

# ABB low voltage wind turbine converters

Reliable technology for wind power

# Profile



## **The wind power market continues to expand**

Today's wind turbine manufacturers and wind farm owners are experiencing steady growth which is predicted to continue. With a renewed push by many governments for increased renewable power capacity, wind energy continually gains more focus.

## **Diverse grid codes provide unique challenges**

But growth does not come without its share of problems. As wind energy production increases, countries and power utilities realize that the way in which wind farms cope with transmission grid faults can significantly impact the stability of the entire transmission grid, possibly leading to black-outs and other service disruptions. To address these concerns, power utilities and regional governments have developed grid code specifications that outline expected wind farm behavior in response to defined fault conditions. The challenge to the wind farm owners and turbine manufacturers is to make sure they can efficiently produce power and achieve the return on investment desired while meeting grid code requirements. Having to make costly retrofits to newly installed turbines in response to grid code changes is not good business.

## **Certification starts inside the turbine**

Turbine manufacturers realize that the wind turbine power converter plays a significant role in meeting these grid code requirements. The selection of the right wind turbine converter is critical in the turbine design and for a higher wind farm return on investment.

## **Flexible suppliers help reduce production costs**

Turbine manufacturers compete for new business by building better turbines while keeping production costs as low as possible. Turbine component suppliers in turn, need to be flexible and competitive in order to meet their customer's needs. This means that the wind turbine converter manufacturer needs to provide the engineering support, be able to customize the converter designs, and provide the flexible, volume production capacity to provide high quality products, on-time and on-budget.

## **Service and support extend the life cycle**

Environmental conditions such as salt, sand, and dust as well as temperature and operating cycles all affect the performance of the wind turbine. Keeping converters running like-new requires that turbine manufacturers and wind farm operators have the right training, preventive maintenance schedules, spare parts and



technical support to get the job done. This is needed in a global environment where suppliers need to be easy to access.

### **ABB provides solutions**

ABB understands these issues and provides products that are engineered and built to provide competitive, cost efficient solutions to the wind industry. ABB's wind turbine converters are based on the same technology and platforms used in ABB's industrial drive technology found throughout the world. The converters are backed by ABB's global service and support network throughout the life cycle of the converter.

### **ABB**

ABB, the global market leader for electrical products and solutions for wind power has over 100 years of experience and global collaboration with the power utilities and the process industries.

During 2008, ABB supplied over 3,000 MW of wind turbine converter power to the wind industry. These factors provide the basis for reliability and trust the wind industry can rely on.

ABB's wind turbine converters include solutions for all environmental conditions with both liquid and air cooled models

available which are designed for use with all of today's wind turbine generator concepts. The converters are supported by a global manufacturing, support and services footprint, with factories located in Europe, Asia and the United States.

And regardless of the converters installed location, ABB's global support and training network is never far away with offices in around 100 countries.

All of these factors bring significant advantages to the wind farm owners, turbine manufacturers, investors, and power utilities:

### **Highlights:**

- Broad wind turbine converter power range
- Support for today's generator concepts
- ABB global presence and service
- Constructed with familiar, high volume industrial components
- Competitive high quality products
- Remote monitoring
- Grid code compliance – fault ride-through
- Designed for harsh operating environments

# Expertise



## Grid code reassurance

As the installed capacity of wind farms increases, the share of power they provide to the transmission network also increases. This means that during times of grid fault, the way a wind farm is able to deal with the fault has a significant impact on the stability of transmission grid.

To regulate these conditions, utility companies have developed regional grid code specifications that wind farms must meet. These grid codes, which outline grid fault conditions and the expected wind turbine behavior in response to these conditions, are becoming more demanding, and vary from country to country. The wind turbine converter plays an important role in helping the wind turbine meet these grid code requirements and to obtain the necessary operational certification.

