
Wind Energy

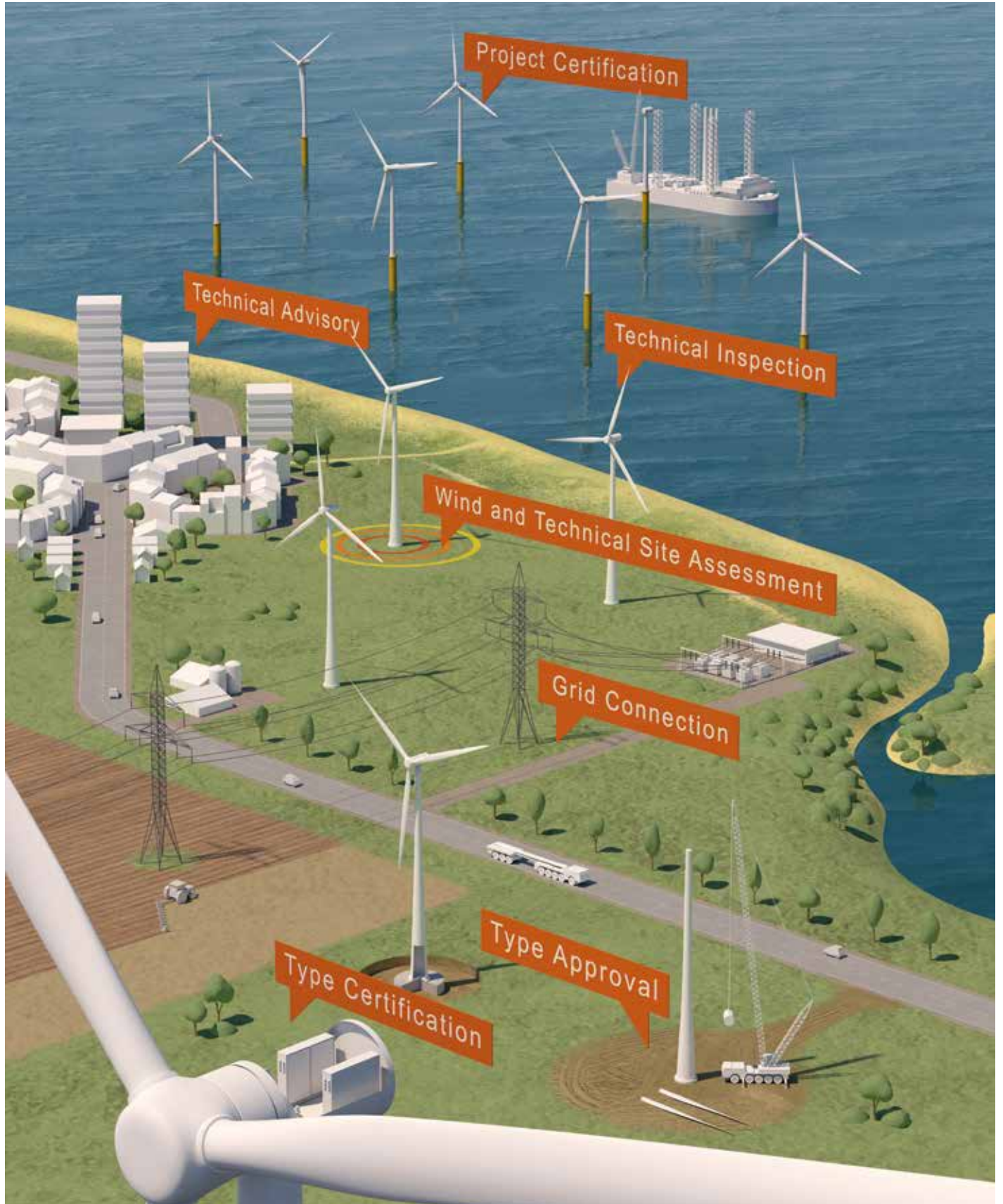
Service Portfolio



TÜV®



Full Service Provider for the Wind Industry



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TÜV NORD in Wind Energy

The **TÜV NORD GROUP** with its operative brands TÜV NORD, DMT and Alter Technology is one of the world's largest and most renowned technical service providers with more than 10,000 employees and experts covering nearly all technical disciplines.

Within the field of **Wind Energy** TÜV NORD offers services in certification, site assessment as well as inspection, surveillance and advisory activities for wind turbines, farms and projects onshore and offshore.

Since 1994 TÜV NORD is accredited by the DAkkS for wind turbine type and project certification for all recognized certification schemes including BSH Offshore Project Certification and is listed as registered body at the Danish Energy Authority.

TÜV NORD is legitimized by the German Government as Authorized Body ("Prüfamt") for DIBt Type Approvals according to the German Building Law ("Typenprüfungen"). Our customers are turbine and component manufacturers or designers, project developers and planners, operators or owners of wind farms along with financiers or insurers. The detailed service portfolio and the reference list are also published on our website.

TÜV NORD is ready to accompany you as a competent and reliable partner throughout the entire lifecycle of your turbine projects with our:

- ✓ strong reputation and recognition worldwide
- ✓ pragmatic and goal-oriented approach
- ✓ efficient process to target short time-to-market in the wind industry

Operating in more than 70 countries worldwide, we owe our leading market position to our technical competence and the wide range of services in the fields of technical advisory, testing and product certification.

