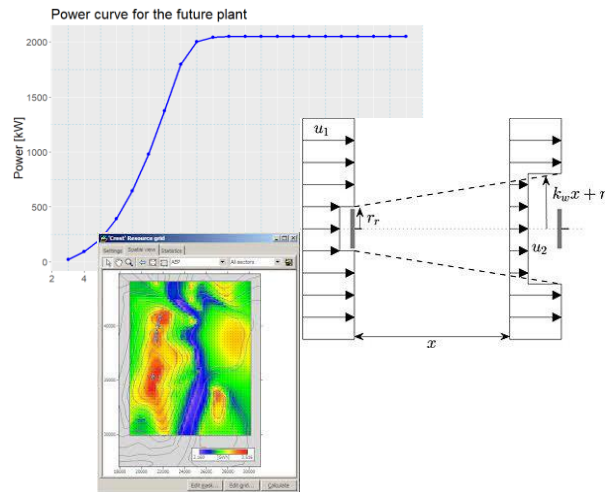
CONWEY: new  
method that  
overcomes the  
shortcomings

# Standard EYA: Physics-driven model (PDM)

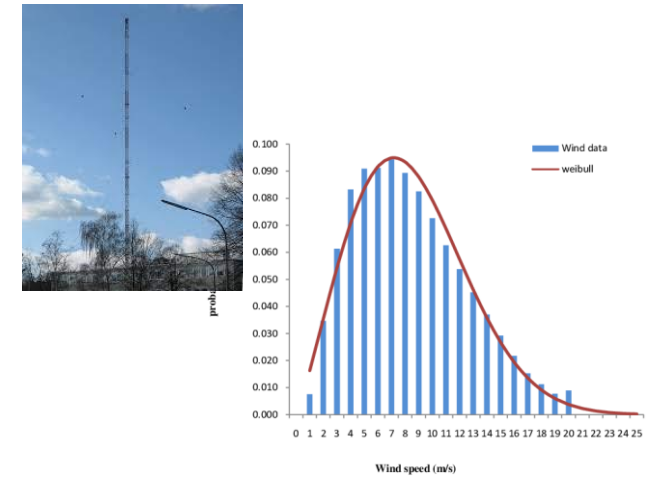
$$E(P) = \int P(U, \theta) f(U, \theta) dud\theta$$

Power production

Farm power curve



Wind resource



## EYA for repowering: literature review

PDM :

$$E(P) = \int P(U, \theta) f(U, \theta) dud\theta$$

Calibration: correcting inputs

$$E(P) = \int P(U, \theta) \mathbf{f}(U, \theta) dud\theta$$

or

$$E(P) = \int \mathbf{P}(U, \theta) f(U, \theta) dud\theta$$

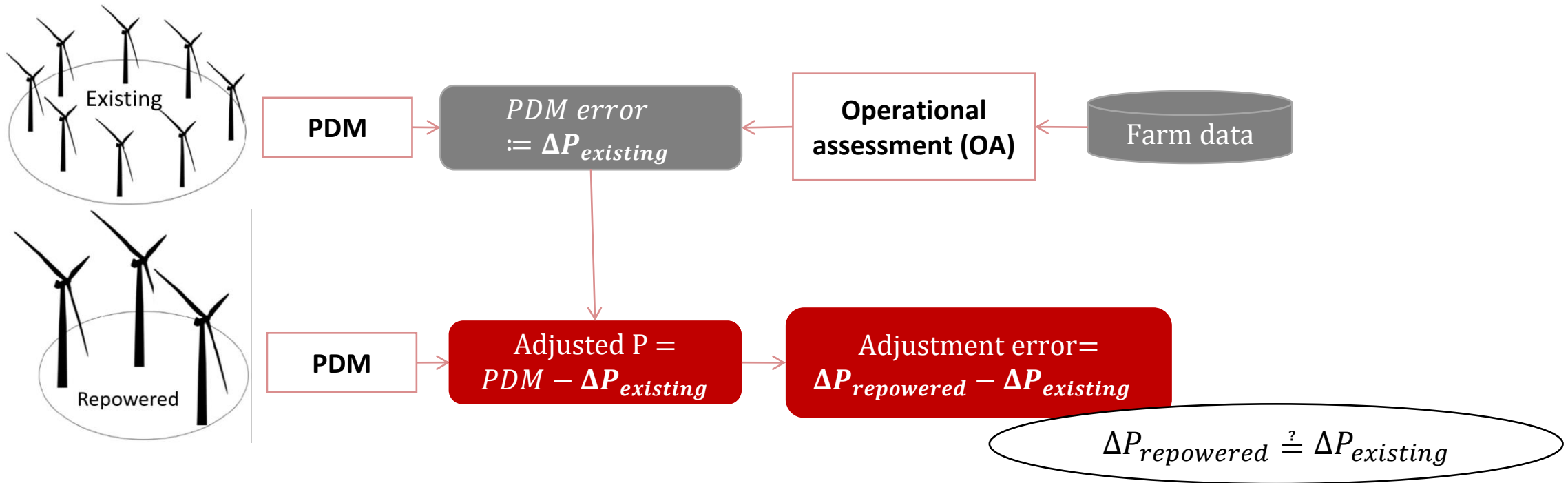
Farm power curve model:

