ANNEXE A

Spécifications techniques des éoliennes

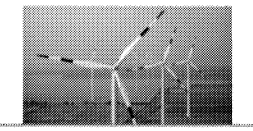
1.5sl/1.5s wind turbine

English

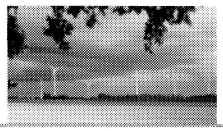
imagination at work

The 1.5sl/s wind turbines – proven results...

Fenner, USA
20 x 1.5s
total capacity: 30 MW



Arneburg, Germany
20 x 1.5sl
total capacity: 30 MW



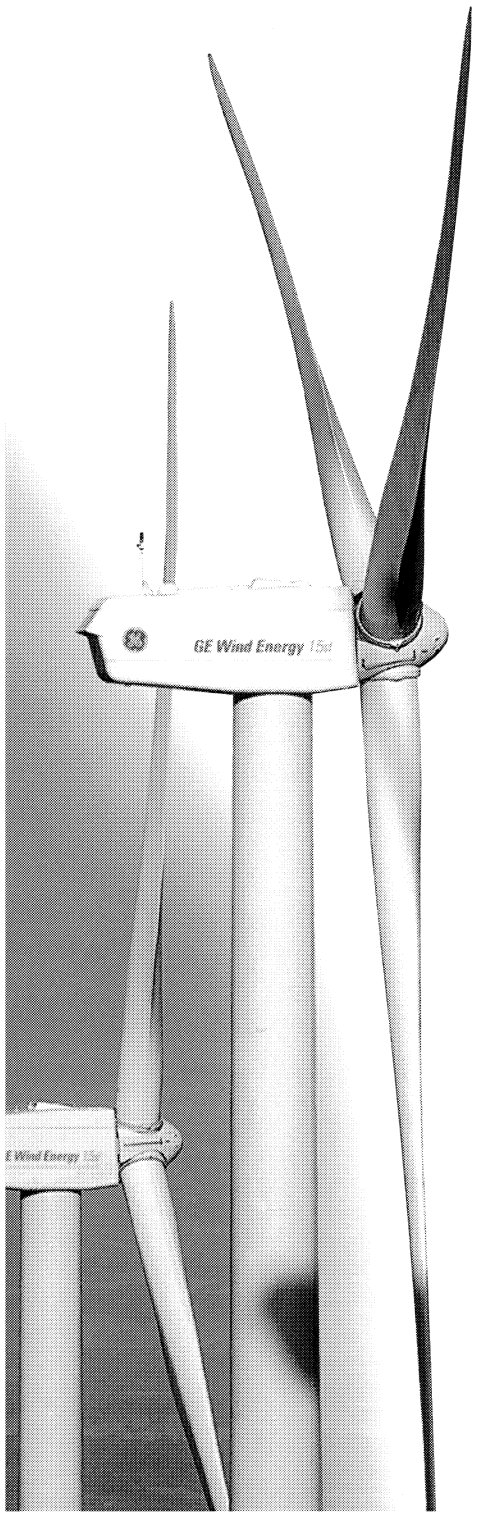
Bassum, Germany
13 x 1.5s
total capacity: 19.5 MW

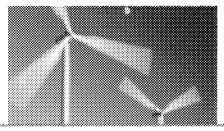
Gatun, Spain
33 x 1.5sl
total capacity: 49.5 MW

When it comes to "megawatt-plus" technology, our proven 1.5 MW wind turbine continues to raise the bar. Without resting on its past successes, our efforts to build on this proven performer include everything from technology investments in reliability and dependability, to more cost effective and versatile configurations. With over 1,300 units in operation worldwide, the 1.5 MW continues to be one of the world's most widely used wind turbines in its class.

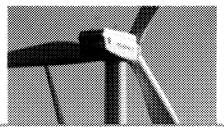
The 1.5 MW machine is active yaw and pitch regulated with power/torque control capability and an asynchronous generator. It utilizes a bedplate drive train design where all nacelle components are joined on a common structure, providing exceptional durability. The generator and gearbox are supported by elastomeric elements to minimise noise emissions.

Slufter, the Netherlands
8 x 1.5s,
total capacity: 12 MW

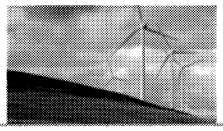




Fenner, USA
20 x 1.5s
total capacity: 30 MW



Caluengo, Spain
33 x 1.5sl
total capacity: 49.5 MW



Slufter, the Netherlands
8 x 1.5s
total capacity: 12 MW

...adaptable solutions.

With variable hub heights and rotor diameters, the 1.5 MW wind turbine is both versatile and adaptable, and has proven itself in a wide variety of wind energy sites around the world, both on-land and off-shore. The 1.5 MW wind turbine features variable-speed control and independent blade pitch to assure aerodynamic efficiency and reduce loads on the drive train, yielding reduced maintenance cost overall and longer turbine life. The turbines' independent blade pitch system also mitigates the need for large emergency braking systems and enables the use of larger rotors to allow increased energy yield. At the same time, GE's unique Wind Volt-Amp-Reactive ("WindVAR") electronics provide transmission efficiencies and enable the turbine to function harmoniously within the local grid. Reliable, cost-effective operation...it was designed in from day one.

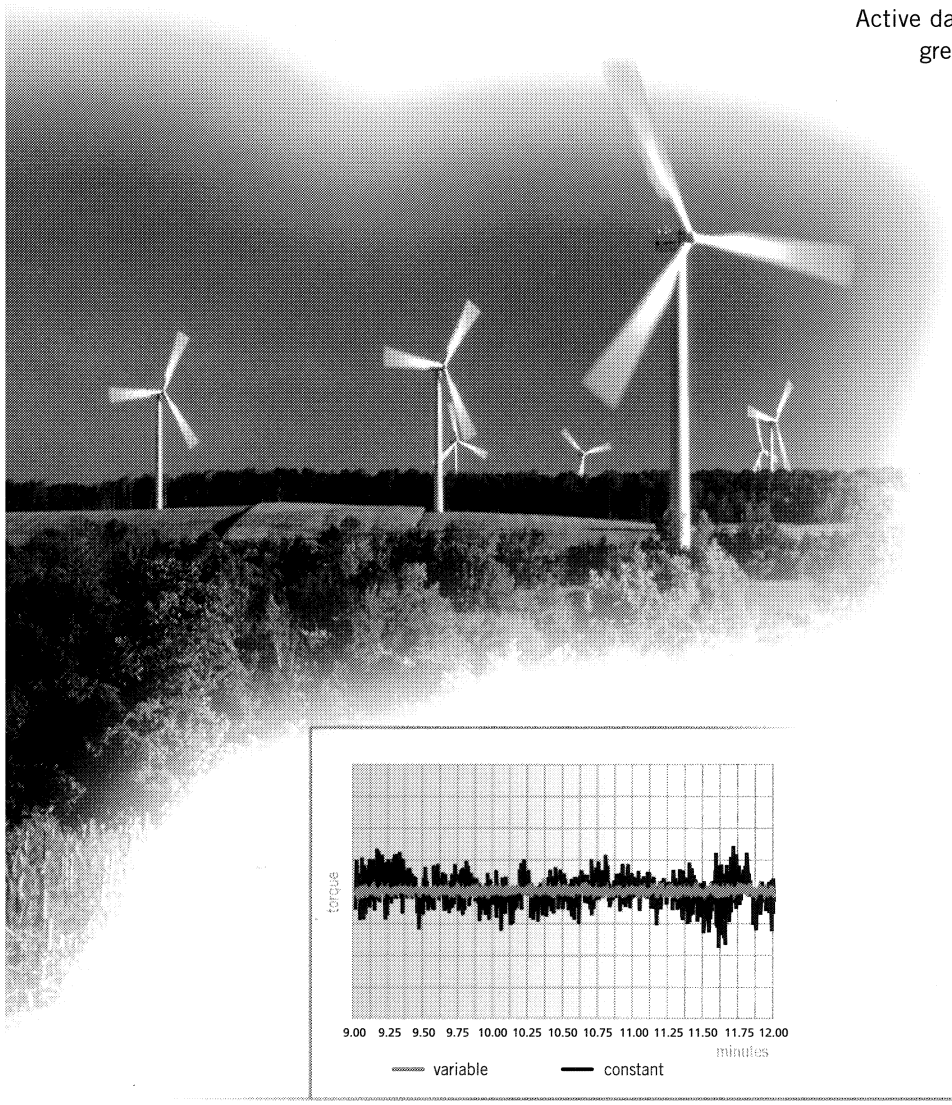
Escurillo, Spain
33 x 1.5sl
total capacity: 49.5 MW

Variable Speed – for higher energy capture and reduced loads.

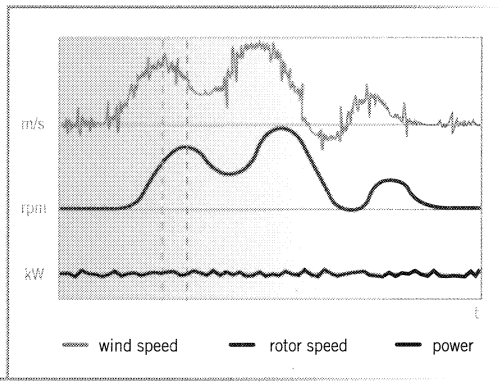
Through the use of advanced electronics, the 1.5 MW turbine features efficient and reliable variable speed control. This feature enables the turbines' control system to continually adjust the rotor rpm level for optimum thrust at each wind speed – allowing the wind turbine to continually operate at its highest level of aerodynamic efficiency. Fixed-speed wind turbines, by contrast, only attain peak efficiency at one speed.

Also, unlike conventional variable-speed machines where all power generated is forced through the converter, the 1.5 MW design is outstandingly efficient. Through the turbines' high-efficiency converter, it is only necessary to convert a quarter of the power generated – substantially minimizing conversion losses. Tower oscillation is kept to a minimum as well, through active damping of the entire turbine system. Active damping also limits peak torque, providing greater drive train reliability, reduced maintenance and longer turbine life.

Fenner, USA
20 x 1.5s,
total capacity: 30 MW



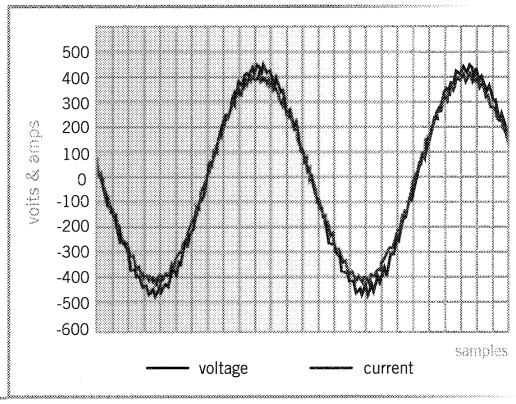
Below – The energy in a wind gust is stored by accelerating the rotor. This leads to reduced loads, improved transmission efficiencies and performance.