More than 30 years of experience have made TÜV NORD a leading Certification Body in the wind industry. We employ specialized and qualified engineers for all technical disciplines surrounding wind turbines. Regular audits by the DAkkS provide evidence for the competence of our personnel and the high quality of our services.



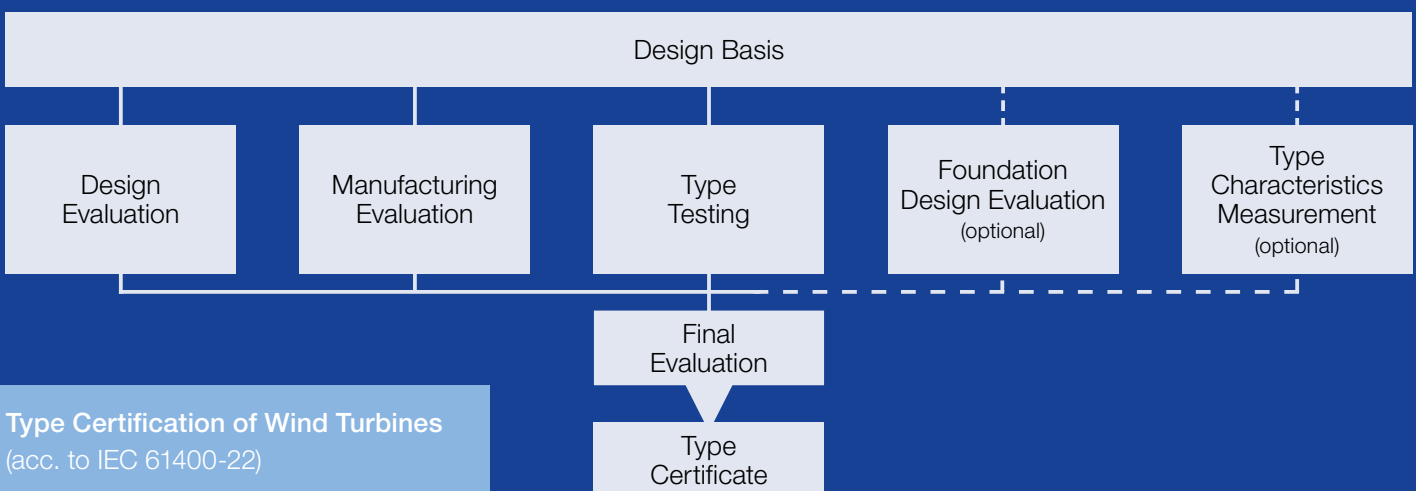
Type Certification

For more than thirty years TÜV NORD has been accompanying turbine manufacturers and suppliers in implementing their products into the markets all over the world. By offering type, component and design certification services, we contribute to ensure safety, quality and efficiency of wind turbine and wind farm projects.

TÜV NORD is accredited for type and project certification according to all recognized schemes incl. IEC 61400-22, IECRE, IEC WT 01, DNV and GL, Danish Type Certification, Indian Type Approval TAPS 2000 and Chinese GB standards.

The scheme below presents the type certification process and its modules according to IEC 61400-22. Other certification schemes are similar or refer directly to IEC 61400-22.

Each of the modules can be independently evaluated and concluded with TÜV NORD conformity statements. These can also be used as individual and re-usable packages since mutual recognition agreements ensure acceptance of certificates between accredited bodies.



Design Basis Evaluation

The design basis defines requirements, assumptions and methodologies which are essential for the design and documentation of the wind turbine.

Design Evaluation

Design evaluation is carried out by independent expert assessment. It is based on design code requirements and documentation provided by customers. Our evaluation comprises load assumptions, safety concept/system, electrical, mechanical and structural components, rotor blade, tower and tower internals, as well as turbine manuals. Customized design solutions and the implementation of site specific conditions such as for cold/hot climate, extended lifetime or earthquake areas can be considered.

