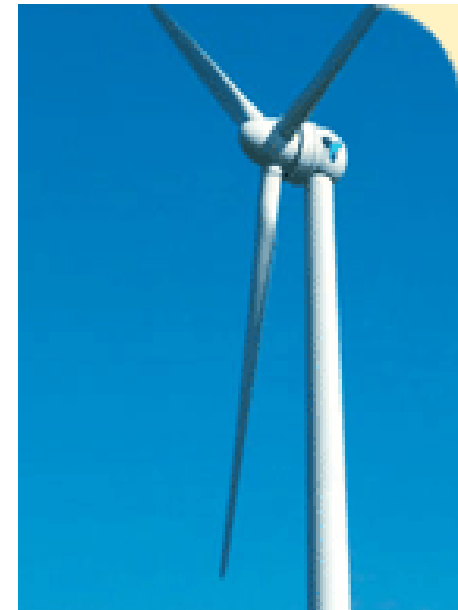


High Energy Production plus Built-in Reliability

– the VENSYS 70 / 77 –

New Gearless Wind Turbines in the 1.5 MW Class

REGEN POWERTECH Pvt. LTD. INDIA



Outline

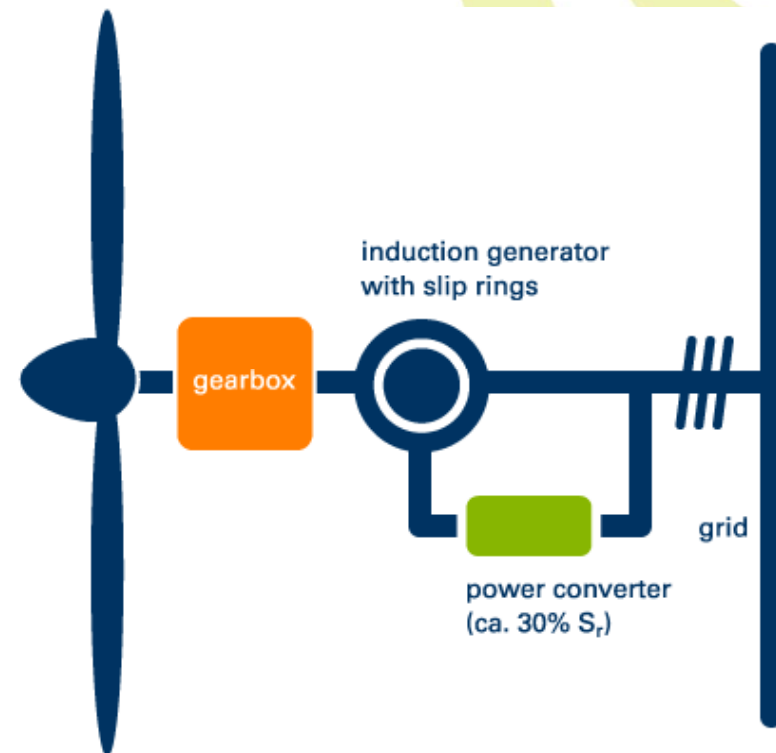
- 1. Generator Systems for Wind Turbines**
 - **Doubly-Fed Induction Generators**
 - **Direct-Drive Synchronous Generators**
- 2. The VENSYS Gearless Technology**
 - **Design Characteristics**
 - **Direct-Drive Generator System**
 - **Pitch and Safety System**
- 3. The New VENSYS 70 / 77**
- 4. Conclusions**

Variable-Speed for Wind – The 2 Competing Systems

Geared drive with doubly-fed induction generator

Advantages compared to gearless systems:

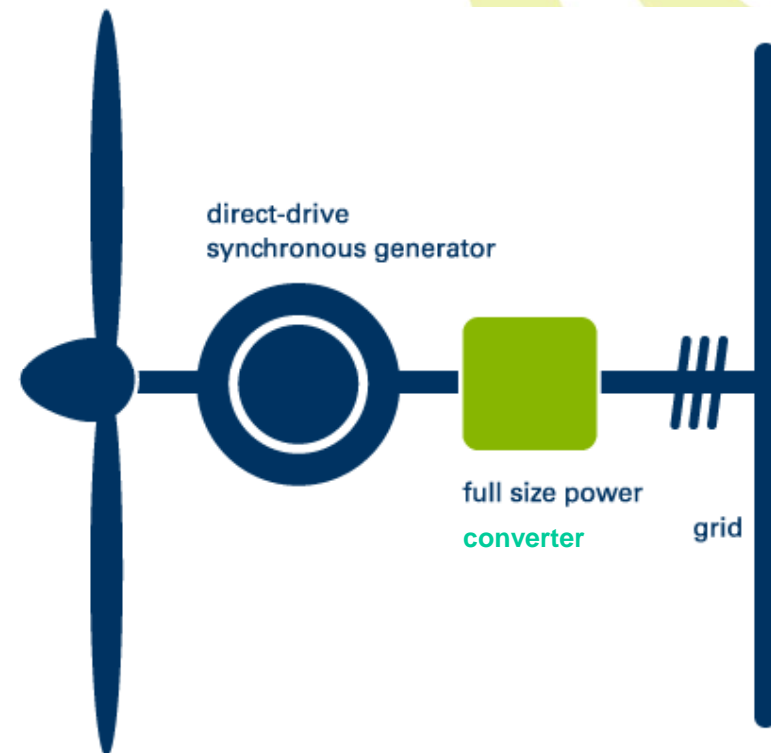
- **Component sourcing from different suppliers**
- **Small dimensions and masses (easier manufacturing and transport)**
- **Smaller power converter rating (but almost identical converter cost)**



