Biome Renewables®

FeatherEdge® - Silence is Power™

November 10th 2025

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Evolved Design

Biome Renewables

Presentation Content

- About Biome
- FeatherEdge Core Team, Board & Technical Advisory
- Wind Turbine Noise
- FeatherEdge Serration Technology
- Development Process
- Key Benefits: Noise and Power
- Applications and Benefits
- How are we different from Standard Serrations
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- Order Process
- Field References

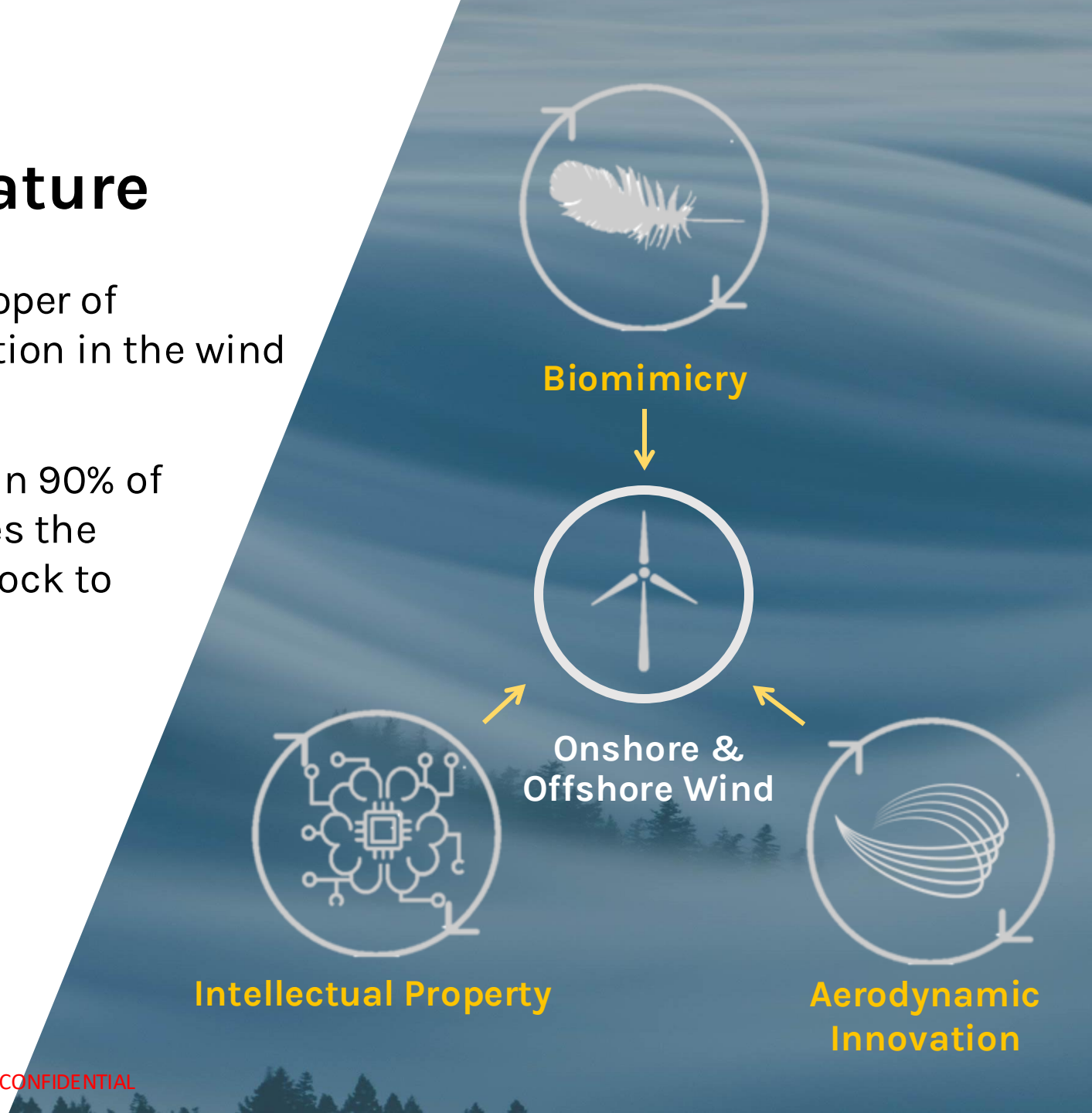
Biome Renewables

Innovation Inspired by Nature

Our mission: to become the leading developer of biologically-inspired aerodynamic innovation in the wind industry.

With 60 patents across 5 patent families in 90% of the wind markets globally, Biome leverages the power of Evolved Design and our DesignClock to redefine expectations in wind.

Offices in Canada and the Netherlands position Biome well to scale in two of the largest and growing wind markets in the world - Europe and North America.



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The FeatherEdge Core Team (1/2)

Ryan Church, MDes
Founder and CEO/CTO

Designer, biologist and inventor with numerous patents. Nominated as a Forbes 30 under 30 in Energy.

Søren Andersen
Head of Engineering

35 years of experience in rotor blade engineering, held senior positions in LM Wind Power.

Bryan Murphy, MBA
CFO and Head of Finance

Finance specialist. Has delivered projects with budgets over $100 million& been involved with numerous start-ups.

Dirk-Jan Kootstra
COO & Head of Manufacturing

25 years experience in rotor blade manufacturing. Worked at GE and with numerous blade-producers globally.

The FeatherEdge Core Team (2/2)

Robin Borgert, Dipl.-Ing. (FH)
Head of Sales

- Mechanical engineer, 25 years of wind industry experience
- 20 years in wind turbines sales, 16 years as Regional Head / Director
- Joined Biome in 2025

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Biome Board & Technical Advisory Group

With our Core Team, Board and Advisory Group, we have **100's of years** of wind, innovation, and management experience.

With this expertise and network, Biome is uniquely positioned to deliver on its mission.