Above – GE Wind Energy's variable speed operation provides reduced mean torque loads and smaller torque excursions for a given power output compared to constant speed wind turbines. The result is less wear on the internal drivetrain components and longer turbine life.

Escurillo, Spain
33 x 1.5sl,
total capacity: 49.5 MW

Dynamic reactive power for transmission efficiency and local-grid compatibility.

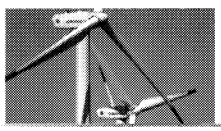


WindVAR Technology:
Leading, lagging or unity power factor

GE Wind Energy's WindVAR power conversion system with VAR control enables the wind turbines to operate at unity, leading or lagging power factor (unity power factor shown left), providing the highest transmission efficiencies and enhanced voltage stability. This is particularly beneficial in weak grid applications.

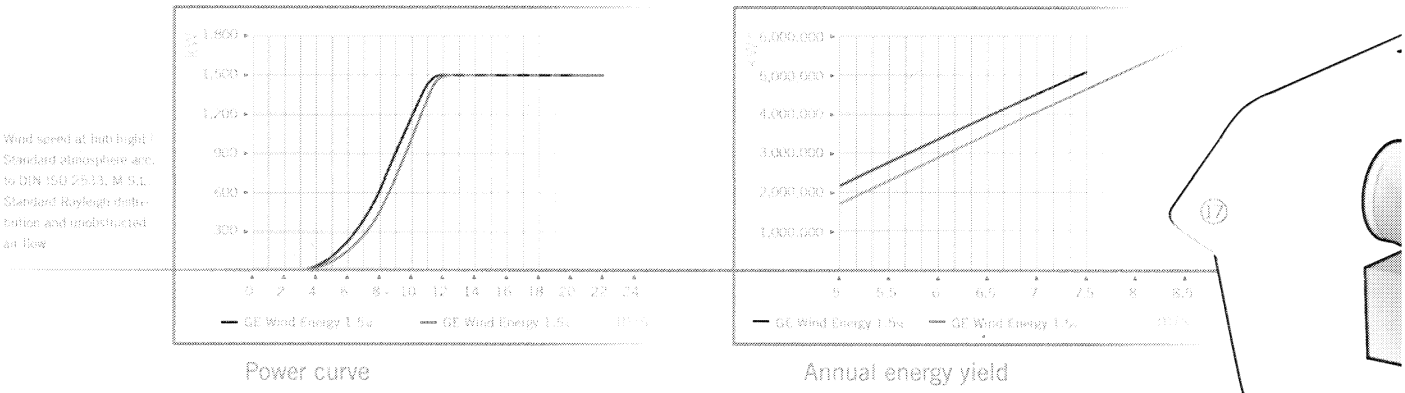
At the heart of the GE Wind Energy technology, our unique WindVAR power electronics system converts the wind turbine's variable-speed operation into constant-frequency power required by the utility. Through WindVAR, voltage is controlled and regulated in real-time. Similar to conventional utility generators, WindVAR enables the turbine to supply reactive power to the grid at the time it's needed, in a fraction of a second, providing transmission efficiencies and enhanced voltage stability. This feature is especially beneficial when the local grid is weak, or in larger turbine installations.

Bassum, Germany
12 x 1.5s,
total capacity: 18 MW



Heede, Germany
11 x 1.5s,
total capacity: 16.5 MW

Trent Mesa, USA
100 x 1.5s,
total capacity: 150 MW

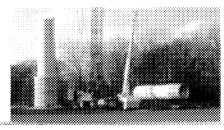


Power curve

Annual energy yield

Support services that keep your goals and expectations at the forefront.

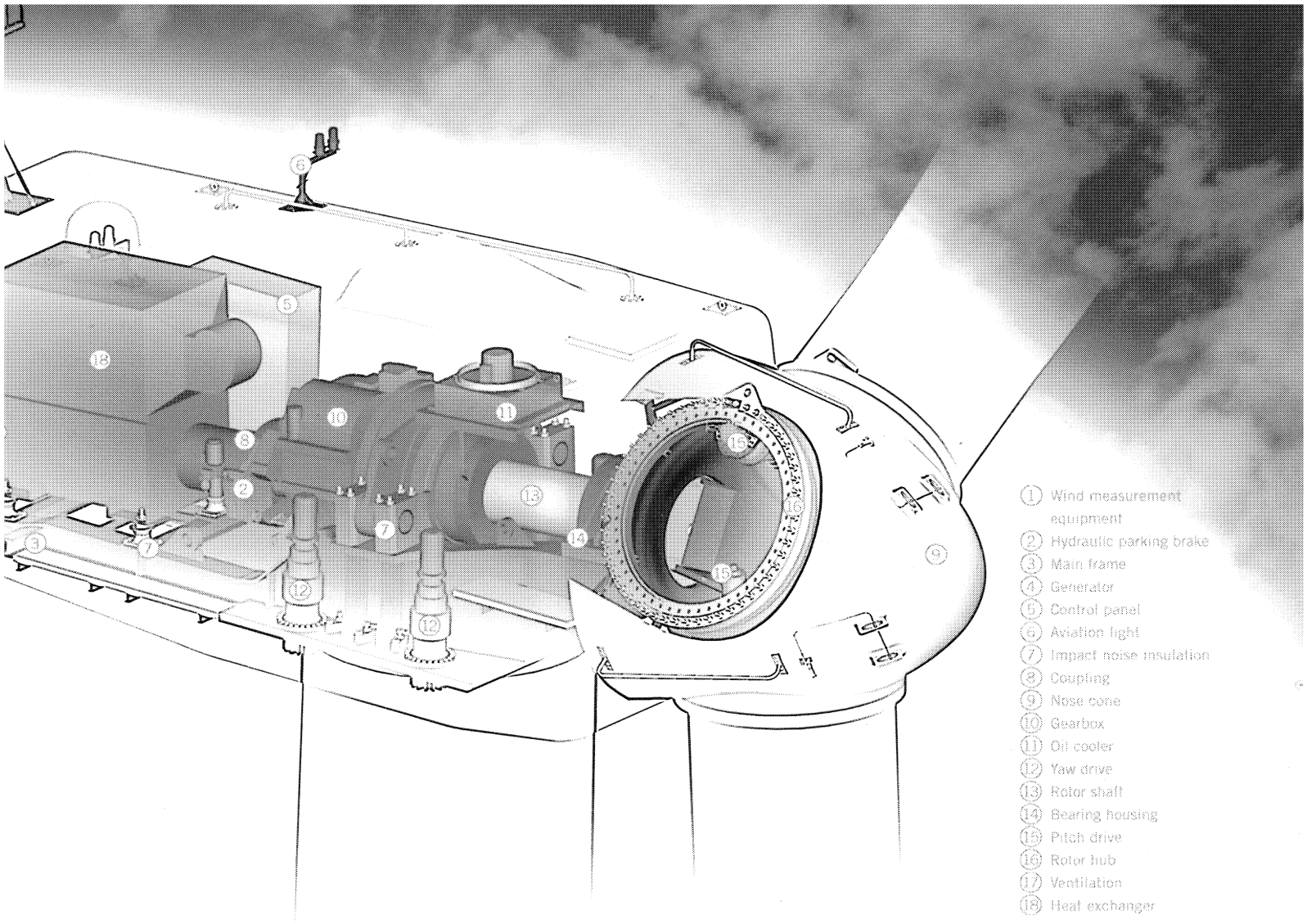
Trent Mesa, USA
100 x 1.5s,
total capacity: 150 MW



With a wide range of capabilities and proven wind project success, we can provide you with your desired level of assistance. From operation and maintenance to project development assistance – we can put our experienced, worldwide resources to work for you.

Once online, your unique project needs are our priority. We will work with you to determine your individual needs and preferred level of assistance – then, we'll be there for you whenever you need us. Our customers are our highest priority and our goal is to deliver the absolute highest customer value – when you're pleased, we are successful.

The installation and commissioning process for our turbines is rigorous. Our commissioning specialists assure that each system's operating and output patterns are optimized for each unique location.



Technical specifications

	1.5sl	1.5s
Operating data		
• Rated capacity:	1,500 kW	1,500 kW
• Cut-in wind speed:	3 m/s	4 m/s
• Cut-out wind speed		
300 s average:	25 m/s	25 m/s
30 s average:	WZ II: 23 m/s, IEC s: 28 m/s	WZ II: 25 m/s, WZ III, IEC II: 28 m/s
3 s average:	WZ II: 25 m/s, IEC s: 30 m/s	WZ II: 27 m/s, WZ III, IEC II: 30 m/s
• Cut-back-in wind speed		
300 s average:	WZ II: 17 m/s IEC s: 22 m/s	WZ II: 19 m/s, WZ III, IEC II: 22 m/s
• Rated wind speed:	11.8 m/s	12 m/s
Rotor		
• Number of rotor blades:	3	3
• Rotor diameter:	77 m	70.5 m
• Swept area:	4,657 m²	3,904 m²
• Rotor speed (variable):	10.1 – 20.4 rpm	11.1 – 22.2 rpm
Tower		
• Hub heights for WZ II:	61.4 / 80 / 85 / 100 m	64.7 / 80 / 85 / 100 m
• Hub heights for WZ III/IEC s:	64.7 / 80 / 85 m	64.7 / 80 / 85 m
Power control:	Active blade pitch control	Active blade pitch control

Operating limits (outside temperature)
- cold weather light: -20° C to +45° C
- cold weather extreme: -30° C to +45° C / -40° C survival without operation

Control system
- PLC (Programmable logic controller) Remote control and monitoring system

Gearbox
- Three step planetary spur gear system

Generator
- Doubly fed three-phase asynchronous generator
  Cos phi ± 0.95 as standard
  Cos phi ± 0.90 on request

Braking system (fail-safe)
- Electromechanical pitch control for each blade (3 self-contained systems)
- Hydraulic parking brake

