Polytech
Wind for life™

ELLE™

Let's put an end to leading edge erosion

ELLE™ is a market-leading product protecting blades from erosion caused by environmental factors, such as rain, hail, and airborne particles, accelerated by the damaging UV rays of the sun.

We have addressed the challenge of leading edge protection from a holistic point of view and offer unmatched performance considering all elements such as durability, functionality, and ease of application.

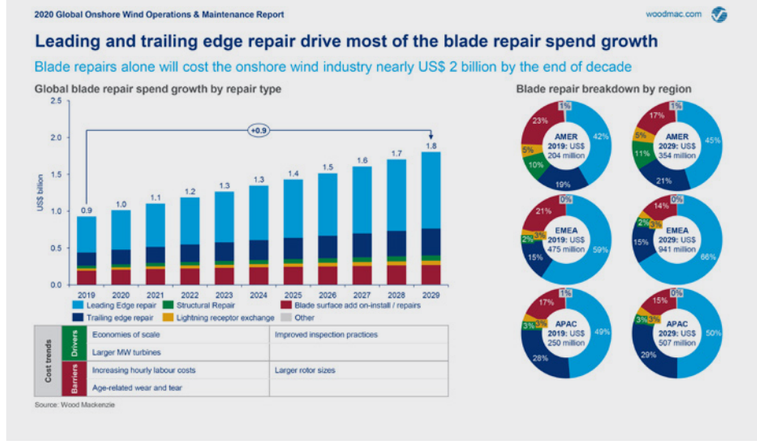
Leading edge erosion – a billion-dollar problem

As rotor blades get longer, they reach increasingly faster tip speeds. And with wind turbines being erected in ever tougher and increasingly remote locations, leading edge erosion becomes even more of a problem.

Repair of leading edge erosion accounts for more than 50% of up-tower blade repair expenses, and will cost the industry $1 billion USD every year by the end of the decade, as forecasted by Wood Mackenzie[1].

We need a solution to stop this trend. But unfortunately, conventional leading edge protection solutions have proven to fail too early, they cannot withstand the environmental conditions, and require re-application. They are therefore unsuitable to prevent erosion of leading edges during a blade's life span.

That is why we have developed ELLE™, a robust polyurethane softshell with unmatched capabilities that puts an end to leading edge erosion.



Leading edge repair will cost the industry $1 billion USD every year by the end of the decade, as forecasted by Wood Mackenzie. Image source:Wood Mackenzie.

1 Liu, D, Garcia da Fonseca, L. 2020 Global Onshore Wind Operations & Maintenance Report. Wood Mackenzie Power & Renewables; 03 February 2021.

ELLE™ – putting an end to leading edge erosion

ELLE™ in action

ELLE™ consists of pre-cast sections made of robust yet soft and flexible polyurethane shells. These shells are applied to the leading edge using a thin but sturdy, moisture-resistant adhesive (activated during installation) and sealer that match the blade material for optimum adhesion. The edge sealer ensures a smooth transition between the shells and the blade with the finest aerodynamical aspects. By absorbing the kinetic energy from rain, hail, and airborne particles, the ELLE™ shell provides optimal protection of the rigid surface of the blade.

ELLE™ is custom-made to fit all blades on the market seamlessly.

Tailored to individual blade designs

ELLE™ is custom-made to fit every blade type on the market perfectly. With its seamless integration into the blade's geometry when fitted, you can avoid erosion-induced energy production loss and maintain your turbines' performance.

Quality and traceability at all times

To ensure that you always get an ELLE™ shell with the highest quality, we use automated, laser-based geometric metering to confirm consistent thicknesses across each ELLE™ shell, and implemented an automated quality control based on artificial intelligence.

Each ELLE™ shell has a unique QR code and serial number that gather all data on each shell, including production date, material batch number, inspection documentation, quality measurements, consumption data, and test reports. We can therefore track every process from raw material batch to finished product, even after installation.

The unique serial number and QR code on each ELLE™ shell ensure complete traceability from production batch to installation.

Convenience and simplicity in focus

You can apply ELLE™ during manufacturing or retrofit it to your installed base.

We know that installations might be postponed at the very last minute due to e.g., bad weather or operational preferences. That is why we designed ELLE™ with a wide weather application window and a shelf life of up to 18 months, giving you increased flexibility, so you can move the installation to the following season if necessary.

ELLE™ is easy and swift to apply for trained technicians. Due to the fast application time of roughly 10 minutes/meter for a factory installation and 20 minutes/meter for uptower installations, ELLE™ minimizes downtime during application.

