WIND POWER SOLUTIONS

Hydro
Wind
Geothermal
Solar
Tidal
Biomass
Nuclear
Coal
Gas
Oil

Air Quality Control Systems
Power Automation and Controls
Lifecycle Management
CO2 Solutions
Over 30 years of experience

With 30 years of experience in wind power, Alstom provides global energy solutions, from developing, designing and setting up wind farms to supplying and maintaining wind turbines.

We offer a wide range of onshore wind turbines with power ratings spanning up to 3 MW. The ECO 100 platform is amongst the most proven multi-megawatt platforms in the market place with over 2,000 MW installed or under construction and 200 cumulative operating years. The ECO 100 platform enables a more effective use of the wind resources. The upgrade of ECO 110 and ECO 122 tubines allows up to 48% of net capacity factor.

We are also a key player in the offshore wind market with the biggest wind turbine ever installed offshore, the Haliade™ 150-6MW, the new generation wind turbine with an output of 6 MW. Each Haliade™ 150-6MW unit is capable of supplying the equivalent of 5,000 homes with electricity. Characterised by its innovative technology, this direct-drive turbine is suitable for all sea conditions and delivers offshore power at the best price.

All Alstom’s wind turbines feature ALSTOM PURE TORQUE®, a unique rotor support concept protecting the drive train and other components from deflection loads, delivering higher reliability, higher operational availability, and lower maintenance costs.

We deliver higher yields in wind energy thanks to our market leading technologies, enhanced by years of operations and management experience, complemented with a state-of-the-art control and monitoring system called WindAccess™. We have developed a high technology allowing to suit with the most demanding grid networks in the world, the Alstom Wind e-control™.
Your Partners in Wind Power Solutions

Clean Power, Clear Solutions 04
How Alstom is helping you meet the challenges of energy sustainability.

From wind farm development to turbines services 08
Your Partners in Wind Power Solutions. From site development, through manufacturing and assembly, to commissioning and services, Alstom optimises every development stage.

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We deliver, we lead, we care
A global footprint.
Technology, adaptability and expertise.

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ECO 100 platform - higher energy yield.

Proven technology 10
Efficiency and reliability thanks to proven designs. Product features that increase yield, flexibility, smooth maintenance and adapt to changing wind and grid conditions.

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Haliade™150-6MW: Innovative technology, reliable and efficient.

Optimising lifetime output 18
A partnership for performance
Integrated control and monitoring.
Lifecycle management.

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Offshore wind farm solutions: Innovative AC platform, HVDC technology
Onshore wind farm solutions: MV/HV substations for switching, controlling and managing transmission system.

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Over 30 years’ experience of designing proven wind turbines.
Development of wind onshore and offshore technology.
Our power generation offering is based on a deep understanding of power markets and our customers’ needs. It is organised around three levers to maximise the return of assets over their entire lifecycle.

**REDUCING THE COST OF ELECTRICITY**

It takes competitive assets to keep electricity affordable. We enable power companies to compete successfully in the market place and provide affordable electricity to consumers. We help you reduce the cost of electricity through:

- Efficiency improvements
- CAPEX reduction / scaling up
- Capacity Factor increase
- Lead time reduction
- Competitive O&M

**LOWERING THE ENVIRONMENTAL FOOTPRINT**

Clean generation is one way of demonstrating environmental responsibility. Another is lowering resource usage, visual impact and noise pollution. In both cases, we can help you meet or exceed regulations and environmental standards. That is why Alstom innovates in the following areas:

- Renewable portfolio
- Natural resource optimisation
- Land use, visual impact and noise
- Recyclability

**INCREASING THE FLEXIBILITY & RELIABILITY**

Intermittent power generation is a growing challenge of energy security, as is maintaining an aging installed base and adapting it to changing market conditions. We help you tackle both issues so that you can enjoy dependable operations with:

- Maintainability and outage time reduction
- Operational and fuel flexibility
- Designs and service for improved availability and reliability
- Climate packages
Clear Solutions
meet the challenges of energy sustainability

OUR COMMITMENT TO OUR CUSTOMERS

REDUCING THE COST OF ELECTRICITY

+ 20%
capacity factor by using POWEROF3™

LOWERING THE ENVIRONMENTAL FOOTPRINT

9,000 tonnes
of CO2 saved by using one ECO 100 wind turbine during one year.