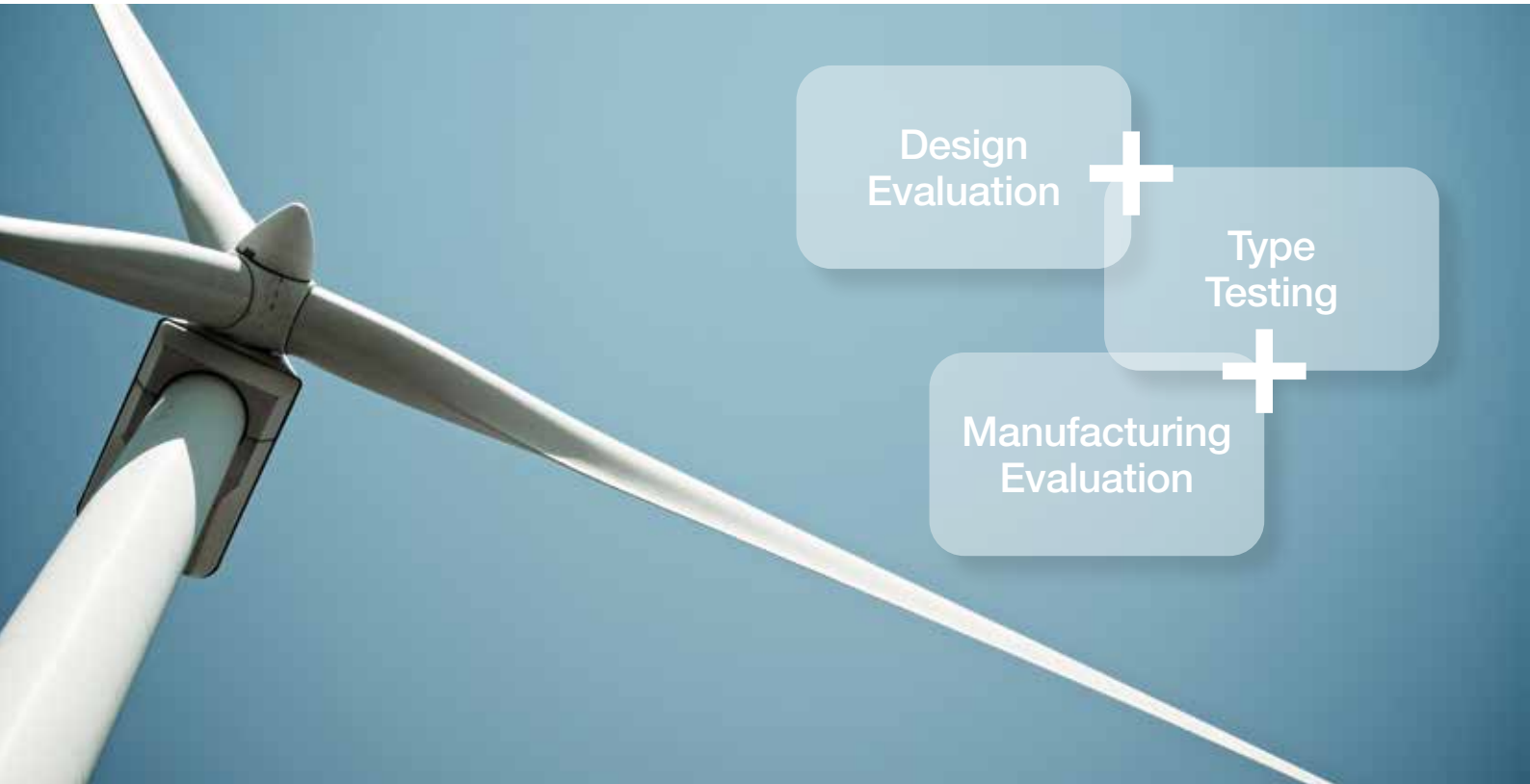
Manufacturing Evaluation

For quality assurance and compliance with the certified design, the implementation of design related requirements is verified by TÜV NORD manufacturing evaluation. Besides, we can accompany you to establish and maintain a certified ISO 9001 quality management system.

Type Testing

During type testing TÜV NORD accompanies you to verify that all relevant assumptions set during the turbine design process as well as the correct and safe functioning of the turbine in all operating conditions are ensured.

Optional modules are scheme-specific and can be included on customer request.



For manufacturers of wind turbine components, TÜV NORD can perform component certification, which would certify the conformity of the relevant component to a chosen standard. The applied procedures as well as the scheme are similar to those within a type certification.

A component certificate can be issued independent to a certain turbine type. Design evaluation is conducted based on design loads. Using loads comparison and other interfaces, the component certification can be implemented into a type certification of the relevant wind turbine on later stage. Most common applications of component certification would be rotor blades, gear boxes or towers.

A component certification offers the following advantages for the manufacturers:

- Component certificate can be implemented into various turbine type certificates with minimal efforts
- Component certification timeline can be independent from turbine certification timeline
- Changes in design or manufacturing processes will not directly effects the type certification
- Added value for market entry

For component certification, the design loads should cover all possible turbine loads especially those required for component type testing. In case of higher turbine loads, then a new test might be required. Interfaces such as bolted connections to turbine as well as lightning protection system should be taken into consideration.