Proven lifetime durability verified by DNV

We have exposed ELLE™ to extensive rain erosion testing according to the DNV-RP-0171 and applied the DNV-RP-0573 to calculate its lifetime. In addition to this, we also followed the extensive methodology outlined in DNV-RP-0573 to evaluate the risk of delamination of ELLE™. And the result? ELLE™ remains intact and will show no erosion during the lifetime of the turbine at most sites in the world. In 2022, DNV verified these lifetime calculations, ELLE™'s estimated durability, and all related test results according to DNV-RP-0573. DNV also highlighted that our predictions in fact underestimate ELLE™'s durability.

RENEWABLES CERTIFICATION
DNV
STATEMENT OF COMPLIANCE
SOC-DNV-RP-0573-08940

The DNV-RP-0573 provides a methodology to evaluate and predict the erosion durability and delamination of leading edge protection systems. We have followed this recommended practice to forecast the durability of ELLE™. The process involved:

1. Extensive rain erosion testing of ELLE™ according to DNV-RP-0171

2. Statistical analysis of data as per ASTM E739 standard practice

3. Combining the rain erosion testing and statistical analysis with material properties such as density, speed of sound and thickness allows us to calculate the erosion strength of ELLE™

4. Utilizing site- and turbine-specific data, such as annual rainfall, average wind speed, tip speed ratio, tip speed, and blade length, we can calculate the durability of ELLE™ for any given site

We have calculated ELLE™'s durability for various sites and turbines around the world. The results show that:

1. In the vast majority of cases, ELLE™ remains in the incubation period for 25 years of operation (i.e., it will not enter the erosion period, nor will it suffer from breakthrough, and no repair is needed).

2. For the most extreme sites with regards to tip speeds and rainfall, ELLE™ may show erosion damage that would require repairs of the tip sections maximum twice during the turbine's lifetime. These repairs, however, would only entail exchanging the damaged shell(s).

3. When using only conventional coatings at site with around 1,000 mm annual rainfall, the leading edges will have visible erosion damages after a few years, which will require repairs up to six times over 25 years. For more extreme sites, this number can be even higher.

4. Conventional coatings will experience severe erosion in the tip section and along the entire blade, which will require repairs. Installing ELLE™, however, will not only protect the tip of the blade, but also the rest of the leading edges from severe erosion during 25 years of operation.

It is therefore safe to say: ELLE™ does in fact put an end to leading edge erosion.

Testing and installation records

We have thoroughly tested ELLE™'s performance with regards to rain erosion, damage progression, UV exposure, saltwater exposure, and adhesion strength of the sealer and tape on various surface materials in our accredited test center. Thereby we made sure to follow the procedures of various international standards like DNV-RP-0171, DNV-RP-0573, and ASTM G73-10.

More than 50,000 ELLE™ shells installed worldwide have proven their performance in all climate zones from the arctic environment to tropical climates both onshore and offshore since 2016.

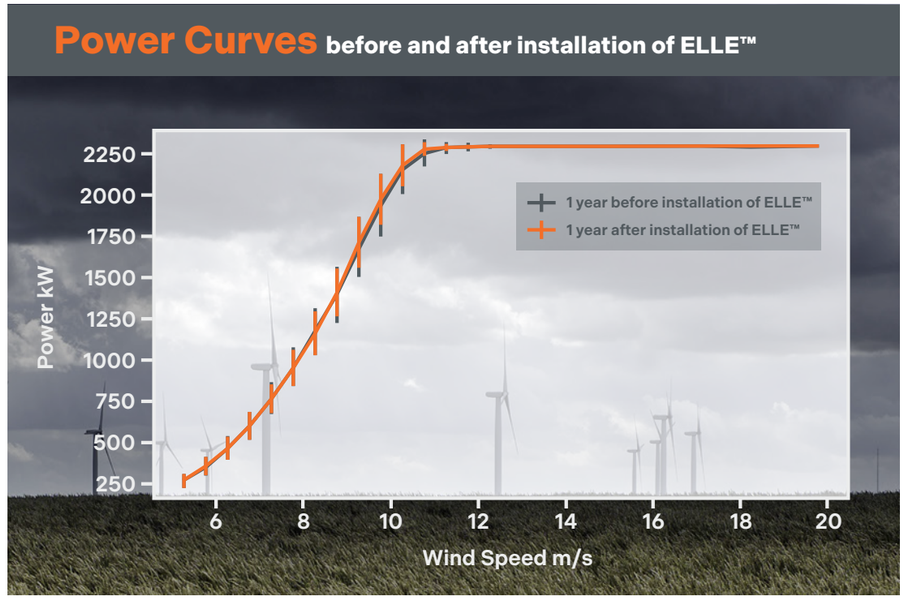
Field studies prove stabilized energy production with ELLE™

One thing is to be certain about ELLE™'s durability given DNV's verification. But how will its installation affect the turbine performance during operation?

