PO. 147

Return on Investment of a Lidar System for Wind Resource Assessment

M. Boquet[1], P. Callard[1], N. Deve[1], L. Sauvage[1], E.G. Osler[2]
[1]LEOSPHERE SAS, France
[2]NRG Systems, USA

NRG Systems – LEOSPHERE: Global Partners in Lidar Wind Technologies

Abstract

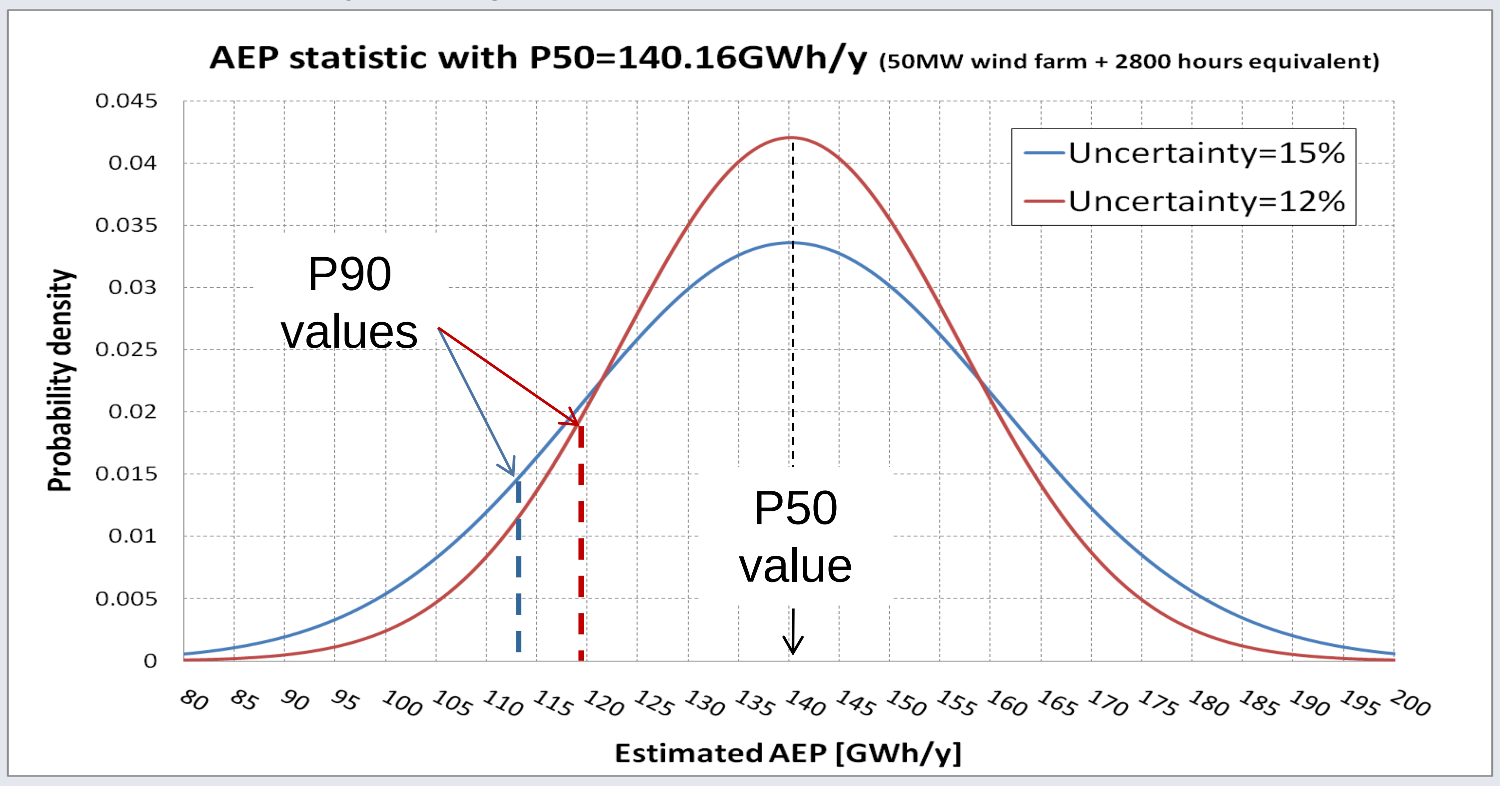
The Annual Energy Production (AEP) is the quantity of energy delivered per year by a wind farm. During the project study, a Wind Resource Assessment Program (WRAP) is designed to estimate the mean expected AEP (**P50**) and the uncertainty on the AEP (**σ_{AEP}**). These two decisive numbers **drive the financing of the project**. Small derivations in the calculated level of uncertainty can have a significant effect on project financing.