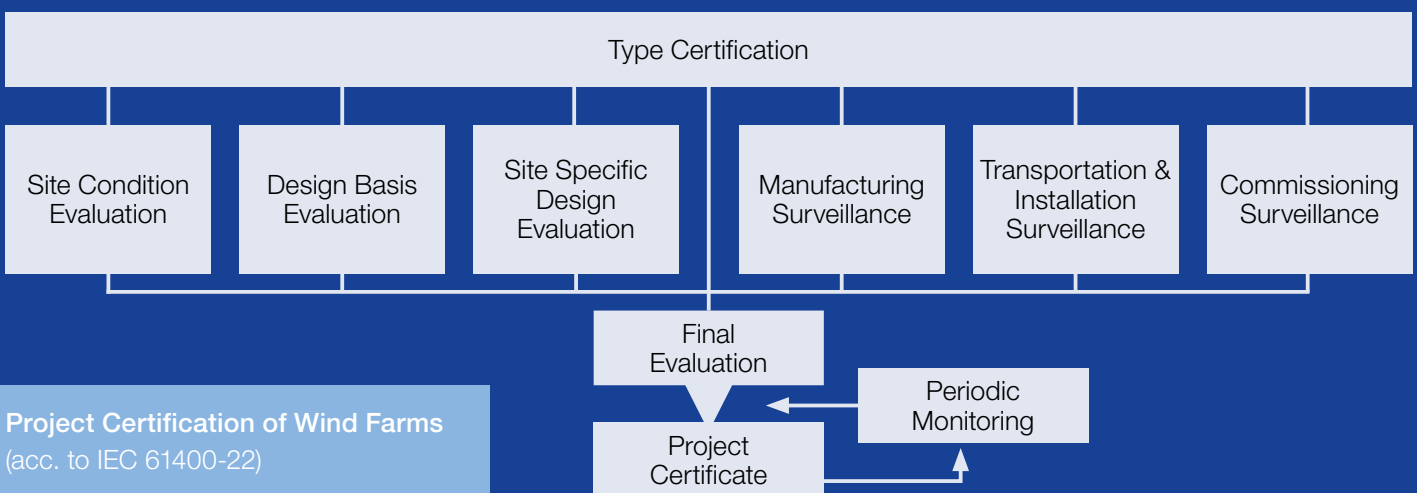
Project Certification

Project certification provides assurance that type certified wind turbines and foundation designs are in conformity with site-specific conditions, local codes and regulations at the project site.

Project certification increases overall project confidence and value while reducing technical and financial risks for all stakeholders.

A typical project certification process with its modules is shown below. Most project certification schemes are based on or similar to IEC 61400-22.

Similar to type certification, each module of project certification can be independently evaluated and concluded with recognized TÜV NORD conformity statements. These can be handled as individual packages which project certifiers can effortlessly integrate to their project certificates due to mutual recognition agreements of certificates between accredited bodies.



Site conditions such as wind distribution, wind farm effects, temperature, soil and terrain complexity as well as electrical network conditions are evaluated based on applicable measurements and/or local codes.

Our site-specific design evaluation assures the site suitability of type-certified wind turbines taking into account prevailing site conditions and customer preferences.

All assessments already generated within the scope of a TÜV NORD type certification will directly flow into the corresponding modules of the project certification and reduce the total amount of time and effort towards leaner project execution.

The implementation of design requirements in project specific manufacturing, transport and installation processes are ensured by TÜV NORD surveillance and on-site commissioning based on strategies agreed with and adapted to the customers' needs. Once the project certificate is issued, periodic monitoring is required to maintain its validity.

With focus on shortest timeline and leanest processes, our certification services are tailored to project specific needs and can be extended to optional activities such as independent inspection for foundation designs, operation and maintenance surveillance as well as modification management and many other services.

Offshore Wind Services

Offshore wind projects are complex in terms of design, manufacturing, transport and installation as well as operation at sea. Many challenges have to be mastered by different parties during the project lifecycle. TÜV NORD offers with its in-depth competences and broad experience support for the offshore wind industry in development and implementation of all offshore wind project phases following all relevant national and international standards.

TÜV NORD offers among others the following main services for offshore wind projects:

- Type and project certification for offshore wind turbines
- Support for BSH releases
- Manufacturing, transport, installation and commissioning surveillance
- Technical advisory services and technical due diligence for offshore windfarms
- Assessment of wind conditions and energy yield
- Periodic or condition-based inspections
- Risk assessments (e.g. ship collision, crane safety etc.)
- HSE surveillance
- Geotechnical assessments
- Design assessment for new and innovative technological concepts and developments

With more than 30 years of extensive experience in all areas of the wind industry, we want support your wind farm projects as a one-stop-shop for offshore and onshore projects making sure that you always feel confident with the right partner at your side.

For further information about our offshore and onshore services and experience, please refer to our reference list available at our website or contact us directly.



Technical Inspection and Surveillance

Whether for onshore or offshore wind projects, technical inspection and surveillance play a key role in ensuring quality, condition and performance of wind turbines, thus providing confidence to all project stakeholders. Some countries, such as Germany, even impose regulations on periodic inspections to ensure safety for installed wind turbines.

TÜV NORD offers an extensive range of technical inspections and surveillance activities for onshore and offshore wind projects. Securing quality and safety while reducing project risks due to unknown field conditions, such as infrastructures is our matter.

Examples of our main services are:

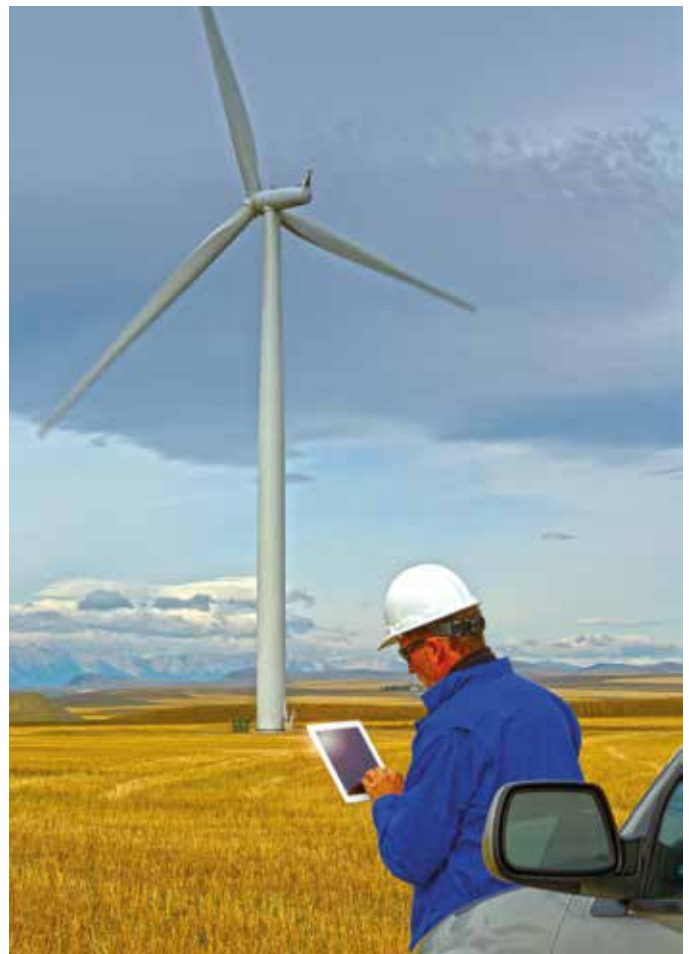
- Commissioning inspections
- Periodic or condition based inspections of turbines and components (e.g. rotor blades, gearboxes, towers, transformer stations, etc.)
- End-of-warranty inspections
- Lifetime extension evaluation
- Inspections of service lifts, cranes, ladders/fall arresters and pressure equipment
- Manufacturing inspections for turbine components
- Transport, construction and installation surveillance

