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Uncertainties in the estimate of Wind Energy Production

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Introduction

- The methods used to estimate The Annual Energy Production (AEP) in a wind farm requires an assessment of the uncertainties associated in all steps.

- The appropriate assessment of uncertainties is critical to determine the feasibility and the risks in developing a wind energy project.

- The main goal of this paper is to present the main sources of uncertainty in energy production estimation process for wind farms and to indicate some improvement in energy reliability to reduce the financial risks of the projects.

Main Sources of Uncertainties

The main sources of uncertainties in the wind projects can be divided in two groups: Wind Resource Uncertainty and Energy Production Uncertainty

Wind Resource Uncertainty	Energy Production Uncertainty
Sensors accuracy	Power curve
Sensors calibration	Wake loss accuracy
Assembly of the sensors	Availability loss accuracy
Long-term wind speed	Others energy losses accuracy
Wind flow simulation	
Other	

To turn the uncertainty of the wind resource into uncertainty in energy production the sensitivity factor is required. The sensitivity factor corresponds to the variation in energy production caused by wind variation, it is specific value for each project.

Wind Resource Uncertainty

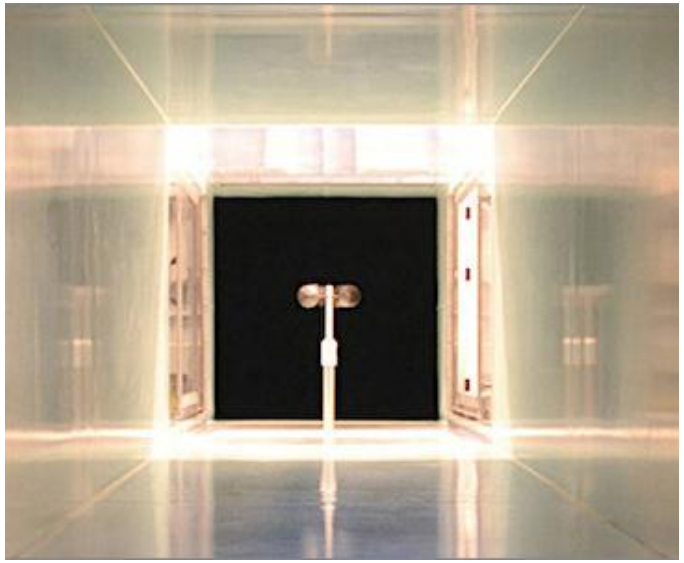
SENSOR ACCURACY

- Good anemometers have higher prices and lower uncertainty in measurement.
- The costs of a high-quality measuring system and its appropriate installation are small when compared with the costs of a wind farm.
- The simple uncertainty range in terms of wind speed and associated with the instrument's accuracy for an isolated sensor is approximately 1% and 6%.

