

# OPTIONS TO INCREASE ANNUAL ENERGY PRODUCTION

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THE POWER  
TO DELIVER

[lmwindpower.com](http://lmwindpower.com)

# AGENDA

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- 1. About LM Wind Power Service and Logistics**
  - 2. Increase annual energy production**
  - 3. Your blades were made to last**
  - 4. Intensive care**
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Service and Logistics:  
**An independent organization that benefits from long-standing knowledge**



# Together we capture the wind to power a cleaner world

The LM Wind Power vision



## **Rotor blades are the “motor”**

- » **The rotor blades represent 20% of the investment in an onshore wind turbine**
- » **Sustaining and increasing the performance of the rotor is the most direct way to influence the cost of energy and therefore the annual energy production of the turbine**
- » **An increase of 4-5% in annual energy production over the normal, 20 year lifespan of the wind turbine pays for the blade set**  
**(i.e. 20% of the investment in an onshore wind turbine)**

# Increase annual energy production



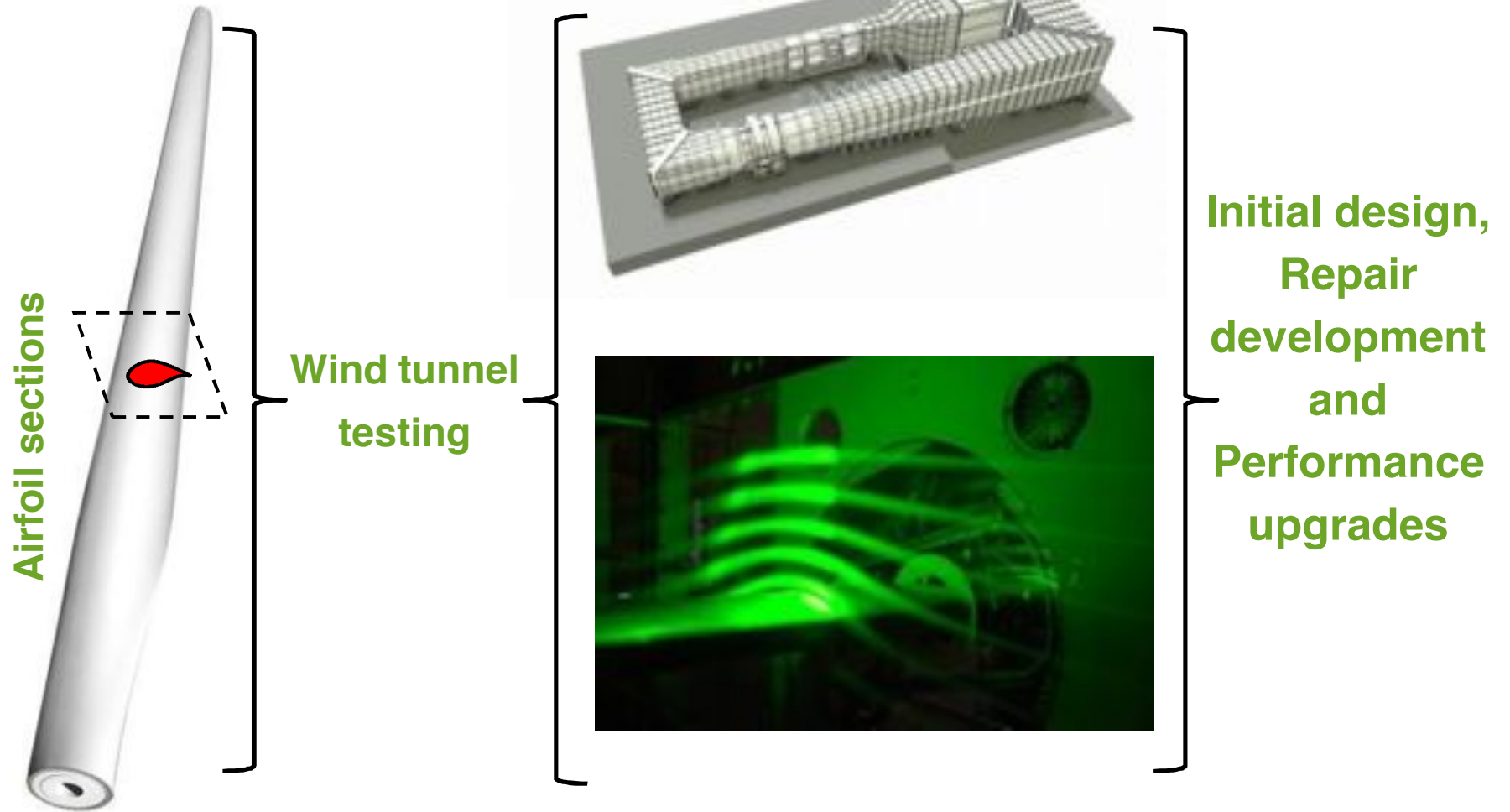
## Know your blades...