Furthermore, we offer auxiliary services such as:

- Blade inspections by rope access including lightning protection system
- Endoscopy inspections of gearboxes and witnessing of tests
- Vibration measurements and condition evaluation of drive train components
- Inspections of auxiliary systems such as ice detection system, range visibility sensor of obstruction light system, etc.
- Witnessing of electrotechnical tests
- Inspection of the turbine safety system
- Non-destructive weld seam testing
- Damage investigation
- Other services

TÜV NORD is an accredited inspection body or “Zugelassene Überwachungsstelle (ZÜS)” for service lifts and pressure equipment by the German Industrial Safety Ordinance (BetrSichV). In addition we are accredited by the DAkkS for all relevant schemes and standards of wind certification as well as by BSH for offshore project certification. We are acknowledged by the German Wind Energy Association (BWE) to perform periodic inspections on wind turbines subjected to mandatory inspections.

We are keen on supporting you with our proven competence, extensive interdisciplinary knowledge and world-renowned objectivity to identify project risks and minimize uncertainties through our accredited and certified technical inspections.



Technical Wind Inspection

TÜV NORD provides inspections, evaluations and assessments of your wind turbines and lifts throughout their operating time including commissioning, periodic inspections and lifetime extension.

The TÜV NORD Wind Inspection team is your competent partner assisting you fast and reliably both onshore and offshore.

Our services include:

- Periodic inspections of the entire wind turbine onshore and offshore
- Condition-based inspections and end of warranty inspections, i.e. in case of conclusion/expiration of full service contracts
- Damage assessment and evaluation by independent experts
- Commissioning of wind energy plants, lifts and cranes
- Expert inspections and special customer examinations of cranes and other equipment
- Assessment and certification of implementations of building permit or BImSchG requirements, installing and functional control
- Installation/ construction surveillance both at home and abroad
- Periodic inspections of lifts according to BetrSichV (ZÜS) as well as inspections after significant modifications
- Manufacturing surveillance and quality control according to BSH standard
- Rotor blade inspections incl. lightning protection via rope access technique
- Gear box video endoscopy
- Oil and fat analysis
- Oscillation measurement of powertrain, gearing and bearing
- Obliquity of tower and nacelle, blade pitch check
- Assessment and certification of environmentally responsible dismantling and disposal of old plants
- Evaluation and inspection of old plants as well as assessment and inspection of lifetime extension
- Inspection of slinging means and load handling device

Feel free to contact us for further informations about our inspection services! Our experts are always available for your questions



Technical Advisory Services & Technical Due Diligence



Due diligence is focused on the economic efficiency of planned or already operating wind farms by identifying and managing potential risks. A complete due diligence includes the analysis of technical, financial and legal risks.

Technical due diligence offered by TÜV NORD includes points such as:

- Plausibility assessment of the wind potential prognosis and energy yields (AEP)
- Plausibility assessment of the certification documents of the chosen wind turbine type
- Technical risk evaluation of the wind turbine concept and technology
- Technical risk evaluation of the foundation construction
- Plausibility assessment of the maintenance and service concept
- Plausibility check of soil assessment reports

Financial and legal due diligence, which would be offered by a network of TÜV NORD's partners, may include the following points:

- Review of interface management, building permit and their related obligations
- Profitability analysis on the base of the profit-loss account and investment sum
- Risk review of the insurance concept
- Contract assessment on scope and completeness
- Contract assessment on legal content

For intensive assistance of wind farm projects, experts of TÜV NORD can accompany customers as owner's or lender's engineer.

With international presence, TÜV NORD is prepared to support its customers on national and regional certification, site and regulatory requirements. Project-specific details can be elaborated together with the customer to develop intelligent and pragmatic solutions.

