ammonit

Measuring equipment for climate research and wind energy

ammonit *– powering wind power*

Quality management

Ammonit has established objectives and principles to ensure the constant development of its products. Ammonit is certified in accordance with ISO 9001:2000.
We work to provide the highest quality and reliability for our customers.

Contents

Dear Reader,

We are pleased to offer you the fruits of our experience with measuring technology for wind energy predictions, wind monitoring and climate research, together with details of our range of Ammonit Data Loggers and custom-made components, and first-class sensors.

This knowledge could be invaluable to you if you are considering any activities that involve meteorological measuring technology. The tips and information will make it much easier for you to pay attention to most important criteria in order to obtain high-quality wind measurements and energy predictions.

This could be the case if you require wind predictions for a location, if you are a consultant called on to make an assessment with far-reaching consequences, if you work for a financial institution that has to decide on whether to provide funding for a project, are a wind farm operator who would like to have unbiased annual measurements, if you need to determine air flows round buildings or generated by trains, or establish a wind index to assess the long-term potential of wind energy at a site.

The field of meteorological measurement has expanded continually in recent years and considerable technological advances have been made. Ammonit has been playing a leading role since 1989 in all matters relating to wind measurement systems and has not only accompanied all the developments but has also been contributing its own innovations. All our experience has found it way into this catalogue.

We ensure highest quality and reliability through the certification of our company in accordance with ISO 9001:2000 and we not only document this with facts and figures, but also with the contents of this brochure. We attach great importance to the highest product quality, and for wind energy predictions we recommend exclusively anemometers of Class 1 (in accordance with IEC 61400-121-CD) with anemometer calibration by accredited institutes (in accordance with EN ISO/IEC 17025:2005) on the basis of the MEASNET guidelines. The quality of our loggers has provided the basis for 20 years of successful operations.

We see this current catalogue both as an all-round overview of our products and also as a guideline for the effective use of meteorological measurement technology. We are pleased to share our knowledge with you, because we are sure that your increased knowledge will be to our advantage in the long-term. This is a reflection of the transparent corporate philosophy which has helped to establish our first-class reputation in this sector. We aim to remain true to our principles in the future by putting all our efforts into the research and development of new products, by the expansion of marketing and logistics structures, and by maintaining high levels of consultancy and customer service.

Ammonit - ***powering wind power!***

Michael Kubatzki
Managing director, Ammonit GmbH

PS:
Our catalogue covers many aspects of wind measuring technology, but it cannot replace the advice of a wind consultant. Particularly if you are inexperienced, we recommend that you should contact an expert at an early stage.

EVEREST – autonomous power supply

Ammonit measuring stations with low-energy sensors are mostly powered by small solar modules providing 5 to 20 Watts, and that means that they can be installed without any problems even at remote locations where there is no access to a power supply. But what if more power is required, for example for heating the sensors, or to prevent the moving parts of anemometers from icing up? Or in a location where a high mast has to be fitted with bright warning lights as an air traffic safety measure?

As part of the EVEREST programme, Ammonit is supporting the development of hybrid systems with solar panels and fuel cells. Together with 14 German, Austrian, and Swiss industrial companies and research institutions, the Fraunhofer Institute for Solar Energy Systems ISE has been developing modular hybrid energy systems since January 2006, with the goal that geoscience measuring stations can be operated cost-effectively and reliably at remote locations where there is no access to a power grid.

In addition to harmonising the various components and developing an innovative energy management system (EMS), the third sub-project involves carrying out field trials lasting several months. In order to test operational reliability under harsh conditions, an Ammonit measuring station has been installed on the Schauinsland mountain in Southern Germany.

www.everest-energie.de

Ammonit – powering wind power

From a local pioneer to a global provider

Ammonit was one of the pioneers in the field of high quality wind measurements and today it is a leading player in the development and production of meteorological measurement systems.

Creativity in Berlin

A key to our success has been the uninterrupted dedication to wind energy coupled with innovative research and development work. Ammonit has a reputation for working together with scientists and engineers to develop intelligent solutions for measurement tasks. International wind consultants, leading research institutes and major manufacturers of energy plant have been loyal customers for many years.

From invention to a leading brand

Ammonit has continually gathered knowledge over two decades through its goal-oriented research and its persistent efforts to identify emerging problems and to provide new solutions. It all began in 1986 with the development of the first WICOM wind computer by the company Kosonanz - representing a group of Berlin engineers. When it was founded in 1989, Ammonit GmbH acquired the rights to WICOM, advanced its technical development step by step and launched a sophisticated product on the market. WICOM was already being used to collect the measurement data for the first German Wind Atlas. In 1999, the brand name was registered for Europe, and since then it has set standards in the professional utilisation of wind energy and has maintained its reputations in the sector. Since 2003 the latest version on the market has been the WiCom-32.

Always one step ahead

As a result of the blend between science, engineering and practical experience, which has been of central importance for Ammonit ever since its inception, the company has managed to keep one step ahead with its own developments. The close co-operation with consultants has given rise to new solutions. Practical implementations and the evaluation of experience with the complicated measuring technology showed the Ammonit engineers the way forward.

Reliable measurement systems

Today, Ammonit provides a whole range of equipment from wind computers for the investigation of wind energy converters through to multi-channel data loggers for the measurement of all energy plant parameters and complete data registration, as required in meteorology and climate research. Our speciality is precision data loggers including the entire periphery for wind energy predictions and monitoring.

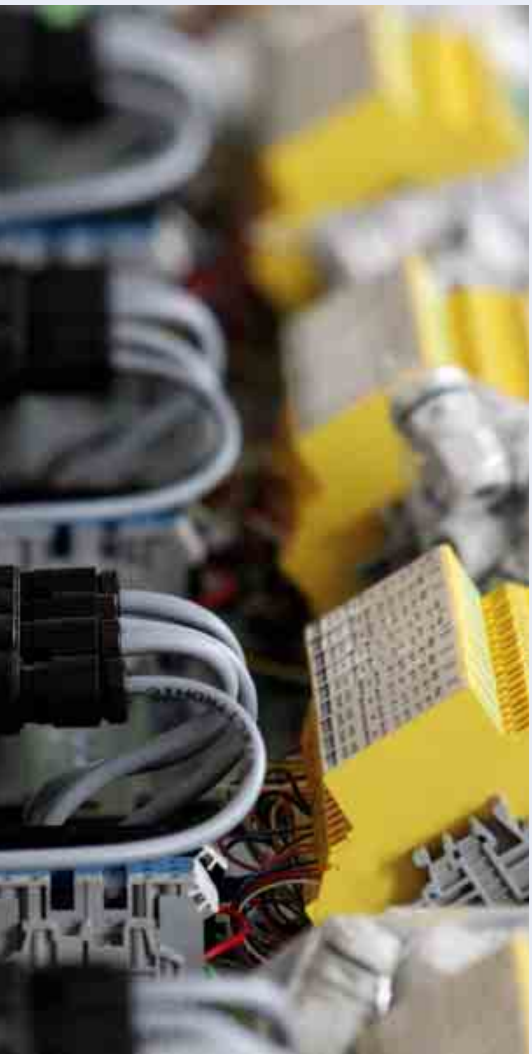
Many accredited wind experts work with Ammonit systems. They know that in addition to the Logger they will have access to the entire range of measurement expertise - from advice throughout the selection and installation of the appropriate equipment to the registration and evaluation of the data. The reports they produce often provide the basis for decisions with far-reaching implications. When it comes to approving investment proposals, financial service institutions now look very carefully at the quality of the measuring equipment that was used.

A new phase of company development

With the inexorable rise of energy renewables, Ammonit GmbH has now entered into a new phase of its development. The rapid growth calls for new strategies and structures. This has included the modernisation of the location in Berlin-Kreuzberg.

Global network, regional presence

The faster a market grows, the more important close contacts with customers become - and this applies not only for erection and installation, but also for technical services and the best possible consultancy. Ammonit is continually expanding these fields and is increasingly paying attention to evaluation services. All this will be of benefit to Ammonit customers worldwide - including regional contact



Activities include above all research and development work in the fields of power supplies (solar and fuel cells), and software development for various tasks such as online-measuring stations and data evaluation programmes.

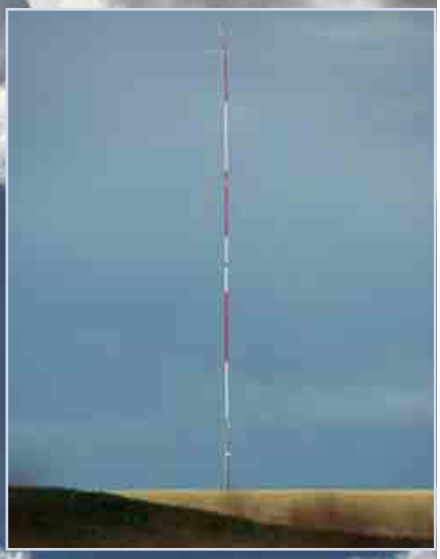
Important topics in the future will include the further adaptation to the SCADA systems of leading manufacturers for wind farm monitoring and the registration and evaluation of operational data for wind farm management systems.

partners. The worldwide dealer network is steadily being expanded - and there is a growing trend towards Poland, Turkey, China, USA, and South America. We provide all our trading partners worldwide with the same standards in best quality.

Ammonit's corporate goal is to offer the entire chain of the measurement process from one hand, in order to ensure more effective, reliable and cost-effective performance. In line with our slogan:
powering wind power.

Wind potential in Poland

The process of investing in the construction of a wind farm begins with the identification of a possible location. Then it is necessary to work with consultants using professional measuring equipment to determine the wind potential of the location.



The Windhunter company in Poland has specialised in erecting measurement masts and installing the entire range of Ammonit measurement systems.
In Stare Stracze near to the town of Zielona Góra, a 50 metre mast was erected by a team of four in only two days, including all the necessary equipment and sensors. Roman Synowski, managing director of the company, usually puts his back into the work as well. Only three days earlier he and his team had been working in northern France on a wind farm being planned by a German investor. The assignment before that was a 100 metre-high mast in northern Poland.

In most cases the team has to work in an open field, without infrastructure and without access to a power supply. And the work is spread over the entire year - with erection by rain, frost or in the heat of summer. A lot of manual work is involved, because with inadequate road access it may be impossible to use a crane. The inaccessibility of the locations means that it is essential that the measuring equipment operates with complete reliability and that it has an autonomous power supply.

www.windhunter.com

Correct analysis – independent monitoring

What you should know about measurements

Meteorological measurements are needed for many applications, for example for weather forecasts, in agricultural meteorology, for industrial control processes or in various fields of research. All these fields of application have their own specific conditions, which require appropriately adapted technology.

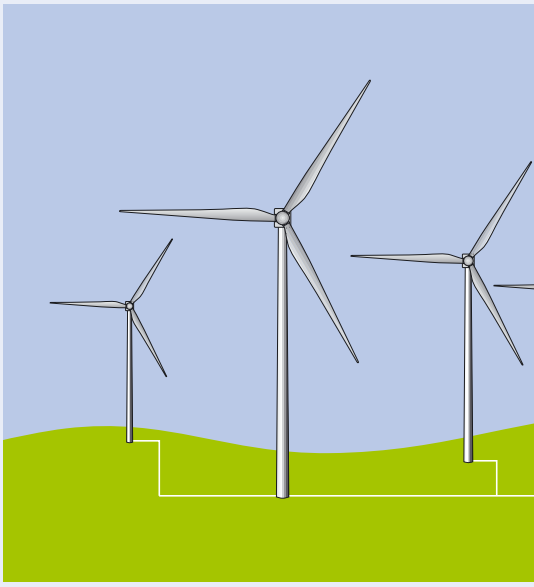
The main tasks of professional wind measuring equipment for energy applications are the wind predictions for new locations, and monitoring and verification for existing wind parks.

Predict - is the location effective?
Before deciding on a location for the installation of a wind farm, meteorological data must be collected with the highest possible precision so that experts are able to assess the wind potential of the proposed site. It is important that there are not gaps in the datasets and that they can be examined for plausibility. The measuring instruments must have been properly installed and the anemometers must be classified (IEC 61400) and properly calibrated (MEASNET).

It is then the task of the experts to place the measurements in a long-term context and, taking local factors into account, to calculate energy predictions for the entire wind farm. The final report will play a key role when it comes to deciding whether to approve the necessary investment.

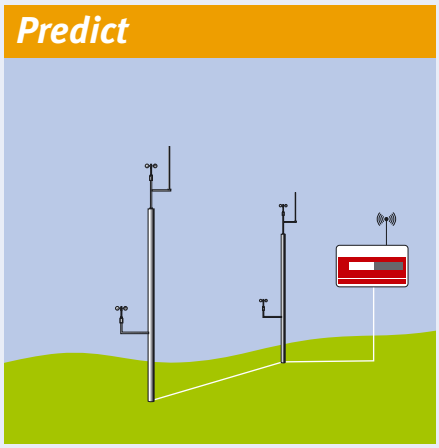
Verify - is the performance acceptable?
Verification of the predictions for annual production for an installed wind park can be provided by taking on-going meteorological measurements, and these may also show up possible optimisation measures. The operator of the wind farm is interested in having a measuring system which is independent of the manufacturer of the wind power generators, and which can be configured and read out independently.

