Vestas®

EnVentus™ Platform

Wind. It means the world to us.™

The **foundation** for the future of wind

We are pioneers. We keep moving and improving. It's what Vestas does. EnVentus™ is the next phase of this journey. By connecting heritage with innovation, Vestas creates solutions that responsibly address tomorrow's energy challenges.

Market opportunities
Our customers are demanding ever more advanced wind turbines, enabling profitable project realisation in increasingly challenging locations as the renewable energy landscape expands and diversifies; larger, more powerful turbines responsive to evolving grid requirements.

Customised to maximise
EnVentus™ represents the next generation in the evolution of wind turbines. Designed to encompass a wide range of turbine configurations, system designs apply modularity to meet customisation and market demands more efficiently. Combined with the extensive Vestas portfolio of solutions, EnVentus™ variants can maximise the potential of each unique wind site.

On the shoulders of giants
EnVentus™ is the realisation of a vision to connect the best engineering from Vestas. Building on more than 151 GW of tried and tested technology, EnVentus™ aims to ensure continued leadership. Using technology and experience from both on- and offshore, the EnVentus™ platform architecture combines advanced proven system designs that deliver innovation.

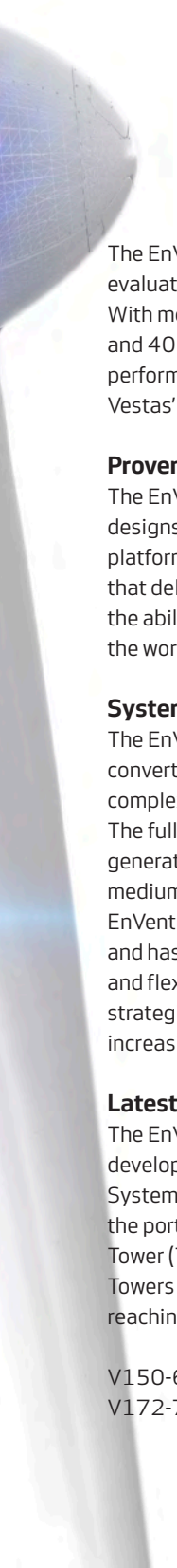
+154 GW

By connecting advanced modular design with more than 154 GW of tried and tested technology, EnVentus™ aims to ensure continued technology leadership.

40 years of experience

The EnVentus™ platform architecture connects proven system designs from the 2 MW platform, 4 MW platform, and 9 MW platform.

Connecting certainty with innovation



The EnVentus™ platform is the result of meticulous and careful evaluation of an unbroken line of Vestas technology solutions. With more than 154 GW of wind turbine capacity installed and 40 years of experience in relentlessly pursuing better performance through technology and service, EnVentus™ is Vestas' next generation in the evolution of wind turbines.

Proven technology
The EnVentus™ platform architecture connects proven system designs from the 2 MW platform, 4 MW platform and 9 MW platform turbine technology. The result is one versatile platform that delivers a higher level of robustness and performance with the ability to meet varying grid compliance requirements around the world.

System efficiency
The EnVentus™ platform architecture features a full-scale converter, proven from the 4 MW platform, capable of meeting complex and differing grid requirements in local markets. The full-scale converter is matched by a permanent magnet generator for maximum system efficiency and balanced by a medium-speed drivetrain. Known from the 9 MW platform, the EnVentus™ powertrain is optimised to reduce structural loads and has been chosen for reasons of mechanical robustness and flexibility. Combined with advanced load management strategies, the EnVentus™ platform enables siting at increasingly complex project conditions.

Latest solutions
The EnVentus™ platform architecture benefits from the latest developments in control systems, applying the Vestas Control System 8000 also operating on the 4 MW platform. Similarly, the portfolio of standard towers are based on Tubular Steel Tower (TST), High Tubular Steel Tower (HTST), Concrete Hybrid Towers (CHT), or Large Diameter Steel Tower (LDST) technology, reaching hub heights of up to 169m.

