

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

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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

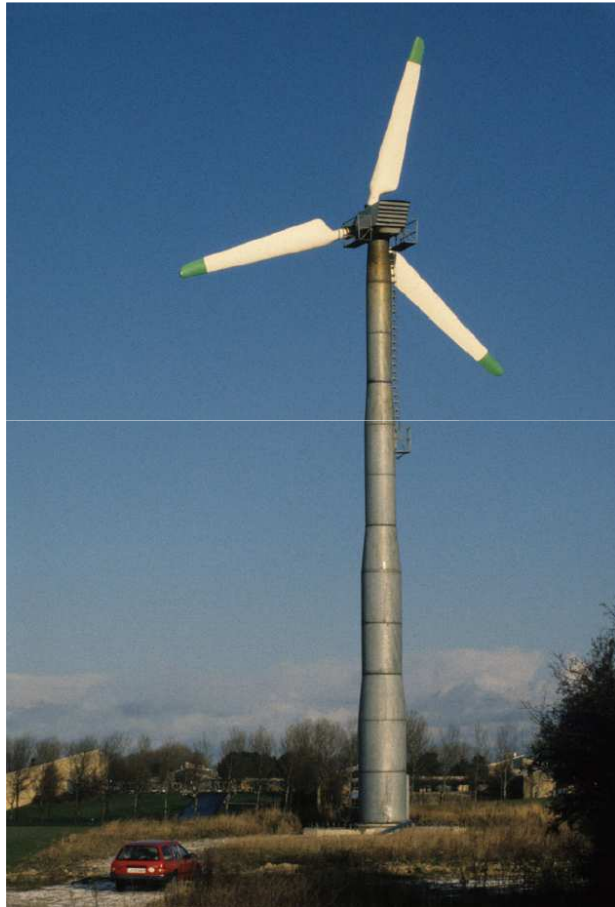
- Giving a guess on a 2020 turbine

Siemens DD technology

- Development steps and the end result

We have come a long way...

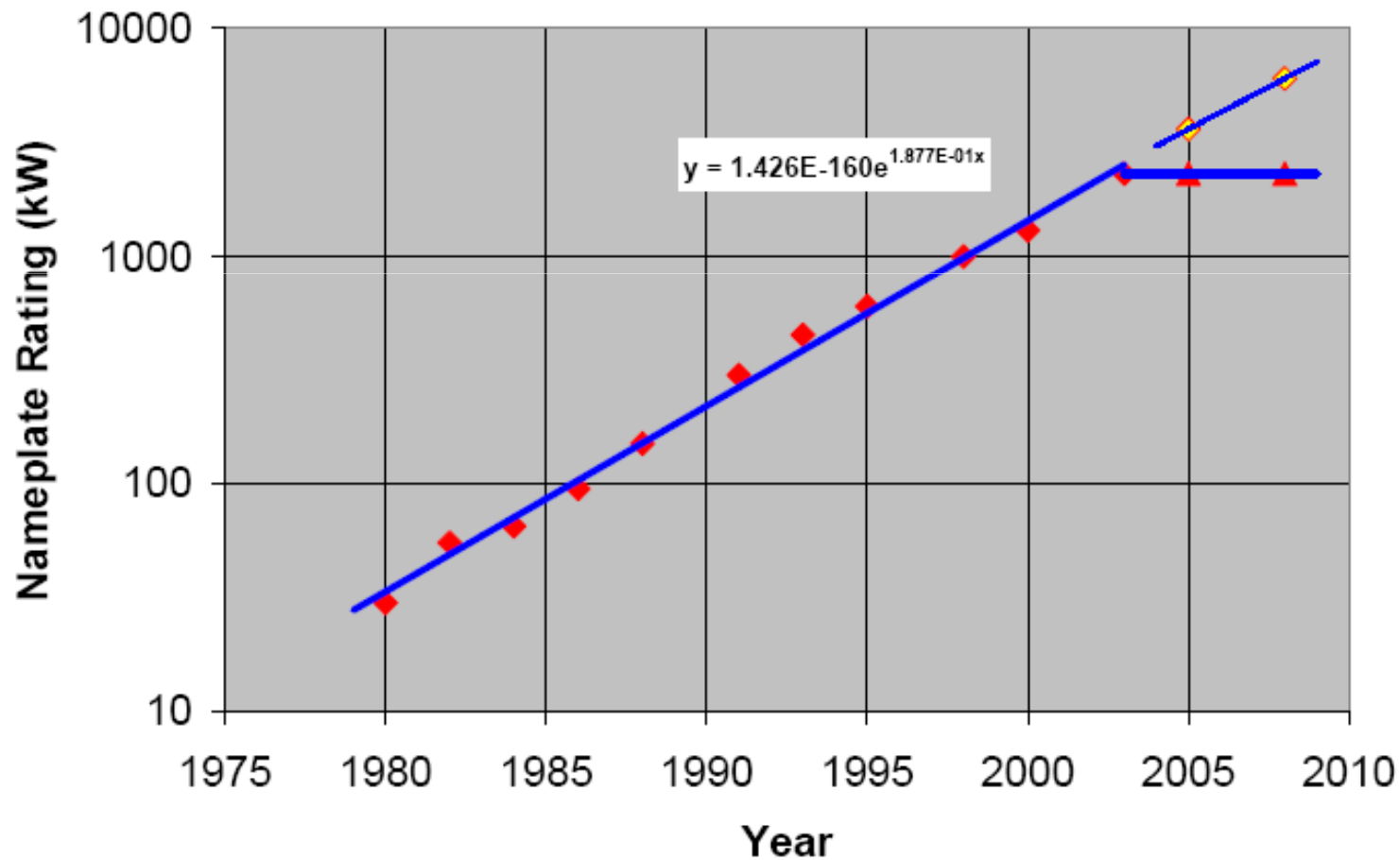
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The turbine size has grown dramatically over the years but has now reached plateau