$$E(P) = \int \mathbf{ML}(U, \theta) f(U, \theta) dud\theta$$

Adjustment: correcting outputs

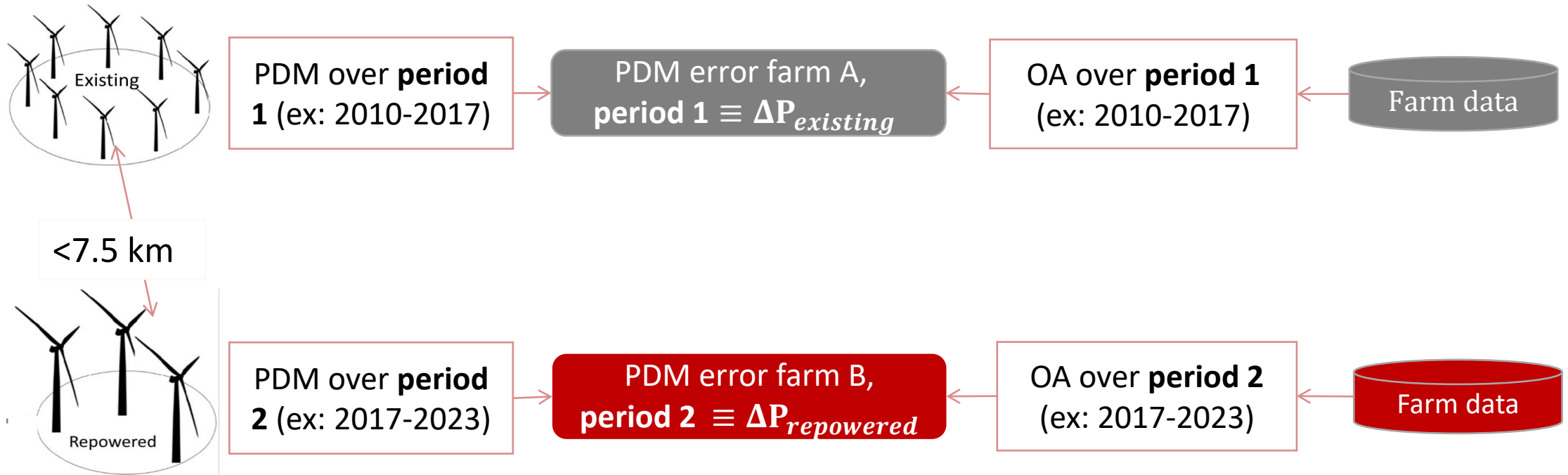
$$E(P) = \int \mathbf{P}(U, \theta) f(U, \theta) dud\theta$$