Wind Resource Uncertainty

SENSOR CALIBRATION

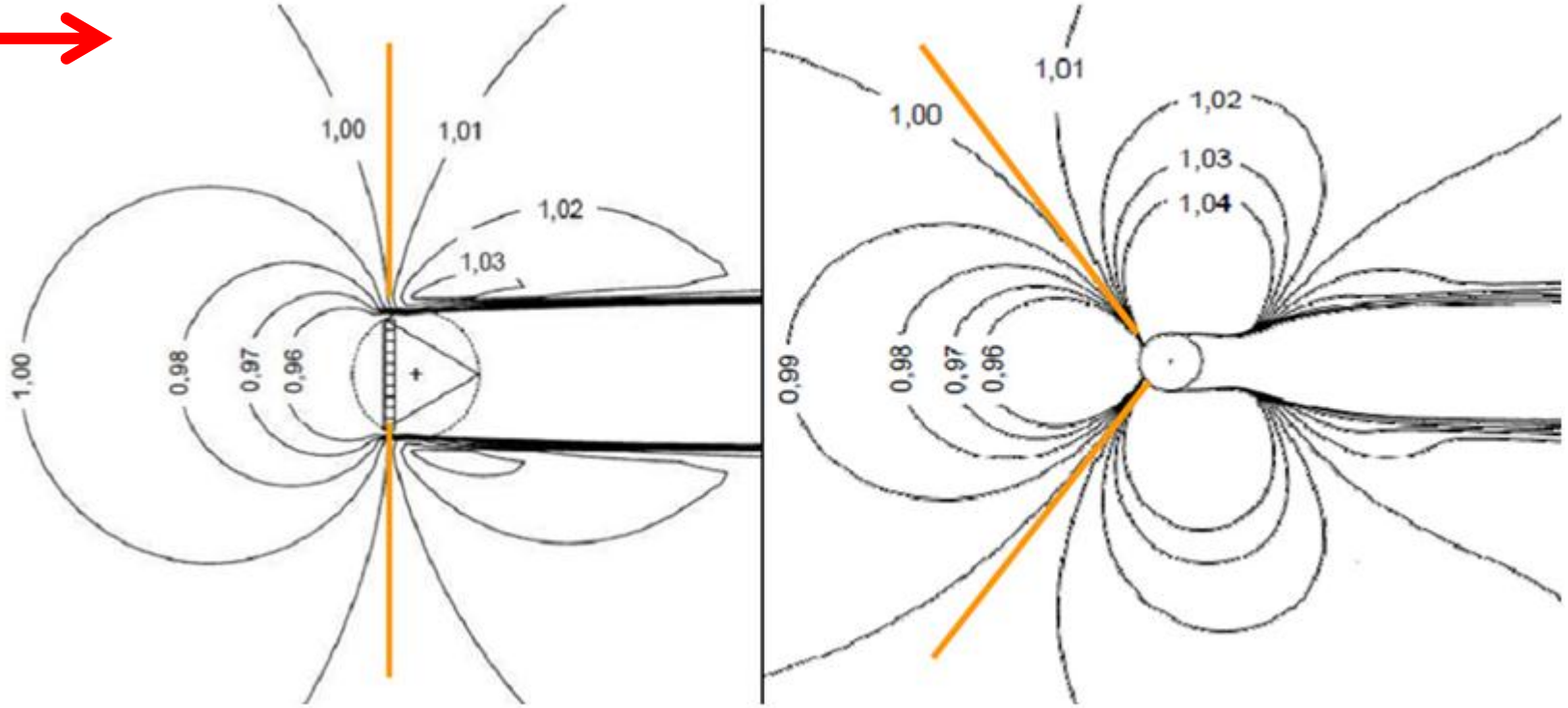
- One important aspect concerning quality warranty of wind measurement is the anemometers calibration in an appropriate wind tunnel.
- The cup anemometer calibration uncertainty is between 1% to 2%.