V150-6.0 MW™ ,V162-6.2 MW™ , V162-7.2 MW™ and V172-7.2 MW™ turbine blades are the result of incremental improvements to proven technical solutions. All EnVentus™ turbines feature slender profile and pre-bent blades, optimised for weight through application of carbon pultrusion material and a structural shell blade design, enabling the optimisation of the structural loads while increasing the rotor sizes. Vestas' most advanced aerofoil design ensures high aerodynamic performance and excellent sound power levels.

Tested to the limit
By applying reusable modules, versatility in offering can be achieved while adhering to Vestas' rigorous testing standards. The Vestas Test Centre is unrivalled in the wind industry. We test nacelle components using accelerated life testing under mixed and aggregated environmental conditions. For critical components, Highly Accelerated Life Testing (HALT) identifies potential failure modes and mechanisms. Specialised test rigs ensure strength and robustness for the gearbox, generator, yaw and pitch system, lubrication system and accumulators. Our quality control system ensures that each component is manufactured to design specifications and performs at site. We systematically monitor measurement trends that are critical to quality, locating defects before they occur.

We know wind

Vestas is the right partner to help you realise the full potential of your wind site. We have the largest installed capacity in the industry and currently monitor over 47,000 turbines across the globe: Tangible proof of our commitment to making renewable energy solutions that are productive, reliable and economical.

Maximised site potential

The Vestas EnVentus™ platform adds four new variants to the wide range of existing Vestas turbines, providing the ability to create an even more finely matched combination of turbines to harness available wind energy in any specific location.

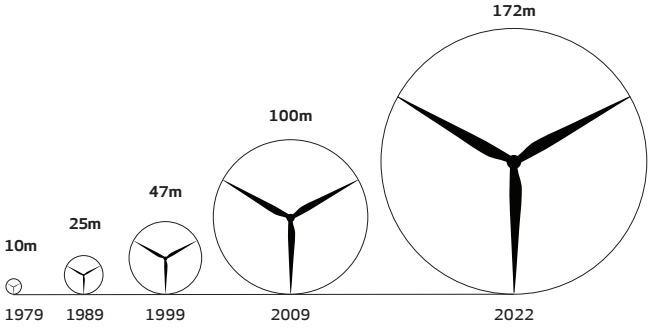
Versatility at the core

Through advanced modularity in design, EnVentus™ aims to meet customisation needs more efficiently combining reusable modules depending on unique market and project conditions. Designed with global applicability in mind, EnVentus™ based variants benefit from a full-scale converter enabling compliance with varying market-specific grid code requirements. The wide range of standard hub heights, options, and modes of operation contribute to the ability to meet specific requirements.

Business case flexibility

The relationship between rotor size and rating help maximise turbine level production. This makes the variants especially suitable for projects limited by the number of wind turbines installed. Combining double-digit* annual energy production improvements in low, medium and high wind speeds, the EnVentus turbines are ready to secure project realisation in auction and permit-based environments.

Rotor size development



V150-6.0 MW™

The V150-6.0 MW™ lifts the larger rotor introduced with V150-4.2 MW™ into stronger wind speeds. Combined with its higher generator rating, it increases the production potential at WTG level by more than 20 percent compared to V136-4.2 MW™ in medium wind speed conditions. Applying Vestas' most advanced aerofoil blade design combined with lower rotational speeds of the EnVentus™ drivetrain, means realisation of power production potential at very low sound power levels. A comprehensive portfolio of standard and site-specific towers allow for application in tip height constraint markets, varying from 180m to 244m.

V162-6.2 MW™

With a swept area of over 20,000m^2, the V162-6.2 MW™ applies a larger rotor to achieve higher energy production paired with a high capacity factor. Due to the large operational envelope, the V162-6.2 MW™ has great relative siteability on both turbulence and average wind speeds. With a maximum Sound Power Level of 104.8dB(A), the V162-6.2 MW™ delivers over 30 percent higher energy production than the V150-4.2 MW™.