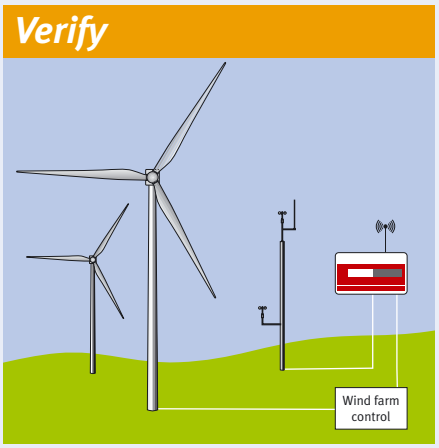
Properly installed professional equipment in the direct vicinity of the wind power generators is also of interest to the manufacturer of the plant. The integration of the data in the company's own SCADA system can make it possible to react quickly to possible faults, or to document the proper performance of machines.



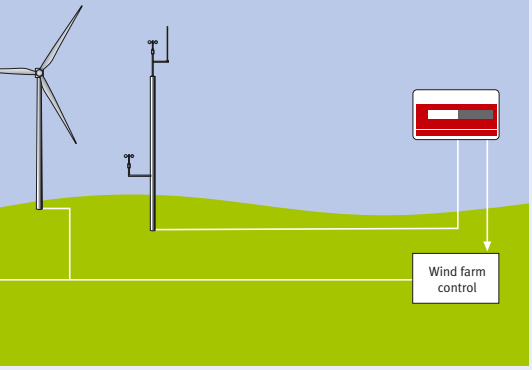
Precision - how great is the risk?
Hardly any other application places such high demands on the accuracy and reliability of measurements as the yield predictions for wind energy exploitation. Even a slight deviation of the results can lead to a large error in the prediction, increasing the risk that the planned investment will not be economically viable. And because the data registration has to be uninterrupted over a period of at least 12 months, it is necessary to avoid even short-term malfunctions.

Calculated over the operational life of a medium-sized wind farm, an error can easily result in a difference in revenue of millions of euros. That makes even the most expensive and complicated measuring system seem cheap in comparison.





SCADA-System



More knowledge - lower costs?

When it comes to precise measurements, the choice of the right sensors and the measurement set up is of crucial importance. If mistakes are made at this stage not all of the data material that is collected will be suitable for a useful evaluation. If you will later be hiring a professional wind expert to analyse the location, then you must provide measurements that are as reliable as possible.

It is always necessary to allow for possible errors when it comes to making predictions. Uncertainties arise right from the start because the mathematical methods that are used are based on ideal models of wind conditions, and calculations for complex terrain are extremely complicated. This makes it all the more important to avoid unnecessary deviations in the mea-

The effects that incorrect measurements can have on energy predictions:

Correct measurement 30 m measurement = 5.3 m/s 50 m measurement = 5.7 m/s	This gives a roughness length of 0.035 m and a wind speed at a height of 85 m of 6.12 m/s	A wind turbine with a 1 500 kW rating and a hub height of 85 m on this site would generate: 2 849 MWh p.a.
Possible measurement errors at 30 m = 5.1 m/s at 50 m = 5.9 m/s caused by • Lack of calibration • Incorrect installation • Skew winds	The result is a calculated roughnes length of 1.156 m and a wind speed at 85 m of 6.73 m/s	These small errors would result in a prediction for the same wind turbine of: 3 543 MWh p.a.
Measurement error at 10m = -0.2 m/s (-3.8%) Measurement error at 30m = +0.2 m/s (+3.5%)		**Overestimation = 24.4%**

The example demonstrates the risk an investor runs by relying on data from inadequate or incorrectly installed measuring equipment. Taking an average price of €0.08/kWh for the example above, the inaccurate prediction could lead to an annual revenue which is €50 000 lower than expected for a single 1 500 kW wind power generator!

surements taken as the basis for these calculations.

Many years of experience with wind measurement technology for the analysis of a location have shown us how important it is to take certain key factors into account when purchasing and installing measuring systems. In part, good measurements are the result of the willingness to invest (above all top quality, calibrated and classified anemometers). But many faults can be avoided without additional costs. Often the secret lies in having the necessary knowledge before you start.

What and where to measure

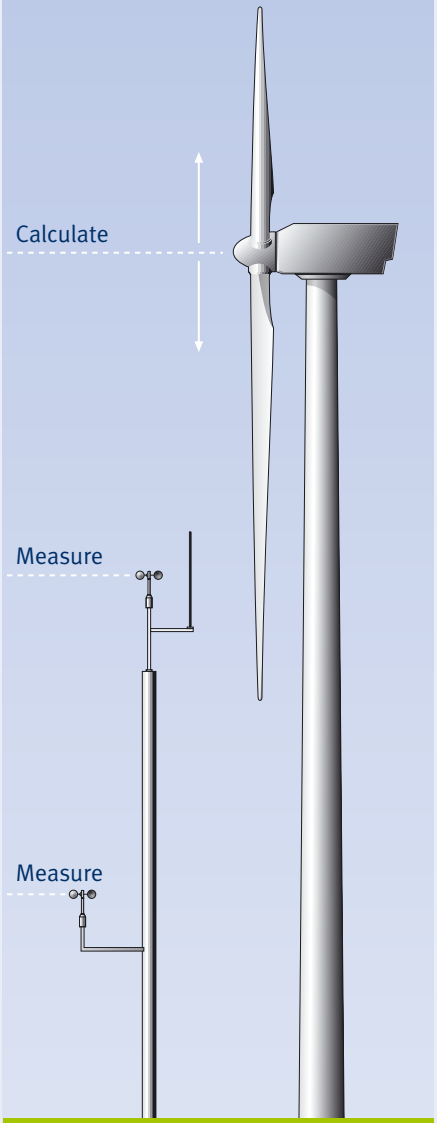
Wind speed

It would be ideal to measure the wind speed at the height at which the hub of the wind rotor is to be installed, but there are two arguments against this. Firstly, this height will not yet be known, and indeed it is one of the things that will be determined on the basis of the measurements, and secondly it would require erecting a very tall, and therefore expensive, measuring mast. The alternative is to use two anemometers at lower heights. This makes it possible to determine the character of the terrain at this location (roughness length Z_0), and then to calculate the wind speed at other heights using a logarithmic model. However, since the differences in mean wind speeds at different heights are small, it is important to be as precise as possible.

- Individually calibrated Class 1 anemometers should be used.
- The lower anemometer must be high enough to avoid being affected by obstacles such as bushes or buildings.

Setting up a 50 metre mast in Poland

Measurement height



- The two anemometers must be at least 15 to 20 m apart. At a simple location (flat land, no obstacles) it is sufficient to use a measuring mast with calibrated anemometers at 10 m und 30 m. In complex terrain, the lower anemometer must be higher off the ground, and in order to maintain the minimum spacing between the two anemometers, the mast must be taller. Measurements may be necessary at 20 m and 40 m, or 30 m and 50 m, and in extreme cases even higher.

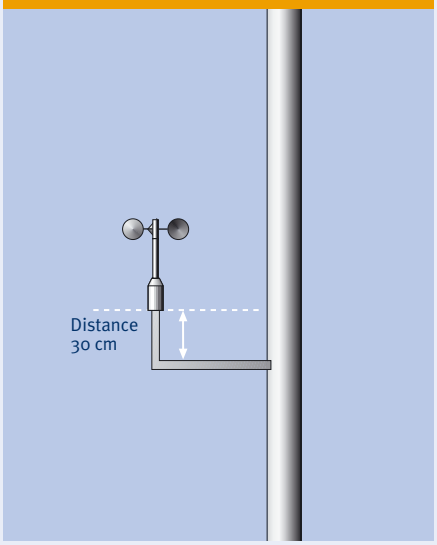
Wind direction

It is also important to measure the wind direction at the site, so that a wind park can be laid out correctly, minimising the shadowing effects between wind power generators. The wind direction only has to be measured at one height, and the wind vane should be installed about 1.5 m below the top of the mast so as not to interfere with the top anemometer.

Air pressure and temperature

Air pressure and air temperature measurements are also needed for wind energy predictions, but because they play a less significant role the sensors do not have to be as accurate. The measurements do not have to be made directly at the location either, so that it is possible to use data from weather stations in the vicinity. However, investing in your own sensors offers the advantage of avoiding the trouble involved in collecting and integrating the external data. The air pressure can

The correct traverse

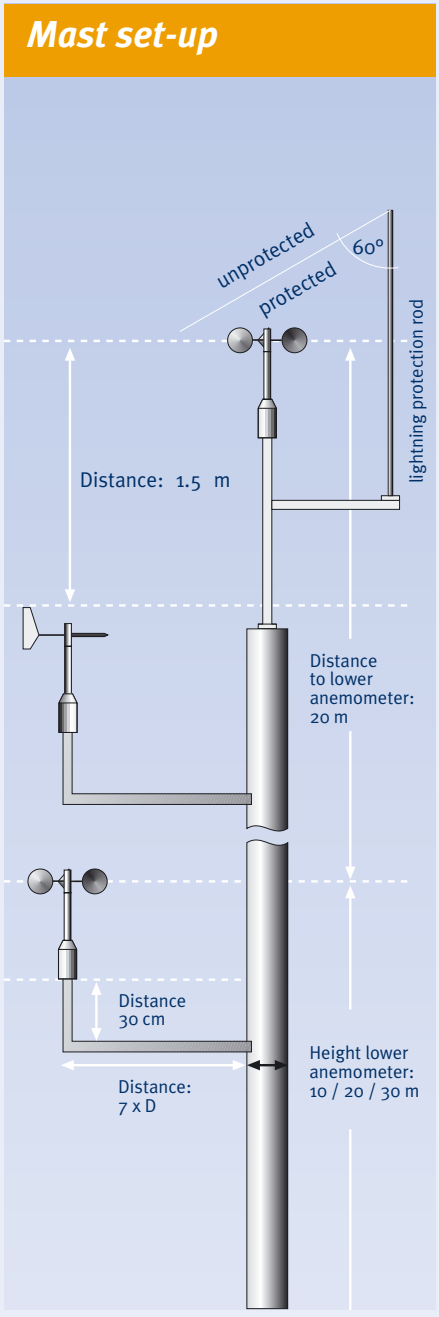


be measured at any height, but most commercially available barometers will require additional protection against the effects of weather, so that we recommend installation in the steel cabinet housing of the Data Logger (see components).

The thermosensor has to be fitted with suitable protection against weather influences and installed at a height of at least 10m, in order to ensure that it is not too close to the heat radiated from the earth's surface. Here it will also be better protected against unwanted attention.

Air humidity does not have any influence on the yield calculations, but it can be an important factor when it comes to assessing the risk of icing at the location.

Mast set-up



Erecting the measurement mast

Setting up the mast as well as possible will improve the data registration. The most important rules are:

- All wind sensors must be absolutely vertical. Even slight deviations lead to a oblique flow and thus to wrong measurements.

- Traverses keep the sensors as far away as possible from shaded or turbulent areas. However, the traverse must not start swinging. This can not only influence the measurement, but also lead to bearing damage of the anemometer.

- The Top-Anemometer must be located centrally on the top of the mast so it is exposed to wind from all directions without obstruction. The diameter of the top piece of the mast (at least 0.5m) should have a diameter similar to the shaft of the anemometer and should correspond to the set-up used during the calibration of the anemometer in the wind tunnel. Next to the anemometer there should only be a thin lightning conductor.

- A second and possibly also a third anemometer should be fitted on a vertical pipe attached to a traverse, so that the anemometer stays 30 to 60 cm over the traverse. A traverse directly under the anemometer can influence results!

  The fitting must be such that the anemometer traverse is at 45° to the main wind direction, which is usually known approximately.

- With a cylindrical mast, the length of the traverse should be at least 7-times the mast diameter. With a framework structure for the mast (side length up to 30 cm), you should choose a traverse length of about 1 m.

- The wind vane should be fitted on a traverse as high as possible, but at least 1.5 m below the top anemometer. The traverse is to be fitted as already described. To calibrate the vane you need a compass, or a good map in order to locate a prominent fixed point on the horizon. The wind vane will be put in place while the mast is still lying on the ground. A good angle measuring tool is useful.

- The lightning rod (approx. 2 cm thick) must be at least 50 cm away from the anemometer and must be free from vibrations. It should be higher than the anemometer, forming an angle of 60° top to top.

- The best place for the cables is inside the mast. The dead weight of free hanging cables over 50 m in length has to be secured with an additional rope. If fitted externally, cables must be connected to mast and traverses at intervals of 50 cm. Be sure that no loose

100 metre measurement mast

cables are flying in the wind, and avoid contacts with sharp edges. Even minor stresses on the cable can lead to damage in the course of long-term operations!