## Globally active in grid code working groups and research

ABB is committed to ensuring their wind turbine converters provide the technical capabilities to support the wind turbine in meeting these diverse grid code requirements. ABB invests significant engineering into research and development, staying active in grid code and power quality working groups supporting power system reliability, and in simulations and research. ABB engineers provide technical feedback on the feasibility of proposed grid code changes, ensuring the current technology and production costs are compatible with the proposed changes. Additionally, ABB engineers provide feedback on proposed grid code specifications that may be unclear or need additional definition in order to be tested properly.

## Low voltage ride-through and grid support

A common requirement for all grid codes is a fault ride-through capability where the wind farm and the turbines must be capable of operating continuously at reduced voltage and must not trip off-line because of transient voltages. Previously, wind farms were required to disconnect from the network when a disturbance, such as a voltage dip, was detected because turbine technology was not fast enough to recover in a stable manner.

Technology has improved as well as the volume of power generated by wind farms. Grid codes have changed to now require wind farms to remain connected during voltage dips and to provide active and or reactive power to the network during the fault. ABB has designed their wind turbine converters to provide full reactive current immediately when the grid fault starts.

## ABB's low voltage ride-through laboratory

ABB has taken the testing and certification process one step further by developing and building a customized 3 MW grid code laboratory located in Helsinki, Finland. The laboratory was designed to replicate a complete wind turbine with generators, wind turbine converters, transformers, medium voltage switchgear, and is connected to Helsinki Energy's 20 kV transmission line. This configuration allows ABB engineers to test the low voltage ride-through behavior of wind turbines in a controlled environment. The laboratory helps reduce on-site testing costs by replacing the variability of the wind with a speed controlled motor driving the generators. This allows testing of multiple power levels more efficiently.

### Computer controlled wind speed and testing

Generators used during testing in ABB's low voltage ride-through laboratory are driven by an ABB low voltage drive which controls the motor connected to the generator. Using the ABB drive allows engineers to adjust the motor speed to replicate the dynamics of pitch control, allowing for realistic increases in wind speed as well as oscillations which can be obtained during and after the voltage dip.

### Custom testing configuration software

ABB engineers use custom testing software to configure the test's fault conditions. These fault conditions may be taken from grid code specifications or from turbine manufacturer's requirements. Engineers can initiate a three-phase, two-phase, or single-phase voltage dip and select the exact instant during the voltage cycle to initiate the fault. Additionally, a sequence of faults in order to emulate the re-closing operations, as well as faults developing from single-phase earth faults to three-phase short circuits, can be programmed for testing in conjunction with other tests. Current, voltage and power measurements are recorded by the testing software which generates a testing report.

### Capitalize on ABB engineering

Wind turbine design demands a significant amount of technical engineering. The wind turbine manufacturer not only has to ensure the technical requirements of the system are accounted for in the design, they also have to ensure the design meets their planned budget and production capabilities.

ABB supports turbine manufacturers during their converter engineering phase, working with the customer to integrate the converter into the turbine design and control system and to answer questions. Additionally ABB engineers help the turbine manufacturer understand how to obtain the best performance out of the converter to increase the overall turbine performance.

### Turbine certification support

Turbine certifications are based on the grid codes used in the region the turbine will be installed. When turbine manufacturers are applying for turbine certification, ABB engineers can help the turbine manufacturer use and maximize the converter's technology to meet the requirements of the grid code.



# Products

## ABB low voltage wind turbine converters

ABB's low voltage wind turbine converters provide flexible, modular solutions for the turbine manufacturer. The converters have a very high power density, and are available with air or liquid cooling options. The power converters are based on the same world leading ABB industrial drive modules installed throughout industries around the world. ABB's entire line of wind turbine converters, with power ratings up to 5 MW, are suitable for nacelle or tower installation and are designed to work with all current generator trends. ABB's wind turbine converters are built and tested to work with grid code specifications (such as E.On, R.E.E and US FERC), and to produce power with low harmonic levels.