Board

Bachir Rabbat
Chairman

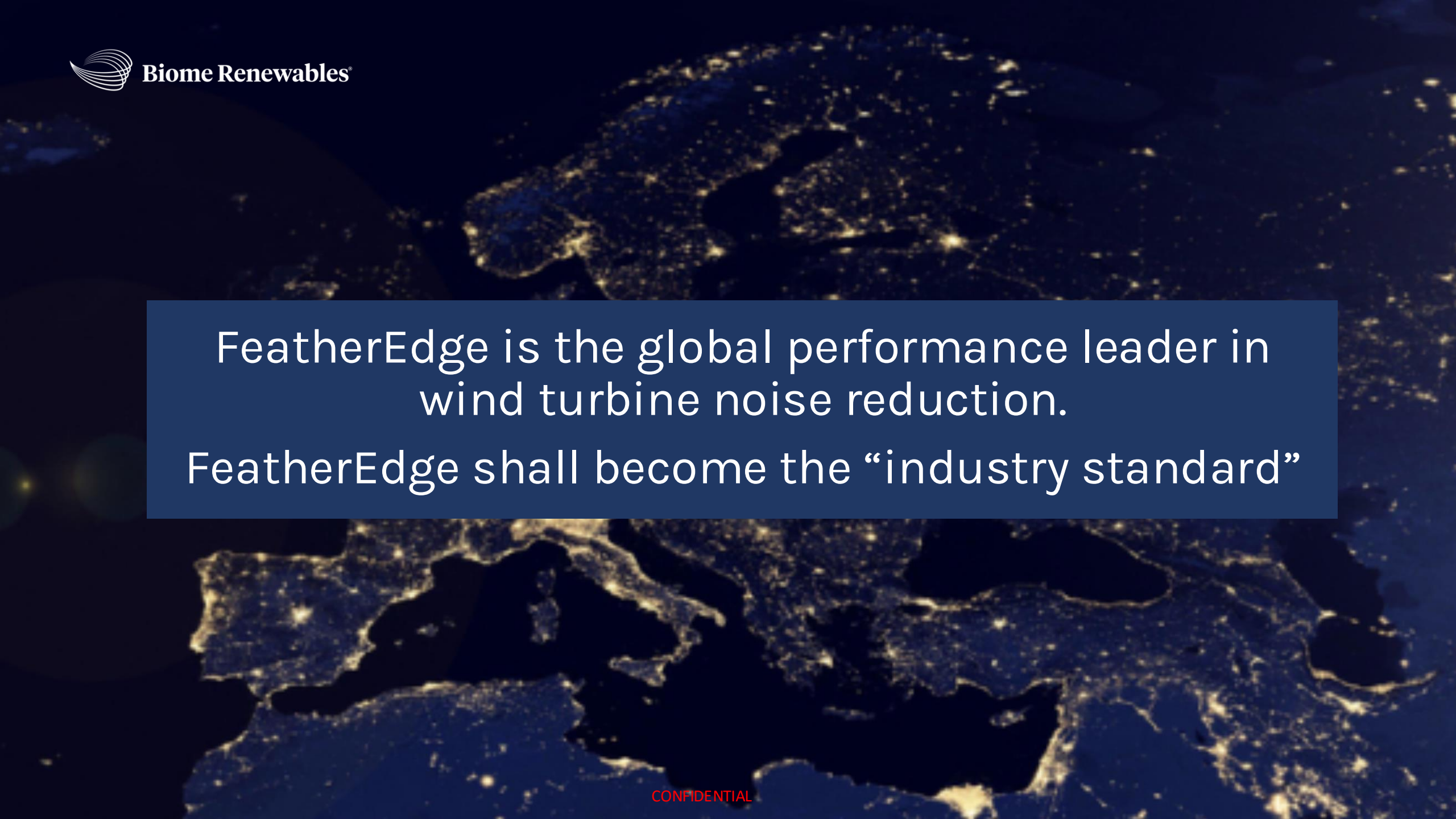
Michael Bernstein
Director

Dr. Ron Dembo
Director

Technical Advisory Group

Frank Virenfeldt Nielsen
Ex. CEO-Gurit / CTO-LM / Vestas

Andrew Garrad, CBE
Co-Founder (DNV)
Wind Energy Pioneer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FeatherEdge is the global performance leader in wind turbine noise reduction.
FeatherEdge shall become the “industry standard”
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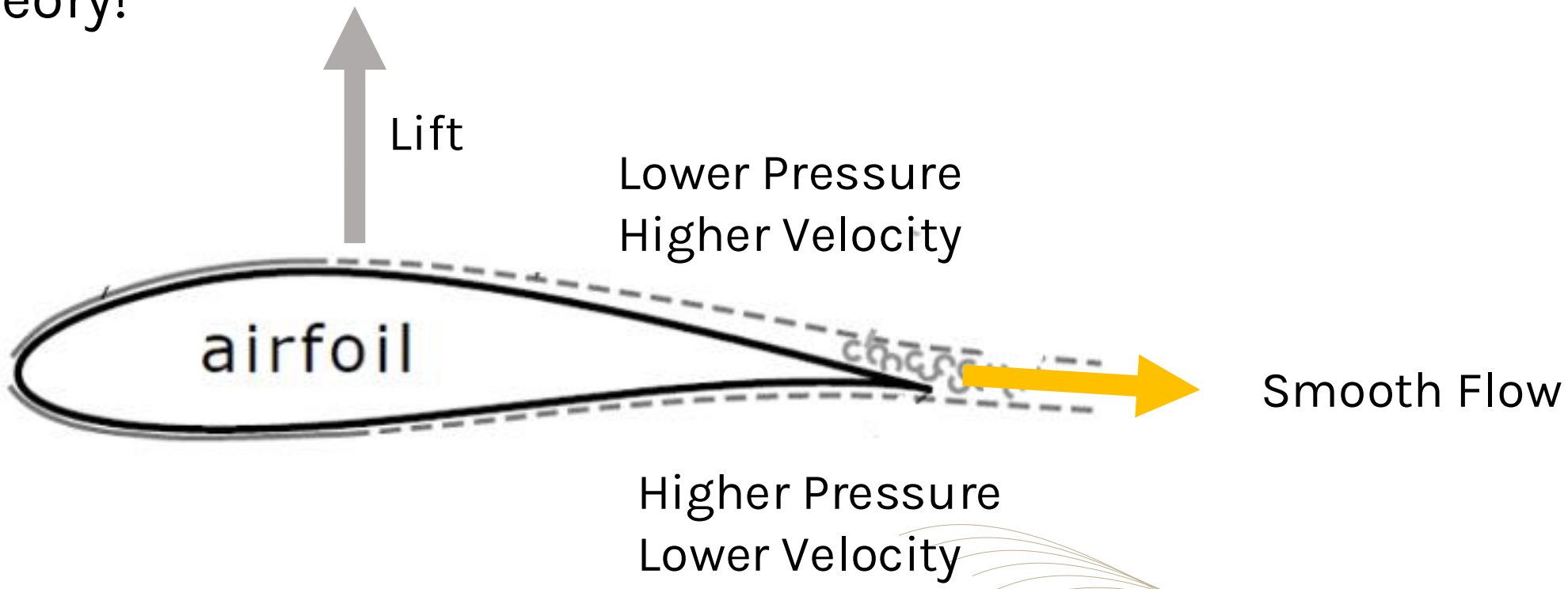
Air Flow on a Wind Turbine Rotor Blade

- In Theory!