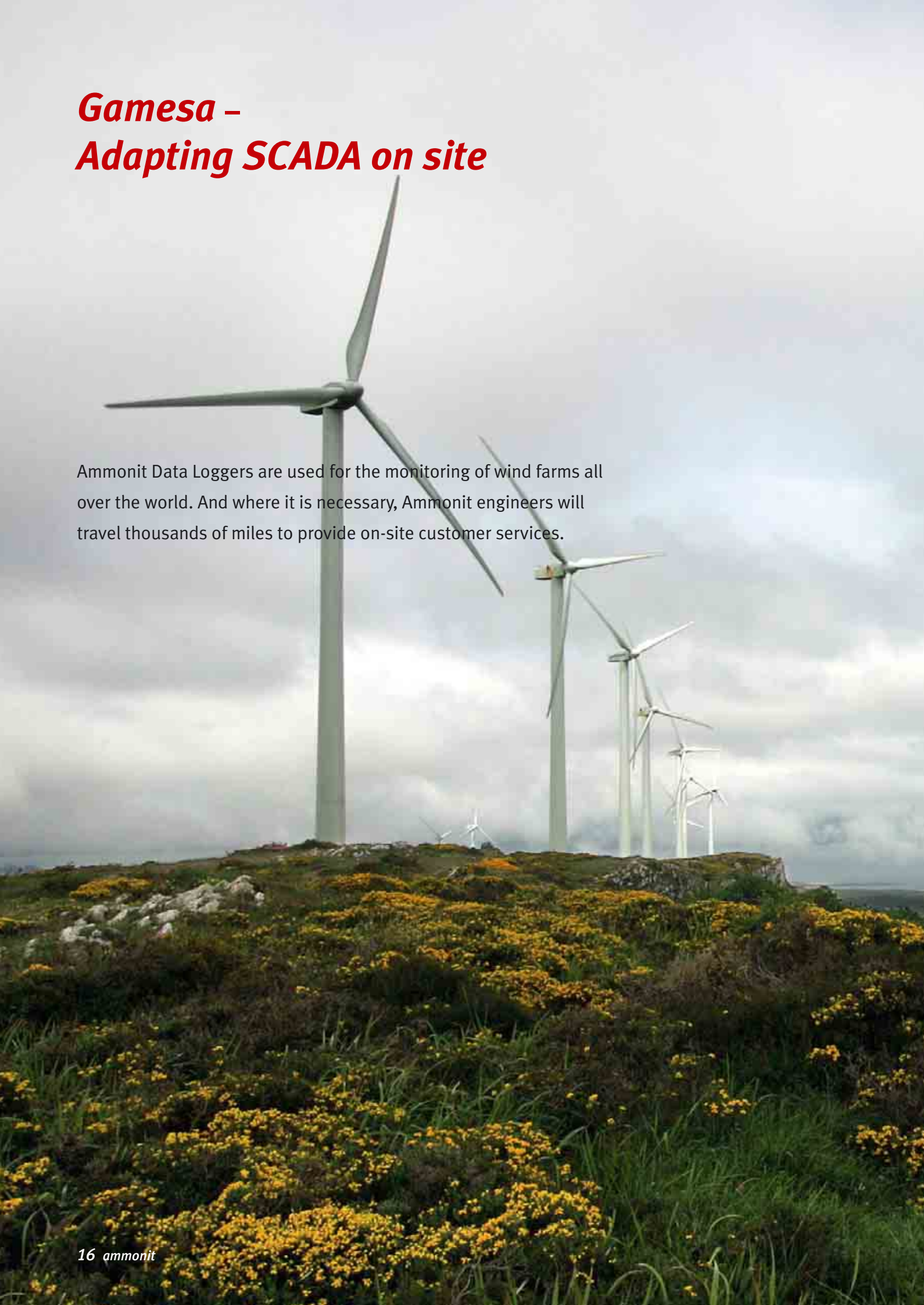
High and "uninteresting"

The other components of a measuring station (cabinet with data logger, solar-power supply and equipment for remote data transmission) should be installed as high as possible, but still within reach for access and maintenance. Experience shows that the solar panel and the GSM antenna are at special risk of theft and vandalism on stations with free access. Try to make your measuring system look less attractive. A GSM antenna for example still works if a grey plastic-pipe is put over it. And a station which works with an ordinary little solar module attracts less attention.

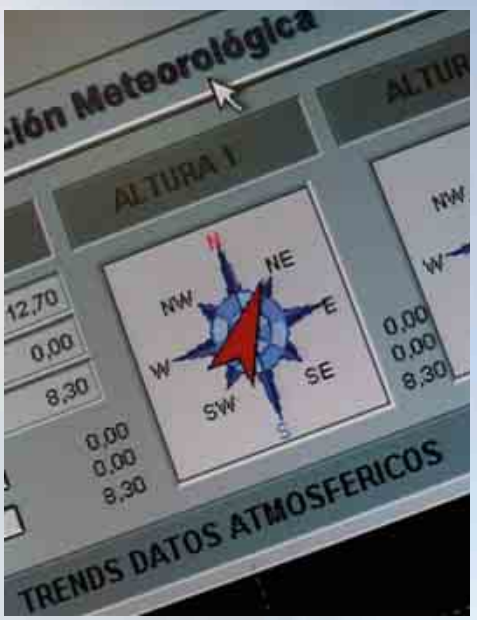
Absolutely vertical

Make sure that the mast is absolutely vertical. If you cannot climb up, you must test the orientation at the lower part with a suitable measuring tool (for example an inclinometer) and then check the mast from all sides for any bends. The human eye is able to notice even small deviations. Electronic tilt sensors fitted near the top of the mast are not only a good help for installation. The inclination of the mast can be monitored, and if remote data transmission is used, the operator of the station will also be given early warning of any problems.

Gamesa – Adapting SCADA on site



Ammonit Data Loggers are used for the monitoring of wind farms all over the world. And where it is necessary, Ammonit engineers will travel thousands of miles to provide on-site customer services.



Gamesa, the Number One manufacturer of wind energy converters for the booming Spanish market, decided to adapt the Ammonit Data Loggers for its own control requirements. In the Montejo wind farm in the mountains to the north of Burgos, the company erected a measurement mast for this purpose.

The operators provided access to the central computer in their operational headquarters and after less than two days of direct cooperation the connections to the SCADA systems (Supervisory Control and Data Acquisition) were fully functional. This means that Ammonit can now ensure all its customers worldwide that Data Loggers with their second interface also operate smoothly in combination with the Gamesa systems - as they do with Enercon, Nordex and Repower.

The SCADA systems are supplied by the manufacturers of the converters, but the meteorological measuring equipment is provided by Ammonit whenever the manufacturers do not produce these instruments themselves. Many wind farm operators also prefer to have a system which is independent of the manufacturer when it comes to checking whether the converters are working properly.

www.ecosem.es

One for all –
Data Logger Series 32

The user-friendly data loggers of the Series 32 offer a wide range of possibilities – and include a direct connection for ultrasonic sensors. All measuring stations are designed for autonomous long-term operations and are not sensitive to weather influences such as temperature fluctuations or high air humidity.

The very low power consumption of the Data Loggers and the selected sensors makes it possible to operate without a connection to a mains power supply, using batteries or a solar module. The wide range of accessories allows simple system solutions even under extreme conditions.

Protected and secure

All Ammonit measuring systems are enclosed in IP65 protective housings, and bear the CE-mark of the European Commission. As an extra precaution, the Data Logger should be installed in a lockable and well-earthed metal cabinet, which not only provides added protection against weather and lightning, but also protects against theft and vandalism. Ammonit has developed strong steel cabinets for this purpose which are also able to house additional components ensuring easy installation of the equipment on site (see also components).

The Series 32 Data Loggers are flexible and the standards of measurement processing and data security meet the requirements of professional wind consultants. But at the same time, they are so simple that even newcomers will be able to use them successfully.

Three Logger types

The only obvious difference between the WICOM-32, METEO-32 and METEO-32X is the number of their input channels. In addition to storing measurements and statistics, Ammonit Data Loggers also have a Slow Motion Recorder (SMR).

Because they are designed to provide reliable meteorological data both for location investigations and also for the monitoring of operational wind farms, all Data Loggers come fitted with the appropriate functions. An RS-485 / 2-wire interface is provided on all Ammonit Data Loggers.

Data storage

The available memory of the Data Loggers is divided into:

- Measurement series memory,
- Wind statistics memory and
- Slow-motion Recorder [SMR]

The data sets for the measurements and wind statistics are structured in blocks. One block in the measurement series memory, for example, contains all the values for one day in sequence. Both individual

Overview of operations of the Data Logger	WICOM-32	METEO-32	METEO-32X
Anemometers	3	3	3
Wind Vanes	2	2	2
Hygrometer		1	1
Thermometer		1	1
Barometer		1	1
Pyranometer		1	1
Rain gauge (or 4th anemometer)		1	1
12-bit ADC			4
16-bit counter			2
Status			2

WICOM-32

The wind computer WICOM-32 is a data logger developed specially for wind energy applications. It registers the wind speeds at three heights and the wind directions at two heights – essential for the precise investigation of a potential site and for energy predictions.

METEO-32

The METEO-32 data logger is a further development of the WICOM-32.
It registers all relevant data for detailed weather observations: Wind speed (at 3 heights), wind direction (at 2 heights), as well as temperature, relative humidity, atmospheric pressure, solar radiation and precipitation.

METEO-32X

The METEO-32X data logger is developed for meteorological measurements. It registers all the relevant data needed for detailed weather observations: Wind speeds (at 3 heights), wind direction (at 2 heights), as well as temperature, relative humidity, atmospheric pressure, solar radiation and precipitation, and offers eight additional free channels for other applications.

memories are organised as ring memories. When the memory is full, the oldest block is then written over.

This means that datasets remain in the memory even after they have been read out, and can be accessed again if required. Data is only deleted when space is needed in the memory for the current measurements. Successive read-outs overlap and so the data can easily be analysed without any gaps.

Measurement series

The Data Logger produces measurement series by registering the readings for the individual parameters at selected intervals ranging from 1 second to 1 day. If required, mean values, maxima and minima and also standard deviations can be registered. The dataset for one day is collected in blocks, which can be read out individually. The measurement series can transferred to a PC via a serial interface in the form of a text file, which means that it can easily be edited and processed using standard software (e.g. MS Excel, etc.)

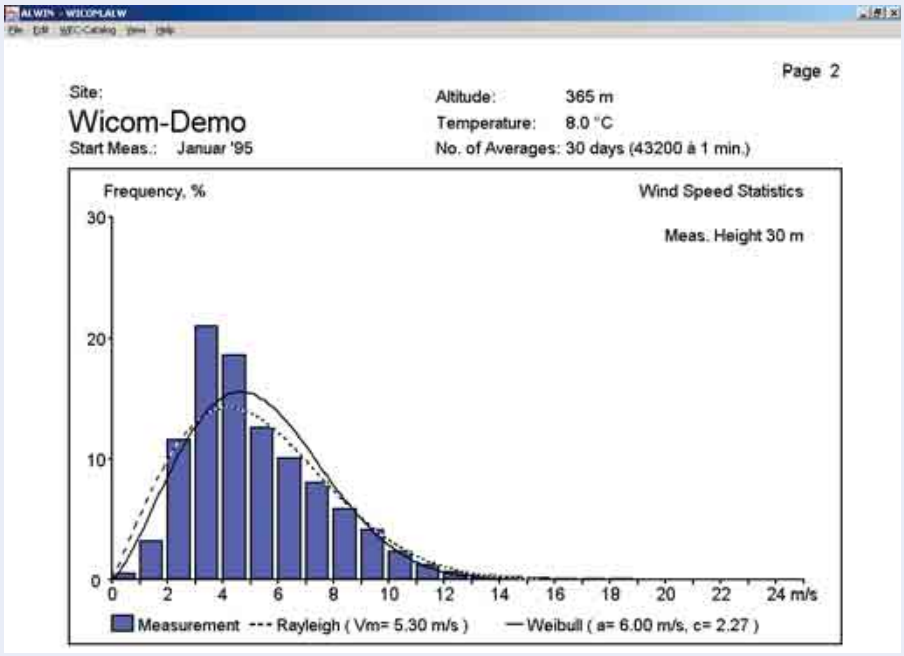
Wind statistics for energy predictions

Input parameters such as wind speed and wind directions are very dynamic. They can change in characteristic ways in the short term (gusting), as well as over very long periods (e.g. seasonal changes). A series of standard methods have been developed for wind energy users to characterise local wind regimes with only a few statistical values and tables. The frequency distribution of wind speed is produced for two anemometers with 29 classes x 1 m/s, so that even locations with strong winds can be analysed fully.

The wind rose shows the distribution of the direction of the wind in 36 sectors, allowing a detailed investigation of energy distribution, which is essential when planning a wind farm.

Roughness length Z_0 (in metres)	**Type of terrain**
0.4	Built-up areas with trees and numerous hedges
0.1	Farm land with some buildings and high wind-breaks
0.03	Open ground with individual, widely spaced obstacles
0.001	Surface waters, flat, open ground (e.g. airport runways, mown fields, etc.)

Definitions based on the European Wind Atlas. The roughness length represents the height at which the wind speed is slowed down to zero by the nature of terrain.



Gentle time control

Without a precise clock, accurate registration of date series is not possible. But electronic clocks are temperature-dependent. At -20°C the deviation is already 75ppm, or 3 minutes per month. Ammonit is not satisfied with simple quartz timers. Using a system that we call "gentle time control", Ammonit Data Loggers now operate with an accuracy of < 5ppm over the temperature range from -30°C to +60°C. That means a time deviation of less than twelve seconds a month.

Statistics for energy predictions

The basis for the prediction of wind energy yields is the determination of the long-term relative frequency distribution of the wind speed at the height of the hub of the wind turbine. It can be represented by:

• The Rayleigh function

If only the mean value of the wind speed is known for a location, then this function can be used to calculate the probable variations around this value.

However, the Rayleigh distribution has a fixed form and can only allow for the regional variations of a site to a limited extent.

• The Weibull function

In order to calculate the Weibull distribution, two parameters are required: the scaling factor A, and the form parameter C. This function describes the wind situation more accurately than the Rayleigh function, because the shape of the distribution can be taken into account.

• Classification of measurement data

This method is used to bring measurement data into a standard form reduced to the necessary minimum.