### Made-to-order production

ABB offers a selection of full power and doubly-fed converter designs. These designs can be customized to meet the unique demands of ABB customers.

ABB wind turbine converter factories, located in Europe, Asia and the United States, offer easily customizable production lines to accommodate unique customer requirements while still maintaining a high production capacity. This ensures high-quality serial production that ABB customers demand.

### Doubly-fed and full power

ABB full power converters isolate the wind turbine generator from line transients and enable fast response to line faults. They provide better ride-through capabilities and support during grid faults. The doubly-fed power converters feature reactive power control, high efficiency at the nominal point, and very low total harmonic distortion (THD).

### Full power converter design advantages

ABB full power converters offer high power density in a compact design. Full power converters are available in different configurations with flexible pre-engineered options. Along with the standard cabinet design, a back-to-back configuration is available.

ABB full power converters over 2 MW feature a design option that uses multiple sub-converters working in parallel. During low wind speeds, the converter uses only the sub-converters needed according to the wind speed. This provides increased converter efficiency and reduced wear-and-tear on the system. The converter sub-modules may even be installed in different locations of the wind turbine providing turbine manufacturers with a degree of freedom to optimally use space in the nacelle and tower.



### Cooling options

Air and liquid cooled models, with cabinet heights starting at 1800mm, provide the turbine manufacturer with the right selection and flexibility to withstand the ambient conditions of the wind turbine. The converters are available with up to IP54 levels of protection and the liquid cooled converters, with totally enclosed cabinets, are designed for operation in very harsh environmental conditions (such as dust, sand and salt).

### Additional liquid cooling benefit

As wind turbine generator power is increasing, turbine manufacturers are taking advantage of the benefits of liquid cooling, since more power can be generated within the same volume of cabinet space. Liquid cooling removes the converters heat losses, preventing them from heating the surrounding turbine equipment and electronics.

### Reliability

The converter power modules are designed with long life in mind regardless of the ambient environmental conditions. For example, line filters use dry film capacitors for longer life, instead of capacitors containing combustible liquids, and warm up resistors are used to remove humidity and cold from the electronic circuits. The modules are designed for easy on-site maintenance, even after they are installed in the nacelle.

## Power converter remote monitoring

Wind turbines generally have a built-in monitoring capability that is used to assess the overall status of the turbine. However, sometimes the wind farm engineers and turbine manufacturers need more information to help assess fault conditions or to analyze the turbine's performance. The converter can provide a vast amount of information that engineers can use.

To access the converter information, ABB provides remote monitoring capabilities. The remote monitoring allows wind farm operators to directly access the converter to obtain data such as DC and AC voltage, power, reactive power, temperature, and speed. The remote monitoring tools can even be configured to send email, in real time, if a critical event occurs in the converter.



# Services



## **ABB life cycle services, investment peace of mind**

ABB offers life cycle services to help keep customer's wind turbine converters operating like new. The ABB services portfolio allows wind farm owners and turbine manufacturers to build a tailor made package of services to fit their needs.

## **ABB engineering support throughout the life cycle**

ABB engineers not only work with turbine manufacturers during the design and converter specification phase, ABB engineers can provide their services throughout the life cycle of the converters.

## **Preventive maintenance helps reduce operating costs**

The turbine converter performs critical duties in power generation and its failure may result in loss of production and revenue.

Adopting and implementing ABB's converter specific preventive maintenance schedules reduces the risk of failure and increases the lifetime of the converter, lowering overall operational costs. ABB develops preventive maintenance kits

containing all the genuine ABB spare parts needed to perform a specific maintenance task, helping to simplify the preventive maintenance process.

## **Technical support**

Technical support is available by phone, email or on-site visits as agreed in an ABB services contract.

## **Spare part management made easy**

Having the correct spare parts available at the correct locations, either at the turbine manufacturer's warehouse, regional stocking centers or at wind farms should be well-planned to ensure the highest wind turbine production and availability. ABB can help plan spare part stocking throughout the life cycle of the wind turbine, starting with spares needed during commissioning and testing throughout the service life of the converter.

