

A photograph of an offshore wind farm with several wind turbines in a row across a blue sea under a clear sky. The water in the foreground shows white foam from a boat's wake.

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# Past and Future Wind Turbine Technology

Søren O. Lind, 26.08.10

## **Background**

- The technical development up to now

## **Future turbine designs**

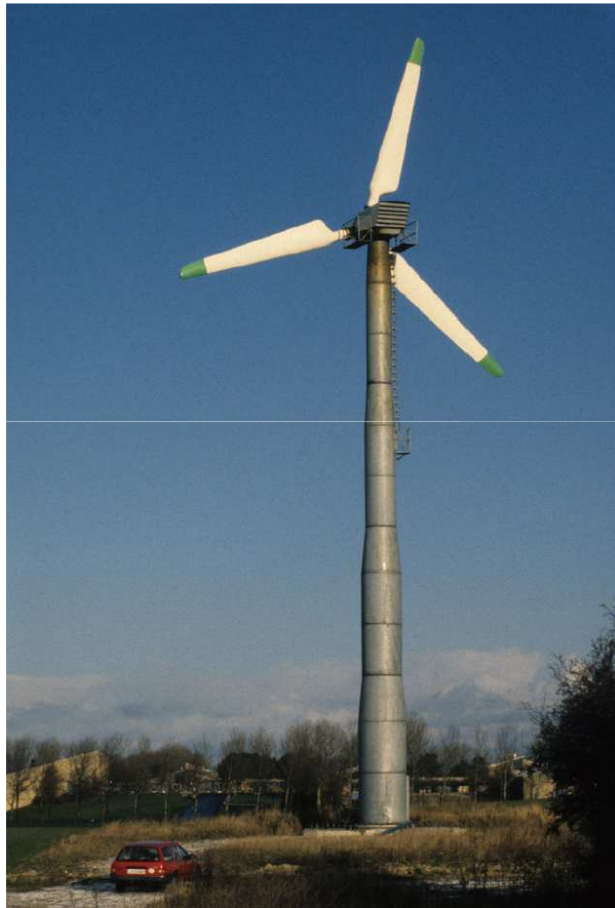
- Giving a guess on a 2020 turbine

## **Siemens DD technology**

- Development steps and the end result

**We have come a long way...**

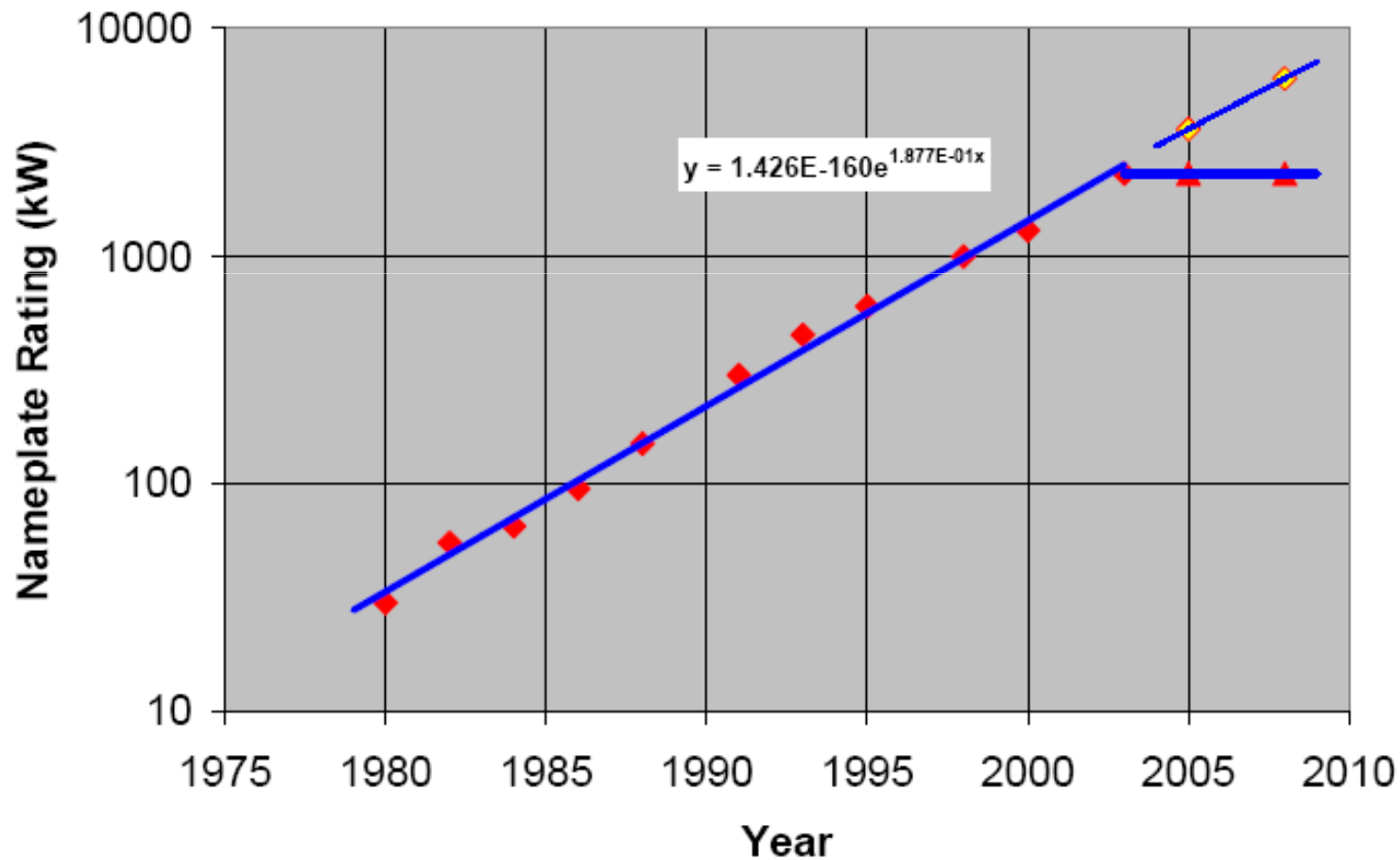
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The turbine size has grown dramatically over the years but has now reached plateau