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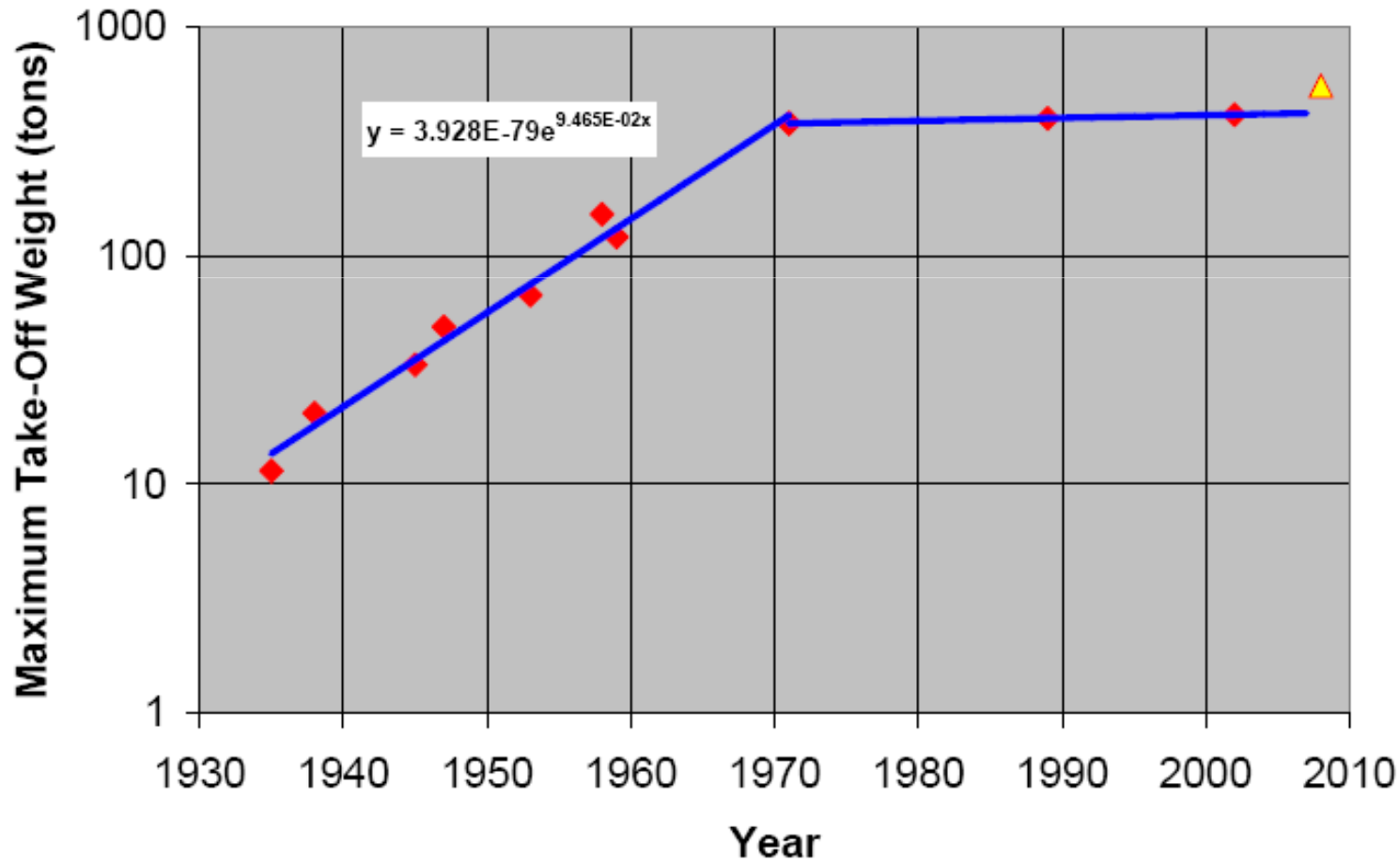
SWP WTG Growth



