EnergieKontor

since 1990

ROTOR BLADE EXTENSION

(RBE)

www.rotorbladeextension.com

Content

EnergieKontor
seit 1990

© Energiekontor AG

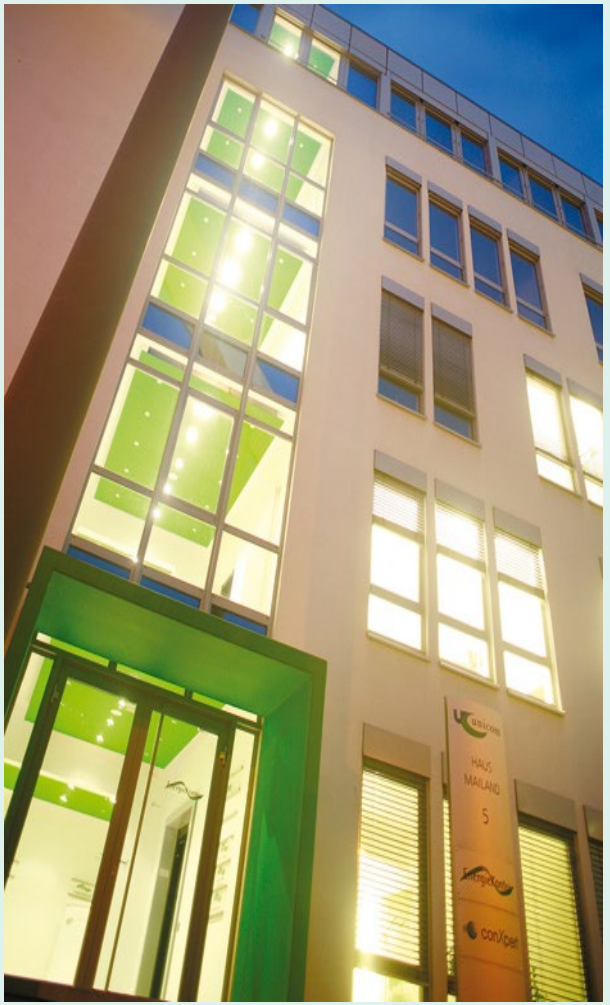
The Company

EnergieKontor
seit 1990

- Founded in 1990
- Headquarters Bremen (DE)
- Subsidiaries: Bremerhaven, Hagen, Bernau, Dortmund and Neubrandenburg - Germany;

  Leeds and Glasgow - United Kingdom

  Lisbon - Portugal
- Public since May 2000
- Business Areas:
  - Development of Onshore Wind and Solar Farms
  - Independent Power Producer
  - Operational Management – Renewable Assets
  - Optimisation of wind turbines



© Energiekontor AG

The RBE Concept

EnergieKontor
seit 1990

- Blade Tip Extensions
- Extends the length of your wind turbine blades
- Installed in days, with limited downtime
- Low effect on WTG lifecycle and components
- Instant Power increase at relative wind speeds
- Multi-agency collaboration led by Energiekontor

Power Curve:

