

# N A N O L I M E S H I E L D

BUILT TO BREAK, ENGINEERED  
TO HEAL.



## Vision

Our vision is to become the global benchmark in sustainable material innovation, protecting wind-turbine blades and other composite energy components through self-healing solutions that extend their lifespan and reduce environmental impact. We envision a future in which critical energy technologies can regenerate themselves, fostering a more resilient and eco-conscious world.



## Mission

Our mission is to develop and deliver smart, sustainable coatings based on mineral nanoparticles technology, designed to heal microcracks in wind turbine blades and similar composite materials. By enhancing durability and reducing maintenance, we aim to support the renewable energy transition and ensure longer-lasting, more efficient green infrastructure.



# The Root of the Problem

- Wind turbine blades are exposed to extreme environmental conditions as rain, ice, sand, and UV which cause surface erosion and microcracks as early as 1-2 years after installation.
- These "minor" damages account for more than 12× the cost of structural failures and can reduce the energy output by 3% or more annually
- Average turbine experiences 1 minor repairs every two years, mostly due to surface degradation and cracks



# Minor Repairs, Major Expenses

## Average annual cost per turbine:

- Structural repairs: €48.5/year
- Minor repairs (erosion, small cracks): €603/year

## Annual downtime :

- Minor repairs: 55.8 hours
- Major repairs: 23.1 hours

Existing mitigation strategies (protective coatings, blade speed reduction, material hybrids) have limited long-term effectiveness.





# Our Solution

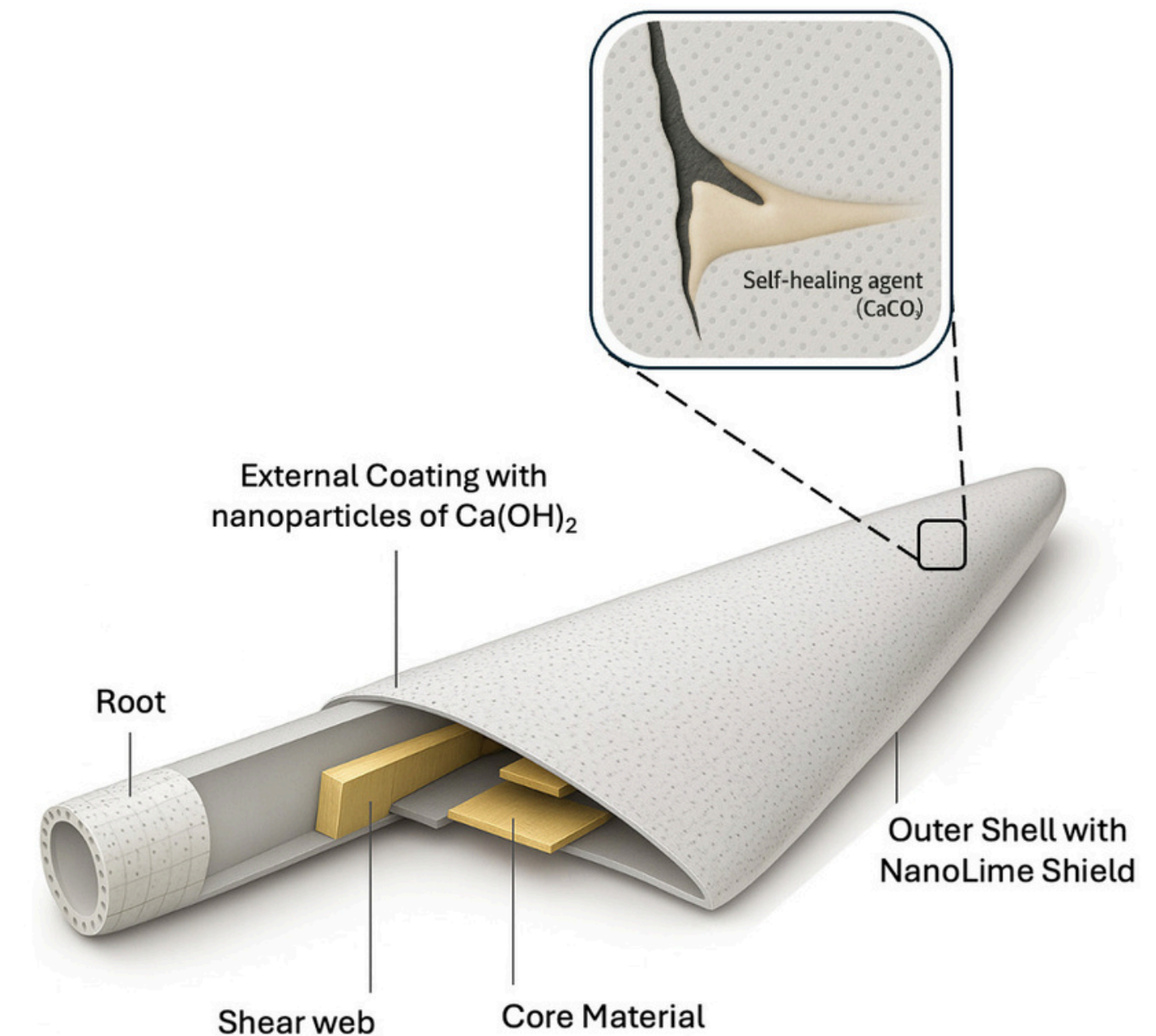
**NanoLime shield** is an advanced self-healing coating for wind turbine blades.