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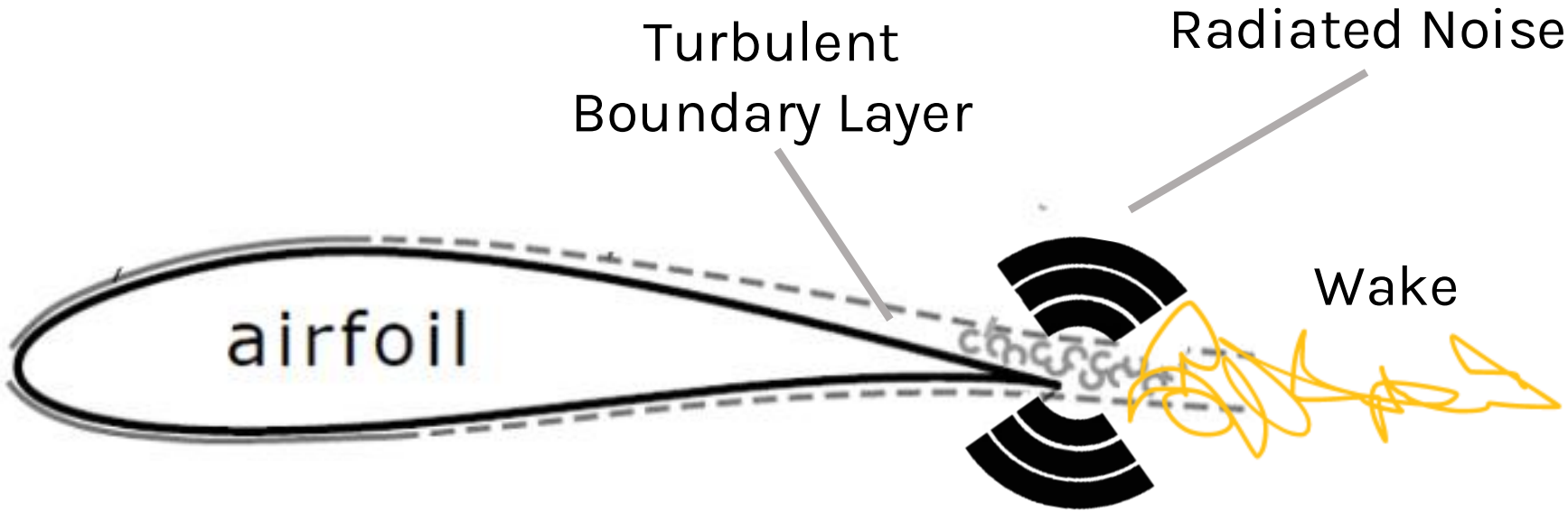
Air Flow on a Wind Turbine Rotor Blade

- In Reality!



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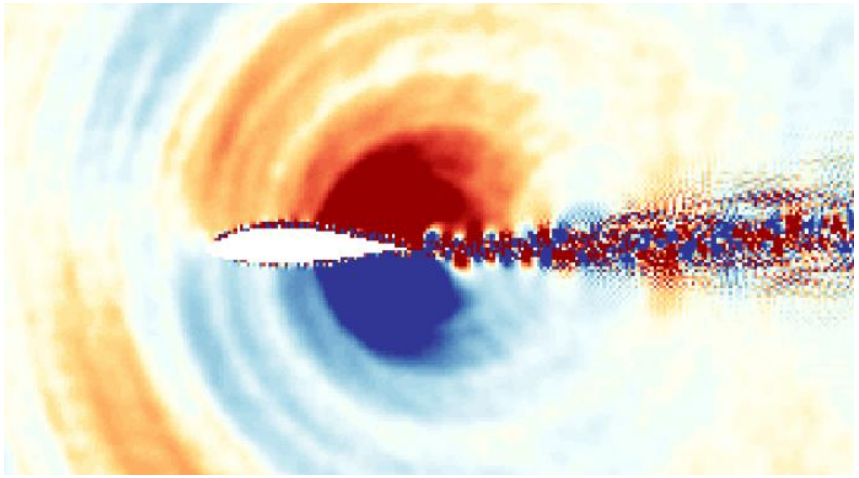
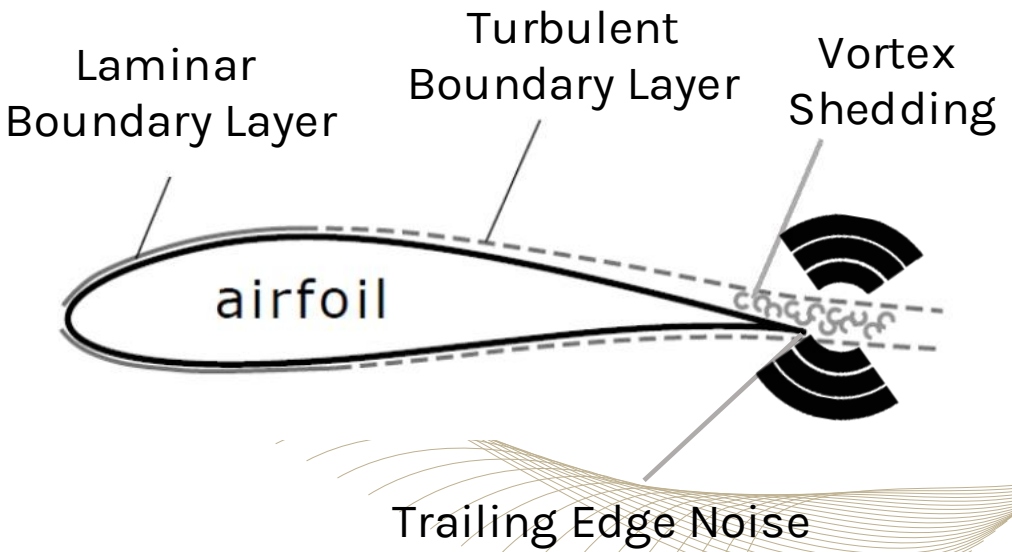
Air Flow on a Wind Turbine Rotor Blade

- Turbulent boundary layer trailing edge noise (TBL-TE noise) is the main source of the noise humans hear associated with wind turbines (the thump).
- As air passes over the leading edge around the profile, a turbulent boundary layer forms.
- When these two streams travelling at two different velocities meet, they interact and produce noise.