$$\uparrow P = \rho \cdot \frac{v^3}{2} \cdot C_p \cdot A_{rotor} \uparrow$$

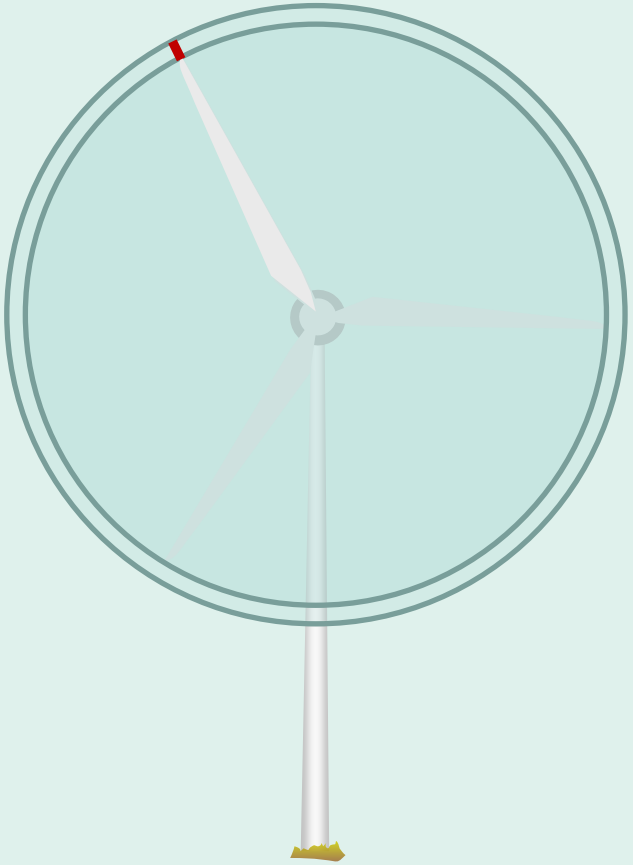
P: power

ρ: air density

V: wind speed

C_p: power coefficient

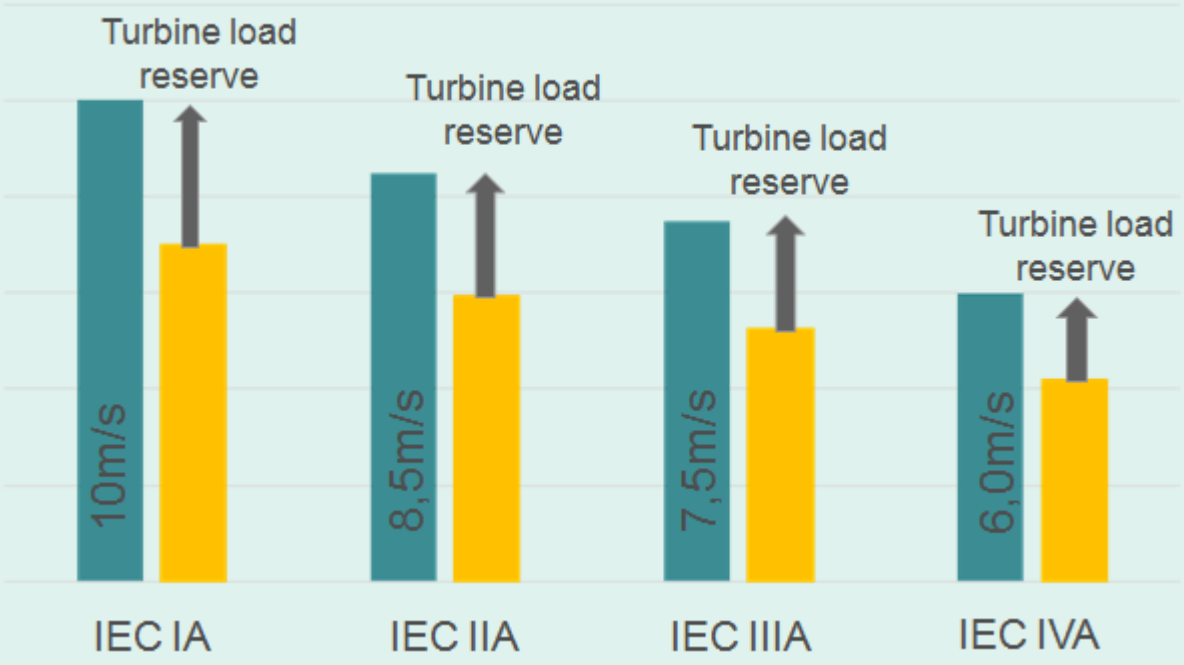
A_{rotor} : swept area of the turbine



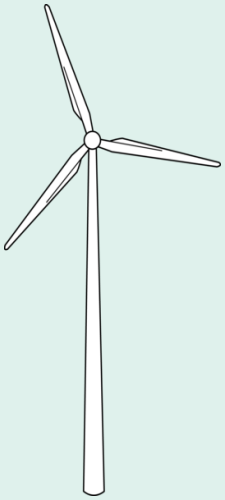
© Energiekontor AG

The Concept

EnergieKontor
seit 1990



If the IEC class of the turbine is higher than the IEC class of the site, a load reserve is present. This load reserve can be transformed into actual Power by installing the RBE product.



