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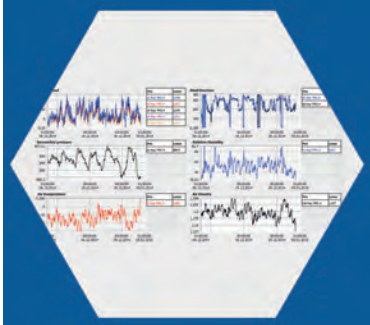


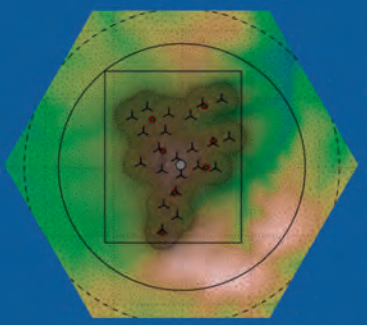

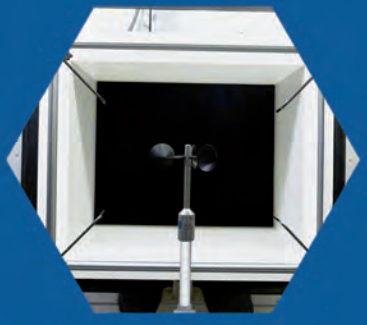
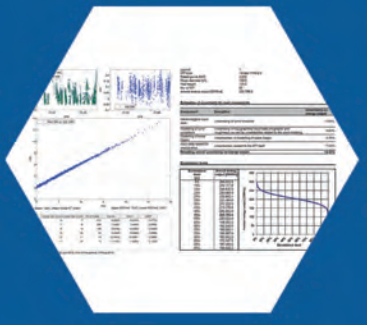


ProfEC Ventus GmbH, Im Ofenerfeld 23, D-26127 Oldenburg, Germany
☎+49 4421 209089-0 ✉info@profec-ventus.com 🌐www.profec-ventus.com

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Member of the Expert Advisory Board for Wind Resource Assessment of the German Wind Energy Association (BWE e.V.)

ISO IEC

Company Profile

ProfEC Ventus is an internationally recognized Measurement Institute, ISO 17025-accredited as Testing and Calibration Laboratory, highly specialized for wind energy advice, services and expert opinions accepted by banks

Our procedures and techniques do comply with relevant and most recent international industry standards for wind energy.

Our accreditations as Testing Laboratory and as Calibration Laboratory following ISO/IEC 17025 prove bankability of our work and expert opinion reports. We perform services in compliance with pertinent norms such as:

- IEC 61400-12
- IEC 61400-12-1 Ed.1 (2005)
- IEC 61400-12-1 Ed.2 (03-2017)
- IEC 61400-12-2
- IEC 61400-1 Ed. 2, Ed. 3, Ed. 3.1
- IEC 61400-2 Ed. 2
- FGW TR6
- FGW TR2
- MEASNET Power Performance Measurement Procedure
- MEASNET Evaluation of Site Specific Wind Conditions
- MEASNET Anemometer Calibration Procedure

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Moreover we take into account other international and national guidelines or regulations wherever advisable, among which BWE recommendations, to which we contribute ourselves as member of the expert advisory board.

Typically with our top-class services we entirely serve the needs and satisfy the expectations of project developers, banks or investors, authorities, international organizations as well as wind turbine manufacturers worldwide.

We work closer, committed, competitive

As a consequence: results are delivered quickly, affordable and absolutely transparent, serving our appreciated Clients at its best.

Our work was proven in more than 35 countries all over the world, among which leading industries for wind energy development and application as well as countries with extreme climate or political regimes. We combine about 40 men-years of professional experience, working closest possible to springs of innovation, latest scientific insights and recent or even trend-setting engineering practices.

On behalf of our Clients, we accompany wind projects from the first idea and site prospection via wind sensor calibration, power performance measurements until optimization of operating wind farms.

Our services, and we don't promise too much, are highly customer oriented. Our Clients can be fully assured that our flexibility as well as commitment and professional approach are fully in line with their requests, needs and ventures.

Feel free contacting us. We'd be keen getting to know how we may assist to realize your plans.

Dipl. Phys. Dipl. Paed.
Mathias Hölzer
Managing Director

MSc. Ing. BA hon.
Andreas Jansen
Managing Director

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Quality Assurance of Services and Committee Work

Proven quality, enabled to certify

ProfEC Ventus GmbH offers a range of services that do result in best possible insights, raising valuable information for our Clients, in order to base substantial project related decisions on it in a safe and consistent way.

Services provided are highly qualitative, often derived from recent research results and hence close to most recent scientific insights and innovative trends. We offer, among highly standardized services as calibrated wind measurement equipment, numerous services based on innovative approaches such as the uncertainty analysis via linear Weibull fit assessment or the customer oriented ***V.Mac*** for measurement data transfer, evaluation and sharing.

Our premise is to increase certainty and reduce uncertainty and doubts for our Clients. Beside that we optimize energy yields of wind farms during the planning phase and during the operational phase.

We serve Clients in an economic way and help to reduce planning and investment costs, while increasing benefits and operational income, although maintaining low risks and high benefits.

Relying on pertinent accepted norms and standards ensures that our quality of work is accepted **worldwide**.

During our daily work we certify compliance of tested subjects in question with in question with

- IEC 61400-12
- IEC 61400-12-1 Ed.1 (2005)
- IEC 61400-12-1 Ed.2 (03-2017)
- IEC 61400-12-2
- IEC 61400-1 Ed. 2, Ed. 3, Ed. 3.1
- IEC 61400-2 Ed. 2
- FGW TR6
- FGW TR2
- MEASNET Power Performance Measurement Procedure
- MEASNET Evaluation of Site-Specific Wind Conditions
- MEASNET Anemometer Calibration Procedure

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Leistungskurve TR 2 FGW 2018 Konformitätsbeleg

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ProfEC Ventus is accredited as Testing and Calibration Laboratory following ISO/IEC 17025 for following services:

- Anemometer Calibration
- Wind Vane Calibration
- Measurement of wind turbine power performance
- Wind Resource (incl. Wind Mapping) and Energy Yield Assessment of Wind Turbines (incl. Assessment of Losses following TR6)
- Installation and Evaluation of Wind Measurements with Anemometers
- Site Classification of Wind Turbines

Quality at is best: our contribution resets the pre-set!

ProfEC Ventus is engaged in several national and internationally accepted bodies focussing on streamlining quality of work, service and results within the global wind energy market. Development of standards, norms and guidelines yield harmonized results, necessary for globally acting wind energy stakeholders as banks, investors, wind turbine manufacturers, project developers, O&M companies etc.

ProfEC Ventus naturally not only applies such standards, but also contributes during the development and acceptance of such, by injecting valuable knowledge and experience to the working groups and boards developing, respectively approving, said standards.

Among others ProfEC Ventus is engaged in:

National committee work

BWE – German Wind Energy Association

- Expert Advisory Board
- Experts' Forum

FGW – Federation of German Wind Power and other Renewable Energies

- Technical Committee – Power Curves
- Technical Committee – Wind Potential

International committee work

DKE National Mirror Committee to IEC – International Electro-Technical Commission

- IEC 61400-12-1 (Power Curve)
- IEC 61400-15 (Site Assessment)

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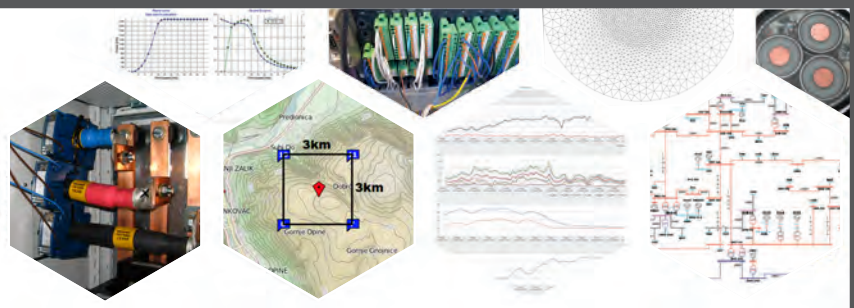

Virtual Measurement Mast

A most advanced meso-scale modelling technique to simulate wind measurement time series yielding results close to real on-site measurements

Advanced re-analysis for modelling of historic weather data and for wind resource forecasting

At any point (i.e. at the virtual measurement mast location) within a planned or existing wind park, we provide a wind data time series and the resulting wind statistics. Furthermore for the entire wind park area and its surrounding wind data time series at a 3km x 3km mesh width are provided.

For virtual measurement mast calculations we rely on more than 30 years of historic wind data that are based on meso-scale modelling.