## **Regional service centers offer repair and reconditioning**

When converter module needs maintenance or repair that cannot be done on-site, ABB has several regional support





centers around the world that are certified to repair or recondition converter modules. This helps reduce costs for the wind farm owner, and offers peace of mind knowing that ABB reconditioned modules are fully tested and returned with a complete warranty. The regional support centers are located in Europe, United States, and China.

#### **Training improves performance**

ABB provides a wide selection of wind turbine converter training to turbine manufacturers and wind farm operators. The training can take place at ABB training centers or at the customers' locations. Additionally, a large selection of e-learning courses is offered to help keep the turbine manufacturers and wind farm engineers up-to-date with the latest converter information.

#### **Contracts made to fit a customer's needs**

Depending on the needs of the turbine manufacturer or wind farm operator, ABB can bundle individual services in one contract. A contract can be made at any stage of the wind turbine converter's service life. Contracts may be composed

of a mix of services, including spare parts agreements, agreements on preventive or corrective maintenance, technical support and training. Benefits include improved cost control, enhanced operational efficiency, lower capital expenditure, reduced downtime and extended lifetime.

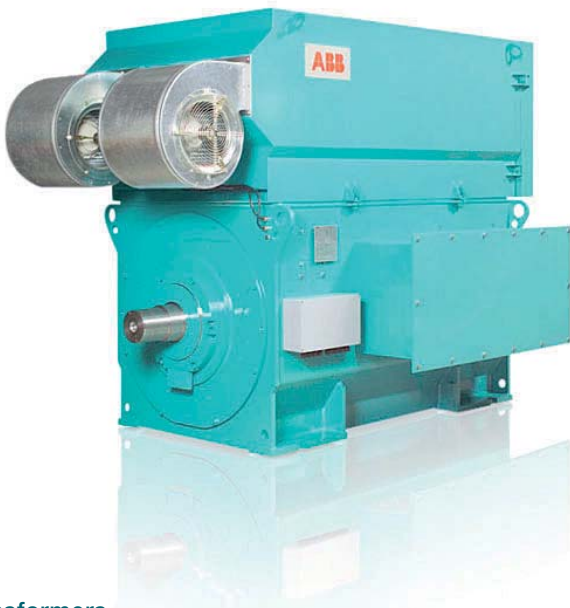
# ABB in wind power

ABB's products and solutions for wind turbines extend beyond just the converter. ABB is the largest supplier of electrical products and solutions to the wind industry. ABB designed products specifically for wind power, enabling grid code compliance and environmentally friendly power generation, transmission and distribution.

## Wind turbine generators

ABB has over 25 years of experience in designing generators for wind turbines, from fixed speed to doubly-fed and permanent magnet synchronous generators. Leading wind turbine manufacturers of all main concepts rely on ABB, the largest manufacturer of multi-megawatt class generators, up to 5 MW and higher.

ABB generators are designed for the harsh operating conditions and stress factors found in wind turbines. The special ABB high performance F-class insulation system and the rigid form-wound windings guarantees a long life time with high overload capability in high temperatures, even with the continuously changing loads common to wind turbines. Bearing construction is designed for reliable operation with long service intervals. Experienced ABB engineers offer valuable assistance in design and system optimization to meet the needs of each turbine manufacturer's unique requirements.



## Transformers

ABB transformers for wind applications include both large transformers used to connect the wind farm substation to the transmission grid, as well as smaller turbine transformers located inside the wind turbine. They are designed for harsh operating environments, specifically salty, sandy and dusty conditions in high humidity, and even in operating temperatures



as low as  $-25\text{ }^{\circ}\text{C}$ . The distribution transformers can be located in the nacelle or in the tower and are designed to convert voltage from the turbine to the wind park transmission line.