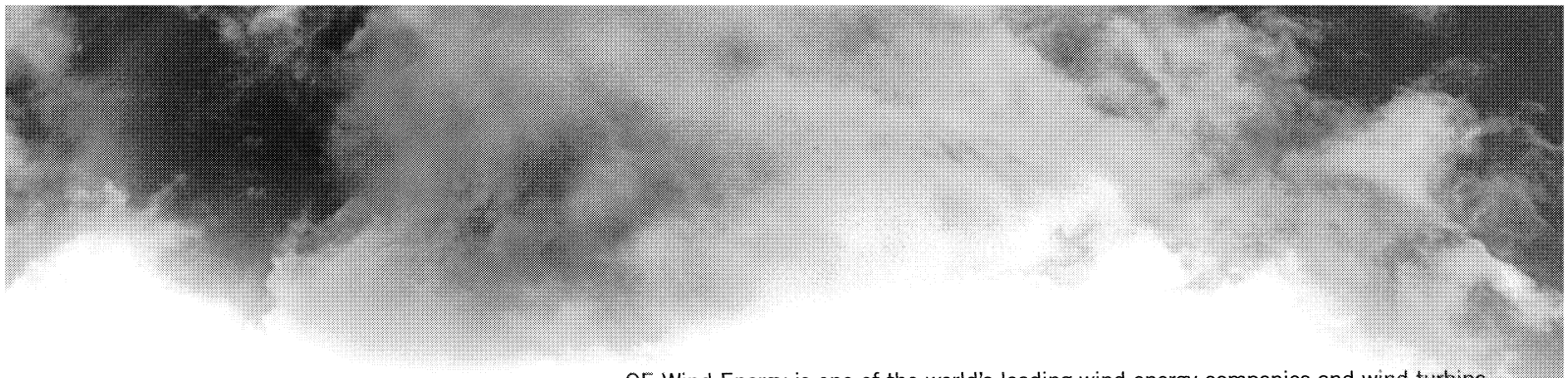
Yaw system
- Electromechanical driven with wind direction sensor and automatic cable unwind

Converter
- Pulse-width modulated IGBT frequency converter

Tower design
- Multi-coated, conical tubular steel tower with safety ladder to the nacelle
- Load lifting system, load-bearing capacity over 200 kg
- Service platform for 100 m hub height (service lift optional)

Noise reduction
- Impact noise insulation of the gearbox and generator
- Sound reduced gearbox
- Noise reduced nacelle
- Rotor blades with minimised noise level

Lightning protection system
- Lightning receptors installed on blade tips
- Surge protection in electrical components



GE Wind Energy is one of the world's leading wind energy companies and wind turbine suppliers. With over 5,600 worldwide wind turbine installations, comprising more than 3,200 MW of capacity, our knowledge and expertise spans more than two decades. We currently design and produce wind turbines ranging from 900 kilowatts to 3.6 megawatts in Germany, Spain and the U.S. In Florida, USA, and the Netherlands, we also manufacture advanced wind turbine blades to assure the highest quality, advanced designs and quick on-time delivery. We know that wind power will be an integral part of the world energy mix in this century and we are committed to helping our customers design and implement energy solutions for their unique energy needs.

Our ISO 9001 Certified production systems, together with our adherence to the rigorous Six-Sigma-control discipline, provide you with quality assurance backed by the strength of GE. As a part of GE Power Systems, we also share the diverse resources of one of the world's leading suppliers of power generation technology and management systems. GE is a company widely known for its commitment to excellence in products and services. Every relationship we pursue bears our uncompromising commitment to quality and innovation.

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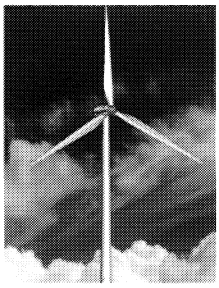
GEA-13550 (7/03, 5M)

V80-1.8 MW

Pitch regulated wind turbine with OptiSlip® and OptiTip®

Vestas



Designed for North America

The Vestas V80-1.8 MW is one of the world's largest commercial wind turbines, optimized specifically to meet North American market requirements. As a natural evolution of Vestas' megawatt-class turbines, it complements the popular Vestas V47-660 kW turbines.

Equipped with well-proven OptiSlip® technology, the design is based on the Vestas V80 that has been operational in Europe since the year 2000. In addition to OptiSlip®, this upwind, 3-blade turbine is equipped with the Vestas OptiTip® blade pitching system. Two different models of the turbine are available. One model has a higher rotor speed and higher production level and is certified for IEC-61400 class 1A wind conditions; the other is a lower rotor speed/lower sound model and is certified for IEC-61400 class 2A wind conditions.

The V80-1.8 MW is optimized for a 60 Hz grid and is in the process of being UL compliant. In addition, Vestas has designed towers for the wind conditions often experienced in North America.

With a rotor diameter of 80 meters, the V80-1.8 MW can be delivered with hub heights up to 78 meters.

Important improvements

Due to its very efficient design, the mass increase of the V80-1.8 MW is marginal compared to our previous MW models. Vestas' aim is to continually optimize turbine weight in relation to machine output in each generation of wind turbines. With a high rating of the generator, the V80-1.8 MW is an ideal choice for sites with limited space because the same installed capacity and a higher energy capture can now be achieved with fewer turbines. The resulting savings on infrastructure, roads and the electric distribution system translate into a higher return on investment.

The V80-1.8 MW has the step-up transformer mounted inside the nacelle. Due to this, the power is instantly transformed to the medium voltage level of the local distribution network. This technology reduces the electrical losses in the tower cables.

For further energy loss reduction, Vestas is using a step-up transformer, which has a very low consumption of its own. Seen over the lifetime of a wind turbine, calculations have shown that megawatt wind turbines will have a significantly higher amount of energy available measured at the medium voltage level when using a low-loss transformer installed in the nacelle.

OptiSlip® optimizes energy production

The V80-1.8 MW's efficiency is enhanced by the presence of OptiSlip®. This Vestas generator feature allows both the rotor and the generator to vary their speed by up to 10% during wind gusts, maximizing power quality and reducing the strain on turbine components.

Though the V80-1.8 MW is particularly well suited for installation in areas with moderate wind conditions, the turbine can adapt to wind conditions in almost any location thanks to OptiSlip®.

OptiTip® optimizes the pitch

Like all other Vestas turbines, the V80-1.8 MW is equipped with OptiTip®, the Vestas microprocessor-controlled pitch regulating system. In 1985, Vestas introduced its first pitch regulation system. This was followed by the introduction of individual blade pitch regulation. The development of these two technologies has made Vestas the market leader in pitch regulation.

The pitch regulating system of the V80-1.8 MW is fitted into the hub and uses a separate hydraulic pitch cylinder for each blade. OptiTip® ensures that the blades are constantly regulated so they are always pitched at the optimal angle for current wind conditions. In addition, this individual pitch regulation for each blade translates into less strain on the rotating system because mechanical braking can be avoided, even in emergency situations.

Sound levels to meet site requirements

Sound may be a major concern when considering the placement of wind turbines in populated inland areas, especially when wind speeds are low. To meet different needs, the V80-1.8 MW turbine can be supplied in two different models with a 2.5 dB difference in sound levels. It should be noted that a reduction of 3 dB(A) is considered to be a 50% reduction of the sound level.

For developers almost half the measured sound level means that two V80 turbines with low sound levels can be placed at nearly the same distance to a sound sensitive location as one turbine with a higher sound level.

Another often forgotten sound aspect of turbines is the fact that the sound level of turbines increases with wind levels until the rated power and background noise increase more than the sound of the turbines. This means that turbine sound can mostly be heard at low wind speeds when the sound level is significantly lower than the normal measurement level at wind speeds equal to 8 m/sec at 10 meters height.

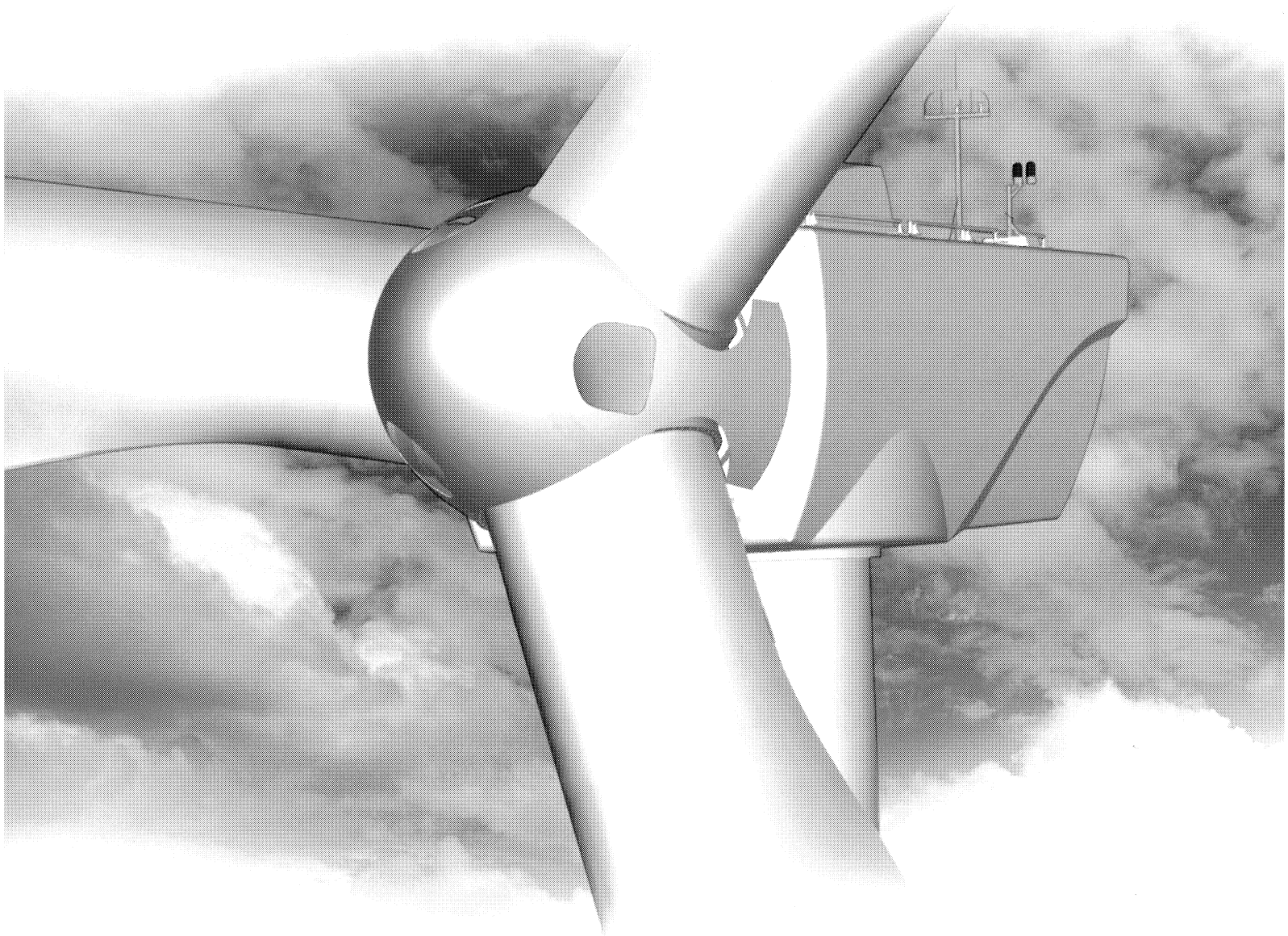
Lightning protection

The Vestas Lightning Protection system is built into the V80-1.8 MW to safeguard the turbine from the forces of nature. The system uses special copper conductors attached to several receptors along the blades to lead lightning to the nacelle and through the tower down into the ground. In addition, the sensitive control units and processors in the nacelle are protected by a shielding system.