The virtual measurement mast (**VMM**) calculations are based on WRF (*Weather Research and Forecasting Model*), a most advanced meso-scale weather model whose quality has been proven in a large number of scientific publications. WRF has been applied and tested for many different weather conditions and has been used for all regions of the World and in about 130 countries. WRF enables high-resolution results in time and space, in order to yield best wind data close to results of on-site measurement masts.

Utilized for meso-scale wind maps, micro-scale wind maps in junction with advanced CFD and for simulations of measurement masts

A major objective of the VMM technique is the provision of a sound and most reliable base of wind data in order to finally estimate the financial returns and the volatility of the cash flow in a most advanced way. Therefore the VMM results are used as data source for long-term alignment of energy yield prognoses.

Alternative utilization purposes are the calculation of meso-scale wind maps, as well as micro-scale wind maps, if run in combination with a flow model like WASP or OpenFOAM (**CFD**), yielding a mesh width as low as 10m x 10m.

Next to the long-term time series modelled at any point of interest (the VMM location) we provide a set of data with horizontal resolution of 3km by 3km (wind speed and wind direction) as true 10-minutes average values. Default wind speed and wind direction data at provided at different selected heights. Temperature and pressure data are provided at each one of these selected heights. These resulting wind data time series are closest to observations of measurement masts installed on-site.

The wind data derived most frequently are used as long-term reference for any site in the World, complying also with WMO requirements regarding wind data used for long-term reference.

During VMM calculations WRF is used to re-analyse the wind conditions of the past. WRF provides historic wind data at the location of a wind park. Extrapolation of this long-term historic data enables forecasts of the wind resources at any site.

How is it done?

For VMM calculations WRF is used with a grid size of 3km. The model calculates the state of the atmosphere during the course of the year. It considers the full physics of the motion of air and estimates the transport of other constituents of the atmosphere as well: the evaporation of water from the soil into the air, the formation of water droplets in clouds or the fall-out of rain, snow or ice. Several other atmospheric processes are kept into account when running the WRF model.

At the end WRF model performs a „dynamic down-scaling“. This means that the meso-scale calculation state of the atmosphere is large-scale weather patterns. For the purpose of wind mapping and Virtual Measurement Masts calculations, ERA-Interim (European Centre for Medium-Range Weather Forecasts (ECMWF)) is used as global re-analysis input. This global re-analysis data prescribe the coarse weather conditions, which will be re-fined by the WRF model. ERA-Interim comprises meteorological information of the wind, temperature, humidity etc. on a grid of about 50km and every 6 hours. WRF re-fines this meteorological information and produces an output with 3km resolution.

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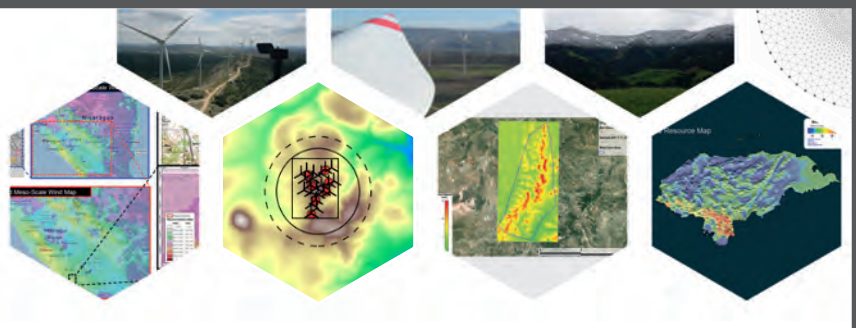

Meso-Scale Wind Maps

A set of modern geo-data used for project site prospection, regulatory spatial development and infrastructure planning; incl. gratis GIS software solutions

Wind maps offer special value for regional spatial planning and for concrete project development

Wind maps have been proven as helpful tool during site prospection and mainly served during first investigations and rough estimate of regional prevailing wind resource potentials.

For an energetically optimal selection of areas for large-scale wind energy development, meso-scale wind maps are the preferred tools of choice to yield a most efficient selection process possible, at lowest possible project development costs.

Meso-scale wind maps do reflect in relative terms but with an acceptable degree of certainty any sites promising higher wind resource and any sites bearing lower wind resource potentials. Such interpretation and statements remain valid with a high certainty within the comparative context of a meso-scale wind map.

Of crucial essence is an appropriate flow model fitting to the corresponding scale

The criteria and requirements attached to a wind map must be narrow for selection of preferred areas on governmental level, enabling decision makers to appoint areas for prioritized wind farm planning. The majority of wind resource raster calculated nowadays is based on high-resolution digitized topographical information in combination with long-term reanalysis data, reflecting the state of the atmosphere and feeding the models. The wind database is, next to the used flow-model, the determining factor for the resulting accuracy of the wind map calculation.

The models used by ProfEC Ventus experts are based on the Weather Research and Forecast Model (WRF) and OpenFoam (CFD - Computational Fluid Dynamics). The first one for the coarse resolution wind mapping, the second one for the downscaling process to derive wind maps of higher spatial resolution, which take into account micro-scale effects.

By that we rely on wind atlas calculation methods for high resolution wind resource map computing, accepted by project developers, banks and energy regulators.

Based on surface-near measurement data we perform **validation** of wind maps rather than merely **calibration**. The latter is an approach, which makes the map fitting to the measurements, but does not offer the possibility to assess the level of uncertainty implicit. It also impedes improvement of the accuracy by being limited to a few measurement spots only, to which the map was calibrated. Validation of wind maps however enables an assessment of the accuracy resp. uncertainty for the complete wind map.

During our experts' participation in the development of diverse international programmes (e.g. ESMAP - World Bank, AfDB and UNDP) for national meso-scale wind mapping, we contributed our unique experience and extensive knowledge to develop wind maps on regional and national level at very diverse parts of the world.

More than just a wind map: a set of modern geo-data used for spatial development and infrastructure planning

Usually our wind maps generated are provided in form of common GIS formats so our Client can incorporate the results into their database or software applications.

We also offer the entire integration of wind maps into our in-house developed GIS steering and development tool. The information can be hosted either online on a server to enable distributed data access, as well as local on the local computers of our Clients. The tool enables spatial analyses and queries, allowing very efficient site prospection activities and conclusion drawing. On top we do offer complete configuration and delivery of a potent, open source GIS application and solution that is free of licensing costs. Our offered GIS software solution comes gratis with a collection of different, most recent geo data and online access to remote sensed geo-databases.

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Site Prospection, Spatial Analyses and Site Selection

Increased efficiency on time and budget during on site selection and reduced risks to start development of a wind energy project at a sub-optimal site

Based on remote sensing data we find best sites for your wind farm project!

Spatial analysis is done as first step of any wind farm project planning. Having explored site finding and prospecting activities all over the world, our staff yields highest accuracy as well as time and budget efficiency during site finding, prospection and selection.

We rely on most recent and accurate remote sensing databases, wind resource reanalysis data, topographical, geographical and infrastructure data (i.e. geo-databases). Wind farm developers, investors project initiators, multi-national organizations and local, regional or national governments typically have a need to locate most suitable wind park sites and areas for very different purposes. May it be for project development or for steering and control of regional wind turbine distribution, national energy matrix and power generation portfolio design.

Our efficiency for your budget

Superior objective of our site prospection activities is the quick and immediate localisation of promising areas with high wind resource potential, good infrastructure in the vicinity and low potential for environmental and social conflicts. Starting with the drawing board in an office environment, we could save in a green field project **40%-50%** of time and costs until a promising site is localized, visited and finally selected, based on our optimized approaches, which are based on different data sources combined within an in-house developed GIS steering and planning software solution.

Used for individual project site selection and for regional as well as national wind energy planning by government authorities

Site prospection often is time consuming. Even more fatal it would be in terms of time and costs to select a site that is supposed to be good, establish a wind measurement system and discovering at a later point that in fact the site is not suitable in terms of the available wind resource.

ProfEC Ventus for that purpose does elaborate GIS-based results that allow application of queries and filters in order to locate most suitable wind farm sites. As filter criteria could be chosen (exemplary only):

- Proximity to high voltage electricity grid (for example less than 30km),
- Wind speed (of for example ≥ 7.6m/s at 50m h.a.g.l.),
- Distance to an asphalted or gravel compacted street (e.g. not further than e.g. 20 km),
- Avoiding environmental protected area nearby,
- Surface roughness length (for example < 0.4m).

Based on such query our GIS tool would highlight as a result all potential sites that are complying with these filtering criteria. Any data in common GIS format could be incorporated and considered in the GIS tool and hence in the query as well. Of course our Clients can incorporate the results into their own, customized database or software applications.

By doing so they safe time, safe efforts, yield better results, reduce the risk of selecting improper or unsuitable sites and avoid environmental or social conflicts when looking at potential sites or regions for wind farm development and planning.