The measured data has to be corrected in two stages:

a) Conversion to hub height

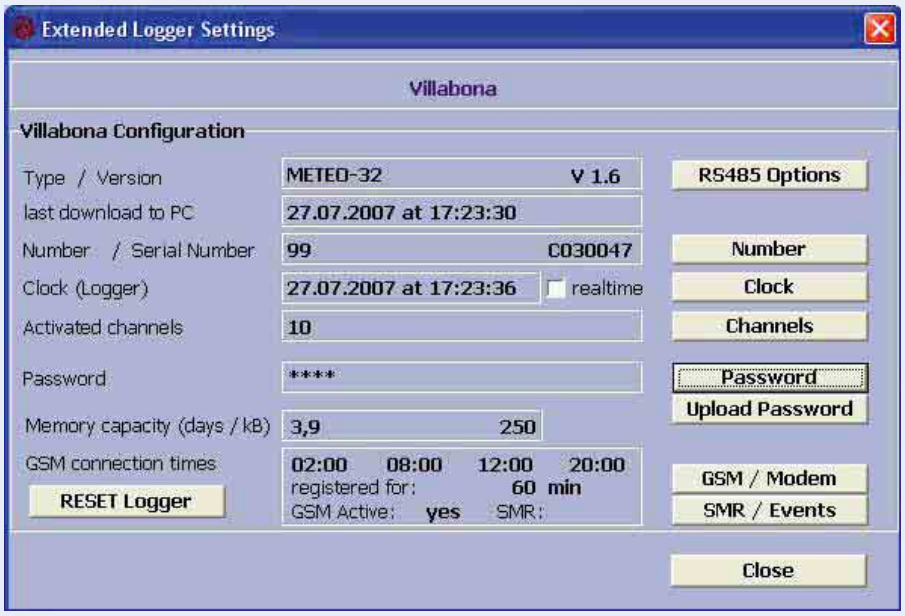
Since the wind measurements are invariably measured at heights much lower than that of the hub of the wind generator, it is necessary to convert the values to the necessary height. To do this, the first step is to determine the roughness length at the location, making allowances where necessary for the differences in the terrain in various directions.

Tables are available for the roughness length that provide approximate guideline values on the basis of descriptions of the terrain. However, it is better to conduct careful measurements of the wind speeds at two heights.

The roughness length represents the height at which the wind speed is slowed down to zero by the nature of terrain.

CALLaLOG2002 software

The CALLaLOG2002 program can be used to configure, monitor and control the data transfer of any number of measuring stations via modem or cable. A number of loggers can be grouped in individual projects, each with their own interface and a separate access time. In this way, all the projects, with any number of measuring systems can be monitored quickly and efficiently.



b) Comparisons with long-term data

Data must be recorded for at least one complete year, in order to take seasonal variations into account. This data covering one year must then always be compared with long-term data, because the wind speed for a year can vary by up to 20 % from the long-term mean. These comparative datasets, which are needed for the corrections, can often be obtained from weather stations in the neighbourhood, from airports, or from wind energy converters already installed in the area. The key is the continuity of measurements (e.g. no discontinuities due to moving the mast) and the similarity of the topography in the locations.

The second interface

The Data Logger is linked to a PC/Laptop via an RS232 serial interface. This allows communication with the CALLaLOG software in order to configure the system and to access data. All Loggers also have another data connection, namely a serial RS485 2-wire line of the type used in many active sensors, measurement modules and SCADA-systems. Simple converters can be used to adapt this to other standards (USB, RS232, Ethernet).

This interface makes it possible to extend the system by up to eight sensors with digital-serial outputs. The user can cascade the measurement system with further Ammonit Data Loggers, control special output modules, or transfer measurement data to other storage systems.

Example 1: Passing data on to the wind farm control

Various producers of wind energy converters use this possibility to integrate meteorological data in their own control system and offer fully fitted measurement masts based on the Ammonit systems. A variety of methods are available:

- The Logger continuously broadcasts date and time, current measurement values and stored data (Broadcast mode).
- Specific requests for data are sent to the logger (MODBUS-protocol in slave mode)
- The SCADA-system works as MODBUS slave and makes a number of registers available which are loaded by the Data Logger on demand. It is also possible to fill history data retrospectively if the control software was out of operation for a period.
- For control processes which require analog input signals, Ammonit offers extension modules which can output measurement values either as voltages (0 ... 10 V) or as currents (0/4 ... 20 mA).

The standards of the Series 32:

1. *Recording measurement series at freely programmable intervals*
2. *Producing wind statistics for energy predictions*
3. *Slow-motion Recording (SMR) of wind data for special events*
4. *Three buttons and a two-line display for easy use*
5. *Designed for use over a temperature range from -40°C to +85°C*
6. *Low-power electronics and standby-operation*
7. *Internal clock with a deviation of < 5 ppm over the entire temperature range (approx. 12 seconds / month)*
8. *Emergency power supply by standard 9 V block battery, lithium type optional*
9. *Socket for external power supply 10 ... 26 V DC*
10. *Separate power supply for wind sensors with trip switch*
11. *GSM/GPRS-option for data transfer and e-mail / SMS*
12. *Remote control and data transmission through the World Wide Web*
13. *Internal monitor of power source and internal temperature*
14. *Plausibility checks of measurement values*
15. *Generation of warnings (GSM-option)*
16. *Non-volatile 4000 KB memory (approx. 2 000 000 measurements)*
17. *Update of user software via serial interface and GSM*
18. *RS232-interface for data transfer (38400 baud)*
19. *Data compression to accelerate data transfer up to 30%*
20. *RS485-interface, e.g. for connecting ultrasonic anemometers, SCADA, visibility sensor*
21. *User friendly software for Multi-Logger-Management with graphical user interface*

Data Loggers Series 32

Input channels	
Recommended sensors	Wind speed Wind direction Temperature Temperature/Humidity Air pressure Precipitation
Housing	Protection Dimensions/Weight Connectors
Power Supply	External Current Emergency power supply
Temperature	Operational range Display readable
Memory **Clock/Backup battery**	
Digital output	
Data output	
Series measurements	Scan interval Log interval Configuration Functions
Statistics	Scan interval Log interval Configuration Evaluation
SMR	Scan interval Memory capacity Configuration
Included delivery	

Example 2: Site Calibration by cascaded Data Loggers

For site calibration it is necessary to register the performance graph for a wind energy converter. A measurement mast is erected as a reference at a suitable location, and a second is erected on the spot where the WEC is later to be located. In order to determine deviations between both measuring points as well as possible and to take these into account for subsequent plant measurements, it is essential that the measurements should be synchronised and the data should be collected in a dataset. This can be simply achieved by cascading the two Loggers, so that one of them only operates as slave and passes data every second to the main station, for example by means of a GSM-modem.

Incidentally, the systems can also be linked by Bluetooth or some other wireless transmission route!

Example 3: Control of mast warning lights

Wind measurement masts are getting taller and taller and they are increasingly required by law to be fitted with warning lights for the safety of air traffic. These fittings must comply with international specifications (Standard: ICAO Annex 14), and light intensities must exceed a threshold Candela value. In some cases a flashing light is required. In the event of problems, the lamps must be switched over to a reserve system and notification must be sent automatically to the responsible operator. This makes it necessary to have a reliable power supply (see EVEREST) and a complicated, processor-based control system with appropriate communications facilities. This can be provided by the existing Data Logger. Ammonit has therefore developed a solar warning light system which is controlled and monitored by the Logger.

	P2500 - WICOM-32	P2510 - METEO-32	P2520 - METEO-32x
			
	3 x Wind speed, 2 x Wind direction	3 x Wind speed, 2 x Wind direction, 1 x Rel. air humidity, 1 x Air temperature, 1 x Air pressure, 1 x Global radiation, 1 x Rain	3 x Wind speed, 2 x Wind direction, 1 x Rel. air humidity, 1 x Air temperature, 1 x Air pressure, 1 x Global radiation, 1 x Rain, 4 x 12-bit-ADC, 2 x 16-bit Counter, 2 x Status
	P6100H, P6171, P6181, P6160 (needs adapt.) P6200H, P6210H,P6245(H)	P6100H, P6171, P6181, P6160 (needs adapt.) P6200H, P6210H,P6245(H) P6311 P6312 P6330, P6331, P6335 P6360(H)	P6100H, P6171, P6181, P6160 (needs adapt.) P6200H, P6210H,P6245(H) P6311 P6312 P6330, P6331, P6335 P6360(H)

IP65, connectors IP67 (closed)
120 mm x 200 mm x 75 mm / approx. 1.2 kg (incl. batteries)
screwed miniature round-socket, Binder series 723

input 12 VDC 10 ... 24 Volt (connector supplied)
approx.: 0,5 mA (between the measurements), 45 mA (measuring)
2 alkaline batteries (9 V E-Block - 6LR61 - PP3), optional lithium batteries

- 40°C ... + 85°C
- 10°C ... + 50°C

All Data Loggers are carefully checked before delivery. Before being delivered to the customer, each appliance must pass a 24-hour test at temperatures from - 30°C to + 60°C.

4000 KByte non-volatile-memory (EEPROM) recorded 2 000 000 values.
Buffered real time clock, error at - 30°C ... + 60°C: < 5 ppm / 3V lithium button cells CR2032, approx. 180 ... 230mAh

Open-Drain, 12 ... 24 VDC, approx. 20mA, e.g. can switch sensor heating on or off via relay (also via SMS)

Display: 2 x 16 character double spaced, RS232 serial: 38 400 baud, E71 ASCII

1 ... 60 seconds
1 ... 9999 scan intervals
Ring memory, subdivided in daily data blocks
Average, maximum, minimum, standard deviation

1 minute
Monthly according to real time calendar
Shift register, subdivided in 4 statistic blocks
29 classes ±1 m/s wind speed distribution (in 2 heights) 36 sector wind rose with unique distributions (anemometer 1)

1 ... 60 seconds
180 Measurement lines
Separate non-volatile memory

User's manual, Batteries, Drying agent, PC-cable, 3 pin plug (ext. supply), CALLaLOG2002 Software.

Wind measurements by Bombardier

Fast trains generate considerable air turbulence, and that can be dangerous. It can pull bystanders under the train (induced air flow) or it can pick up stones from the track ballast. Manufacturers of railway vehicles have to demonstrate that all their products have the lowest possible measurement values.

In order to measure both these effects Bombardier Transportation, Aero- and Thermodynamics utilised a measurement system that was developed in cooperation with Ammonit and Adolf Thies GmbH (Sensor System).

Bombardier tests all its new and older traction unit models at higher speeds (up to 100 m/s, or 360 km/h). Measurements are made at the level of the rail surface of air turbulences that are generated as the railway vehicle passes, because this is what can lead to flying stones. In order to achieve this, high-resolution sensors had to be adapted mechanically to the conditions. The ultrasonic sensors operate at 250 Hz to measure the wind speeds and directions of flow. The software for data recording was developed by Ammonit.

Bombardier rated the cooperation with Ammonit as a success: “The type of sensors we required for the measurement of passages over rail track ballast by high-speed trains were not available on the market. Therefore we had to use a special development based on available ultrasonic anemometers integrated into a sensor measurement system. Ammonit carried out this integration for us, so that we were able to take the system into operation on schedule. Meanwhile the measurement system has been used successfully in various international measurement campaigns and has proved its value.”

Components – custom-made and effective

Installation cabinets - GSM/GPRS - Power supply

A good measuring station requires quick and easy connections, online control and updates as well as an autonomous power supply. The steel Ammonit installation cabinets, GSM/GPRS system and solar power supply make it easier to gather data reliably on location.

Installation cabinets - easy installation

Although meteorological data loggers are weatherproof, it is advisable to install them in a lockable, earthed metal cabinet to provide additional protection not only against storms and lightning, but also against theft and vandalism.
Ammonit has developed its own range of robust installation cabinets to accommodate the data logger together with additional components. This is specially designed to enable problem-free on-site installation.

Clear and uncomplicated
With the installation cabinets, the data logger and the selected optional components are already in position and the internal wiring is in place. All the equipment is carefully arranged so that the system can be put into operation quickly and reliably, even in poor weather conditions. All you have to do is to introduce the sensor cables through the prepared bushings and connect these to the conveniently positioned screw terminals.

The advantages of assembly in an Ammonit cabinet:

1. Earthing connections between all components to ensure the best possible screening of the whole system.

2. The Logger is mounted on an elevated aluminium plate, allowing easy access and replacement if necessary.

3. All components are attached to an assembly plate with space for the easy installation of any additional options at a later date.

4. 30° diagonal terminal strips make it easier to connect cables.

5. Holes provided for the incoming cables: a complete set of cable fittings is included.

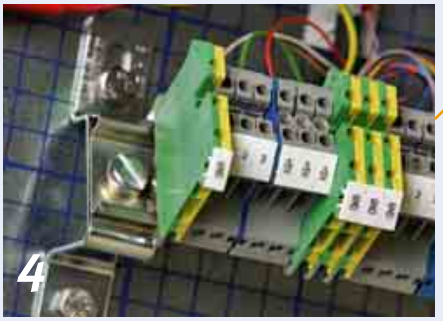
6. Drainage points for condensation.