V162-7.2 MW™ & V172-7.2 MW™

With flexible ratings of 6.5 MW, 6.8 MW and 7.2 MW, the V162-7.2 MW™ and V172-7.2 MW™ improve annual energy production through enhancements in powertrain and power conversion systems. Improved siteability in hot climates is enabled through the optional larger CoolerTop. The modularised nacelle design improves transportability of the nacelle unit and provides flexibility to service and upgrades over the turbine's operational lifetime. The V172-7.2 MW™ is designed for low to medium average wind conditions, whereas the V162-7.2 MW™ caters more for applications in medium to high wind segments, especially where tip height restrictions may apply.

*Depending on site specific conditions.

WIND CLASSES

Turbine type	Low wind speeds	Medium wind speeds	High wind speeds
EnVentus™ turbines			
V150-6.0 MW™			
V162-6.2 MW™			
V162-7.2 MW™			
V172-7.2 MW™			

All of Vestas

As part of the suite of Vestas offerings, the EnVentus turbines can be combined with an extensive list of technology options to create customised solutions to suit the needs of each unique project. By adding options to the standard turbine, we can enhance the performance and adaptability of the wind power project and facilitate a shorter permitting cycle at restricted sites. These options can be a decisive factor in realising your specific project and the business case certainty of your investments. Additionally, the well-established Vestas manufacturing and global supply chain setup ensure the ability to deliver, while supporting local requirement.

Options available for the EnVentus™ platform:

- Additional operating modes
- Aviation Markings on the Blades
- Vestas Bat Protection System
- Aviation Lights
- Condition Monitoring Solution
- Fire Supression
- Lightning detection
- Load Optimised Modes
- Low Temperature Operation to -30°C
- Oil Debris Monitoring System
- Vestas Shadow Flicker Control System
- Service Personnel Lift
- Vestas Ice Detection™
- Vestas Anti-Icing System™

The knowledge **to control**

Knowledge about wind project planning is key
When planning a wind power plant, there are a broad range of factors over its entire lifecycle that will impact its success in the long-term. These range from financing and siting, to grid requirements and the regulatory framework. One of the first and most important steps is to identify the most suitable location for your wind power plant. Vestas' siting capabilities cover all the steps from finding a site, until delivering a fully optimised power plant set up.

Using the largest weather library in the industry, site-specific met mast campaigns and advanced analytical tools, Vestas examines a broad spectrum of wind and weather data to evaluate potential sites and establish which of them can provide optimum conditions for your project. In addition, Vestas can optimise the layout of your wind power plant and the technology selection with high accuracy by implementing detailed simulations of the conditions on site and analyse their effects over the whole operating life of the plant. Put simply, it finds the optimal balance between the estimated ratio of annual revenue to operating costs over the lifetime of your plant, to determine your project's true potential and provide a firm basis for your investment decision.

The complexity and specific requirements of grid connections vary considerably across the globe, making the optimal design of electrical components for your wind power plant essential. By identifying grid codes early in the project phase and simulating extreme operating conditions, Vestas' Electrical PreDesign provides you with an ideal way to build a grid compliant, productive and highly profitable wind power plant. It allows customised collector network cabling, substation protection and reactive power compensation, which boost the cost efficiency of your business.

Advanced monitoring and real-time plant control
All our wind turbines can benefit from VestasOnline® Business, the latest Supervisory Control and Data Acquisition (SCADA) system for wind power plants.

This flexible system includes an extensive range of monitoring and management functions to control your wind power plant. VestasOnline® Business enables you to optimise production levels, monitor performance and produce detailed, tailored reports from anywhere in the world. The VestasOnline® Power Plant Controller offers scalability and fast, reliable real-time control and features customisable configuration, allowing you to implement any control concept needed to meet local grid requirements.

Condition monitoring and maintenance
Operating a large wind power plant calls for efficient management strategies to minimise downtime and operational expenses. Vestas offers 24/7 monitoring, performance reporting and predictive maintenance solutions to improve turbine performance and availability.