## Low voltage AC drives and motors

Low voltage motors and drives are used for various applications in wind power such as pump and fan applications as well as yaw systems. ABB low voltage AC drives help reduce mechanical wear and tear, provide soft-starting controls, help save energy and provide better control of the application. The drives are designed for easy installation and commissioning and are backed throughout their life cycle by ABB's global service and support network.

## Low voltage contactors, breakers and more

ABB offers a complete selection of low voltage products including circuit breakers, contactors, manual motor starters, overload relays, fieldbus communication modules, PLC's, terminal blocks, arc guard systems, pilot devices and limit switches for use in wind turbines.

For main circuits, breakers and contactors go hand in hand, with breakers providing protection and contactors used for switching. As the market leader, ABB offers coordinated (as per IEC 60947) breakers and contactors for higher reliability and increased safety. ABB molded case ( $T_{max}$ ) and air circuit breakers ( $E_{max}$ ) provide fast and efficient short circuit protection. ABB has developed a range of modern electronic coil large contactors (AF range) for wind power, including low voltage ride through versions.

## Converters for small wind turbines

ABB offers a selection of wind turbine converters for small wind turbines. The converters operate in the same manner as the larger scale wind turbine converters and have a full selection of built-in and optional features that allow the converters to be incorporated into various small wind turbine designs.



## ABB, maximizing your return on investment

### Maximize return on investment

ABB understands that wind farms exist to generate power, which in turn generates profits. The generated power needs to meet regional grid code requirements, be high quality, and be reliable. Additionally, wind farm owners and turbine manufacturers need to know that the company they invest in is capable of providing all the services and support that are needed, in a professional and timely manner. These values are at the heart of every ABB low voltage wind turbine converter that comes off the production line. ABB is the right partner to provide wind turbine converters and peace of mind to the wind industry.

### Global resources

ABB is a global company with global resources, and has the manufacturing capacity and the services demanded to deliver high quality, long lasting converters that produce reliable, high quality power.

### Local support

ABB's research and expertise is global, but its service is local, with offices in around 100 countries. Investors in ABB products and services know they are getting world-class products and services that they demand.

### Highlights:

- ABB is the global leader for wind power electrical products and solutions
- Offices globally located in around 100 countries
- Global support and service
- Global manufacturing
- High quality products
- ABB's grid code testing laboratory provides reassurance and technical expertise
- Converters produce reliable, high quality power
- ABB, your partner in wind power

# Contact us

[www.abb.com](http://www.abb.com)  
[www.abb.com/windpower](http://www.abb.com/windpower)

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# ABB low voltage wind turbine converters ACS800, liquid-cooled 0.6 to 6 MW



**ABB low voltage wind turbine converters are designed to help increase turbine kilowatt-hour production through high availability, grid code compliance and long life cycles.**

The converters are designed for all of the turbine main electrical drivetrain concepts: full converter and doubly-fed. ABB liquid-cooled converters feature totally enclosed, compact cabinets protecting the internal electronics from dust, salt, sand and other environmental pollutants. Liquid-cooling transfers the heat from the converter to outside the turbine.

In case of grid faults, full power converters decouple the generator from the grid and provide dynamic and flexible response to fault conditions. Both full power and doubly-fed converters provide active and reactive power control, and have very low total harmonic distortion (THD) levels.

The converters use ABB's direct torque control (DTC) for generator control. DTC monitors generator torque 40,000 times per second, ensuring immediate reaction and control.

The converters may be installed in either the wind turbine's nacelle or tower. The full power converters over 2 MW offer a design option for parallel connected sub-converters.

ABB's converters are designed for long life and ease of maintenance. A complete set of life cycle services including pre-purchase engineering, training, spare part management, and preventive maintenance plans helps turbine manufacturers and wind power plant operators produce more kilowatt-hours.

ABB manufacturing capacity ensures that global products are produced locally. This provides the high-volume, high-quality production supporting customers around the world.