Wind Resource Uncertainty

UNCERTAINTY DUE TO ASSEMBLY OF THE SENSOR

Wind Direction →

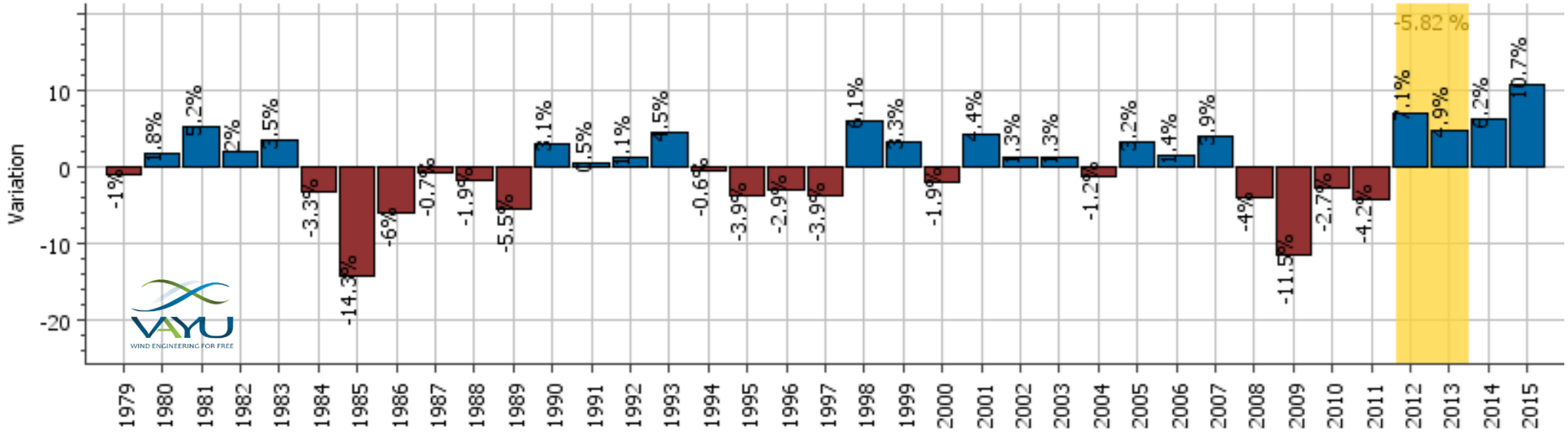


Triangular Lattice Met Mast

Tubular Met Mast