Wind Resource Prognosis

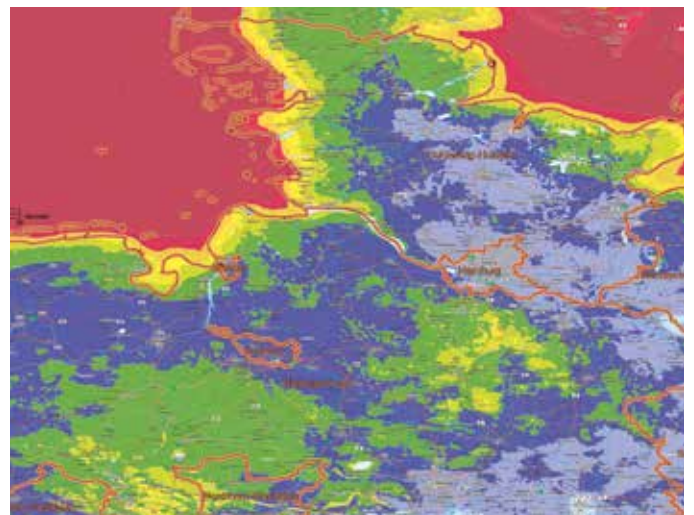


The wind potential at a proposed wind farm site is the basis for estimation of expected energy yields. Wind potential maps allow for precise assessment of strong and low wind areas within a proposed wind farm area and also serve as basis for the determination of suitable sites for wind measurement campaigns.

For areas where high density of information on wind conditions is available, such as in Northern Germany, TÜV NORD determines the wind potential on basis of long-term time series of local weather stations and production data of wind turbines in the vicinity of the site.



In areas without or with insufficient information on wind conditions, wind potential can be determined by mesoscale modeling, using global climate data as input. These data contain information about the wind conditions at higher altitudes. In addition, information on near-surface wind conditions can be used from a 100 km distance to transfer them on the planned wind farm site, taking mesoscale effects into account.



Example for a wind potential map of Northern Germany modeled by TÜV NORD:

- Area: 340 x 340 km, horizontal resolution 250 m
- Horizontal resolution possible up to 50 m for all hub heights
- Calibration using wind measurement data and turbine production data
- Determination of the mean wind speed and energy flux density at hub height
- Determination of wind frequency distribution at hub height

Our site assessment and environmental services are tailored and constantly extended in accordance to the needs of our customers and their projects. This page and the following pages show extracts of our main services. Contact us for further details and support.



The assessment of long-term wind conditions and the prognosis of the energy yields of the wind turbines are important starting points in wind farm planning. They are carried out by using recognized analytical methods based on the Technical Guideline for Determination of Wind Potential and Energy Yields (TR6) by FGW Germany. TÜV NORD is accredited by DAkkS according to DIN EN ISO/IEC17025:2005.

Available data bases pursuant to the specifications of the TR6 are taken into account; advice on complex requirements and contexts relating to wind farm planning is provided.

Complex sites require complex models. For wind turbine sites in mountainous terrains, the determination of wind potential and expected energy yield is additionally based on three-dimensional, non-linear flow models, so-called CFD models (Computational Fluid Dynamics).

Our full bankable energy yield assessments contain in their conclusion a detailed analysis of probabilities. Immission control requirements such as species protection, shadowing or noise emissions can be taken into consideration regarding the expected energy yield losses.

To minimize expected energy yield losses, TÜV NORD can support you by dedicated environmental analysis, finding the optimal wind farm configuration and turbine operational modes to concurrently optimize the predicted energy yield.





For sustainable and profitable wind energy projects, it is important that the selected wind turbines match perfectly with the local wind, climate and terrain conditions. Site-suitability assessment provides assurance that the environmental conditions, which affect loading, durability and operation of the turbines, are in compliance with the turbine design.

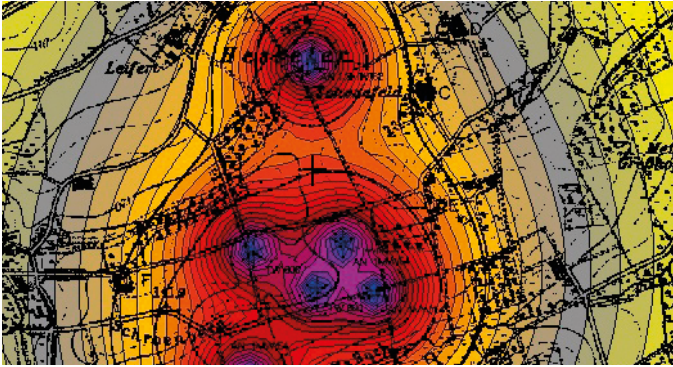
Site-suitability is evaluated according to recognized standards such as IEC 61400-1. Wind speed and turbulence parameters determine which wind turbine class is suitable for the site. Within wind farms, wind loading can experience unproportional rise due to turbulence or wake effects caused by neighboring turbines. The result of turbulence assessment can provide statements regarding the structural integrity of the wind turbines.

Our experts from TÜV NORD are available to support you from the early planning phase up to the final wind farm layout, including modifications and wind farm extensions.

For example these conditions are checked by TÜV NORD:

- Climate conditions (e.g. air density)
- Mean wind speed
- Weibull shape factor “k”
- 50-year wind
- Effective turbulence intensity
- Vertical flow inclination
- Wind shear
- Complex terrain

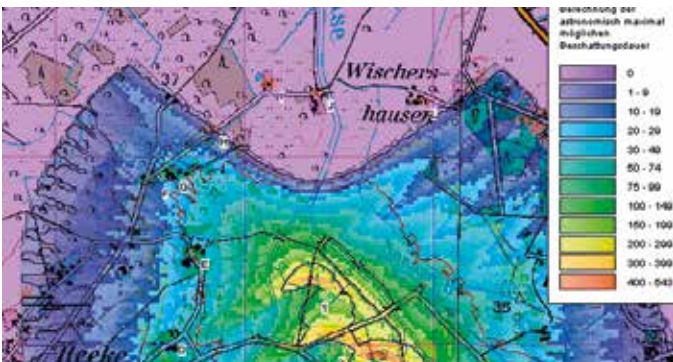
If one of these conditions does not match with the Type Certification, site specific assessment of the load assumptions and subsequent component load comparison is possible. Separated evaluation of turbulence can be done as part of structural integrity assessment, which is required in some countries for acquiring building permits. For complex or threshold situations, advanced CFD simulation can be performed.