Variable-Speed for Wind – The 2 Competing Systems

Direct-drive synchronous generator – Advantages:

- Fewer components, higher reliability
- No gearbox (less losses, maintenance, noise)
- Higher partial load efficiency (3–5% higher energy production for permanent-magnet excitation)
- No generator slip rings and brushes (lower maintenance cost)
- Low voltage, low speed, reliable generator rotor (especially true for permanent-magnet excitation)



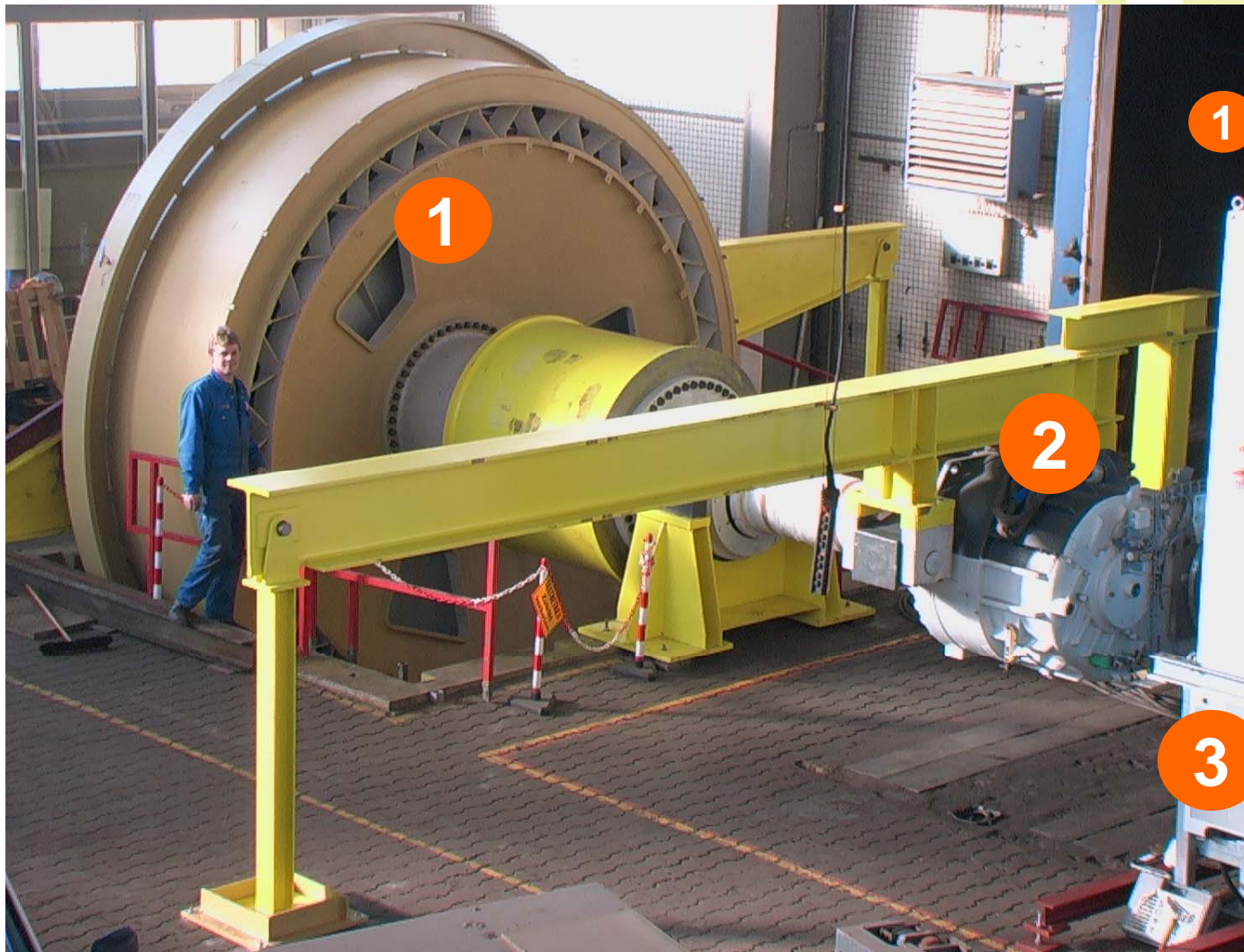
Pros & Cons of Variable-Speed Systems

	Doubly-fed induction generator with gearbox	Direct-drive generator with direct-current excitation	Direct-drive generator with permanent-magnet excitation
Main current suppliers	Vestas, GE, Gamesa, Nordex, REpower, etc.	Enercon, MTorres, Lagerwey, etc.	VENSYS, Goldwind, Scanwind, etc.
Current world market share	70 %	30 %	< 1 %
Average drive train efficiency	89 %	90 %	93 %
Tower top mass	100 %	130 %	100 %
Manufacturing cost	100 %	~ 110 %	~ 105 %
Reliability	--	+	++
Power quality	-	++	++
Component sourcing	+	+	+

➔ Direct drive with permanent magnets offers the highest potentials

➔ General industry trend: automation, railways, marine propulsion, etc.