Same trend is known from other technologies

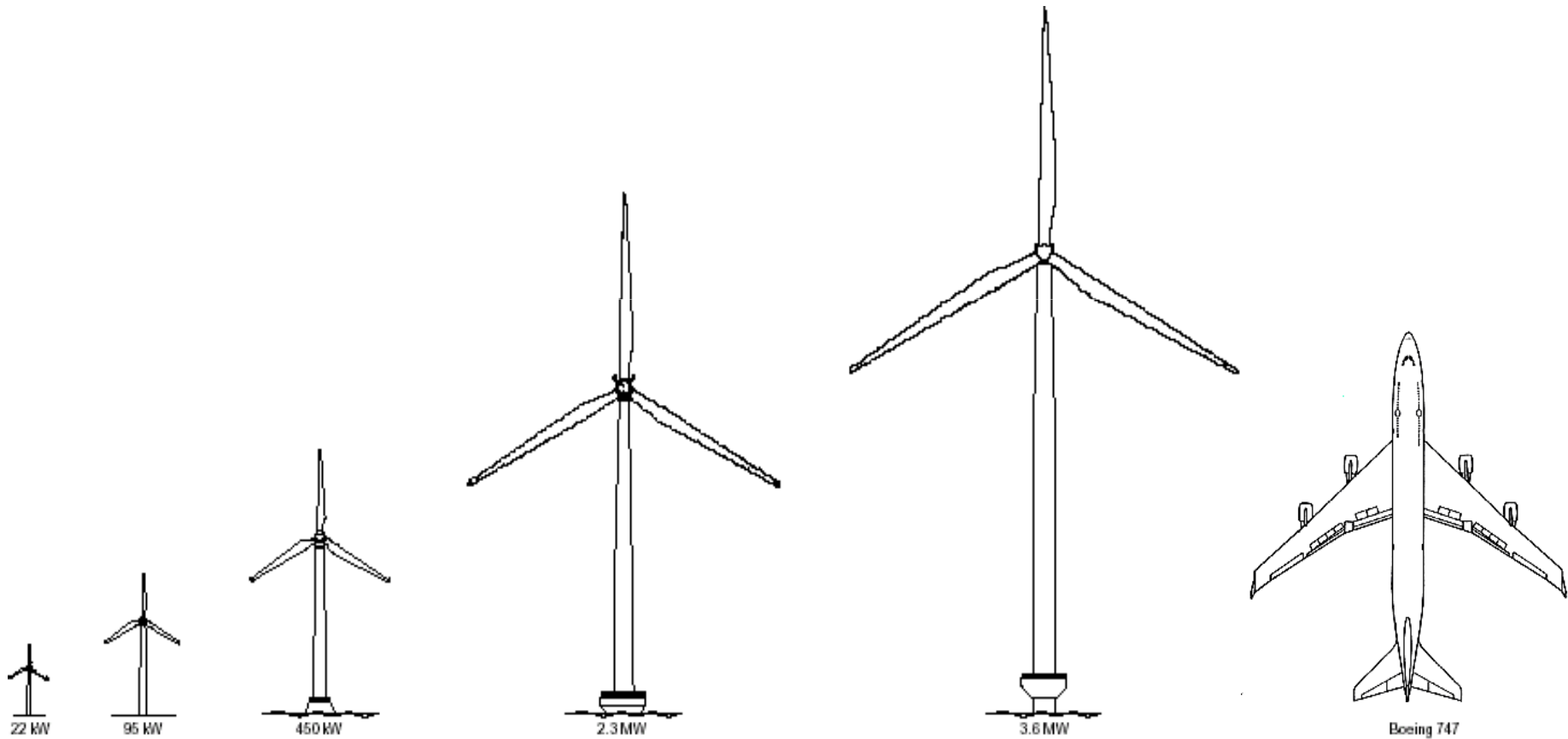


Commercial Aircraft MTOW Growth



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

