the growing demand of electricity:

a new challenge for renewable energies

white paper 2022

nabla
wind hub

How can we answer the growing demand of electricity while avoiding CO_2 emissions?

This white paper addresses the issue of generating a more competitive wind energy while **reducing its costs** through different solutions. By combining **life extension** (up to 40 years of power generation), **performance improvement** (through rerotoring techniques, achieving +25% of AEP), and **O&M optimization** (predictive & preventive actions, cutting around 10% of the OPEX) we can significantly reduce the Levelized Cost of Energy (LCOE), and make wind power an affordable energy source. Considering that the reduction of CO_2 emissions into the atmosphere is a key objective in mitigating the effects of climate change, the implementation of these solutions becomes essential in order to meet the growing demand of electricity with renewables.

After reading this white paper, you will have learned:

- about the growing demand of electricity
- about the solutions we can implement for reducing the cost of wind energy
- how to reduce the Levelized Cost of Energy (LCOE) of wind energy
- about the environmental and social (positive) impact of redeveloping wind farms

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1. Abstract

Today, there is a clear tendency towards the increased use of electricity in our daily tasks/routines. The electricity is acquiring a more important role in the global economy, and previsions do not expect it to decline. The European Union's roadmap foresees that, by 2050, the demand of electricity could double its current share in final energy demand reaching percentages of amounts between 36-39%. This highlights the importance of accelerating the commercial penetration of renewable energy sources, which are still not cost-competitive enough.

At this point, the renewable energy still has a long way to be able to attend the increasing electricity demand without depending on fossil fuels. To change this reality, it is essential to keep pushing down the costs for renewable energy production in order to become more attractive to investors. In this sense, the Levelized Cost of Energy (LCOE) is a key metric when comparing and measuring the cost effectiveness that different alternative methods of energy production will have through their life cycle. Therefore, paying close attention to the parameters presented in the calculation of the LCOE the outcomes will be to:

- reduce the CAPEX amount and the O&M costs,
- increase the energy production,
- and extend assets useful life.

From nabla, it is intended to act on three of the LCOE key parameters for the reduction of wind energy costs through **life extension**, **O&M optimization** and **performance improvement,** withing the redevelopment of wind assets.

2. The need of answering the growing demand of electricity while avoiding CO2 emissions

Globally, energy consumption is responsible for being the largest source of CO2 emissions. About two-thirds of the world's greenhouse gas emissions are related to the burning of fossil fuels that are used for heating, electricity, transportation, and industry. As a result, the challenge we face today as a society to curb climate change is conditioned, among other aspects, by the increased use of renewable energy sources.

One of the most important facts when dealing with the energy transition is the growing global demand of electricity, due to the electrification of transport and heat, and the considerable demand of digital devices and air conditioning systems. As described in the International Energy Agency (IEA) report, "the electricity is the heart of modern economies, and it is providing an increasing share of energy services". Hence, the challenge is to answer and fulfill the growing demand of electricity using renewable energies, leaving in the past the use of fossil fuels and its harmful greenhouse gas emissions.

Nowadays, the transport is the one leading the global change towards the electrification of the markets. In 2020, the sales of electric vehicles increased more than 40% compared to the previous year, reaching a global sales record of 3.1 million and a market share of 4.6%. However, although the demand for electric vehicles is increasing worldwide, Europe and China are currently the potential markets leading the sales; Europe ranks first with 1.4 million electric vehicles sold in 2020, followed by China with 1.2 million. The demand of the electrical vehicle is expected to increase until reaching the 80% of the total production by 2050. As a consequence, it is considered that an additional 150 GW of electrical capacity will be needed to charge the total electric fleet.

At this stage, the renewable energy must demonstrate its capacity to answer the growing demand of electricity without depending on the supply produced by fossil fuels. Currently, solar PVs and wind power cover almost 10% of total electricity generation, although this share is estimated to reach the 70% by 2050. Therefore, the path to net-zero emissions requires the use of all available clean and efficient energy technologies. In this regard, an annual addition of 630 gigawatts (GW) of solar photovoltaics (PV) and 390 GW of wind are needed to supply the future electricity demand by 2030.