PM Direct-Drive Efficiency Full Load TabTest with 1.2 MW



1 1.2 MW Generator

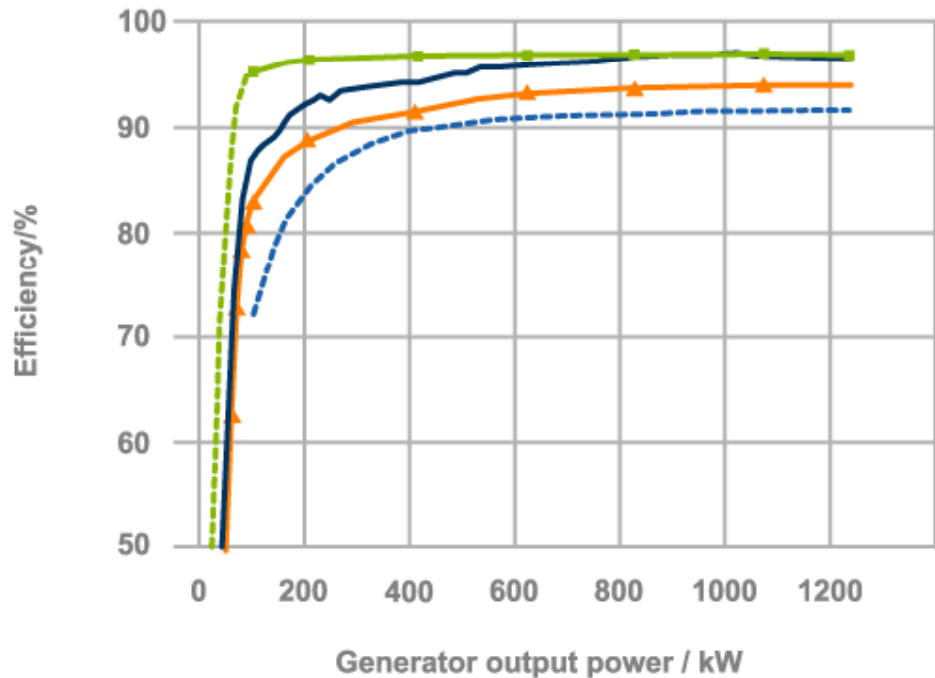
2 Gearbox

3 DC motor

3

PM Direct-Drive Efficiency Full Load TabTest with 1.2 MW

Efficiency measured directly: $\eta = 1 - P_{out} / P_{in}$