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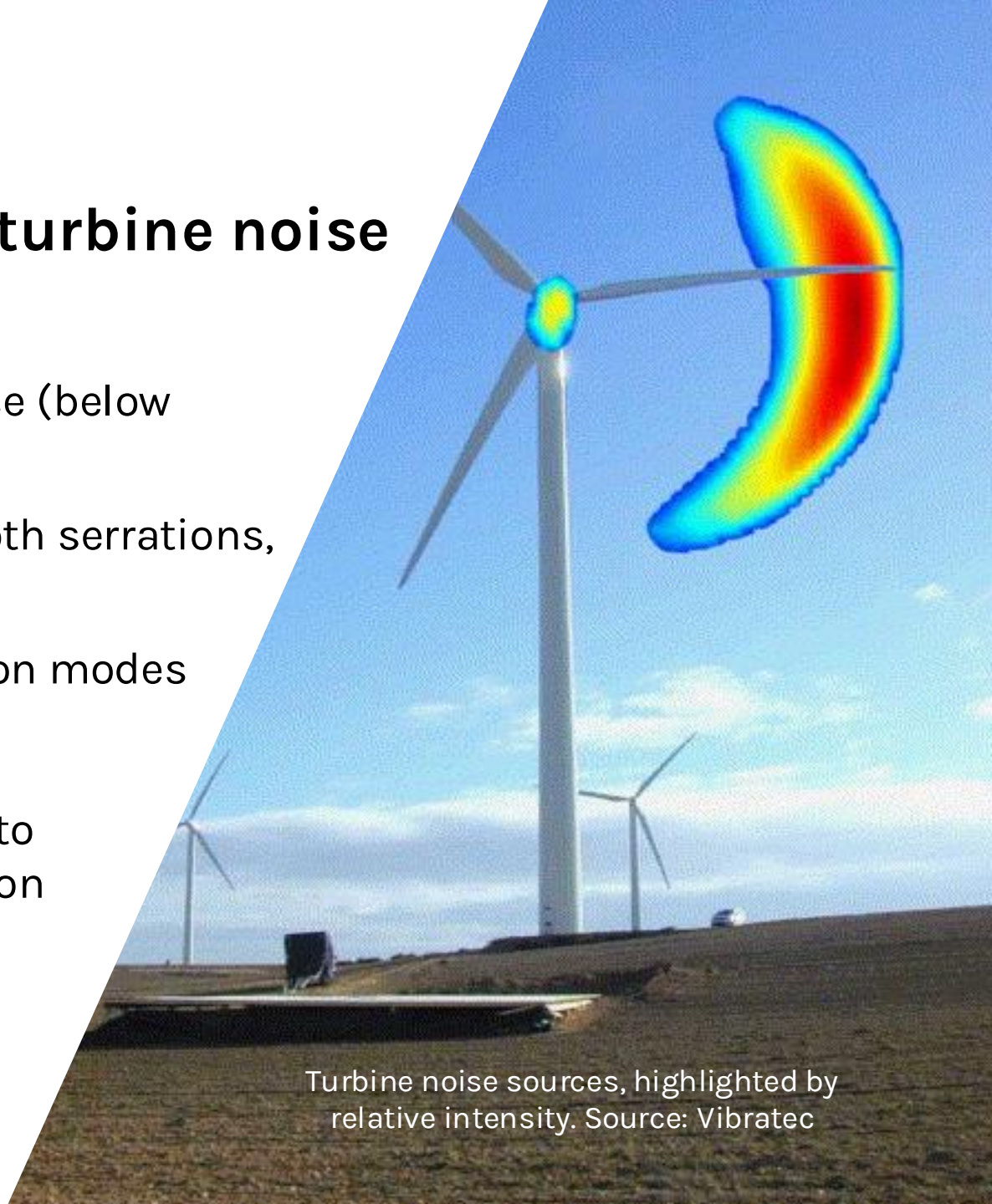
Blades are the dominant source of turbine noise

- “Thump” primarily caused by low frequency noise (below 1000Hz)
- Industry response for noise reduction is saw-tooth serrations, found on all new onshore turbines
- Still, many turbines must run in “noise” reduction modes
- 2-5% production loss per 1dB noise reduction
- Losses due to curtailment can be >25% AEP due to daytime and even lower nighttime noise reduction



Turbine noise sources, highlighted by relative intensity. Source: Vibratec

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FeatherEdge delivers 2-3 dB additional Reduction

- Biome's novel **FeatherEdge®** technology utilizes destructive interference to reduce sound, an industry-first!
- Additional 2-3 dB(A) reduction compared to standard sawtooth serrations.
- Low frequencies are specifically targeted, increasing the reduction to 3-6 dB(A) at a receptor point.
- Superior results proven by measurements in IEC & Receptor Testing.

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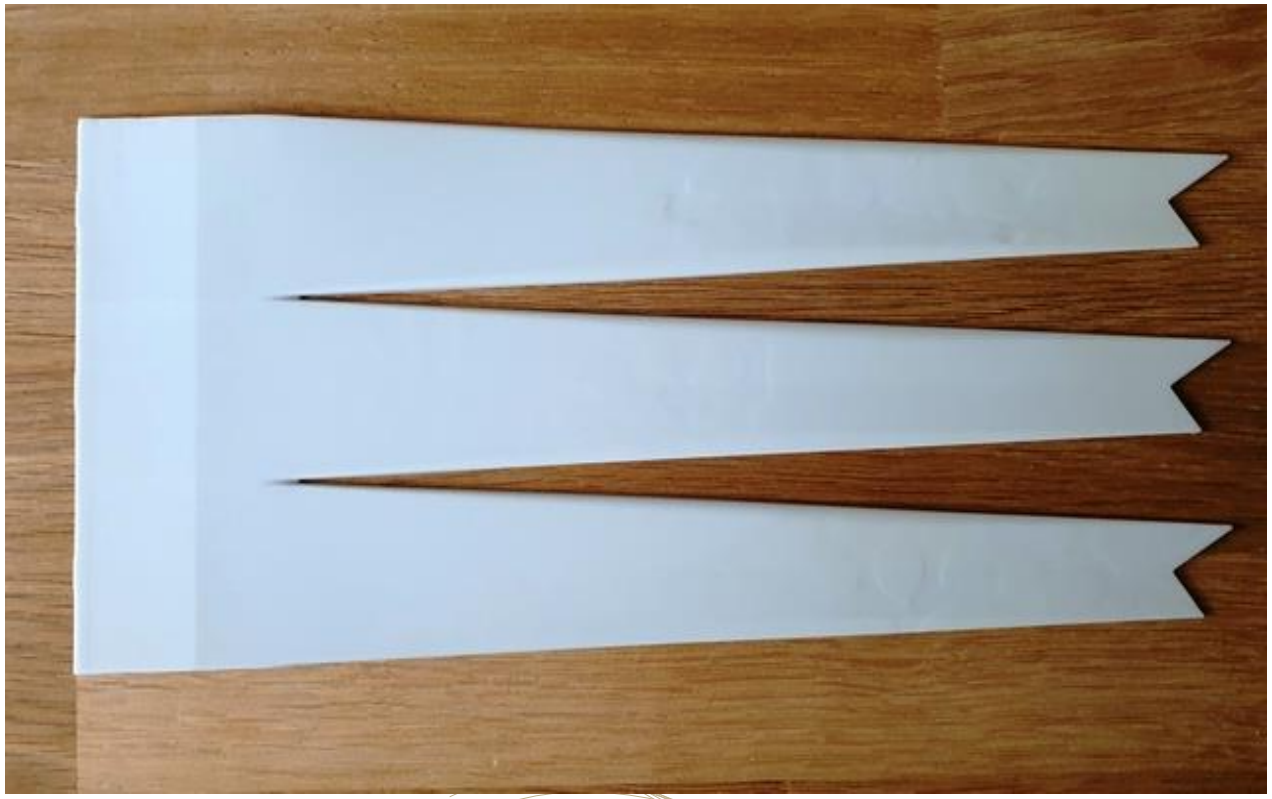
Standard Serration compared FeatherEdge®