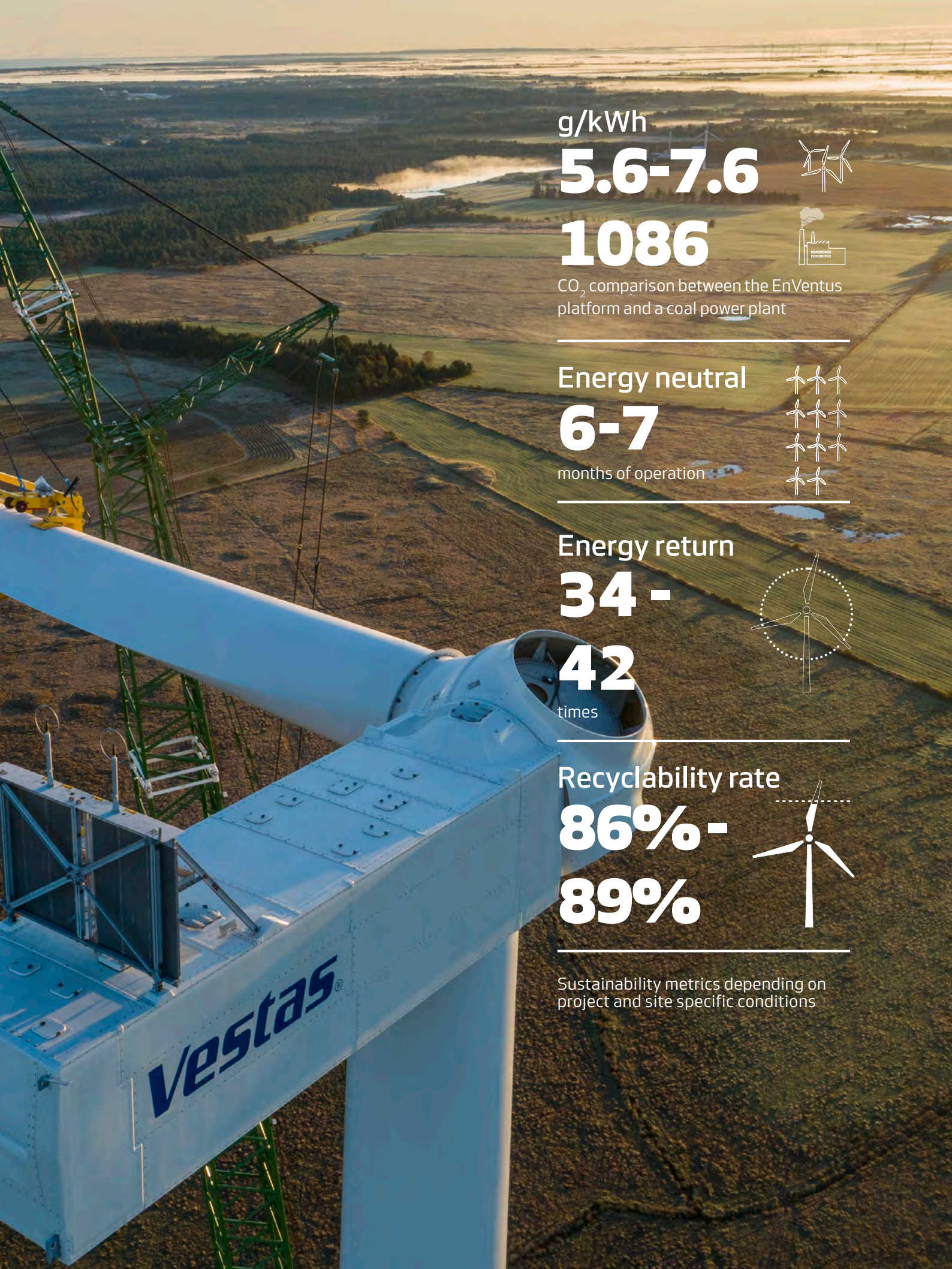
Vestas Condition Monitoring Solution (CMS) enables to predict the failure of components by analysing vibration signals, preventing major equipment damages and enabling to optimise the service planning according to the energy production and weather conditions. Additionally, Vestas' Active Output Management® (AOM) provides detailed plans and long-term agreements for maintenance, online monitoring, optimisation and troubleshooting. It is possible to get a full scope contract, combining turbine technology with guaranteed time or energy-based availability performance targets, thereby creating a solid base for your power plant investment.