11x17

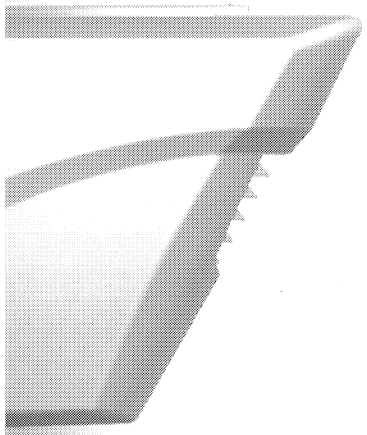
2.7/2.5/2.3 wind turbine

English



imagination at work

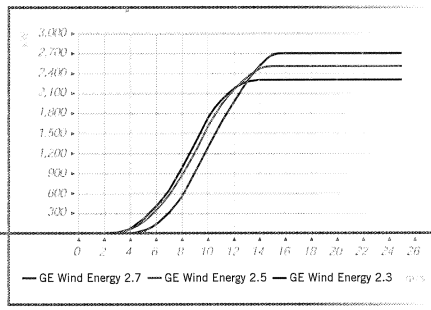
Count on greater returns – Introducing the new 2.X megawatt class.



The new GE Wind Energy 2.X...A wind turbine design that establishes a new class of power. The 2.X machines offer a variety of tower and rotor sizes to customize and optimize energy capture, machine compatibility with both 50 and 60 Hz grid systems, an on-board crane for simplified service, and a modular design that can be transported with ease.

The 2.X provides a compact drive train, state-of-the-art electrical system and an overall modular design to provide ease of transportation.

Power curve



Wind speed at hub height | Standard atmosphere according to DIN ISO 2533, M.S.L. Standard Rayleigh distribution and unobstructed air flow

More power to you.

With a goal to increase customer value, our talented team of engineers have brought yet another series of solutions to the GE Wind Energy portfolio – our new 2.X MW series wind turbines. Available with rated capacities of 2.3, 2.5, and 2.7 megawatts, the 2.X series combine some of the highest land-based wind turbine capacities available today with a cost effective, modular design to optimize shipping logistics and minimize the need for large-capacity cranes. And, because each wind site holds its own unique challenges, the 2.X series also offers a wide variety of rotor and tower options to assure full optimization of your wind project site.

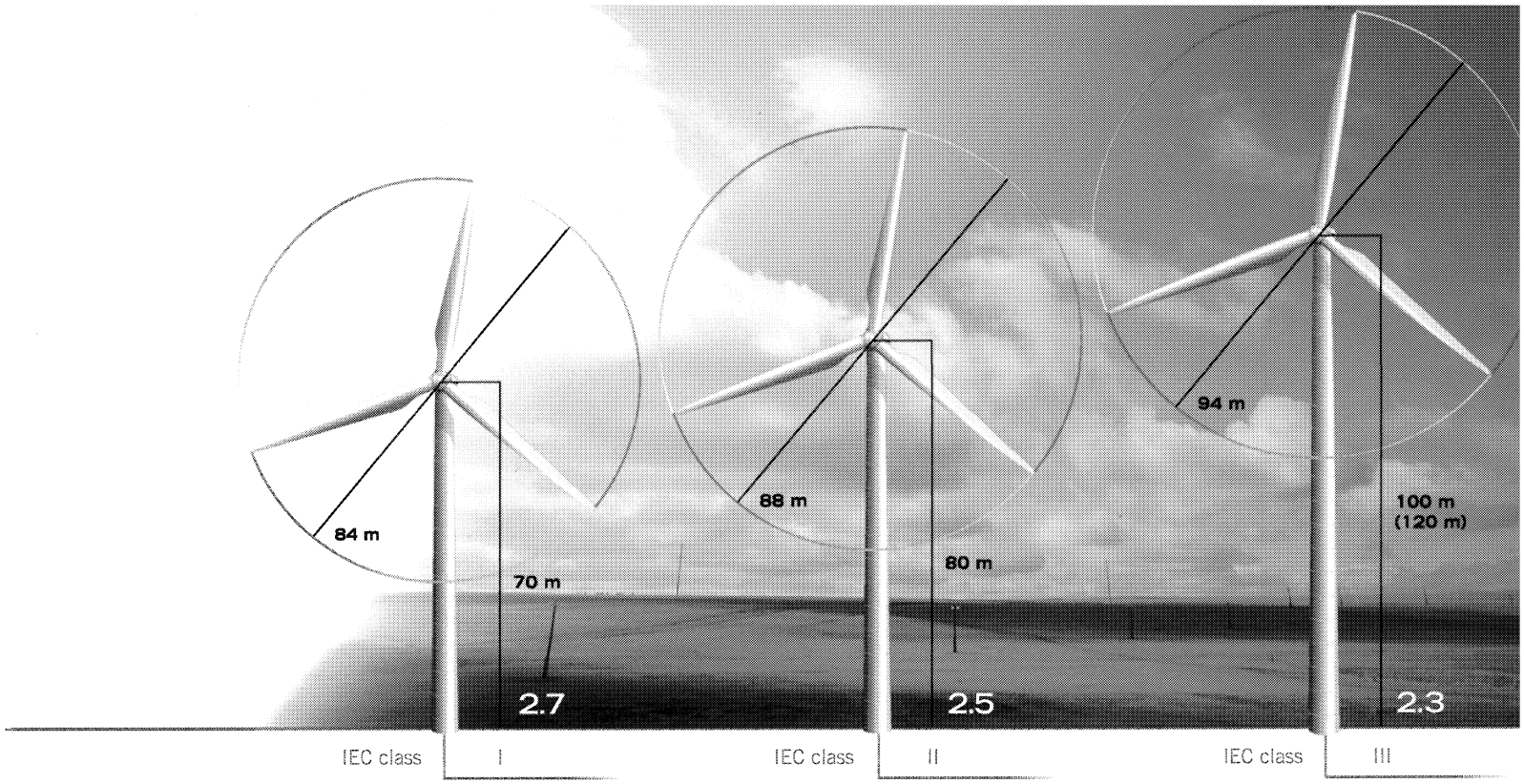
Proven technology + added value.

Our 2.X planning began with what we know best. Technology and components were designed utilizing both customer feedback and the extensive field knowledge and technical expertise gained from the manufacture and operation of over 1,800 GE Wind Energy 1.5 MW wind turbines. With installations around the globe, this turbine is one of the world's most widely sold MW class machines.

Like other GE wind turbine models, each 2.X series wind turbine features variable-speed and blade pitch operation, and unique Wind Volt-Amp-Reactive ("WindVAR") control electronics for seamless grid interaction.

To this successful platform, we added flexibility – a variety of tower and rotor sizes to customize and optimize energy capture at each wind site, overall machine compatibility with both 50 and 60 Hz grid systems, and an on-board crane is designed-in to simplify service requirements and minimize cost.

Since transportation logistics associated with moving extremely large machines to remote sites can be complex and challenging, GE Wind Energy's engineers specified a modular, easy-to-transport design as an important design criteria for the 2.X machines. With the addition of one standard-size shipping container to house the drive-train, the 2.X nacelle is easily transported in three pieces utilizing transport requirements similar to our popular 1.5 MW machine. The 2.X's modular design also minimizes the weight of the lift during installation, enabling the use of crane sizes comparable to those used for 1.5 MW machine installations. This new class of wind turbine provides highly cost effective operation - especially at wind sites where space is limited, or where minimal installations are preferred.



Maximum efficiency with minimal loads.

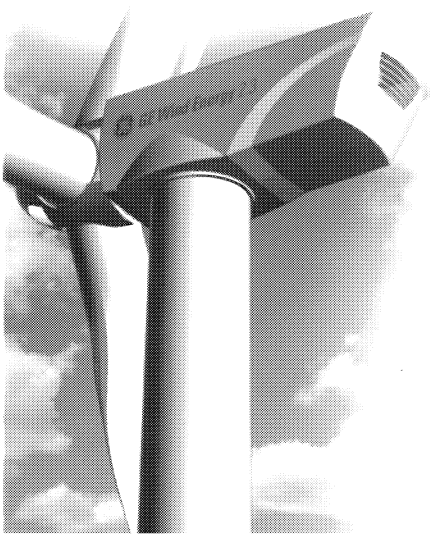
With the same advanced electronics and reliable variable speed controls common to all GE Wind Energy turbines, the 2.X wind turbines provide high energy capture. Through these advanced electronics, the turbine's control system continually adjusts rotor rpm levels for optimum lift at each wind speed – assuring that the wind turbine operates continually at its highest aerodynamic efficiency.

Tower oscillation is also minimized through active damping from the rotor down through the entire turbine system. Active damping also limits peak torque, providing greater drive train reliability, reduced loads and maintenance. The result: longer turbine life and minimal down time.

Form follows function. Because total cost-efficiency and availability are the standards used to judge the quality of a wind turbine. What could be better than a design concept whose optimized form and function support these two core aspects?