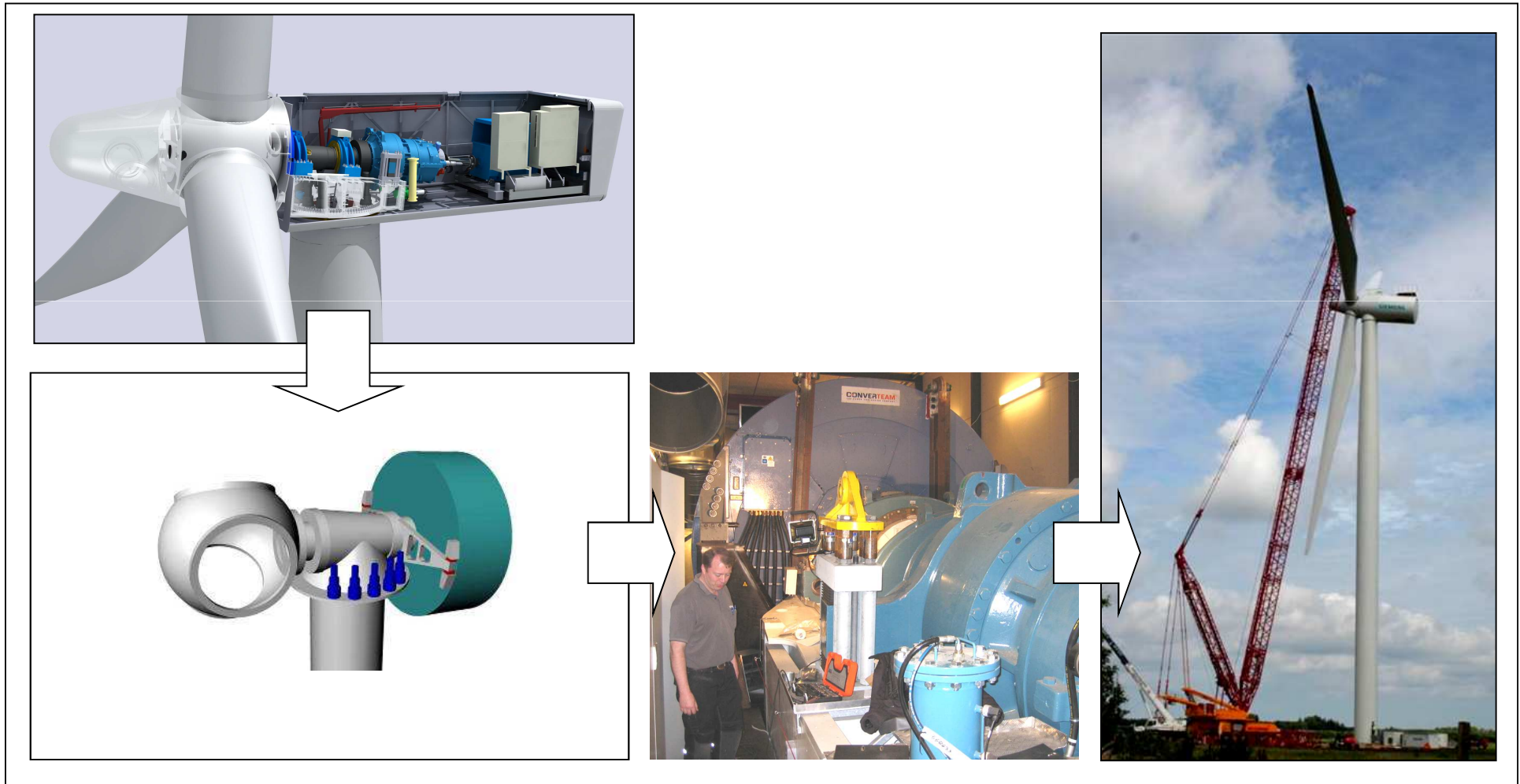
- **Direct Drive**
- Possibly sliding bearings

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!