UNCERTAINTY IN THE LONG-TERM WIND SPEED

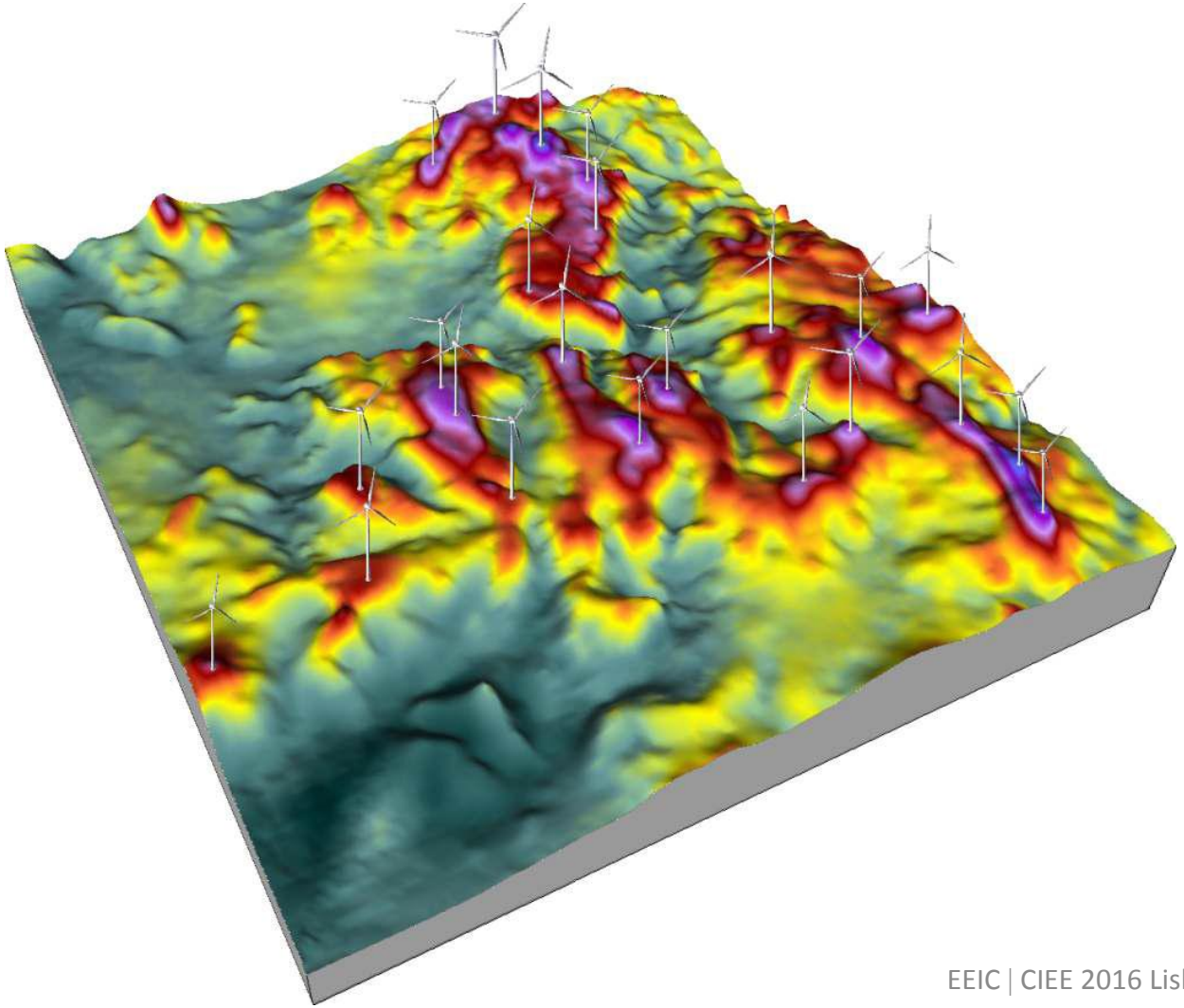
Wind measurements in short periods (1-3 years) are not indicative of long-term wind resource due to inter annual variability.