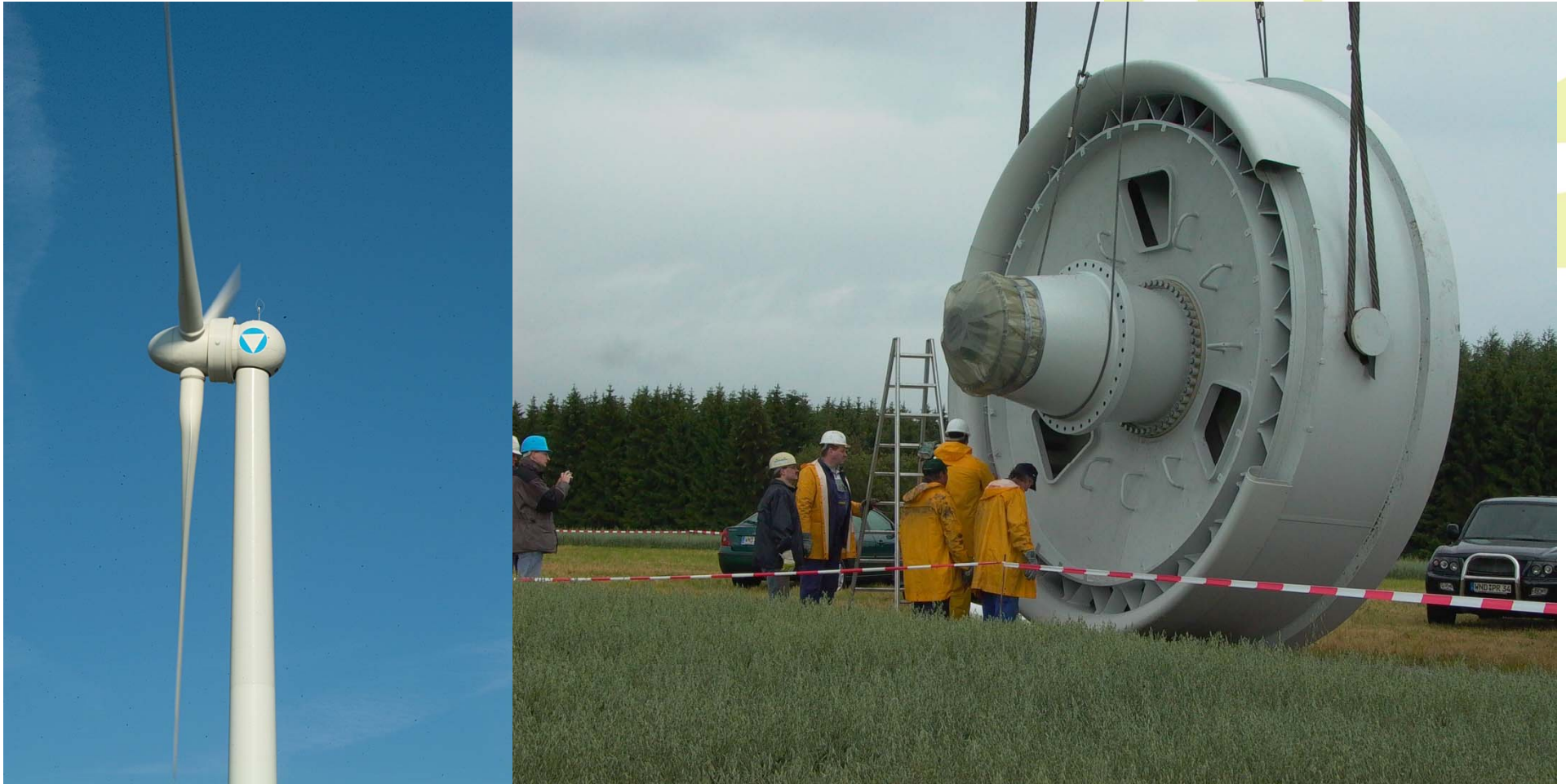
➔ **Rated total efficiency over 94%**

➔ **Up to 5% higher efficiency than conventional drive train!**

➔ **3 – 5% higher energy production!**

- Generator only
- Total drive
- Frequency converter
- Typical generator + gearbox (calc.)