## Highlights

- Products for the main electrical drivetrain concepts, doubly-fed and full power
- Totally enclosed compact cabinets, all parts and components installed inside the cabinet
- Grid side contactor or breaker for safe connection and disconnection
- IGBT power modules with integrated DC capacitors and control electronics
- Very low THD
- DTC for generator control
- Optional parallel connected sub-converter configuration
- Global manufacturing capacity
- Global service and life cycle services

# Technical data

Converter model	ACS800-67LC	ACS800-77LC	ACS800-87LC
Converter type	Converter for doubly-fed induction generator (DFIG)	Full power converter for permanent magnet and asynchronous generators	
Generator power range	1 to 3.8 MW	0.6 to 3.3 MW	1.5 to 6 MW
Optional sub-converter configuration		Available from 1.9 MW	Available from 3.6 MW
Cooling	Liquid cooling with totally enclosed cabinet		
Control principle	direct torque control (DTC)		
<b>Electrical data</b>			
Rated grid voltage	525 to 690 V AC, 3 ph, $\pm 10\%$		
Rated generator voltage	According to generator, up to 12 kV	0 to 750 V AC	
Nominal frequency	50 $\pm$ 3 Hz / 60 $\pm$ 3 Hz		
Efficiency at converter's rated point	$\geq 97\%$	$\geq 96.5\%$	
Generator side du/dt	1,000 to 1,400 V/ $\mu$ s		
Grid harmonics	Max 3%	Max 4%	
Total harmonic current distortion (n = 2 to 40)	with DFIG generator current		
<b>Environmental limits</b>			
Ambient temperature	Transport -40 to +70 °C Storage -40 to +70 °C Operation -30 to +50 °C		
Coolant inlet temperature	+5 to +45 °C	+5 to +50 °C	+5 to +45 °C
Optional high coolant inlet temperature	Up to +50 °C	Up to +55 °C	
Altitude	0 to 1000 m		
Optional high altitude	Up to 4000 m		
Degree of protection	Totally enclosed cabinet IP54 / UL type 12		
Cabling connections	Top or bottom		
Cooling connections	Left or right side		
Cabinet configuration	Line-up, back-to-back or several separate		
<b>Control</b>			
Field bus interface	EtherCAT, PROFINET IO, PROFIBUS-DP, CANopen and Modbus, ControlNet, InterBus-S, DeviceNet		
Ethernet interface	Ethernet interface with PC browser is included		
Control tool link	Optical DDCS communication link for communication with PC tools as standard		
<b>Converter supports wind turbine to comply with grid code requirements</b>			
Transmission code 2007	FRT	FRT	FRT
Germany	Grid support*	Grid support	Grid support
REE P.O. 12.3	FRT	FRT	FRT
Spain	Grid support	Grid support	Grid support
Technical regulations	FRT	FRT	FRT
TF 3.2.6	***	***	***
Denmark			
National Grid Electricity Transmission, Issue 3, Revision 21, July 2007	FRT	FRT	FRT
USA	Grid support*	Grid support	Grid support
111 FERC 61,252	Active current/power**	Active current/power	Active current/power
111 FERC 61,353	FRT	FRT	FRT
USA	***	***	***
CEPRI	FRT	FRT	FRT
WED-QR-C01-E-06	***	***	***
China			
<b>Product compliance</b>			
Product markings	CE		
Optional	UL508A UL508C CSA C22.2 No 14-05		
EMC	2 <sup>nd</sup> environment, unrestricted distribution, category C3		
EN 61800-3/ A11 (2000), EN 61800-3 (2004)			
Quality assurance system	ISO 9001		
Environmental system	ISO 14001		

\* when  $U_{dip} > 20\% U_n$

\*\* with symmetrical fault when  $U_{dip} > 50\% U_n$

\*\*\* grid code does not require grid support

FRT = fault ride-through

# Full power converters



## ACS800-77LC, 0.8 to 3.3 MW

- Robust grid code compliance
- Nacelle or tower installation
- Redundant configuration available at higher ratings