The WRAP enumerates a quantity of independent uncertainties, some of which can strongly influence the global AEP uncertainty. Among the uncertainty related to the wind resource estimation (σ_{WS}) are the **wind profile vertical extrapolation** from mast height to hub height and **horizontal extrapolation** from measurement location(s) to turbine locations.

We propose to study the use of a **Lidar system further to a mast to achieve a reduction of AEP uncertainty**. This leads to optimized financing of a wind farm project, allows reducing the equity investment and increasing the Return on Equity (RoE) of the investor. **The Return on Investment (RoI) of a Lidar system is eventually extremely positive through the financial gain of uncertainty reduction minus the Total Cost of Ownership** (TCO) of the Lidar.

Wind Resource Assessment Program (WRAP): Estimation of future Annual Energy Production (AEP) & Uncertainty on the future

The AEP is a combination of the wind resource available on site and the turbines Power Curve. The AEP prediction is usually considered as a Gaussian statistic with a mean value P50 and an uncertainty on this value σ_{AEP} which directly drives the **exceedance probabilities Pxx**. For example, a P90 of 110GWh/year means there is 90% chance that the wind farm will produce at least 110GWh yearly. The lower the uncertainty the higher the P90:



Reducing the AEP uncertainty of a few points leads to a consequent increase of energy expected at P90

Sources of Uncertainty & Reduction through the use of a Lidar

Uncertainties are related to both turbine response and wind resource estimation.

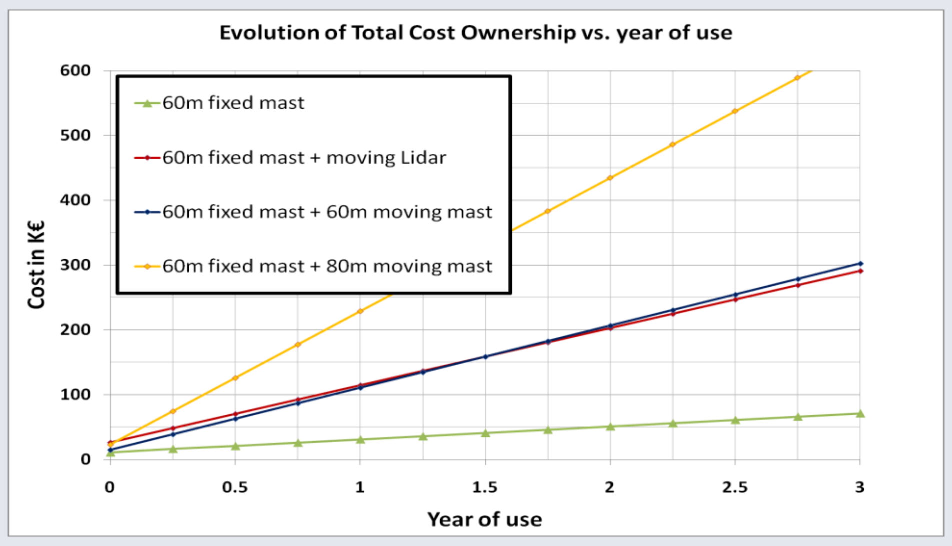
The intensity of uncertainties **varies from project to project** and is highly dependent on project size and site complexity. However, based on the experience of several independent wind energy experts and wind farm developers using Lidars, we provide **sample values** for the main sources of uncertainty.

The use of a Lidar in combination with a fixed mast offers a reduction of several uncertainties according to the following promising practice: **one fixed mast for the whole WRAP period + one moving Lidar for shorter periods of time**.

Sources of uncertainty	60m mast	60m mast + moving Lidar
Sensor accuracy	2%	2%
Hub height extrapolation	**2%**	**0%**
Turbine locations extrapolation	**5%**	**2%**
Long-term representativeness of measurement period	**2%**	**2.5%**
Long-term scaling (correlation with meteo/airport data)	4%	4%
Total WS uncertainty	7.3%	5.5%
Uncertainty ratio between AEP and WS	1.9	1.9
Wind farm efficiency (PC, wake effect, losses…)	6	6
Total AEP uncertainty	15.1%	12.1%

Lidar Total Cost of Ownership (TCO) for onshore WRAPs

The cost of AEP uncertainty is significant enough to warrant the development of new methodologies for the WRAP. A way to reduce the high horizontal uncertainty is via the use of a moving measurement system (60m mast, 80m mast or Lidar) further from a fixed mast. Note that 80m mast and Lidar also allow for the reduction (or cancellation, in the case of the Lidar) of the vertical extrapolation uncertainty. We compare the TCO when performing such methodology where the additional system is moved every 3 months from one location to another:



- 60m mast: equipment 15k€, 1 installation or dismantlement 7k€, maintenance 5k€/year.

- 80m mast: equipment 40k€ (2 years amortization), 1 installation or dismantlement 20k€, maintenance 6k€/year.