On top we do offer configuration and delivery of potent GIS application and solution, built upon open source GIS software that is free of licensing costs. Latter saves our Client procurement of costly GIS software licenses. Our GIS software solution comes gratis with a collection of different, most recent and high-resolution geodata and online access to remote sensed geo-databases for regular, automated actualisations.

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Wind Measurement System Configuration

Accredited as testing laboratory following IEC 17025 for installation and evaluation of wind resource measurements conform to IEC 61400-12-1, MEASNET and FGW standards

We offer appropriate sensors for everything relevant to be measured

For high quality, banks-conform wind measurement campaigns, as requested by experienced banks and investors, the entire measurement system should be tailor-made to the wind project planned at a specific site. Thereby in any case it is crucial to comply with pertinent standards, and even to go beyond them. The equipment standardly recommended by ProfEC Ventus is in line with ISO / IEC 61400-12-1 and MEASNET (as the most frequently considered benchmark for bankable measurement equipment and measurement system characteristics), and also can be tested against any other banks requirements worldwide. Highest reliability and accuracy of the measurement systems are our superior objective, lowering the uncertainties involved!

Our onshore wind measurement masts rage from **40m to 160m** and include tubular as well as lattice tower structures from galvanized steel or aluminium.

Our free-standing offshore wind measurement masts range **up to 110m** height with boom lengths of about 20m.

We deliver and/or install individual equipment components as well as pre-confectioned measurement systems including all cables and junctions for out of the box installation and operation.

Suitable sensors, equipment, industrial data logger with flexible configuration, calibrations and communication interfaces like UMTS, (W)CDMA(2000) or satellite modems enable our clients to access their measurement stations at any time and virtually anywhere in the world. As fall-back option Serial, USB and Compact Flash interfaces can be used. If any wireless network is present, data files to the Client and/or to our Virtual Measurement Access (***V.Mac***) Platform on a daily base.

All items are proven and do operate under most extreme conditions from -50°C in the middle of a snow-desserts of Mongolia to +60°C like in highly remote desert conditions, or rural, tropical oceanic island situations. Our systems provided still achieve a complete 100% data coverage even under such extreme conditions.

For special needs, high requirements and environmental standards

We perform data logger calibraton, line-2-line calibration of the entire measurement system and we offer optional calibraiton for all measurement sensors.

In case of huge wind farm areas or (semi-) complex terrain, often several wind measurement masts are recommended. To don't stress the budget! Alternating masts can be applied.

A second recommendation we make are in-situ tests of the anemometers, which permits to assess, if recalibration of sensors is already needed or not yet necessary, maintaining a low uncertainty of the sensors by valid and permanent calibration. Therefore we recommend a control anemometer of different type and make compared to the primary anemometer, yielding in a more reliable and consistent result of the in-situ comparison.

Data Management and Supervision Service for all Client Stations and Data

In combination with *V.Mac*, we allow our Clients to real-time monitor and observe their measurement stations and data via Internet browser.

V.Mac allows sharing data and reports, downloading data, inviting stakeholders with limited access to see specific data only, to easily perform quick checks on data quality and completeness, trends, etc. *V.Mac* service is free of charge for one year and comes with every data logger we are going to provide. We also do offer this service for other data and data loggers our Client may already have. Our *V.Mac* service can be applied independently of the hardware used, as long as data are made available to be stored on the *V.Mac* server of our Client or of us.

Also automated alert messages via email or SMS are possible, allowing to immediately take actions in case that defined threshold levels are crossed (e.g. battery voltage drop, wind speed etc.).

Please try out our ***V.Mac*** here and feel free to explore its possibilities and strengths: **http://www.profec-ventus.com/services/v-mac.html** and get a free test account.

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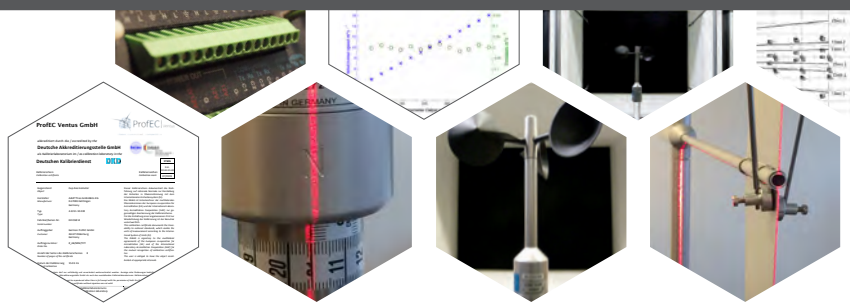

Accredited Calibration of Wind Sensors and Measurement Equipment

ProfEC Ventus as calibration laboratory performs calibration of cup anemometers and wind vanes, entirely respecting the pertinent ISO/IEC 17025, IEC 61400-12-1 and MEASNET standards

Mandatory for any project

Next to our accreditation as **Testing Laboratory**, ProfEC Ventus GmbH also is accredited as **Calibration Laboratory** in accordance to IEC 17025 for calibration of Cup Anemometers and Wind Vanes incompliance with IEC 61400-12-1 Ed.1 (2005), IEC 61400-12-1 Ed.2 (03-2017) and MEASNET Cup Anemometer Calibration Procedure.

ProfEC Ventus was the first Laboratory accredited for wind vane calibrations in accordance to the recent IEC 61400-12-1 Ed.2 (03-2017).

Moreover we contribute to the proceedings of pertinent norms and regulations such as the IEC 61400-12-1 Ed.2 drafts and are working as Member of the German Calibration Service (DKD / PTB) as part of the group „*Flow Measurands*“ (Strömungsmessgrößen).

All that makes us to one out of a few recognized entities worldwide that offer such high-quality calibrations of wind sensors.

Our R&D department further improves measurement sensors and performs research on measurement and calibration subjects, always investigating and exploring new ways to improve the accuracy of measurement results.

Measuring precisely matters

None-calibrated sensors, same as sensors not calibrated in accordance to pertinent norms and guidelines, introduce unnecessary errors and uncertainties during interpretation of measurement results.

The response of a sensor to the wind speed or wind direction precisely needs to be known, in order to measure as close as possible to the real physical value prevailing.

That especially is the case for wind speed sensors, recognizing that wind speed has a cubic relation to the kinetic energy contained within the wind, which any wind project is supposed to harvest.

Small errors introduced already can cause significant differences in the energy yield prognosis and uncertainties due to absence of a calibration or due to unsuitable calibration procedures.

Both as a consequence cause sub-optimal or even prohibiting project financing terms.

An experienced investor or bank will try to balance any uncertainties by an increased interest rate, increased guarantees to be given by the project owner in turn to secure the loan granted and/or an increased equity share to be provided.

Considering **that** right from the beginning, enables to counter balance such risks and uncertainties by always maintaining a proper calibration of the measurement sensors.

We in that sense do offer a competitive and attractive graduated pricing, depending on the urgency that a freshly calibrated sensor needs to be sent out to our Client and on the quantity of sensors to be calibrated for particular Clients during the year.

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V.Mac - for Instant, Remote Data Monitoring, Supervision, Evaluation and Control

ProfEC Ventus does offer with each data logger access to the measurement data sent by the measurement station and saved to a data server. Data supervision, checks, filtering and advanced analyses can be performed by aid of *V.Mac* anywhere and at any time

Accessing from everywhere real time measurement data collected anywhere

Our Virtual Measurement Access (***V.Mac***) services offers to our Clients customized login, measurement data supervision, measurement data download and account content sharing opportunities. Driver of this product is our vast knowledge about our Client's demands and requests and the insufficient offer on the market for suitable, flexible and professional solutions.

Hence we did not wait long and we have been implementing a web-browser based *V.Mac* that even can be run App-based from mobile device.

V.Mac enables our Clients to always have real-time access and look onto any of their measurement stations everywhere in the world. Also the data of measurement stations from other equipment and service providers can be integrated easily in order to enable data sharing and provision via *V.Mac*.

Analysis, supervision, control, access and sharing of measurement data never was easier

Our clients using the *V.Mac* service cannot only see or filter their measurement data immediately, they also can compare the measurement data, download them, download general and customized reports and files, plotting them visualizing the measurement environment in Google Earth, getting an immediate impression of the annual energy yield for various selected wind turbines and much more. Also it is possible to share data, reports, etc. with any third person (clients, investors, stakeholders, WT manufacturer, etc.) by assigning to them a subordinate account with (limited) user rights that freely can be selected.

V.Mac by that becomes a very powerful and very comfortable tool, easy to use and to share, enabling permanent supervision of data and performance of data analyses.

V.Mac saves our clients the costs for data supervision by external third parties, which may easily be up to 8000 USD/year/station.

For our Clients operating several measurement stations, we do offer customized configuration and system establishment of *V.Mac*, establishing their own corporate *V.Mac* on their own server structure. Training provided and manuals are part of the service offered.

Alternatively we offer data storage on our own, mirrored servers, if a Client rather wishes that.

