GL Renewables Certification

Certification and Standards for Wind Turbines

September 2013, Kimon Argyriadis

www.gl-group.com

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Who we are

GL Group - Business Segments

oil & gas

GL Noble Denton

- Technical Assurance
- Advanced Engineering Consulting
- Asset Performance & Maintenance
- Marine Operations & Consulting
- Project Execution
- Software Products

GL Noble Denton is a world class technical service provider for the oil and gas industry

maritime services

Germanischer Lloyd

- Ship Newbuilding
- Maritime Systems & Components
- Fleet Service
- Maritime Solutions

Germanischer Lloyd is dedicated to ensuring the safety of life and property at sea, and the prevention of pollution of the marine environment

renewables

GL Garrad Hassan

- Engineering Consulting
- Marine Operations
- Measurements
- Software Products
- Training

GL Renewables Certification

- Component Certification
- Type Certification
- Project Certification
- Training & Seminars
- Guidelines

GL GH is recognised worldwide as a provider of services at all stages of onshore and offshore wind projects.

GL RC, is a leading certification body primarily focussed on the certification of wind farms, wind turbines and their components.

GL's History in Wind Energy (1)

- 1977
  - First activities in Wind Energy
- 1980
  - Examination GROWIAN and Small Turbines
- 1984
  - Testfield Pellworm / Kaiser-Wilhelm-Koog
  - R&D-Project for Load Calculation, Measurements and Guidelines
- 1986
  - 1st Guideline
  - Project for Test of Small Wind Turbines
- 1993
  - Regulations for the Certification of Wind Energy Conversion Systems

GL‘s History in Wind Energy (2)

- 1994
  - European Offshore Study
- 1995
  - First Guideline for the Certification of Offshore Wind Turbines
- 1999
  - Regulations for the Certification of Wind Energy Conversion Systems
- 2003
  - Guideline for the Certification of Wind Turbines (Supplemented 2004)
- 2005
  - Guideline for the Certification of Offshore Wind Turbines
- 2007
  - Partnership with Helimax

GL‘s History in Wind Energy (3)

- 2008
  - Three Practices:
    - Certification,
    - Turbine Measurements and
    - Consulting & Engineering
- 2009
  - New Business Segment: Renewables
  - Competence Centres:
    - Renewables Certification,
    - Renewables Turbine Measurements and
    - Renewables Consulting & Engineering
  - Merger with Garrad Hassan
- 2010
  - Guideline for the Certification of Wind Turbines edition 2010

GL's History in Wind Energy (4)

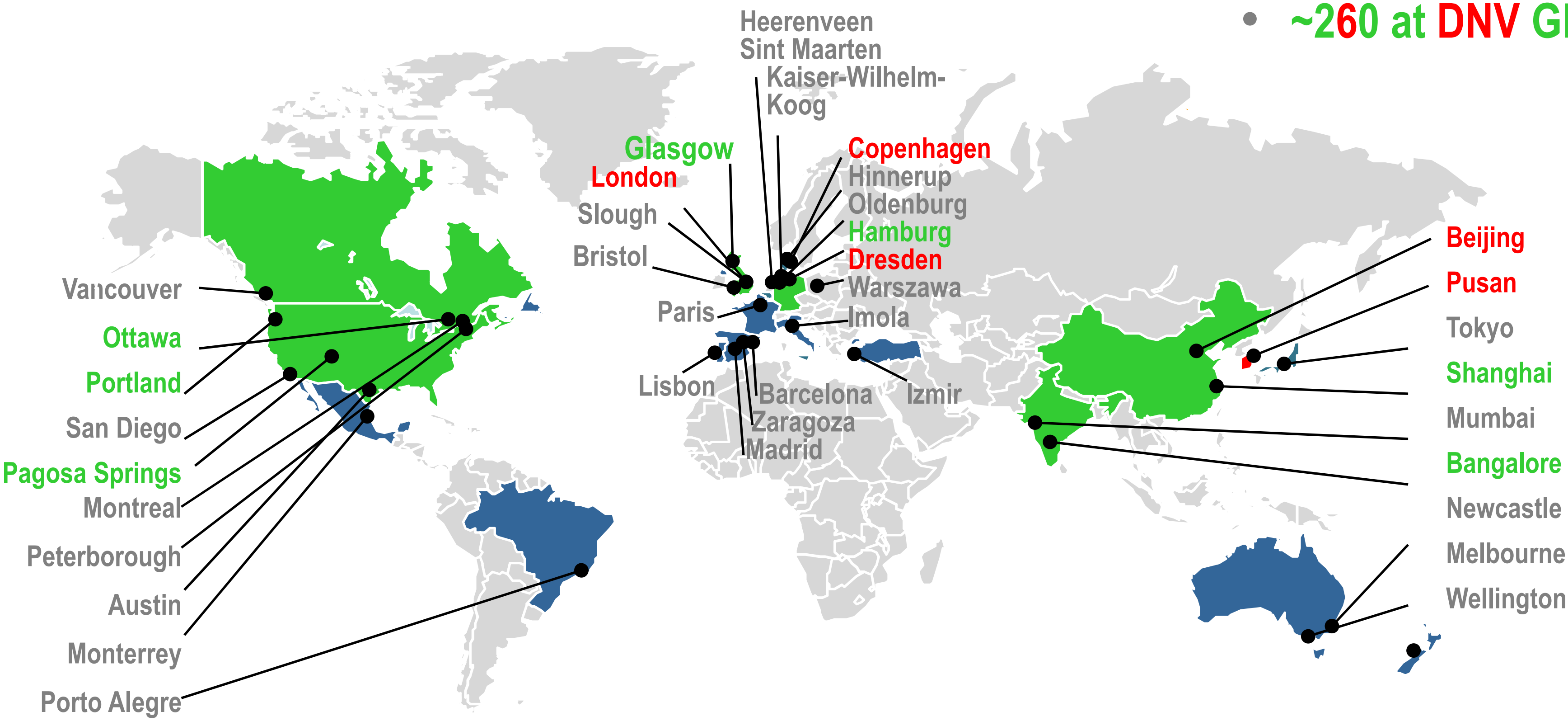
- 2011
  - Chinese Edition of Guideline for Wind Turbines
  - Kick-off for 3rd edition of „Guideline for the Certification of Offshore Wind Turbines“
- 2012
  - Publication of the new Guideline for the Certification of Offshore Wind Turbines
- 2013
  - Technical Note on Training Systems
  - New edition of CMS-Guideline
  - …

Our strategic answer: Joining forces

DNV	DNV GL Group	GL
▪ Founded 1864	▪ To be formed in 2013	▪ Founded 1867
▪ Høvik, Norway	▪ Head office in Høvik	▪ Hamburg
▪ 10,400 employees	▪ 17,100 employees	▪ 6,700 employees
Dedicated competences in:	A leading company in:	Dedicated competences in:
▪ Tankers	▪ Classification	▪ Container ships
▪ Offshore Classification	▪ Oil & Gas	▪ Energy efficiency
▪ Power & Transmission	▪ Energy	▪ Marine operations
▪ System certification	▪ Business Assurance	▪ Renewables

Our Geographical Reach – Experts in DNV GL Renewables Certification

- ~900 staff
- ~40 locations
- ~20 countries
- ~260 at DNV GL RC



Certification
What is it?

What is it? – Certification *Wikipedia*

- **Certification** refers to the confirmation of certain characteristics of an object, person, or organization. This confirmation is often, but not always, provided by some form of external review, education, assessment, or audit
  - Professional, where a person is certified
  - Product, if a product meets minimum standards
  - Accreditation is a specific organization's process of certification

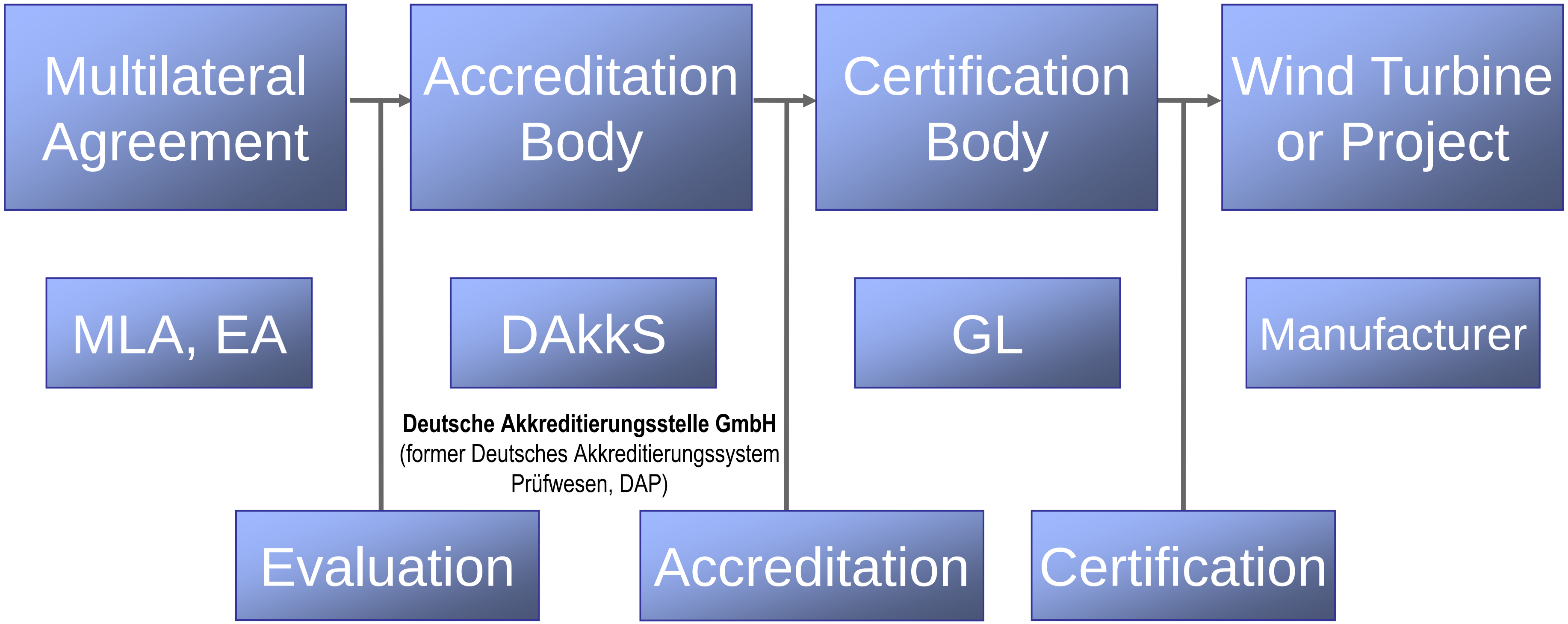
What is it? - Certification *ISO / IEC 17000*

- **Certification**
  - third-party attestation related to products, processes, systems or persons
- **Attestation**
  - issue of a statement, based on a decision following the review, that fulfilment of specified requirements has been demonstrated
- **Review**
  - verification of the suitability, adequacy and effectiveness…
- **in short:**
  confirmation for compliance of a product or a service with defined requirements

1st, 2nd and 3rd party conformity assessment

- **First-party conformity assessment activity**
  - conformity assessment activity that is performed by the person or organization that **provides** the object
- **Second-party conformity assessment activity**
  - conformity assessment activity that is performed by a person or organization that has a **user interest** in the object
- **Third-party conformity assessment activity**
  - conformity assessment activity that is performed by a person or body that is **independent** of the person or organization that provides the object and of user interests in that object
- Wikipedia: Third-party certification involves an independent assessment declaring that specified requirements pertaining to a product, person, process or management system have been met

Evaluation, Accreditation, Certification...



Normative environment

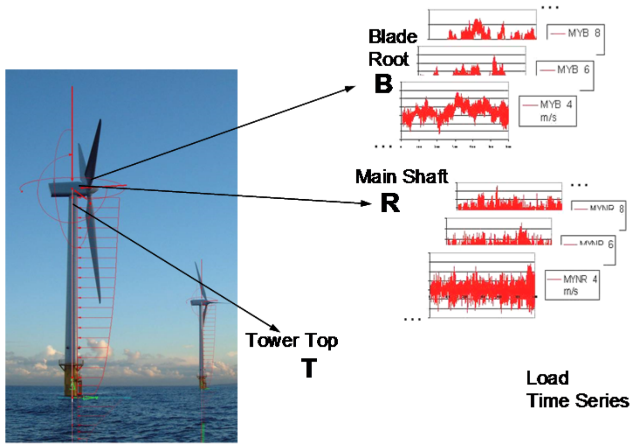
- Accreditation bodies operate according to ISO/IEC 17011. Accredited entities in specific sectors must provide evidence to the accreditation body that they conform to other standards in the same series:
- ISO/IEC 17020: "General criteria for the operation of various types of bodies performing inspection" (2004)
- ISO/IEC 17021: "Conformity assessment. Requirements for bodies providing audit and certification of management systems" (2011)
- ISO/IEC 17024: "Conformity Assessment. General requirements for bodies operating certification of persons" (2003)
- ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories" (2005)

Definition of Certification

Certification is to confirm the compliance of a design or a product (or a service) with defined requirements.

(DIN EN ISO/IEC 17000)

GL RC is accredited to certify according to all common standards in the wind and marine industry (GL, DNV, IEC, BSH, etc.)



Standards in Wind Energy (History)


australianclimatemadness.com


California - wattsupwiththat.com


Palm
Springs
Windmills
Damaged in
High Winds
gogov.com


Burnfield Complete Ardossan
Windfarm Turbine Demolition |
Glasgow ...
burnfielddemolition.co.uk
McNALLY'S
325D


www.windaction.org | Fenner wind turbine collapse

Safety is the basis for success

- Renewable energy devices had technical problems impact on survivability and availability
- GROWIAN, ...

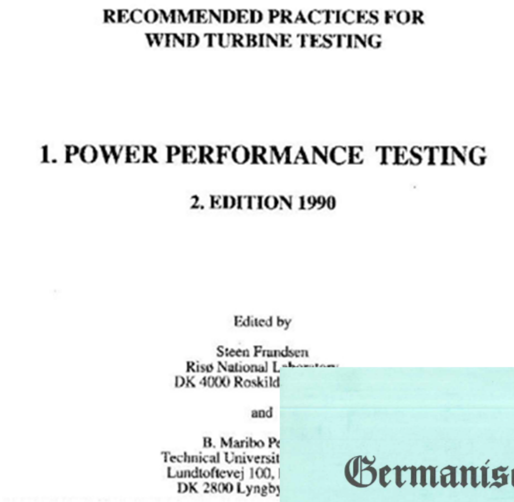
→ **Certification**

- Independent technical evaluation/surveillance. Risk reduction during design/realisation
- Better attention and quality in the production

- Compliance with requirements to ease international acceptance

→ **Standardisation**

Guideline & Standard Development ...