Forms protective  $\text{CaCO}_3$  upon exposure to  $\text{CO}_2$ , the reaction is accelerated by moisture, with higher humidity leading to faster and more effective mineralization

## NanoLime shield

- Contains reactive components that trigger a self-healing process when exposed to air or humidity.
- Ensures uniform distribution across the blade surface
- Requires no external curing or maintenance to heal microcracks
- Provides long-term protection against erosion, fatigue and crack propagation

## NanoLime shield



# Inside the Shield

## Smart coating layer

- 50 - 200  $\mu\text{m}$  top-layer applied over paint
- Contains 50–200 nm  $\text{Ca}(\text{OH})_2$  particles (25 vol %)
- No micro-capsules  $\rightarrow$  homogeneous and reactive surface

## Formulation & Application

- Dispersion in ethanol or water (5–20 wt%)
- Stabilised with ethyl alcohol, easy to spray
- Integrated during blade painting stage via robotic application

## Performance Gains

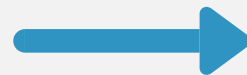
- Seals surface cracks  $\leq 200 \mu\text{m}$  in under 30 min
- Restores ~80 % of local stiffness
- Improves fatigue life (+25 %) and reduces erosion (–40 %)

# From Crack to Closure

## Crack Exposure

Trigger: wind, sand, rain, salt spray

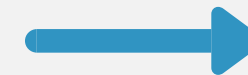
- External stressors (abrasion, impact, fatigue) cause micro-cracks or surface abrasions.
- These openings expose unreacted  $\text{Ca}(\text{OH})_2$  nanoparticles embedded beneath the carbonated  $\text{CaCO}_3$  layer.
- Typical cracks are  $< 10 \mu\text{m}$ , originating from the outer surface of the blade



## Autonomous Carbonation Reaction

Reaction:  $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

- Exposed nanoparticles react spontaneously with atmospheric  $\text{CO}_2$ , accelerated by humidity.
- The reaction forms new calcium carbonate ( $\text{CaCO}_3$ ), which begins to fill the crack.
- No catalyst or curing step is required: reaction is thermodynamically favoured ( $\Delta G \approx -80 \text{ kJ/mol}$ )



## Crack Sealing & Surface Recovery

Outcome: regeneration of the protective layer

- The newly formed  $\text{CaCO}_3$  reseals the fissure, restoring the continuity of the barrier layer.
- The coating maintains its self-healing capability over time, as each new crack reactivates carbonation.
- This allows continuous protection without capsules, manual intervention, or performance drop

# Market

	2024	2030	2035
Global wind-blade repair material Market :	686 M	1.05B	1.94B
Coatings slice (44%) :	275 M	465 M	855 M

TAM (Total Addressable): 2024 blade-repair coatings = US \$ 275 M

SAM: focus on offshore + >70 m onshore blades ( $\approx 35\%$  of coatings spend)  $\rightarrow \approx$  US \$ 95 M/yr