© Energiekontor AG

Existing Installed Applications

EnergieKontor
seit 1990

Currently Installed Products:

- **RBE Bonus 1.0MW**

RBE length	1m
Modified diameter	56m
Rotor area increase	7,6%
Add. Weight/blade	30kg

- **RBE Bonus 1.3MW**

RBE length	1,5m
Modified diameter	65m
Rotor area increase	8,6%
Add. Weight/blade	45Kg

Installation of these products:

On a hanging blade – 6 days per turbine

© Energiekontor AG

Rotor Blade Extension - Installed

EnergieKontor seit 1990

Debstedt WF - Germany:

- 11x AN Bonus 1.0MW
- WF in Operation since 1999
- **1 RBE installed in 2009**

Production Measurements:

- Original: December/2005 until October/2009
- Modified: November/2009 until current date
- **Annual Energy Production (AEP) increase of 7% (*)**

(*) results provided by Operations Department at Energiekontor

Penedo Ruivo WF - Portugal:

- 10 x AN Bonus 1.3MW
- In Operation since 2005
- **2 RBE installed in April/2014**

Production Measurements:

- Original: 2005 until March/2014
- Modified: April/2014 until current date
- **Annual Energy Production (AEP) increase of 5-8% (**)**

(**) results provided by INEGI – Institute of Mechanical Engineering and Industrial Management, Portugal

© Energiekontor AG

Rotor Blade Extension - Installed

EnergieKontor
seit 1990

These Energiekontor wind farms have recently been upgraded with new RBE sets and are currently showing positive signs that the optimisation is successful.

Energiekontor is currently assessing the results and hope to publish some interim results soon.

Penedo Ruivo WF - Portugal:

- Installation of 10 RBE in AN Bonus 1.3 MW turbines – 2016 - 2019

Seixinhos WF - Portugal:

- Installation of 8 new RBE on AN Bonus 1.3 MW turbines – 2016 - 2019

Montemuro WF - Portugal:

- Installation of 8 RBE on AN Bonus 1.3 MW turbines – 2017 - 2019

© Energiekontor AG

Rotor Blade Extension – In Progress

EnergieKontor seit 1990

Senvion MM82 – RE40 Blades:

- Installation of specially designed RBE for the MM82 with RE40 blades
- 2 UK wind farms owned and operated by Energiekontor
- Project is at advanced stage of engineering design
- Planned installation dates – 2 WTGs in May 2021, followed by 19 more WTGs in 2022
- Estimated AEP increase at these wind farms is approximately 8%
- Exciting times at Energiekontor

GE 1.5sl - LM37.7 Blades:

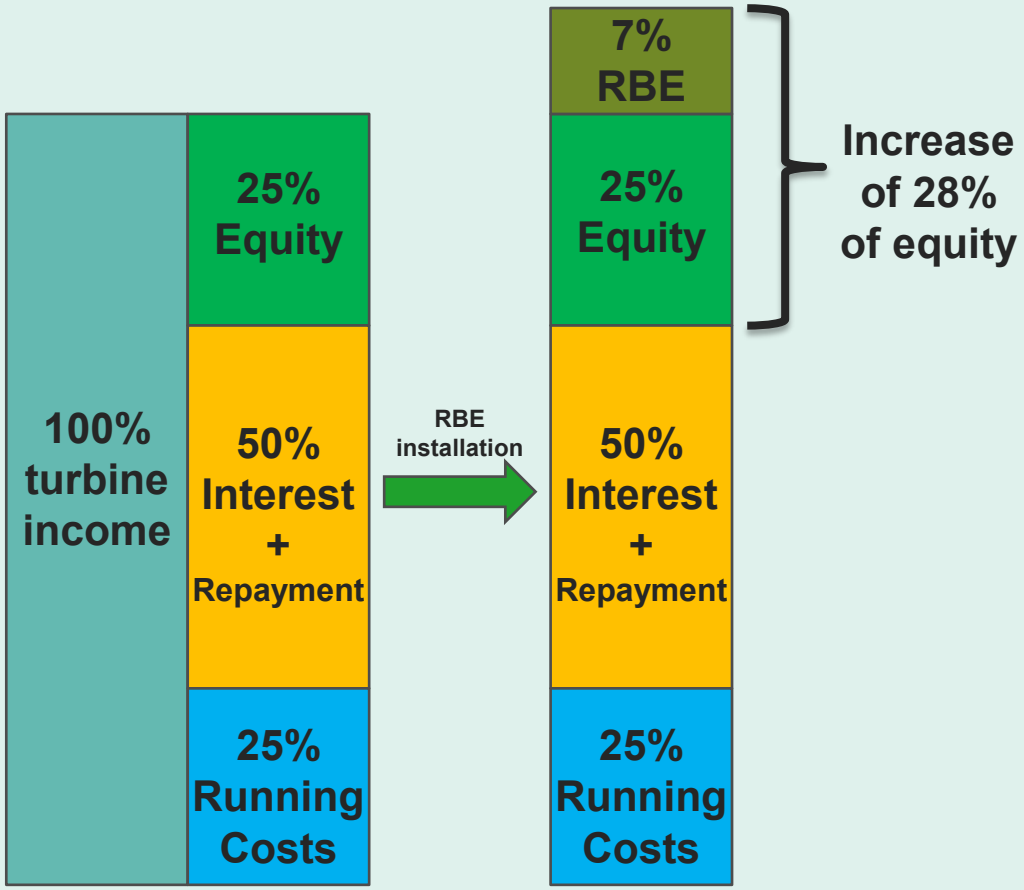
Currently working on the early stage development of new RBEs for this type **to achieve up to 9% of AEP increase**.