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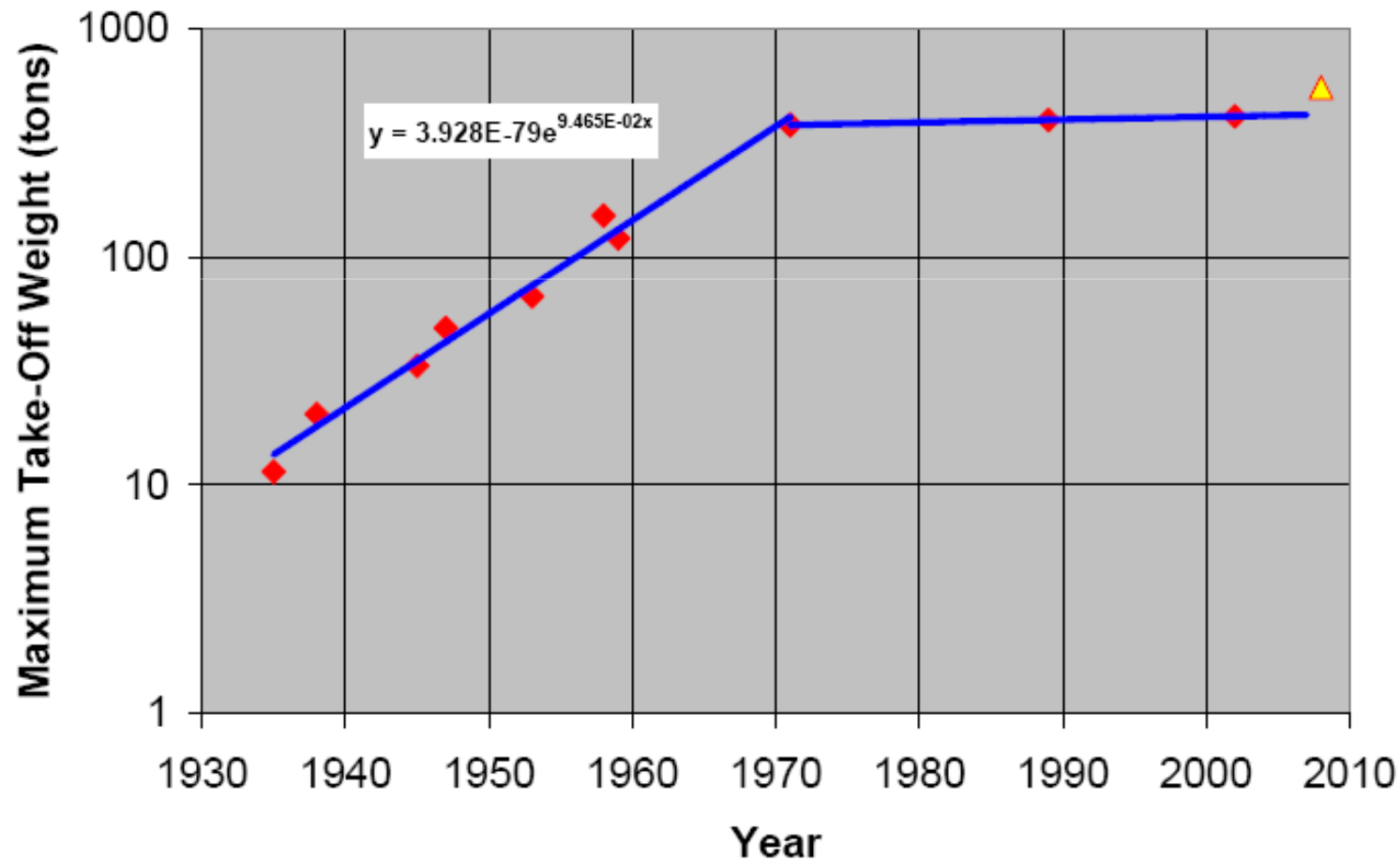
SWP WTG Growth



Same trend is known from other technologies