SOM: realistic 5-yr grab =  $\sim 3\%$  of SAM  $\approx$  US \$ 3 M ( $\approx 600$  blades / 200 turbines at an average US \$ 5 k per blade retrofit package)



# Business Model

## Costs

Bill of materials : 0,86 USD/L

COGS : 1,75 USD/L

Cost per blade : 105 USD (60 L per blade)

## Revenues

Industrial Mark-up :  $\text{COGS} \times 2,5$

Channel margin : industrial markup  $\times 1,4$

## Business strategies

1) Price for OEM ( per blade ) : 250 USD

2) Price for wind farm( per blade ) :

- 370 USD without application
- 3000 USD with application costs (on shore)
- 5000 USD with application costs (off shore)

# Competitors



Product :  
*3M™ Wind Blade Protection Coating W4600*



Product :  
*Hempablade Edge 171*



Product :  
*International® Wind Blade Protective Coatings*



Product :  
*Vitrimer-based healable coating system*



Product :  
*Self-healing ceramic coating*

# Environmental Impact



## **Fewer interventions, fewer resources**

Traditional coatings require maintenance every 2–5 years. Thanks to its nanoengineered formulation, Nanolime Shield can extend coating lifespan up to 13×, reducing interventions by up to 80% over a turbine's 25-year life.

This means significantly less transport, solvent use, waste, and replacement materials — resulting in a much lower logistical and energy footprint.



## **Less CO<sub>2</sub> lost, more clean energy produced**

A damaged blade can cause energy losses of up to 3% (~0.18 GWh/year), equivalent to 72 tons of CO<sub>2</sub> not avoided annually per turbine.

Nanolime Shield prevents these losses → up to 72,000 tons of CO<sub>2</sub> saved per year across 1,000 turbines.



## **Zero microplastic release**

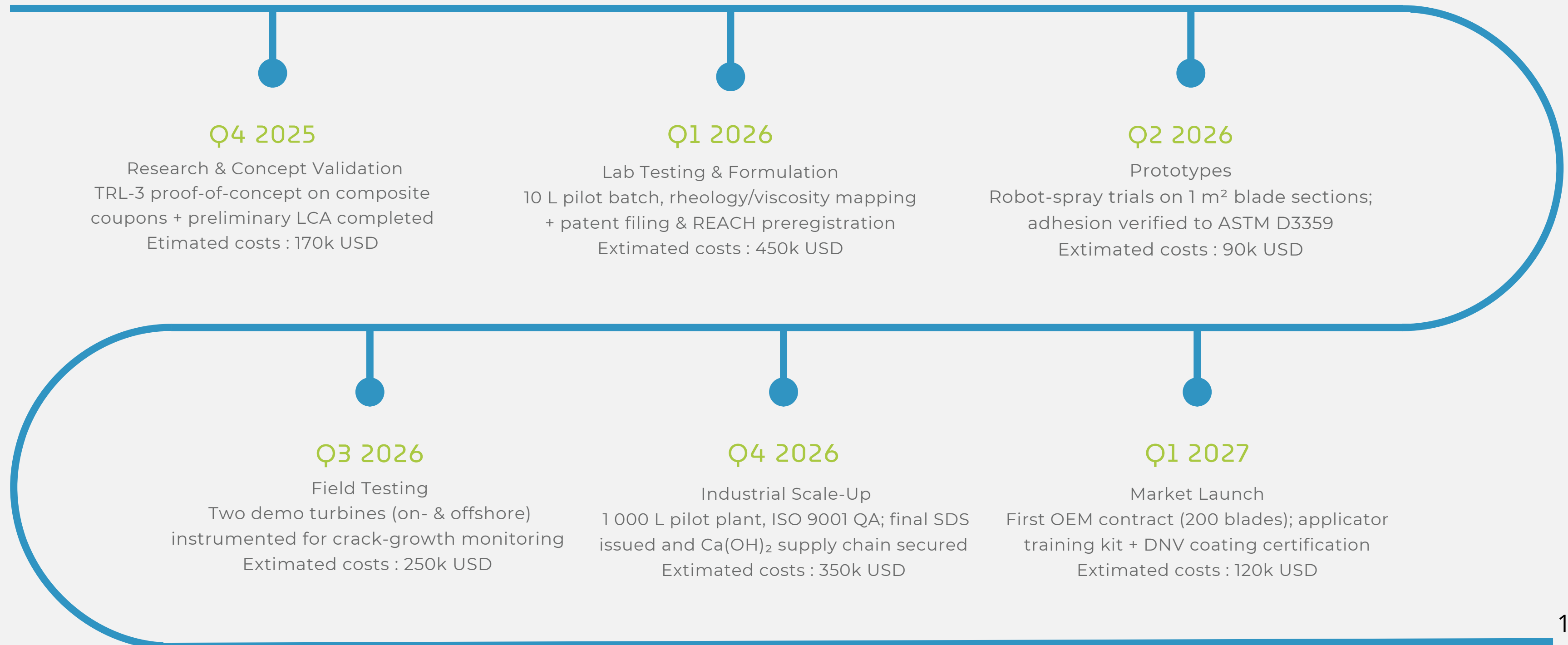
Polyurethane and epoxy coatings release up to 30–40 kg of microplastics per turbine per year. By 2030, up to 38 tons/year could be released globally by offshore wind farms.