Noise Immission Assessment

Noise immission can be critical for wind turbine run time and energy yield. TÜV NORD assessment serves to determine the most economical operational modes for wind farm projects. Impact of noise immission is calculated with established methods and tools while considering the following factors:

- Expanded noise sources e.g. industrial area
- Immission locations with directional effects
- Acoustic background noises such as freeways



Shadow Flicker Assessment

Shadow flicker can also be a limiting factor during the planning of a wind farm project. Our shadow flicker assessment helps to reach the most optimal wind farm design in compliance with legal licensing standards.

Environmental Impact Studies

The environmental impact of wind turbines is one of the main aspects in the planning stage of wind farms. Impact of wind farms on birds, bats, water pollution as well as impact of offshore wind farms on marine flora and fauna can be determined by our environmental experts. We also assist our customers in the application process for permits according to the Federal Immission Control Act (BImSchG) in Germany.



Risk Assessment

Risk assessment is necessary for safe operation of wind turbines located close to populated areas due to potential hazards. Hazard risks are present near e.g. traffic infrastructure, chemical plants, industrial areas, pipelines, power lines or dikes. Potential hazards are shedding of ice fragments, blade fracture, fire, tower structural failure, etc. Minimum distances to overhead power lines can also be examined due to damage-relevant turbine's wake in accordance with mandatory standards.

TÜV NORD risk assessments are aimed at construction permission procedure and contain:

- Hazard identification
- Risk analysis and illustration
- Risk assessment
- Concepts for risk reduction



Geotechnical Investigation & Consultancy

A safe and economic foundation design is crucial for all construction projects including wind turbines. The reliability of all further structural components and service installations depend on a successful foundation design. Modern wind turbines with increasing hub heights and larger rotor diameters produce extremely high bearing loads and have stringent requirements for the subsoil conditions. Suitability should be carefully assessed by geotechnical experts to avoid expensive project risks such as damage to the foundation base or even turbine collapse due to unsuitable subsoil properties.



TÜV NORD geotechnical site investigations provide necessary data for optimized foundation design and confidence regarding site load bearing capacity. TÜV NORD site investigations and geotechnical reports conform to the requirements and regulations of Eurocode 7 or national standards, depending on customer needs. Safe and economic foundation designs for innovative foundation design methods such as floating or re-adjustable foundation bases even on critical locations (e.g. refilled quarries and coal mines) are possible.

Please contact us for further details.



TÜV NORD has long experience and references in the fields of site investigations and foundation design consultancy for wind farm projects. For the planning of wind farm projects, our experts offer site investigations worldwide. Among others, our main geotechnical services for investors, project developers and turbine manufacturers are:

- Geological desk studies
- Special types of drillings, borings and soundings
- Soilmechanical laboratory tests
- Geophysical investigation methods
- Structural safety calculations
- Quality and safety management
- Inspection of the excavation pits
- Geotechnical reports
- Plausibility check of geotechnical reports



Electrical components and systems often need to fulfill additional requirements to those covered by the chosen certification standard. Diverse legislative regulations and stipulations by end users concerning electrical safety, reliability and grid connection usually need to be verified prior to getting the turbines connected.

TÜV NORD as one-stop-shop supports you with advice, evaluation, inspection and certification for:

- Components inside the turbine such as generator, converter, pitch system including emergency power supply e.g. by batteries, etc.
- Components outside the turbine such as transformer station, switch gear installation, electrical connection lines, etc.
- Lightning protection and earthing systems of wind turbines, transformer stations, etc.
- Condition monitoring systems (CMS)

In this context TÜV NORD offers a wide field of services like:

- Verification of the component design according to technical standards, specifications, extreme environmental conditions, etc.
- Evaluation of manufacturer documentation of the electrical components
- Prototype confirmation of wind turbines
- Quality assurance during manufacturing process e.g. by manufacturing evaluations
- Commissioning of wind turbines (on- and offshore)



Electrical Safety of Components

When electrical products are put into operation in the European Union, directives regarding electrical safety are to be fulfilled. Declarations of conformity drawn up by manufacturers' responsibility are required. To ensure correctness and a smooth process, preliminary assessment by TÜV NORD experts is recommended – in particular for imports from countries outside the EU.

New Services Under Continuous Development

With growing challenges TÜV NORD is developing its services to new customer needs. Secure energy and data supply for wind turbines and production facilities, energy storage and energy efficiency management are only some of the additional fields we are active in. Please contact us if there is more we can do for you.