Please feel free to explore the possibilities and strength of *V.Mac* free trial access on our homepage.

In case of questions or request for individual configuration and menus: do not hesitate contacting us.

We are flexible to program your particular needs in a way that *V.Mac* incorporates all envisioned functions to your full satisfaction.

Immediate default notices shorten reaction time for corrective actions

V.Mac can be freely configured. May it be in terms of the graphic design, the type of graphics shown at the welcome screen or by setting alert functions. If for example a threshold is surpassed or undercut, an alert message in form of an automated email or SMS could be sent to our Client, informing about the situation at the measurement station. Typical such alert messages are used for extreme temperatures, extreme wind speeds, battery voltage drops, „no signals", etc. Once such alert message was sent and received, one could instantaneously online check the data, and, if needed, immediate actions could be taken to prevent a default to happen or to continue.

The real time characteristics allow a very short reaction time for detection of abnormal situations, as well as for any preventive or corrective measures to be taken. Therefore critical data gaps belong to history and a very high data coverage rate of up to 100% is easily been reached.

Please try out our ***V.Mac*** here and feel free to explore its possibilities and strengths: **http://www.profec-ventus.com/services/v-mac.html** and get a free test account.

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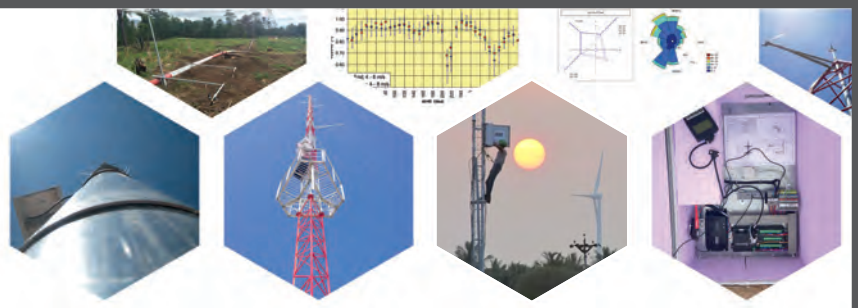

Alternating Masts Change Location every 3-4 Months

Accredited as testing laboratory following ISO / IEC 17025 for wind resource and energy yield assessments conform to ISO / IEC 61400-12-1, MEASNET and FGW standards

Mast alteration – a powerful tool generating more measurement data by imitating measurement masts

In cases of complex terrain, same as in cases where procurement expenses for several wind measurement systems shall be kept at a minimum, changing positions of measurement masts offers an appropriate solution to save costs by imitating measurement masts and reducing the costs for multiple wind measurement masts installed instead.

The principle relies on the same procedure as applied during site calibration in accordance to IEC 61400-12-1: if two the measurements at masts do correlate sufficiently, one mast can be removed and the derived from the remaining mast the time series at the removed mast can be extrapolated with vast certainty.

Alternating masts save costs by reducing the need for multiple wind measurement masts

During site calibration the behaviour of a wind measurement mast will be mimicked, based on comprehensive matrix calculations for different atmospheric situations of stability, classified by wind shear parameters. Advanced correlation and filtering procedures make possible the removal of one of the two masts. Though, validity of the measurement at both sites still is maintained by imitating the removed wind mast at its former position. This saves costs for example in the following cases:

- An old, or small, or not bankable measurement mast (M1) existing already on site that has an overlapping measurement period with a newly installed, bankable, higher mast (M2) for example.

The correlation between the old and the new mast enables backward extrapolation of the data measured at the new mast, modelling the history of the mast M2 for a period that this mast was not even installed. This procedure extends the measurement period of the new mast M2 towards the same period as the old mast M1 had been measuring in the past. This approach provides higher data security and hence lower overall uncertainty. Underlying correlation principles are similar as in case of a long-term correlation or if data gaps are filled.

- A mast is changing location (alternating mast), meant to measure for several months at several locations within the same objected area. This mast M1 is always correlated to a steady reference mast (M2) with a fixed position. Applying such an alternating mast M1 enables simulation of the wind measurement at M1 for the entire measurement period of the steady mast M2. For all sites where an alternating mast M1 had been taken measurements, the measurement period at M1 can be extrapolated to history and forward to cover the same measurement period as investigated with the reference mast M2.

This procedure reduces costs for more measurement masts and equipment, as the alternating mast M1 may, within one year, imitate and hence substitute up to 4 steady masts.

In general the procedure reduces the uncertainties linked to the wind database investigated for the objected area by increasing the measurement period for each single measurement point in combination with multiple measurement points.

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Sensors, Masts and RSD (SODAR / LIDAR)

100 % data availability and permanent access to the measurement station, even under extreme environmental conditions, is no magic to us

Measurements everywhere at all times

ProfEC Ventus offers high quality hardware that regardless climatologic conditions is not only prepared for wind measurements in any part of the world, but also is most reliable, accurate, robust, flexible and modular. Given the very low uncertainties involved, our provided measurement hardware is highly bankable and in compliance with relevant standards as IEC 61400-12-1, FGW TR6, FGW TR2, MEASNET Power Performance Measurement Procedure, MEASNET Evaluation of Site Specific Wind Conditions etc.

Our logger hardware comes with a customer friendly data management and analysis service *V.Mac* (Virtual Measurement Access), offering quick data analyses, data access, resource evaluations and data sharing by individual user rights that our Clients can assign to the stakeholders to whom they grant a sub-account.

V.Mac (Internet browser based or mobile App based) is flexible and can incorporate any data a Client wants to incorporate, also from measurements not performed by us. *V.Mac* saves our Clients hiring an external, additional data management service worth more than about 8000 USD per year/station, if compared to business as usual offers from appreciated competitors.

We have proven a 100% data availability and system operation in extreme low temperature regions of **-50°C** as in Gobi desert to extreme humid, tropical highlands and extremely remote island situations as Micronesia. We are prepared for all situations and challenges while offering an excellent quality service to our Client.

The uttermost high accuracy of offered devices does significantly lower potential uncertainties and increases the likeliness for a more attractive financing structure at less risk.

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FGW TR 2 Leistungskurve Kennlinienmessung 2018

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ProfEC Ventus Germany measnet

From offshore to moon

Our onshore wind measurement masts range from **40m to 160m** and include tubular as well as lattice tower structures from galvanized steel or aluminium.

Our freestanding offshore wind measurement masts range up to **110m** height with a boom length of about 20m.

The design of any mast installed follows recent standards for banks compliance in terms of IEC 61400-12-1, FGW and MEASNET. We perform data logger calibration, line-2-line calibration of entire measurement systems and we offer optional calibration for all measurement sensors.

We deliver and install individual equipment components as well as pre-confectioned measurement systems including all cables and junctions for plug&play, out of the box installation and operation. Suitable sensors, equipment, calibrations and communication interfaces like GSM, GPRS, Edge, UMTS, 3G, LTE and (W)CDMA(2000) modems, WLAN-routers or satellite communication packages enable our clients to access their measurement stations at any time and virtually anywhere in the world. As fall-back option Serial, USB and Compact Flash interfaces still can be used at any moment on site.

Climbing protection, safety equipment, aviation lights, signal painting, sophisticated lighting protection measures, cameras, bird flight diverters or bat counters are part of our standard delivery for measurement masts, sensors and equipment.

We offer rental or purchase of remote sensing devices (RSD) such as LIDAR or SODAR to round off wind measurement campaigns with a met mast or for stand alone applicatons.

To save Clients‘ budgets, we offer alternating mast techniques as well as anemometer in-situ tests, telling us the right moment for anemometer re-calibration: not too early, not too late.

Please view our ONE STOP WIND SHOP and check our recent prices at: https://shop.profec-ventus.com

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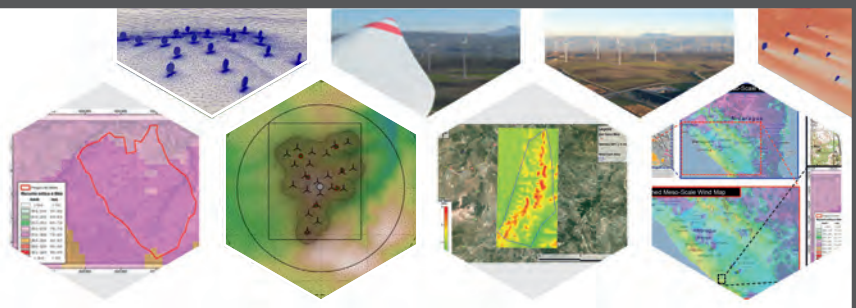

Micros-Scale Wind Maps

Accredited following IEC 17025 as testing laboratory for wind resource assessments, energy yield prognoses and energy yield optimization based on micro-scale wind maps

Wind maps offer special value during project planning, site assessments and optimization of energy yields during wind farm planning

For an energetically optimized selection of precise wind turbine positions and wind farm constellation, same as to compare different wind energy projects, micro-scale wind maps are the tool of choice to yield highest possible energy generation at lowest possible infrastructure costs. The wind maps are calculated based on high-resolution digitized topographical information in combination with wind measurement data. The wind measurement database thereby is, followed by the processing flow-model, the determining factor for the accuracy of the resulting wind map. The wind data can either be measured (used for concrete and bankable project development) or derived on re-analysis data, preferably in combination with a meso-scale downscaling **CFD** application (used for prefeasibility, preliminary project preparation and site preposition phase) like OpenFoam.