Consequently, renewable energies are and will play a central role in future electricity supplying, bringing also an attractive technological leap for developing countries and achieving a significant carbon reduction.

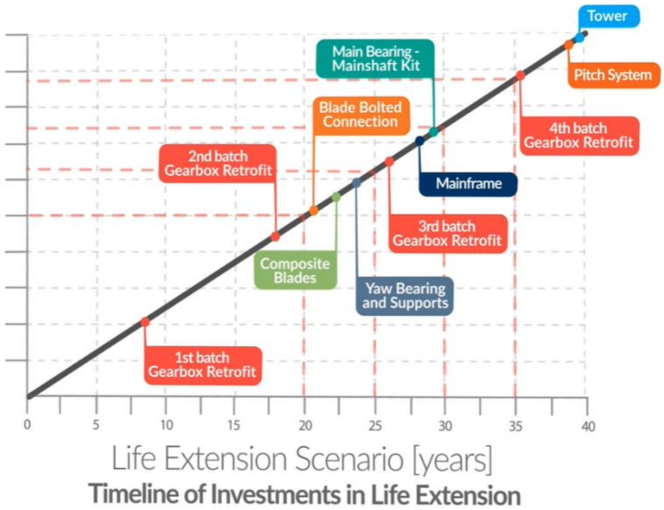
3. How do we reduce the cost of wind energy?

With the rapid growth of the electricity demand, renewables will be the fastest-growing energy source in the next decades. According to the IEA's annual projections, the global energy necessity will continue to increase, and the development of clean and renewable energy sources must accelerate in order to meet this increasing demand. Therefore, the key is to optimize the use of renewable energy to make it the basis of the electrical resource.

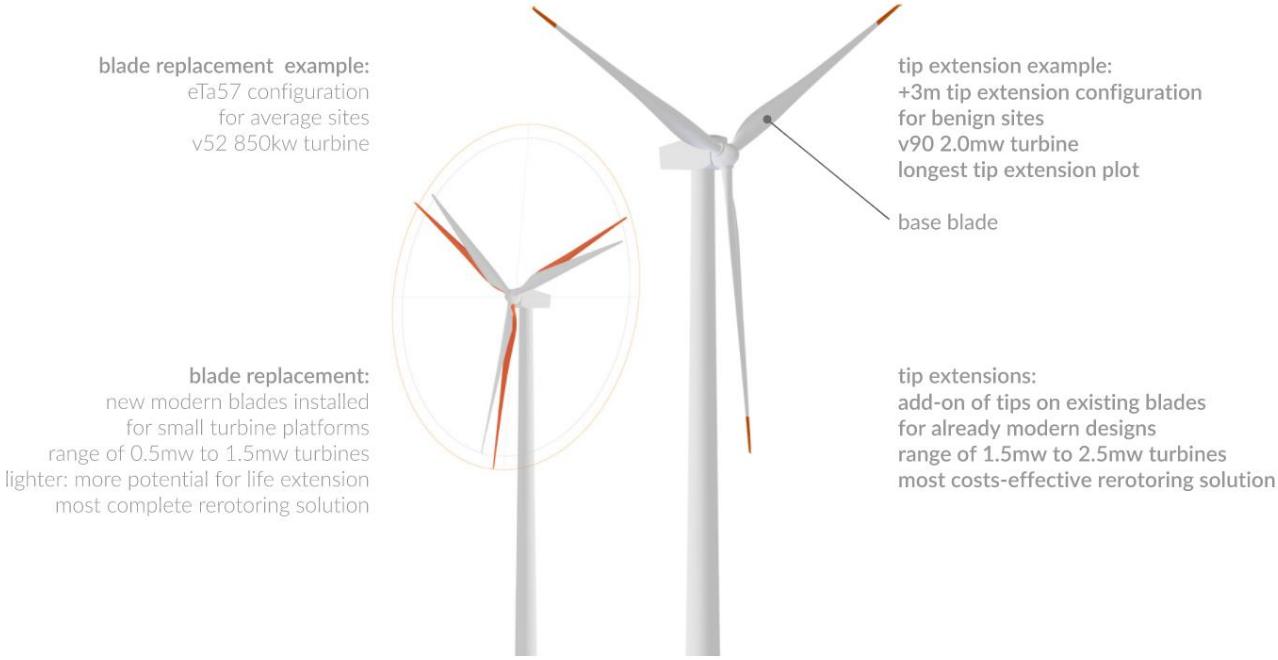
Specifically speaking, the **wind energy** must be cost-competitive towards conventional power generation sources, becoming cheaper than carbon-based energy. For this, it is essential to develop new solutions that make the wind sector a cost-competitive and successful source of energy, by improving the technology so wind turbines can be more efficient producing more energy at less cost. Accordingly, the wind power sector keeps on growing and consolidating as a key investment target: any solution aiming to grant wind technology being more affordable turns into a natural step.