RECOMMENDED PRACTICES FOR
WIND TURBINE TESTING

1. POWER PERFORMANCE TESTING

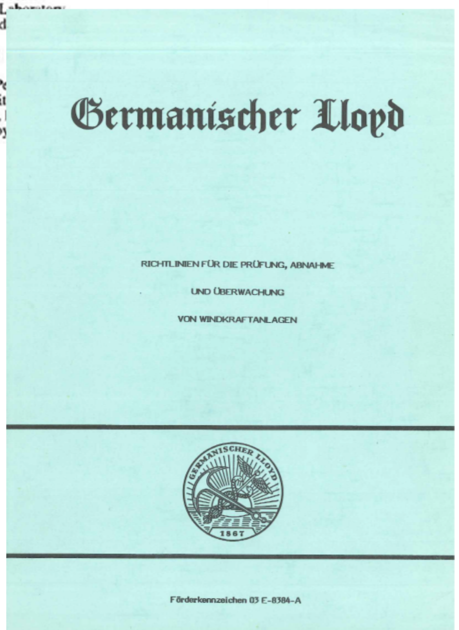
2. EDITION 1990

Edited by

Steen Frandsen
Risø National L
DK 4000 Roskild

and

B. Maribo P
Technical Universit
Lundtoftevej 100,
DK 2800 Lyngby


Germanischer Lloyd

RICHTLINIEN FÜR DIE PRÜFUNG, ABNAHME
UND ÜBERWACHUNG
VON WINDKRAFTANLAGEN

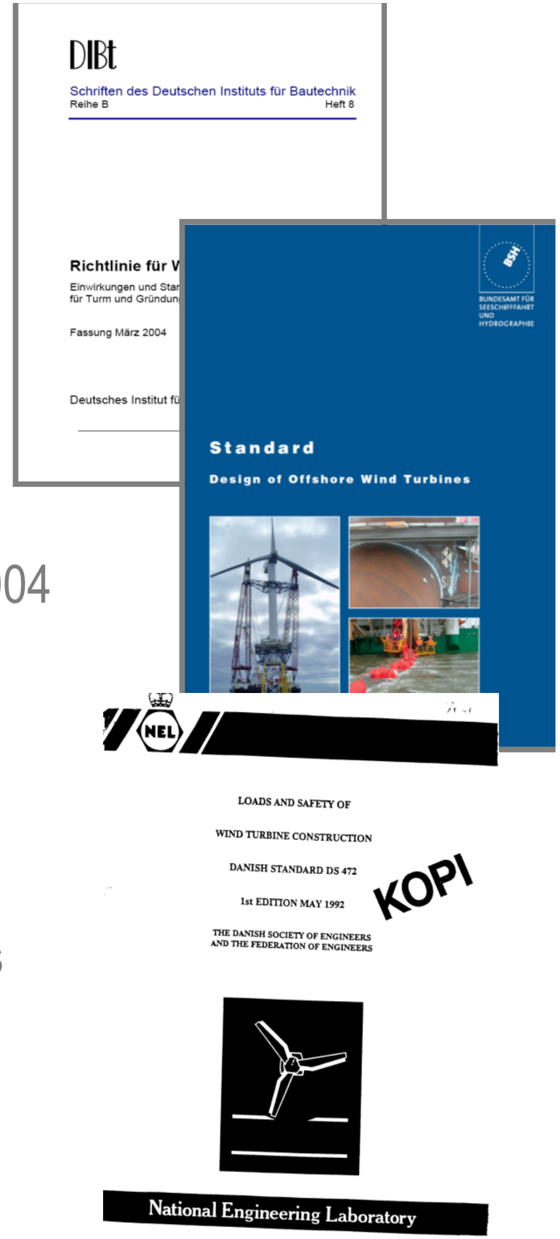
1867

Förderkennzeichen 03 E-8384-A

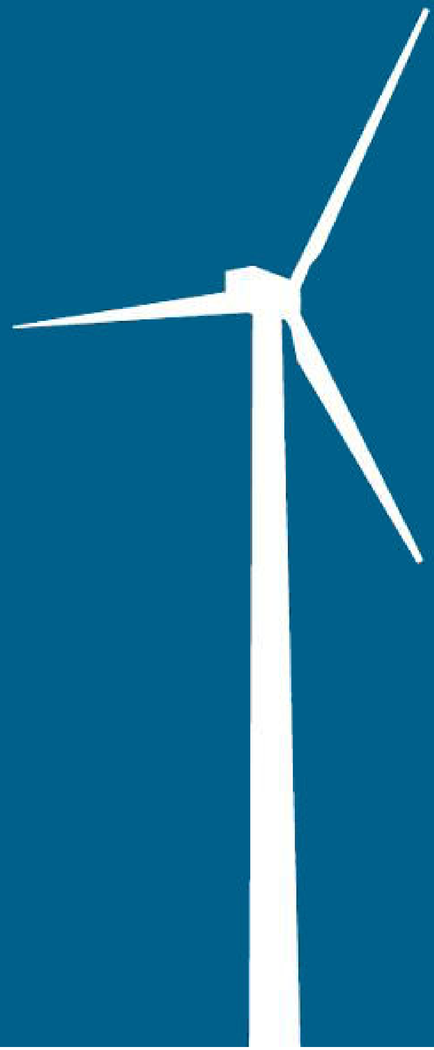
- First efforts in the late 70's (Denmark, Schleswig Holstein)
- IEA Recommended practices http://www.ieawind.org/Task_11/recomend_pract.html
- Focus on power performance, measurements, load analysis, safety system
- First GL Guideline in 1986
- European wind turbine design standard, (test centres for wind energy, ECWETS) in 1988 EWTS 1 (1996) & EWTS 2 (1999),

Guideline & Standard Development

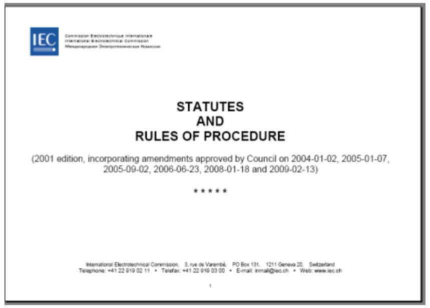
- National Requirements in
  Germany- DIBt,
  Denmark - DS472
  The Netherlands - NEN6096
- Offshore requirements, Denmark 2001, Germany BSH 2004
- IEC Standardisation within TC 88
  (first standard IEC 1400-1 in 1994)
- Use of Oil & Gas industry standards in offshore
- Two main streams in development: IEC & GL
- DNV develop standards for blades and support structures
- New entrants develop certification rules based on IEC standards (ABS, BV, LR)



Certification Schemes



Certification


STATUTES
AND
RULES OF PROCEDURE

(2001 edition, incorporating amendments approved by Council on 2004-01-02, 2005-01-07, 2005-09-02, 2006-06-23, 2008-01-18 and 2009-02-13)

* * * * *

- Certification system:
  - defines certification bodies and their procedures,
    certification schemes to be applied
  - accreditation, mutual recognition, application procedure, certificates
- Certification scheme:
  - defines scope for certification,
    scope assessment and standards or guidelines to be considered
  - defines what is Type-, Project Certification, A-DA,..., IPE, GCC,...
  - at GL-IV-1 Chapter 1, GL-IV-2 Chapter 1, IEC 61400-22, DNV OSS-901
- Standards and Guidelines
  - define requirements to be fulfilled
  - GL-IV-1&2 Chapters 2-14, IEC61400-xx, DNV J-101,…

Wind Turbine Certification Basics

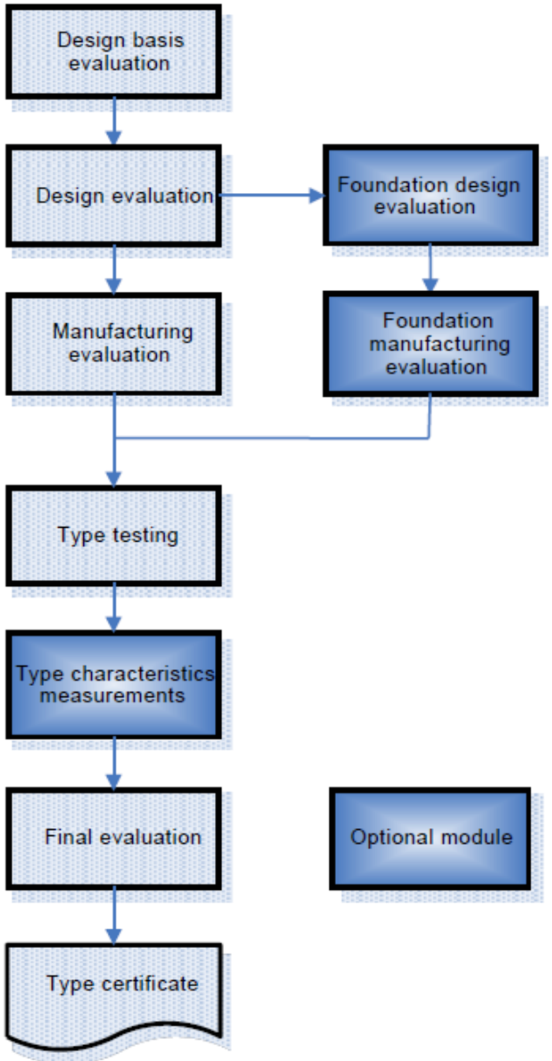
- **Safety of**
  - Human live
  - Environment
  - Structure

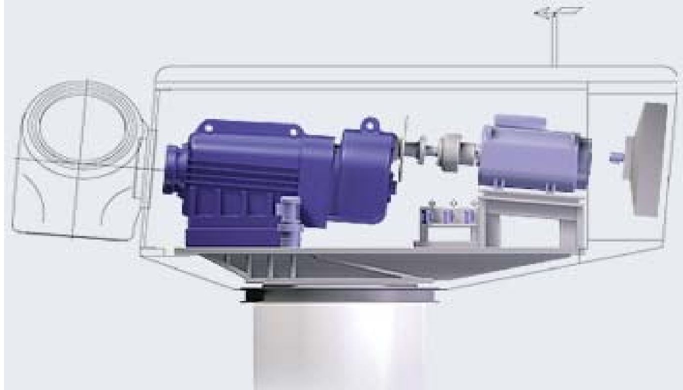
- Non-manned structures
- Safety level similar to non manned oil&gas industry structures
- Systems are both site specific as well as serial products

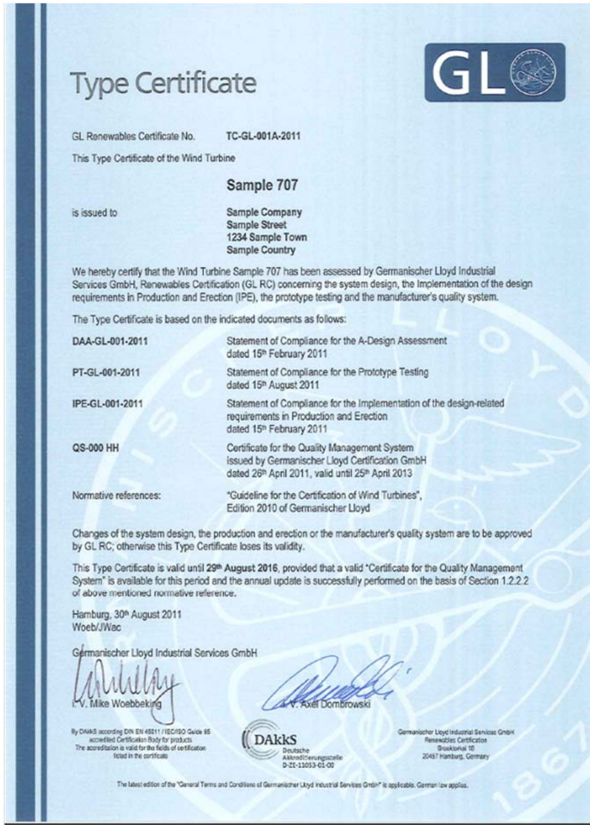
Support structure/cabling → Site specific → Project Certification

Machinery + → Serial product → Type Certification

IEC 61400-22 : Type Certification







Type Certificate

GL

GL Renewables Certificate No. TC-GL-001A-2011

This Type Certificate of the Wind Turbine

Sample 707

is issued to

Sample Company
Sample Street
1234 Sample Town
Sample Country

We hereby certify that the Wind Turbine Sample 707 has been assessed by Germanischer Lloyd Industrial Services GmbH, Renewables Certification (GL RC) concerning the system design, the implementation of the design requirements in Production and Erection (IPE), the prototype testing and the manufacturer's quality system.

The Type Certificate is based on the indicated documents as follows:

DAA-GL-001-2011	Statement of Compliance for the A-Design Assessment dated 15th February 2011
PT-GL-001-2011	Statement of Compliance for the Prototype Testing dated 15th August 2011
IPE-GL-001-2011	Statement of Compliance for the Implementation of the design-related requirements in Production and Erection dated 15th February 2011
QS-000 HH	Certificate for the Quality Management System issued by Germanischer Lloyd Certification GmbH dated 26th April 2011, valid until 25th April 2013
Normative references:	"Guideline for the Certification of Wind Turbines", Edition 2010 of Germanischer Lloyd

Changes of the system design, the production and erection or the manufacturer's quality system are to be approved by GL RC; otherwise this Type Certificate loses its validity.

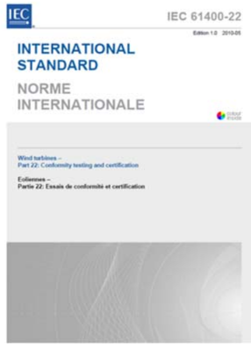
This Type Certificate is valid until 29th August 2016, provided that a valid "Certificate for the Quality Management System" is available for this period and the annual update is successfully performed on the basis of Section 1.2.2.2 of above mentioned normative reference.

Hamburg, 30th August 2011
Woeb/JWac

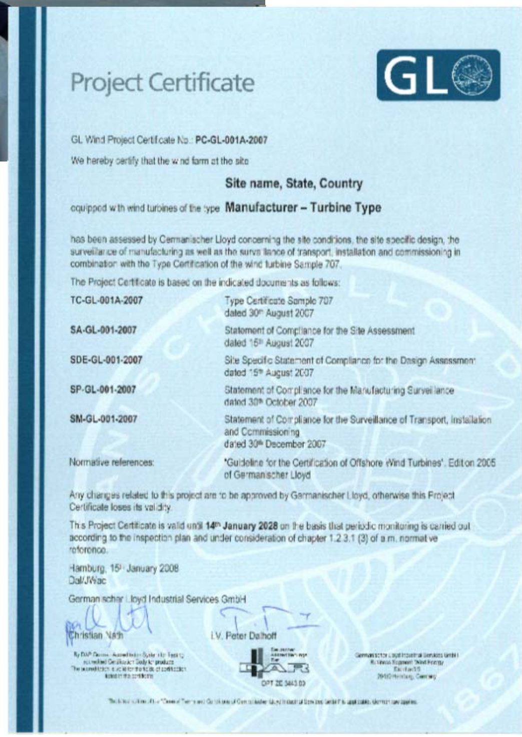
Germanischer Lloyd Industrial Services GmbH

V. Mike Woebbeking V. Axel Dombrowski

DAkkS



IEC 61400-22: Project Certification



Project Certificate

GL Wind Project Certificate No.: **PC-GL-001A-2007**

We hereby certify that the wind farm at the site

Site name, State, Country

equipped with wind turbines of the type **Manufacturer – Turbine Type**

has been assessed by Germanischer Lloyd concerning the site conditions, the site specific design, the surveillance of manufacturing as well as the surveillance of transport, installation and commissioning in combination with the Type Certification of the wind turbine Sample 707.

The Project Certificate is based on the indicated documents as follows:

TC-GL-001A-2007	Type Certificate Sample 707 dated 30th August 2007
SA-GL-001-2007	Statement of Compliance for the Site Assessment dated 15th August 2007
SDE-GL-001-2007	Site Specific Statement of Compliance for the Design Assessment dated 15th August 2007
SP-GL-001-2007	Statement of Compliance for the Manufacturing Surveillance dated 30th October 2007
SM-GL-001-2007	Statement of Compliance for the Surveillance of Transport, Installation and Commissioning dated 30th December 2007
Normative references:	'Guideline for the Certification of Offshore Wind Turbines', Edition 2005 of Germanischer Lloyd

Any changes related to this project are to be approved by Germanischer Lloyd, otherwise this Project Certificate loses its validity.