To analyze the uncertainty in the long-term wind prediction is important to consider the uncertainty in historical wind conditions and the uncertainty in future wind variability.

Wind Resource Uncertainty

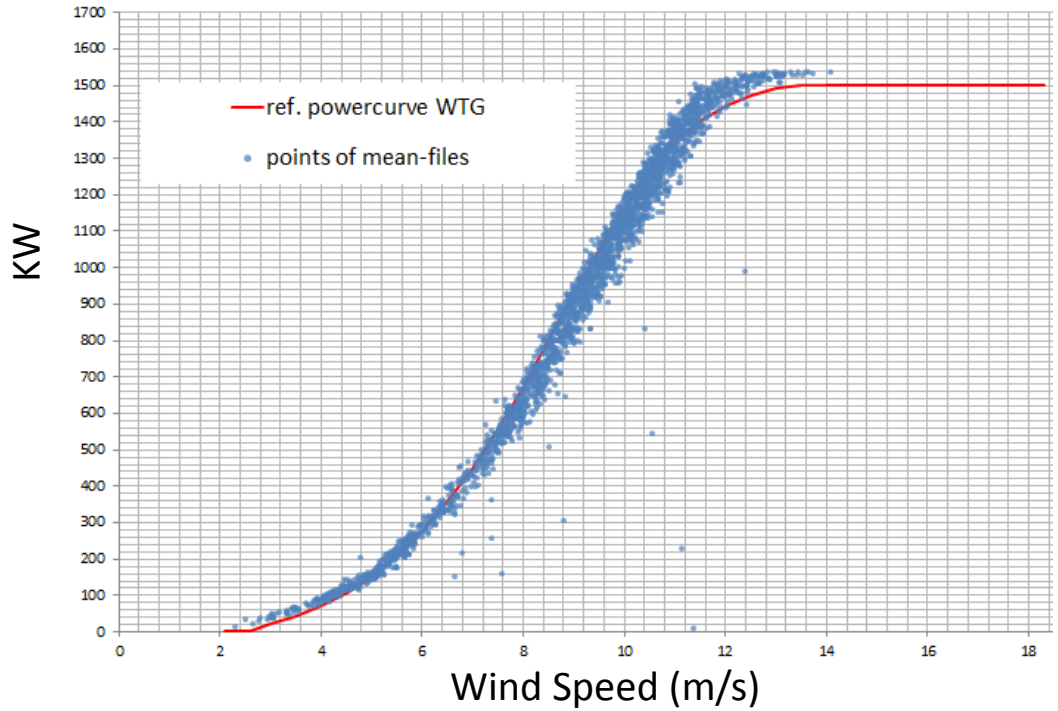
UNCERTAINTY IN THE WIND FLOW SIMULATION

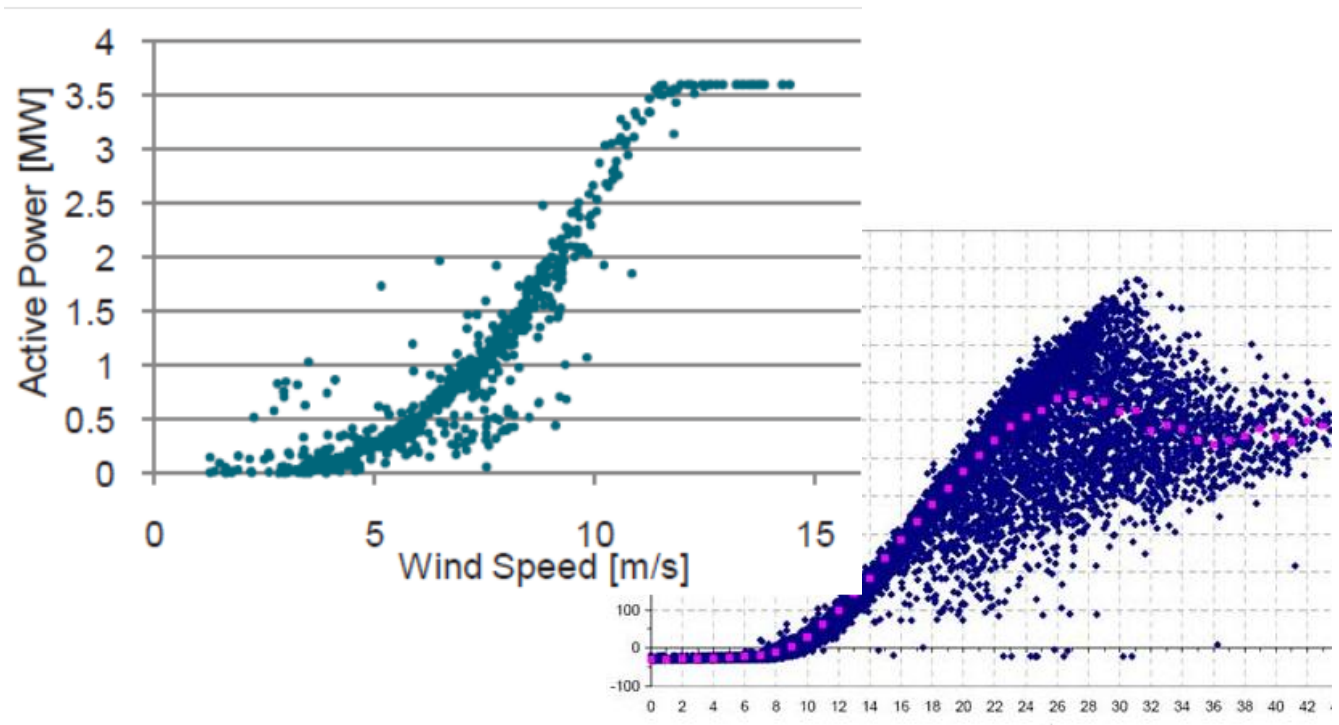


- Describe the wind behavior of the meteorological towers to the location of turbines.
- The range of uncertainty can be very wide, but a typically is 3% to 6%.