To this effect, by extending wind turbines life, improving their performance, and optimizing the maintenance of the assets, it is possible to redefine each business case by maximizing the Internal Rate of Return (IRR) and making wind energy one step closer to be cost-competitive with fossil fuels. All these solutions manage to reduce the levelized cost of energy (LCOE), essential when evaluating and comparing different sources of energy from an investment point of view.

- Firstly, the **life extension plan** helps to maximize the life expectancy of the wind assets by providing adequate maintenance strategies. With this, we gain more control over the operation and maintenance costs while making more profitable the initial investment. The Life extension plan is based on identifying the life expectancy of each system or component of the wind turbine for each unit of the wind farm, allowing the maintenance protocols to be applied in advance. The analysis consists of site-specific wind conditions modeling, operation conditions modelling (with SCADA records), visual inspections of the turbines and the analysis of the local orography of the wind farm. Additionally, nabla uses its own independent aeroelastic models, which have been validated to evaluate all fatigue loads on components. **This life extension plan can double the useful life of the wind asset**, giving the opportunity to increase the profits and reduce the LCOE.



- Secondly, the **performance improvement** is the main driver of annual production, and therefore, the responsible for decreasing the LCOE as the total costs will be divided among more outputs (megawatt-hour). In this regard, the wind assets can optimize their annual energy production through different rerotoring solutions, such as, retipping or reblading, plus other retrofits as recontroling or aerodynamic add-ons. This is due to each wind farm's potential to be unlocked, as the turbine design conditions are conservative compared to the reality of sites. Therefore, **acting in the blades with tailored designs can maximize the energy production achieving +25% of AEP by increasing the rotor diameter**.



- Finally, **optimizing the O&M** of wind assets is essential when it comes to reducing wind energy costs and optimizing the performance of existing assets. This step is highly related to the life extension plan since identifies in advance the maintenance protocols to be applied in each case. By using predictive analysis, it's possible to stablish the probable preventive, corrective, and containment actions to be applied in the maintenance of wind turbines to minimize unexpected failures, extend equipment lifetime, reduce unnecessary maintenance, and alleviate the consequences of operation interruption. Predictive maintenance contributes to reducing OPEX by up to 9%, which translates into a 10% decrease in the LCOE.

4. How nabla wind hub impacts in the LCOE?

The wind farm redevelopment concept, which consist of the combination of extending useful life up to 40 years, increase AEP up to 25%, and optimise the O&M cost by 9% is the result of a number of technical innovations that the market will standardize soon, meaning that the immediate future of the wind industry is to deliver platforms deliberately designed to produce 40 years or more, while requiring the fewest O&M costs, and enough flexible to increase AEP when the site conditions allow it.