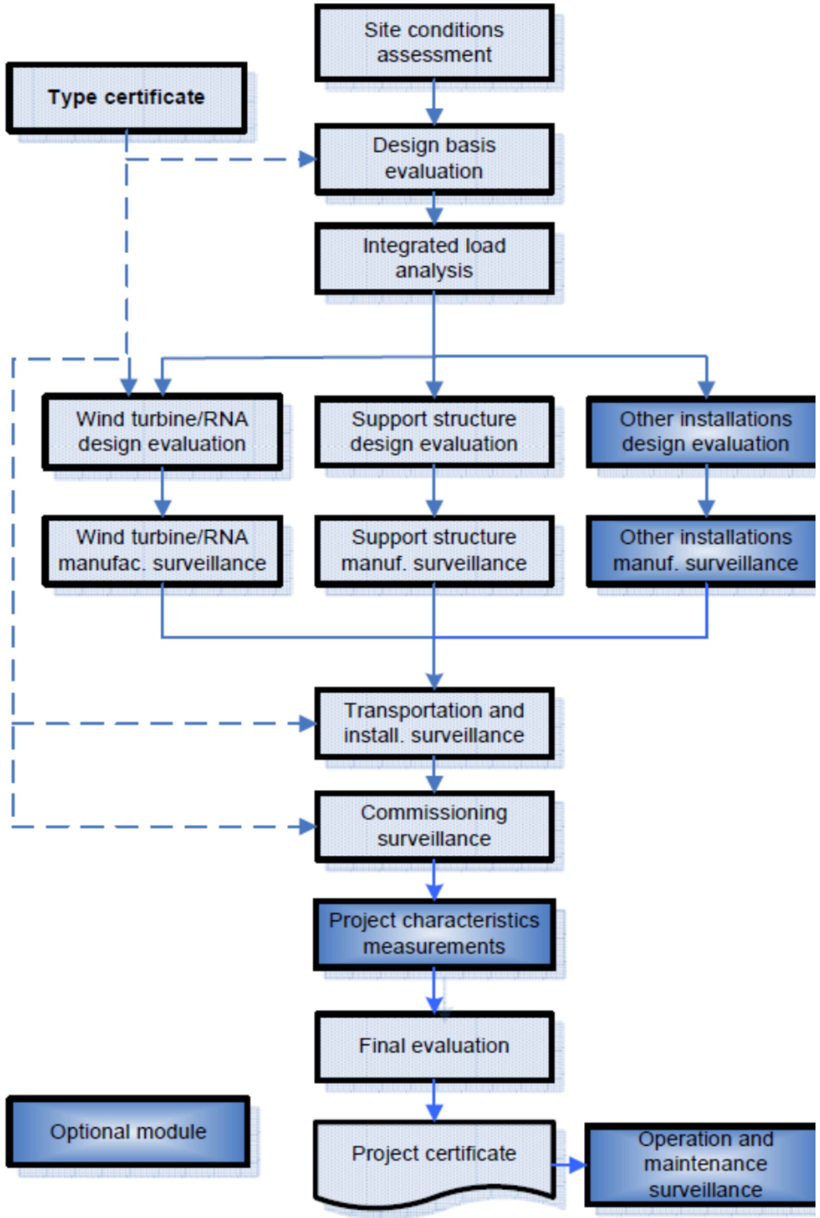
This Project Certificate is valid until **14th January 2028** on the basis that periodic monitoring is carried out according to the inspection plan and under consideration of chapter 1.2.3.1 (3) of a.m. normative reference.

Hamburg, 15th January 2008
Dal/JWac

Germanischer Lloyd Industrial Services GmbH

Christian Nath   i.V. Peter Dalhoff

DPT ZE 3443.03



Different Certification procedures

Service

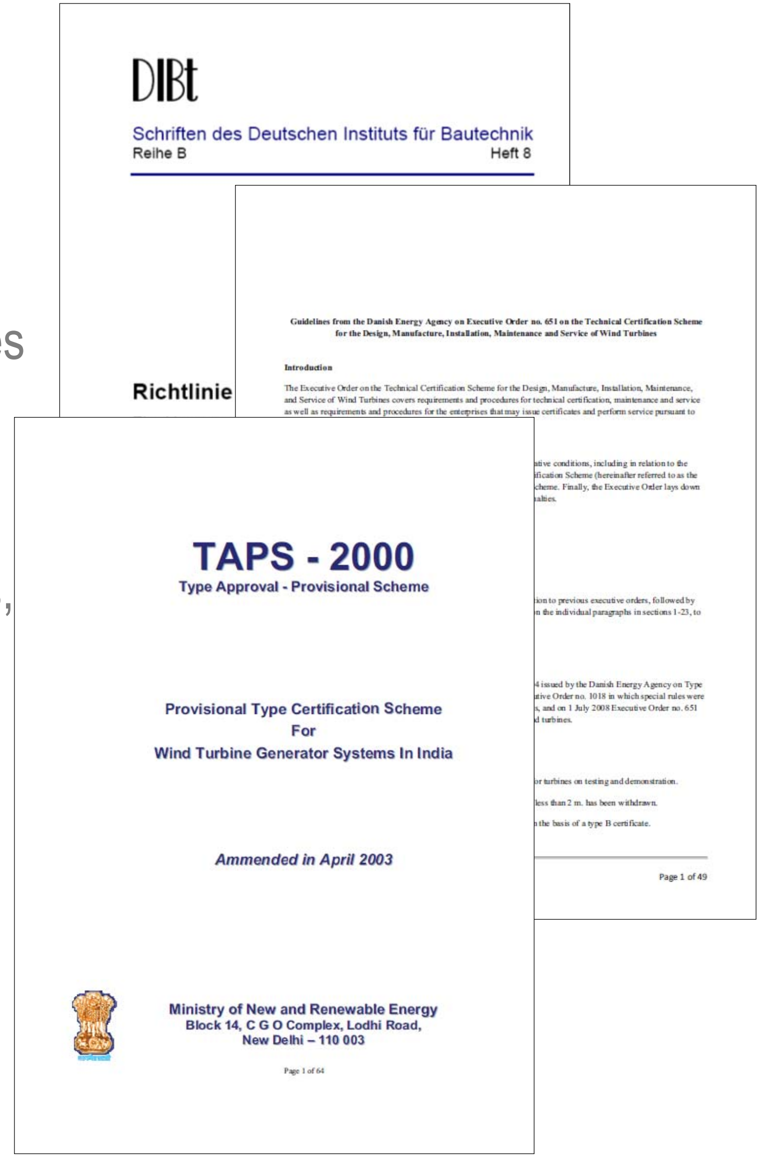
Item	GL	DNV	IEC	ABS	BV	LR
Type Certification onshore	✓	✓	✓			
Type Certification offshore	✓	(✓)	(✓)			
Project Certification onshore	✓		✓			
Project certification offshore	✓	✓	✓	✓	✓	✓

Document

Item	GL	DNV	IEC	ABS	BV	LR
Type Certification onshore	IV-1	DSS-904	IEC 61400-22			
Type Certification offshore	IV-2					
Project Certification onshore	IV-1		IEC 61400-22			
Project certification offshore	IV-2	OSS-901	IEC 61400-22	195/196	WFPC 100	Guidance

National Requirements

- Germany: DIBt-Guideline
  Richtlinie für Windenergieanlagen (Guidelines for Wind Turbines)
- Denmark: Executive order on the technical certification scheme for the design, manufacture and installation of wind turbines, from the Danish Energy Authority ("Energistyrelsen") No. 651 dated 26.6.2008
- The Netherlands: Pre-Standard
  NVN 11400-0 Wind Turbines or
  IEC 61400-22 plus IEC 61400-1
- India: TAPS – 2000 Type Approval – Provisional Scheme
- …


DIBt

Schriften des Deutschen Instituts für Bautechnik

Reihe B Heft 8

Richtlinie

Guidelines from the Danish Energy Agency on Executive Order no. 651 on the Technical Certification Scheme for the Design, Manufacture, Installation, Maintenance and Service of Wind Turbines

Introduction

The Executive Order on the Technical Certification Scheme for the Design, Manufacture, Installation, Maintenance, and Service of Wind Turbines covers requirements and procedures for technical certification, maintenance and service as well as requirements and procedures for the enterprises that may issue certificates and perform service pursuant to

Page 1 of 49

TAPS - 2000

Type Approval - Provisional Scheme

Provisional Type Certification Scheme
For
Wind Turbine Generator Systems In India

Ammended in April 2003

Ministry of New and Renewable Energy
Block 14, C G O Complex, Lodhi Road,
New Delhi – 110 003

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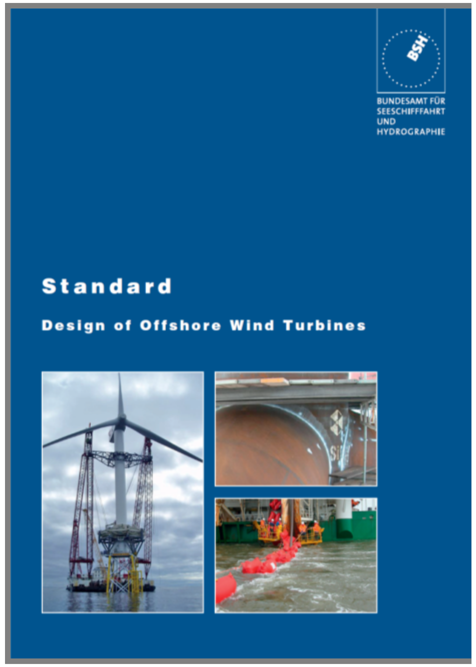
Requirements within BSH-release



- BSH Standard Konstruktive Ausführung von Offshore-WEA published by BSH in 2005
- A Type and a Project Certification are required.
  (But not defined!)
- BSH does not know IEC 61400-22
- References to DNV standards and GL Guidelines
- Certifications according to GL or DNV or IEC are accepted
- Additional requirements exist

- Standard is under review
- Additional standard for geotechnical investigation

Wind Turbine Certification

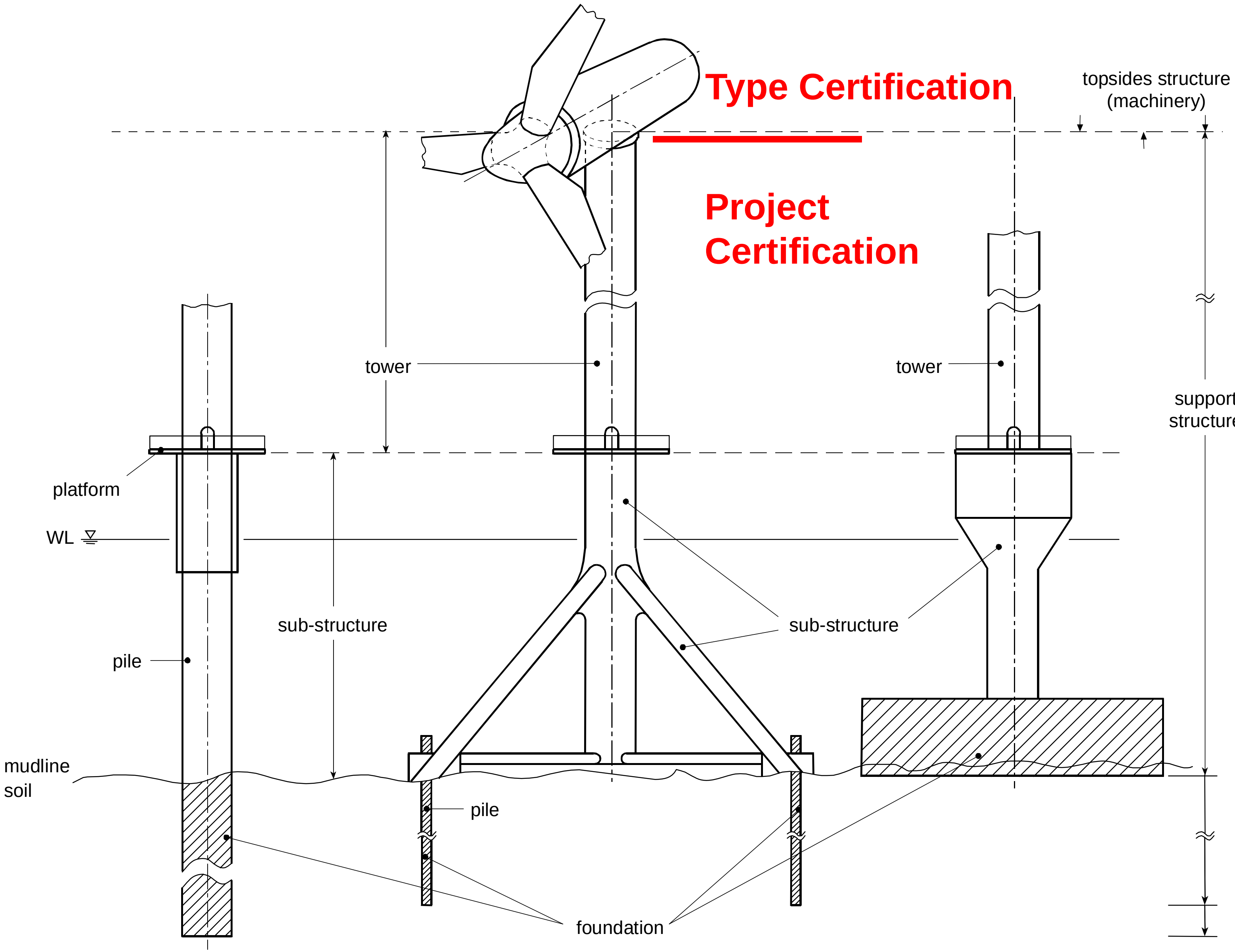
Wind Turbine Certification Basics

- **Safety of**
  - Human live
  - Environment
  - Structure

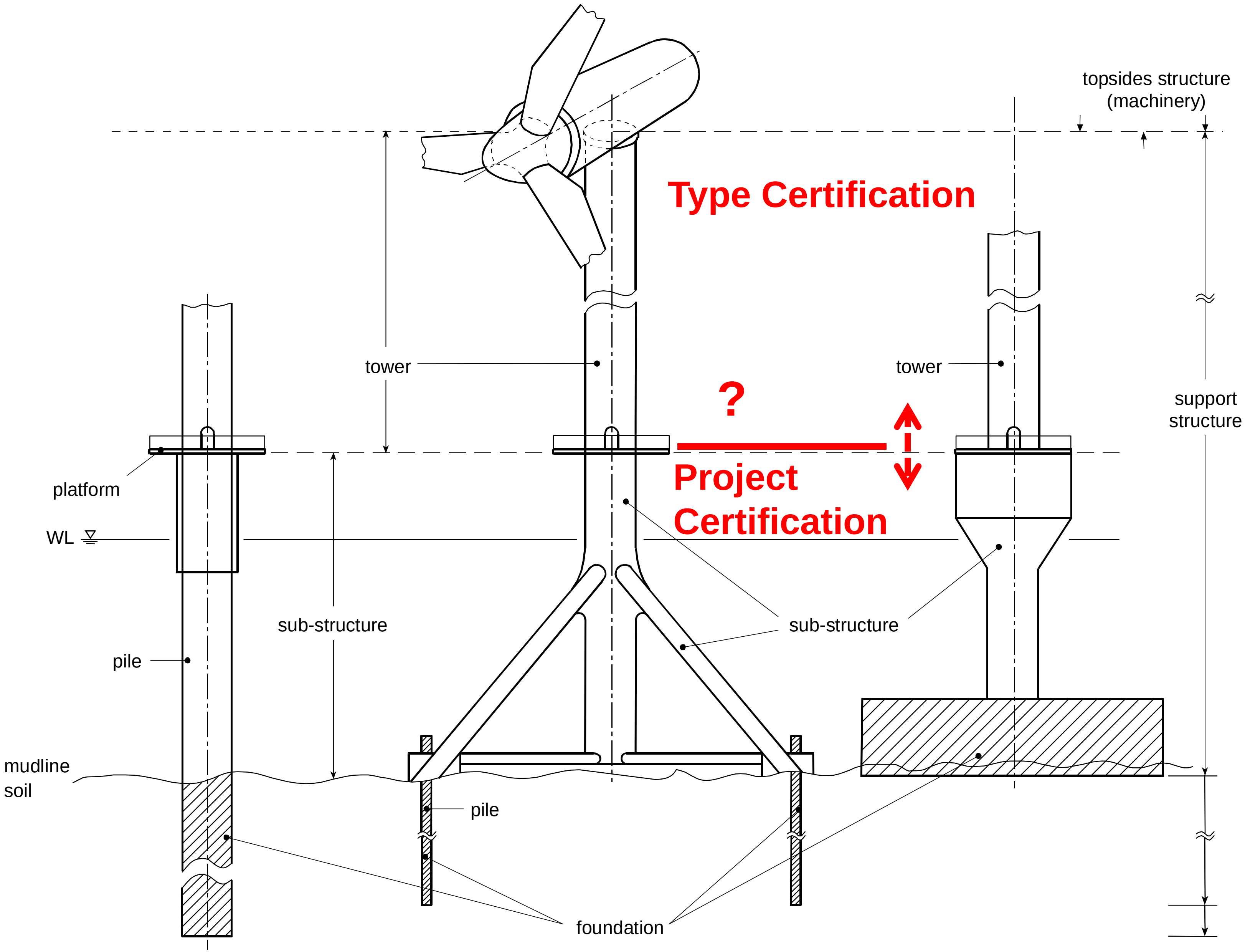
- Non-manned structures
- Safety level similar to non manned oil&gas industry structuress
- Systems are both site specific as well as serial products