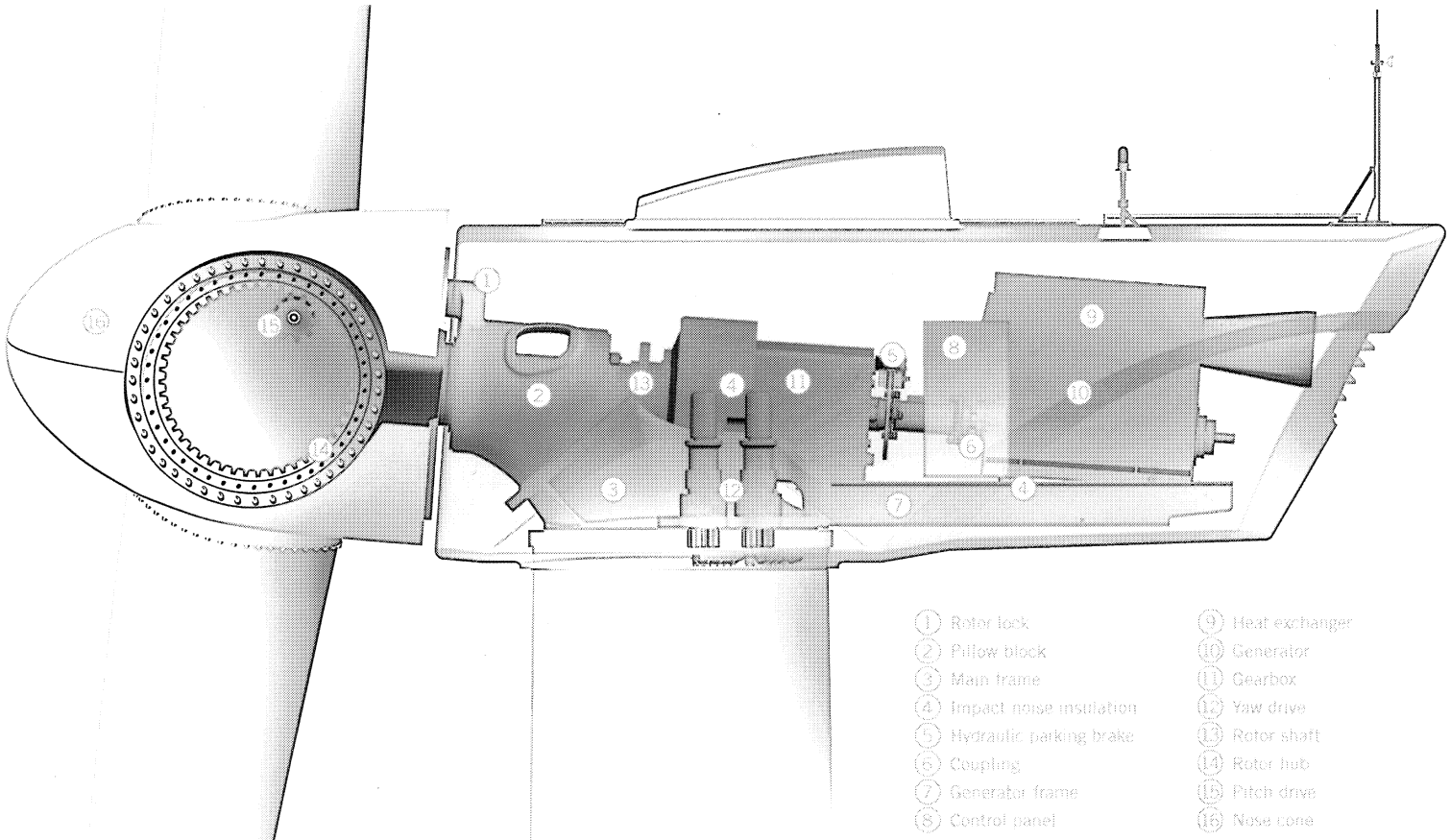
The 2.X is versatile.

While the new 2.X MW class maintains a common nacelle design and turbine platform, it also offers versatility in the form of varying hub heights and rotor diameters. With hub heights available up to 120 meters, and a wide variety of rotor diameters (up to 94 meters), we can help to optimize your tower and rotor configuration to provide the most economic return for your unique project.



Grid-friendly power generation.

GE Wind Energy's WindVAR control electronics, available in all GE Wind Energy models, eliminates undesirable voltage increases or fluctuations. Each turbine controls – in real time – the quality of the power delivered to the grid. This enables our turbines to supply reactive power to the local transmission system whenever it's needed. Voltage regulation is delivered in a fraction of a second, insuring safety, transmission efficiency and cost-effective power delivery. This feature is especially beneficial to customers connecting to weak local grid systems, or when connecting larger installations which are located a distance from the point of delivery.



Technical Specifications

	2.7	2.5	2.3
Operating data			
• Rated capacity:	2,700 kW	2,500 kW	2,300 kW
• Cut-in wind speed:	3.5 m/s	3.5 m/s	3.0 m/s
• Cut-out wind speed:	25 m/s	25 m/s	25 m/s
Rotor			
• Number of rotor blades:	3	3	3
• Rotor diameter:	84 m	88 m	94 m
• Swept area:	5,542 m²	6,082 m²	6,940 m²
• Rotor speed (variable):	6.5 – 18.0 rpm	6.0 – 16.5 rpm	5.5 – 14.9 rpm
Tower			
• Hub heights:	58 / 70 m	80 m	100 / 120 m
• Construction method:	Tubular steel	Tubular steel	concrete / tubular steel (hybrid)
Power Control:	Active blade pitch control	Active blade pitch control	Active blade pitch control
IEC class:	I	II	III

Gearbox
- Three step planetary spur gear system

Generator and Converter
- AC-Generator with IGBT converter

Braking system (fail-safe)
- Electromechanical pitch control for each blade (3 self-contained systems)
- Hydraulic parking brake

Yaw system
- Electromechanical driven with wind direction sensor and automatic cable unwind

Lightning protection system
- Lightning receptors installed along blades
- Surge protection in electrical components

Noise reduction
- Impact noise insulation of the gearbox and generator
- Sound reduced gearbox
- Noise reduced nacelle
- Noise reduced rotor blades

Control system
- PLC (Programmable logic controller)
- Remote control and monitoring system

Condition Monitoring
- Measurement and remote monitoring system for early detection of defects

Crane system
- Small on-board crane for service work and replacement of standard moving parts

Subject to technical alterations, errors and omissions.

GE Wind Energy is one of the world's leading wind energy companies and wind turbine suppliers. With over 6,100 worldwide wind turbine installations, comprising more than 4,000 MW of capacity, our knowledge and expertise spans more than two decades. We currently design and produce wind turbines ranging from 900 kilowatts to 3.6 megawatts in Germany, Spain and the U.S. In Florida, USA, and the Netherlands, we also manufacture advanced wind turbine blades to assure the highest quality, advanced designs and quick on-time delivery. We know that wind power will be an integral part of the world energy mix in this century and we are committed to helping our customers design and implement energy solutions for their unique energy needs.

Our facilities conform to the international ISO 9001 Quality Systems Standard. This standard, together with our adherence to the rigorous Six-Sigma-control discipline, provide you with quality assurance backed by the strength of GE. As a part of GE Power Systems, we also share the diverse resources of one of the world's leading suppliers of power generation technology and management systems. GE is a company widely known for its commitment to excellence in products and services. Every relationship we pursue bears our uncompromising commitment to quality and innovation.

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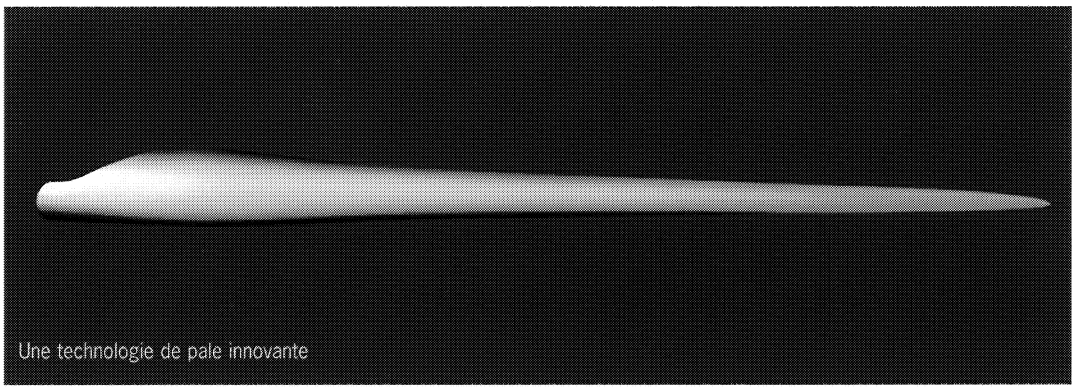
GEA-13549 (11/03, 5M)

V90-3,0 MW
Une solution efficace pour une puissance optimale

Vestas



Une technologie de pale innovante

Une solution efficace pour une puissance optimale

Depuis plus de 20 ans, Vestas est un pionnier en matière de recherche et développement, de fabrication, de commercialisation et de maintenance d'éoliennes. Cela a contribué à améliorer la compétitivité de l'énergie éolienne. Notre industrie se développe rapidement. Par conséquent, il est particulièrement important de s'intéresser aux performances globales des éoliennes conçues suivant une technologie respectant les règles de l'art. Avec l'introduction de l'éolienne V90-3,0 MW, Vestas repousse une fois de plus les limites du possible dans la technologie éolienne.

Basée sur une nouvelle approche de développement testée dans ses moindres détails et combinée à la technique industrielle Vestas reconnue et éprouvée, la V90-3,0 MW est une extension naturelle de la gamme des éoliennes de forte puissance.

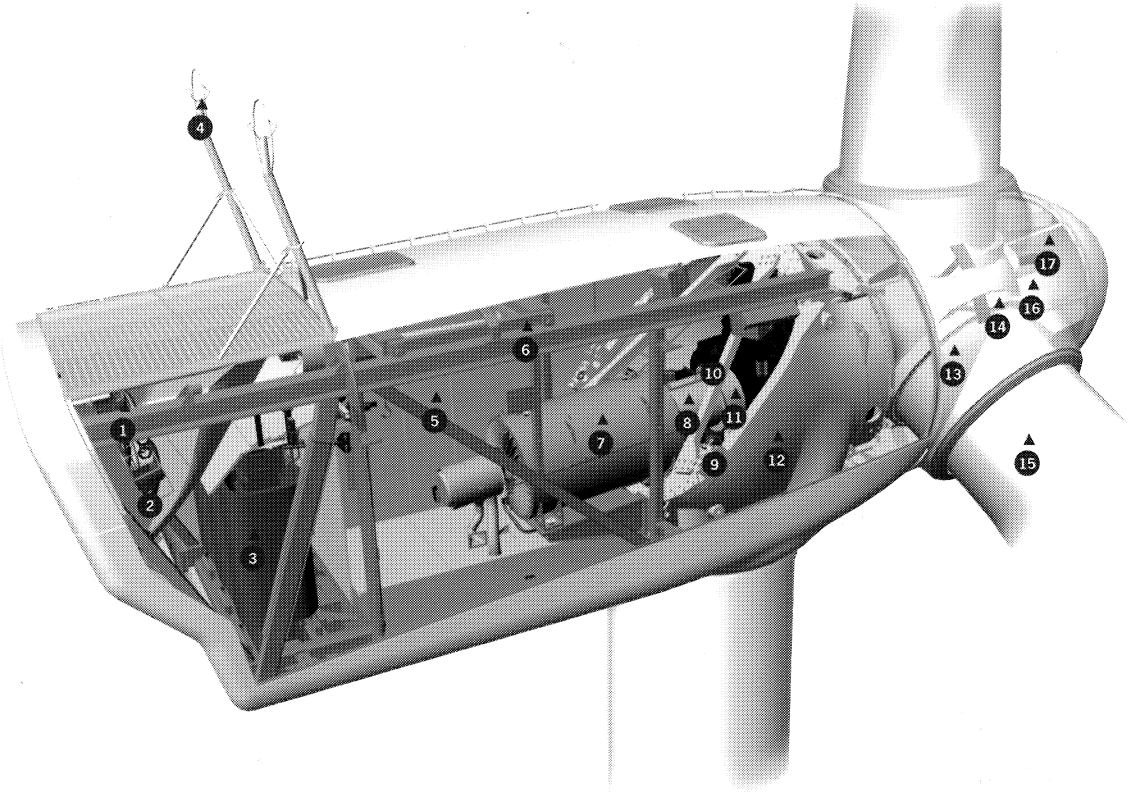
L'objectif visé par le développement de la V90-3,0 MW était d'obtenir une réduction du coût de revient par kilowattheure (kWh) produit, calculé sur la durée de vie totale de l'aérogénérateur, soit 20 ans.

