Planning Guidelines for Utility Feeding Wind Power Plants with SMA Windy Boy Inverters

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1 Introduction

With experience from the use of the proven Sunny Boy inverter in more than 330,000 applications all over the world, we now have the Windy Boy product line, a new family of inverters for network coupling of small wind turbines. Since May 2005, there have been various device types available with a power range of 1000 to 6000 W which all are suitable for use with wind generators from a variety of manufacturers and power ranges.

With the Windy Boy inverters it is now possible to operate small, grid-connected wind turbines with permanent magnet generators and downstream 3-phase rectifiers. Grid-connected means that the energy generated by the wind turbine can be fed into an existing house power grid, a stand-alone power system (combined with a Sunny Island), or directly into the mains grid. The inverter converts the direct current (DC), which varies with speed, from wind generators into grid-compatible alternating current (AC). The inverter requires the constant presence of mains-grid voltage!

The Windy Boy inverter has a special operational mode for wind generators which allows performance adjustment to the characteristic curve of the generator. In this way you can obtain maximum yields from your wind turbine.

A wide input voltage range, high efficiency and a freely configurable output characteristic curve with the highest level of reliability are only some of the properties that are useful for your grid-connected system, or in a stand-alone system. The Windy Boy is compatible with all SMA types of communication (RS232, RS485, Powerline, USB-Service-Interface, Radio, Display), providing numerous possibilities for diagnosis, data visualization and remote maintenance of your small wind turbine system.

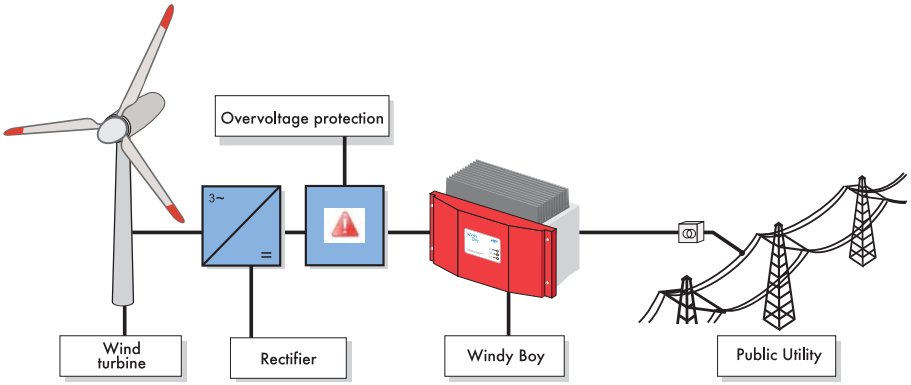
These planning guidelines will describe in greater detail the requirements and functions of a "wind turbine for mains grid feed-in" in order to facilitate system design and the choice of components. You also receive valuable practical tips and answers to frequently asked questions that have already been resolved.

You will find attached a summary of the Windy Boy's most important technical data, a planning checklist, as well as addresses and contact details.

This document is not a replacement for the operating instructions and installation manual that come with the product.

Components for a grid-connected wind turbine

A grid-connected wind turbine consists chiefly of the following components:



In order to operate your wind turbine safely and efficiently, technical information on all the components is required.

You can note the corresponding values and select recommendations or mark selected areas off in the following tables.

Please use the following sections in the sequence provided as guidelines for your system planning.

2 Wind turbine

At low wind range, permanent magnet generators of varying performance and voltage class are mostly used.

The wind turbine ought to be designed to be 3-phase. The level of output AC voltage and frequency are variable depending on wind speed and the wind turbine's rotation speed.

It is necessary to be aware of the following wind turbine data to achieve optimal system planning. Site-specific data must also be available or estimated.