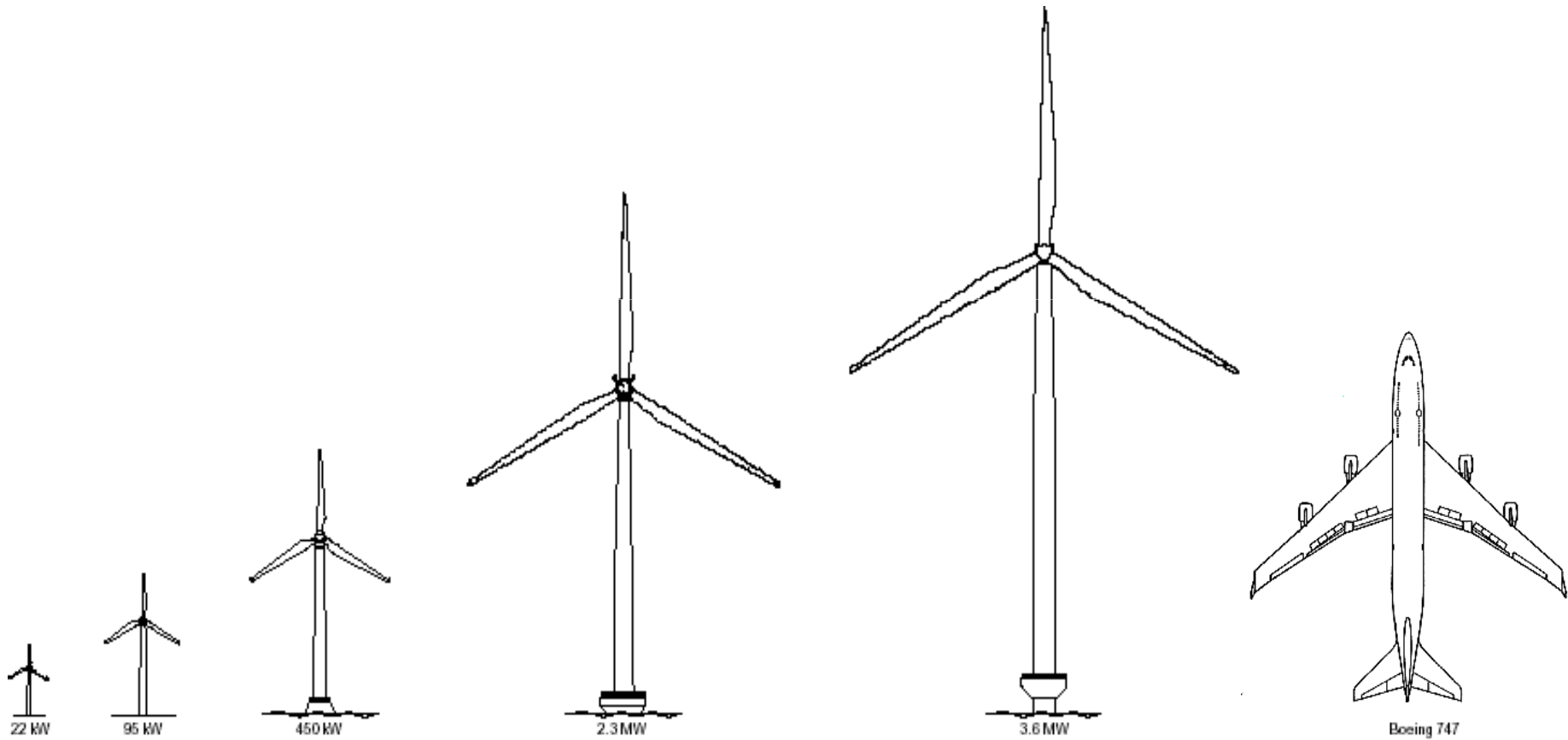
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Commercial Aircraft MTOW Growth