The final micro-siting model used at ProfEC Ventus in most cases is the Wind Analysis and Application Software Program (WASP and WASP Engineering) as worldwide acknowledged micro-scale wind atlas calculation method with low uncertainties, accepted by virtually all banks and utilities for high resolution wind energy yield prognoses. Though, we rely on OpenFoam in case of semi-complex and complex terrain as an alternative option.

Both mico-siting models are also of high value in case of analyses and corrective actions to be taken during optimization of an operating wind farm, which is of crucial essence if a wind farm in operation does not reach the expected energy yield prognosis results.

Often wind maps are misinterpreted or erroneously calculated, being based on wrong model assumptions and pretending too optimistic accuracy levels

For purposes of site selection (may it be on municipal, administrative level to appoint planning areas or for the concrete development of a wind farm project at a specific site), the criteria and the requirements associated with a micro-scale wind map should be very precise and accurate. Wind maps dedicated to such purpose should be generated by aid of micro-scale models that do precisely incorporate and respect the local topography and resolution of input wind data. Utilization of unsuitable models lead to erroneous results.

The wind map, once generated, should be verified in order to derive the level of uncertainty attached to the result. Knowing the level of uncertainty helps to avoid misinterpreting the wind map.

Only selection of an appropriate model for individual situations yields in more accuracy and higher energy generation

During wind farm planning and development, sufficient resources should be used to optimize the wind farm design right at the beginning. Appropriate energy yield optimization starts with optimized wind turbine positions in relation to the wind resource probability distribution and wind rose, topography and wind turbine characteristics. Micro-scale wind maps are optimal tools to localize most promising wind turbine spots and to yield an optimized level of energy generation.

Validation of the used model and determination of uncertainties attached to the results are essential for further interpretation, use of results and are part of our daily work.

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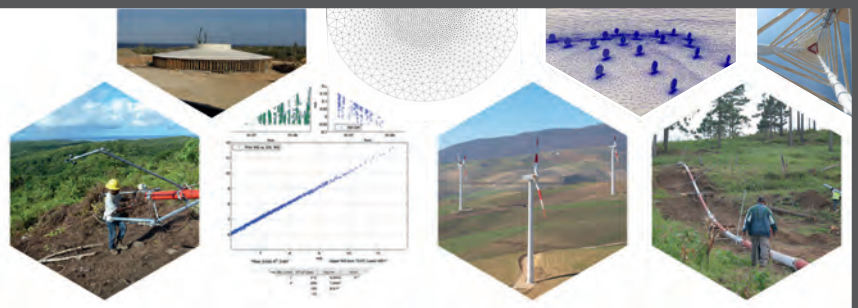

Site Classification, Turbulence Intensity Assessment and Extreme Wind Speed Analyses

Low load and high load scenario comparison enables an optimal economic decision

Fitting the wind turbine to the site characteristics saves costs

At some point during project development the wind turbine is selected and the questions arises about the wind class prevailing on-site. According to IEC 61400-1, the wind class depends on the site's turbulence intensity (TI). Depending on the wind class, the wind turbine type may be more or less solid and stable in order to withstand the loads. Therefore more or less strong and heavy materials are used for that wind turbine type, influencing the price of a turbine as well as the design, transport and foundation parameters. Beside the best choice of the wind turbine for a given site, local building and construction codes may demand turbulence analysis in order to assure structural and operational safety of wind turbines. To prove compliance we usually refer to EN 1991-1-4:2005 (+A1:2010): Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions, as well as to the DIBt Guideline (regulation for wind turbines – influences and structural safety proves for tower and foundation).

Ambient turbulence level and wind turbine aerodynamics influence spacing between the turbines

High turbulence intensity allows a closer spacing in terms of wake flux energy recovery and hence increases the spatial efficiency of a wind farm. This however must be off-set against the higher stress due to higher fatigue loads a wind turbine may experience by a higher turbulence level. The distance between wind turbines not only is a safety matter, but it may happen that the owner of adjacent wind turbines is not the same and hence both want to avoid influencing each other (e.g. wake losses, increased fatigue loads related to effective turbulence intensity etc.), for which minimum distances are maintained and recommended in dependence of the site characteristics.

Higher spatial efficiency vs. lower wind turbine prices, less operational and maintenance costs

Special attention should be given to near-shore, offshore and forest sites, where beyond 100m height above ground level turbulence intensity typically increases at high wind speeds (about > 16 m/s), as the wind speed changes the surface roughness, which in turn causes higher turbulences within the Prandtl boundary layer. Deviation should be made during application of a suitable flow model in order to take such effects into account.

The turbulence characteristics must be analysed and the site must be classified accordingly, in order to take the optimal decision in terms of wind turbine strength, spatial efficiency and energy yield.

Beside that an assessment of the maximum wind speed expected during a period of 50-years should be performed, in order to avoid such extreme events stressing wind turbine design specifications.

As a consequence different scenarios can be elaborated for the wind farm design, for example:

- Low load scenario: less wind turbines installed, lower load and stress per turbine, lower turbulence intensity, less wind turbine and infrastructure costs and less operating and maintenance costs by lower fatigue loads.
- High load scenario: more wind turbines installed, higher load and stress per turbine, higher turbulence intensity, higher wind turbine and infrastructure costs and higher operating and maintenance costs by increased fatigue loads.

Comparison of both scenarios allows deriving an optimal economic decision.

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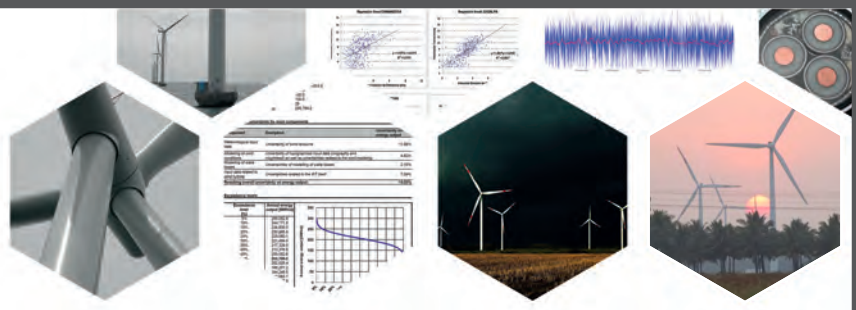

Accredited Wind Resource and Energy Yield Assessment

Accredited as acknowledged testing laboratory following ISO / IEC 17025 for wind resource and energy yield assessments conform to ISO / IEC 61400-12-1, MEASNET and FGW standards

Banks and investors welcome prognosis results derived based on accredited services, proving compliance with highest international standards for bankability

We offer bankable wind resource and energy yield prognoses, starting with data processing, evaluation, correction and finishing with bankable reporting of energy yields, including P50, P75, P90, P95 levels of confidence, assessment of losses and a vast assessment of uncertainties involved.

During data correction and uncertainty analysis we consider in-depth correction of measurement data with respect to influences that the sole physical presence of the mast causes (e.g. mast blockage, wake effect, speeding-up, lighting rod etc.).

On the way we perform advanced statistical analyses to fill data gaps in case sensors failed or the measured time series contains data gaps or errors. This reduces data uncertainty and yields in results with higher accuracy based on higher data availability. It lowers the need to exchange sensors, if a sensor shows malfunction, and as long as sufficient other sensors (preferably redundant) still maintain operative.

Each corrective action taken will be evaluated and the uncertainties of such procedures will accordingly be taken into account following ISO / IEC 61400-12-1, and ISO / IEC Guide 98-3:2008 (BIPM) „Guide to the Expression of Uncertainty in Measurement“ (GUM).

Reduction of uncertainties by advanced techniques and experts' insight

To further control and reduce uncertainties, so-called in-situ test of installed anemometers should be performed. This in-situ test is an advanced cross comparison of anemometers and permits estimation, if (re-) calibration of sensors is needed already or can be surrendered to a later time. The recalibration intervals, and thus exchange of sensors, can be postponed by this method, saving time and costs, and on top yielding low uncertainty related to the sensors by permanently maintaining valid calibration characteristics.

Deriving the long-term persistent wind climate on site taking into account inter-annual fluctuations

The cleaned, filtered and corrected set of measurement data subsequently needs to be correlated with at least one independently verified and representative long-term wind regime.