2.1 Wind turbine (manufacturer's specifications)

	Your data	**Unit**
maximum wind turbine output in 'moderate' wind conditions of 5 m/s		W
appropriate output voltage in 'moderate' wind conditions of 5 m/s		V
maximum wind turbine power output in 'strong' wind conditions of 12 m/s		W
appropriate output voltage in 'strong' wind conditions of 12 m/s		V
Wind turbine nominal power output		W
Wind turbine maximum power output		W

	checked:
Wind turbine power output curve (e.g. manufacturer's diagram)	
Energy yield characteristic curve (e.g. manufacturer's diagram)	

2.2 Site-specific data

Unlike photovoltaic applications with a predictable performance distribution, wind turbines can be operated for longer periods under full load.

The following data should be examined for optimal inverter product choice regarding performance and service life:

	Your data	Unit
Average annual wind speed		m/s
Anticipated annual system full-load hours		hours p.a.

The 'full-load hour' data are an important basis for calculation of wind park investment fund offers as they form the basis of the anticipated revenues of wind-generated electricity. However, these full-load hours are purely a value to aid calculation and have nothing to do with the actual amount of operating hours during which the wind turbines produce electricity.

For low wind range applications, the full-load hour data are an important basis for selecting your wind turbine's inverter at the right level.

Full-load hours are calculated by dividing the annual production in [kWh/p.a.] by the wind turbine's nominal power output in [kW].

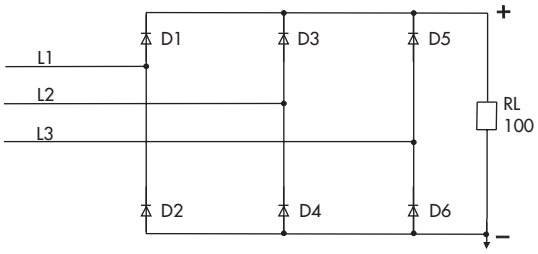
Annual production is derived from the energy yield characteristic curve of the wind generator in question at average wind speeds for the site.

3 Rectifier

The alternating current from the generator must be rectified.

For a 3-phase system, a B6 bridge rectifier is required.

B6 bridge rectifier



- *Please keep in mind for subsequent calculations that the rectifier's output voltage (DC) is higher by a factor of 1.41 than the specified or measured effective voltage (AC) for the generator!*
- *The remaining DC voltage ripple should not exceed 10%. This is usually given when using a B6 bridge rectifier.*
- *Please check whether the manufacturer delivers the turbine with built-in rectifier or whether this component must be acquired as an optional extra.*
- *Please check that all input voltage data of the inverter refer to direct current (DC).*

4 Overvoltage protection

Many wind turbine manufacturers offer an extra electronic overvoltage protection module. This component prevents damage to the downstream inverter due to excessive wind turbine output voltage.

Overvoltages can occur under the following conditions:

- High turbine rotation speeds under strong wind conditions
- An increase in turbine rotation speed caused by disconnecting the inverter from the mains grid and, as a result, load shedding e.g. in the case of mains interference or power outage.

The overvoltage protection system has the following tasks:

- When a pre-defined voltage is reached, the inverter is disconnected from the generator and a short-circuit slows the generator and/or brings it to a standstill.
- Some devices reduce the turbine rotation speed, and thus the generator output voltage, by activating a resistor assembly (Dumpload). The electrical energy generated by the turbine is then converted to heat.

In grid-connected systems, we recommend the use of one of the electronic protection mechanisms described here.
Overvoltage at the inverter's DC input can lead to destruction of the Windy Boy. In addition to this, you lose the right to all warranty claims, even if the maximum input voltage of the inverter is only exceeded for a short time.

The electronic protection systems described here are always preferable to mechanical solutions (pitch control, "turning out of the wind").

Please make sure that your system is fitted with electronic overvoltage protection:

	Manufacturer and principle
Overvoltage protection achieved by:	

	Your data	**Unit**
Limiting DC voltage at:		V

5 Inverter

The inverter's task is to convert the DC voltage prepared by the bridge rectifier into alternating current and feed it into the public grid. Additionally, the electricity produced by the wind turbine should be optimally fed into the grid, meaning that good overall system efficiency is assured.