DNV also carried out a benchmark study on near-shore turbines in Denmark, where ELLE™ was installed on newly repaired blades. They compared power output and wind speed data recorded by the SCADA system from one turbine before and after the installation of ELLE™, and the same data from a parallel, unmodified turbine (i.e., without ELLE™) as a reference. DNV concluded that there was no evidence of ELLE™ influencing turbine performance. This also means that ELLE™ did not (and does not) reduce performance even if installed on newly repaired blades.

In another benchmark study, we analyzed turbine performance after ELLE™ was installed on eroded blades on turbines in onshore Canada. One year after ELLE™ installation, the turbines' annual energy production levels stabilized, and had even shown a slight increase of 0.4% compared to the year before.

These benchmark studies from operational turbines prove that ELLE™ not only protects the blades from erosion, but stabilizes, and even increases the energy production and turbine performance slightly.



Benchmark analysis of an onshore wind turbine in Canada showing the turbine's annual energy production levels before and 1 year after the installation of ELLE™ (using the same wind distribution and using wind data from the measurement tower at the park)

Value proposition

ELLE™ with its blade-specific design, full traceability, and proven lifetime durability represents significant value for both the OEMs and asset owners. A one-time investment providing you security, predictability, cost reduction and value for a lifetime.

OEMs	Asset owners
■ Proven lifetime protection against leading edge erosion	■ Significant operating budget optimization by avoiding leading edge repairs
■ Reducing maintenance cost by avoiding leading edge erosion and related repairs	■ Shells delivered in vacuum bags ready to be installed
■ Zero CAPEX investment in equipment for factory installation	■ ELLE™ is designed for up-tower installation using rope or basket
■ Easy installation process	■ Swift and easy application process to ensure minimum downtime
■ Enables covering leading edge in service contracts	■ Installation can be halted and restarted if necessary
	■ ELLE™ can be applied in a wide weather window. 5-35°C | 41-95°F, 30-90% rH

Should you invest in ELLE™?

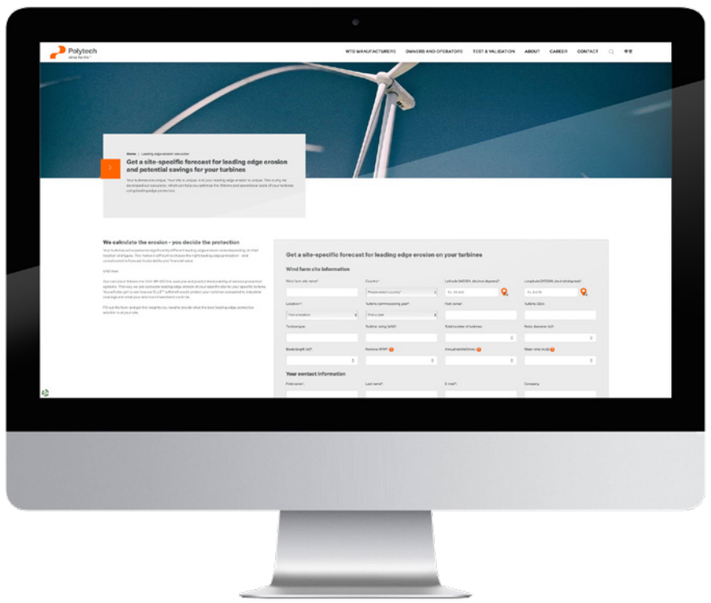
All sites and turbines are different, which has a trickle-down effect on your operating expenses and levelized cost of energy. This means that we need to investigate, whether ELLE™ is the right solution for you and if it is worth your investment.

That is why we have created the "Leading Edge Erosion Calculator".

Our calculator is based on the extensive test results verified by DNV according to the DNV-RP-0573, where we evaluated and predicted the durability of ELLE™.

With this tool, we can calculate the leading edge erosion risk at your specific site for your specific turbine. By combining these results with leading edge protection installation costs, we can also calculate your return on investment and payback period. You will also get to see how our ELLE™ shell would protect your turbines compared to industrial coatings.

Fill out the form on our website and get the insights you need to decide what the best leading edge protection solution is at your site.



Try our Leading Edge Erosion Calculator!

We offer specialized ELLE™ application training for technicians at our dedicated training facilities in Denmark. We also offer trainings on-site.

ELLE™ training

We offer specialized ELLE™ application training at our dedicated facility in Denmark or at your site. The purpose of the trainings is to qualify third-party subcontractors and/or direct customers in installing/replacing ELLE™. We provide all the materials for the training and can provide you flexible training times to fit your needs.

To enquire about ELLE™ training, please contact Sales at *polytech.com/contact*.

ELLE™ training			
Scope	**Pre-requisite**	**Duration**	**Min-max participants (per trainer)**
Qualified handling and installation of ELLE™ shells; use of installation documents and acceptance catalogue; fast-prep	None	2 days	2-4

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Contact

Are you interested to learn more about ELLE™
or get a site-specific evaluation for your project?
Then contact our Sales team at *polytech.com/contact*

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