Standard Saw-Tooth Serration



Short Section of FeatherEdge®

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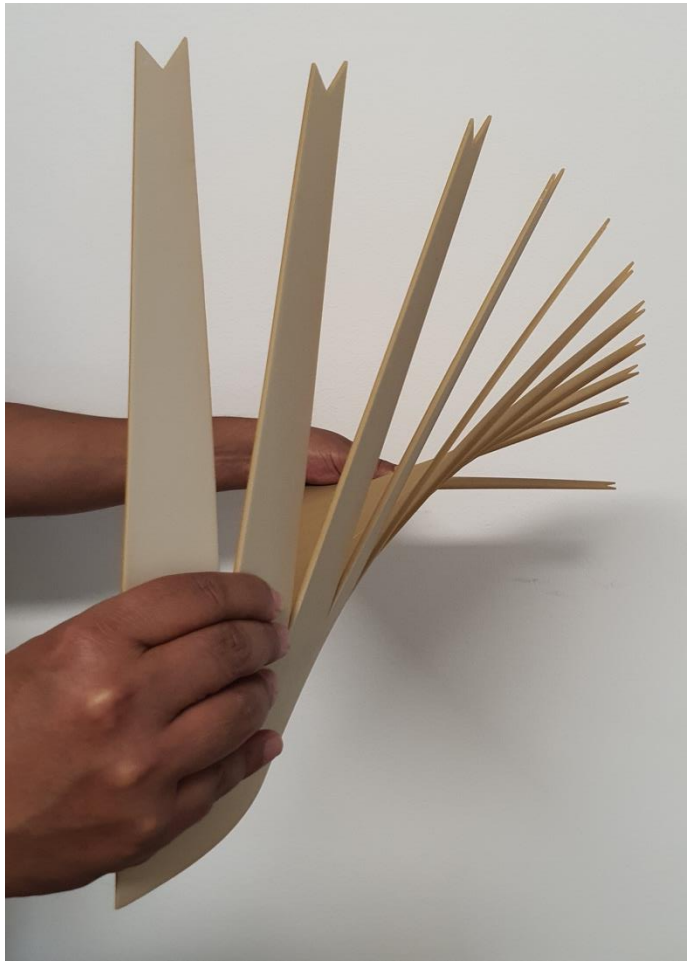
FeatherEdge® Serration System – What is different?



1. Flexibility – better adjustment to local air flow; low loads
2. Length – improved power production (3-6%)
3. Shape – noise cancelling effect
4. Increased blade specificity – greater variance in sizing
5. Durability – due to adhesive installation is final

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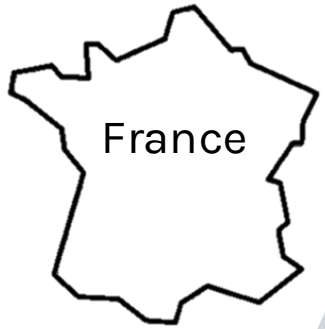
Industry Leading Noise Reduction



- First test of FeatherEdge® in summer 2023 on a 3.45 MW turbine in France
- OEM's standard serrations replaced by FeatherEdge
- IEC 61400-11 (ed. 3) noise measurements by Deutsche WindGuard GmbH
- Results show significant noise reductions:

Broadband (10Hz-10kHz)

@10m Height 7 m/s: reduction **3.4 dB(A)**

Medium-Low frequency (Below 1000Hz)

@10m Height 7 m/s: reduction **6.0 dB**

~50% reduction of original sound power level!

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Industry Leading Noise Reduction

- Subsequent test of FeatherEdge® in spring 2025 on a 5.56 MW turbine in Germany
- OEM's standard serrations replaced by FeatherEdge
- IEC 61400-11 (ed. 3) noise measurements by T&H GmbH
- Receptor Testing by deBAKOM GmbH
- Results again showed significant noise reductions:

IEC

Broadband (10Hz-10kHz)

@Hub Height 10 m/s: reduction **2.1 dB(A)**

Medium-Low frequency (Below 1000Hz)

@Hub Height 10 m/s: reduction **5.0 dB**

Receptor (5m) at 700m: 3-4dB reductions

Field Trials on a 5.56MW Turbine

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FeatherEdge® - a Decade of Development

- Idea born after watching a BBC documentary with David Attenborough on how owl's fly silently
- IP dating back more than a decade
- Technology has gone through multiple optimization loops
- Wind tunnel testing with multiple OEMs beginning 2022
- Acoustic testing with multiple OEMs beginning 2023
- The technology is fully commercial (TRL 9) in 2025; ENERCON partnership secured – more coming!

* Experiment! Wie kann eine Eule so leise fliegen? | Super Powered Owls | BBC

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Certification of FeatherEdge®

- The Feather Edge serration system has received a Design Evaluation Conformity Statement No. IECRE.WE.CS.24.0338-R0 (Evaluation Report ER-8121914798-003-001-00, dated 2024-12-16) from TÜV Nord
- Based on IECRE OD-501
- For serration & glueing system
- Temperature range -40°C to +50°C
- Design loads:

The serrations withstand the operation on rotors with tip speeds of 100 m/s, deriving from load case DLC6.3 and gust speed of 50 m/s in wind class 1A conditions for 30 years

IECRE Design Evaluation Conformity Statement
Wind Turbine Component - OD-501-T04
TÜV NORD CERT GmbH
™