Une technologie innovante sur une pale de 44 mètres

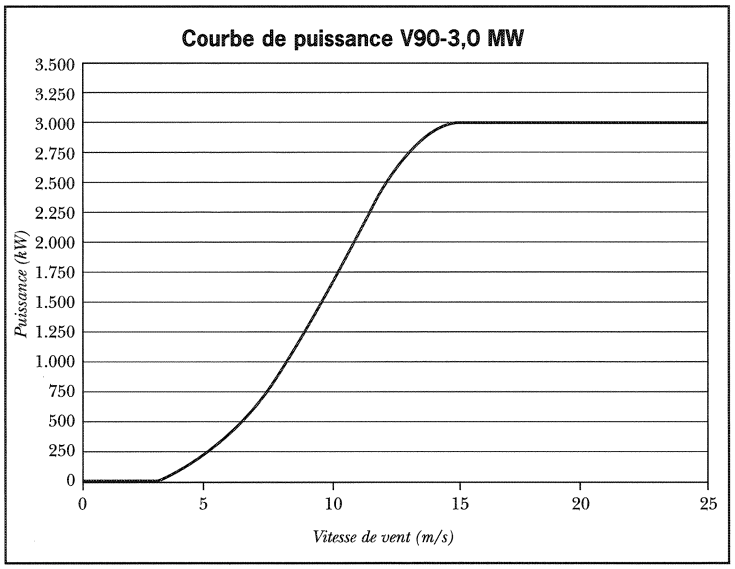
Si l'on s'en tient à une approche classique, concevoir une machine de puissance supérieure revient invariablement à fabriquer une machine plus lourde et plus grande. Cependant, ceci affecterait l'objectif final de produire davantage d'énergie pour un coût de revient moins élevé par kWh.

La conception de la nouvelle pale de la V90 laisse entrevoir un nombre appréciable de nouvelles possibilités de développement. Celle-ci est extrêmement légère, une avancée accomplie par Vestas grâce à l'utilisation d'une gamme de nouveaux matériaux. Par exemple la fibre de carbone – un matériau résistant, rigide et très léger a été utilisée en remplacement de la fibre de verre pour l'élaboration de la structure supportant la charge des pales. Grâce à la résistance de cette fibre, il est devenu possible de réduire la quantité de matériau employée pour la réalisation des pales et donc de diminuer appréciablement le poids total ainsi que les charges. Grâce à cette évolution, les nouvelles pales de 44 mètres de la V90 sont plus légères que celles de 39 mètres de nos V80.

De plus, Vestas a fait de formidables progrès au niveau des profils aérodynamiques des pales. Ceux-ci sont les premiers d'une nouvelle génération permettant d'augmenter la production d'énergie, de réduire l'impact de la rugosité sur le bord d'attaque de la pale, et de maintenir une bonne continuité géométrique entre un profil aérodynamique et le suivant. La géométrie de ces nouvelles pales a été définie en optimisant la relation entre l'impact général de la charge sur l'éolienne et sa production annuelle d'énergie. Le profil aérodynamique a été développé en collaboration avec le Laboratoire National de Risø, au Danemark. La conception innovante de la pale Vestas améliore la performance de l'éolienne et permet d'augmenter son rendement, tout en réduisant les charges transférées à la machine.



1. Refroidisseur d'huile
2. Refroidisseur d'alternateur
3. Transformateur
4. Anémomètre ultrasonique
5. Régulateur supérieur VMP avec convertisseur
6. Treuil
7. Alternateur OptiSpeed®
8. Liaison composite
9. Couronne d'orientation
10. Multiplicateur
11. Frein
12. Châssis
13. Roulement de pale
14. Moyeu
15. Pale
16. Vérin de réglage de pas
17. Régulateur au moyeu



Caracteristiques techniques

Rotor

Diamètre:	90 m
Surface balayée:	6.362 m²
Vitesse de rotation:	16,1 rpm
Intervalle de fonctionnement:	9-19 rpm
Nombre de pales:	3
Régulation de la puissance:	Pas variable/OptiSpeed®
Frein à air:	Trois vérins distincts de régulation du pas

Tour

Hauteur de moyeu:	65 m, 80 m, 90 m, 105 m

Données opérationnelles

Vitesse de démarrage:	4 m/s
Vitesse de vent nominale:	15 m/s
Vitesse de coupure:	25 m/s

Alternateur

Type:	Asynchrone avec OptiSpeed®
Puissance nominale:	3.000 kW
Données d'exploitation:	50 Hz 1.000 V

Multiplicateur

Type:	Planétaire/axes parallèles

Contrôle

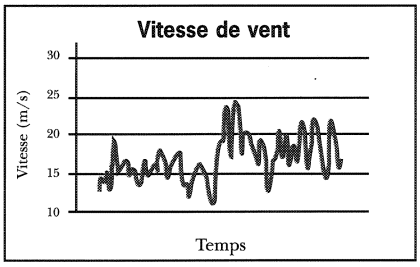
Type:	Commande par microprocesseur de l'ensemble des fonctions de l'éolienne avec possibilité de télésurveillance. Système OptiSpeed® pour la régulation et l'optimisation de la puissance et système OptiTip® pour le réglage des pales.

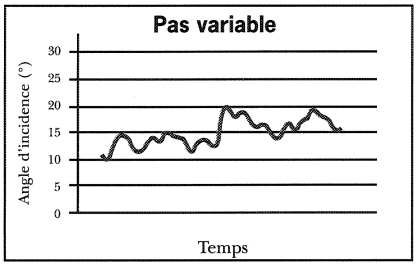
Poids

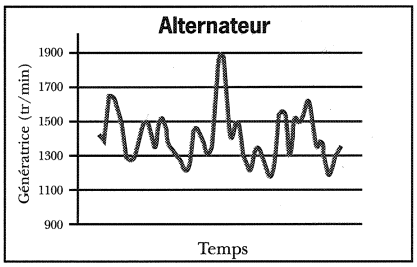
Moyeu:	65 m	80 m	90 m	105 m
Tour:	115 t	156 t	205 t	275 t
Nacelle:	66 t	66 t	66 t	66 t
Rotor:	38 t	38 t	38 t	38 t
Total:	219 t	260 t	309 t	379 t

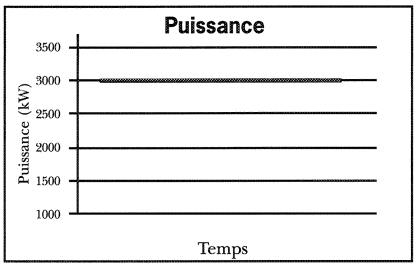
t = tonnes métriques

Toutes ces caractéristiques sont susceptibles d'être modifiées dans avis préalable.



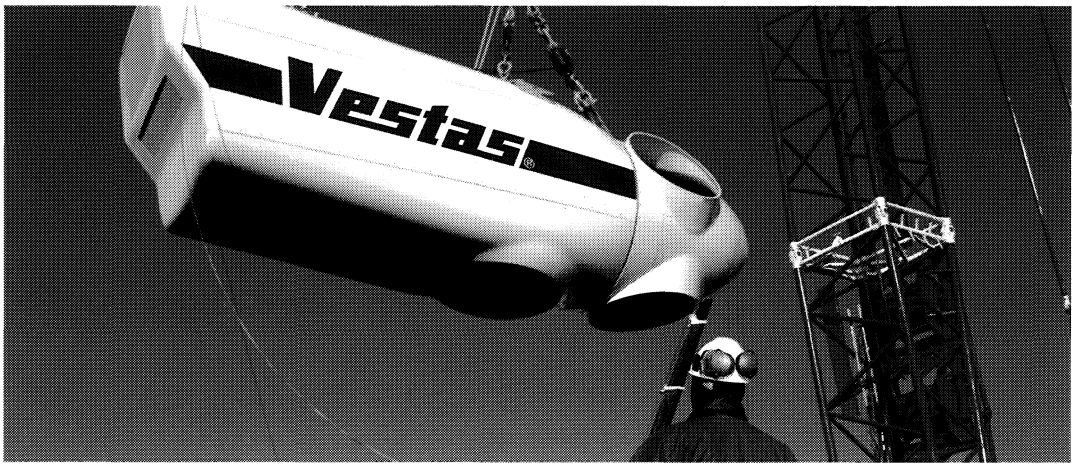






Le système OptiSpeed® permet une variation d'environ 60% des vitesses de rotation du rotor et de l'alternateur, ce qui minimise les oscillations indésirables sur le réseau électrique et réduit les contraintes sur les pièces essentielles de la construction.

* Vestas OptiSpeed® n'est pas disponible aux USA et au Canada.



Une conception révolutionnaire de la nacelle

Vestas a choisi de s'aventurer sur des chemins non expérimentés pour la conception d'une nouvelle nacelle fiable et résistante qui puisse générer davantage d'énergie sans impliquer une augmentation de taille et de poids de la nacelle ni des charges supportées par la tour et la fondation.

Vestas s'est surpassé pour obtenir une nacelle de V90-3,0 MW qui est le résultat de cette nouvelle conception révolutionnaire. Ses particularités innovantes permettent aux forces agissant sur la machine d'être absorbées par un châssis optimisé. De plus le moyeu est désormais fixé à un support large, localisé sur la périphérie du multiplicateur, ce qui élimine, entre autre la nécessité d'un arbre principal standard. Le résultat s'apprécie dans une construction globalement plus légère. La nouvelle conception du multiplicateur a été vérifiée par des experts indépendants, et des tests complémentaires ont prouvé son efficacité. Dans cette optique, le laboratoire de recherche de Vestas a accompli des tests en grandeur nature sur les multiplicateurs.

Cette nouvelle conception a influencé les contraintes dimensionnelles de la construction, ce qui aboutit à une réduction de la longueur totale de la nacelle comparée à celle de la V80. D'autre part les charges supportées par le système de transmission sont minimisées. En définitive, le poids final de cette nouvelle nacelle est presque identique à celui de la nacelle de la V80.

Le transport et la logistique faisant désormais partie intégrante de la construction de parcs constitués d'éoliennes de la gamme multi-mégawatts, Vestas a une nouvelle fois innové en concevant une nacelle qui intègre son propre système de support pour le transport. Si, jusqu'à présent, la seule option possible était de charger la nacelle sur un véhicule semi-remorque spécial, aujourd'hui la nacelle de la V90 est autosupportée puisque les fixations de transport peuvent être accrochées directement à la structure de transport.

Une tour légère et résistante

Grâce à un certain nombre d'améliorations dans la phase de conception, Vestas introduit aujourd'hui une nouvelle tour pour les turbines de type V90-3,0 MW.