To better understand how these impacts in the LCOE we will decompose its formula and analyse parameter by parameter the effect of the different redevelopment features:

$$\text{Total Lifetime Cost} = \sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}$$

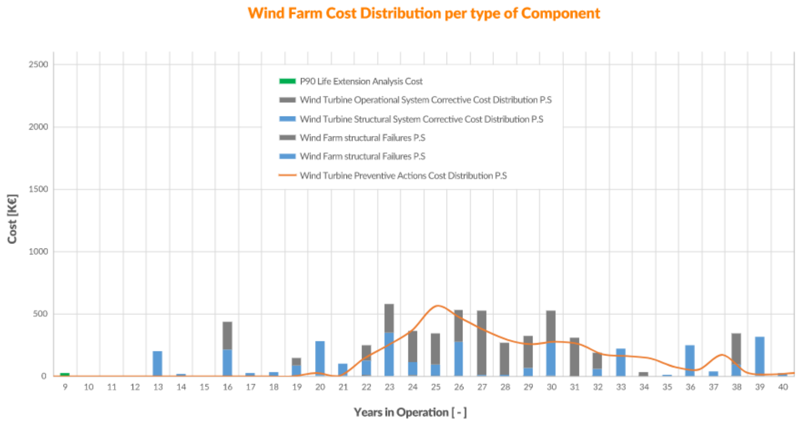
$$\text{Total Lifetime Output} = \sum_{t=1}^{n} \frac{E_t}{(1+r)^t}$$

$$\text{LCOE} = \frac{Total\ Lifetime\ Cost}{Total\ Lifetime\ Output}$$

$$\text{LCOE} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

- **It: investment expenditures in the year t.** As a result of an extended life, higher performance and optimized O&M costs, this value does not suffer any direct variation, but it's financing and insurance will definitely be redefined to better conditions and lower repayment risk assumptions.

- **Mt: operations and maintenance expenditures in the year t**. The capacity of performing complex loads simulations (following the highest standard as per IEC 61400-28) allows forecasting components failures in time, allowing at the same time to even forecast the expected failure mode. This key predictive information is the basis for formulating tailor-made (site condition based) preventive actions for each component, and allows a rationalization of activities and components stocks, therefore offering lower values in this parameter. In a redevelopment project this parameter can achieve 0.91Mt.