Vestas' transparency towards **Sustainability**

Vestas Sustainability
In 2020, we introduced our sustainability strategy, Sustainability in Everything We Do. At Vestas we are working to improve our own environmental performance, create value for local communities, promote a safe, diverse, and inclusive workplace, while leading the transition to a world powered by sustainable energy. We believe these efforts will help to elevate the standards of our industry as a whole. Read more about Vestas sustainability strategy at www.vestas.com/en/sustainability.

Life Cycle Assessments (LCA)
Since 1999, we have been developing wind turbine LCAs to give 'cradle-to-grave' evaluations of the environmental impact of our products and solutions.These evaluations concentrate on two key actions: documenting the environmental performance of Vestas wind turbines and analysing the results to reduce the environmental impact of our turbines. The LCAs provide environmental impact transparency to help customers achieve their own sustainability ambitions. To view our current portfolio of Life Cycle Assessments visit the following page: www.vestas.com/en/sustainability/reports-and-ratings.

As part of our commitment to customers, we also offer customised wind power plant LCAs, called Vestas® SiteLCA™. These assessments determine key indicators of environmental performance, taking the wind turbine type, site specific conditions and production supply chain into consideration. SiteLCA™ provides customers or project developers with transparent environmental facts for a specific wind power plant.



g/kWh

5.6-7.6

1086

CO_2 comparison between the EnVentus platform and a coal power plant

Energy neutral

6-7

months of operation

Energy return

34 - 42

times

Recyclability rate

86%-89%

Sustainability metrics depending on project and site specific conditions

V150-6.0 MW™ IEC S
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	6,000kW
Cut-in wind speed	3m/s
Cut-out wind speed*	25m/s
Wind class	IEC S

Standard operating temperature range from -20°C to +45°C

*High Wind Operation available as standard

SOUND POWER

Maximum	104.9dB(A)*

*Sound Optimised Modes available dependent on site and country

ROTOR

Rotor diameter	150m
Swept area	17,672m²
Aerodynamic brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60Hz
Converter	full scale

GEARBOX

Type	two planetary stages

TOWER

Hub height	105m (IEC S) 125m (IEC S/DIBt S) 148m (DIBt S) 155m (IEC S) 166m (DIBt S) 169m (DIBt S)

TURBINE OPTIONS

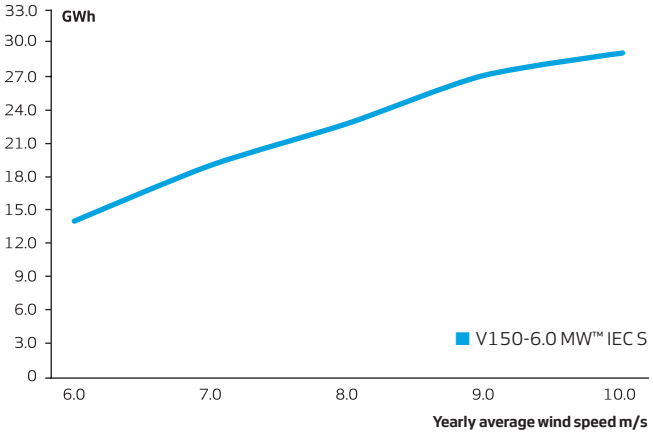
- Condition Monitoring System
- Oil Debris Monitoring System
- Service Personnel Lift
- Low Temperature Operation to -30°C
- Vestas Ice Detection™
- Vestas Anti-Icing System™
- Vestas Shadow Flicker Control System
- Aviation Lights
- Aviation Markings
- Fire Suppression System
- Vestas Bat Protection System
- Lightning Detection System
- Power Optimised Modes

SUSTAINABILITY

Carbon Footprint	7.6g CO_2e/kWh
Return on energy break-even	6 months
Lifetime return on energy	42 times
Recyclability rate	89%

Configuration: HH=166m, Vavg=8.5m/s, k=2.22. Depending on site-specific conditions. Metrics are based on a preliminary stream-lined analysis. An externally-verified Lifecycle Assessment will be made publicly available on vestas.com once finalised.