Support structure/cabling → Site specific → Project Certification

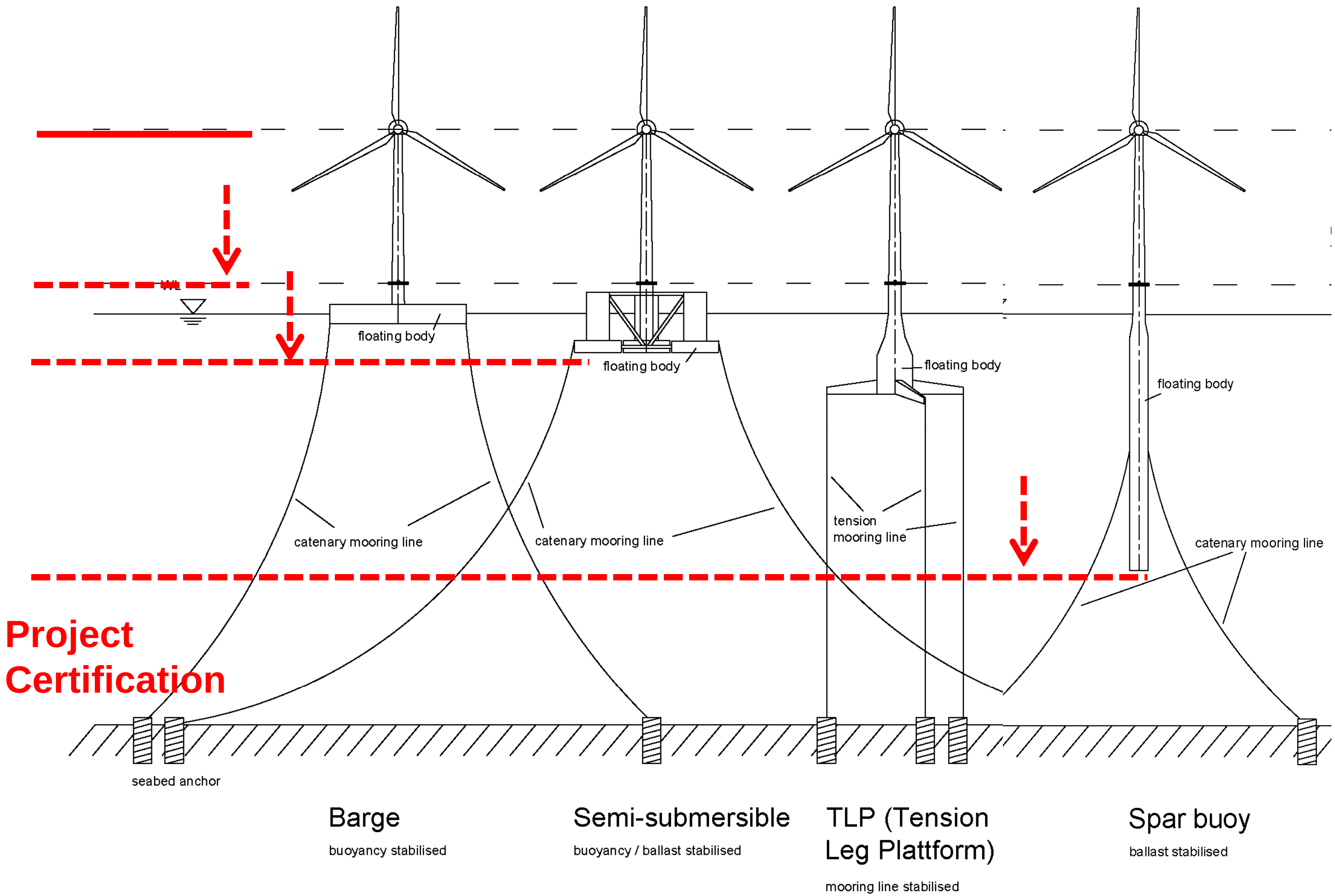
Machinery + → Serial product → Type Certification



Type Certification
topsides structure
(machinery)
Project
Certification
tower
tower
support
structure
platform
WL
sub-structure
sub-structure
pile
mudline
soil
pile
foundation


topsides structure
(machinery)
Type Certification
tower
tower
?
Project
Certification
support
structure
platform
WL
sub-structure
sub-structure
pile
mudline
soil
pile
foundation

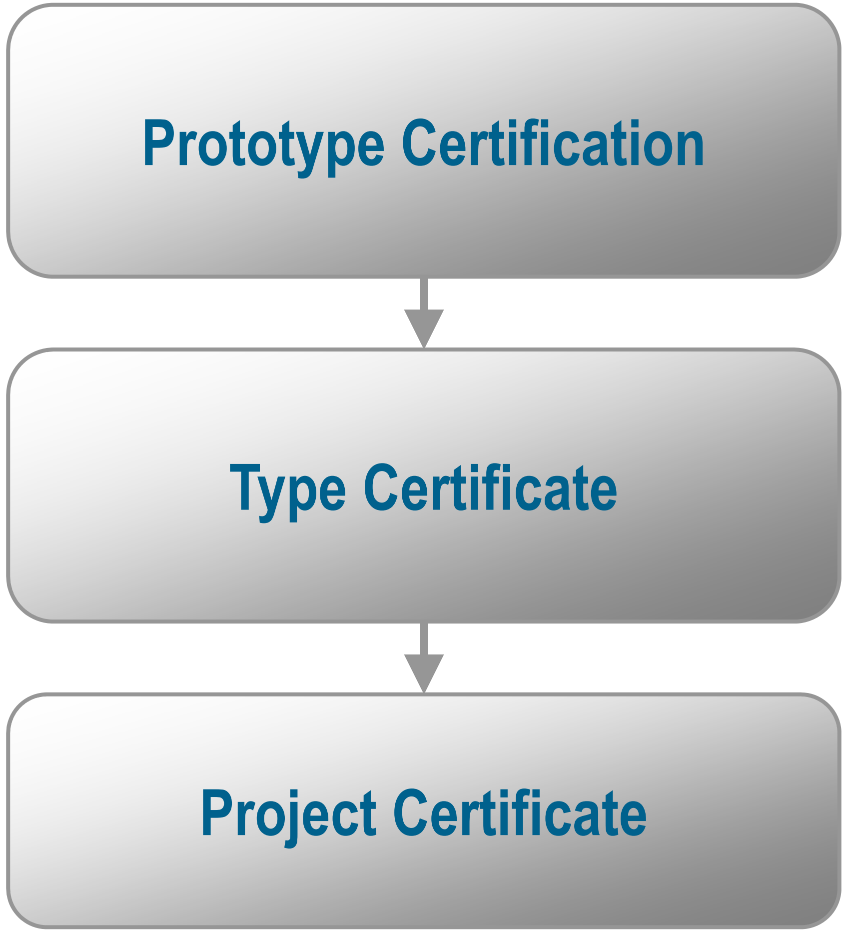
Type Certification



Principal Certification Steps

- Principal safety of the prototype
  Plausibility check
  Limited parallel analysis

- Assessment of the serial product
  Complete design assessment
  Prototype test results
  QM & Manufacture quality
  Implementation of design in manufacture
- Evaluation of the power plant for a dedicated installation site including review of site assessment



Certification Components

Design Assessment

Design Assessment and Certification of major components

- Plausibility of the design
- Examination of drawings, assumptions and analysis
  Examination of components (design and tests)

+

Practical Test

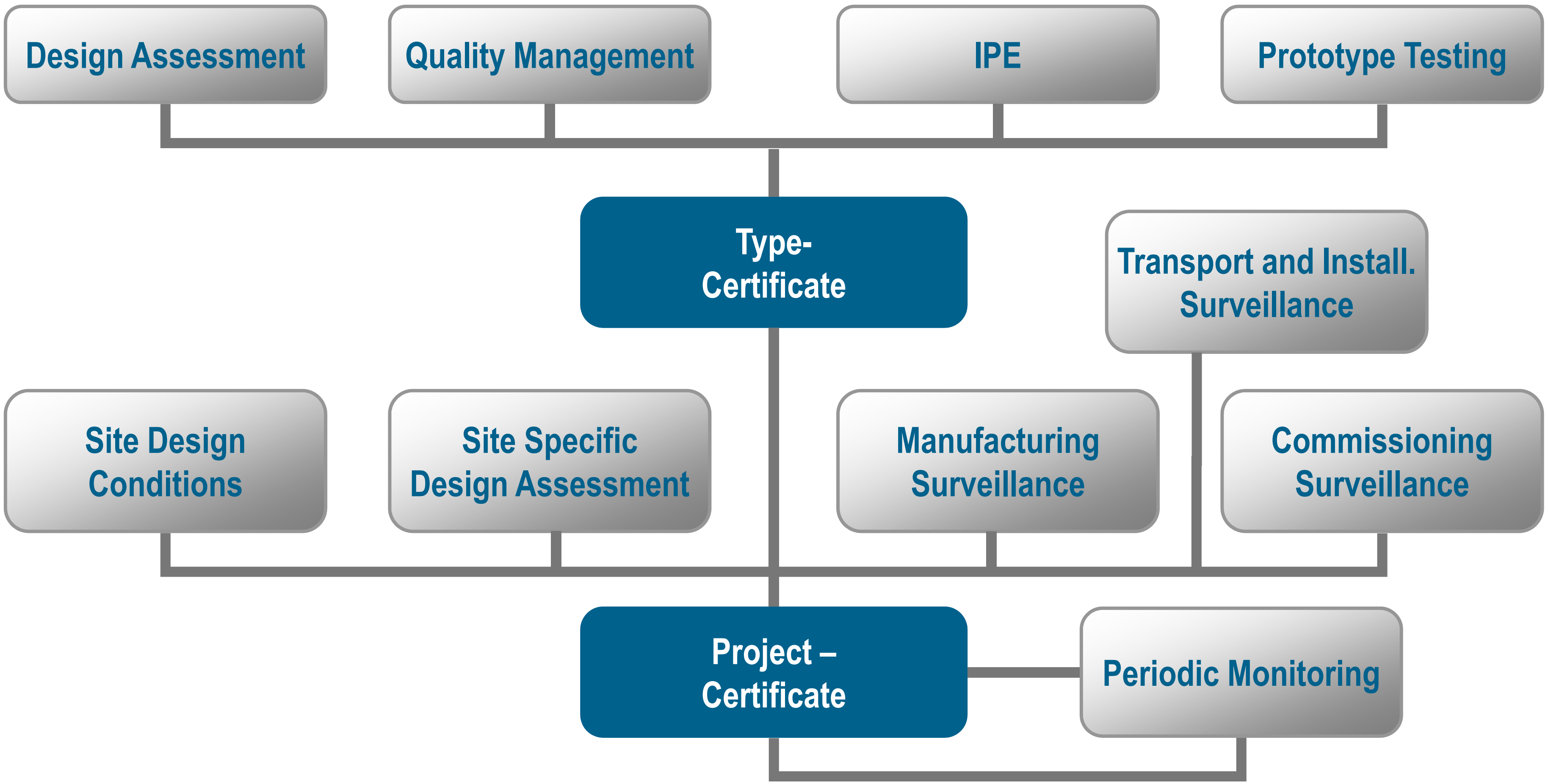
- Test of the device
- Comparison of test results with assumptions

+

Inspection & Quality Control

- Examination of fabrication quality
- Witnessing of installation

Type and Project Certification



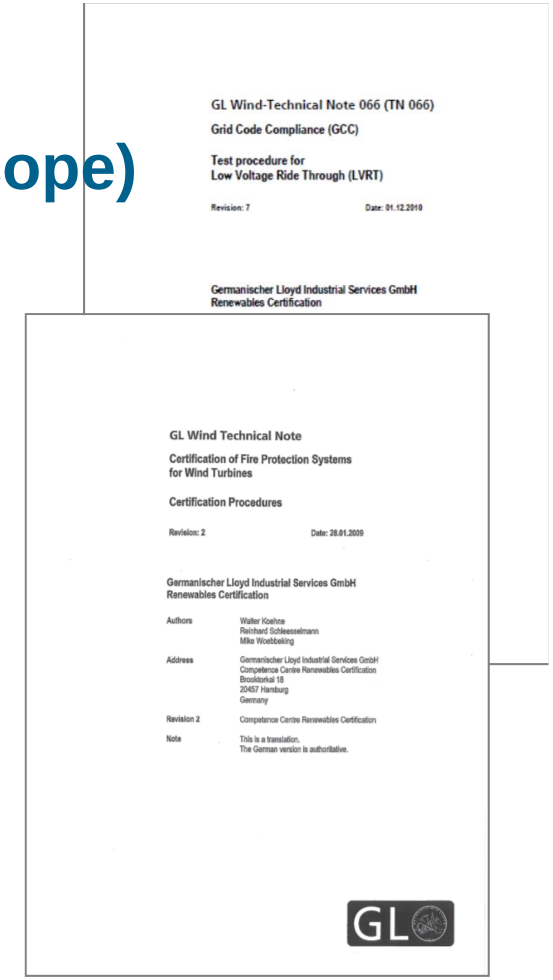
Standards Overview

Actual GL Guidelines in detail

- Guideline for the Certification of Wind Turbines, GL-IV-1, 2010
- Guideline for the Continued Operation of Wind Turbines, GL-IV-1-12, 2009
- Guideline for the Certification of Offshore Wind Turbines, GL-IV-2, 2012
- Guideline for the Certification of Condition Monitoring Systems for Wind Turbines, GL-IV-4, 2013
- Guideline for the Certification of Ocean Energy Converters, Edition 2005
- Richtlinie zur Erstellung von technischen Risikoanalysen für Offshore-Windparks, GL-IV-3, 2002

Actual GL Technical Notes in detail (Supplement to Guidelines to extend scope)

- TN for the Certification of Wind Turbines for Extreme Temperatures (here: Cold Climate), Edition 2011, Rev. 4
- GL TN 065 Grid Code Compliance (GCC) Certification procedure, Ed. 2010, Rev. 7
- GL TN 066 Grid Code Compliance (GCC) Test procedure for Low Voltage Ride Through (LVRT) , Ed. 2010, Rev. 7
- TN for Certification of Training Programs and Training Systems in the Renewable Energy Industry, Ed. 2013, Rev 2
- TN for the Certification of Fire Protection Systems for Wind Turbines, Edition 2008
- TN for the Certification of Service Providers in the Wind Energy Industry , Ed. 2009, Rev 6



GL Wind-Technical Note 066 (TN 066)

Grid Code Compliance (GCC)

Test procedure for
Low Voltage Ride Through (LVRT)