INCREASING THE FLEXIBILITY & RELIABILITY

90%
non-torque loads are reduced
increasing reliability thanks to ALSTOM PURE TORQUE® system.
Technology through innovative solutions
Alstom invests heavily in research and development (R&D) on a global and local scale, to provide state-of-the-art technology, to meet customers’ needs and stay at the forefront of technological innovation. The expertise and vision of our wind experts and the synergies between our different areas of high-technology power generation equipment allow us to consistently offer cutting-edge technology to our customers.

Adaptability through flexible solutions
Project management for Alstom means adjusting and optimising our methodology throughout the life cycle of a project according to our clients’ needs, local requirements and extreme situations. For Alstom Wind, the main objective is to add value at every stage of the project.

Expertise and resources close to our customers
- **Project Execution Strategy providing a solid foundations for project success**: Alstom’s Project Execution Strategy identifies the approach that leads to effective execution of the project, meeting the requirements (scope, quality, time and cost) and even going beyond them. A short lead-time and on-time delivery are two of the cornerstones for project execution success.
- **Manufacturing process**: Manufacturing is one of the core processes contributing to Alstom’s success and performance. To improve lead time and quality, increase safety over the course of the manufacturing process, and foster knowledge transfer, Alstom Wind applies its own Wind Manufacturing Concept (WMC). WMC is based on lean principles and the Kaizen culture, with a clear focus on the customer to bring continuous improvements to the manufacturing process.
Our “globally local” strategy – combining global experience with local strong presence and expertise – prioritises production wherever the client is. This encourages local economic growth, creates new direct and indirect employment opportunities and introduces new regional expertise thanks to our cross-training experience. Alstom Wind is supported by a global sales organisation which gives a global reach and the ability to serve customers wherever the wind blows.

We deliver  Alstom offers a range of new generation wind turbine products that represent the culmination of over 30 years of development and innovation. Since then, more than 2,600 turbines have been installed or are under construction in almost 200 wind farms delivering over 5,000 MW.

We lead  The heart of a wind farm is the turbine. In the search for optimised performance, Alstom’s wind turbines offer a host of cutting edge design features that increase power output. And by maintaining productivity in lighter breezes and stability in stronger gales, we lead the market in measured availability.

We care  By choosing Alstom as your provider you can enjoy a partnership with one of the most trusted names in power generation. Alstom backs its promises with ongoing support and services, which give owners long-term investment and performance security.

Worldwide presence

Richmond (USA)
R&D Group North America
Operations North America

Amarillo (USA)
Assembly WTG

Camaçari (Brazil)
Assembly WTG

Sao Paulo (Brazil)
Operations Latin America

Canoas (Brazil)
Tower Manufacturing

Nantes (France)
MRE Engineering centre

Cherbourg (France)
** Blades and Towers

Saint Nazaire (France)
Nacelles (protos, pre-series)
Nacelles and Generators

Toulouse (France)
Site development & Sales offices

Barcelona (Spain)
Headquarters Operations Europe & MEA

Bunuel (Spain)
Assembly WTG

Beijing (China)
Operations APAC

Melbourne
Sales office

* Operational in 2014
** Operational in 2015
Alstom offers onshore and offshore wind turbines ranging from 1.67 MW to 6 MW, providing solutions for all types of geographical locations and weather conditions. Additionally, climate kits allow operation in deserts or very cold environments. With a design optimised for simple assembly, erection in complex terrains is even easier. Whatever your location, reliability matters most, so Alstom turbines come with the unique and proven ALSTOM PURE TORQUE® design and WindAccess™, a modular and comprehensive monitoring and control system. Other design details contribute to low noise, safe operations and convenient maintenance.

We engineer reliable solutions and offer:

- The PURE TORQUE® concept for drive train reliability
- Best-in-class components and materials
- Manufacturing and module assembly
- Intelligent remote monitoring and control systems
- Substation design and construction

Alstom’s Plant Integrator™ approach optimises performance by balancing the interactions between complex subsystems in a power plant. For Alstom’s wind offering, this is implemented primarily at the design and planning stages.