© Energiekontor AG

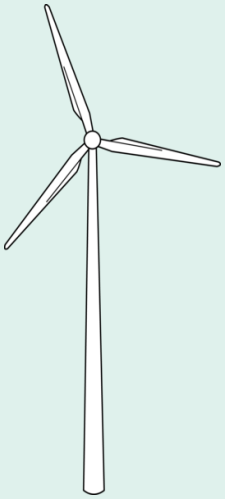
The Concept – Economic approach

EnergieKontor
seit 1990

Example for AN BONUS 1.0MW



An increase of 7% of the total obtained power from the turbine reflects in a gain of almost 30% on the income of the company for each turbine.



© Energiekontor AG

Technical Impact Analysis

EnergieKontor
seit 1990

Loads, Structure

- Cut-Off-Wind speed adapted to limit maximum loads
- Edgewise and flap wise bending remains within tolerances

Sound

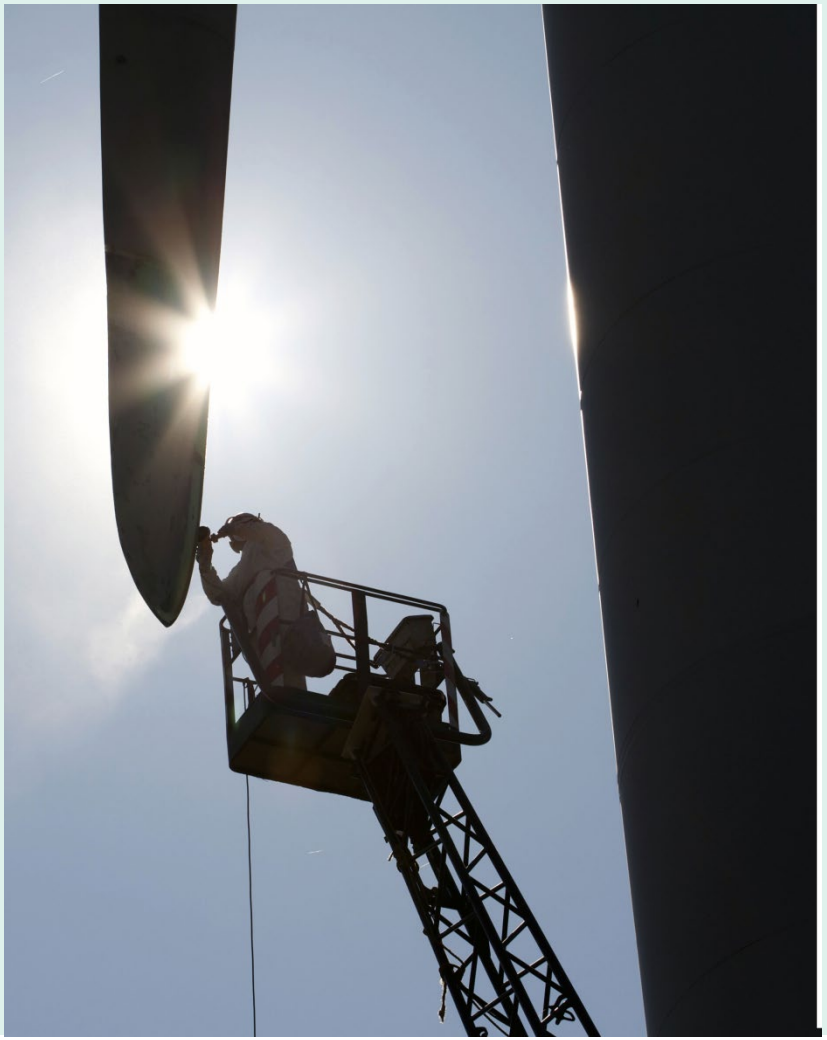
- Sound level has no significant increase