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

V162-6.2 MW™ IEC S
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	6,200kW
Cut-in wind speed	3m/s
Cut-out wind speed*	25m/s
Wind class	IEC S

Standard operating temperature range from -20°C to +45°C

*High Wind Operation available as standard

SOUND POWER

Maximum	104.8dB(A)*

*Sound Optimised Modes available dependent on site and country

ROTOR

Rotor diameter	162m
Swept area	20,612m²
Aerodynamic brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60Hz
Converter	full scale

GEARBOX

Type	two planetary stages

TOWER

Hub height	119m (IEC S/DIBt S) 125m (IEC S) 166m (IEC S/DiBt S) 169m (DIBt S)

TURBINE OPTIONS

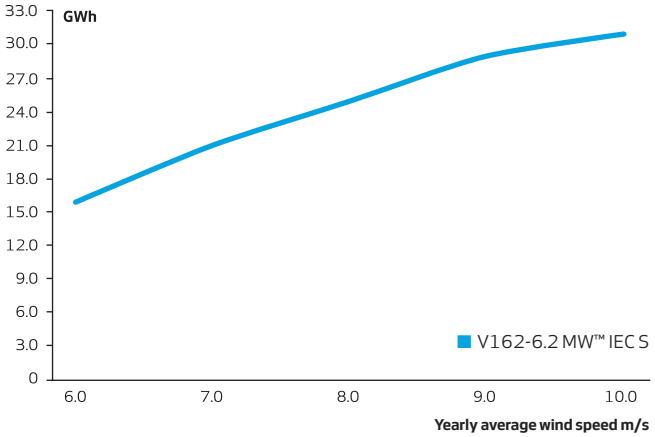
- Condition Monitoring System
- Oil Debris Monitoring System
- Service Personnel Lift
- Low Temperature Operation to -30°C
- Vestas Ice Detection™
- Vestas Anti-Icing System™
- Vestas Shadow Flicker Control System
- Aviation Lights
- Aviation Markings
- Fire Suppression System
- Vestas Bat Protection System
- Lightning Detection System
- Power Optimised Modes

SUSTAINABILITY

Carbon Footprint	6.1g CO_2e/kWh
Return on energy break-even	6 months
Lifetime return on energy	39 times
Recyclability rate	88%

Configuration: HH=166m, Vavg=8.5m/s, k=2.48. Depending on site-specific conditions. Metrics are based on a preliminary stream-lined analysis. An externally-verified Lifecycle Assessment will be made publicly available on vestas.com once finalised.

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

V162-7.2 MW™ IEC S
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Standard rated power	7,200kW
Cut-in wind speed	3m/s
Cut-out wind speed*	25m/s
Wind class	IEC S

Standard operating temperature range from -20°C to +45°C

*High Wind Operation available as standard

SOUND PO WER

Maximum	105.5dB(A)*

*Sound Optimised Modes available dependent on site and country

ROTOR

Rotor diameter	162m
Swept area	20,612m²
Aerodynamic brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60Hz
Converter	full scale

GEARBOX

Type	two planetary stages

TOWER

Hub height	119m (IEC S/DIBt S) 169m (IEC S)* 169m ((DIBt S))

*Includes 3m raised foundation

TURBINE OPTIONS

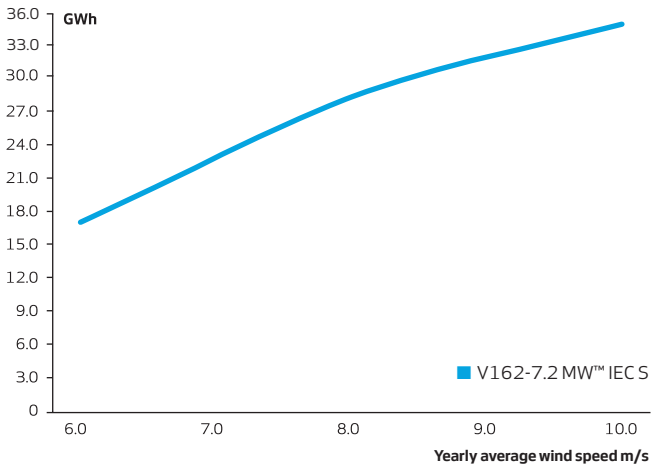
- 6.5 MW Operational Mode
- 6.8 MW Operational Mode
- Oil Debris Monitoring System
- High Temperature CoolerTop
- Service Personnel Lift
- Low Temperature Operation to -30°C
- Vestas Ice Detection™
- Vestas Anti-Icing System™
- Vestas Shadow Flicker Control System
- Aviation Lights
- Aviation Markings
- Fire Suppression System
- Vestas Bat Protection System
- Lightning Detection System