7. Assembly base-plate and installation cabinet are earthed at a central point.

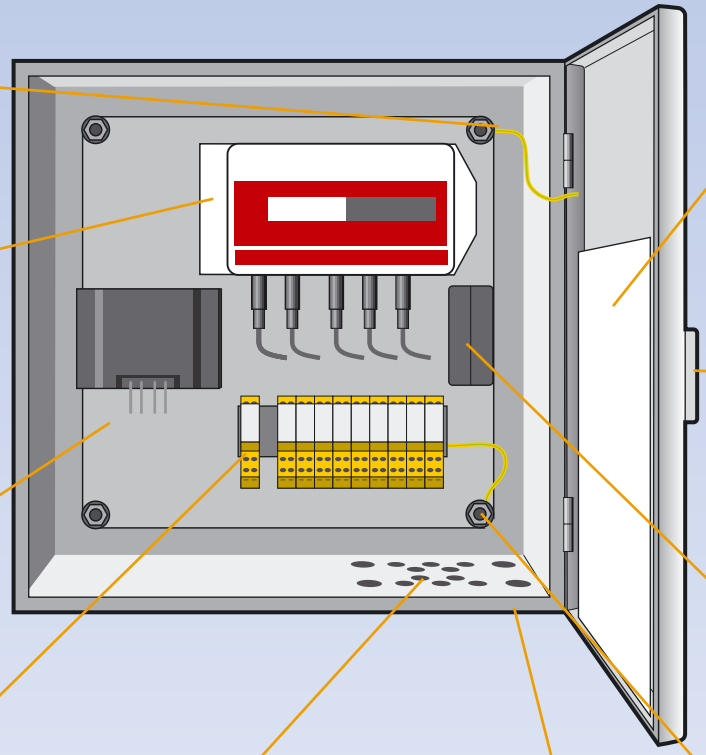
8. Option GSM/GPRS modem: the SIM-card holder is easily accessible.
Assembly base-plate and installation cabinet are earthed at a central point.

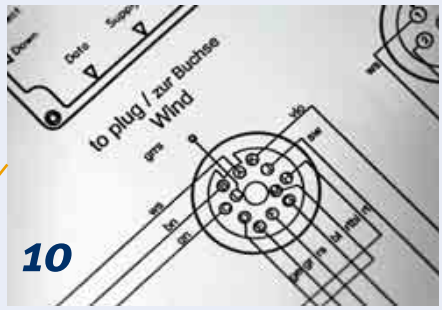
9. Fittings to allow you to use your own padlock (no standard locks all using the same key!)

10. Circuit diagram inside cabinet: the terminal numbers and the wire colour coding can be checked at a glance when connecting up the sensors.



The layout of the installation cabinet





10


9


8


5


6


7

Steel cabinets

Steel Cabinets - Model

Housing
Material
Dimensions
Door
Weight

Supplied accessories

Steel cabinets
with screw terminals

Steel cabinets
with overvoltage protection

Steel cabinet and options

	Steel cabinet 400 x 400 x 200 mm	Steel cabinet 500 x 500 x 250 mm
	Powder-coated sheet steel / IP55 400 x 400 x 200 mm Door hinges right, polyurethane seal 12 kg (approx.)	Powder-coated sheet steel / IP55 500 x 500 x 250 mm Door hinges right, polyurethane seal 14 kg (approx.)
	Connecting diagram, lock, 1 set of cable fittings, Stainless-steel screws M8 / 40 mm, Installation and wiring for the Ammonit Data Logger	Connecting diagram, lock, 1 set of cable fittings, Stainless-steel screws M8 / 40mm, Installation and wiring for the Ammonit data logger
	P9105 Steel cabinet for WICOM-32 P9106 Steel cabinet for METEO-32 P9107 Steel cabinet for METEO-32X	P9125 Steel cabinet for WICOM-32 P9126 Steel cabinet for METEO-32 P9127 Steel cabinet for METEO-32X
	P9155 Steel cabinet for WICOM-32 P9156 Steel cabinet for METEO-32 P9157 Steel cabinet for METEO-32X	P9175 Steel cabinet for WICOM-32 P9176 Steel cabinet for METEO-32 P9177 Steel cabinet for METEO-32X
	P8250M Solar power supply, 5 Watt P8251M Solar power supply, 5 Watt with overvoltage arresters P8255M Solar power supply, 20 Watt P8256M Solar power supply, 20 Watt with overvoltage arresters P8350M Mains power supply P8351M Mains power supply with heating transformer P8352M Mains power supply with overvoltage arresters P8353M Mains power supply with heating transformer and overvoltage arresters P8150M.63 Quad-band GSM/GPRS system with non-directional antenna P8151M.63 Quad-band GSM/GPRS system with directional antenna P6160.002M Adapter for AC-anemometer P6161.002M Adapter for Young propeller “M” = including installation in steel cabinet	P8250M Solar power supply, 5 Watt P8251M Solar power supply, 5 Watt with overvoltage arresters P8255M Solar power supply, 20 Watt P8256M Solar power supply, 20 Watt with overvoltage arresters P8350M Mains power supply P8351M Mains power supply with heating transformer P8352M Mains power supply with overvoltage arresters P8353M Mains power supply with heating transformer and overvoltage arresters P8150M.63 Quad-band GSM/GPRS system with non-directional antenna P8151M.63 Quad-band GSM/GPRS system with directional antenna P6160.002M Adapter for AC-anemometer P6161.002M Adapter for Young propeller “M” = including installation in steel cabinet

GSM / GPRS / Satellite – mobile data access and control

When meteorological stations are in remote locations there is usually no access to mains electricity or a telephone line. As a consequence it is necessary to visit the site regularly to collect data and to check that the station is still in good working order. Not only are these visits costly and time consuming, but there is the additional disadvantage that the checks will not be frequent enough to allow a direct reaction to any faults in the system.

Measurement stations online

The solution is wireless. Many countries now have a widespread mobile communications network that can be used for the data transfer.

Ammonit offers a GSM/GPRS system with Quadband technology as an option for its measuring stations, providing easy and inexpensive access to the station via PC and mobile telephone.

What GSM offers:

- Unlimited data exchange between PC and measuring station with the logger software provided
- Checks on the measurement station and access to measurements via mobile telephone with replies as text messages (SMS)

What GPRS offers:

- Automatic, daily dispatches of data by e-mail to a mail box
- Automatic dispatch of measurement data via the Internet onto a data server

Use of the simple and reliable GSM-network is recommended above all for national projects (measurement station and data recipient in the same country). For transnational operations possible increased costs should be borne in mind (roaming charges). In these cases, data transfer by GPRS may be preferable; the configuration is a little more complicated and a local data card is required. But the operating costs are then much lower.

Operating conditions

It is possible to study the international GSM-networks by going to ***www.gsmworld.com/roaming/gsminfo/index.shtml***

It is important that the local network operator provides the services needed for the data transfer. You will require:

- Data Asynch. 9600bps -MO / MT (data)
- SMS - MO / MT (text message & e-mail functions)

Note! There may also be regional and local variations in signal strengths and accessibility which are not included in the overview. A simple test is to check on location

whether a mobile telephone works! To operate the GSM-modem a telephone card is required (mini-SIM) with a free data channel. It is important that the data channel can receive a call because the connection will be made from the office computer. Cards from the locality can be used or from the country in which the data will be downloaded.

Station control by mobile telephone

Remote control of the measurement system without a PC is possible using the text messaging function of a mobile telephone. If a command is sent to the telephone number of the station, you will receive a reply within a few minutes, or whenever the GSM-system is activated the next time. In order to reduce the power consumption, the modem will only be activated at required times of the day via the data line. On-site, the connection status is directly visible on the display of the Data Logger (registered, online, signal quality, ringing, etc.)

Order number P8150.63/P8151.63
Modem & accessories
Order number P8150M.63/P8151M.63
including installation in steel cabinet

Data transmission by satellite
When stations can be connected neither by GSM nor by GPRS, then a satellite system is available. Considerable costs are involved in setting up and maintaining such systems, but they can be reduced by the use of a second system (Modem to Modem Connectivity).

What a satellite offers:

- Unlimited data exchange between PC and measuring station
- Global operations by means of the Iridium satellites

Power supplies – Mains, Solar cells, Fuel cells

Where a location offers access to a mains power supply then the power consumption of the measurement systems does not pose any problems. Ammonit cabinet options for power units range from simple plug-in units to top-hat rail mounted industrial adapters of various classes. Where required, they can be supplied with accumulator buffer, overvoltage protection and transformers for sensor heating.

Small solar power systems

It is very unusual to find a power supply at the types of locations that usually come into consideration for wind energy converters, so that it is usually necessary to install an autonomous source of power. Basic measurement stations with low-energy sensors can usually be powered by a small solar module with a rating of 5 to 20 Watt and can thus be operated without difficulty at remote locations. The solar module is provided together with an accumulator and electronic charge control with internal temperature compensation. The main function of the charge control is to ensure that the accumulator is not charged past its maximum or minimum charging points. Temperature compensation involves an internal temperature sensor which registers the ambient temperature, because this is important for the charging and operation processes in the accumulator. This can help to ensure that a long-term power supply can be provided without any interruptions. If required, the supply can be fitted with additional overvoltage protection.

All-year power supply

The amount of usable sunshine received in the winter months is much lower than in the summer. When it comes to designing a stand-alone system for all-year operations it is important to make sure that it is optimised for the low radiation levels of winter time.

Thanks to the exceptionally low power consumption of Ammonit Data Loggers and selected sensors and GSM/GPRS system, the network is able to operate independently in most places with only a 5 Watt solar module.

Increased power requirements

Where power requirements are higher and reliability of the power supply is an important factor, conventional power supply systems may not always be appropriate. This can be the case both with the use of sensor heating and for mast warning lights. Sensor heating is intended to prevent the moving parts of anemometers from freezing up, but it requires about 20W of additional power for each anemometer. And since this will mostly be required in the winter months, it would involve very large, expensive solar panels.

Depending on the relevant national regulations, wind measurement masts above a certain height will also have to have warning lights for the safety of low-flying planes. The lights have to comply with international specifications, and in particular their intensity must be above a certain minimum level. The reliability of the power supply is a top priority because these are safety-relevant installations.

Solar power supply		P8250(M) Solar Power supply, 5 Watt	P8255(M) Solar Power supply, 20 Watt
Solar modules	Dimensions	277 x 227 x 22 mm	524 x 325 x 34 mm
	Weight	1 kg	2.35 kg
	Rated Power	5 W	20 W
	Operating voltage	17 V DC	17 V DC
	Operating current	0.3 A	1.2 A
Accumulator	Dimensions	151 x 65 x 100 mm	
	Weight	2 kg	
	Connector	4.8 (6.3) mm	
	Rated capacity	7.5 Ah	
Solar charge control	Dimensions	130 x 88 x 37 mm	
	Weight	150 g	
	Nominal voltage	12 V DC	
	Max. load current	6.3 A	
	Multiple colour LED	Indication Charge Voltage by changing colour	
	Green LED	Indication Charge current	

In both cases a solar power supply is expensive and will not be reliable in winter (lack of sunshine, snow cover). Small wind energy converters can themselves freeze up, and the use of mobile diesel generators is not acceptable for environmental reasons.

Within the framework of the "EVEREST" programme, Ammonit is therefore taking part in the development of hybrid systems with solar cell and fuel cell (see page 5).

Solar module 5 Watt

Solar module 20 Watt

Sensors – top quality for every measurement task

The nature of the planned measurement task is decisive when it comes to selecting the appropriate sensors. For applications relating to climate research the criteria placed on sensors will not be the same as those for wind energy predictions.

But in every case the quality of the sensors will be crucial for the reliability of the measurement data. And so at Ammonit we only work together with established manufacturers.
If weather influences are being recorded, as part of monitoring e.g. a waste depot, then small deviations are not of major importance. For such applications it is generally possible to use inexpensive sensors.

If it is necessary to provide heating for a sensor, then this will require a higher current and the power supply must be able to provide this. If available, a mains power supply might then be the simplest option.

Note that while we do our best to provide accurate, up-to-date information, the manufacturer's data sheet should be consulted in any cases of doubt.

Cup anemometers

For wind energy predictions, the **wind speed** is generally measured using a cup anemometer. This has some disadvantages (e.g. the inertia of the cups, overspeeding effect), but these are known and have been found to be relatively unimportant. More important are the linearity of the output signal and the relative insensitivity both to turbulences caused by the mast and traverses, and to cross winds.

Anemometers with large cups have much better properties than those with cups which are small in relation to the diameter of their shaft. Opto-electronic transformers and AC-generators have proved to be the most suitable transducers. One of the reasons is that they are robust. And most opto-electronic transformers supply a very high pulse-rate (at least 10 Hz per m/s), which is needed for recording at short measuring-intervals or for the evaluation of turbulence.

Class 1 anemometers
If anemometers are to be used for wind energy predictions, even small deviations can have a considerable influence on the accuracy of the energy calculations, because the wind energy is proportional to the cube of the wind speed. Therefore only Class 1 anemometers (in accordance with IEC 61400-121-CD) should be used for wind energy predictions. An anemometer of this type has to be tested both in a wind tunnel and in the field, and must not show more

than a one percent deviation from the ideal anemometer for the determination of the horizontal component of the wind speed.

Calibration

Anemometer producers guarantee a specified accuracy for their products, for example ± 0.3 to 0.5 m/s (or 3 to 5% for speeds above 15 m/s). The measurements usually remain well within this tolerance range and this is sufficient for all needs in weather forecasting and in industrial processes.

However, such tolerances are not acceptable for reliable wind energy predictions (see p. 34). The anemometer should be calibrated by a specialised institute in accordance with EN ISO/IEC 17025:2005, and on the basis of MEASNET regulations; they should also provide a certificate of compliance (ISO 3966 1977, IEA guidelines) The results of each anemometer calibration are presented in a calibration report, which describes which aspects of the performance of the anemometer have been measured. In addition, the measurement set-up should be described in the report, including the reference equipment and when this was last checked.

Ideally, the anemometers should be calibrated a second time after use. This makes sure that there have been no changes while measuring. The repeat calibration is provided by many wind experts, and it is part of the standard service offered by Ammonit.