Une conception intelligente a permis une tour plus légère. L'idée novatrice a été notamment d'utiliser des aimants plutôt que de souder les éléments à l'intérieur de la tour tout en augmentant sa capacité de résistance. Ainsi le poids de la tour de 80 mètres de la V90-3,0 MW est de seulement 156 tonnes alors qu'un modèle de taille identique pour une V80 affiche un poids de 200 tonnes. Cette diminution du poids total de la tour, d'environ 44 tonnes, réduit également les coûts de transport.

Une maintenance et un service moins exigeants

Une autre amélioration significative apportée au modèle V90-3,0 MW est la nécessité d'une seule visite préventive annuelle alors que les autres modèles en exigeaient deux. L'accès aux éoliennes a été simplifié par un agencement intérieur optimisé dans la tour et la nacelle. Plus un espace est étudié pour être fonctionnel, plus il est aisé d'y effectuer les tâches de service et maintenance.

Les besoins d'entretien ont été réduits grâce à l'amélioration d'un grand nombre de points particuliers ; par exemple la lubrification automatique du support de pales ou du système de transmission. Ces améliorations, parmi tant d'autres, ont permis à la V90-3,0 MW de ne nécessiter qu'une seule visite de contrôle annuelle. Finalement il en résulte que les coûts d'entretien et de fonctionnement au kWh sont moindres.

Avec l'introduction de la V90-3,0 MW, Vestas développe une fois de plus une éolienne remarquable, autant adaptée pour les projets sur site terrestre que maritime.

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Vestas

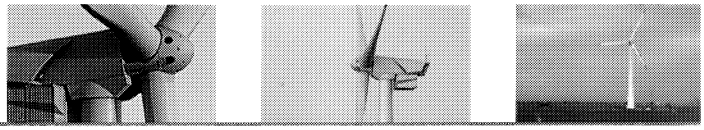
V47.0

3.6s offshore wind turbine

English

imagination at work

The 3.6s offshore wind turbine – combining proven technology with valuable offshore expertise.



Barrax, Spain, 1 x 3.6s (prototype), total capacity: 3.6 MW

In Spain, our 3.6 MW prototype, erected in September 2002, is installed on farmland southeast of Madrid. Off the coast of Ireland, seven GE 3.6 MW machines are installed as a demonstration platform. These 3.6 MW units are the first expressly designed for offshore applications.

As the world's first wind turbine expressly designed for offshore use, our new 3.6 MW series machine combines the best of our successful 1.5 MW technology with valuable expertise gained from building and operating one of the world's first megawatt-class off-shore wind farms.

A larger version of our proven 1.5 MW design, the 3.6 MW machine was specifically designed for high-speed wind sites. With a rotor diameter of 104 meters and a swept area of 8,495 square meters, the new wind turbine is ideal for offshore markets worldwide. Active yaw and pitch regulated with power/torque control capability and a double-fed asynchronous generator, it utilizes a distributed drive train design where all nacelle components are joined on a common structure, providing exceptional durability. The generator and gearbox are supported by elastomeric elements to minimize noise emissions.

The 3.6 MW wind turbine also features variable-speed control and independent blade pitch to assure aerodynamic efficiency and reduce loads on the drive train, providing reduced maintenance and longer turbine life. The turbine's independent blade pitch system mitigates the need for large emergency braking systems and enables the use of a large rotor for increased energy yield. At the same time, GE's unique Wind Volt-Amp-Reactive ("WindVAR") electronics provide transmission efficiencies and enable the turbine to function harmoniously within the electricity grid.

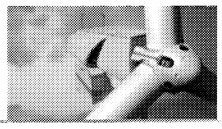
Arklow, Ireland
7 x 3.6s offshore
total capacity: 25 MW

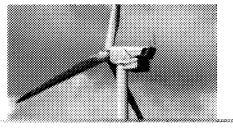
From innovation to success to knowledge to innovation...

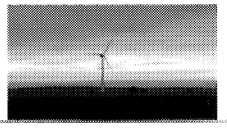
A multitude of innovations that can provide greater returns on your investment.

During year 2000, the world's first "megawatt-class" offshore wind farm, "Utgrunden", was completed off the south east cost of Sweden. Designed, built and operated by our team, this knowledge base and know-how has been incorporated into our 3.6 MW offshore wind turbines.

Our multi-megawatt class isn't just a trendsetter in terms of power – many of its features also set new standards. Innovations include higher-efficiency blades resistant to dirt and abrasion, an improved gearbox concept, and structure adjustments to enhance load absorption and optimize assembly and transport. From an optional 40-ton internal crane to simplify the exchange of major components, including the gearbox and generator – all without external support by heavy cranes – to a second, optional two-ton gantry crane which facilitates easy repair and maintenance within the nacelle...simplified service requirements were a key design goal.



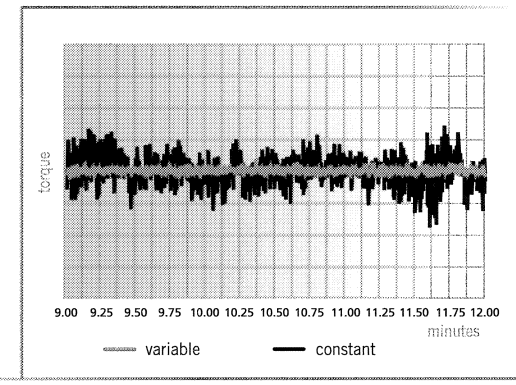




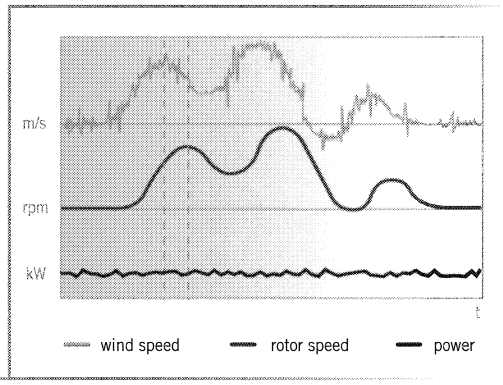
The 3.6 MW technology also features exceptionally robust components, including marinized paint systems and lubrication filter systems – our higher-strength structural components assure greater reliability and longer service intervals – an important cost-savings feature, particularly when it comes to the rigors of offshore power generation.

The integration of an electrical container located directly underneath the nacelle houses sensitive electrical components, including the control panel, converter, switching systems and transformer. The container also enables easy access during maintenance work and improved protection against corrosion. In addition, the 3.6 MW wind turbines can be outfitted with a helicopter hoisting platform on the nacelle to provide heli-access to the machine.

Variable Speed – for higher energy capture and reduced loads.



GE's variable speed operation provides reduced mean torque loads and smaller torque excursions for a given power output compared to constant speed wind turbines. The result is less wear on the internal drivetrain components and longer turbine life.



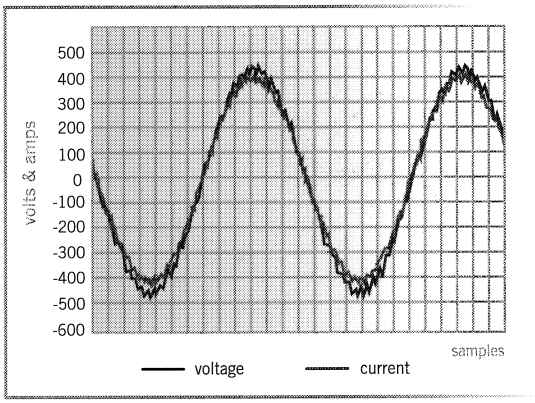
The energy of a gust is stored by accelerating the rotor. This leads to reduced loads, improved transmission efficiencies and performance.

Through the use of advanced electronics, the 3.6 MW turbines feature efficient and reliable variable speed control. This feature enables the turbines' control system to continually adjust the rotor rpm level for optimum lift at each wind speed – allowing the wind turbine to continually operate at its highest level of aerodynamic efficiency. Together with its new high-performance blades, variable rotor speed technology ensures an extremely high-energy yield. Loads are also minimized due to the turbines pitch-regulated rotor. Tower oscillation is also kept to a minimum, thanks to active damping of the entire turbine system. Active damping also limits peak torque, providing greater drive train reliability, reduced maintenance and longer turbine life.

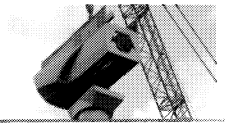
Dynamic reactive power for transmission efficiency and local-grid compatibility.

At the heart of the GE technology is the company's unique WindVAR power conversion system which converts the wind turbine's variable-speed operation into the constant-frequency power required by the utility. Through WindVAR, voltage is controlled and regulated in real-time. Similar to conventional utility generators, WindVAR enables the turbine to supply reactive power to the grid at the time it's needed, in a fraction of a second, providing transmission efficiencies and enhanced voltage stability. This feature is especially beneficial when the local grid is weak, or in larger turbine installations.

WindVAR power conversion system:
Leading, lagging or unity power factor:



GE's WindVAR system enables the wind turbines to operate at unity, leading or lagging power factor (unity power factor shown above), providing the highest transmission efficiencies and enhanced voltage stability. This is particularly beneficial in weak grid applications.

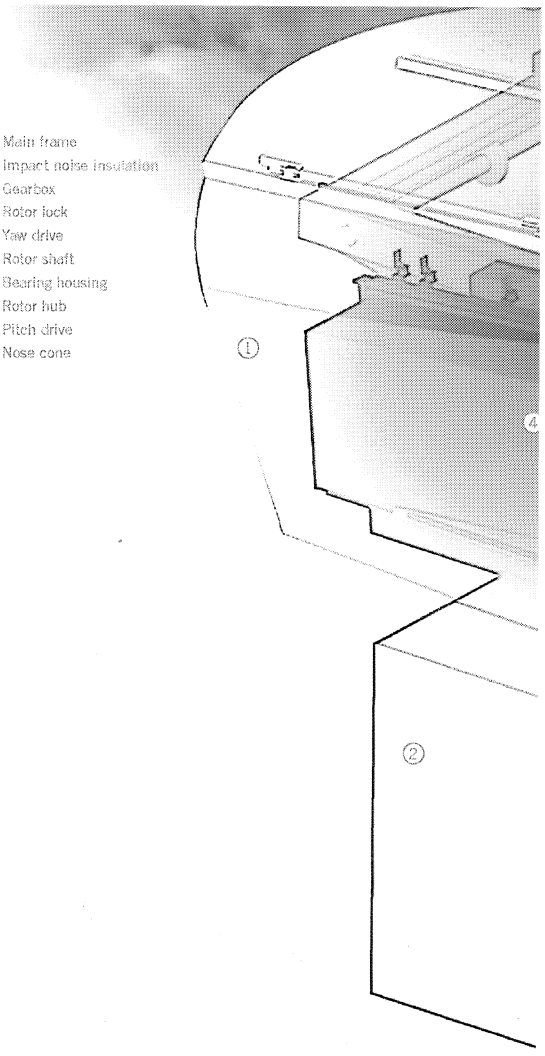


The installation and commissioning process for our turbines is rigorous. Our commissioning specialists ensure that the operating and output patterns of each system are optimized for the specific location in which it is installed.