- Lidar: equipment 130k€ (3 years amortization), 1 installation or dismantlement 0.5k€, maintenance 6k€/year, power supply 15k€/year.

With 3 years equipment amortization, the Lidar's investment has a better operational RoI than a 60m moving mast after 1.5 yrs of use.

Impact of a Lidar on wind farm financing

Wind farm investment is usually financed by **bank loans and equity** with a ratio determined by the Debt Service Coverage Ratio (DSCR). Banks can require a DSCR of 1.2 based on the P90 as a minimum "guaranteed" revenue to secure their loan payment capacity.

The **Internal Rate of Return (IRR)** is a determinant indicator that can be extracted to understand the **financial benefit of increasing the leverage**. It indicates the profitability of an investment, and can also distinguish a project as the preferred choice by an investor where several independent investment opportunities are considered. On the same wind farm project, reducing the uncertainty leads to an IRR increase:

Hypothesis:
- 50 MW wind farm
- P50 = 2800 hours
- Capex = 1.5M€/MW
- Revenue = 80€/MWh
- O&M = 20€/MWh
- Inflation = 2%
- Project period = 20 years
- Interest rate = 6%
- Debt period = 15 years

Further investment = 0€	= 70 k€ (Lidar for 1 year)
σ = 15%	σ = 12%
P50 = 140.16GWh/y	P50 = 140.16GWh/y
P90 = 113.8GWh/y	**P90 = 119.1GWh/y**
Leverage = 77%	**Leverage = 82%**
IRR = 15.3%	IRR = 16.6%
Equity investment = 17.3M€	Equity investment = 13.5M€

Global Economic Benefit

On a 50MW wind farm project, through the application of a good wind measurement strategy, the developer **increases his yearly guaranteed revenue by 420k€** at P90, leading to a **higher bank loan**. Thus, the **developer saves 3.8M€ in the equity investment** and significantly **increases its Rate of Return**.

However, to achieve significant financial gains through uncertainty reduction, the complementary remote sensor needs to have **high operational capabilities**, i.e. being easily **transportable and deployable on even hardly car reachable terrains**, and having its **own power supply**. Since an interruption during the measurement period is also prejudicial, the system has to take **continuous wind data under any weather conditions**. Moreover, the system accuracy has to reach cup standards and must show a **bias inferior to 2% in complex terrains**.

After years of research on remote sensing, the wind industry has found a definitive answer to this very demanding operational and metrological equation through the adoption of laser anemometry technologies. Meeting all these challenges into a rugged 45kg "box" took Leosphere and NRG five years of work in cooperation with developers, consultants, manufacturers from 20 countries who have spared millions of euros of equity resources and expanded their investment capacity on bigger and newer projects.

References

1. H. Klug, Martin Strack, DEWI. "P50 – P75 – P90 How to Reduce the Financial Risks of a Wind Farm Project". EWEC 2004.
2. M. Taylor & al., AWS Truewind, LLC. "An Analysis of Wind Resource Uncertainty in Energy Production Estimates". EWEC 2004.
3. G. Randall, Global Energy Concepts, LLC. "Uncertainty in Correlations and Long-term Adjustments". AWEA Wind Resource & Project Energy Assessment Workshop 2007.
4. T. Hiester, Noble Environmental Power, LLC. "Energy Yield Calculations". AWEA Wind Resource & Project Energy Assessment Workshop 2007.
5. M. Brower, AWS Truewind, LLC. "Data – Modeling". AWEA Wind Resource & Project Energy Assessment Workshop 2007.
6. L. Soulié, EDF Energies Nouvelles, E. Dupont, EDF R&D. "Virtual Met Tower Project – An example of operational use of lidar data and associated return on investment for the development of large wind farms". EWEC 2009.
7. D. Jaynes, Garrad Hassan GL. "LIDAR Validation and Recommendations for Wind Resource Assessments". AWEA WindPower 2009.
8. D. Faghani & al., Helimax-GL. "Remote Sensing: Practical Use for a Wind Power Project". AWEA Wind Resource Assessment Workshop 2009.
9. M. Elkinton. Garrad Hassan-GL. "Wind Resource Assessment". AWEA Wind Resource Assessment Workshop 2009.
10. K. Comstock, GEC-DNV. "Losses, Array Design, Uncertainty and Economics". AWEA Wind Resource Assessment Workshop 2009.
11. M. Hill & al., GL. "Advantage of Restructuring Project Financing Once an Operational Track record is Established". CanWEA 2009.
12. M. Boquet & al., Leosphere SAS. "Wind Lidar measurement optimization in complex terrain". EWEC 2010.
13. www.awea.org, www.ewea.org, www.bwea.com, www.wind-energy-the-facts.org

ewec 2010 Warsaw – Europe's premier wind energy event
European Wind Energy Conference & Exhibition 2010, Tuesday 20 - Friday 23 April 2010, Warsaw, Poland
Call4Posters