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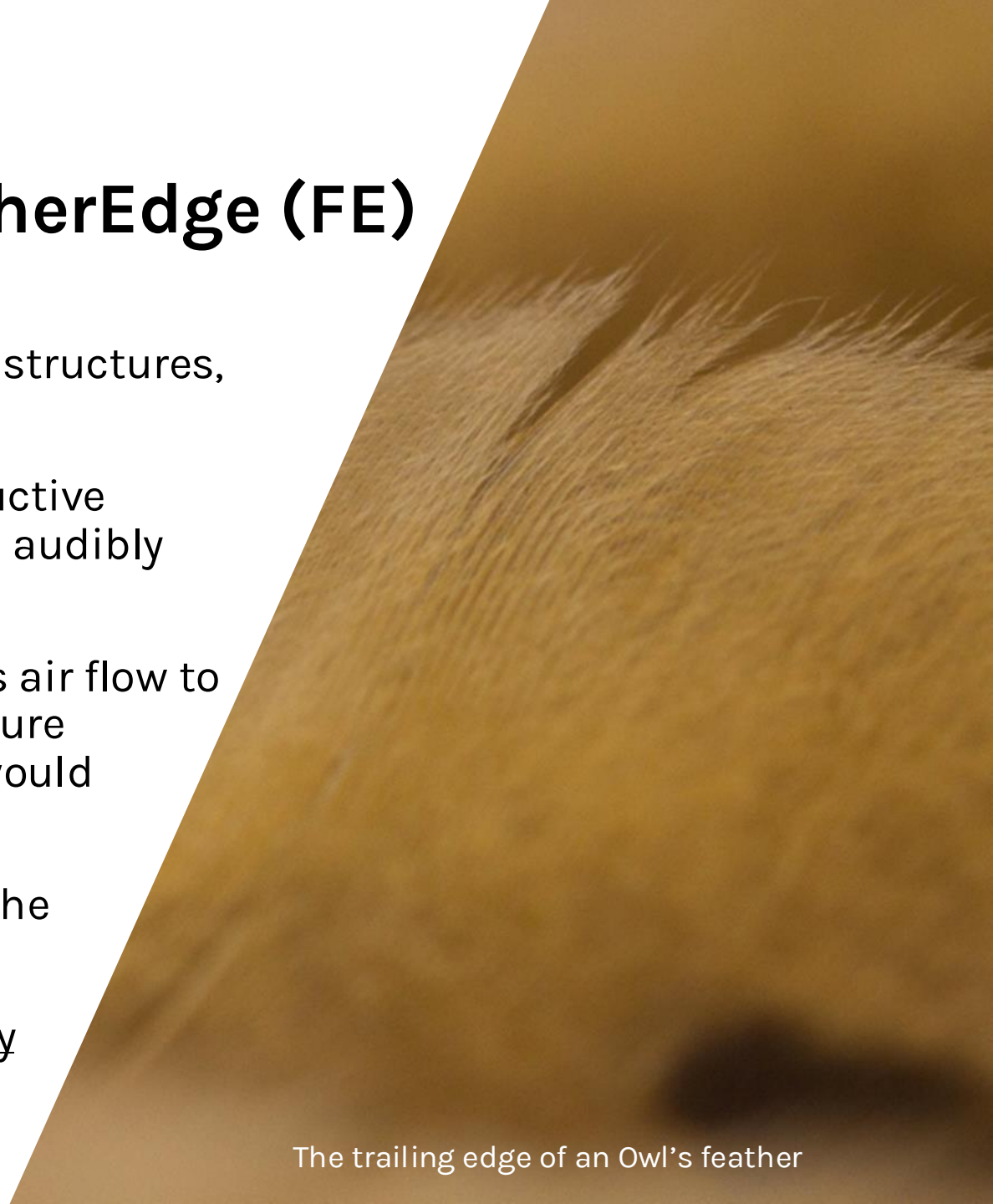
Biomimetic Advantage of FeatherEdge (FE)

- Trailing edges of owl feathers are highly evolved structures, organizing airflow & limiting sound dissipation
- Inspired by this, FE utilizes the physics of destructive interference, knocking out sound waves that are audibly noticeable
- Double-tip trailing edge of FE specifically directs air flow to mix at discrete locations, guiding how the pressure equalizes & reducing turbulence & noise that would otherwise form
- Mechanism not yet used on other serrations in the wind industry
- FE flexibility, shape & function patented globally



The trailing edge of an Owl's feather

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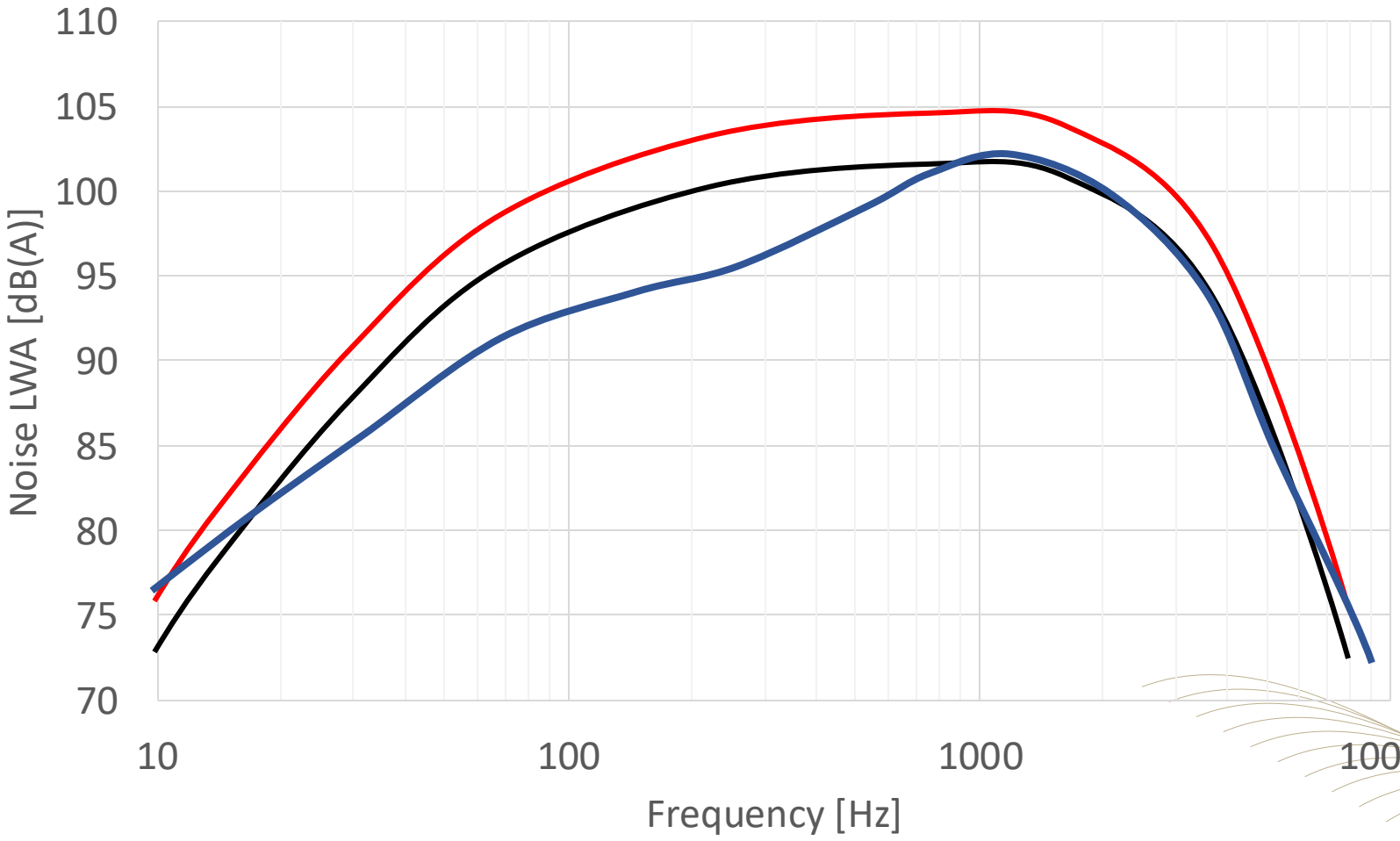
FeatherEdge vs. Sawtooth Serration - Noise Reduction