# Energy adjustment approach



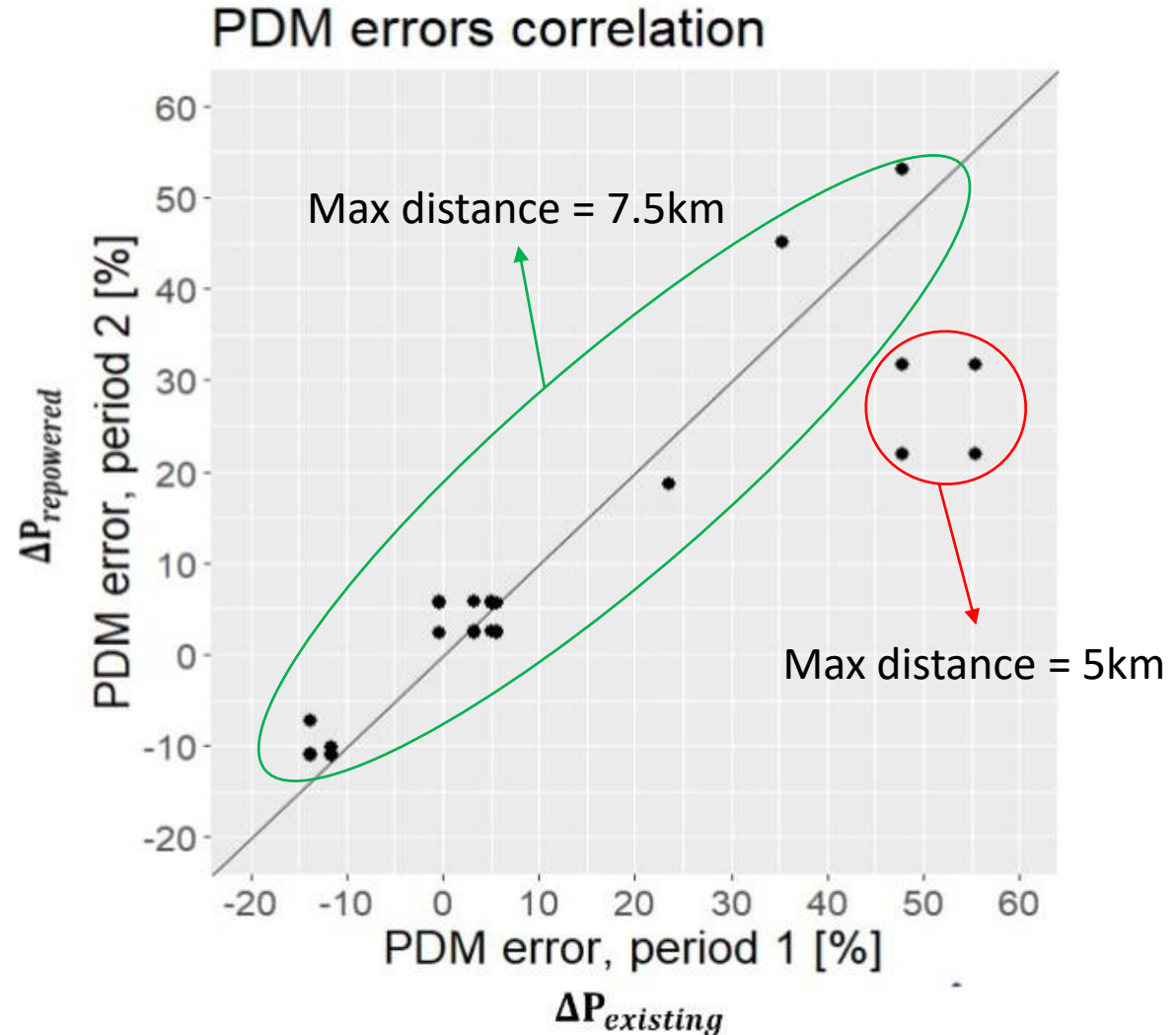
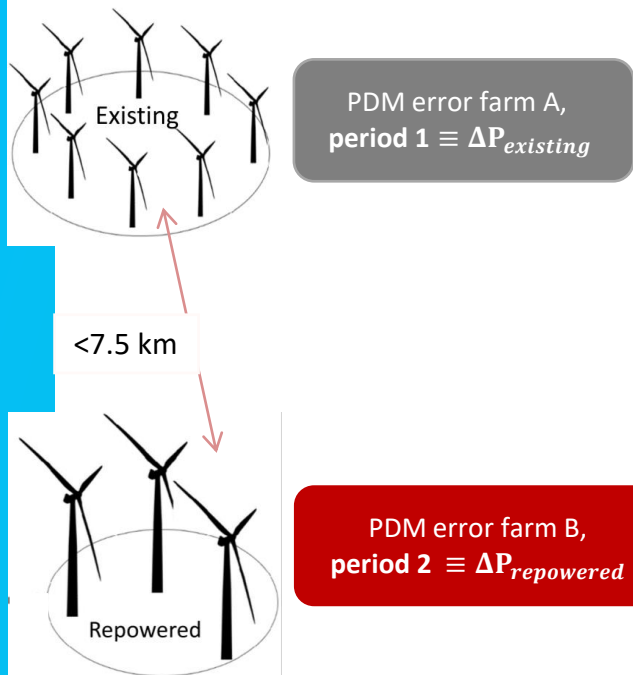
Are the PDM errors similar for a repowering project?