### Profile matters

- » The aerodynamic properties are crucial in determining how well the blade can extract energy from the wind
- » By changing profile, materials and structures, blades can be optimized for any operating conditions
- » Degraded profiles directly impact performance



# Aerodynamic performance



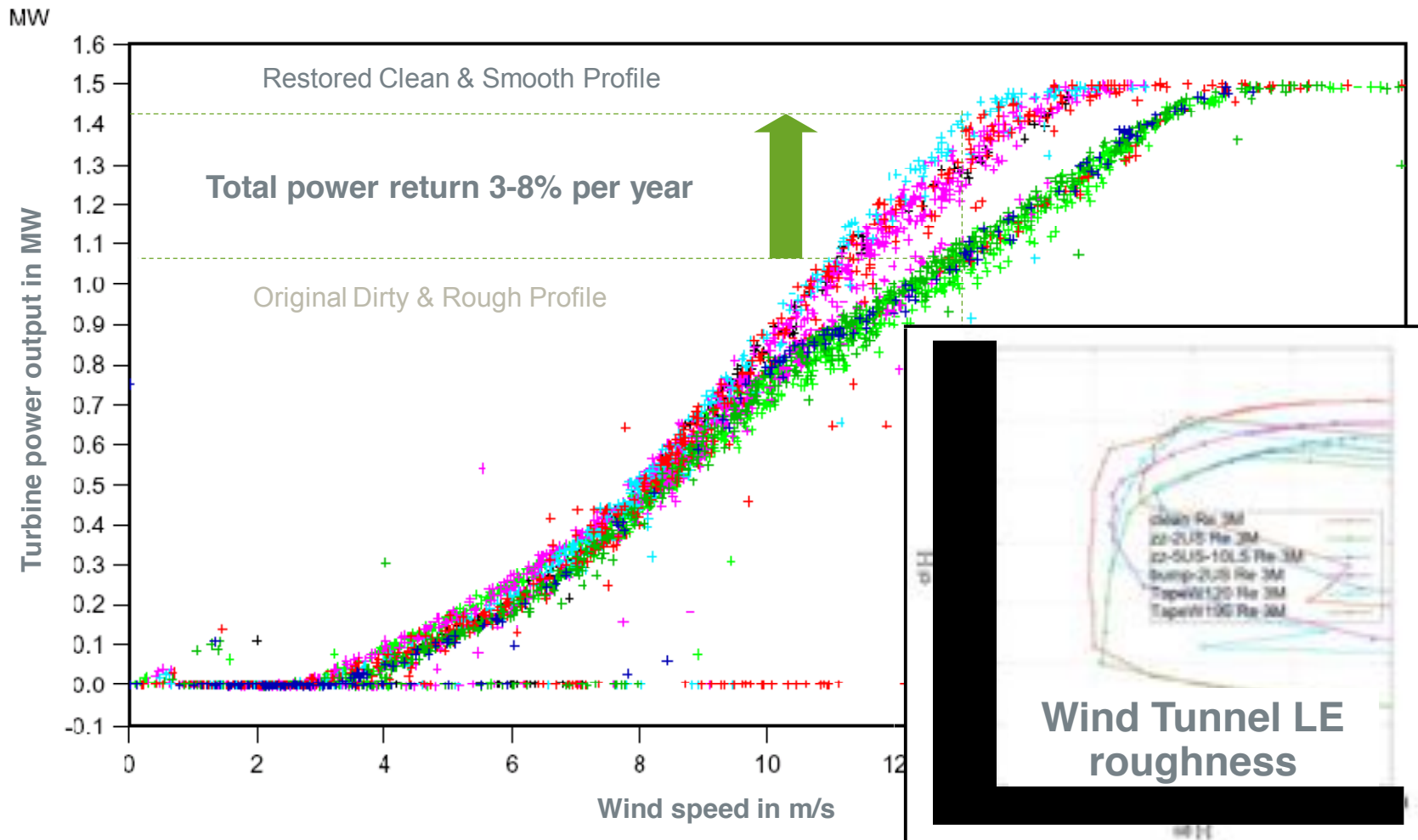


## Increase your returns

- » **Improve rotor performance and influence the annual energy production of the wind turbine**
  - » Preventative maintenance pays off
    - » Complete inspection recommendations
    - » Complete full End of Warranty inspection
  - » Ensure adequate repair processes are applied
  - » Boost your performance
    - » Vortex
    - » T-spoiler