The Windy Boy inverter models vary according to performance class, DC input voltage range and price.

Therefore, the user is faced with the following question: "Which wind turbine goes with which inverter... and vice versa?"

The technical data table for all available Windy Boy inverters serves as a guide (see section 9 "Appendix A: Technical Data" (Page 27)).

5.1 Criteria for selecting the 'right' Windy Boy

An important factor to remember when choosing the 'right' Windy Boy for your wind turbine is the power and voltage range classification of the planned wind turbine system. To get this right, you require all the data from the preceding sections.

5.1.1 Power range classification

To classify the wind turbine in the Windy Boy's power range, you require the generator's nominal power output data and the full-load hour calculation (see section 2.2 "Site-specific data" (Page 8)).

In the technical data of the Windy Boy inverter (appendix A), details are given of the wind turbine's maximum possible output for 5000 full load hours (in a location exposed to strong winds) and 2500 full load hours (location with moderate wind conditions) per year.

If your calculation/assumption of full load hours is:

- < 2500 hours: you could select the next smaller Windy Boy
- up to 2500 hours: use of wind turbines up to the given output is possible
- up to 5000 hours: use of wind turbines up to the given output is possible
- > 5000 hours: you could select the next larger Windy Boy.

To improve total power output, several Windy Boy inverters can be used in parallel on the DC side with a wind turbine. This makes single- or multi-phase feed-in possible on the AC side.

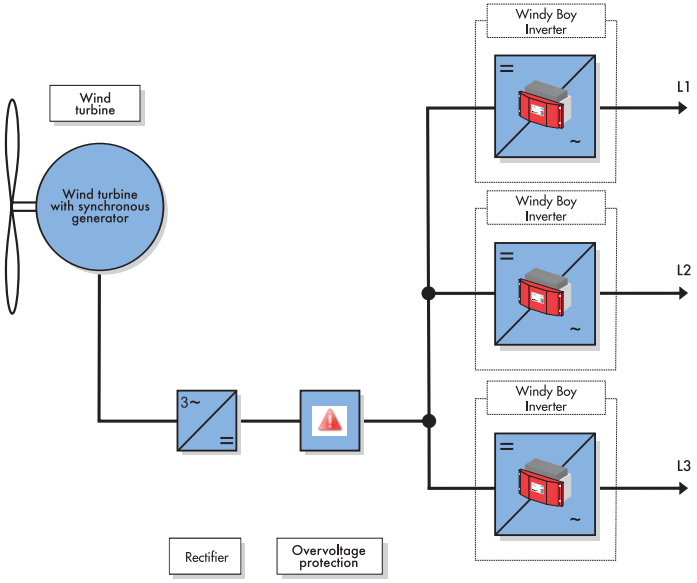


Figure 5.1: Example of parallel connection of three Windy Boys (3-phase) on the DC side

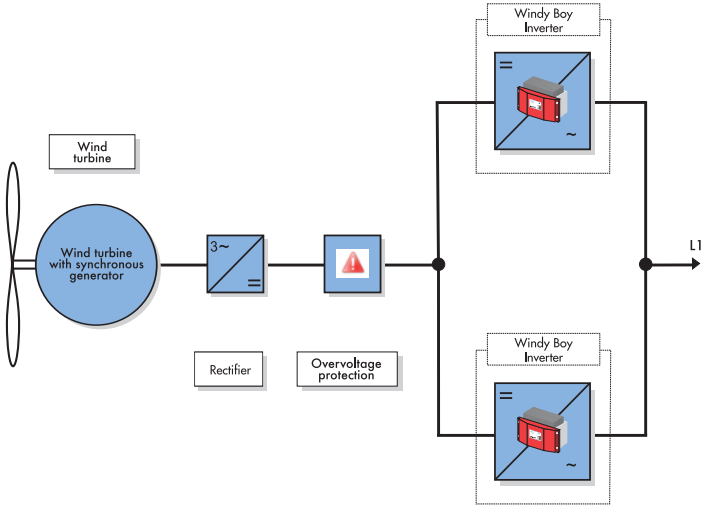


Figure 5.2: Example of parallel connection of two Windy Boys (1-phase) on the DC and AC side

We recommend combining like equipment type with like. Combining different equipment types is only possible when the maximum DC input voltages for the equipment given in the technical data are identical.