Nanolime Shield, being mineral-based, releases no microplastics.

On 1,000 offshore turbines: up to 30 tons of plastic emissions avoided annually.

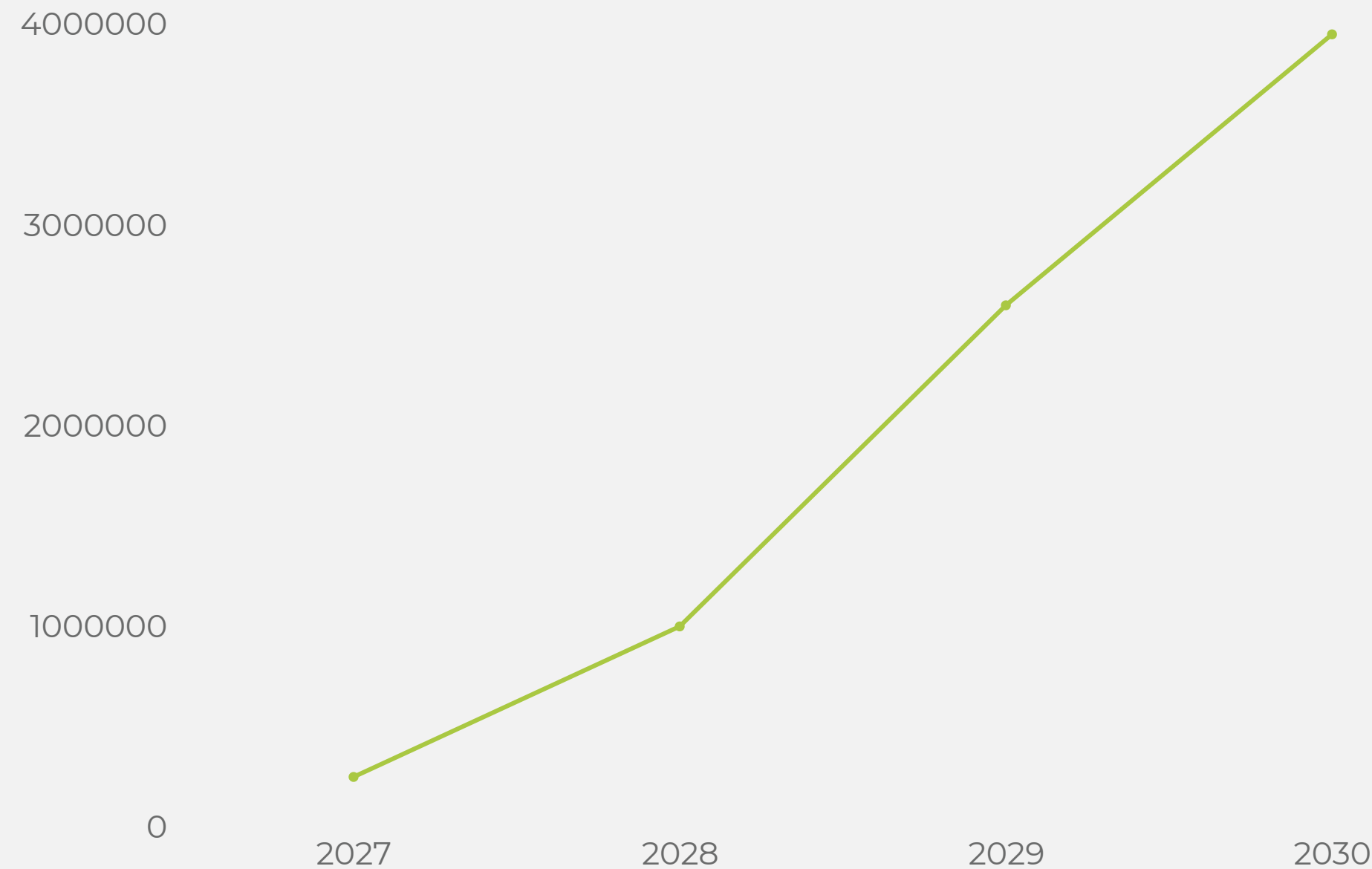


# From Lab to Blade



**TOTAL ESTIMATED COSTS : 1,43M**

# Healing Clean, Scaling fast



## Revenue growth overview

- Rapid revenue growth: from \$250k (2027) to ~\$3.9M (2030) – CAGR  $\approx$  150%.
- Main driver: adoption of the coating in OEM production lines; from 200 pilot blades to ~8,000 blades/year by 2030.
- OEM package – ~\$250 per blade; ~8 000 blades/year by 2030, contributing  $\approx$  50 % of 2030 revenue
- Retrofit service upside: the “product + application” package – \$3,000 per blade; ~5200 blades/year, accounts for  $\approx$  40% of 2030 revenues.