Anemometers

Heating in remote locations
At locations where temperatures are frequently around 0° C and air humidity is high, measurements are often falsified by icing on the anemometers. Where a mains power supply is available, it is possible to provide heating to overcome this.

However, in remote locations, heating may be problematic or even impossible. At temperatures below -10° C there is often no further requirement for heating, because the air is so dry that icing no longer takes place. It is possible to make use of this fact in combination with a control system to reduce the winter power requirement to a manageable level. This is explained in an example at the end of the catalogue.

Classification (IEC 61400-121)

Measurement range

Measuring accuracy (without calibration)

Resolution

Start-up wind speed

Survival wind speed

Delay distance

Housing and cup material

Ambient temperature (ice free)

Heating

Transducer

Operating supply

Output signal

Connector

Weight

Exchange of bearing, recalibration

Manufacturer

	P6100H Anemometer "first class"	P6171 Anemometer "Vector"	P6181 Anemometer "WindSensor"
			
	Class 1	Class 1	Class 1
	0.3 ... 75 m/s	0.2 ... 75 m/s	0 ... 70 m/s
	< 3% of reading or < 0.3 m/s	< 0.2 m/s (< 10 m/s) or 2% of reading (> 10 m/s)	1 % (4 ... 16 m/s)
	0.05 m/s	0.05 m/s	0.6 m/s
	< 0.3 m/s	0.2 m/s	< 0.4 m/s
	85 m/s (max. 30min)	Max. 75 m/s	
	< 3 m (ASTM D 5096-96)	2.3 m ± 10%	1.8 m
	Anodized aluminium, carbon fibre-reinforced plastic	Anodized aluminium and weatherproof plastic	Anodized aluminium and plastic
	- 50 ... + 80 °C	- 30 ... + 70 °C	- 35 ... + 60 °C
	24 V AC/DC, 25 W		
	Optoelectronic scanning	Optoelectronic scanning	Magnetic switch scanning
	5 V DC (3.3 ... 42 V) - approx. 0.3 mA	5 V DC (4.75 ... 28 VDC) - 1 mA	4 ... 30 V DC - < 1 mA
	approx. 1000 Hz @ 50 m/s	approx. 1000 Hz @ 50 m/s	ca. 80 Hz @ 50 m/s
	Male plug 8-pin Binder series 423	Cable 3 m	Triaxial male cable connector Lemo Ser. E
	Sensor: 0.5 kg With packaging: approx. 1 kg	Sensor: 0.5 kg With packaging: approx. 1 kg	Sensor: 0.5 kg With packaging: approx. 1.5 kg
	Recommended approx. every 24 months	Recommended approx. every 24 months	Recommended approx. every 24 months
	Thies, DE	Windspeed Limited, GB	WindSensor, DK

Wind vanes

Wind vanes

In order to survey the **wind direction**, wind vanes should be used which are able to supply accurate data through 360° with no North Gap, and with sufficiently good resolution. General meteorological measurements only require a 12-sector vane, but for wind energy applications a precision of 2.5° is desirable.

The best results are achieved using potentiometers and serial opto-electronic sensors, which have very low power consumption.

There are also considerable differences when it comes to size and weight of the vanes. Heavy vanes stand more stably in the wind, and larger vanes react even to very light winds. However, neither criterion is too important for wind energy predictions. Inexpensive vanes often have a limited operational life at locations with strong winds, because their electro-mechanical components are not durable enough.

When calculating mean wind directions, Ammonit Data Loggers automatically make allowance for the “North jump” so that the mean of 350° and 10° is North and not 180°.

Measurement range

Measuring assurance

Resolution

Damping coefficient

Housing

Survival wind speed

Ambient temperature

Heating

Transducer

Operating supply

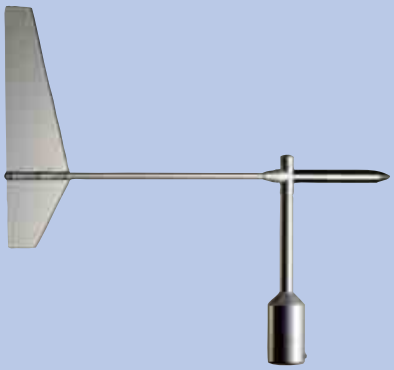
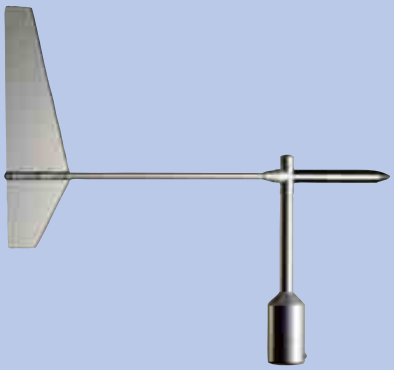
Output signal

Weight

Mast fixture

Exchange of bearing

Manufacturer

	P6200H **Wind vane “first class” potentiometer**	**P6210H** **Wind vane “first class”**	**P6245 / P6245H** **Wind vane “compact” potentiometer**
			
	0 ... 360° without north gap	0 ... 360° without north gap	0 ... 360° without north gap
	1°	1°	± 2°
	1°	0.35°	1°
	0.25	0.25	
	Anodized aluminium, inox. steel	Anodized aluminium, inox. steel	Anodized aluminium, plastic, inox. steel
	85 m/s (< 0.5 h)	85 m/s (< 0.5 h)	Max. 60 m/s
	-50 °C ... + 80 °C	-50 °C ... + 80 °C	-30 °C ... + 70 °C
	24V AC/DC, max. 25 W	24V AC/DC, max. 25 W	Optional, 24V AC/DC, max. 20 W
	Potentiometer	Optoelectronic	Potentiometer
	4 V ... 42 V DC - 2.5 mA max.	3.3 V ... 42 V DC - ≈ 2.5 mA, < 1.4 mA standby	50 V DC max. - 100 mA max.
	0 ... 2 kΩ	Serial 10 bit gray code	0 ... 2 kΩ
	Sensor: 0.7 kg With packaging: approx. 1.7 kg	Sensor: 0.7 kg With packaging: approx. 1.7 kg	Sensor: 0.55 kg With packaging: approx. 1.5 kg
	Onto a mast tube R 1”	Onto a mast tube R 1”	Mast tube with PG 21 or drill diameter: 29 mm
	Recommended approx. every 24 months	Recommended approx. every 24 months	Recommended approx. every 24 months
	Thies, DE	Thies, DE	Thies, DE

Temperature and humidity sensors and rain gauge

Additional meteorological sensors

Here too, the quality of the sensors used is vital for the reliability of the measurement data. Sensors should be chosen to ensure that standalone measurements and long-term operations are not restricted. Particular importance is therefore attached to long-term stability and reproducibility of sensor data and of course also to low power consumption. The information we provide is taken from the manufacturer's data sheets, which should be consulted in any cases of doubt.

As well as wind speed and direction, air pressure and temperature also play a part in wind energy predictions, so that it is worth collecting this data. The following selection includes frequently used standard meteorological sensors. Applications with other sensors are also possible, and Ammonit is happy to provide advice about the measurement sensors you will require.

To measure the air temperature, PT100 sensors are generally used. However, combined temperature and air humidity sensors can be used at little extra expense. It is important that the temperature sensors are well protected from the influences of the weather and the sun. A suitable housing can prevent overheating and makes it easier to install the system on the mast.

Temperature and humidity sensors and rain gauge
Range
Measuring accuracy
Peripheral error
Resolution
Response time
Measurement principle
Power supply
Output signal
Protection Sensor/Electronics
Weight without cable
Manufacturer

	P6311 Temperature sensor TP **P6312 Temperature and humidity sensor KP** 		**P6360/P6360H Rain gauge, catchments area 200 cm²** P6360 without heating P6360H with heating 
	Temperature - 30 °C ... + 70 °C	**Relative humidity** 0 ... 100%	**Precipitation** 0 ... 50 mm/h
	± 0.2 K	± 2%	± 2% (> 25 mm/h: ± 3%)
	± 0.004%/K (< 10 °C, > 40 °C)	< 0.1%/K (< 10 °C, > 40 °C)	
	0.1 °C	1%	0.1 mm
	≤ 3 min.	≤ 3 min.	
	Pt100 - 1/3 DIN	Capacitive	Tipping bucket
	9 ... 30 V DC - approx. 1 mA	9 ... 30 V DC - approx. 1 mA	With heating, 24 V AC, 18 W
	0 ... 1 V DC	0 ... 1 V DC	Reed switch, max. 24 V - 500 mA
	IP 30 / IP 65	IP 30 / IP 65	
	0.350 kg	0.350 kg	2 kg
	Mela Sensortechnik, DE	Mela Sensortechnik, DE	R.M. Young, US

Air pressure sensors

Air pressure sensors	**P6330 Air pressure sensor AB60**	**P6331 Air pressure sensor PTB100**
		
Range	800 ... 1100 hPa	800 ... 1060 hPa (on request: 600 ... 1060 hPa)
Supply voltage	7 ... 24 V DC	10 ... 30 V DC
Temperature range	- 10 °C ... + 60 °C	- 40 °C ... + 60 °C
Linearity	± 0.50 hPa	± 0.25 hPa
Hysteresis	± 0.3 hPa	± 0.03 hPa
Long term stability	± 0.3 hPa/a	± 0.1 hPa/a
Output voltage	0 ... 5 V DC	0 ... 5 V DC
Manufacturer	Ammonit, DE	Vaisala, FI

Ultrasonic anemometers

P6335 Air pressure sensor
Young 61202
P6336 External measurement point

600 ... 1100 hPa
10 ... 30 V DC
- 50 °C ... + 60 °C
± 0.01 hPa
± 0.02 hPa
0 ... 5 V DC
R.M. Young, US

Other possible measurements include precipitation, diffuse and direct solar radiation, and useful solar radiation, which can be measured for example by means of a reference solar cell module.

Precipitation is best measured with a tipping bucket rain gauge. These are robust and can be supplied with heating. The precipitation levels are stored to an accuracy of 0.1 mm per square metre.

For solar applications it is essential to measure the global solar radiation with a pyranometer. This is expressed in Watts per square metre. These sensors are supplied in a variety of types, for example by Kipp & Zonen (NL), so that an appropriate one is available for each particular requirement. More details are provided at: www.kippzonen.com
(under Pyranometers)

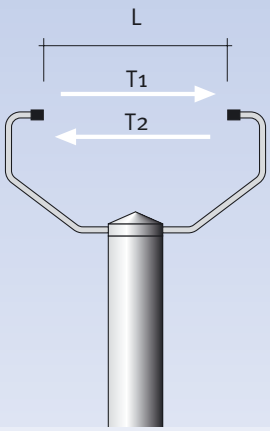
Ultrasonic anemometers belong to the new generation of wind sensors. They register air flow in one, two, or three dimensions with a data quality which is superior to most conventional equipment. Resolution and measurement frequency are an order of magnitude better that standard cup anemometers.
Ultrasonic anemometers have no moving parts. This means that they have neither a starting threshold nor inertial errors, and with no wear, regular maintenance visits and recalibration are a thing of the past. The signal quality is maintained over the entire working life of the anemometer because worn and dirty bearings are no longer a problem.

Ultrasonic anemometers are now the first choice whenever particularly high quality data is required or where long-term reliability and low maintenance is important.

The unimpeded registration of air flows in the cm/s range is important for example for micrometeorological investigations. Research institutions and meteorological services use these sensors for their field measurements. In road and rail transport, ultrasonic anemometers monitor critical weather influences – for example side winds on bridges or the flow of air for tunnel ventilation, and they can also trigger an alarm if wind squalls threaten building facilities. Other important applications include air safety, environmental monitoring of air pollution, and not least the control of wind energy converters.

Ultrasonic anemometers

The measuring principle: Ultrasonic anemometer



The measuring principle

Ultrasonic anemometers consist basically of one or more pairs of sonotrodes (loudspeaker-microphone combinations) mounted at a fixed spacing L. Several times a second, ultrasound impulses pass to and fro between the pairs of sensors. These waves are transmitted at the speed of sound C.
The wind speed component V between the pair of sensors is superimposed on the sound signals and leads to slightly different times for the signals in the one direction (T_1) and the return distance (T_2):

$T_1 = L / (C + V)$ and $T_2 = L / (C - V)$

From which we obtain, for the wind speed component:

$V = 0.5 \times L \times (1 / T_1 - 1 / T_2)$

The important point is that this expression for the wind speed does not include the speed of sound, which would vary with air temperature, air pressure and humidity.

By using a number of pairs of sonotrodes the individual components for a plane or a space can be determined and used to calculate the overall wind speeds and directions.