Windy Boy combinations enabling increased power output:

WB 1100 WB 1700	$U_{DC,max}$ = 400 V
WB 2500 WB 3000 WB 2800i	$U_{DC,max}$ = 600 V
WB 3300 WB 3800	$U_{DC,max}$ = 500 V
WB 5000(A) WB 6000(A)	$U_{DC,max}$ = 600 V

5.1.2 Voltage range classification

In order to operate the turbine in the correct DC voltage range, you must know its DC output voltage in moderate wind conditions, e.g. at 5 m/s. This value ought to be greater than or equal to the Windy Boy's DC nominal voltage specification (see section 9 "Appendix A: Technical Data" (Page 27)).

If the voltage is lower, grid feed-in will only be possible at higher wind speeds. You must also check whether the parallel operation of, for example, two Windy Boy inverters with lower DC nominal voltage specifications is possible.

You must also make sure that the inverter's maximum DC input voltage is never exceeded.

Please check which Windy Boy type(s) your wind turbine should be combined with:

	Your data
Windy Boy type	
Quantity	

5.2 Performance adjustment to the characteristic curve of the generator

Once you have selected your Windy Boy, you can further adjust the inverter to the generator's characteristic curve using the software provided. The aim is to thus achieve optimum yield by best combining the Windy Boy with your wind turbine and system location.

In order to carry out these adjustments to the Windy Boy, it must be equipped with a communications interface. In this way, adjusting the operating parameters can be carried out very easily via PC. An additional benefit comes from being able to display system parameters and spot values on your PC and to collect and save yield data.

One very simple possibility is to set parameters using the USB-Service-Interface (optionally available). This is a special cable that enables direct communication between a PC with a USB connection and an individual Windy Boy with no built-in communications interface.

The Windy Boy cover is opened and the USB-Service-Interface is connected to an appropriate socket. The other end is connected to the USB port of a PC. All you need to do is install the Sunny Data software on your PC, which is available for free from the download area at www.SMA.de.

Once you have finished making your adjustments, the service cable is removed and the Windy Boy is closed.

The Windy Boy is compatible with all SMA communications products (RS232, RS485, Powerline, Radio), providing, in addition to simple communication via the USB-Service-Interface, numerous possibilities for diagnosis, system monitoring, data visualisation and remote maintenance of your wind turbine system. Please check which communications interface your Windy Boy should be fitted with:

	Your selection
USB-Service-Interface (type: USBPBS)	
Powerline	
Radio	
RS232	
RS485	

You will find further information on the various communications systems at www.SMA.de.

The setting options for Windy Boy performance adjustments to the characteristic curve of the generator and explanations of the necessary operating parameters are given in detail in the Windy Boy operating manual.