- Off-shore retrofit package – \$5,000 per blade; ~70 blades/year, accounting for < 10 % of 2030 revenue
- Manufacturing capacity – 1 000 L per day ( $\approx$  6 000 blades/year); a second line comes online in 2028 to reach 8 000 blades/year

# The Lime Team



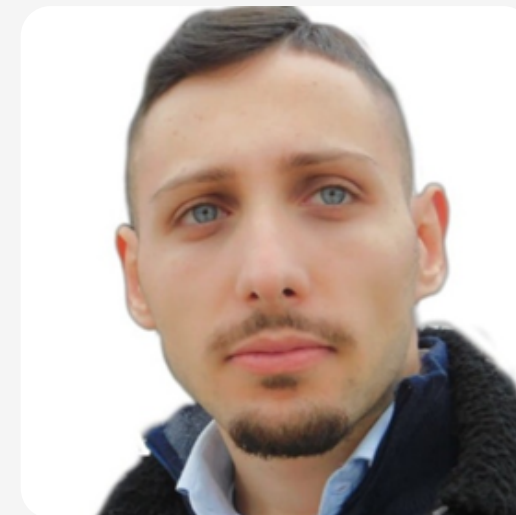
**Antonio Abbatecola**  
(CTO)



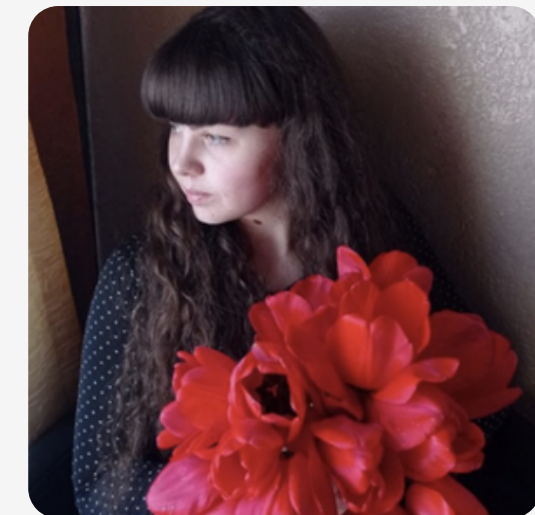
**Antonio Gaglione**  
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**Mariem Hanchi**  
(COO)



**Paolo Riccardi**  
(CPO)



**Iryna Maistrenko**  
(CFO)



# Thank you for your attention!



N A N O L I M E  
S H I E L D

Build to **break**  
Engineered to **heal**.