Revision: 7 Date: 01.12.2010

Germanischer Lloyd Industrial Services GmbH
Renewables Certification

GL Wind Technical Note

Certification of Fire Protection Systems
for Wind Turbines

Certification Procedures

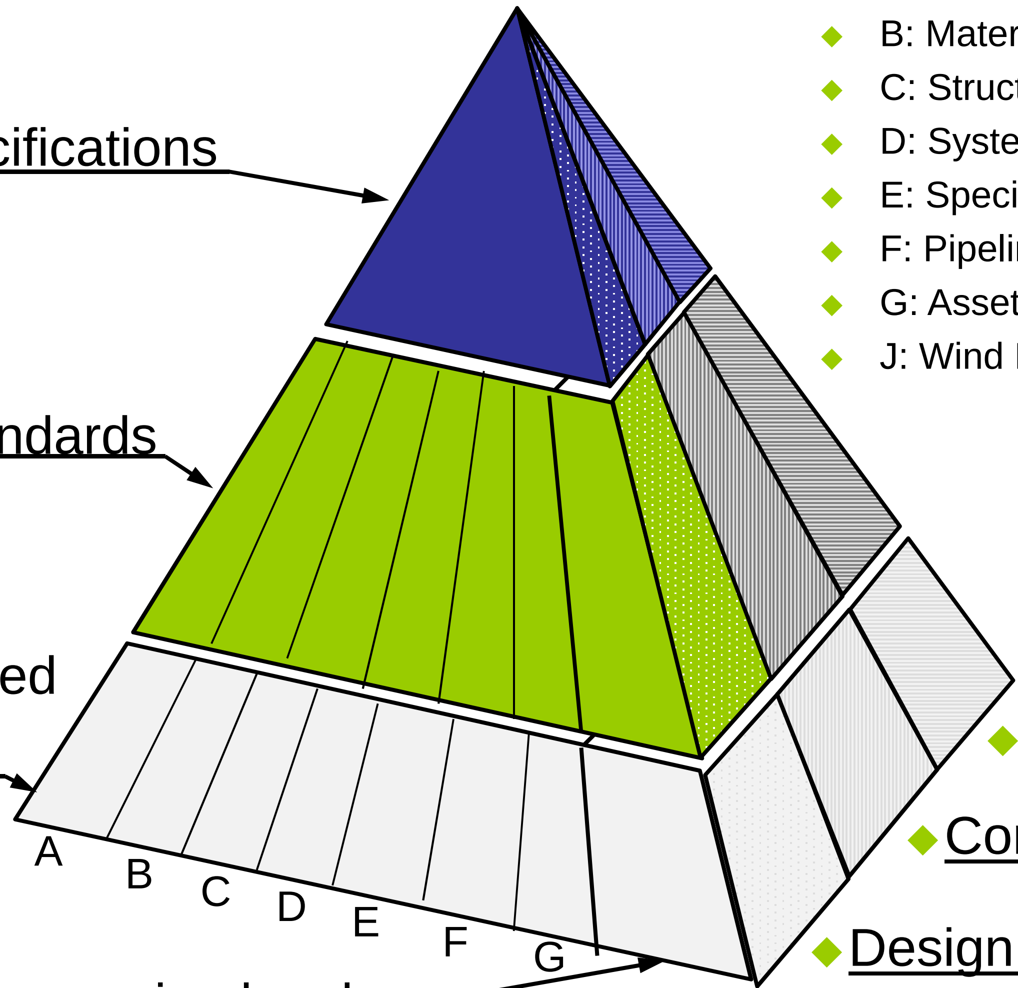
Revision: 2 Date: 28.01.2009

Germanischer Lloyd Industrial Services GmbH
Renewables Certification

Authors	Walter Koehne Reinhard Schleesselmann Mike Woebbeking
Address	Germanischer Lloyd Industrial Services GmbH Competence Centre Renewables Certification Brooktorkai 18 20457 Hamburg Germany
Revision 2	Competence Centre Renewables Certification
Note	This is a translation. The German version is authoritative.

DNV Offshore Standards

- A: Quality and Safety Methodology
- B: Materials Technology
- C: Structures
- D: Systems
- E: Special Facilities
- F: Pipelines and Risers
- G: Asset Operations
- J: Wind Energy



- Service Specifications
- Offshore Standards
- Recommended Practices
- Internationally recognised codes

- Operation
- Construction
- Design

DNV

- **Wind industry standards structure part of offshore standards**
- **DNV standards based on IEC procedure**
- **DNV-DSS-904**, Type Certification of Wind Turbines, Jan. 2012
- **DNV-OSS-901**, Project Certification of Offshore Wind Farms, June 2012

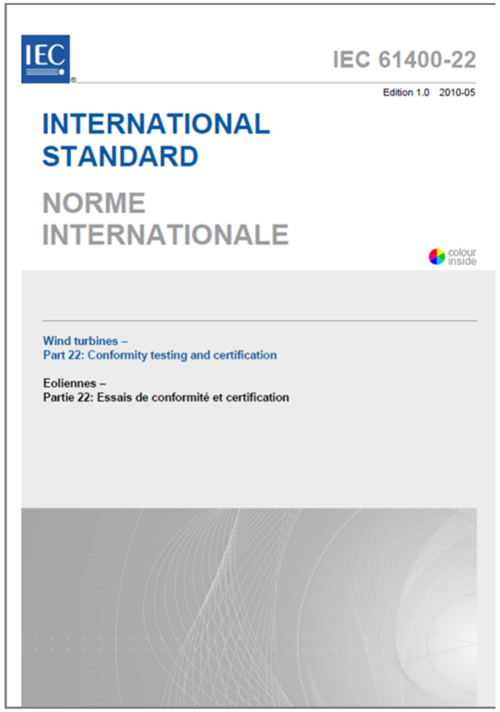
- DNV-OS-J101, Design of Offshore Wind Turbine Structures, Jan. 2013
- DNV-DS-J102, Design and Manufacture of Wind Turbine Blades, Offshore and Onshore, Oct. 2010
- DNV-OS-J103, Design of Floating Wind Turbine Structures, Jun. 2013
- **...**
- DNV-OS-J201, Offshore Substations for Wind Farms, Oct. 2009
- DNV-OS-J301, Standard for Classification of Wind Turbine Installation Units, Oct. 2010
- ...
- DNV-RP-F401, Electrical Power Cables in Subsea Applications, Feb. 2012

ABS - BV - LR

- **ABS**
  - Guideline for Building and Classing “(Bottom Founded) Offshore Wind Turbine Installations”, Dec. 2010, Reviewed Jan. 2013
  - Guideline for Building and Classing”Floating Offshore Wind Turbine Installations”, Jan. 2013
  - Class sign (like ships etc.), reference to IEC and API
  - Includes Cyclones on very simplified manner
- **BV**
  - Guide on Offshore Wind Farm Project Certification (Based on IEC 61400 Series) BV-WFPC 100, Dec. 2012
  - Description how to apply IEC 61400-22
  - Classification and Certification of Floating Offshore Wind Turbines, NI 572, DTR00 E, Nov. 2010
  - Very rough guidance, reference to offshore standards and IEC
- **LR**
  - “Guidance on offshore wind farm certification” , April 2012
  - Basis for certification are IEC 61400-22.
  - Based on IEC 61400-1, ISO 19901-1 and ISO 19901-4
  - Reference for floating to LR Floating offshore structure rules (FOIFL)

IEC TC 88, 61400 series

- **IEC 61400-22: Conformity Testing and Certification of Wind Turbines**
- IEC 61400-1: Design Requirements
- IEC 61400-2: Small Wind Turbines
- IEC 61400-3: Design Requirements for Offshore Wind Turbines
- *IEC TS 61400-3-2: Design Requirements for Floating Offshore Wind Turbines*
- IEC 61400-4: Gears for Wind Turbines
- *IEC 61400-5: Rotor Blades Wind Turbines*
- *IEC 61400-6: Tower and Foundations for Wind Turbines*
- IEC 61400-11: Acoustic Noise measurement Techniques
- IEC 61400-12-1: Power performance measurements
- IEC 61400-13: Measurements of mechanical loads
- IEC 61400-14: Declaration of sound power level and tonality
- IEC 61400-21: Measurement of power quality characteristics
- *IEC TR 61400-23: Full scale blade structural testing*
- *IEC TR 61400-24: Lightning protection*
- *IEC 61400-25(-1-6): Communication*
- *IEC TS 61400-26: Availability*
- *IEC 61400-27: Electrical simulation models*


IEC 61400-22

Edition 1.0 2010-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Wind turbines –
Part 22: Conformity testing and certification

Eoliennes –
Partie 22: Essais de conformité et certification

IEC Standards Development

Standardisation

- **I**nternational **O**rganization for **S**tandardization (ISO)
- **I**nternational **E**lectrotechnical **C**ommission (IEC)
  - global organization
  - standards for all electrical, electronic and related technologies
  - basis for national standardization
  - references when drafting international tenders and contracts
- European Committee for Electrotech. Standardization
  Comité **E**uropéen de **N**ormalisation **Elec**trotechnique
- National Standardization Organizations

IEC Standards

- Standardisation body: IEC, ISO, Cenelec
- IEC: international Electrotechnical Committee (www. iec.ch)
- Steering committee: TC 88, USA chair, NL secretary
- 24 participating countries

IEC
Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

Objectives of IEC

- meet the **requirements** of the **global market** efficiently
- ensure primacy and maximum **world-wide use** of its standards and conformity assessment schemes
- assess and **improve** the **quality of products** and services covered by its standards
- establish the **conditions** for the interoperability of **complex systems**
- **increase** the **efficiency** of industrial processes
- contribute to the improvement of **human health** and **safety**
- contribute to the **protection** of the **environment**

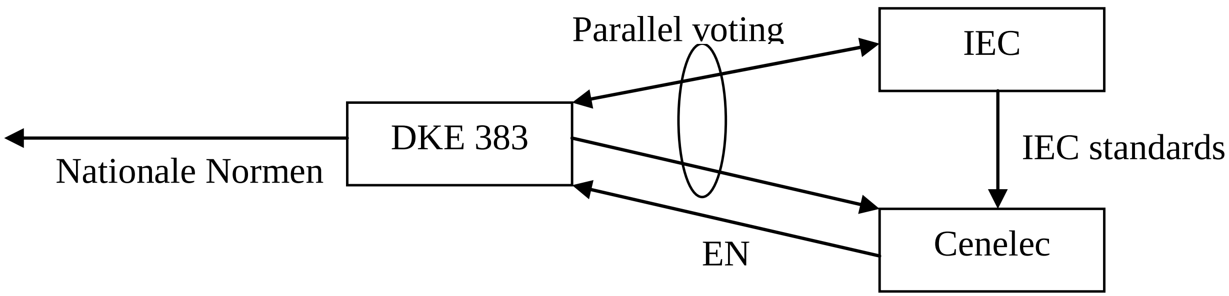
IEC Terminology

SMB	Standardization Management Board
TC	Technical Committee TC88 Wind Turbines
O-Member	Observer Member (of a TC)
P-Member	Participating Member (of a TC)
NC	National Committee

- Indian
- German
- …

IEC Standards

- Members of IEC are national standard committees
- Individual companies can participate to the process via a selection mechanism on national level
- IEC standards are world wide
- In Europe: automatic adoption as EN standard (CEN/Cenelec) via parallel voting process



Creating an IEC standard can be very lengthy process

1	**proposal** stage	NWP	-3
2	**preparatory** stage	preparation of WD (working draft)	0 12
3	**committee** stage	development and acceptance of CDV (committee draft for voting) CD document circulates for comments	24
4	**enquiry stage**	development and acceptance of FDIS (final draft International Standard) or Technical Specification CDV document circulates for 1st voting (5 months)	36
5	**approval stage**	approval of FDIS FDIS document circulates for final voting (2 months)	
6	**publication**	international standard	48

Preparation Stages Int. Standards

Committee stage

- CD Committee Draft (for comment)

Enquiry stage

- CDV Committee Draft for Vote (five months voting period)

Approval stage

- FDIS Final Draft International Standard (two months voting)

Publication stage

- IS International Standard

Types of IEC Publications

International consensus products:

- International Standard (e.g. -1, -2, -3, ...)
- Technical Specification (TS)
- Technical Report (TR)
- Guide (e.g. Guide 65)
- Publicly Available Specification (PAS)

Limited consensus products:

- Industry Technical Agreement (ITA)
- Technology Trend Assessment (TTA)

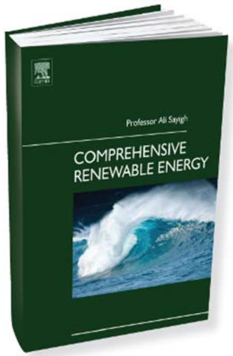
From Frans Van Hulle: Standardisation in wind energy: role for EWEA?

Standards in wind energy: overview

Table 1 Availability of international standards (mainly IEC wind energy standards of the series IEC 61400) for different aspects in the various stages in turbine life

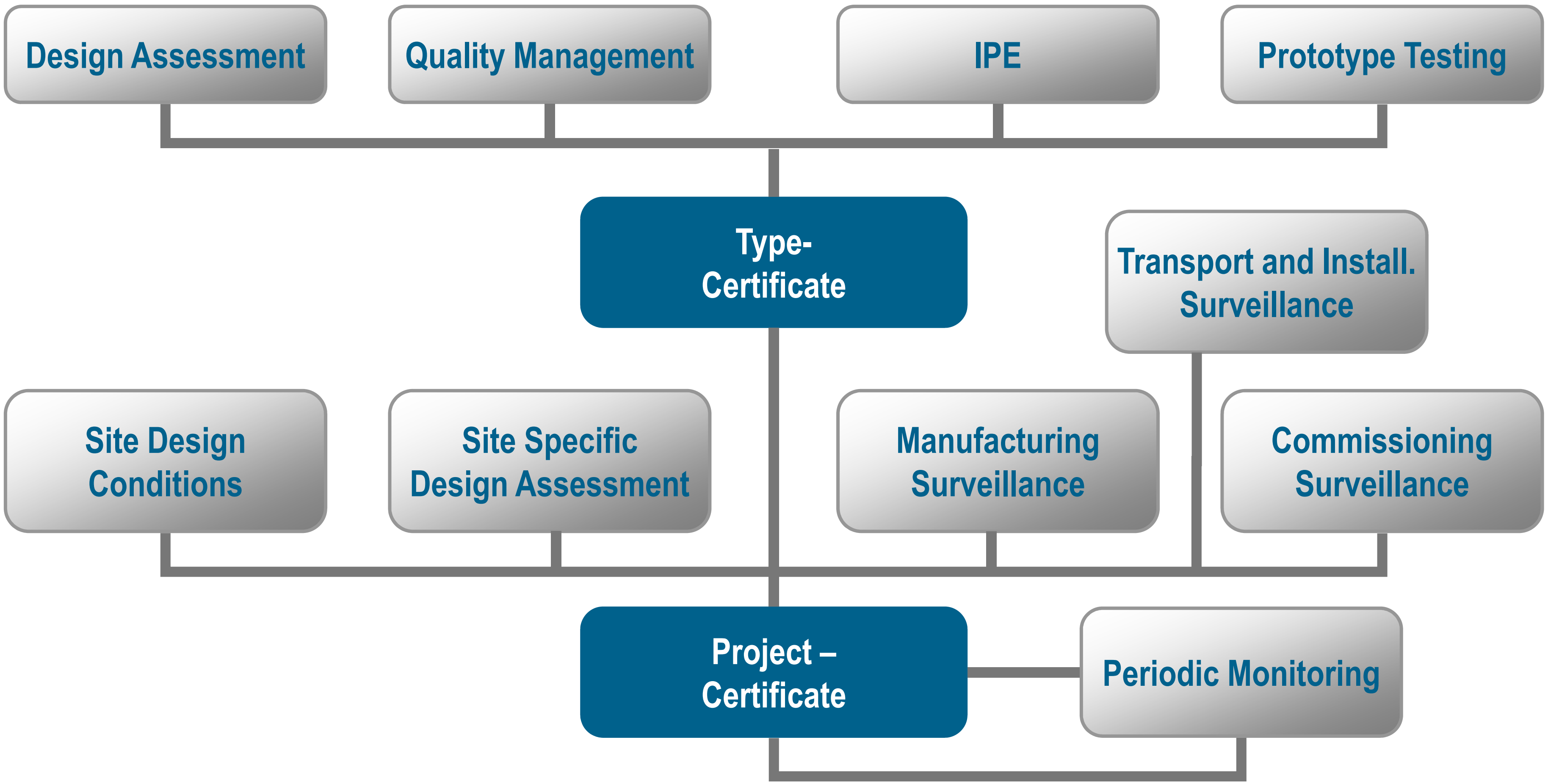
	Design						*Testing*				*Other*
Stage in wind turbine life	*Wind turbines*	*Small wind turbines*	*Offshore wind turbines*	*Gearboxes*	*Protective measures*	*Certification (type certification, project certifcation, component certifcation)*	*Power performance*	*Acoustics*	*Loads and components (blades)*	*Electrical*	*Communication*
Design and manufacturing	x	x	x	x	x	x			x		
(Proto)type testing					x	x	x	x	x	x	x
Installation and commissioning	x	x	x		x	x	x	x	x	x	x
Network connection						x				x	x
Operation and maintenance	x	x	x		x	x	x	x		x	x
Decommissioning											

x = standard available.
Gray-shaded cell = not applicable case.