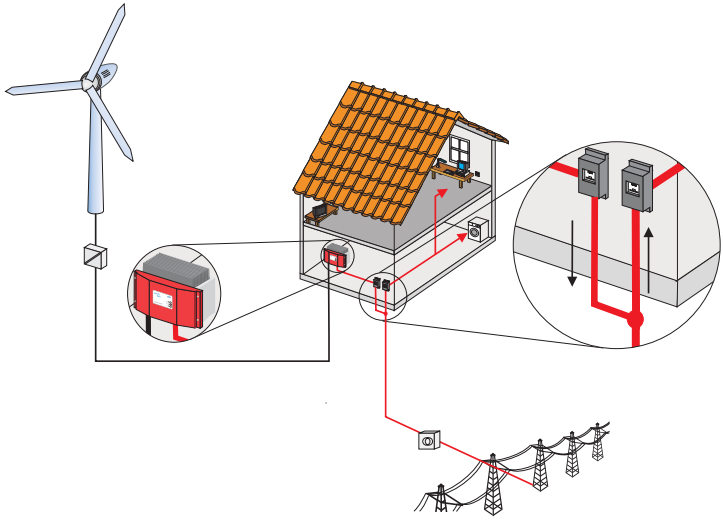
Parameter setting specifications can not be provided by SMA as many and precise wind turbine details dependent on the planned location would have to be available. As this is often not the case in practice, experience shows that establishing parameter settings by trial and error provides the best results.

6 Grid

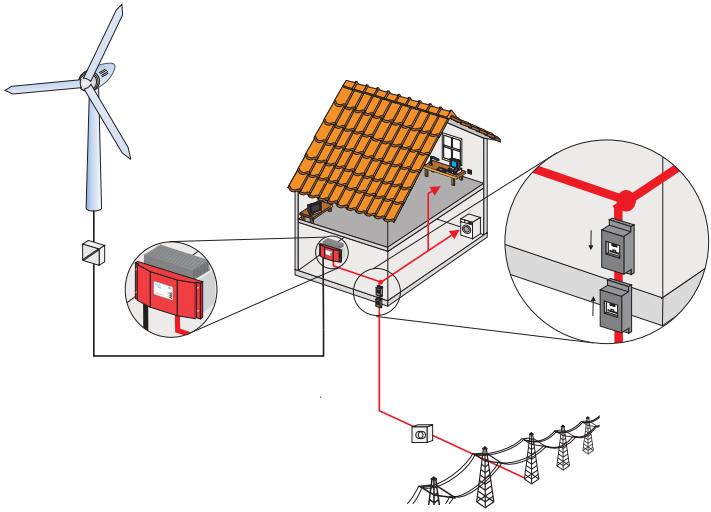
The Windy Boy grid inverter, which is developed especially for wind turbines, can be adjusted to the wind turbine's power output characteristic curve using the appropriate software and can feed electricity into the domestic grid even at very low wind speeds. It is irrelevant whether one sells one's cost-effectively produced electricity exclusively to the energy supplier (direct grid feed-in) or, for example, uses it oneself during the day and feeds the surplus energy into the grid at night (surplus feed-in). Feed-in to a stand-alone system is also possible in combination with a Sunny Island.

Feed-in to a public grid can be carried out in a number of ways:

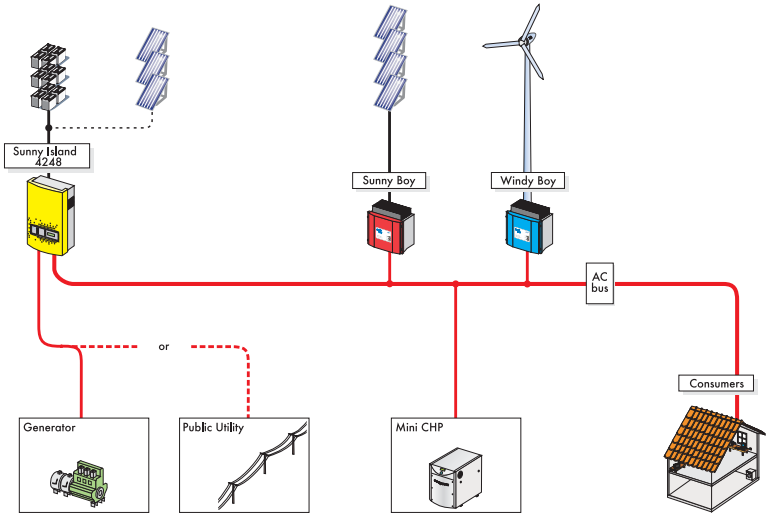
Direct grid feed-in



Surplus feed-in



Integration into a stand-alone system in combination with a Sunny Island



As a basic principle, a feed-in application must be made to and approved by the electricity supply company.