# Energy adjustment approach validation

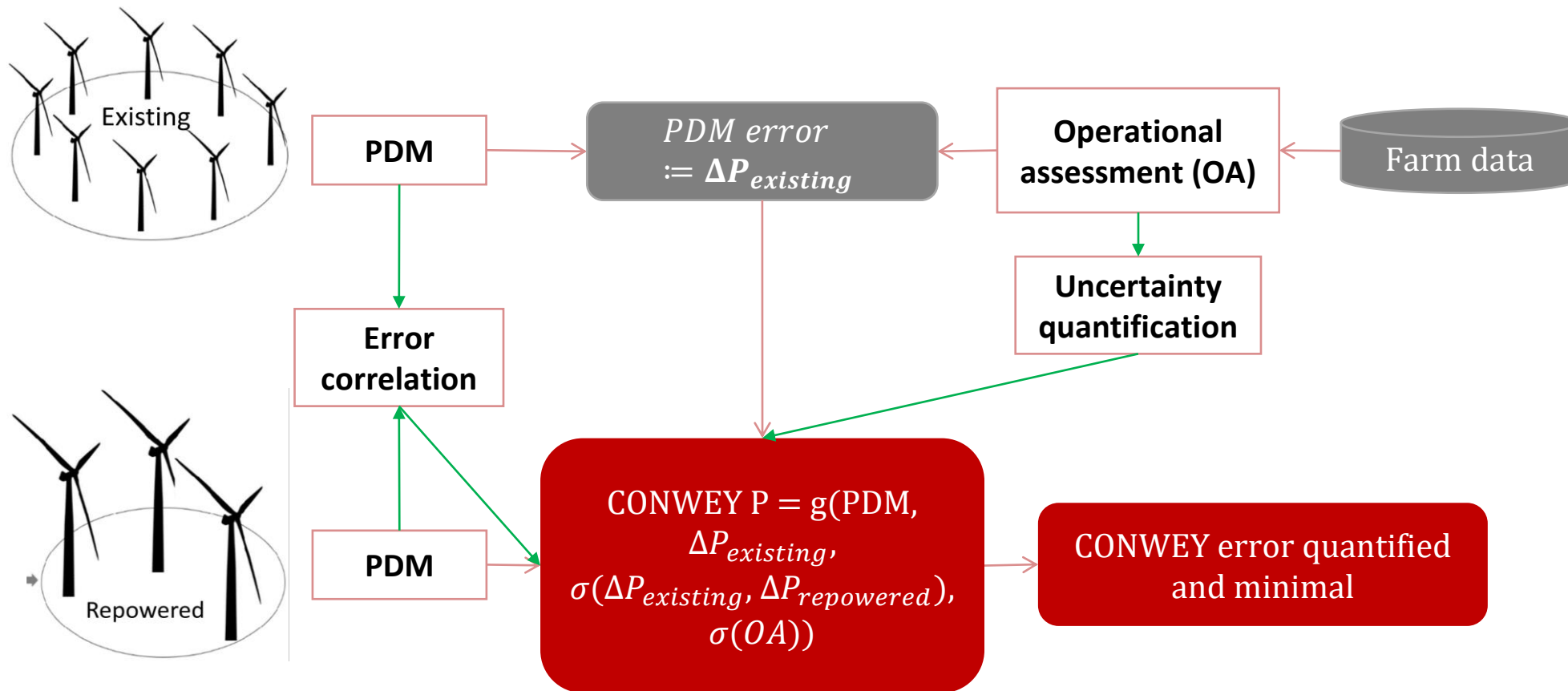


**~100 years of SCADA datasets for 25 pairs of colocated wind farm.**

# Energy adjustment approach validation



# CONWEY: optimized adjustment method



Repowering project (FR): PDM and CONWEY uncertainties are 8.83% and 6.92%

# EYA methods for repowering projects

- PDM errors correlate for nearby wind farms. It opens the doors for reduced uncertainty in power production prediction,
- PDM errors correlation is a factor of similarities between projects and not only distances,
- **CONWEY** is a new EYA method that accounts for projects similarity to estimate of power production with low uncertainty.

- Contact : [Paul.mazoyer@engie.com](mailto:Paul.mazoyer@engie.com)
- PDM error correlation: article in IOP conference series
- CONWEY: preprint available on <https://hal.science/>  
(CONWEY - A new methodology for assessing the energy yield of repowered wind farms with quantified reduced uncertainty)