Van Hulle F (2012) Testing, Standardization, Certification in Wind Energy. In: Sayigh A, (ed.) Comprehensive Renewable Energy, Vol 2, pp. 371–389. Oxford: Elsevier.

Type and Project Certification



Type Certification

Type Certification - overview

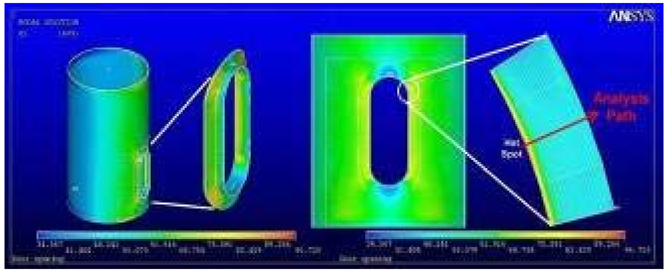
Design Assessment

Quality Management

IPE
Implementation of Design Requirements in Production and Erection

Prototype Testing

Type-Certificate




Type Certificate

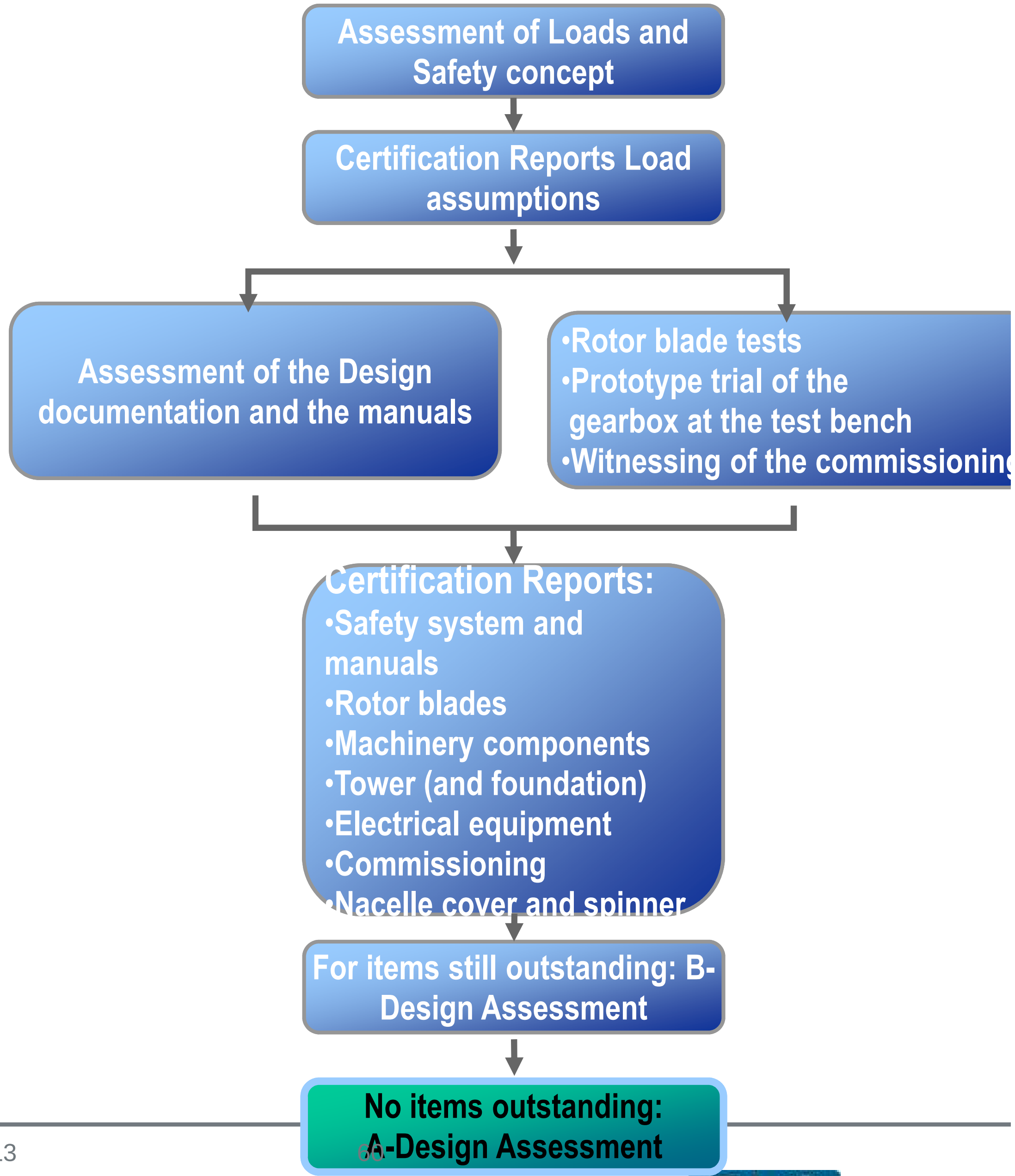
GL

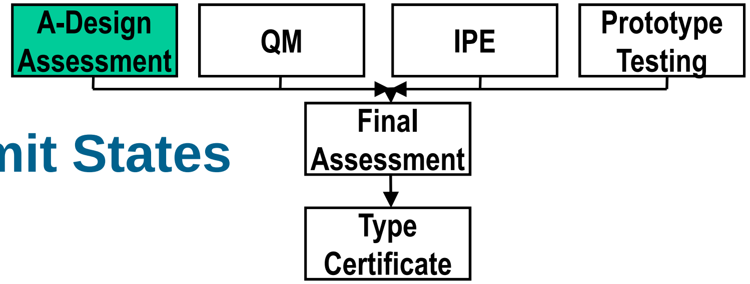
Main IEC standard for Wind Turbines is IEC 61400-1 and 61400-3 for offshore

- Originally published in 2005, amendment in 2011
- Now 61400-1 ed. 4 in work. CD to be published in early 2014. Ed. 2 of 61400-3 one year later
- Main Focus on:
  - Safety System
  - External conditions and wind class definition
  - Load analysis
  - Load case definition
  - Safety factors
  - Some guidance on site assessment
- Basic requirements regarding mechanical, structural and electrical engineering, commissioning and operation

Design Assessment, GL Guideline

- General Conditions for Approval
- Safety System, Protective and Monitoring Devices
- Requirements for Materials and Corrosion Protection
- Load Assumptions
- Strength Analyses
- Structures
- Machinery Components
- Electrical Installations
- Manuals





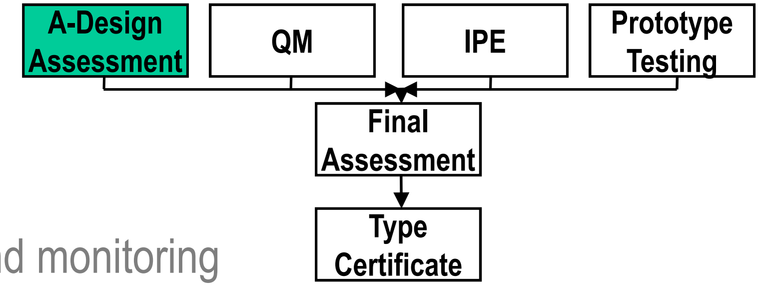
GL Guideline, Safety Level, Limit States

- Safety level:
- Normal safety level
  (unmanned structure, low influence on environment) Target ≈ $5\ 10^{-4}$
- Low safety level (secondary structures)
- High safety level, manned structures only

- Requirements to the safety system
- Load case definitions
- Safety factors

Limit states:

- Ultimate Limit State (ULS/FLS)
- Serviceability Limit State
- No Accidental Limit State

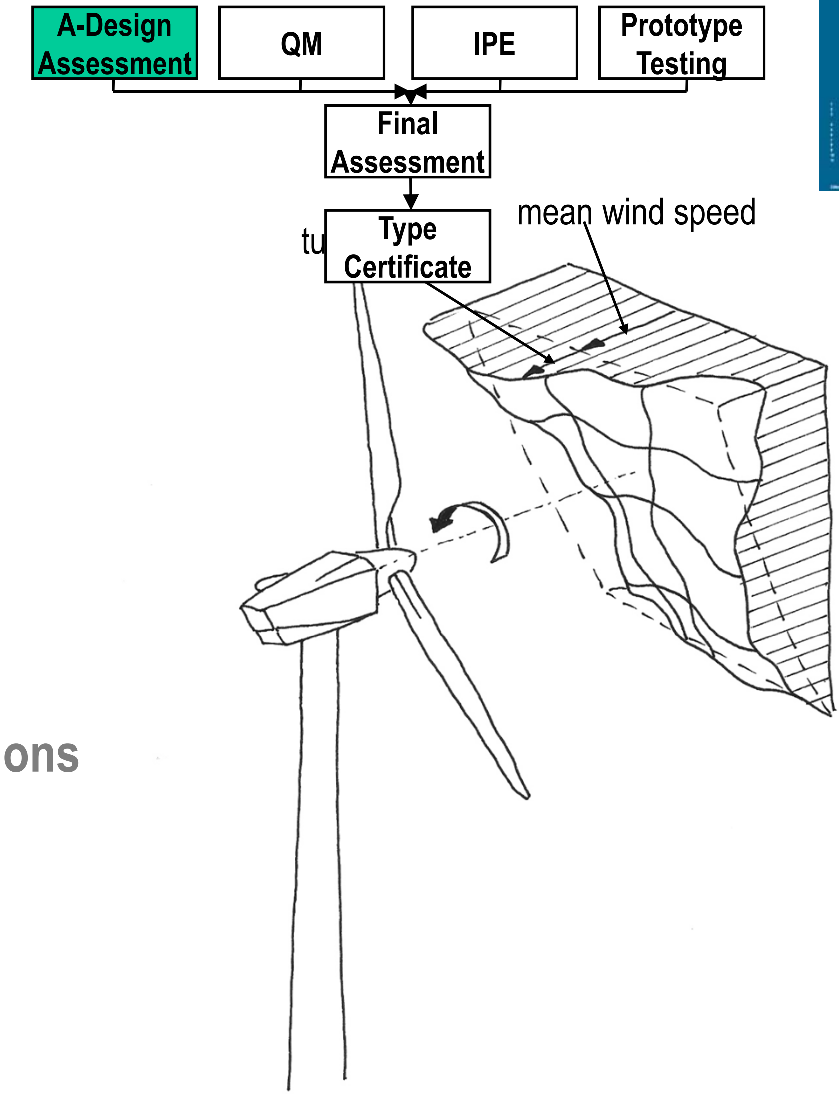


GL Guideline, Safety Concept

- Analysis of safety system, protective and monitoring systems
- Basis:
  Engineering knowledge, experience or formal risk analysis
  e.g. Failure Mode and Effect Analysis (FMEA)
  - Safety system is independent from control system
  - Safety system overrides control system
  - Testing of control and safety system during commissioning
  - Single failure concept
  - Redundant safety system
  - Emergency stop
  - Special requirements possible e.g.
    - Leakage detection / Bilge pumps
    - Collision warning systems

Load Assumptions

- GL Guideline chaprer 4
- IEC 61400-1, IEC 61400-3
- DNV J-101



- full flexibility and maximum options
- additionally update of
  load case catalogue

Wind Turbine Classes

Wind turbine class	I	II	III	S
– V_{ref} [m/s]	50	42.5	37.5	Values to be specified by the manufacturer
– V_{ave} [m/s]	10	8.5	7.5	
– A I_{15} (-)	0.18	0.18	0.18	
– a (-)	2	2	2	
– B I_{15} (-)	0.16	0.16	0.16	
– a (-)	3	3	3	

example: GL IV-1

GL Guideline, Load Cases, Basic Philosophy

Load Group	Design condition	Environmental conditions	Recurrence period
I	Normal operation, parked	Extreme	≤ 50 years
II	Operation, emergency stop, fault, parked after fault	Normal	≤ 1-year
III	Installation, Maintenance	To be defined by the designer	-
IV	Secured/Parked during installation	Normal	≤ 1-year

Design Load Cases IEC 61400-3 (extract)

Design situation	DLC	Wind condition	Waves	Wind and wave directionality	Sea currents	Water level	Other conditions	Type of analysis	Partial safety factor
1) Power production	1.1	NTM $V_{in} < V_{hub} < V_{out}$ RNA	NSS H_s=E [H_s| V_{hub}]	COD, UNI	NCM	MSL	For extrapolation of extreme loads on the RNA	U	N (1,25)
	1.2	NTM $V_{in} < V_{hub} < V_{out}$	NSS Joint prob. distribution of H_s, T_p, V_{hub}	COD, MUL	No currents	NWLR or ≥ MSL		F	*
	1.3	ETM $V_{in} < V_{hub} < V_{out}$	NSS H_s=E [H_s| V_{hub}]	COD, UNI	NCM	MSL		U	N
	1.4	ECD $V_{hub} = V_r – 2$ m/s, V_r, $V_r + 2$ m/s	NSS (or NWH) H_s=E [H_s| V_{hub}]	MIS, wind direction change	NCM	MSL		U	N
	1.5	EWS $V_{in} < V_{hub} < V_{out}$	NSS (or NWH) H_s=E [H_s| V_{hub}]	COD, UNI	NCM	MSL		U	N
	1.6a	NTM $V_{in} < V_{hub} < V_{out}$	SSS $H_s = H_{s,SSS}$	COD, UNI	NCM	NWLR		U	N
	1.6b	NTM $V_{in} < V_{hub} < V_{out}$	SWH $H = H_{SWH}$	COD, UNI	NCM	NWLR		U	N

Partial Safety Factors for Loads γ_F

Source of loading	Unfavourable loads Type of design situation			Favourable loads
	Normal and extreme N	Abnormal A	Transport and erection T	All design situations
Aerodynamic	1,35	1,1	1,5	0,9
Operational	1,35	1,1	1,5	0,9
Gravity	1,1/1,35*	1,1	1,25	0,9
Other inertia	1,25	1,1	1,3	0,9

* In the event of the masses not being determined by weighing.

"Guideline for the Certification of Wind Turbines" Edition 2010

Partial Safety Factors for Loads γ_F

Unfavourable loads			Favourable loads
Type of design situation (see Tables 1 and 2)			All design situations
Normal (N)	Abnormal (A)	Transport and erection (T)	
1,35*	1,1	1,5	0,9

* For design load case DLC 1.1, given that loads are determined using statistical load extrapolation at prescribed wind speeds between V_{in} and V_{out}, the partial load factor for normal design situations shall be γ_f =1,25.