# Preventative maintenance pays off

## Field measured mechanical loads



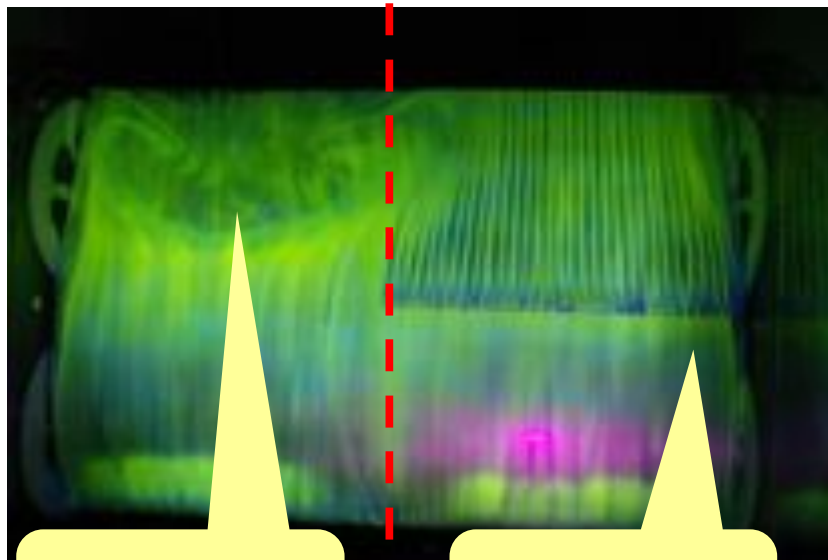
# Boosting your performance

## Cost efficient up-tower options to increase AEP exist

Vortex generator flow visualization

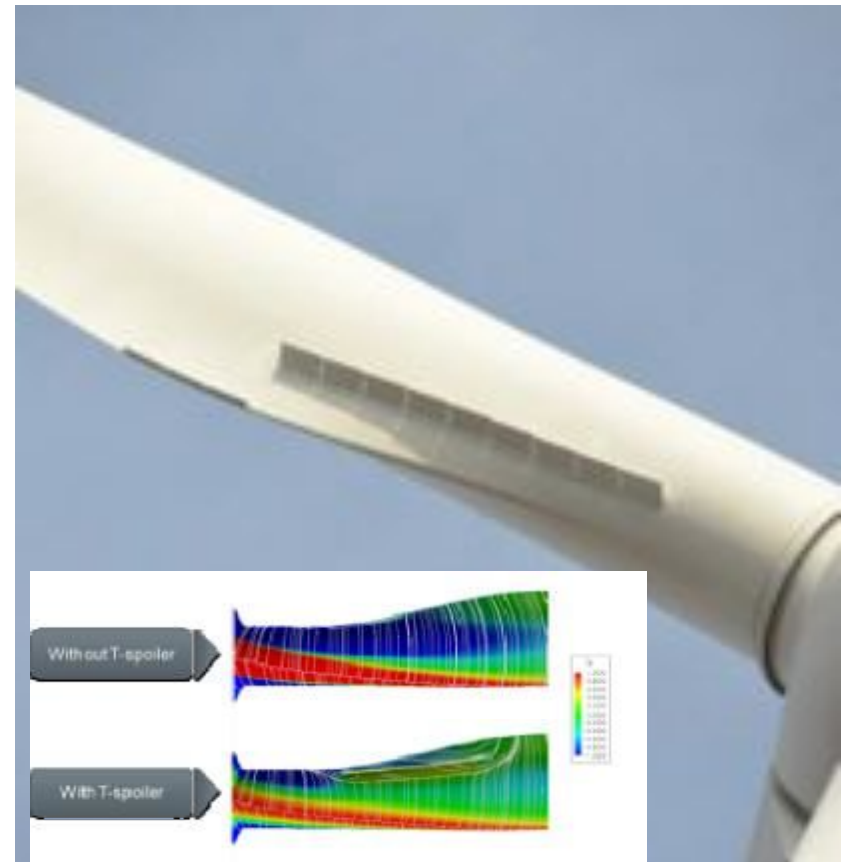
Clean surface

Vortex generators



Flow is separating without vortex generators

Vortex generators maintain attached flow



Boost package streamlines & pressure contour plots

## Blades were made to last




## Thunderstorm and lightning: bad agents



**Blades for wind turbines are made to operate in harsh conditions**

- » The complexity of nature provides weather conditions that are not always foreseeable in design calculations
- » Safe mitigation of these risks requires skillful attention

A dramatic night photograph of a lightning storm. A bright, jagged lightning bolt strikes the ground in the center of the frame, illuminating the dark sky. The background shows silhouettes of trees and streetlights, with a few lights glowing in the distance. The overall atmosphere is dark and intense.

**“Just imagine extreme weather conditions with regular hailstorms hitting the blades at more than 300 km/hour. The fluctuating temperatures and variable humidity could then later damage the blade during operation. Effective inspections and repair require a proper understanding of the blade design. Blades will perform and last a lifetime if they are thoroughly maintained.”**

**Frank Virefeldt Nielsen, Chief Technology Officer**

## Intensive care



## Blades are a wear component



- » The structural life of rotor blades is based on composite materials, fracture mechanics, design margins and actual loading (operation, wind)
- » Composite materials degrade when loaded
- » Fatigue starts with micro cracking that is not visible with the naked eye
- » As components continue to wear out further, micro cracks develop into visible cracks
- » Minor issues may be repaired with less down time



## Monitoring and preventive maintenance



- » Maintenance, as recommended by OEM, will prevent minor defects developing into structural cracks
- » Surface damage caused by erosion or lightning may be repaired at low cost if tackled early
- » Most rotor blade structures are sensitive to stress concentrations from minor damage that may develop over time

## Condition monitoring and preventive maintenance



- » Linking turbine operation SCADA data to blade operation conditions will identify sites with highest operational loading.
- » Provides indicator of life consumption and modified maintenance strategies.
- » Early analysis and repair of visible cracks are important to avoid larger repairs in the future.

# Questions?