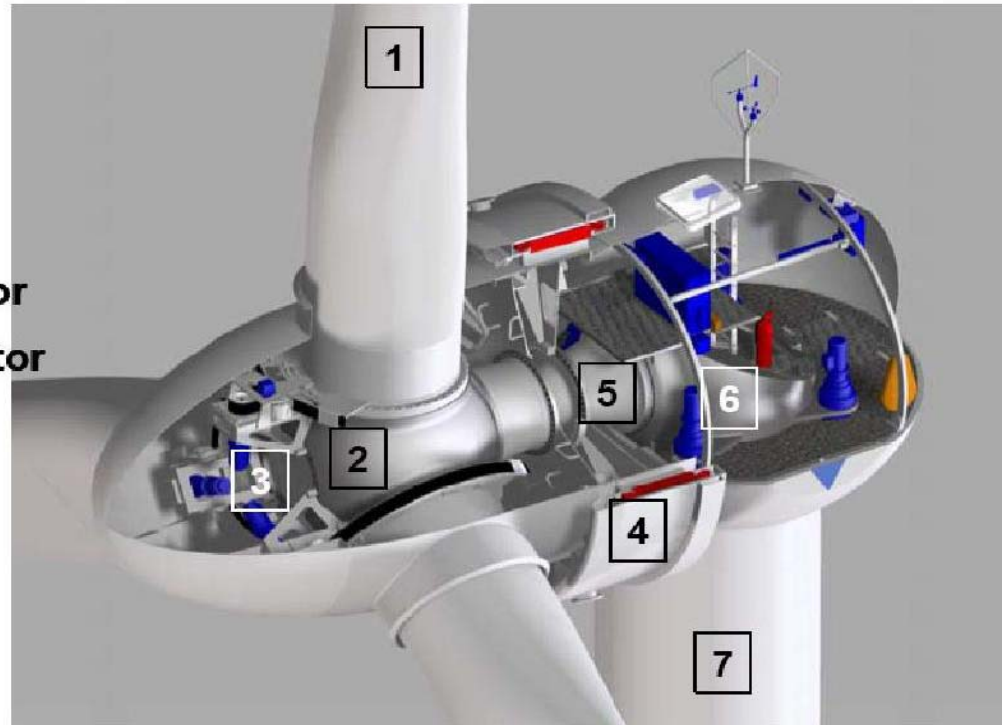
Vensys – Gearless Technology



➔ **Simple design with fewer components – built-in reliability**

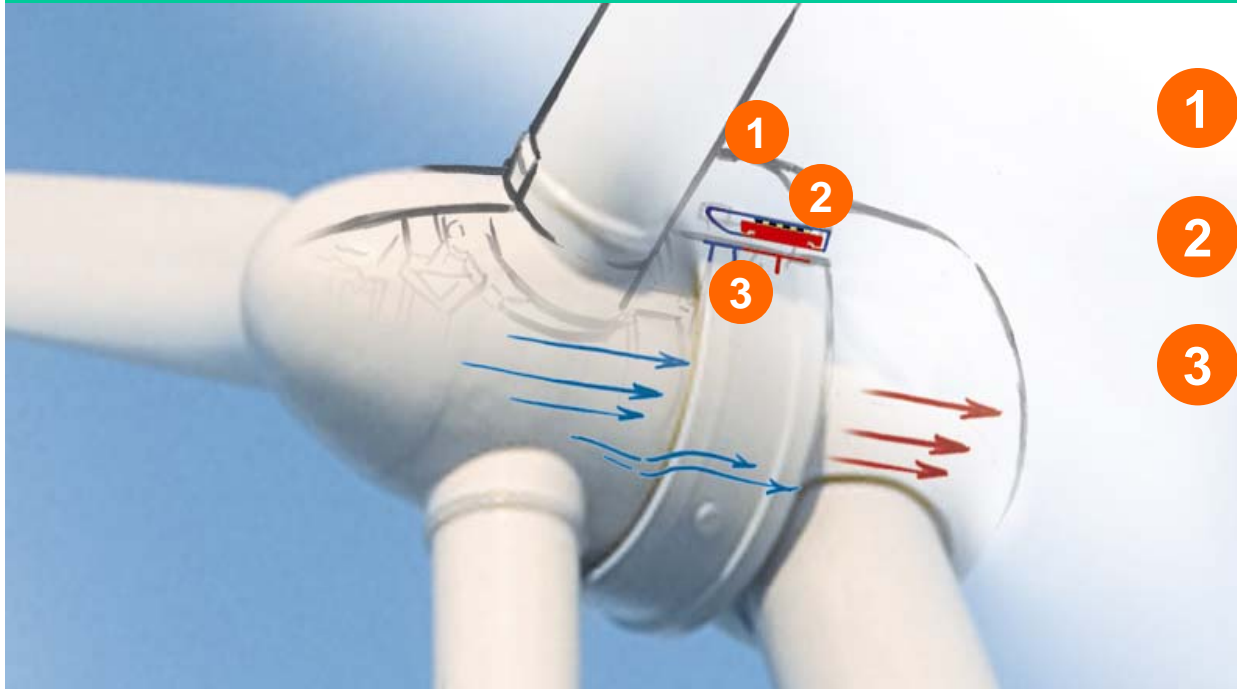
Vensys – Gearless Technology , Main Tower Top Components

- 1 Rotor blade
- 2 Cast hub
- 3 Pitch drive
- 4 Generator rotor
- 5 Generator stator
- 6 Main frame
- 7 Tower



➔ Simplifying the design by reducing it to what is really essential: using the smallest possible number of high-quality and tested components: no gear, no generator bearings, no couplings, no generator excitation.

Vensys – Gearless Technology, Passive Generator Cooling



- 1 External rotor with permanent magnets
- 2 Internal stator
- 3 Cooling duct



Patented passive cooling system

- **Totally enclosed generator, stack cooling with backside cooling fins (IP 23)**
- **Only small amount of external air gets contact with winding**
- **Perfectly cooled magnets, high flux, no demagnetisation**
- **Outstanding cooling performance: max. temperature rise 30°K at 1.2 MW!**