If for normal design situations the characteristic value of the load response $F_{gravity}$ due to gravity can be calculated for the design situation in question, and gravity is an unfavourable load, the partial load factor for combined loading from gravity and other sources may have the value:

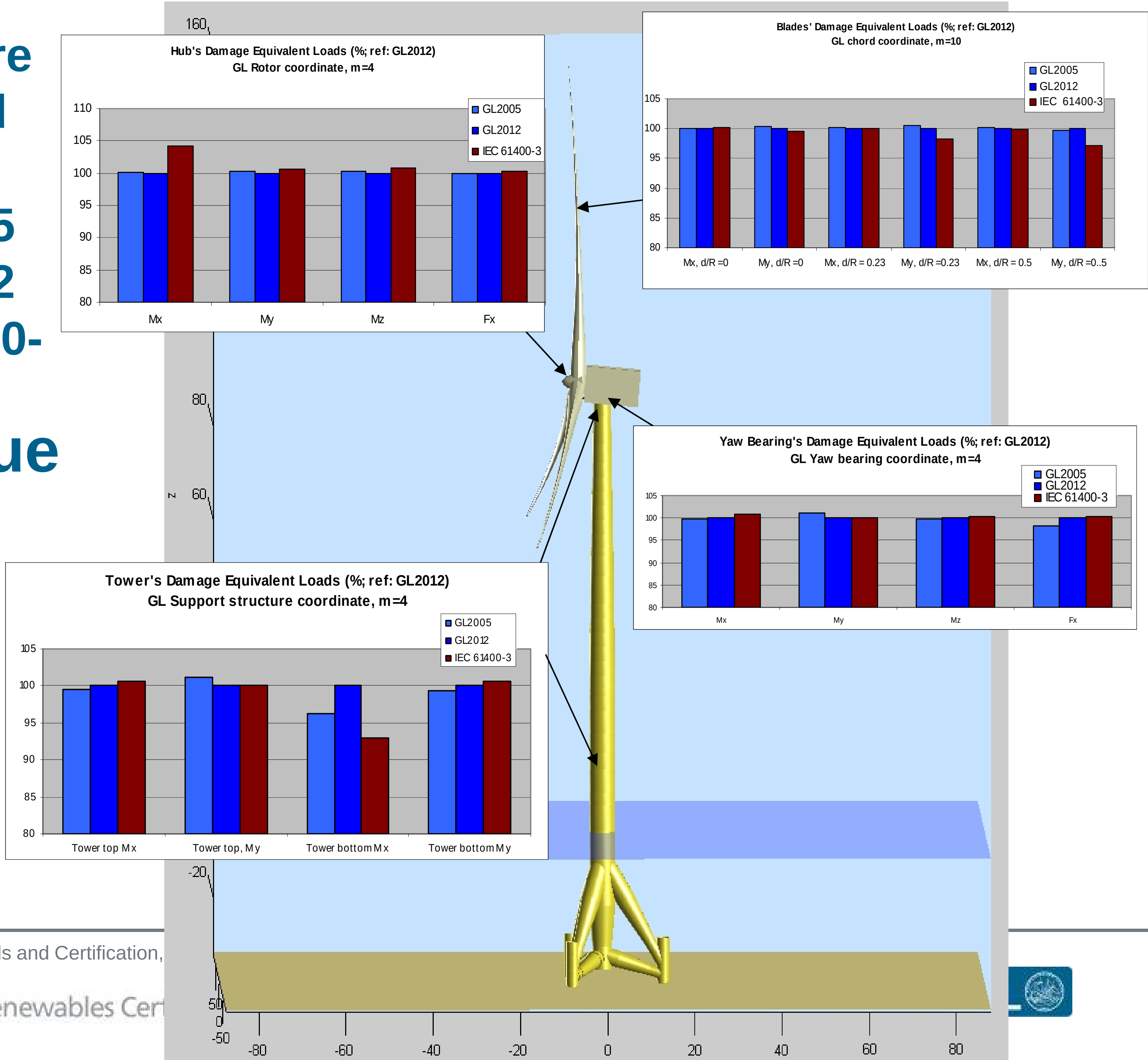
$$\gamma_f = 1{,}1 + \varphi \varsigma^2$$

$$\varphi = \begin{cases} 0{,}15 \text{ for DLC1.1} \\ 0{,}25 \text{ otherwise} \end{cases}$$

$$\varsigma = \begin{cases} 1 - \left| \dfrac{F_{gravity}}{F_k} \right|; & |F_{gravity}| \le |F_k| \\ 1; & |F_{gravity}| > |F_k| \end{cases}$$

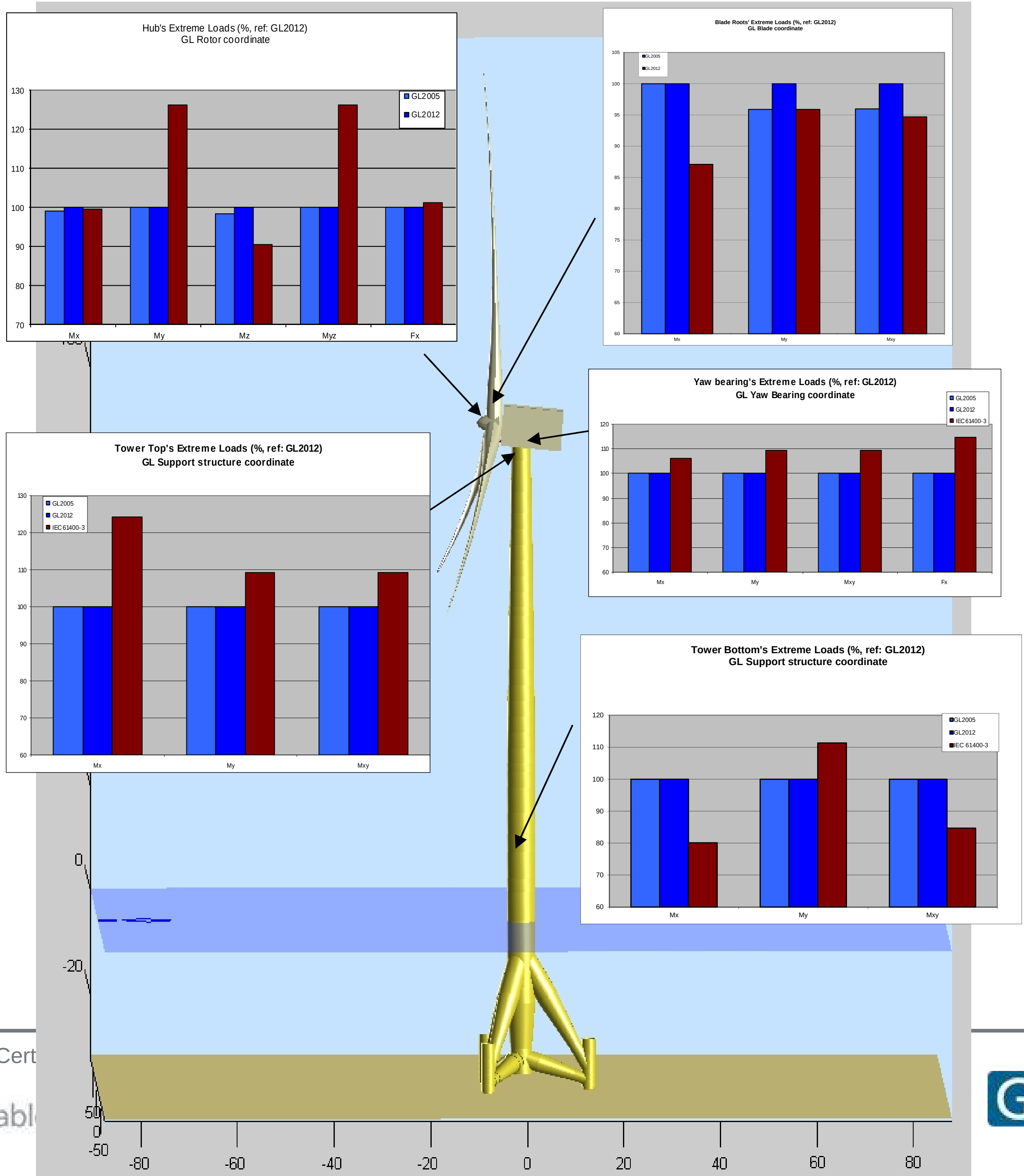
Pretension and gravity loads that significantly relieve the total load response are considered favourable loads.

Compare of load levels GL2005 GL2012 IEC61400-3 Fatigue



Compare of load levels GL2005 GL2012 IEC61400-3

Extreme



Small Wind Turbines (SWT)

- **IEC 61400-2: Small Wind Turbines**
  - Simplified requirements
  - Limit to rotor swept area smaller than or equal to 200 m2, generating electricity at a voltage below 1000 V AC or 1500 V DC for both on-grid and off-grid applications


NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
61400-2

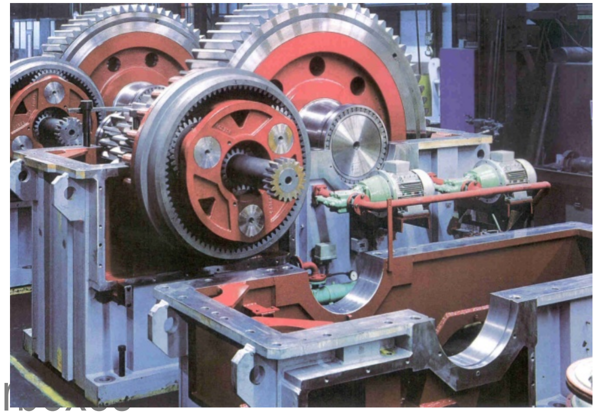
Aérogénérateurs –
Partie 2:
Exigences en matière de conception des petits aérogénérateurs

Wind turbines –
Part 2:
Design requirements for small wind turbines

IEC

Source: Helix Wind

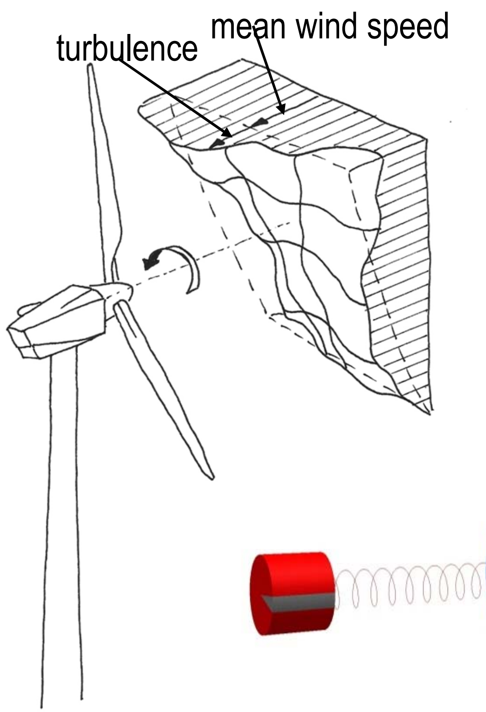

Source: WINDTEST



Machinery Components

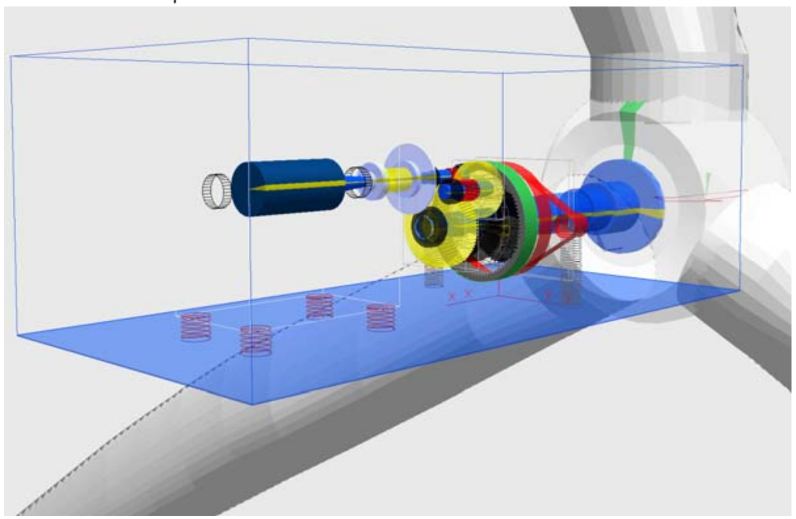
- **GL Guideline** Chapter 6 and 7
- **IEC 61400-4**, Design requirements for wind turbine gearboxes
- Reference to other ISO standards
- Gears:
  - **ISO 6336** – Calculation of load capacity of spur and helical gears
  - **AGMA 2001/2101** – Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
  - Bearings:
  - **ISO 281** – Rolling bearings – Dynamic load ratings and rating live of bearings
  - **IEC 81400-4** – Wind turbines -- part 4: Design and specification of gearboxes

Drive Train Dynamics

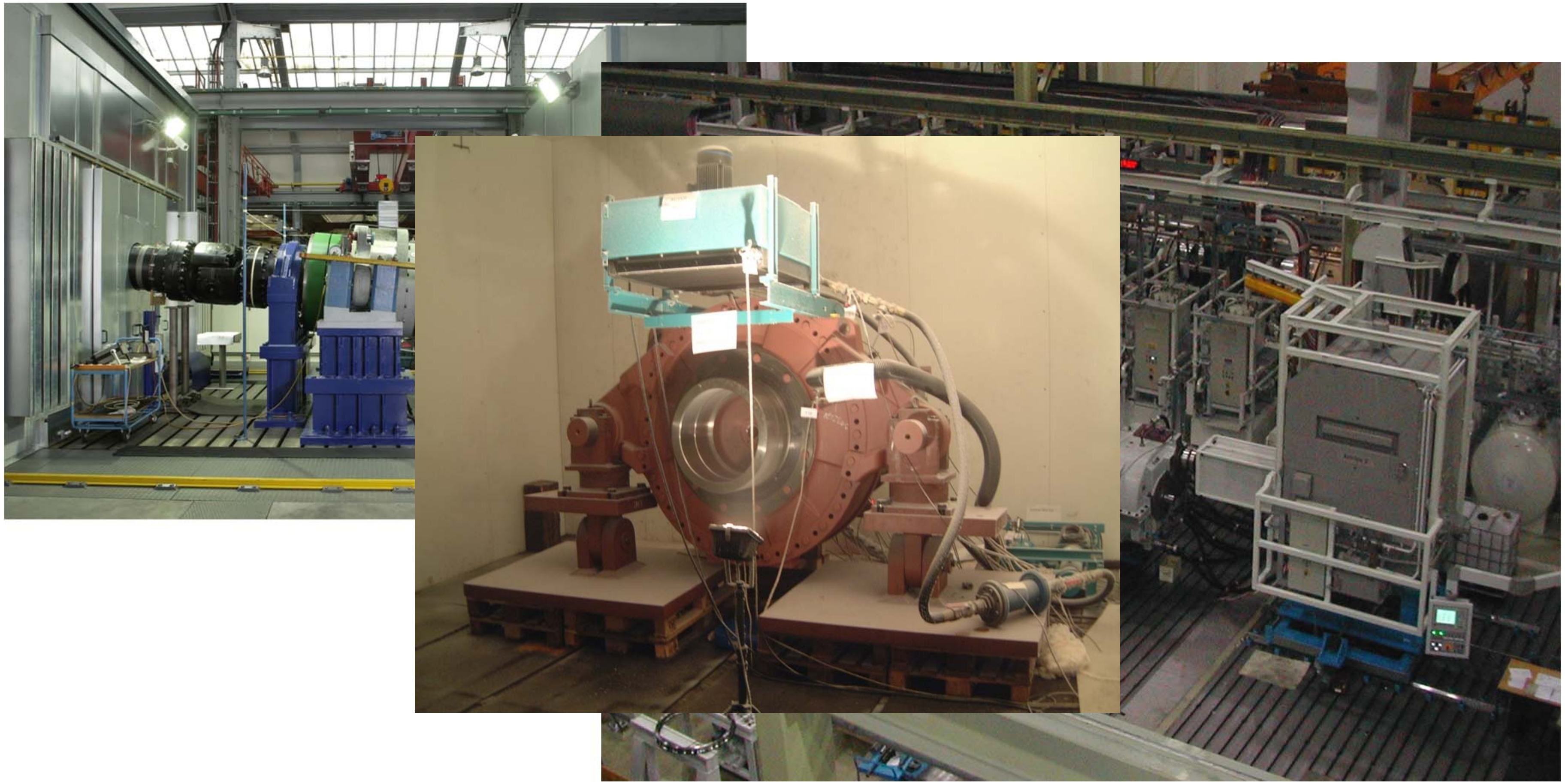


- Load assumptions for the design of turbines are based on simulations of a global model
- Dynamic properties of e.g. drive train and internal loads are neglected