Alstom will be besides you at every stage of your project optimisation, providing following services:

- Site localisation
- Land localisation
- Wind measurement and simulations
- Environmental impact assessment
- Offshore substructure and foundation concept
- Land lease and permitting
- Grid design

Alstom’s Plant Integrator™ approach optimises performance by balancing the interactions between complex subsystems in a power plant. For Alstom’s wind offering, this is implemented primarily at the design and planning stages.
Alstom has built wind farms in Argentina, Brazil, Ethiopia, Finland, France, Italy, Japan, Mexico, Morocco, Portugal, Turkey, Spain, UK and USA.

No matter how remote the location or complex the terrain, we can prepare the site and organise the grid connections.

Alstom’s commitment is to go wherever our customers see their opportunity. That is why Alstom has facilities in Europe, North and South America and expanding activities in other new markets.

Alstom’s wind farm installation teams offer:

- Civil engineering work
- Module transport and on-site assembly
- Erection and commissioning
- Electrical infrastructure commissioning
- Wind farms grid connection

Alstom is responsible for the operating and maintaining services of the majority of its installed wind fleet. As part of our clean power strategy we are committed to harnessing wind power more effectively.

We optimise performance and reduce uncertainties of your wind farms through:

- Corrective, preventive and predictive maintenance
- Parts delivery and upgrade packs
- Integrated control and remote monitoring services
- Field service and O&M contracts (Wind farm & Grid)

Lifecycle Management

During operation, wind turbines produce an endless supply of fossil-free power. So Alstom’s top priority is to maximise the turbine lifetime yield. We also examine the entire product lifecycle to further improve wind’s positive environmental balance and increase the your return on investment. Alstom also offers comprehensive services and long-term agreements to help new and established customers to develop their wind portfolios.
ENGINEERING INNOVATIONS DRIVE EVOLVING EFFICIENCY

The evolution of Alstom’s wind turbines was marked by engineering innovations that allowed an increase in the size and power output. Electrical pitch and yaw systems now perfectly control the energy uptake. Deflection stresses are handled by the PURE TORQUE® system. Compared to standard industrial designs, the system reduces non-torque loads by 90% and failure rate by 5-8 times. Modular manufacturing simplifies assembly and testing. Better utilisation of the nacelle space improves efficiency, safety and ergonomics.  

These high-technology power generation equipments allow us to consistently offer cutting-edge technology to our customers.
technology
thanks to design

ALSTOM PURE TORQUE®

All Alstom’s wind turbines feature ALSTOM PURE TORQUE®, a unique rotor support concept protecting the drive train and other components from deflection loads, delivering higher reliability, higher operational availability, and lower maintenance costs.

Coping with extremes

Because the best wind is often found in the harshest climates, Alstom offers environmental packs.

Effective operation in the most demanding climate conditions

- **Standard version**
  Operating temperatures: -10°C to +40°C
  Standstill temperatures: -20°C to +50°C

- **Cold Climate version**
  Operating temperatures: down to -30°C
  Standstill temperatures: down to -40°C

- **Desert Climate version**
  Operating temperature: up to +45°C
  Nacelle dust insulation
  Improved cooling capacity
  Blades sand protection

Wind conditions

Electrical yaw and pitch controls rapidly adapt the rotor alignments to changing wind conditions in order to keep the nominal power supply to the grid constant. The turbine braking system is also based primarily on pitch control and each blade is equipped with an autonomous power supply to ensure the safe braking of the turbine even in the most extreme conditions.

Optimise production to your site conditions
For higher energy yield
The electricity generated by one wind turbine from Alstom ECO 100 range meets the needs of 2,000 households and avoids the production of 9,000 tonnes of CO2 per year.
The ECO 100 platform is amongst the most proven multi-megawatt platforms in the market place with over 2,000 MW installed or under construction.
The large wind turbines – the ECO 100 has a swept area larger than an Airbus A380 – are the answer for projects that require both high energy yield and high reliability from the wind turbines.

