

Return on Investment of a Lidar System for Wind Resource Assessment

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Abstract

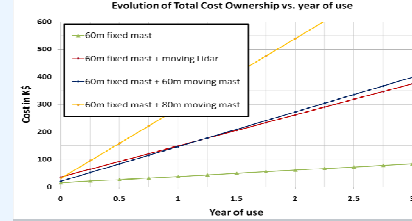
The Annual Energy Production (AEP) is the quantity of energy delivered per year by a wind farm. During the project study, a Wind Resource Assessment Program (WRAP) is designed to estimate the mean expected AEP (P50) and the uncertainty on the AEP (σ_{AEP}). These two decisive numbers drive the financing 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 study the use of a Lidar system in addition to traditional met mast measurements 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.

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 fixed mast(s). Note that 80m mast and Lidar also allow for the reduction (or cancellation, in the case of the Lidar) of the vertical extrapolation uncertainty resulting from the use of wind turbines with increasingly taller hub heights. We compare the TCO when performing such methodology where one moving system is added to one fixed mast and is relocated every 3 months within the project site:



- 60m mast: equipment \$20K, 1 installation or dismantlement \$10K, maintenance \$3K/year.
- 80m mast: equipment \$50K (2 years amortization), 1 installation or dismantlement \$25K, maintenance \$6K/year.
- Lidar: equipment \$180K (3 years amortization), 1 installation or dismantlement \$0.5K, maintenance \$6K/year, power supply \$20K/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 based on the P99 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:

- 50 MW wind farm
- P50 = 2800 hours
- Capex = 2M\$/MW
- Revenue = \$100/MWh
- O&M = \$25/MWh
- Inflation = 2%
- Project period = 20 years
- Interest rate = 6%
- Debt period = 15 years

Further investment = \$0	= \$90K (Lidar for 1 year)
$\sigma = 15\%$	$\sigma = 12\%$
P50 = 140.16GWh/y	P50 = 140.16GWh/y
P99 = 104.7GWh/y	P90 = 111.8GWh/y
Leverage = 76.5%	Leverage = 84%
IRR = 13.3%	IRR = 14.9%
Equity investment = \$23.5M	Equity investment = \$16M

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 \$710K at P99, leading to a higher bank loan. Thus, the developer saves \$7.5M in the equity investment and significantly increases its Rate of Return.

In order to achieve significant financial gains through uncertainty reduction, however, the complementary remote sensor needs to have high operational capabilities, i.e. being easily transportable and deployable even in hard-to-reach terrain, 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 all weather conditions. Moreover, the system accuracy has to match cup anemometer standards and show a bias of less than 2% in complex terrain.

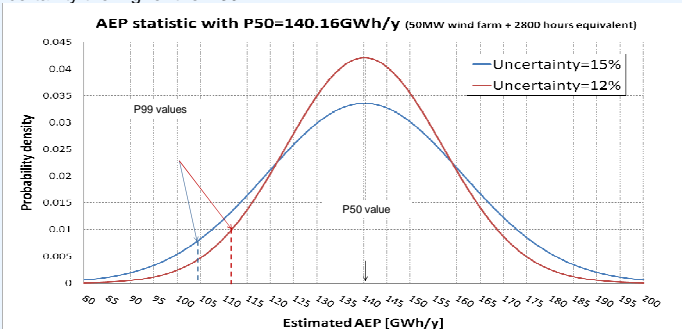
After years of research on developing a remote sensing device that ideally complements traditional mast measurements, the wind industry has found an unparalleled answer to this very demanding operational and metrological equation through the adoption of laser anemometry technologies. Meeting all these challenges into WINDCUBE™ v2 took Leosphere and NRG Systems five years of work in cooperation with developers, consultants, and manufacturers from 20 countries who have spared millions of dollars of equity resources and expanded their investment capacity on bigger and newer projects.

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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 P99 of 110GWh/year means there is 99% chance that the wind farm will produce at least 110GWh yearly. The lower the uncertainty the higher the P99:



Reducing the AEP uncertainty of a few points leads to a consequent increase of energy expected at P99

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 at a minimum one met mast offers a reduction of several uncertainties according to the following promising practice: fixed mast(s) for the whole WRAP period + moving Lidar(s)* at various additional locations for shorter periods of time.

*The actual number of met masts and Lidars required at a project site is contingent upon a variety of factors, including terrain, project size, and assessment campaign goals.

Sources of uncertainty	60m mast	60m mast + 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%