Typical generator rating kW	Rated generator current A	Rated grid current A	Rated grid apparent power kVA	Module setup	Cabinet width with control cabinet mm	Cooling flow rate l/min	Cabinet weight kg
800	898	720	860	2 + 2	2300	100	2000
1050	1143	941	1120	2 + 2	2300	100	2000
1150	1143	1397	1670	2 + 3	2600	125	2300
1300	1334	1397	1670	3 + 3	2800	140	2500
1600	1697	1397	1670	3 + 3	2800	140	2500
1800	1697	1843	2200	3 + 4	3300	170	3000
1900	2286	1882	2240	2 x (2 + 2)	2 x 2300	2 x 100	2 x 2000
2200	2286	2338	2790	(2 + 2) + (2 + 3)	2300 + 2600	100 + 125	2000 + 2300
2200	2286	2794	3340	2 x (2 + 3)	2 x 2800	2 x 125	2 x 2500
2400	2668	2338	2790	(3 + 2) + (3 + 3)	2600 + 2800	125 + 140	2300 + 2500
2600	2668	2794	3340	2 x (3 + 3)	2 x 2800	2 x 140	2 x 2500
3100	3394	2794	3340	2 x (3 + 3)	2 x 2800	2 x 140	2 x 2500
3300	3394	3240	3870	(3 + 3) + (3 + 4)	2870 + 3300	140 + 170	2500 + 3000
3300	3394	3686	4400	2 x (3 + 4)	2 x 3300	2 x 170	2 x 3000

Cabinet height 2000 mm and depth 600 mm.

Cooling circuit pressure loss 150 kPa with hydrostatic pressure included.



## ACS800-87LC, 1.75 to 6 MW

- Robust grid code compliance
- Compact size, back-to-back configuration
- Optimized for tower base installation

Typical generator rating kW	Rated generator current A	Rated grid current A	Rated grid apparent power kVA	Module setup	Cabinet width mm	Cooling flow rate l/min	Cabinet weight kg
1750	1697	1843	2200	3 + 4	1600	185	3000
2000	2230	1843	2200	4 + 4	1800	197	3250
2300	2230	2330	2740	4 + 5	1800	210	3400
2400	2230	2736	3270	4 + 6	2200	222	3650
2800	2785	2736	3270	5 + 6	2200	235	3800
3000	2785	3192	3810	5 + 7	2600	247	4350
3200	3324	3192	3810	6 + 7	2600	260	4500
3600 to 6000	Contact ABB for the ratings						

Cabinet height 2000 mm and depth 1300 mm.

# Doubly-fed converter



## ACS800-67LC, 1.7 to 3.8 MW

- Small and light weight
- Lowest harmonics and highest efficiency at rated point

Typical generator rating kW	Rated generator current A	Rated grid current A	Rated grid apparent power kVA	Module setup	Cabinet width with 690 V power cabinet mm	Cooling flow rate with power cabinet l/min	Cabinet weight kg
1700	898	480	570	1 + 2	2200	92	2000
2250	1143	480	570	1 + 2	2200	92	2000
2600	1143	941	1125	2 + 2	2400	100	2200
3000	1334	720	860	2 + 3	2600	113	2500
3800	1697	941	1120	2 + 3	2600	113	2500

Cabinet height 2000 mm and depth 600 mm.

### Converter options

- Removable cabinet doors
- Cabling direction
- Cooling connections
- Low voltage ride-through options
- Redundancy (parallel) sub-converter connections
- Pulse encoder interface
- Power cabinet options

### ABB global support

ABB offers a full spectrum of life cycle services, from pre-purchase engineering, installation and commissioning, spare parts management, technical support, training, preventive maintenance schedules, spare part kits to retrofit and refurbishment.

For more information please contact:

[www.abb.com/windpower](http://www.abb.com/windpower)  
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