The Windy Boy complies with all the VDEW (Verband der Elektrizitätswirtschaft – German Electricity Industry Association) regulations for the parallel operation of electrical power units on the low-voltage grid of the electricity supply company as well as numerous standards in different countries. This also encompasses the regulations of the German Professional Association for Precision Engineering and Electro technology relating to "Independent disconnection device for electrical power units" (SMA grid guard) and/or DIN VDE 0126. In addition to this, the Windy Boy conforms to the electromagnetic tolerance regulations and the low-voltage regulations of the relevant combined European norms, as confirmed in the CE declaration of conformity.

You will find the certificates necessary for approval to be presented to the electricity supply company in the Windy Boy accessories kit or download them at www.SMA.de.

The most important certificates are:

- "Declaration of conformity with VDEW guidelines on inverters for grid supply".
- The Windy Boy is equipped with the independent disconnection device "SMA grid guard" and it is covered by the industrial trade association "SMA grid guard" import certificate.

The following certificates are available:

	checked:
Windy Boy declaration of conformity	
Windy Boy import certificate (SMA grid guard)	
Nominal apparent power certificate	

7 Wiring

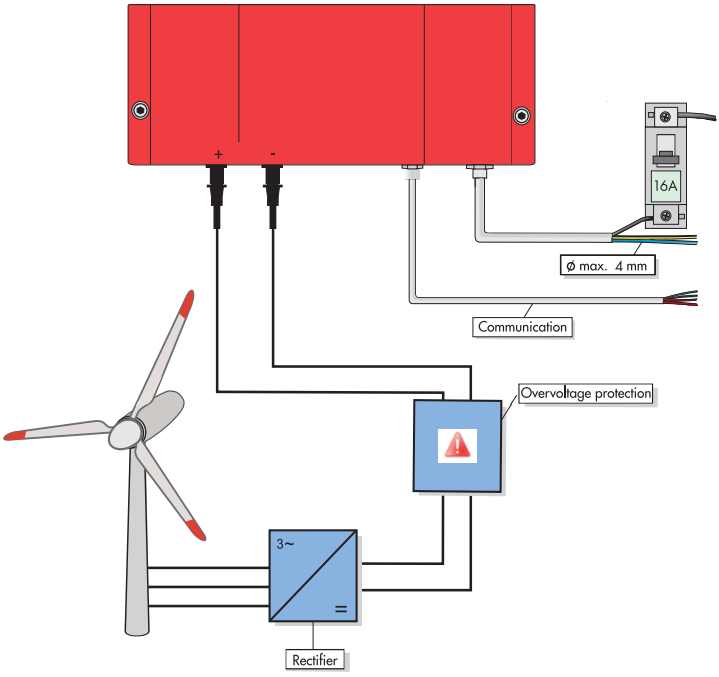
All Windy Boy DC connections are equipped with "Multi-Contact 3mm" connectors as standard. This connector system is widespread in photovoltaics and satisfies criteria for meeting the toughest of demands both indoors and outdoors. Other connector systems, such as "Multi-Contact 4mm" or "Tyco", are available upon request.

The Windy Boy's connection to a rectifier or your wind turbine's overvoltage protection on the DC side can be carried out in one of two ways:

- Connecting to upstream equipment via customized cables with "Multi-Contact 3mm" connectors,
- or, more straightforwardly, via the Multi-Contact Adapter Set (3mm) which is optionally available at SMA. The set contains two cables, approximately 80cm long, each fitted with a DC plug and an open end (with butt connector and shrink tubing) to be connected to the upstream components.