Energy Production Uncertainty

UNCERTAINTY DUE TO POWER CURVE





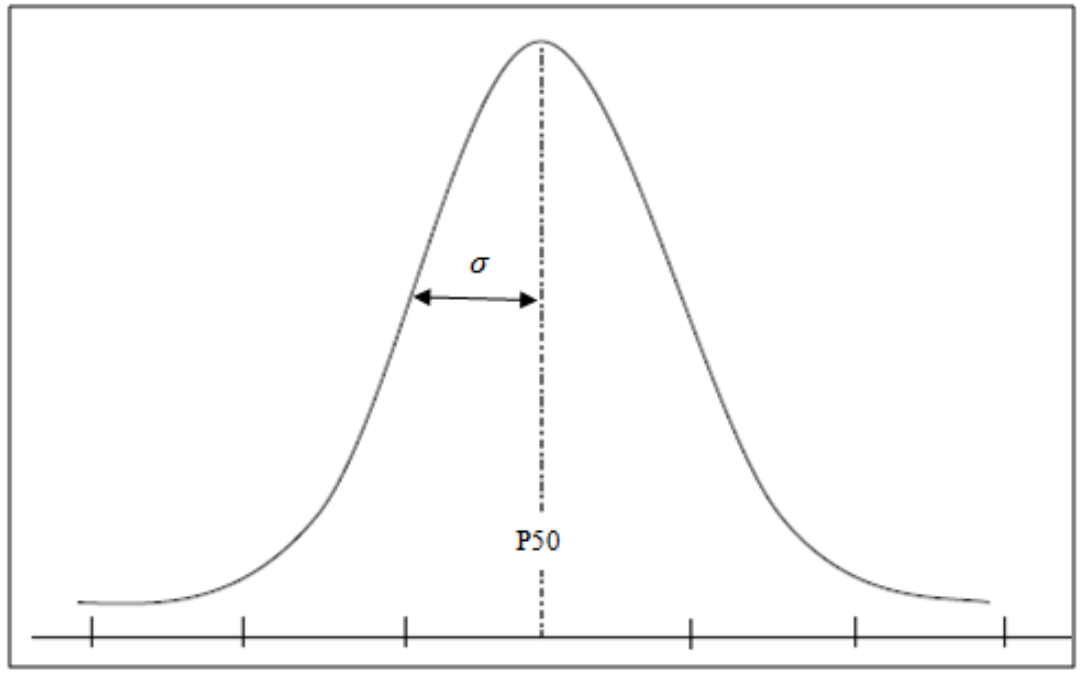
When the power curve measurement test is carried out according to the international procedures, the uncertainty typical is between 4 and 6%.

If the power curve measurement test is not made, the uncertainty of the power curve can be seen between 8% and 10%.

Energy and Probability of Exceedance

An interesting way to present the project uncertainties is by giving the probabilities of exceedance in terms of expected annual production of the wind farm.

The net AEP and total uncertainty determine, respectively, the mean and standard deviation for a normal Gaussian distribution.