# Wind turbines and aircraft are in same range regarding dimensions...

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## ...But quite different in other respects!

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### Overall price

- Aircraft: Typically >\$1000 per kg
- Wind turbine: Typically <\$10 per kg

### Wing / Blade price

- Aircraft: Typically >\$1500 per kg
- Wind turbine: Typically <\$15 per kg

### Fatigue load cycles

- Aircraft: Typically <50.000 large cycles
- Wind turbine: Typically >100.000.000 large cycles

### Maintenance

- Aircraft: Daily inspection, weekly maintenance
- Wind turbine: Bi-annual inspection, annual maintenance

# Technology development - Key industry-wide factors since 2000

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## **New Grid Requirements**

- From “Let the system operator manage faults – you just get off!”
- To “You need to assist in stabilizing – stay on no matter what!”

## **Variable Speed Dominance**

- From Majority of turbines constant-speed, directly connected
- To All now have variable speed with different converter systems

## **Aerodynamic Improvements**

- From Relatively content – now it would not get much better
- To Surprisingly large improvement potentials still up for grabs

## **Rotor Loading**

- From Roughly 400 W per sq.m swept area
- To Many mainstream products in 300 W per sq.m range

## **Industrialisation of Offshore Wind power**

- From Pilot projects totalling 10 MW installed capacity in real offshore
- To Major industry, >1000 MW and growing every day

# Technology development – the 2020 turbine is likely to have:

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## Same overall topology as now

- Three blades, upwind rotor

## Simple rotor

- Robust blades with minimal joints
- Possibly active load control on blades (non-electrical)
- Simplified pitch system