Vensys – Gearless Technology – The Generator

VENSYS 70/77 Generator

Rated output: 1.5 MW

Stator voltage: 690 V

Rated speed: 19.0 or 17.3 rpm

Degree of protection: IP 23

Insulation class: Class F

Dimensions: $D < 5\text{ m}$, $L < 1.5\text{ m}$

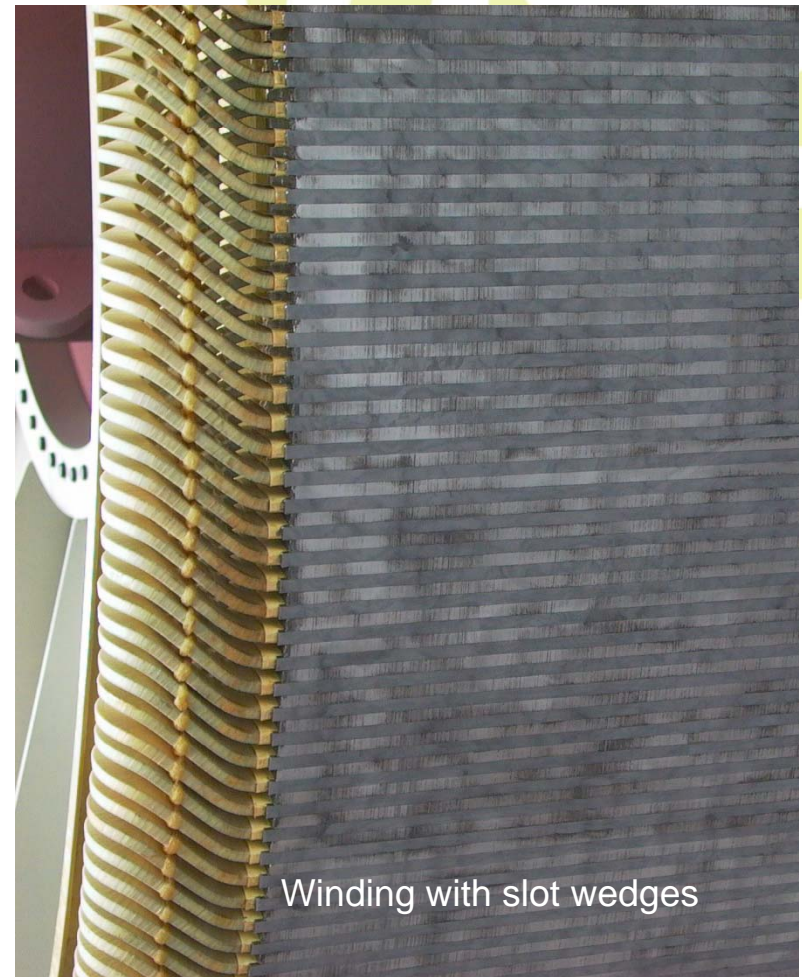
Generator mass: $< 40\text{ tons}$



1.2 MW generator stator

The VENSYS Winding:

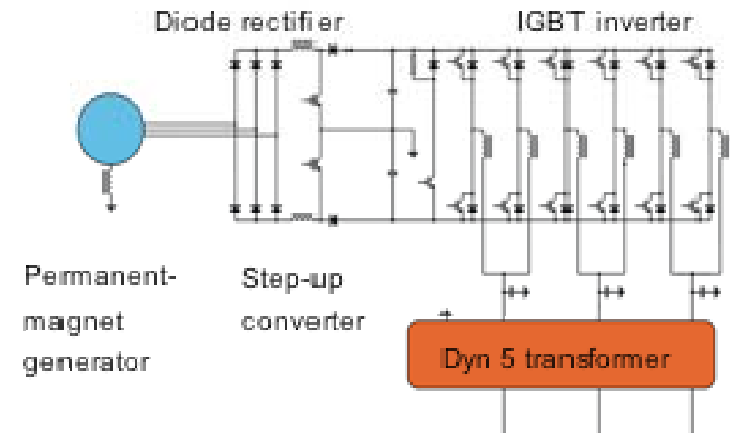
- **Pre-formed winding**
- **Medium-voltage (2000 V) insulation system – low-voltage (690 V) operation**
- **Proven insulation technology using materials from experienced suppliers**
- **Fractional slot winding: smooth pole-slot interaction and sinusoidal voltage for further noise reduction**



Vensys – Gearless Technology – The Frequency Convertor

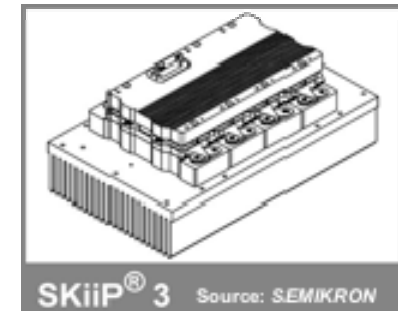
VENSYS Variable-speed Technology:

- **Passive diode rectifier: high efficiency, low EMI.**
- **Very low harmonics to the grid.**
- **Automatic adjustment to 50 Hz or 60 Hz.**
- **Measured and certified low-voltage ride through operation.**
- **Full reactive power control.**
- **High reliability: air cooling with only 1 fan, robust converter control.**
- **Good serviceability: modular design with fast IGBT exchange.**



“Low-tech converter” of highly integrated IGBT modules

- **Integrated current sensor**
- **Integrated temperature sensor**
- **Integrated heat sink**
- **Integrated driving circuit & protection**