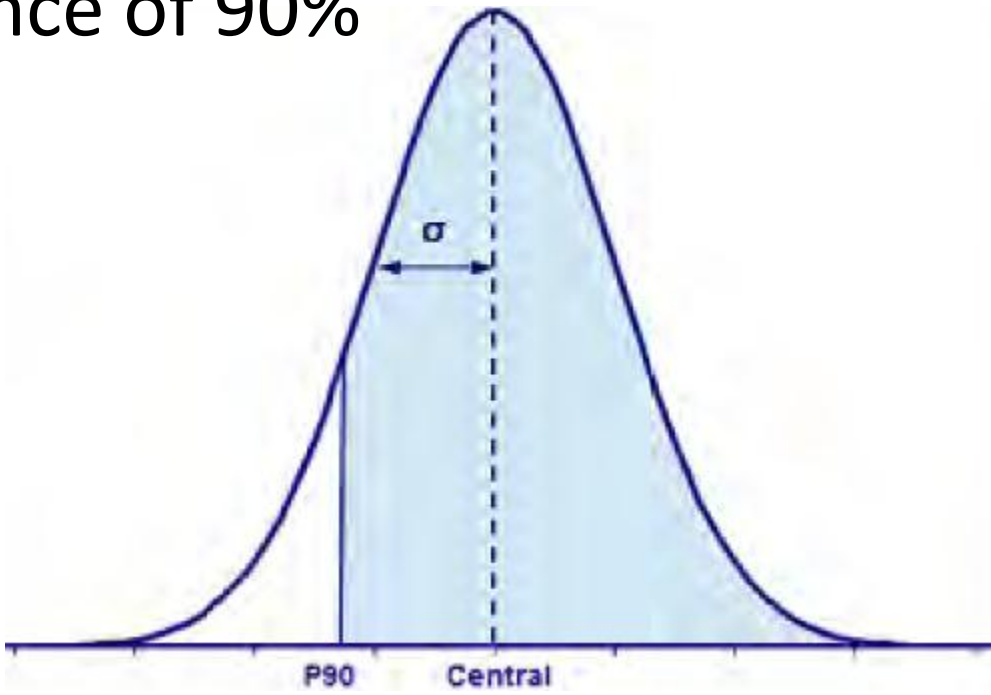


Energy and Probability of Exceedance

P_{50} - Energy with Probability of exceedance of 50%

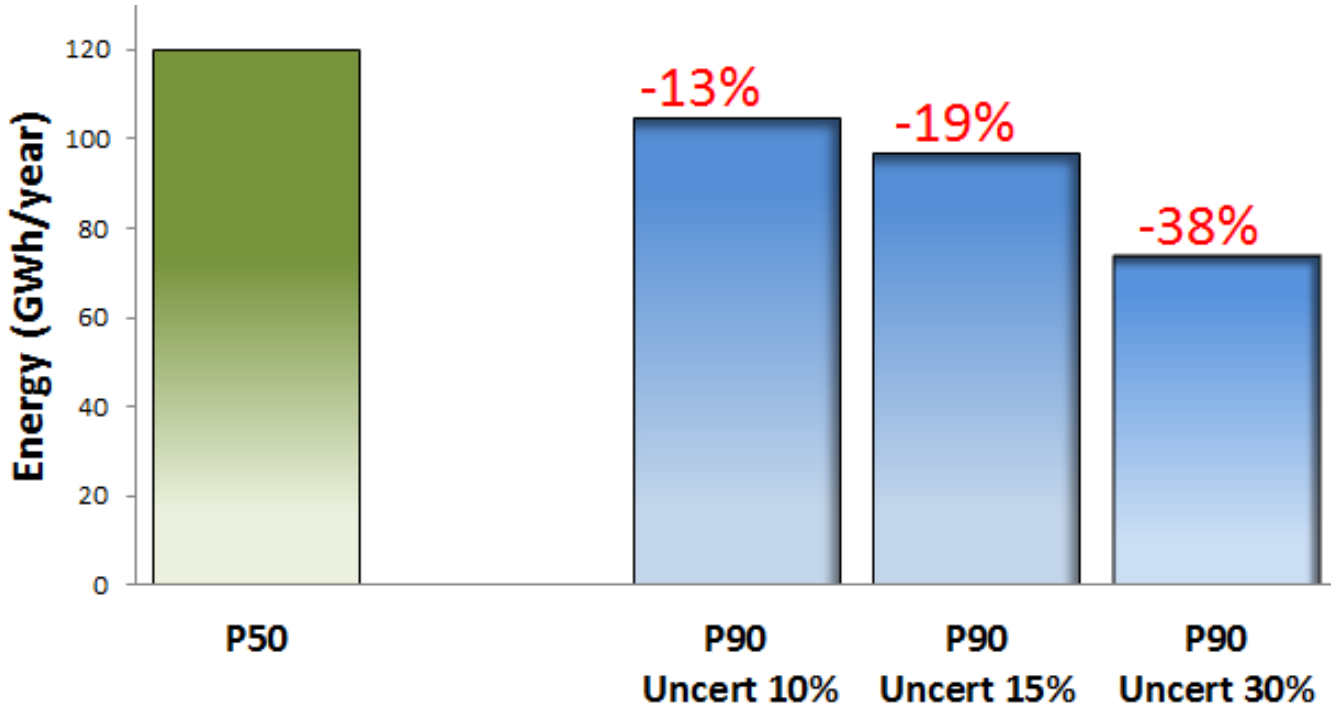
P_{90} - Energy with Probability of exceedance of 90%

With the P_{50} value and uncertainty total of the project it is possible to calculate the annual energy production for the desired probability of exceedance



Energy and Probability of Exceedance

P50 (GWh/year)	Uncertainty	P75 (GWh/year)	P90 (GWh/year)
120	10%	112	105
	15%	108	97
	30%	96	74



Conclusion

- It is recommended to use first class anemometers and they need to be correctly calibrated.