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**Annex**

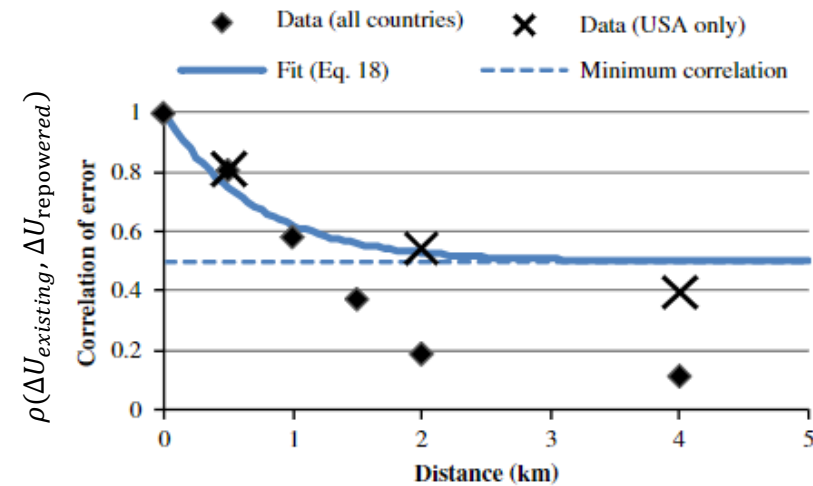
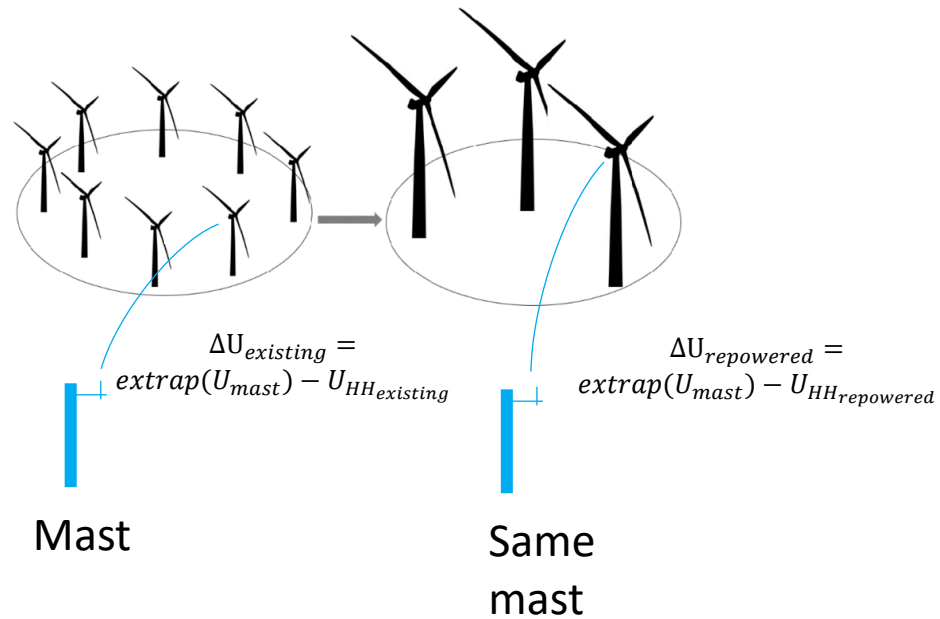
# CONWEY: example for a repowering project

- **Similarities:** same layout and hub height
- **Differences:** different periods and types of turbines
- $\rho(\Delta P_{existing}, \Delta P_{repowered})$  derived from expert elicitation

Type	Values
$\Delta P_{existing}$	1.68%
$\rho(\Delta P_{existing}, \Delta P_{repowered})$	69.33%
$\sigma(OA)$	4%
CONWEY correction $g(\dots)$	-0.98%
<b>Uncertainty</b> $\sigma(\Delta P_{conwey})$	+/- 6.92%
<b>Uncertainty</b> $\sigma(\Delta P_{PDM})$	+/- 8.83 %

# Why would PDM error be correlated?

Example of flow modeling errors



Sample autocorrelation of the flow modeling errors for simple terrains [1].

$\Delta P_{existing}$  is dependent on  $\Delta U_{existing}$

$\Delta P_{repowered}$  is dependent on  $\Delta U_{repowered}$

Since  $\rho(\Delta U_{existing}, \Delta U_{repowered}) \neq 0$  then  $\rho(\Delta P_{existing}, \Delta P_{repowered}) \neq 0$

# Why would PDM error be correlated?

## The error sources in PDM:

- **Correlated** errors: wind speed measurement, flow modeling and power curve site specific,
- **Uncorrelated** errors: power curve, sub-optimal performances, vertical extrapolation and losses.

It is expected that  $\rho(\Delta P_{existing}, \Delta P_{repowered}) \neq 0$  however  $\Delta P_{existing} \neq \Delta P_{repowered}$