SUSTAINABILITY

Carbon Footprint	5.8g CO_2e/kWh
Return on energy break-even	6 months
Lifetime return on energy	41 times
Recyclability rate	86-87%

Configuration: HH=166m, Vavg=8.5m/s, k=2.48. Depending on site-specific conditions. Metrics are based on a preliminary stream-lined analysis. An externally-verified Lifecycle Assessment will be made publicly available on vestas.com once finalised.

ANNUAL ENERGY PRODUCTION



Assumptions
One WTG, 100% availability, 0% losses, k factor = 2,
Standard density = 1.225

V172-7.2 MW™ IEC S
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Standard rated power	7,200kW
Cut-in wind speed	3m/s
Cut-out wind speed*	25m/s
Wind class	IEC S

Standard operating temperature range from -20°C to +45°C

*High Wind Operation available as standard

SOUND PO WER

Maximum	106.9dB(A)*

*Sound Optimised Modes available dependent on site and country

ROTOR

Rotor diameter	172m
Swept area	23,235m²
Aerodynamic brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60Hz
Converter	full scale

GEARBOX

Type	two planetary stages

TOWER

Hub height*	112m (IEC S)**
	117m (IEC S)**
	150m (IEC S)**
	164m (DIBt)
	166m (IEC S)
	175m (DIBt)

*Site specific towers available on request

**Preliminary

TURBINE OPTIONS

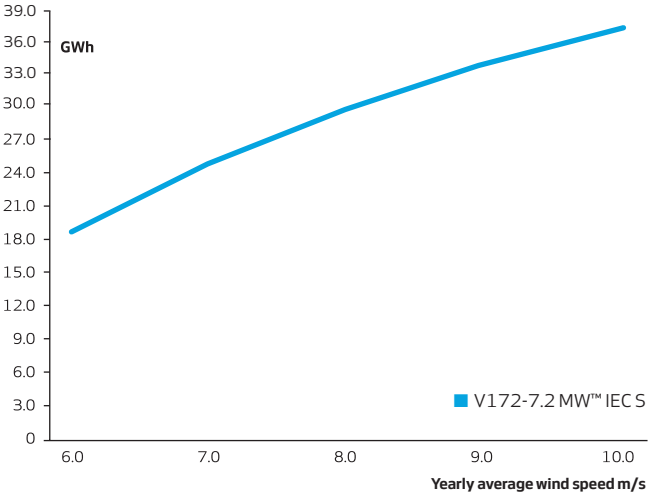
- 6.5 MW Operational Mode
- 6.8 MW Operational Mode
- Oil Debris Monitoring System
- High Temperature CoolerTop
- Service Personnel Lift
- Low Temperature Operation to -30°C
- Vestas Ice Detection™
- Vestas Anti-Icing System™
- Vestas Shadow Flicker Control System
- Aviation Lights
- Aviation Markings
- Fire Suppression System
- Vestas Bat Protection System
- Lightning Detection System

SUSTAINABILITY

Carbon Footprint	6.2g CO_2e/kWh
Return on energy break-even	7 months
Lifetime return on energy	34-35 times
Recyclability rate	87%

Configuration: HH=166m, Vavg=7.5m/s, k=2.48. Depending on site-specific conditions. Metrics are based on a preliminary stream-lined analysis. An externally-verified Lifecycle Assessment will be made publicly available on vestas.com once finalised.

ANNUAL ENERGY PRODUCTION



Assumptions
One WTG, 100% availability, 0% losses, k factor = 2, Standard density = 1.225

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