Our applied procedures guarantee most accurate prognosis results for the derived long-term wind climate and hence yield highest level of precision at low levels of uncertainties.

Optimising wind farm energy yields by site-specific micro-scale wind mapping

Appropriate energy yield optimization starts with optimized wind turbine locations in relation to the long-term wind resource probability (wind speed frequency distribution and wind direction distribution), topography and precise wind turbine characteristics (type of power curve, cut-off hysteresis, operational mode, etc.). Thereby a micro-scale wind resource raster (wind map) is an optimal tool to localize most promising wind turbine positions within an objected planning area and to yield an optimal level of energy generation on long term. We offer site-specific wind mapping services with very high resolution, enabling our Clients to energetically optimize a wind farm project by determination of the precise location of each single wind turbine within the wind farm. We hereby rely on linear as well as CFD models, depending on the site characteristics.

Validation of the prognosis results, determination of the level of uncertainties and assessment of the quantiles of probability for each wind turbine individually result in a bankable wind energy yield prognosis, entirely respecting our accreditation as testing laboratory regarding Wind Resource and Energy Yield Assessment of Wind Turbines (incl. Assessment of Losses following TR6) following ISO / IEC 17025.

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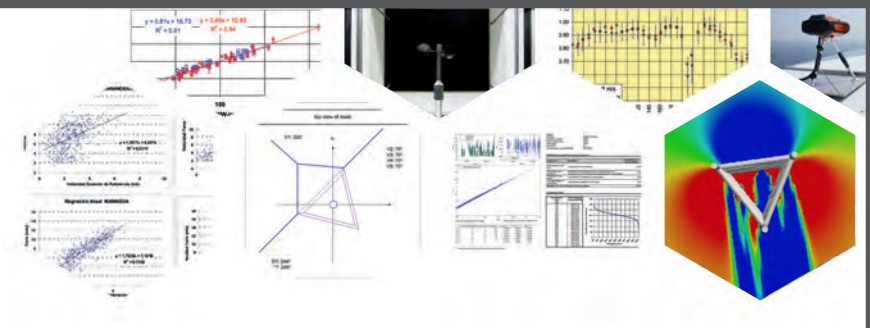

Accredited Uncertainty Assessments of Wind Resource and Energy Yield

Accredited as testing laboratory following ISO / IEC 17025 for wind resource and energy yield assessment, including uncertainty assessment conform to ISO / IEC 61400-12-1, MEASNET and FGW standards

Bankable determination of uncertainties is a key component for project financing and the optimization of financing conditions

Our Clients, especially banks, investors and project developers, entirely rely and trust on our expert opinions and bankable reports. Our assignments are presented to the financing banks and to wind turbine manufacturers, in order to negotiate their involvement and underlying contract terms. Therefore, we consider it the most important to not only measure the wind resource as precise as possible, but also to determine the involved uncertainties by advanced and most accurate approaches. Uncertainties in that aspect are determined for the wind resource as well as the energy yield potential.

In general uncertainties can be decreased by calibrated equipment installed in accordance to IEC 61400-12-1 and to MEASNET standards. Also the height of measurement matters, as well as the amount of measurement masts spread over a projected wind farm area of interest and the measurement period. Assessing the **„wind resource“** as precise as possible is the most important parameter to yield low uncertainties.

Assessing highly relevant uncertainties by application of advanced techniques and procedures

Most innovative and unique during our uncertainty assessment is that we concentrate very much on the uncertainties evolving from the quality of transition from the wind climate measured to a Weibull distribution (Weibull fit), which rarely is considered among the wind energy sector yet.

Though, the interpretation of the wind climate by an applied Weibull fit may imply huge uncertainties attached to this standardly and widely accepted procedure.

We therefore do precisely determine, if a so applied Weibull-fit actually does under- or overestimate the measured wind resource potential. This in-house developed procedure is rather unique and we do amend it by a standard uncertainty assessment in accordance to internationally accepted norms and standards, including the uncertainties originating from the wind measurement equipment, representativeness of the measurement period, long-term alignment, power curve, flow model, etc.

With lower uncertainties to higher P75, P90 and P95 values, which balance financial risks of investors

Derived from the uncertainties, the probability of exceedance with given levels of confidence P50, P75, P90 and P95 are depicted as important parameters for financial project evaluation and risk assessment. Both are governing indicators for risk management of banks and investors, which will adopt the Term Sheet for loan provision by an appropriate Equity / Debt ratio and an interest rate corresponding to appropriate risk reflection.

It is all about quantifying the uncertainty of annual energy yield predictions.

Investor decisions are commonly based on P50 and P90 (P95 or even P75 are sometimes used) levels. Better instrumentation and sensors, as well as accurate mounting and long-term data assessment, are considered for assessing the P50 value. The level of uncertainty influences the difference between the P90 and P50 level of energy generation. The lower involved uncertainties are, the smaller the difference between P50 and P90. Low uncertainties directly increase the value of a project by lower financial risks for banks and investors, leading to more attractive financing conditions granted.

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Modelling and Validating Simulations of Electrical Characteristics of Power Generators and Systems

Optimally introducing & managing increased shares of intermitted, volatile RE-sources in sophisticated interconnected networks or stand-alone hybrid systems

Increased shares of intermitted renewables challenge interconnected networks historically designed for conventional power generators

We optimize RE-generator operation and design characteristics as well as grid infrastructure and its operational management in order to reduce losses and to increase efficiency and security of supply with as overall objective a **more affordable and less vulnerable energy supply** based on increased, sustainable resources. We perform grid analyses for different scenarios and determine weak points and characteristics, as well as technological and operational management solutions.

Meeting national and international requirements with respect to norms, standards and grid codes by advanced application of verified models and validation of results

Our work results comply with international standards and national grid code requirements, yielding advanced, validated modelling results. Our Expert Team is skilled not only to examine grid-connected or interconnected system modelling, design and forecasting, but also stand-alone or hybrid systems.

Modelling in accordance with the grid connection regulations and relying on FGW TR4, is required for the certification of the power generation systems in accordance to FGW TR8 „Certification of the Electrical Characteristics of Power Generating Units and Systems in the Medium, High and Highest Voltage Grids“.

Models validation is indispensable

With increasing share of renewables in the interconnected generation matrix, grid stability and security of the system increasingly become the focus of recent and future work. FGW TR8 takes that into account and requires certain specifications to allow generators to interconnect to the interconnected network. Our modelling validates the operation and electrical characteristics of any generating systems under question. Former are essential to be proven prior to grid connection.

ProfEC Ventus is capable of providing such models that demonstrate real performance characteristics with validated results. Based on our expertise we can provide a detailed structure of models and support the verification of the models to complete the certification procedures. Our service hereby includes:

- **Impact analysis of intermitted power:** static and dynamic studies for high wind power penetration areas with the objective of assessing the system stability against variations of different parameters of the grid and the wind farm.
- **Wind turbines modelling and simulation studies:** creation of simple and complex models depending on project requirements using well-known modelling software such as DIgSILENT, MATLAB, Python, Homer and others. These services are provided for grid operators, wind turbine manufacturers, energy traders and takers, etc.
- **Grid analyses:** measurements of voltage dips, frequency variations, overvoltage, phase shifts, flicker, harmonics and others for the verification and validation of the models.
- **Testing of wind turbines and PV plants:** in accordance to FGW TR8 and IEC 61400-21.
- **Recommendations and modelling:** retro-fits, enhancements or reinforcements for grids or if generator components or operational management and patterns change.

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Modelling and Validating Simulations of Electrical Characteristics of Power Generators and Systems

Optimally introducing & managing increased shares of intermitted, volatile RE-sources in sophisticated interconnected networks or stand-alone hybrid systems

Model adaptation based on final design parameterization

We provide sophisticated models for each energy generator (source based) in the hybrid or interconnected systems and utilize appropriate tools to model individual components or entire systems. The models will be parameterized based on the final systems to be installed and respecting the case-to-case necessities.

Design and simulation of operational scenarios for recommended and critical system mode identifications

Several operational scenarios based on varying sources, amount of generators and loads, generator types and parameterization can be simulated and evaluated. Based on the simulation results, the operational scenarios will be evaluated in order to determine the most suitable operation modes, patterns and policies of the plant or the entire system, considering ambient conditions and framework parameterization. Also edge scenarios that may be seen as “critical” would be detected in order to derive necessary conclusions and measures for prevention.

Any analysis will be accompanied with recommendations that perfectly fit to the Clients situation and meets FGW TR3 standard and national standards and codes.

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Assessment of Losses

ProfEC Ventus performs an accredited service regarding analysis and assessment of losses in accordance to the Technical Guideline FGW TR6, as a worldwide applicable reference standard

Losses reduce the net feed-in of energy and can become critical for the financial stability of projects

Losses principally describe the difference between the useable gross energy yield produced by the wind turbine under operating conditions and the net energy yield at the point of measurement for grid injection (mostly at the point of common coupling (PCC)). Location of this point may vary depending on the local regulations and hence the losses, resp. the escaped income related to losses, vary either.