Fatigue Loads

- Approx. 25% **LESS** load cycle
- No change to initially calculated WTG lifetime or ability to extend

Certified by DEWI-OCC

Patented by Energiekontor



© Energiekontor AG

Machine and Blade Surveys

EnergieKontor
seit 1990

Technical Surveys of Prototype

Surveyed 3 years after installation by independent auditors

Scope of Surveys

- Endoscopic inspection of gear box
- Vibration analysis of complete drive train
- Visual check of main bearing
- Rotor blade and machinery visual check
- Multiple WTG minor components

Report Conclusions

“Normal and no unusual wear on all inspected components”

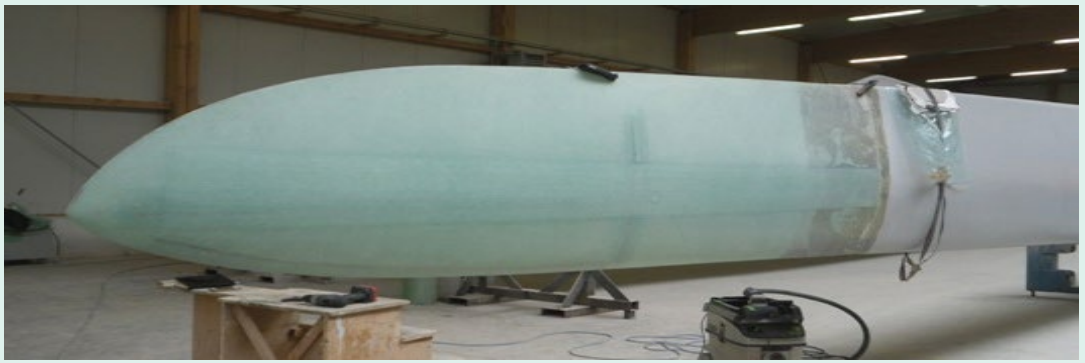
“Low additional maintenance”

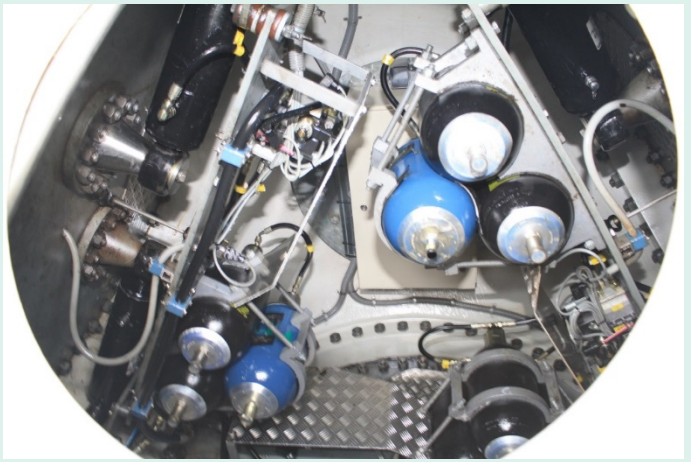
© Energiekontor AG

Tests performed

EnergieKontor seit 1990

- Load measurements on blade's roots and main shaft, according IEC 61400-13.
- Gear box and main bearing analysis.
- Natural frequency of the blade measurement.
- Distance from the modified tip blade to the tower.





© Energiekontor AG

Conclusion

EnergieKontor
seit 1990

- Available now for 1.3 MW
- Safe operation due to reduced cut-out limit
- No additional noise impact
- Simplified installation process
- Significantly improved performance

- Close to no production losses due to short installation time
- Short return on investment period (~3 years)
- No influence on WTG safety aspects
- Further RBE prototypes (other types of turbines) in development for 9% AEP increase – MM82/RE40 and GE1.5sl/LM37.7

© Energiekontor AG

CONTACT US

energiekontor@rotorbladeextension.com

www.rotorbladeextension.com

www.energiekontor.de

© Energiekontor AG