- Multiple measuring towers are very important to reduce the uncertainty. The maximum distance between proposed turbine location and meteorological tower should be lower than 6km for flat terrain and 2km for complex terrain.

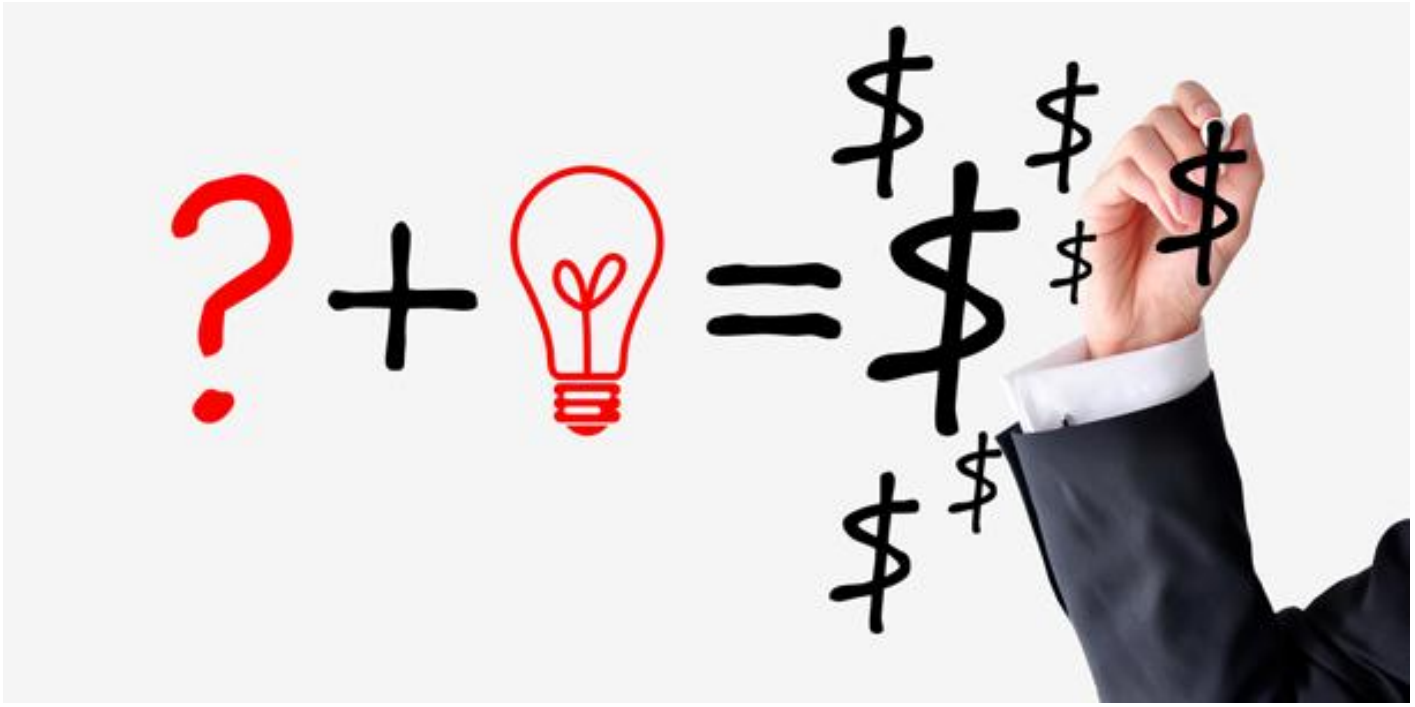
- The proper wind flow model is important to reduce the uncertainty. The linear model is recommended to flat terrain and neutral climatic conditions. For complex terrain, usually CFD model is recommended.

It is important to properly quantify the uncertainties of a wind project because they may represent significant variations in energy production.

The uncertainty analysis is paramount in assessing economic viability of a wind power project.

Next Step

It is essential to define a standard methodology for the calculation of uncertainties in energy production on wind farms in order to avoid significant differences in the calculated energy of the same project from different independent certifiers.



Thank you

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