Infrastructure, within which wind energy is embedded, as well as requirements from grid operators or even environmental same as social concerns are getting more complex and hence the likeliness of technical and non-technical losses increases.

May it be that there is too much intermitted renewable energy generating capacity (wind, solar, run-off-river hydro etc.) connected to the grid, or may it be that environmental or social restrictions (bird migration, bats, noise, shadow, etc.) do cause situations, in which a wind turbine or wind park cannot operate at full capacity.

Next to losses as a result of regulations, there are losses related to turbine standstill times for repair, maintenance and malfunctions. Such losses should be assessed, qualified and quantified.

To mention only a few of them, we perform loss assessments related to most importantly:

- Wake effects and obstacles causing a change of the wind field characteristics across the rotor plane
- Availability of the wind turbines (malfunctions, repair and unscheduled maintenance), grid and electrical facilities
- Electrical efficiency regarding self-consumption of the WT as well as efficiency of the wind turbine power electronics (e.g. the transformer) etc.
- Power performance and efficiency of the WT with regards to site specific characters and cut-off hysteresis
- Environmental losses as icing, site access, temperature caused malfunctions etc.
- Power reduction due to sector management (e.g. caused by radar or turbulence thresholds), grid instability, environmental concerns (bird migration, bats, marine mammals, noise, shadow flicker, etc.)

Assessing the probability of unforeseen losses enables to safeguard a solid cash flow prognosis

Several losses, especially regarding environmental concerns, can be derived from regulations that apply to specific situations. Assessment and quantification are comparatively easy in such case.

However, there are losses that do occur spontaneously, arbitrary and unforeseen like hardware repair and (software) malfunctions of wind turbines, or the unexpected behaviour of a given power curve at a particular site. Such losses can be derived based on empirical findings and long-term experience, which some of our speciality working fields.

Taking such loss scenarios into account helps to prevent a cash-flow collapse in critical situations and does safeguard financial stability of a project, as it enables the project operator to form accordingly quantified financial reserves.

Knowing precisely the losses prevents wrong expectations

We assess losses following most modern approaches and in compliance with FGW TR6. A realistic and accurate loss assessment, avoiding too optimistic as well as too pessimistic assumptions, helps the investors to negotiate suitable PPAs, define a more accurate financing strategy, reducing equity capital ratio, interest rates and financial guarantees to be provided by the lender.

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Site Calibration

Accredited as Testing Laboratory following ISO / IEC 17025 for wind resource and energy yield assessment incl. site assessment and power performance measurements conform to IEC 61400-12-1, MEASNET and FGW standards

Mandatory in complex terrain

In cases of complex terrain, where power performance measurement or power curve verification shall be performed, site calibration is the enabling tool.

During power curve verification in flat terrain an undistorted, free sector is determined that lets assume that the wind speed measured at the wind mast is precisely the same free flow wind speed that hits the wind turbine at hub height, just before blockage effect of the wind turbine comes into force.

That relation of undistorted, free flow wind speed between mast and turbine cannot be maintained in complex terrain, though, as the wind speed measured at the wind measurement mast will be affected by topographical and maybe roughness characteristics of the terrain. Meaning that at the wind turbine another wind speed is present as if compared to the wind mast.

For power curve verification in such (semi) complex situations two masts are used to measure the wind and to subsequently derive the relationship between both masts. Having derived the proper statistical relationship enables removal of one mast, and putting a wind turbine exactly at that same position where the measurement mast was located before. This procedure enables to measure the power performance of a wind turbine (P-V curve) even in very complex terrain, mimicking the exact wind speed for the point of the wind turbine by site calibration following 61400-12-1.

Depending on the site characteristics as well as in cases where an ex-post site calibration may be impossible (e.g. as a WT is already operating and economic constraints may oppose dismantling of that WT for site calibration), we perform Power Performance Verification by aid of the nacelle anemometer as described in IEC 61400-12-2.

Preferably the Nacelle Transfer Function (NFC) of another WT and/or site can be taken into account during that process, significantly lowering measurement term and cost.

During any such procedure ... of course also the uncertainties likewise need to be considered and assessed in a bankable way.

Cost saving during normal project development with multiple measurement masts

During usual wind project planning, site calibration offers an appropriate solution to save costs by imitating measurement masts and reducing the costs for further wind measurement masts installed.

In case of huge wind farm areas or (semi-) complex terrain, often several wind measurement masts are recommended in order to assess the necessary degree of certainty requested by most banks and investors in order to offer (more) attractive financing conditions.

As a rule of thumb we recommend: each multiple of about 40 MW capacity to be installed (with some degree of variation depending on the site complexity, turbulence etc.) demands an additional measurement mast, in order to assess the wind resource and uncertainties at an acceptable level of accuracy.

Do not stress the budget! Alternating mast techniques can be applied. With a given amount of masts at a fixed position, other masts can change their location with a frequency of about 4-6 months. Advanced correlation techniques between the fixed mast(s) and the alternating masts allow mimicking and imitating the wind resource at each of the alternating masts' positions and heights, prolonging with acceptable uncertainty the measurement to the same period as measured at the fixed mast. Each alternating mast could therefore replace up to 3 fixed masts during one-year time.

In general the procedure reduces the uncertainties linked to the wind database investigated for the objected area by increasing the measurement period for each single measurement point in combination with multiple measurement points.

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Leistungskurve TR 2 FGW 2018 Konformitätssiegel

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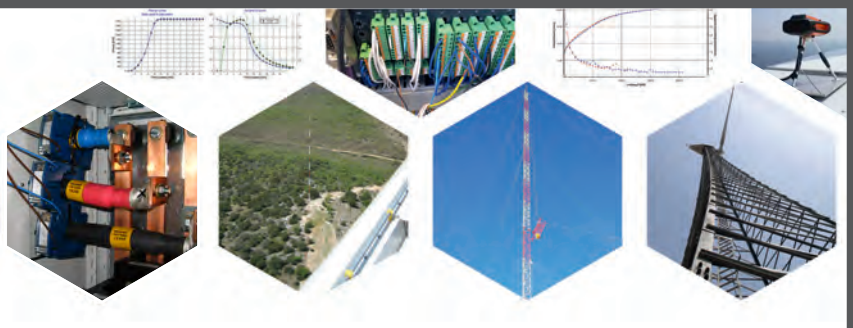

Power Curve Measurements and Power Performance Verification

Accredited as acknowledged testing laboratory following ISO / IEC 17025 for power performance measurements and power curve verifications conform to ISO / IEC 61400-12-1, MEASNET and FGW standards

Profitable wind resource is available but where remains the prognosticated power generation?

A power curve describes the power output generated by a wind turbine as function of the wind speed that the wind turbine is experiencing at hub height.

Both, the wind turbine manufacturers offering a product to potential clients or developing a new product prototype, in the same way as their clients, developing a wind farm project and trusting on a profitable power output of the wind turbines, have an uttermost interest to ensure that the considered power curve is met during operation and under real conditions, and that this power curve is maintained for a guaranteed period at least.

Power performance measurement and power curve certification are the appropriate means to prove this.

To verify the power curve, we perform an accredited service and measure power performance according to internationally accepted norms and standards as

- IEC 61400-12-1
- IEC 61400-12-2
- IEC 61400-1
- FGW TR2
- MEASNET Power Performance Measurement Procedure.

We perform power performance and wind measurements for hub heights up to **160m** by aid of measurement masts and we do perform higher measurements by aid of **LIDAR and/or SODAR** remote sensing devices and techniques.

Power performance: a matter of sales contracts, advertising brochures and project cash flow expectations

Also banks and investors, having an interest in the success of a financed project, may prompt for power curve verification. Typical needs for a power curve measurement and verification exists especially if:

- a wind turbine, or even worse the entire wind farm, on average is not yielding the P50 expectation value referring to the annual energy yield production prognosticated.

If in such cases neither analyses of operational data nor due diligence of the on-site available wind resource potential could explain the underperformance: power performance measurement and power curve verification are the next recommended activities to be performed.

- after the 2 year warranty period provided by the turbine manufacturer, responsibility and all technical risks are fully transferred to their actual client. Just before that moment the client (or investors) may want to have certainty that the wind turbines still are as good and as powerful as they were promoted during sales negotiations and as highlighted in brochures, but especially as agreed on in the sales contracts..
- any shareholder wants to have full certainty and guarantee that the product he bought really meets the expectations and promises negotiated and agreed upon within the sales contracts and performance guarantee conditions.
- a new wind turbine type or prototype is developed and tested prior or at market entry.