Ultrasonic anemometers

Coordinates

Measurement range

Accuracy

Resolution

Output rate

Output signal

Ambient temperature

Power requirement

Current (12V)

Heating

EMC

Weight

Manufacturer

	P6022 WindSonic	**P6027, P6028 WindObserver II**	**P6032N,P6033N New WindMaster**(Pro)
			
	2-Dimensional (x,y)	2-Dimensional (x,y)	3-Dimensional (x,y,z)
	wind speed: 0 m/s ... 60 m/s wind direction: 0° ... 360°	wind speed: 0 m/s ... 75 m/s wind direction: 0° ... 360°	wind speed: 0 m/s ... 45 (60) m/s wind direction: 0° ... 360°
	wind speed: ± 4% wind direction: ± 3°	wind speed: ± 2% wind direction: 2°	wind speed: ± 1.5% RMS (< 20m/s) (optional ± 1% RMS) wind direction: ± 2° (< 25 m/s) (optional ±0.5°)
	wind speed: 0.01 m/s wind direction: 1°	wind speed: 0.01 m/s wind direction: 1°	wind speed: 0.01 m/s wind direction: 1°
	1 Hz, 2 Hz, 4 Hz	1 Hz, 4 Hz, 10 Hz	1 ... 20 (32) Hz
	RS232 RS422/485 optional Analog optional (0 ... 5 V, 4 ... 20 mA)	RS422/485 Analog optional (0 ... 5 V, ± 2.5 V, 4 ... 20 mA)	RS232 RS422/485 Analog optional (0 ... 5 V, ± 2.5 V, 4 ... 20 mA)
	- 35° C ... + 70° C	- 55° C ... + 70° C	- 40° C ... + 70° C
	9 V DC ... 30 V DC	9 V DC ... 30 V DC	9 V DC ... 30 V DC
	25 mA	50 mA	85 mA
		3 A @ 24 V AC/DC	
	BS EN 50081-1:1992 (Emission Class B) BS EN 50082-1:1997 (Immunity)	BS EN 50081-1:1992 (Emission Class B) BS EN 50082-1:1992 (Immunity) FCC class A	Emissions BS EN 61000-6-3 Immunity BS EN 61000-6-2
	0.5 kg	1.5 kg	1 (1.7)kg
	GILL Instruments Limited, GB	GILL Instruments Limited, GB	GILL Instruments Limited, GB

Measuring systems
Examples

1. Standard system for wind energy predictions or wind farm monitoring - for example with a 50 m high measuring mast

The main tasks for which professional wind measuring equipment are used for energy applications are the weather predictions for new locations, and the monitoring of existing wind farms.
In order to obtain the best measurements of wind velocities at various heights and thus to determine the hub height for a proposed WEC installation, it is necessary to use two anemometers. The wind direction for a location only needs to be measured at one height. For a professional survey, additional meteorological measurements are also necessary such as air pressure, ambient temperature and relative humidity. The key points relating to the mast installation are discussed in the chapter on location analysis.

You will require:
- Data logger METEO-32 (Order no. P2510)
- Installation cabinet with connection clips (Order no. P9106)
- GSM / GPRS system for data transfer (Order no. P8150M.63)
- Solar power supply (Order no. P8250M)
- Two Class 1 anemometers, calibrated by an accredited institute in accordance with MEASNET guidelines [Order numbers P6100H (anemometer) und P6199 (calibration)]
- Cable for the anemometer 50 m or 30 m (Order no. P6100.K/)
- A wind vane with 50 m cable (Order no. P6245/)
- An air pressure sensor (Order no. P6330M)
- A temperature/humidity sensor (Order no. P6312/010)
- Weather and radiation protector for the temperature/humidity sensor (Order no. P6300)

The Data Logger METEO-32 is designed for four anemometers and two wind vanes.

2. Heating wind sensors without access to mains electricity

In a remote location without access to a mains power supply, it is difficult to heat sensors when it gets cold. Every anemometer requires a 1A heating current. The heating is switched on by an internal activator at temperatures below 3° C, which can mean that in winter a 24 V-accumulator with a capacity of 80 Ah would already need recharging after

only one day. At the same time, at temperatures below -10° C it is often not necessary to heat any more because the air is so dry that icing is no longer a threat. There are two possible ways to tackle the problem:

a) Install heating for the sensors and install cable connections at a convenient level so that an additional accumulator can be attached by hand in an emergency (as an alternative to climbing up the mast, or simply waiting for the springtime thaws).

b) Install the sensors and cables as above and fit a 24 V accumulator with the largest possible capacity, which is linked to a switching relay. The heating can then also be activated remotely by a text message.

In both cases measurements will be lost from time to time. As long as there is still a danger of icing you should not begin with the heating. It is only worthwhile trying to free the anemometer when the external temperature and air humidity make renewed icing seem unlikely.

In addition to the standard system you will require:
- Cable with a heating power line for the sensors
- A relay matrix module with five outputs, in order to be able to switch the heating on and off by text message (Order number P5630M)

3. For analog exporting of signal data

It would often be convenient to be able to make the sensor systems installed on the Data Logger available to another recipient, for example so that the measurement data could be integrated in parallel in the SCADA system of a wind farm control system and processed online. In this case it is not necessary to go to the trouble of taking signals from each individual sensor, but use can be made of an option of the RS485 interface.
For control systems which require analog input signals, extension modules will be installed which output the measurement values either as a voltage (0 ... 10V) or as a current (0/4 ... 20 mA).

In addition to the standard system you will require:
- Two analog output modules, in order to export the data (Order number P5610M).

Europe's highest wind farm

On the Niedere Tauern mountain range in Austria at an elevation of 1900 metres above sea level lies the Tauern Wind Park, currently Europe's highest wind farm.

The mountain ridge between Kobaldeck and Pichlerstein on which the eleven wind energy converters are situated runs at right angles to the prevailing wind direction and with its exposed location is ideally suited for converting wind energy. The measurements that were carried out showed a mean wind velocity of 7 m/s, which corresponds to the wind conditions on the North Sea coast. The WECs with a rating of 1.75 MW each are able to provide 0.8 percent of the electricity requirements of the Steyr region.

Both the Energiewerkstatt Österreich and the German Wind Energy Institute used Ammonit measuring equipment in the period 1997 to 2002 to carry out wind surveys for the assessment report. Despite the difficult climatic conditions and the inaccessible sites, the Ammonit Data Loggers that were used proved their reliability. And the Data Logger installed ten years ago on a 10 metre mast is still delivering data with which the operators can confirm that predictions and real yields are close to one another.

www.tauernwind.com /
www.energiewerkstatt.org

Global-Player - Partners worldwide

Why so many have already decided in favour of Ammonit

Wind energy is booming all over the world. Nearly all industrialised countries are looking to increase their involvement in energy renewables. Ammonit is able to respond to these international demands thanks the expertise collected over the years. Ammonit is supplying more and more measuring systems all over the world.

In 1986, the WICOM wind computer was used in the Sinai, and soon afterwards Ammonit Data Loggers were being used in development aid programmes in 30 countries all over the world. The experience gained then is still of considerable value today.

The international markets in the wind energy sector have developed very differently. One of the key foreign markets for Ammonit since 1989 has been Turkey – and it is currently becoming even more important. As a result of many years of cooperation, Ammonit measurement systems have established a very good reputation there. The quality of Data Loggers has proved convincing in Poland and Portugal, and Spanish manufacturers have also recently come to recognise the potential of Ammonit.

As a new step, Ammonit is planning to open its own office in the United States. In China, negotiations are underway with potential trading partners. There, as in other places, Ammonit faces competition from providers of cheaper equipment, but investors and banks are increasingly convinced by the combination of quality measurements and international expertise, even for applications on other continents.

Quality and experience are the key reasons why partners all over the world choose Ammonit.

On the coast, in the mountains, in the plains...

We chose Ammonit in 2004 because we were looking for high-quality measuring instruments which allow us to measure under a wide range of conditions. We have installed Ammonit equipment on three continents, Africa, America, and in Europe – particularly in France. The equipment works there very well in a wide range of locations: along the coast, in the mountains and in the plains.

Carles DE ANDRES RUIZ

Company: ENCIS SARL, France

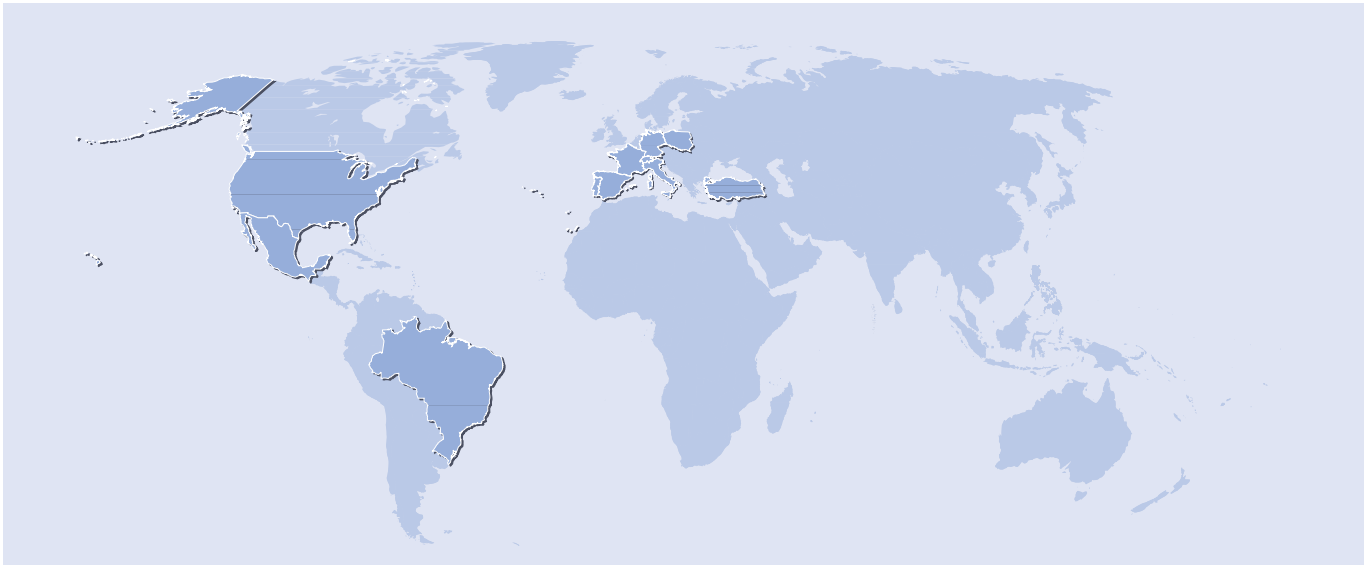
ENCIS SARL, France

interwind, Switzerland

Continual know-how transfer

We have been marketing Ammonit measuring system in Spain for ten years now with growing success. Right from the start we were convinced by the high quality standards. We had a difficult time to begin with in Spain, because the measurement standards there were lower. However, as quality expectations grew so we became more successful. Today Ammonit is very widely known and has an appreciable share of the market. We have got on excellently with Ammonit systems. Reliability and ease of use with a broad range of performance are factors that speak for the systems. Thanks to the continuous transfer of know-how to us in Spain, we have been able to make ourselves independent of Germany for

ECOSEM, Spain



windhunter, Poland

large parts of the service. But we receive excellent support from Ammonit whenever we need it. We see our daily task in developing the wind energy market. A challenge is extending our activities in new sectors, e.g. agriculture, industrial requirements or environmental monitoring.

Dr. Pablo Exss Sonne, Director
Company: Lineal Service / Ecosem S.L., Spain

Quick, direct, personal

We have had six years of good experience with Ammonit measuring systems as a Polish company, and not only in Poland but all over the world. An advantage for us is the friendly attitude of the personnel, the direct advice, and the rapid delivery service – even for short-term orders. The well-known brand product itself convinces with its ease of use, good software, and low susceptibility to faults.

Roman Synowski
Company: windhunter sc, Koszalin Poland

RE-CONSULT, Turkey

Flexible and easy solutions

Our customers attach great importance to quality, and for this reason we have been offering Ammonit products since the end of 2005. Ammonit offers us ease of installation, reliable read-outs of measurement data, and an open ear for any difficulties, with quick suggestions for a solution. That means we are able to offer our customers flexible and easy solutions for virtually every wish.

Lev Martinez Aguilera
Company: Climatik, Mexico

Light years closer

Excellent quality and very good service are the main reasons why I have been working together with Ammonit since 1998. Bankable wind measurements are still very rare in Turkey, but they are of key importance. With Ammonit as partner a company is light-years closer to obtaining financing.