**POWEROF3™: one product, three rotor diameters, optimised output**
This concept allows project developers to combine up to three wind turbines of the ECO 100 range within the same site, according to the specific wind conditions found in the different positions of the wind farm. This approach ultimately increases the capacity factor of the project by up to 20%.

Applicable to 3 wind classes POWEROF3™ optimises the Cost of Energy
- increase the Annual Energy Production of the wind farm: capacity factor of a wind farm can be increased by up to 20%
- common spare parts, standardised operation and maintenance procedures for the whole site thanks to product platforming lower cost of energy in a wide range of wind projects.
ECO 100, ECO 110 & ECO 122
Extensively proven 3MW-range platform in the industry
Higher energy yield, lower noise emissions
Suitable for all wind classes

Power: 2.7 to 3 MW
Rotor: ø 100, 110, 122m

Makes the most of the onshore wind resource
The ECO 100 range of wind turbines offers high yield and leading efficiency across all wind classes. Optimised energy production and lower cost of electricity thanks to POWEROF3™.

Customised and flexible solutions

Three turbines make up the platform:
• The medium and low wind (IEC Class III-A, II-B) 2.7/3 MW onshore ECO 122 wind turbine combines high power and high capacity factor to boost energy yield in low and medium wind regions worldwide. At a wind speed of 7.5 m/s the turbine delivers a net wind farm capacity factor up to 42%, equivalent to 3,600 full-load hours each year. Its 122 metre rotor diameter and swept area of 11,700m² – one of the largest in the 2 MW to 3 MW turbine segment – maximise the harvest of energy and the return on investment to create new business opportunities for customers from low wind sites.
• The high and medium wind (IEC Class II-A, I-S, ) ECO 110 3 MW turbine has one of the largest rotors available for class I-S and II-A sites to maximize the energy yield of the turbine.
• The high wind (IEC Class I-A) ECO 100 3 MW turbine has one of the leading capacity factors for turbines in this wind class.

Because wind speed increases with height, taller towers allow turbines to capture more energy.

In partnership with the benchmark leaders for specialised civil engineering, Alstom develops higher hybrid, full steel and full concrete wind turbine towers for the ECO 122 2.7/3MW. The advanced technology in the erection of the towers combined to the complete tower-range in full steel, full concrete and hybrid, allows to target more complex environments with competitive costs and lead-time, in accordance with local conditions, health and safety specifications, and to our client’s complete satisfaction.
Alstom has developed and installed the Haliade™ 150-6MW, the first new generation direct-drive offshore wind turbine. Suitable for all offshore conditions, uncompromising on reliability, the turbine delivers a leading cost of offshore energy while supplying electricity for up to 5,000 households.
Haliade™ 150-6MW

High yield offshore wind turbine

Innovative technology: ALSTOM PURE TORQUE®
Reliable: Direct-drive permanent magnet generator (PMG)
Efficient: 150m diameter rotor for high energy yield

Power: 6 MW
Rotor: ø 150m

High yield, uncompromising reliability

Built upon its ALSTOM PURE TORQUE® technology for drive train reliability, Alstom has developed and installed a 6 MW direct-drive wind turbine suitable for all offshore conditions. Proven technology and innovation are combined to deliver market-leading cost efficiency.

The turbine incorporates dedicated offshore technology in collaboration with some of the industry’s leading component suppliers. There can be no compromises on a power-generating product that operates in the industry’s most challenging environmental conditions.
Innovative technology and cost-competitive power generation

INNOVATIVE TECHNOLOGY
- The ALSTOM PURE TORQUE®: The pure torque design protects the generator to ensure and improve its performance by diverting unwanted stresses from the wind safely to the turbine’s tower though the main frame.
- The innovative « Advanced High Density » direct-drive Permanent Magnet Generator (PMG) is more compact and lightweight design compared to earlier generation direct-drive systems.

RELIABLE
- Alstom’s unique and proven rotor support with direct-drive PMG increases reliability, maximises turbine availability and reduces maintenance costs.

EFFICIENT
- Strength, durability and efficiency are maximised with the 150m diameter rotor combined with 73.5m light blade
- Yield improved by 15% compared to the existing offshore turbines
- Supplying 5,000 households with electricity.