An appropriate wind turbine sales contract considers good performance guarantee and warranty conditions in case of wind turbine under-performance

In the end: if a wind turbine does not yield the praised power performance, compensation measures may be negotiated in accordance to the losses made based on wind turbine underperformance.

We do assist our Clients during contract negotiations for wind turbine purchase, ensuring good warranty conditions (e.g. high wind turbine availability and site specific energy yields) and appropriate guarantee conditions (e.g. financial compensations in case wind turbines fall behind any expectations) at a reasonable price.

Moreover we do perform acknowledged analyses and accepted calculations in order to determine the magnitude of financial loss as consequence of wind turbine under-performance.

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Leistungskurve TR 2 FGW 2016 Konformitätssiegel

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Design and Efficiency Optimisation, Component Development and Guidance for Small Wind Turbine Certification

ProfEC Ventus supervises setup and establishment of production floors for manufacturing small wind turbines for rural electrification by aid of a simple, reliable and robust design

Optimal and reliable performance especially matters at rural context

We are providing professional and scientific assistance for the development and optimization of small wind turbines up to 15kW and individual components. Thereby we look at the product development, engineering, manufacturing and testing of individual components, as well as on the testing and certification of entire wind turbines.

As a result, costs of production are reduced, making the turbines affordable in most rural context.

Knowing precisely about key components makes the difference in efficiency and durability. Therefore we have been contracted for governance and supervision during establishment of an entire standardized manufacturing floor with the superior objective to produce small, certified wind turbines. During our design and optimization work we do focus on compliance to internationally accepted IEC norms and ISO quality standards, most remarkably:

- IEC 61400-2: 2013 Ed 3.0: Wind turbines - Part 2: Small wind turbines
- IEC 61400-11 : 2012 Ed 3.0: Wind turbines - Part 11: Acoustic noise measurement techniques
- IEC 61400-11: 2012 Ed 3.0: Wind turbines - Part 11: Acoustic noise measurement techniques
- IEC 61400-12-1: Power Performance measurements of electricity producing wind turbines
- ISO 9001:2008: Quality management systems — Requirements

Learnt from the big, applied to the small

We do assist on the improvement of the technical design, efficiency, aerodynamic, control, durability and quality of wind turbine components for small wind energy converters, leading our Clients to a reliable series production, yielding internationally accepted and proven wind turbines as product.

Of essence is an economic and reliable design for rural applications

In rural and remote locations high reliability of wind turbines is essential. Especially the initial procurement costs cause a barrier and do matter in the context of rural electrification. Also of importance are operational costs as well as the spare part availability, and the presence of skilled technicians who could repair wind turbines in case of any failure.

Knowing about this importance for rural electrification, we have been adopting a concept of a small wind turbine that could be built anywhere in the world by local resources, ending in a robust design with high technical reliability that can be operated, maintained and repaired locally and at local costs.

From the wind turbine tower via the charge controller to the battery: all can be acquired or manufactured in a regional context, becoming independent from the import of goods from industrialized countries, which cause prices sky rocking in a contradictorily way to sustainable rural electrification and poverty alleviation.

As critical factor must also be seen the chance for local technicians conducting maintenance and repair of the wind turbine themselves. This finally is a key that enables economic operation on long-term, without the need to fly-in technicians or spare parts from abroad.

We elaborate proper operational and maintenance schemes and provide training to local technicians to enable a complete local service for manufacturing, operation and repair.

The overriding objectives of our consulting services provided on small wind turbine design and component optimization are:

- yielding local low cost production
- high reliability
- high system efficiency
- high system availability as well as
- compliance to internationally accepted production standards
- compliance to internationally accepted safety norms
- compliance to internationally accepted quality of performance.

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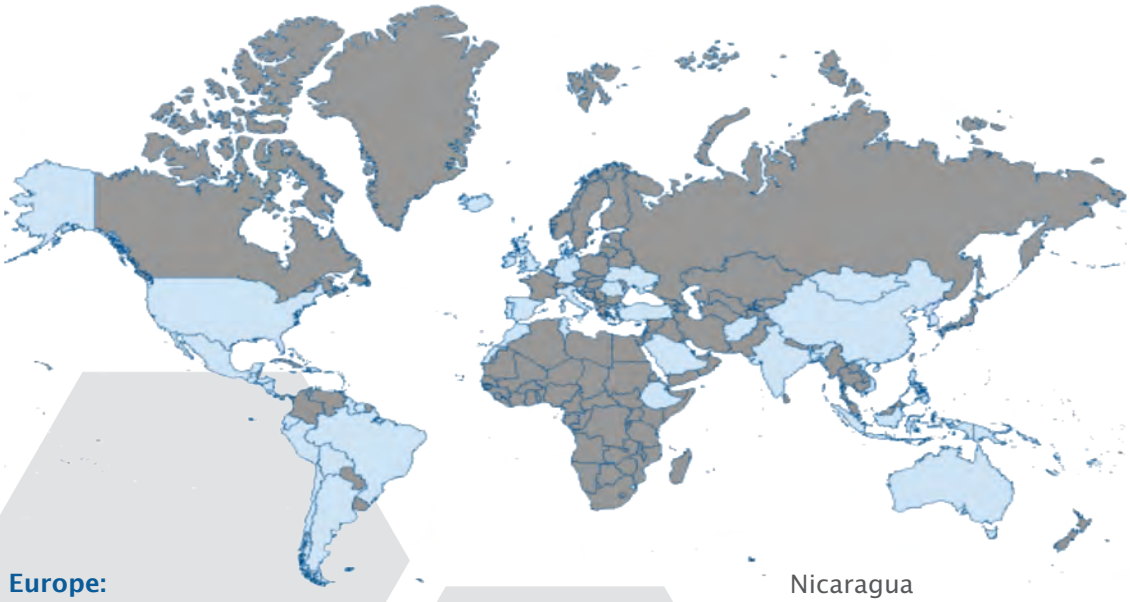
References

Our staff gained project experience having worked in for example ...



Europe:

Belgium
Denmark
Germany
Iceland
Ireland
Italy
Portugal
Romania
Slovenia
Spain
The Netherlands
Turkey
Ukraine
United Kingdom

Central America, North America and the Caribbean:

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Barbados
Bolivia
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Ecuador
El Salvador
Guatemala
Guyana
Honduras
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Mexico
Nicaragua
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Saint Kitts and Nevis
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United States of America

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Bangladesh
China
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Afghanistan
Lebanon
Saudi Arabia

Africa:

Ethiopia
Morocco
Swaziland
Tunisia

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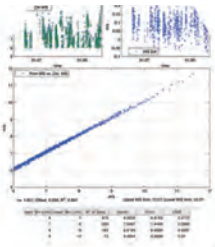
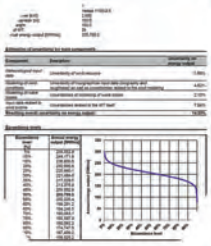


Wind Resource and Energy Yield Assessment

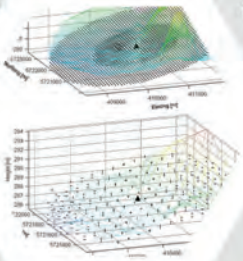
Wind Measurement System Configuration

Site Classification, TI Assessments and Extreme Wind Determination

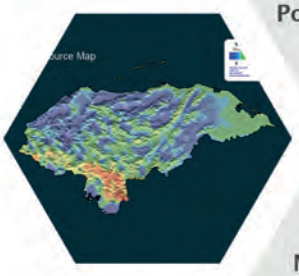
Power Curve Measurements and Power Performance Verification



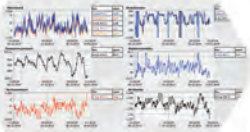
Uncertainty Assessment and Quantiles of Probability



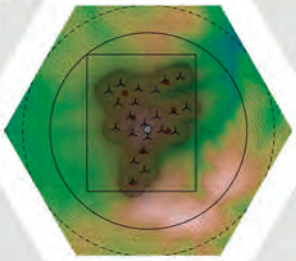
Site Calibration



Meso Scale Wind Maps



V.Mac - Virtual Measurement Access & Free Data Host



Micro Scale Wind Maps

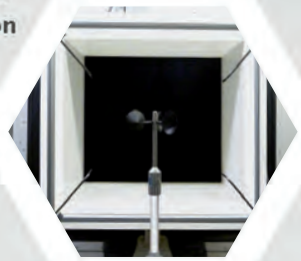
Assessment of Losses

Site Prospection, Spatial Analyses and Site Selection

Small WT Design and Efficiency Optimisations

Hardware and Sensors

Electrical generator, grid node and system analyses



Wind Sensor Calibrations

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ProfEC Ventus measnet Germany

ProfEC Ventus GmbH, Im Ofenerfeld 23, D-26127 Oldenburg, Germany
☎+49 4421 209089-0 ✉ info@profec-ventus.com 🌐 www.profec-ventus.com