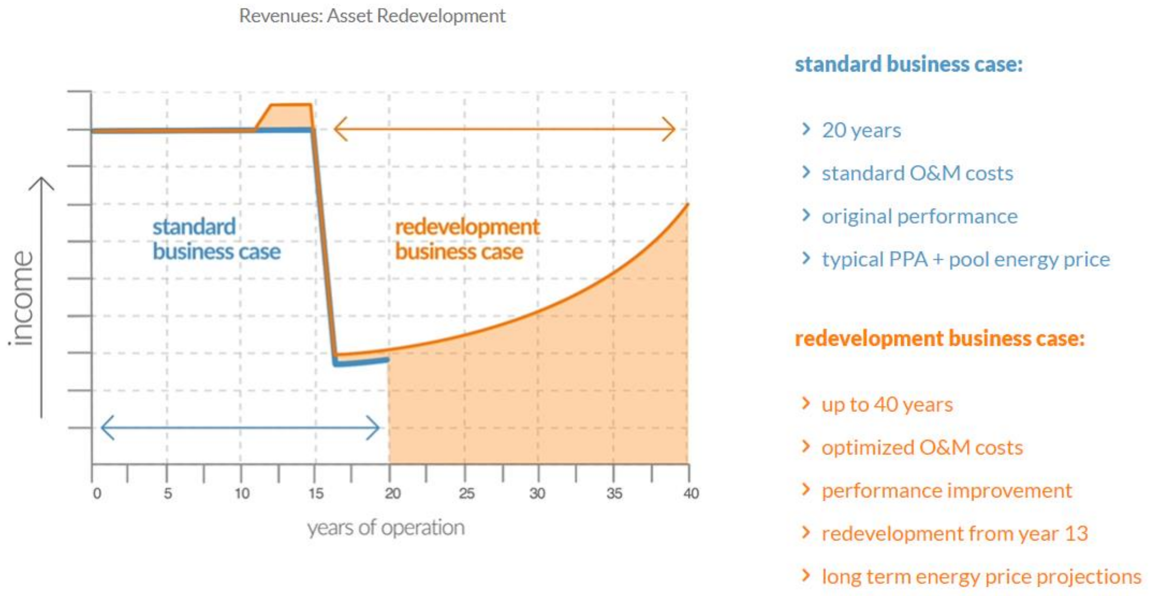


- **Ft: fuel expenditures in the year t**. As a derivative of the predictive technology through complex wind modeling (CFD), specific aeroelastic models, operation modeling and load loops under the lowest uncertainty standards, major failures are delayed or mitigated, triggering lower use of heavy machinery. Also, the optimised planning on works in the wind farm have a positive impact in this parameter. According to our calculations these cost can be reduced in a 20%, depending on the size of the platforms and orography; 0.8Ft.

- **Et: electrical energy generated in the year t.** Annual Energy Production increases through different retrofit techniques such as recontroling, aerodynamic add-ons, or rerotoring (which are proven as the most costeffective) will impact increasing this parameter. On the particular case of reblading projects, the substitution of longer, but also lighter and slender blades, imply, aside AEP increases of 25%, a lower fatigue accumulation regime, which impact also in the O&M costs. In the best scenario: 1.25Et.

- **r: discount rate.** In low-risk business cases the project finance conditions find notable improvements. As long as technologies and methodologies are certifiable, or aligned with industry standards as IEC 61400-28, results and protocols become bankable.

- **N: expected lifetime of system or power station.** As mentioned earlier, any increase of this parameter, under competitive, profitable and sustainable conditions, will definitely have a profound impact in the resulting €/kwh of LCOE. Nabla has been the first ISP worldwide to certify a wind farm to 40 years (with SGS): 2N.



Even being subject by a number of external parameters, by applying complete redevelopment program, it's relatively easy to reach overall improvements of 10% of the LCOE.

5. The lower the LCOE, the greater the social and environmental impact

In terms of environmental impact, a standard 20 year certified life wind farm has a footprint:

- About 5 gCO2eq / kWh in onshore
- About 10 gCO2 eq / kWh offshore

90% of these emissions are concentrated in manufacturing and EPC. Extending life to 40 implies eliminating a manufacturing process and EPC in the total period.

Which practically reduces the park's carbon footprint by 40%:

- From about 5 gCO2eq / kWh to 3 gCO2eq / kWh in onshore
- From about 10 gCO2 eq / kWh to 6 gCO2 eq / kWh offshore

On top of that, delaying repowering works to a pace of 40 years of interval bring a peaceful coexistence of wind energy and the environment, as it will be stressed half the times than following a 20-years lifetime standard. This aspect also favorizes local professional tissue, as workshops, jobs, and companies which qualify for servicing the wind assets will see a wider stability, and foster local integration and technology transfer processes.

6. CONCLUSION

Europe only will face a need of additional 150GW of capacity installed in the coming 30 years. CO2 levels and climate change don't allow relying anymore on electricity produce from fossil fuels. Renewable energies are therefore key in the ongoing energy transition process. Among them wind energy is proven as one of the most reliable and mature source of renewable energy which, together with PV, is firm candidate to match LCOE levels as conventional sources of energy.

Nabla as specialists in wind energy is an independent player in the industry that believes that this potential is already available. Combining technology and advanced methodologies it's possible to identify this potential and unlock it safely, turning the wind farms more productive, cheaper, and more reliable in the long term. The combination of life extension, performance improvement and O&M optimisation is called redevelopment and can be achieved following the best practices wrapped in the IEC 61400-28 standard.

Redevelopment of existing and planned wind farms can easily cut 10% on the LCOE, reduce 40% the CO2 footprint of the facility and contribute to local economies bringing stable jobs for periods of 40 years. Wind energy is already a grown up and is ready to play a key role in the energy transition for a greener future.

7. ANY QUESTION?

If you have any further questions, please do not hesitate to contact us:

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