Turbine Noise Spectrum:

Turbine without serrations

Turbine with sawtooth serrations

Turbine with FeatherEdge®

Human Hearing Range:
16 – 20,000 Hz
Critical Turbine noise travelling long distance:
< 1,000 Hz

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A Game Changer in Onshore Wind

- FeatherEdge uniquely reduces low-frequency noise like no other serration system
- Low-frequency noise is the critical part of the spectrum, being audible at distant locations
- FeatherEdge® allows for turbines to be placed 500-800m closer to receptors* at same noise level, which equates to up to 20% more turbines in the same available wind farm area, considering wake.

OEM Sawtooth **-1.5dB** → **-0.1-2.8dB**

FeatherEdge® **-3.6dB** (Delta -2.1dB) → **-5.5dB** (Delta -4dB)

ENERCON E-160 EP5 E3

(IEC measurement) ~250m

(House/receptor) 700m

*Minimum set-back distances to receptors still apply during the development phase and vary by geography.

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FeatherEdge® Power Boost

- Available for any rotor blade worldwide, the geometry and passive-adaptive functionality deliver improved blade aerodynamics in the outer 1/3 of your blade – which is where 80% of your power comes from.

- FeatherEdge shifts your power curve to the left in the partial-load regime, enabling any wind turbine to unlock these gains.

- Independent Expert's Opinion from TÜV SÜD to IEC 61400-12-1 and -2 have demonstrated AEP uplift:

  - Senvion MM92: **6.15% AEP** ↑
  - Enercon E-160 EP5 E3: **3.41% AEP** ↑

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FeatherEdge® Power - Offshore

- Serrations are used today in offshore wind to enhance the aerodynamics and reduce blade tip velocity, thus reducing leading edge erosion.

1.5% ↓ Wake

DEUTSCHE WINDGUARD

- Through detailed aero-elastic simulations, advanced control optimization settings can be determined to unlock the full aerodynamic benefits of FeatherEdge® for different turbine platforms and enhance the power optimization market.
- Wind tunnel validation has proven FeatherEdge's® superior aerodynamics showing wake benefits that could greatly benefit the entire industry.
- Biome is currently engaged with OEMs in this effort.

SGRE's 14-236 DD turbine with SGRE-Dinotail off to RWE's Kaskasi offshore wind farm in Germany (2023)

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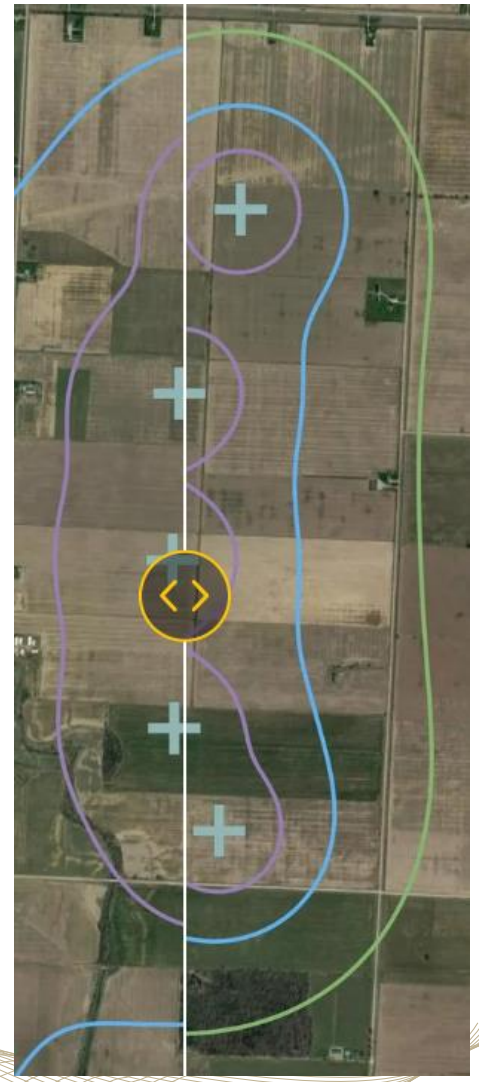
Use Cases for FeatherEdge - Developers

- Critical wind farm neighbourhoods: noise reduction
- Utilisation of better operating modes where noise related day&/nighttime reductions apply = more AEP (2-5% per dB improvement)
- Creating noise budge in existing wind farms for new turbines (existing infrastructure, permits, rights)
- More turbines in new wind farms due to lower sound power level
- All sites: harvest general AEP Effect (ca. 3-6%, depending on turbine and site conditions)



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Use Cases for FeatherEdge - OEMs

- More competitive turbine with higher AEP & reduced noise -> optimized noise modes
- Trend of larger rotors is driving higher noise emissions -> Better economics and value
- Higher tip speeds are possible while keeping the same noise level
- Variable spot pricing means higher tariffs in low wind, where these larger rotors are being sited
- Passive-adaptive functionality means load impact is marginal, & can be integrated into existing blade designs, or optimize new blade designs.

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Potential of FeatherEdge – Case Study Noise & AEP

Enercon E-160 E3 5.56MW in Germany with original serrations:

Annual energy production (AEP) 16.3 Mio kWh @ 7.3m/s average wind, 106.8 dB(A) sound power level

Daytime (6:00 – 22:00):	Mode 0s (106.8 dB(A), no reductions)	@ 11.0 Mio kWh/a
Nighttime (22:00 – 6:00):	Mode IVs (103.7 dB(A), 40dBA @receptor)	@ 5.3 Mio kWh/a

After **retrofit of FeatherEdge**:

Daytime (6:00 – 22:00):	Mode 0s (104.7 dB(A), no reductions)	
Nighttime (22:00 – 6:00):	Mode 0s (104.7 dB(A), **38dBA @ receptor**) -> **+12 % yield**	

New AEP: [(11 Mio kWh) + (12% x 5.3 Mio kWh)] x 1.0341* = 17.5 M kWh (+7.36%)

Proven AEP effect (TÜV Süd report) **+3.41% at 7.3m/s average annual wind speed*

Net 1.2 Mio kWh/a @ 0.85 EURO/kWh = Additional 102,000 Euro / a!