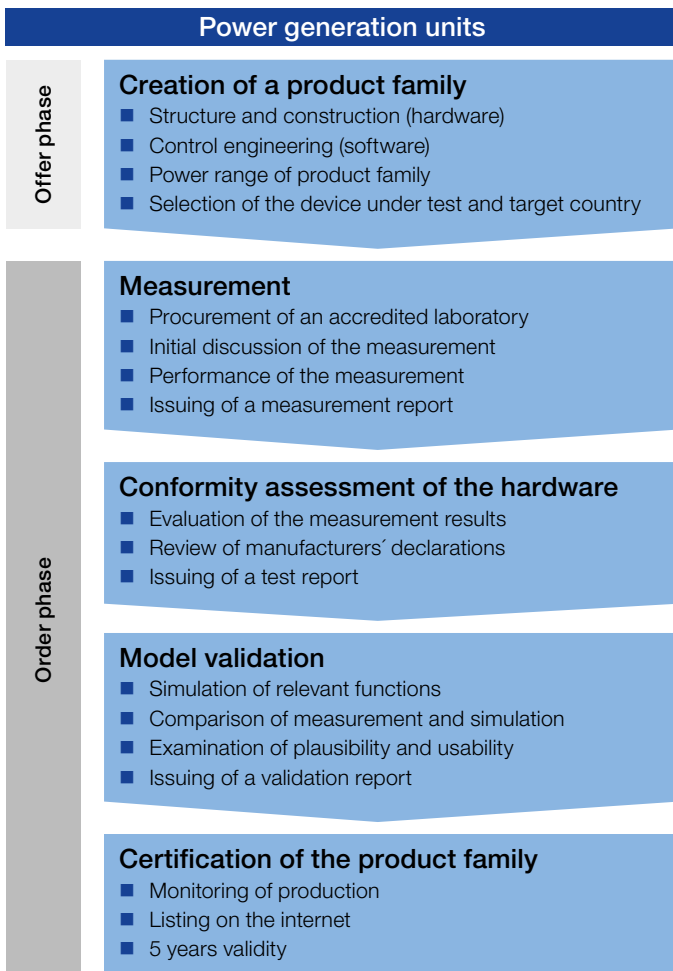


Grid Connection

Grid Code Compliance

When connecting wind energy generation systems (wind farms) to a low-, medium- or high-voltage grid, evidence of electrical characteristics has to be provided. Wind farms must contribute to grid stability by delivering system services. The evidence can or must be provided by means of certification, depending on the voltage level. In the first step, this certification covers the generation unit and in the following step covers the generation plant itself. This means that certification of grid code compliance is directed towards generation unit manufacturers and their sales operations (unit certification) and also to investors, planners, erectors and installers of generation plants (system certification).

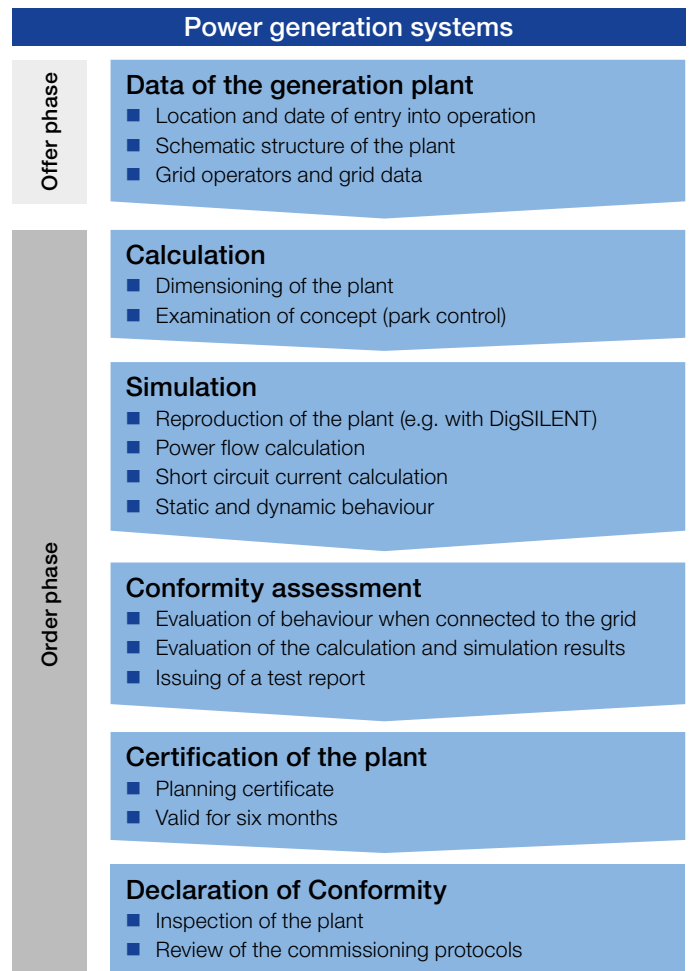
Certification Procedure



Examined Requirements

The requirements for generation units and plants are aimed at grid behavior during normal operation, cases of grid disturbance and also on systems services. Based on measurements, computer simulation as well as manufacturers' documentation, e.g. the following aspects are assessed:

- Active and reactive power output behavior
- System perturbation (harmonics, flicker)
- Dynamic grid support during failures (low and high voltage ride through)
- Protective devices and protection concept
- Dimensioning of the operating equipment within the plant



TÜV NORD in Wind Energy



With global presence and local offices in more than 70 countries worldwide, TÜV NORD serves the wind industry with state-of-the-art and customized product portfolios. Please contact our head office in Germany or one of our international offices for further information or inquiry.

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