Vensys – Gearless Technology – The Pitch System

Ultra Caps instead of lead-acid batteries

> **No maintenance!**

AC drives instead of DC motors

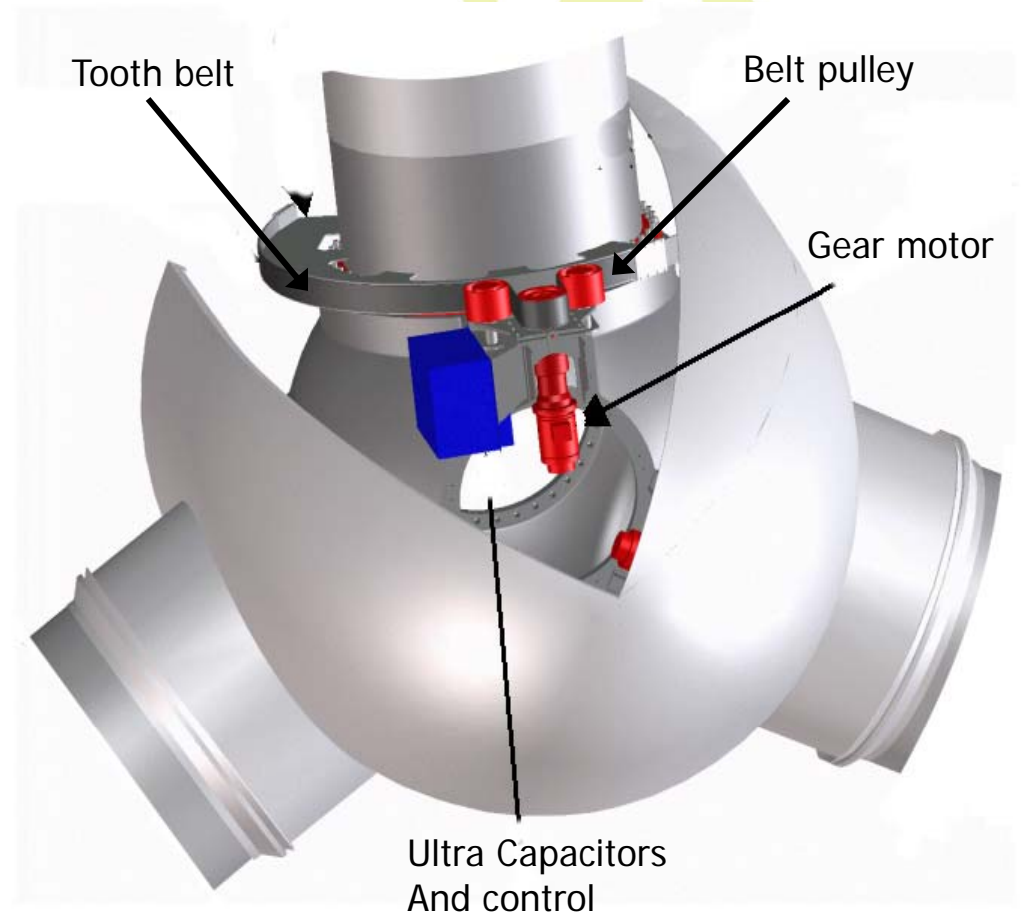
> **No maintenance!**

Tooth belt instead of spur gear

> **No maintenance!**

→ **Reliable pitch system**

with certified safety performance under lightning conditions!



Vensys – Gearless Technology – PROFIsafe Safety System

> Using existing fieldbus network!