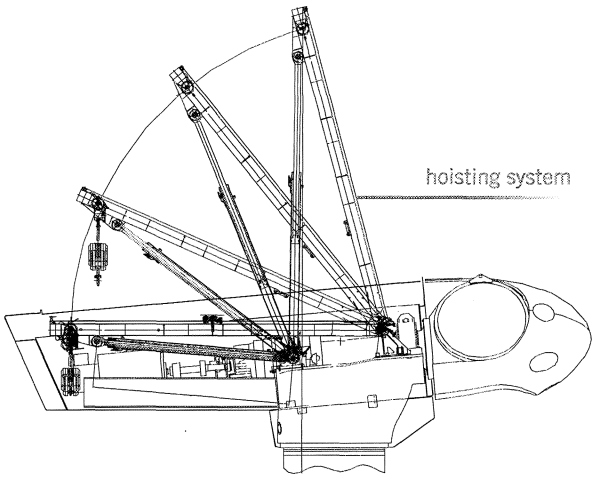
Installation and support services that keep your goals and expectations at the forefront.

With a wide range of capabilities and proven wind project success, we can provide you with your desired level of assistance. From operation and maintenance to project development assistance – we can put our experienced, worldwide resources to work for you.

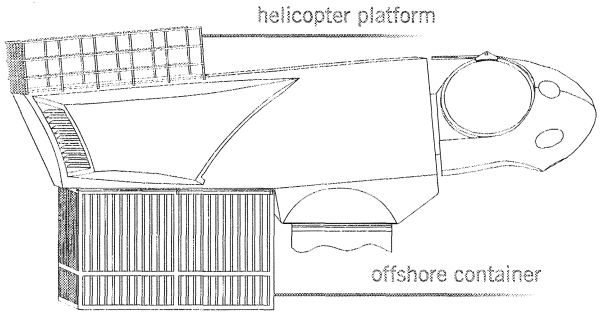
Once online, your project needs are our priority. We will work with you at your preferred level of assistance – then, we'll be there for you whenever you need us. Our customers are our highest priority and our goal is to deliver the absolute highest customer value – when you're pleased, we are successful.



1. Ventilation
2. Offshore container
3. Small gantry crane
4. Heat exchanger
5. Control panel
6. Generator
7. Oil cooler
8. Coupling
9. Hydraulic parking brake
10. Swiveling crane
11. Main frame
12. Impact noise insulation
13. Gearbox
14. Rotor lock
15. Yaw drive
16. Rotor shaft
17. Bearing housing
18. Rotor hub
19. Pitch drive
20. Nose cone

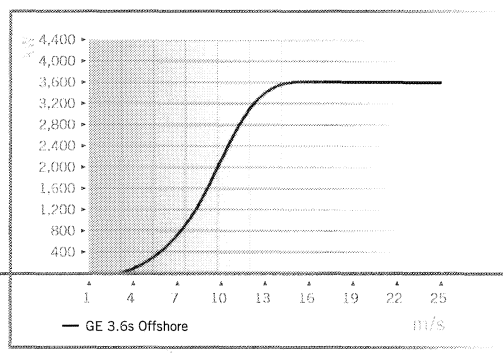


Our optional hoisting system, comprised of an integrated hydraulic crane and a small gantry crane, eliminates the need for large and expensive external cranes.

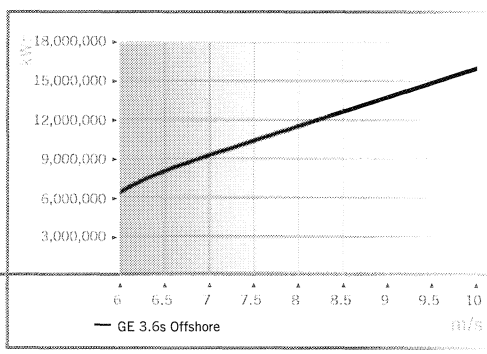


The electrical container, located directly beneath the nacelle, provides direct access for support staff. It also houses the entire electrical system including transformer, converter and controls. An optional helicopter hoisting platform provides quick access to offshore wind units – especially during turbulent seas.

Technical data



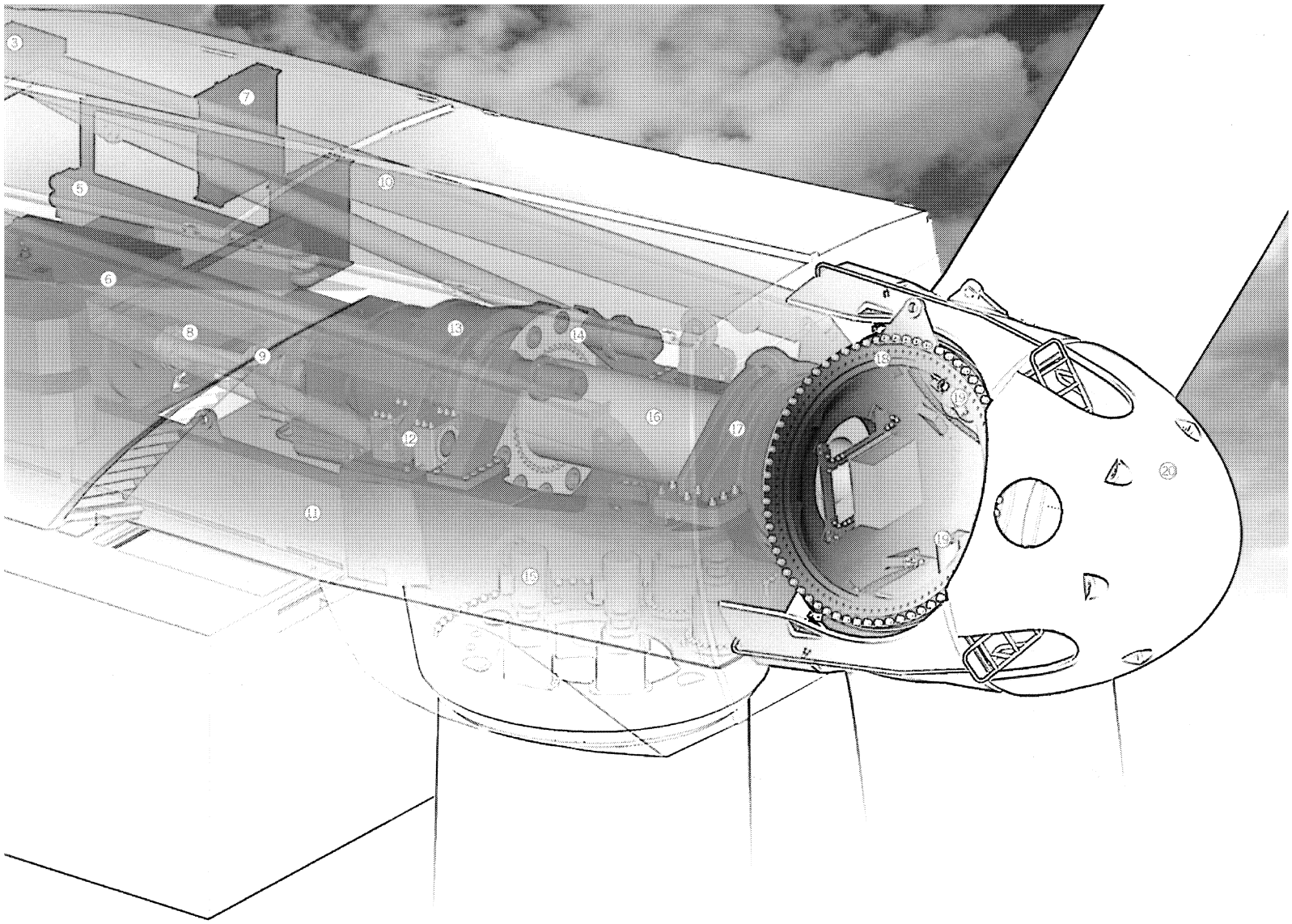
Power curve



Annual energy yield

Power output

Wind speed at hub hight I
Standard atmosphere acc.
to DIN ISO 2533, M.S.L.
Standard Rayleigh distri-
bution and unobstructed
air flow



3.6s offshore

Operating data

• Rated capacity:	3,600 kW
• Cut-in wind speed:	3.5 m/s
• Cut-out wind speed:	27 m/s
• Rated wind speed:	14 m/s

Rotor

• Number of rotor blades:	3
• Rotor diameter:	104 m
• Swept area:	8,495 m²
• Rotor speed (variable):	8.5 – 15.3 rpm

Tower

• Hub heights:	Site dependent

Power control: Active blade pitch control

Design data IEC 61400-1 ed2: Type class IB

Gearbox
- Three step planetary spur gear system

Generator
- Doubly-fed asynchronous generator

Converter
- Pulse-width modulated IGBT frequency converter

Braking system (fail-safe)
- Electromechanical pitch control for each blade (3 self-contained systems)
- Hydraulic parking brake

Yaw system
- Electromechanical driven with wind direction sensor and automatic cable unwind

Control system
- PLC (Programmable logic controller) Remote control and monitoring system

Offshore container
- Protecting converter, low and medium voltage switch gear, transformer and control system

Noise reduction
- Impact noise insulation of the gearbox and generator
- Sound reduced gearbox
- Noise reduced nacelle
- Rotor blades with minimised noise level
- Onshore version: Noise reduced operation (optional)

Lightning protection system
- Lightning receptors installed along blades
- Surge protection in electrical components

Tower design
- Hybrid tower made of prestressed concrete and tubular steel segment, tubular steel tower (offshore design according to location)

Hoisting system
- Optional integrated hoisting system to service major components, making external cranes unnecessary

GE Energy is one of the world's leading suppliers of power generation and energy delivery technology. We provide our customers with equipment, service and management solutions across the power generation, oil and gas, transmission and distribution, distributed power and energy rental industries.

As one of the world's leading wind turbine suppliers, our current product portfolio includes wind turbines with rated capacities ranging from 1,500 to 3,600 kilowatts and support services reaching from development assistance to operation and maintenance. We currently design and produce wind turbines in Germany, Spain and the U.S. In Florida, USA, we also manufacture advanced wind turbine blades to assure the highest quality, advanced designs and quick on-time delivery.

Our facilities are registered to ISO 9001:2000. Our Quality Management System, which incorporates our rigorous Six Sigma methodologies, provides you with quality assurance backed by the strength of GE. We know that wind power will be an integral part of the world energy mix in this century and we are committed to helping our customers design and implement energy solutions for their unique energy needs. Every relationship we pursue bears our uncompromising commitment to quality and innovation.

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