Christian Johannes, General Manager
Company: re-consult Rüzgar Enerjisi Danismanlik, Iç ve Dis Ticaret Ltd. Sti., Turkey

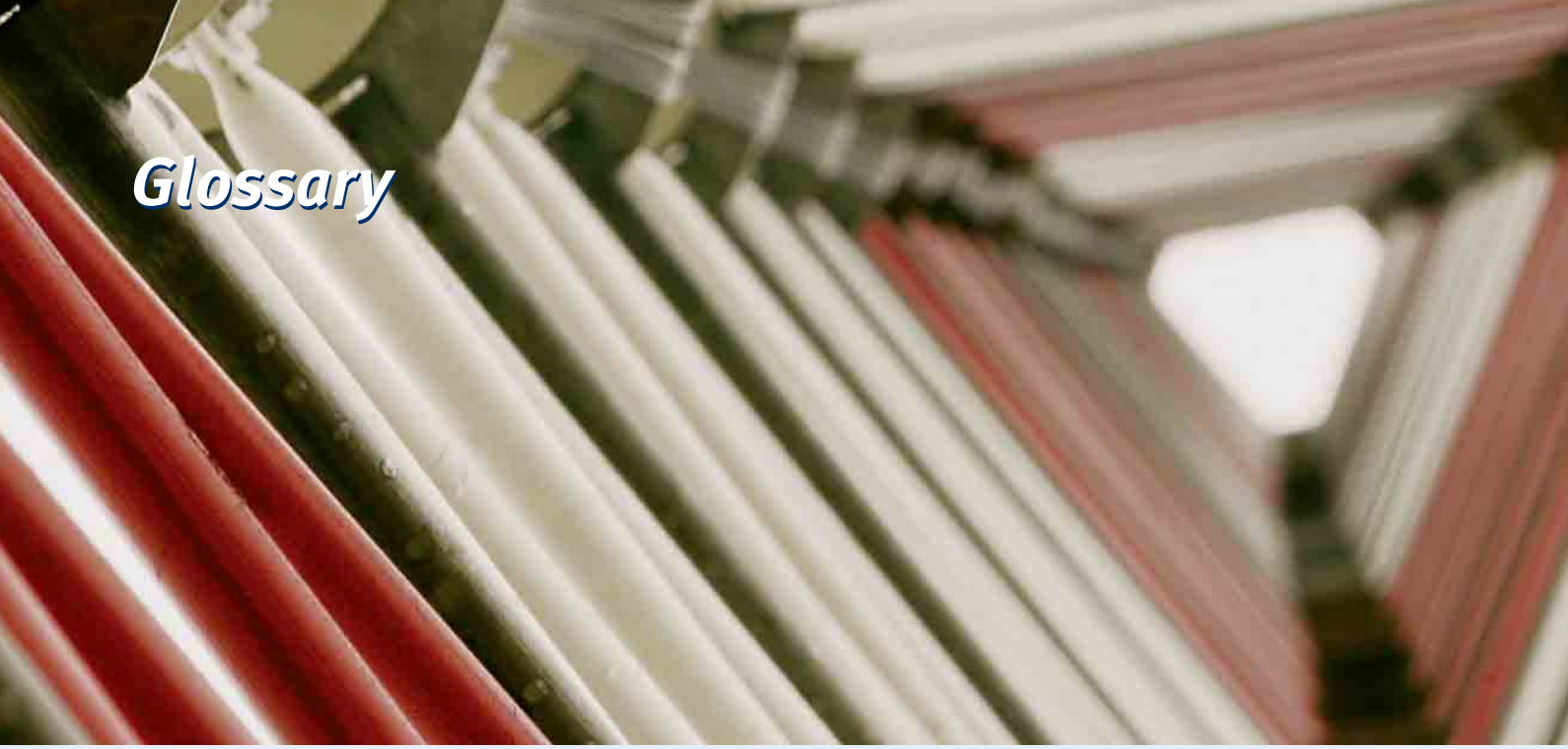
4000 kilometres away

We have been involved with wind energy since 1992 and our attention was drawn to Ammonit at an early stage. With our dealerships we have always been interested in the best in the branch because we prefer to invest in advance in good arguments rather than have to come up with poor excuses afterwards. Ammonit systems have very low power consumption, which cuts costs for the photovoltaic modules.

IEM, Brazil

The CALLaLOG software and ALWIN are particularly user-friendly. In Brazil – ten thousand kilometres from Germany – everything has to work smoothly. We have more than a hundred measuring stations, some of them 4000 kilometres away from our company headquarters. So we have to be able to rely on the components. And with Ammonit and their suppliers we can.

Hans Dieter Rahn
Company: IEM Intercambio Eletro Mecanico, Brazil



Glossary

A

Ammonit
This stands for **A**mbient **M**easurement and **Monit**oring.
Ammonites are extinct marine cephalopods. The name is derived from the Ancient Egyptian god Amon, who is sometimes represented with a ram's head. The horns were reminiscent of the fossilised spiral shells of the ammonites.

Anemometer
Sensor for measuring the wind speed. For wind energy predictions a Class 1 anemometer is needed (in accordance with IEC 61400-121-CD), which should be calibrated by an accredited institute (EN ISO/IEC 17025:2005) in accordance with MEASNET regulations.

ALWIN
Evaluation software

B

Barometric sensor
Sensor for air pressure

C

Candela
Unit for the luminous intensity of a light source in a given direction.

CE-mark
Classification of a product and confirmation of quality in accordance with European Union directives

D

Data logger
Device to register analog or digital measurement data

Data Logger
The Ammonit Data Loggers of Series 32 are described on p. 18-25

G

GSM
Global System for Mobile Communications

GPRS
General Packet Radio Service, based on the GSM network

I

Iridium
Global satellite communications system

ISO
International Standardisation Organisation

M

MEASNET
Measuring **Net**work of Wind Energy Institutes
The international network of institutes involved in wind energy utilisation. They ensure high quality measurements by means of uniform evaluation standards and recommendations. They ensure results can be compared by mutually checking their quality criteria at regular intervals.
All members must be accredited in accordance with ISO/IEC 17025 for the measures approved by MEASNET.
More information at ***www.measnet.com***

Measurement series
Ammonit Data Loggers produce series of measurements which can be stored at intervals between 1 second and 1 day. If required, means or maxima, minima and the standard deviation can also be registered.

O

Overvoltage protector
A device or component which protects cables and equipment against excessive voltages.

P

Pyranometer
Sensor for measuring global solar radiation

Q

Quadband technology
Covers all common GSM-frequencies and guarantees accessibility round the world wherever a network can be accessed.

R

Roughness length
The height at which the wind speed is reduced to zero by buildings, vegetation and terrain.
Table of the roughness length Z_0:
see page 20

Ring memory
If no more memory is available, the oldest block will be written over. This helps to prevent data loss. All Ammonit-Data Loggers have a non-volatile ring memory of 4MB.

S

SCADA-System
Supervisory **C**ontrols **A**nd **D**ata **A**cquisition

Shadowing
Disturbances caused when waves are unable to disseminate due to obstacles

SMR
Slow-motion recorder for wind data A programmable event (e.g. if a value for the wind speed is higher than a set limit value), the data for the wind input in the measurement interval are recorded directly to a separate memory. In all 180 lines can be stored, which for 1 second measurement intervals is the equivalent of a 3 minute period, for lower measurement frequencies a correspondingly longer period will be recorded. All Data Loggers can also be used as a wind alarm system. If the SMR starts due to a storm, at the same time an SMS can be sent and/or a system can be switched off.

Solar power supply
Provided by a stand-alone solar system made up of a solar module, accumulator und electronic battery charger with internal temperature compensation.

Statistics
Give a rapid overview of relevant data for wind energy, without expensive software. Ammonit statistics are compatible with ALWIN evaluation software.

T

Thermo-hygro sensor
Combined sensor for measuring ambient temperature and air humidity.

W

WICOM
First wind computer, standard today in professional applications.

Wind vane
Sensor which supplies the data used to determine the wind direction.

References –
Measurement Systems Wind Energy (Selection)

Wind Consultancies

Many professional wind consultancies rely on the data loggers of Ammonit measuring systems. Most of them run their stations with calibrated sensors, overvoltage protection devices and accessories for remote data transfer.

Cube Engineering GmbH (DE), Deutsche WindGuard (DE), Deutscher Wetterdienst (DE), Deutsches Windenergie-Institut (DE), Ecosem (ES), Energiewerkstatt (AT), Erelis SNC (FR), Germanischer Lloyd Windenergie GmbH (DE), INEGI (PT), INETI (PT), Interwind (CH), Lithuanian Energy Institut (LT), re-consult (TR), SIIF Energies France (FR), Ventos (BR), Wind-Consult (DE), windhunter sc (PL), Windtest Grevenbroich / Kaiser-Wilhelm-Koog (DE)

Manufacturers of Wind Turbines

WEC manufacturers need reliable data for the development of their wind generators. Often they make a measurement system available to their customers to support them in economic calculations or to check the efficiency of an installed wind farm.

Aerogeneradores Canarios (ES), Aventa (CH), DeWind (DE), Ecotecnia (ES), Enercon Energieanlagen (DE), Gamesa (ES), GE Wind Energy (DE), Fuhrländer (DE), NEG Micon (DK), Nordex (DE), REpower Systems AG (DE), Siemens (DE), Südwind Energiesysteme (DE), Suzlon (IN), Vergnet (FR), Vestas (DK)

Project development / Operators

Nothing increases wind farm planning security as much as a reliable prognosis of the wind potential. This is why wind farm development companies have been installing Ammonit wind computers at many international locations for years.

Aksa Enerji (TR), Aufwind (DE), Austrian Wind Power GmbH (AT), Boreas (DE), CESI (IT), EnerSys (DE), EnXco (UK), Eolica (IT), Finerge (PT), GEO (DE), JUWI (DE), Lahmeyer (DE), MVV Energie AG (DE), Ostwind International (FR), P & T Tecnologia Iber (ES), Projekt (DE), red project management (DE), Reetec (DE), RES (UK), Volkswind (DE), WKN Windkraft Nord (DE), WPD (DE)

Universities / Research institutions

A lot of universities and research institutions set up departments for wind energy for basic research of optimal use of wind energy. They need measurement projects to obtain a reliable data base. The energy prognosis software ALWIN is used to calculate the meteorological influences regarding to energy yield.

CDER Marrakech (MA), C. v. O. Uni. Oldenburg (DE), Cubasolar (CU), Czech Technical Uni. Prague (CZ), DLR (DE), ENEA Renewable energy sources department (IT), Fraunhofer Institut (DE), Hohot Livestock Machinery Research Inst. (CN), Training Inst. for Science Hanoi (VN), ISET Kassel (DE), LAPAN National Institute of Aeronautics Jakarta (ID), Nat. Engineering Research Centre of Sri Lanka (CL), Polytech. Inst. of Bucarest (RO), Riga Technical Uni. (LV), TU Berlin (DE), Uni. Publica de Navarra (ES), Uni. van Amsterdam (NL), Uni. of Eng. & Technology Bangladesh (BD)

Public Energy Utilities

Initially public energy utilities were rather critical of wind energy, but more and more have now set up their own divisions for wind energy development. These divisions work at the optimal load distribution and the operation of own wind energy converters.

CRE Cooperativa Rural de Electrificacion (BOL), EDF (FR), Eesti Energia AS (EST), E.on (DE), EPM Medellin (CO), Electricidade dos Acores (PT), INEL Empresa de Ingenieria Para La Electricidad (CU), Latvian Power Society Riga (LV), Petrobras (BR), RWE Energie AG (DE), Union Electrica (CU) and more than 25 municipal and regional electricity companies in Germany

National / International Organisations

Utilization of wind energy makes a significant contribution to environmental protection. Many national and international organisations support the development of renewable sources of energy by financing training courses and measurement programmes.

GTZ Gesellschaft für Technische Zusammenarbeit (DE), KfW Kreditanstalt für Wiederaufbau (DE), United Nations Industrial Development Organisation (UNIDO)
supporting a range of projects in:
Argentina, Azores (Portugal), Bangladesh, Bolivia, Brazil, Cape Verde, China, Cuba, Haiti, India, Indonesia, Madagascar, Madeira (Portugal), Marocco, Mauritius

Order numbers

Order number	*Name*
Data Logger:	
P2500	WICOM-32, 5-channel Wind Computer
P2510	METEO-32, 10-channel Data Logger
P2520	METEO-32X, 18-channel Data Logger
Wind speed:	
P6100H	Optoelectronic anemometer "first class", heatable, without cable
P6171/03	Optoelectronic anemometer "vector" with anti-surge protection, cable 3 (needed cable type 1 and "junction box")
P6181	Anemometer "WindSensor"
P6140/	Optoelectronic anemometer "compact" incl. cable
P6140H/	Optoelectronic anemometer "compact" incl. cable with heating cores
P6160	AC generator anemometer "#40 Maximum", without cable
P6161	Young Propeller Anemometer for vertical measurements, CFT Propeller
P6100.K/	Cable for Anemometer "first class", assembled, without heating cores
P6100H.K/	Cable for Anemometer "first class", assembled, with heating cores
P6199	Anemometer-calibration conducted by DKD accredited laboratory according to Measnet procedure, with certification
Wind direction:	
P6200H	Potentiometric wind vane "first class", heatable, without cable
P6245/	Potentiometric wind vane "compact" with cable
P6245H/	Potentiometric wind vane "compact", heatable with cable
P6200.K/	Cable for Wind vane "first class", assembled, without heating cores
P6200H.K/	Cable for Wind vane "first class", assembled, with heating cores
Meteorology:	
P6330	Air pressure probe "AB 60", piezoresistive, without cable, protection IP30

Order number	*Name*
P6331	Air pressure probe "PTB 100A", capacitive, without cable
P6311/010	Air temperature probe "TP" 0 ... 1V, 10 m cable (type 1)
P6312/010	Air temperature / humidity probe "KP", 2 x 0 ... 1V, 10 m cable (type 1)
P6300	Weather- and radiation shield for air temperature (/ humidity) probe
P6360	Tipping bucket rain gauge, without heating
P6360H	Tipping bucket rain gauge, with heating
Steel cabinets: with installation and cabling of Data Logger & connections	
P9105	Steel cabinet with screw terminal for WICOM-32
P9106	Steel cabinet with screw terminal for METEO-32
P9107	Steel cabinet with screw terminal for METEO-32X
P9155	Steel cabinet with 10-wire overvoltage protection for WICOM-32
P9156	Steel cabinet with 16-wire overvoltage protection for METEO-32
P9157	Steel cabinet with 24-wire overvoltage protection for METEO-32X
Options: with installation and cabling into a steel cabinet	
P8250M	Solar power supply, 5 watt
P8251M	Solar power supply, 5 watt with overvoltage protection
P8350M	Main power supply
P8351M	Main power supply with heating transformer
P8352M	Main power supply with overvoltage protection
P8353M	Main power supply with heating transformer & overvoltage protection
P8150M.63	Quad-band GSM/GPRS system with non-directional antenna
P8151M.63	Quad-band GSM/GPRS system with directional antenna
P6160.002M	Adapter for AC anemometer
P6161.002M	Adapter for Young Propeller
Single parts:	
P6171.PK211	Cable extension box - "junction box"

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