Simplified maintenance through faster and simple replacement of few components

Increased reliability due to reduced cabling and fewer components

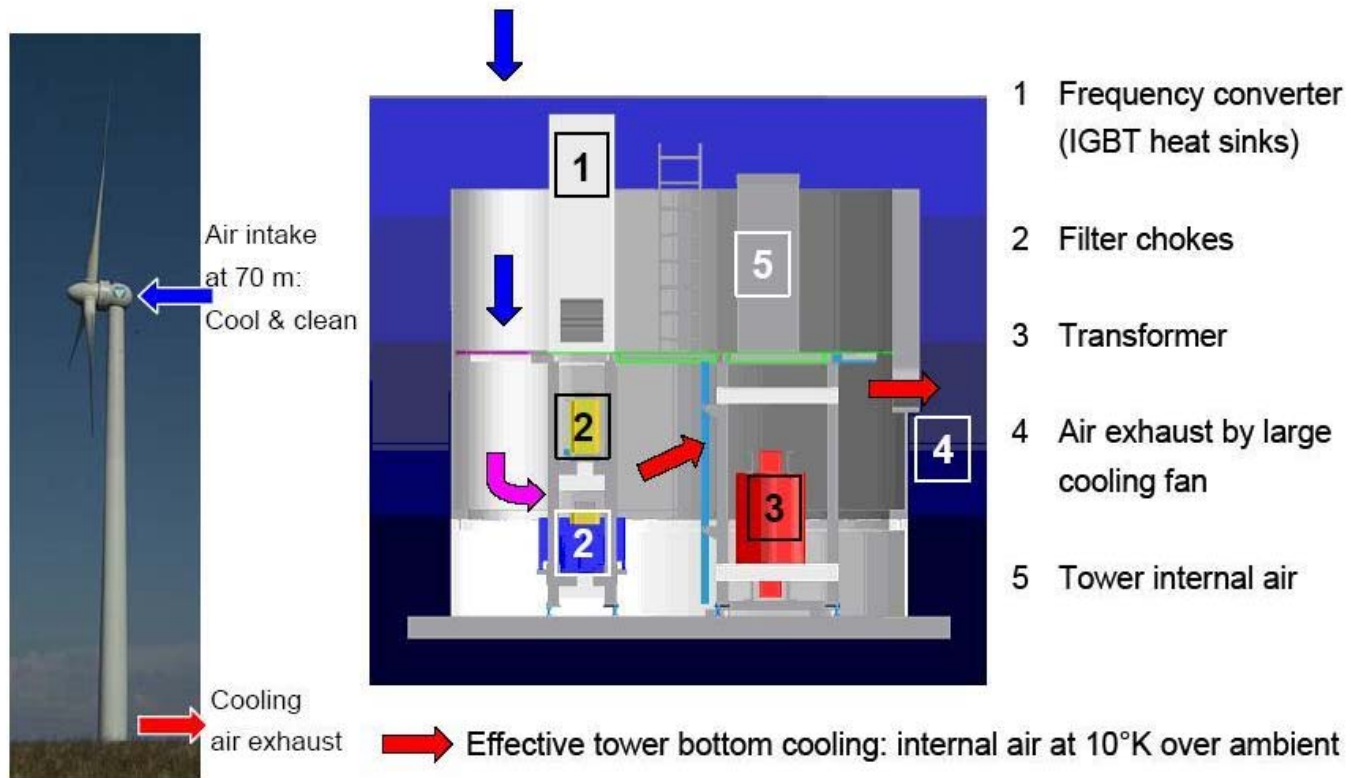
Source: Beckhoff TwinSAFE



➔ Simple, flexible and cost-effective decentralised safety system

Vensys – Gearless Technology , Tower bottom cooling

Effective tower bottom cooling



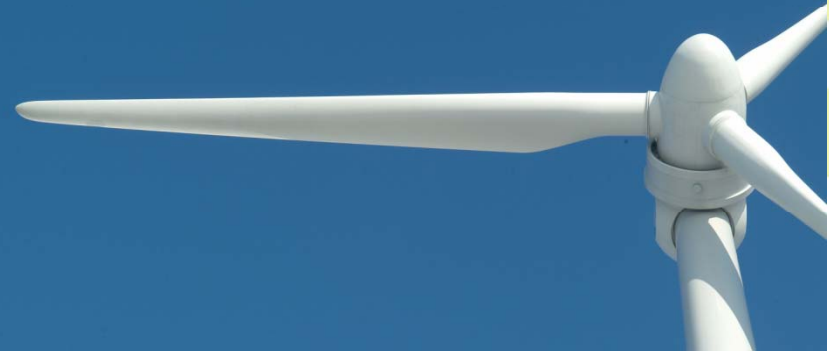
Vensys – 1.5 MW – Based on the Proven 1.2 MW Turbines

VENSYS 62 –

Running on 3 continents:

- **Europe (Sitzerath, Germany)**
- **Asia (Dabancheng, China)**
- **America (Spring Hill, Canada)**

VENSYS 62 / 1.2 MW



1.5 MW vs. 1.2 MW – Identical components:

- **Generator + Frequency converter**
- **Base frame, Axle and hollow shaft**
- **Yaw bearing and brakes**
- **Rear-side main bearing (cylinder-roller bearing)**
- **Pitch system**
- **Nacelle cover**

Goldwind 62 / 1200



Vensys – 70/77, 1.5 MW – Product Overview

Turbine type	VENSYS 70	VENSYS 77
Rated power / kW	1500	1500
Rotor diameter / m	70.5	77.0
Hub heights / m	65.0 / 85.0	61.5 / 85.0 / 100.0
Speed range / rpm	9.0 – 19.0	9.0 – 17.3
Tower top mass / t	82	84
Wind speeds / m/s	3.0 – 13.5 – 25.0	3.0 – 13.0 – 22.0
Wind classes	DIBt WZ III IEC IIa	DIBt WZ II IEC IIIa
Prototype erection	08 / 2006 Dabancheng / China	06 / 2006 Germany



Conclusions

Common goal – making wind more cost competitive!

Typical Industry Approach – High Risk:

- Blade feedback control with new sensors for load reduction.
- New highly compact gearbox designs with unproven components.
- New drive-train (one-stage gearbox + medium-speed generator).
- Carbon blade technology.
- Highly innovative converter and control technologies.

The VENSYS Low-Risk Approach:

- Maximum energy production through high efficiency.
- High reliability through minimum number of components.
- Low maintenance cost through minimum number of components.

→ *VENSYS technology most suitable for "globalisation" of wind power*