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FeatherEdge® – Stick to the Glue!

Why use structural MMA adhesive, if double sided tape is “cheaper”?

- ✓ FeatherEdge Serration & MMA designed for 30 years (no tape available on market with even just 20 years design life)
- Tape solutions has in some cases shown lower field reliability, leading to serrations falling off the blade
- Repair / renewal of taped serration is in total more expensive than glueing with MMA adhesive using the Biome system
- ✓ Glued serrations provide increased health & safety and improved sustainability

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FeatherEdge® - Uptower Installation Process (1/2)

1. Work requires a platform

2. Removal of paint / gel coat along trailing edge of last 1/3 of rotor blade (down to, but not into laminate)
3. Glueing FeatherEdge serrations elements with MMA, supported by Biome clamping system

FeatherEdge® - Uptower Installation Process (2/2)

4. Sealing the serration edges with Topcoat
5. No coating / painting of FeatherEdge serration necessary (UV impact is designed into the material)
6. 1 week work / turbine with good weather, 160m rotor, including removal of existing serrations

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Uptower Installation Process – Platform is Top!

Why use a platform, if a rope access is “cheaper”?

- ✓Increased work health & safety, no risk of rope stuck / damaging serrations
- ✓spare for clamps & plexus for FE installation
- ✓up to 4 persons (speed; rope only 2)
- ✓better quality of work results
- ✓ work at higher wind speeds than rope
- ✓ optional weather protection

Source Plattform Picture: ScottishPower Renewables Trials New Turbine Blade Access Platform | Scottish Construction News

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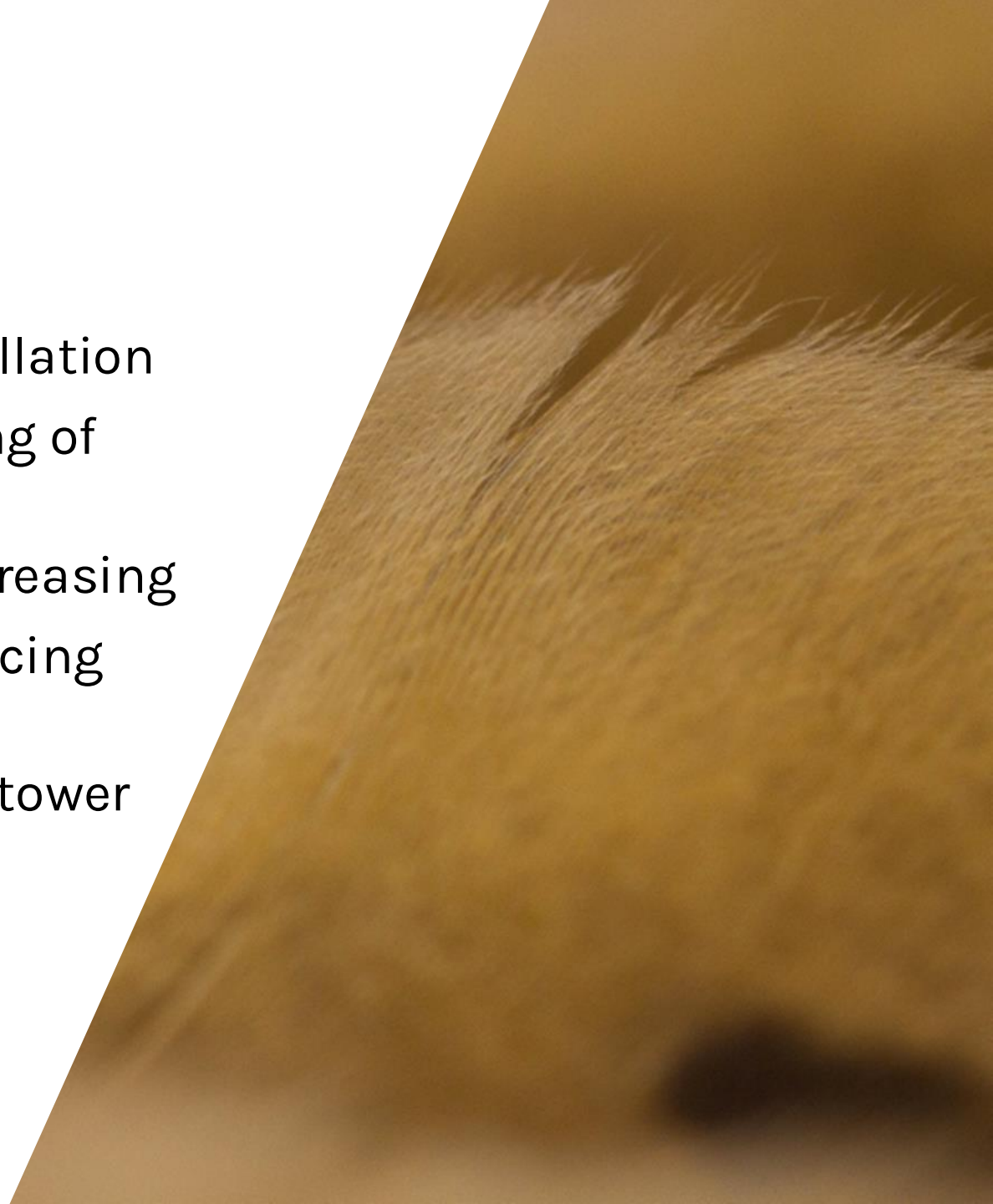
Availability of FeatherEdge

- Delivery available, with or without installation
- Lead time depends on quantity & timing of existing orders (3-6 months)
- Production capacity is permanently increasing
- Suitable for un-serrated blades or replacing standard serrations
- Installation in factory, on ground or up-tower (platform)



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FeatherEdge Order Process

1. Customer contacts Biome. Project data sheet is shared
2. Customer completes & returns project data sheet
3. Biome prepares & sends offer including blade specific FeatherEdge design
4. Customer accepts offer
5. Biome sends order confirmation & invoice for down payment
6. Production and delivery upon down payment

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Deliverables of Biome Renewables

1. Blade specific FeatherEdge design (number and type of FeatherEdge segments) – Blade Chord Data necessary
2. Production and delivery of FeatherEdge serrations
   a) 2 year defects notification period (negotiable)
   b) 1 spare of each serrations size included per turbine
   c) Shipping cost within Europe included / excluded as per offer
   d) Shipping cost outside Europe excluded / or ex-works pick-up by customer
3. Delivery of adhesive & topcoat
4. List of certified installers, installation instructions and Biome installation clamps (purchase or hire of clamps)
5. Unbeatable business case

Biome Renewables®

Thank You for your time!

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