Please check which accessories are required for the DC wiring:

	Your selection:
Multi-Contact Adapter Set 3mm from SMA (SWR-MC Multi-Contact Adapter Set ALT)	
2 x 3mm Multi-Contact plug with cable	



8 Summary

We are happy to have provided important information on planning a grid-connected wind turbine with the appropriate Windy Boy inverter via these guidelines.

If you have any further questions regarding Windy Boy products, you will find all important contacts and addresses in section 11 "Contact" (Page 31).

9 Appendix A: Technical Data

	WB 1100LV	WB 1100	WB 1700	WB 2500	WB 2800i	WB 3000	WB 3300	WB 3800	WB 5000A	WB 6000A
Input Data										
Input voltage range	21 ... 60 V	139 ... 400 V	139 ... 400 V	224 ... 600 V	224 ... 600 V	268 ... 600 V	200 ... 500 V	200 ... 500 V	246 ... 600 V	246 ... 600 V
Nominal DC operating voltage	25 V	180 V	180 V	300 V	300 V	350 V	200 V	200 V	270 V	270 V
Recommended generator power for 2500 full-load hours per year	900 W	900 W	1395 W	2070 W	2340 W	2475 W	2970 W	3420 W	4500 W	5400 W
Recommended generator power for 5000 full-load hours per year	800 W	800 W	1240 W	1840 W	2080 W	2200 W	2640 W	3040 W	4000 W	4800 W
Output Data										
Max. AC output	1100 W	1100 W	1700 W	2500 W	2800 W	3000 W	3600 W	3800 W	5500 W	6000 W
Rated AC power	1000 W	1000 W	1550 W	2300 W	2600 W	2750 W	3300 W	3800 W	5000 W	6000 W
Efficiency										
Max. efficiency	92,0 %	93,0 %	93,0 %	34,1 %	94,0 %	95,0 %	95,2 %	95,6 %	96,1 %	96,0 %
Euro-ETA	90,4 %	91,6 %	91,8 %	93,2 %	93,0 %	93,6 %	94,7 %	94,7 %	95,0 %	95,1 %
Other										
Dimensions (w x h x d) in mm	434 x 295 x 214	322 x 320 x 180	434 x 295 x 214	434 x 295 x 214	440 x 305 x 226	434 x 295 x 214	450 x 352 x 236	450 x 352 x 236	430 x 600 x 450	430 x 600 x 450
Weight	28 kg	22 kg	25 kg	30 kg	31 kg	32 kg	41 kg	41 kg	63 kg	63 kg

10 Appendix B: Checklist

The following checklist lists all the technical considerations given in these system guidelines again.

Description	**Your data**	**Unit**
Rectifier		
Rectifier available		
Rectifier type		
Wind turbines		
Max. generator power at 5 m/s		W
DC output voltage at 5 m/s		V
Max. generator power at 12 m/s		W
DC output voltage at 12 m/s		V
Wind turbine open-circuit DC voltage		V
Wind turbine maximum power output		W
Wind turbine nominal power output		
Wind turbine power output curve		
Wind turbine energy yield characteristic curve		
Average site wind speed		m/s
Annual full-load hour calculation		hours p.a.
Overvoltage protection		
Overvoltage protection achieved by...		
Voltage limitation at		V
Windy Boy		
Windy Boy type		
Number of Windy Boys		units
Communication with RS232, RS485, Powerline, Radio Visit www.SMA.de		
Communication with the USB-Service-Interface Order no.: USBPBS		
DC connection adapter set		
Other installation material		
DC cables		
AC cables		
Fuses		
Energy meter		

11 Contact

If you have any questions or technical problems concerning the Windy Boy, please contact our hotline. Please have the following information available when you contact SMA:

- Inverter type
- Type of wind turbine and AC/DC converter
- Type of overvoltage protection
- Communication
- Serial number of the Windy Boy

Address:

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Hannoversche Strasse 1 - 5
34266 Niestetal
Germany

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www.SMA.de

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