## Simple drive train

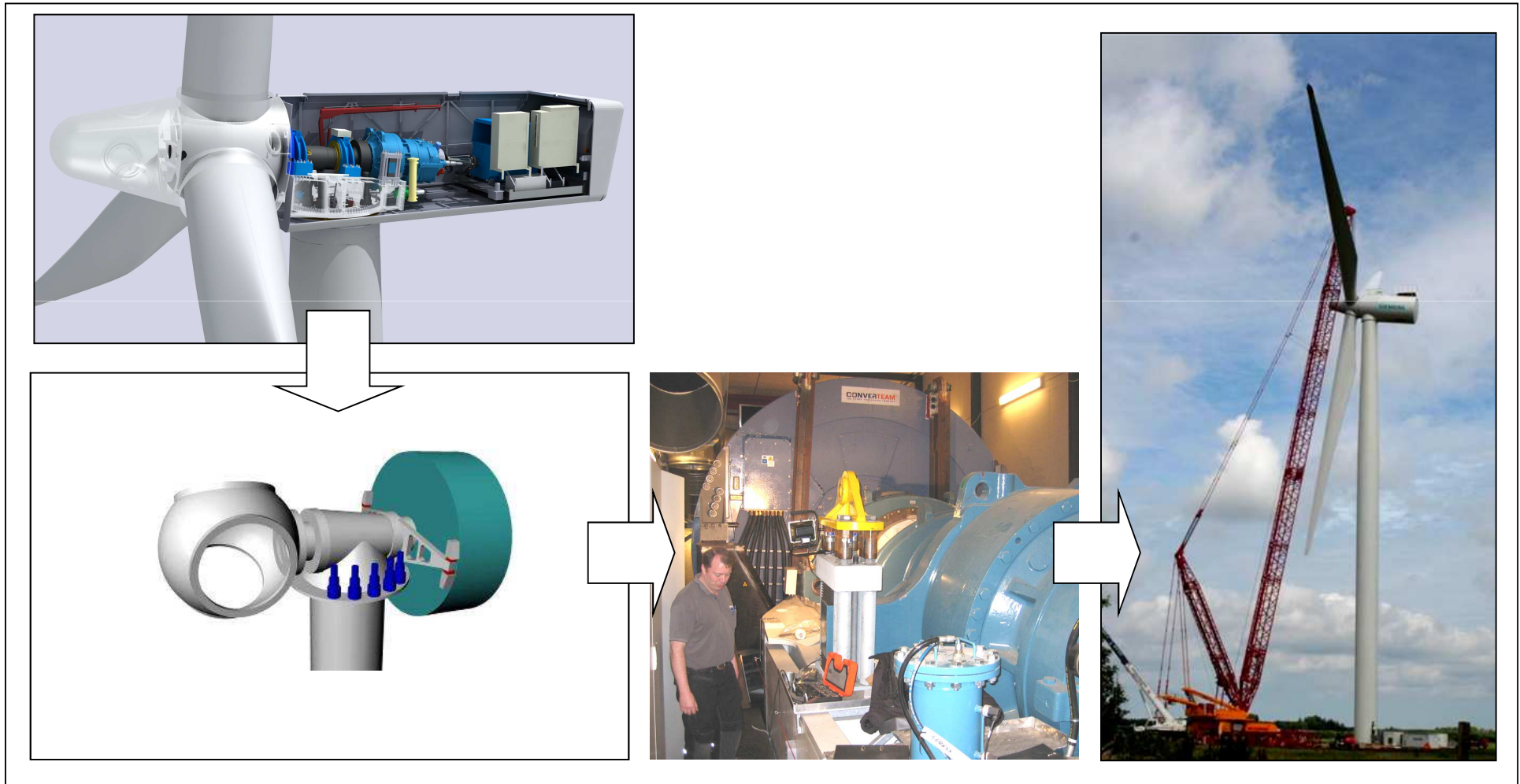
- **Direct Drive**
- Possibly sliding bearings

## Power conversion and control

- Turbine power converter
- Potentially direct HV DC from turbine
- Elements of grid requirements managed centrally

# First step. Two 3.6-107 DD “Proof of Concept” turbines installed in 2008

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## Next step. Turning it into a commercial product in 2010.

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### The new, The SWT-3.0-101

- Direct Drive technology – no gearbox
- Innovative generator topology with outer rotor leading to compact and lightweight nacelle – diameter 4.2 m, weight 73 t
- Maximum efficiency due to permanent magnet excitation, minimum losses in drive train, and passive cooling system
- Simplified design with 50% less parts than in equivalent geared design
- Has outside dimensions permitting transportation using normal trailers





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**Thank you for your attention!**