Advanced design and flexible services for enhanced lifecycle operation

The turbine has been designed following Class I-B specifications of the standards IEC-61400-1 / IEC-61400-3. It is suitable for sites with a reference wind speed of 50m/s (10-minute average) and a 50-year extreme gust speed of 70m/s (3-second average).

Several design features ensure that the Haliade™ 150-6MW provides the highest possible yield in all circumstances.
- Failure tolerance for continuous production: 3 independent generation and conversion lines ensure uninterrupted operations
- 95% of yawing capacity can be reached with only 6 of its 7 yaw motors
- A ring topology maintains communications even with an isolated cable fault
- Software-controlled de-rating strategies guarantee operation in the event of faults in the power line or cooling systems

SAFETY FIRST - Alstom’s commitment to health and safety is uncompromising.
- The modular design ensures easy assembly, transportation and logistics
- The hub can be accessed directly from the nacelle
- The nacelle is equipped with a 1 tonne capacity crane in the central frame
- A maintenance trolley inside the frame eases transport of components
- A helicopter winching area allows for quick rescue in case of emergency at sea
A partnership for performance

Alstom operates a global network of local service centres and offers a full range of packages and services. Alstom Service main goals are to:

• Maximise availability
• Improve energy generation
• Optimise component and system lifetime

The keys to achieving these objectives lie in effective planned maintenance, suitable upgrades and retrofits. In accordance with our clean power strategy, we always consider profitability and commercial excellence in the wider context of environmental, health and safety (EHS) considerations.

Alstom ensures a complete maintenance:
• Corrective maintenance through the equipment control: repair breakdowns or perform unscheduled emergency maintenance. In order to minimise the negative impact, a stock of spare parts and critical components is stored either on the wind farms themselves or in our warehouses.
• Improved performance through our predictive maintenance: as a complement, predictive maintenance actions are also performed (such as oil analyses, vibration measurements, thermographs, etc.) in order to anticipate any slowly developing malfunctions and further minimise any unforeseen breakdowns.
• Increasing the system lifetime through the preventive maintenance: the maintenance actions are programmed in the wind turbine maintenance manual (operations and regular inspections), and are necessary to guarantee the life of the machines and operation under optimum conditions.
CONTROL AND MONITORING

Building on 30 years of wind turbine experience, Alstom has developed solutions to address both onshore and offshore requirements.

**WindAccess™ Integrated control and monitoring**

WindAccess™ monitors and collects data from the wind turbines, meteorological mast and substation so that the wind farm can be operated like a conventional power plant.

WindAccess™ has been designed for greater connectivity and efficiency. Thanks to the system’s web-based interface, operators can access their wind farms from any location at any time, while the system’s open communication protocols enable the wind farm’s easy integration with all other renewable assets in the operator’s portfolio.

**Wind e-control™**

To comply with the most demanding grid networks in the world, Alstom has developed a state-of-the-art technology allowing to interface and control the output of the wind power plant.

A high level of flexibility and adaptability developed at hardware and software levels.
offshore wind farm solutions

Alstom Grid has been pioneering the way for offshore wind farm grid connections with the design and construction of the first offshore substations in the UK and Germany. Since then, we have constantly improved the design of our solutions, learning from the execution of multiple contracts.

Innovative AC platform

As projects have increased in size and substations are located further offshore, the solution design has evolved. Alstom Grid has therefore ensured that “form follows function” by co-operating with project developers and suppliers of other elements of the projects. From these collaborations have come both fully integrated topside solutions installed upon monopole and jacket structures and also self-floating and self-installing solutions that remove the need for the mobilisation of scarce and expensive marine crane spreads. The weight of such platforms can range from 400 tonnes for a simple solution to more than 4,000 tonnes for 400 MW floating, self-installing platforms.

Global Track record in HVDC

- An industry pioneer with over 50 years of world-recognised expertise
- Leader in HVDC with over 30,000 MW of installed capacity worldwide

Efficient transmission over long distances with HVDC technology

For far offshore wind farms direct current often provides the best techno-economic solution for transmission of power to the shore. For this purpose, Alstom Grid has developed the HVDC MaxSine™ VSC technology, which combines its extensive knowledge of HVDC systems and Voltage Source Converters.

