ELLE™

Let’s put an end to leading edge erosion
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.

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.

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.

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.

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 production loss and maintain your turbines’ performance.

Quality and traceability at all times

We produce ELLE™ in an environment with strict quality control to ensure that you always get the highest quality. Each ELLE™ section has a unique QR code and serial number, so that we can track every process from raw material batch to finished product, even after 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 minimum shelf life of 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

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. And the result? ELLE™ remains intact and will show no erosion during the lifetime of the turbine at most sites in the world.

The DNV-RP-0573 provides a methodology to evaluate and predict the durability of erosion 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, no erosion will be visible, 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 a 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 after 25 years of operation.

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

Warranted against breakthrough & delamination

All ELLE™ shells now come with a standard 5-year warranty against breakthrough and delamination. This means that if for any reasons your ELLE™ shells show breakthrough or delamination within five years, we will provide you replacement shells free of charge.

If you prefer longer warranty on your ELLE™ shells, then ‘ELLE™ Lifetime’ might be the solution for you.

ELLE™ Lifetime is a solution package where we provide you ELLE™ shells with extended warranty. You can choose a 10-, 15-, 20-, or 25-years package that includes 100% breakthrough and delamination warranty.

Whichever package you choose, ELLE™ Lifetime comes with a simple and transparent price structure that gives you increased safety when planning your operational expenses. And if you want to optimize your yearly budgets, you can also spread the payments over up to five years.

We want as many of you as possible to benefit from a lifetime warranty. So even if you bought your ELLE™ shells one-off with the standard 5-year warranty, you could still enter the warranty extension from year 6 onwards.
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. Thousands of ELLE™ shells have also proven their performance in all climate zones from the arctic environment to tropical climates both onshore and offshore since 2016.

Let us take care of everything - ELLE™ as turnkey solution

Tackling leading edge erosion on a larger operating turbine park can be a massive undertaking. To take the load off your shoulders and to minimize your risks and costs, we also offer ELLE™ as a turnkey solution.

The turnkey solution allows our experts to take care of all aspects of your ELLE™ installation project from planning to commissioning. This also includes tasks and various resources that are often an additional workload for site operational teams, such as:

- Platforms & Materials
- Trained and competent technicians certified to operate onshore as well as offshore
- Transport to site & Accommodation
- Communication between stakeholders and contractors
- As-built documentation

We safeguard the project and deal immediately with any issues that might occur. We ensure a quick and efficient delivery, where the combined blade repair and ELLE™ installation minimizes your downtime and cost of operation.

Turnkey solutions are a great way to carry out larger retrofit campaigns with desirable warranty options and time- and cost-efficient execution. And your only job as a customer is to specify the task and the process. We then take care of the rest.

We offer ELLE™ as a turnkey retrofit solution, where we take care of all aspects of the project from planning to handover.

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Tender

- Inquiry from client
- Technical clarification
- Alignment of scope of supply between client and Polytech
- Issue quotation
- Negotiation of contract
- Contract awarding

Planning

- Detailed planning of activities
- Plan and hold project meetings
- Select ISP contractors
- Project follow-up
- Manufacturing of materials
- CHSE management
- MS Project timeline sharing

Execution

- Mobilization on site
- Secure materials & manpower
- Equipment & Tools
- Daily planning
- Liaise with operational team on site
- DPR & CHSE reporting
- Supervision on site
- Quality Management

Project Closing

- Handover of delivery
- As-built documentation
- Lessons learned
**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.

<table>
<thead>
<tr>
<th>OEMs</th>
<th>Asset owners</th>
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<tbody>
<tr>
<td>Proven lifetime protection against leading edge erosion</td>
<td>Significant operating budget optimization by avoiding leading edge repairs</td>
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<tr>
<td>Reducing maintenance cost by avoiding leading edge erosion and related repairs</td>
<td>Shells delivered in vacuum bags ready to be installed</td>
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<tr>
<td>Zero CAPEX investment in equipment for factory installation</td>
<td>ELLE™ is designed for up-tower installation using rope or basket</td>
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<td>Easy installation process</td>
<td>Swift and easy application process to ensure minimum downtime</td>
</tr>
<tr>
<td>Also available as a turnkey solution</td>
<td>Installation can be halted and restarted if necessary</td>
</tr>
<tr>
<td>5 - 25 years of warranty against breakthrough and delamination</td>
<td>ELLE™ can be applied in a wide weather window. 5-35°C</td>
</tr>
<tr>
<td>Also available as a turnkey solution</td>
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**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 follows the DNV-RP-0573 to evaluate and predict the durability of erosion protection systems. This way, we can calculate leading edge erosion at your specific site for your specific turbine. By combining these results with leading edge protection installation costs, we can calculate your return on investment and payback period. You will also get to see how our ELLE™ softshell 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!**

In addition to the Leading Edge Erosion Calculator, we can also offer you to spread the costs of ELLE™ over the first five years. This gives you financial flexibility if you have constraints on your yearly maintenance budget.

**ELLE™ training**

We offer specialized ELLE™ application training at our dedicated facility in Denmark, at your site or online. 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™ trainings, please contact Sales at polytech.com/contact.

<table>
<thead>
<tr>
<th>Training name</th>
<th>ELLE™ Basic</th>
<th>ELLE™ Replacement</th>
<th>ELLE™ Winglet</th>
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<tbody>
<tr>
<td>Scope</td>
<td>Qualified handling and installation of ELLE™ shells; use of installation documents and acceptance catalogue; fast prep</td>
<td>Qualified handling and replacement of existing leading edge protection shells with ELLE™</td>
<td>Qualified handling and installation of Winglet shells</td>
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<tr>
<td>Pre-requisite</td>
<td>None</td>
<td>ELLE™ Basic</td>
<td>ELLE™ Basic</td>
</tr>
<tr>
<td>Duration</td>
<td>2 days (online: 1 day)</td>
<td>1 day</td>
<td>1 day</td>
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<tr>
<td>Min-max participants</td>
<td>2-4</td>
<td>2-4</td>
<td>2</td>
</tr>
</tbody>
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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