Efficient grid connections

- Complete turnkey solutions for sustainable energy connections including wind farms
- HVDC Line Commutated Converter (LCC) for energy highways
- HVDC MaxSine™ Voltage Source Converter (VSC) for offshore, onshore & multi-terminal applications
- Long-term maintenance contracts
Alstom Grid is a world-leading provider of engineered solutions and products for smart and conventional power grids. We provide integrated and customised turnkey solutions for Alternating Current (AC) and Direct Current (DC) substations, from Medium (MV) up to Ultra High voltages (UHV).

Complete solutions for onshore wind energy projects

For onshore wind farms, Alstom delivers complete MV/HV substations for switching, controlling and managing your transmission systems and contributing to a rapid return on investment. Successful wind generation needs integrated, flexible systems that can cope with difficult operating conditions and stringent standards.

- Our local experts will work hand-in-hand with you to meet your exact needs at every stage of the project
- We offer turnkey air-insulated and gas-insulated substations
- Complete product portfolio: circuit breakers (Live tank or Dead Tank), disconnectors, instrument transformers, protection and control integrated solution.

HV air-insulated equipment

Alstom Grid manufactures a complete range of high voltage air-insulated equipment, up to 1100 kV: live and dead tank circuit breakers, disconnectors (centre break, vertical break...), current and voltage transformers. If space is a constraint, we have developed a cost-effective compact switchgear, the HYpact, combining disconnectors, current transformers and a circuit breaker in a single SF6 insulated tank (one module per phase). Non-conventional instrument transformers (optical) are also available.

Substation automation solution

Alstom Grid is a world leader providing complete protection and control systems for wind farm electrical networks. Our solutions range from electrical protection relays in the substation and the turbine switchgear through to bay controllers, gateways and all the necessary control and configuration software tools.

e-terra : smart solutions to manage wind power

In its portfolio of smart grid solutions, Alstom Grid offers the latest e-terra renewable solution management systems for wind farms, combining wind generation forecasting with real-time monitoring, control and simulation. The benefits are superior monitoring and control capabilities, an improved knowledge of current production, reduced uncertainty on future production, an optimised resources dispatch including minimised reserve and control actions resulting in an improved grid reliability with lookahead network security analysis.
Today, Alstom is an established international wind turbine manufacturer operating wind farms in Argentina, Brazil, Ethiopia, Finland, France, Italy, Japan, Mexico, Morocco, Portugal, Spain, Turkey, UK and USA. Alstom’s 2,600 turbines currently installed or under construction can generate around 5,000 MW*.

**Wind farms installed or under construction**

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity (MW)</th>
</tr>
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<tbody>
<tr>
<td>Argentina</td>
<td>51</td>
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<tr>
<td>Belgium</td>
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<td>Brazil</td>
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<td>UK</td>
<td>258</td>
</tr>
<tr>
<td>USA</td>
<td>155</td>
</tr>
</tbody>
</table>

* Status March 2014
Alstom

Alstom is a global leader in the world of power generation, power transmission and rail infrastructure and sets the benchmark for innovative and environmentally friendly technologies.

Alstom builds the fastest train and the highest capacity automated metro in the world, provides turnkey integrated power plant solutions and associated services for a wide variety of energy sources, including hydro, nuclear, gas, coal, wind, solar thermal, geothermal and ocean energies. Alstom offers a wide range of solutions for power transmission, with a focus on smart grids.

Power generation

Alstom Power offers solutions which allow their customers to generate reliable, competitive and eco-friendly power. Alstom has the industry’s most comprehensive portfolio of thermal technologies – coal, gas, oil and nuclear – and holds leading positions in turnkey power plants, power generation services and air quality control systems. It is also a pioneer in carbon capture technologies.

Alstom offers the most comprehensive range of renewable power generation solutions today: hydro power, wind power, geothermal, biomass and solar. With ocean energies, we are developing solutions for tomorrow. Alstom is one of the world leaders in hydro power, the largest source of renewable energy on the planet.