- Why Drive Train Dynamics:
  - Analysis of the dynamic behavior of the drive train using a detailed simulation model
  - Verification of model parameter assumptions representing the drive train in global model
  - Verification of design loads
- GL Guideline Appendix 7.A on Drive Train Dynamics



Gearbox – Prototype and Serial Test



N1

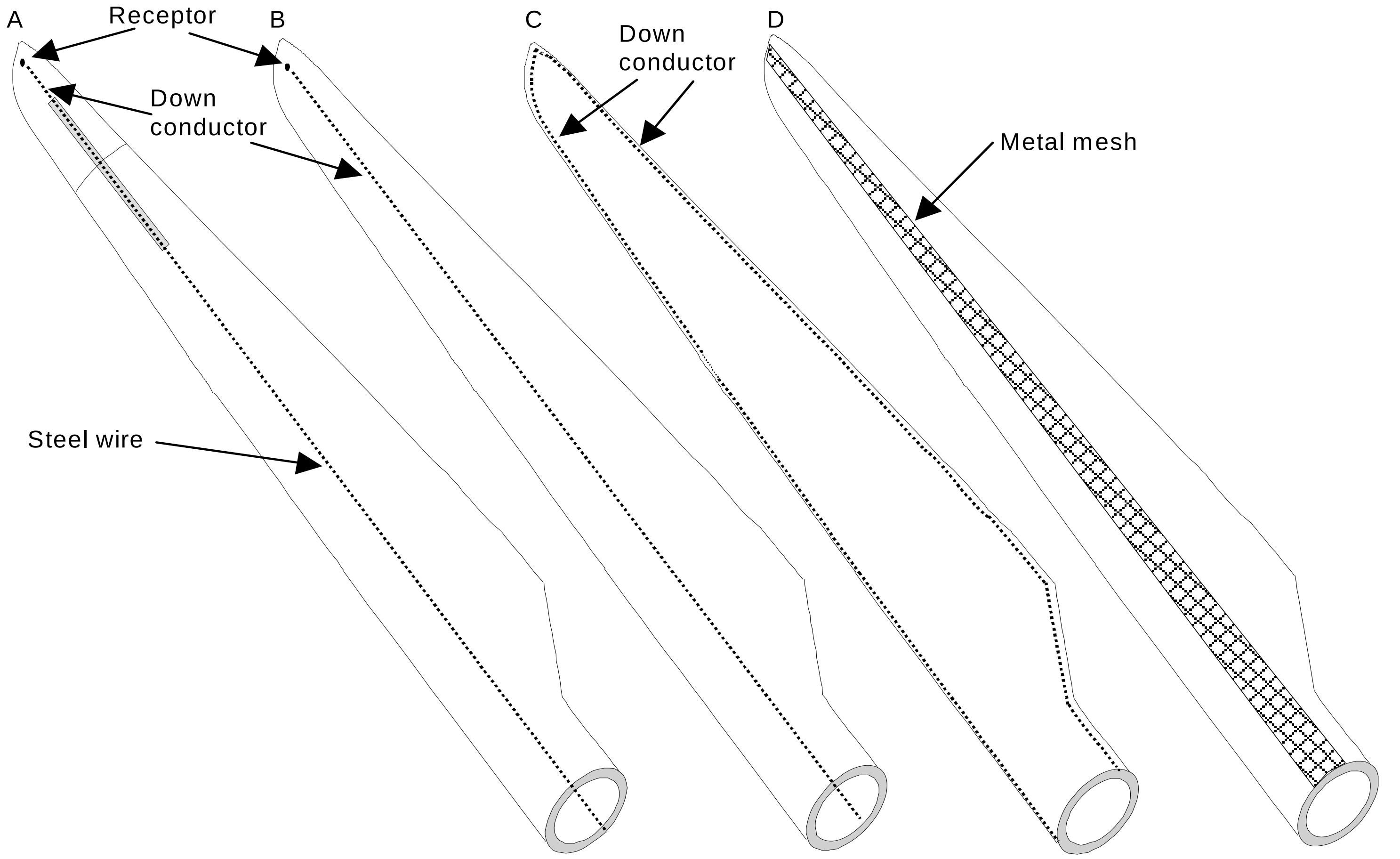
Lightning Protection

N1

The red path is ended.
The energy is now feeded to the grid.
What happens there you will hear from torge
some more important components I will show you now

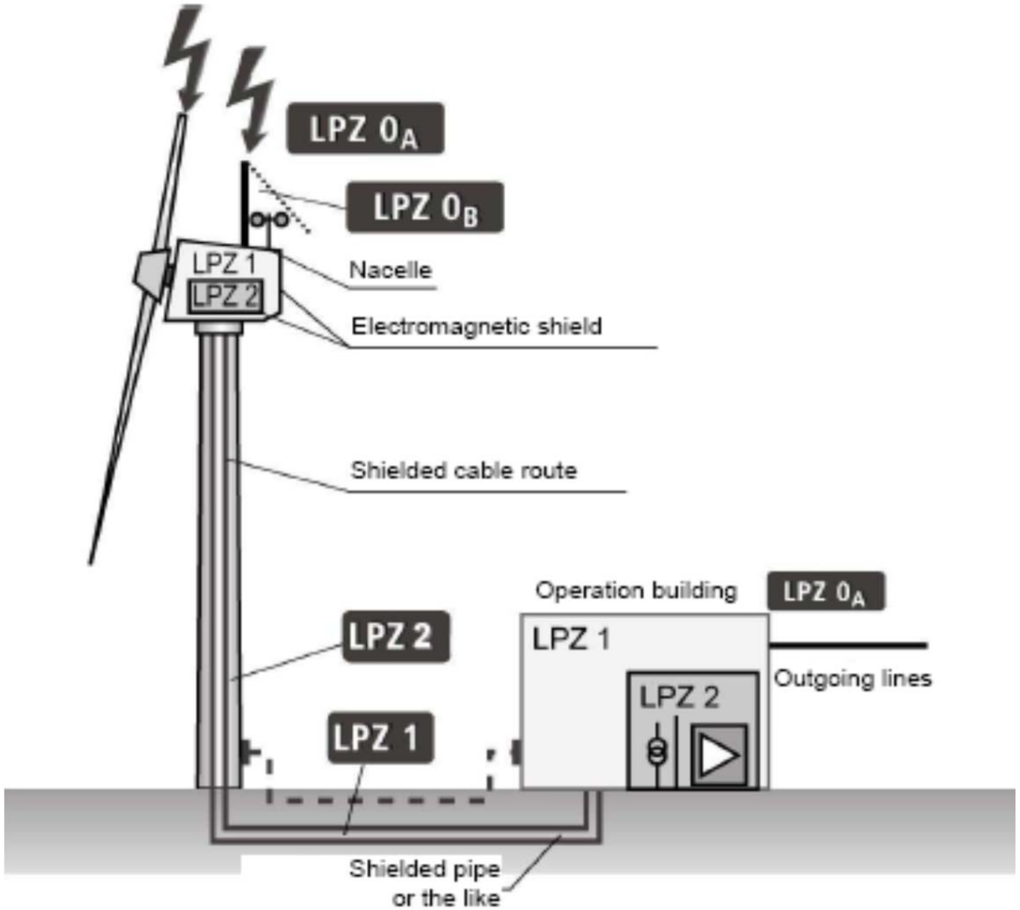
NiFr; 10.10.2012

Lightning protection at Rotor Blades



IEC 61400-24

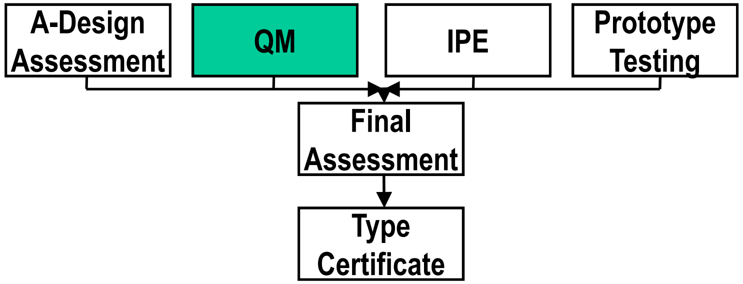
Overvoltage Protection System



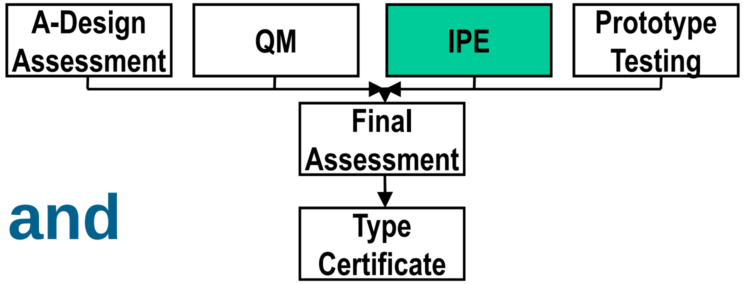
LPZ:
Lightning
Protection
Zone

IEC 61400-24

Quality Management (QM)



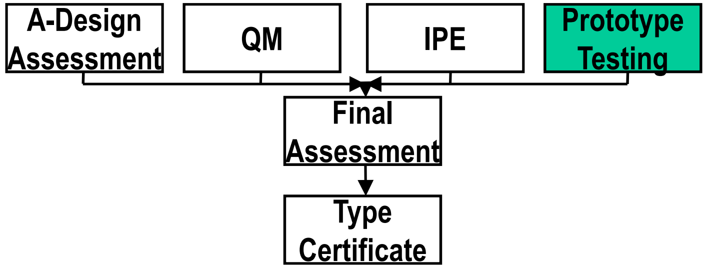
- Verification that requirements of ISO 9001:2008 regarding design and manufacturing are fulfilled
- Certification of QM system



Implementation of design requirements in Production and Erection (IPE)

- It has to be approved and assessed that the **requirements** stipulated in the technical **documentations** are observed and **implemented** in **production** and erection
- **One-time surveillance** during production and erection (depending on quality management measures)
- Definition of important / **critical production processes** regarding quality requirements (resulting from Design Assessment)

Prototype Testing

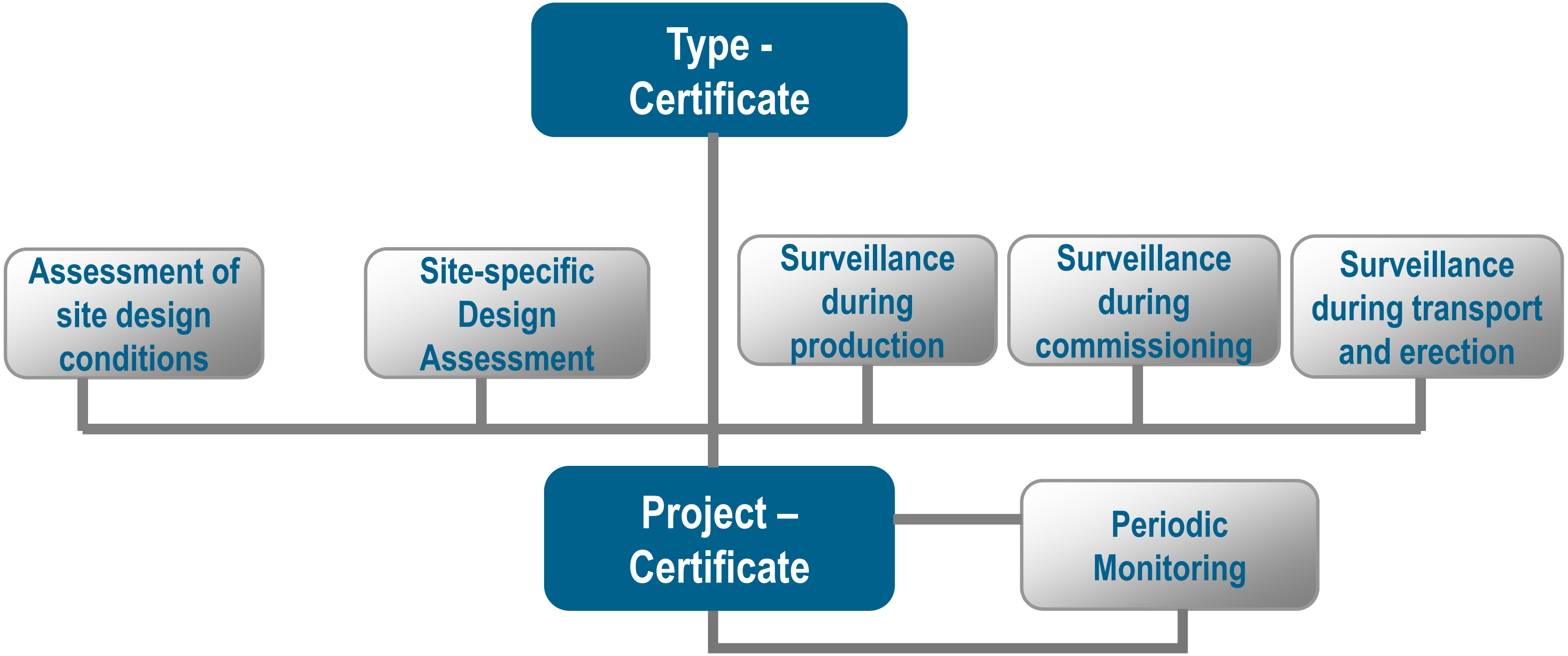


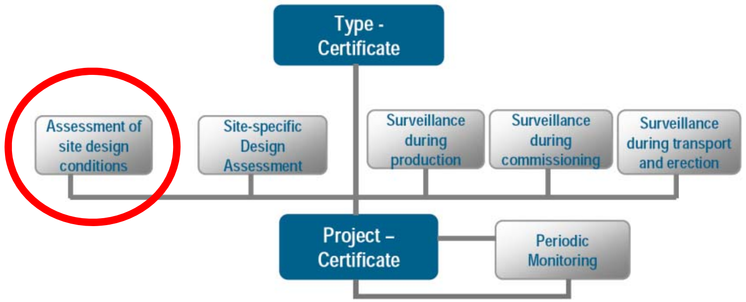
- measurement of the power curve IEC 61400-12-1
- measurement of the noise emission (optional) IEC 61400-11
- measurement of the electrical characteristics
- test of wind turbine behaviour
- load measurements, IEC 61400-13
- test operation of the gearbox at the wind turbine

Power Curve

Project Certification

Project Certification (GL IV-2)





Site Design Conditions

- wind & wave conditions
- soil conditions
- influence of the wind farm configuration
- other environmental conditions, such as: salt content of the air, temperature, ice and snow, humidity, lightning strike, solar radiation etc.
- electrical grid conditions…

  … and connections

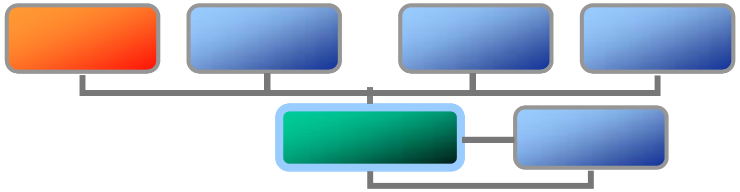
- main definitions in GL-Guideline or IEC 61400-1 and IEC 61400-3

Site-specific Design Assessment

wind park site

wind turbine

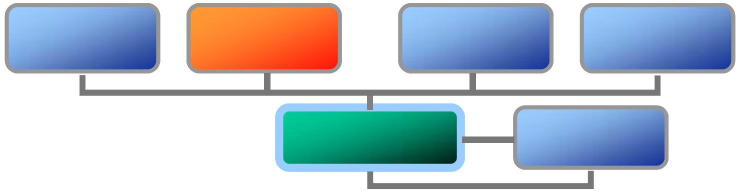
Do they match?



Site Design Conditions

- Site Assessment
  - Environmental Conditions
  - Soil Investigation
- Further Items include
  - Load Case Definitions
  - Determination of Rules for materials, corrosion protection
  - Assumptions for WTG: masses, eigenfrequencies, …
  - Concept for Transport, Erection and Inspection
  - Specification of specific Analysis Methods

  ➔ leading to the Design Basis



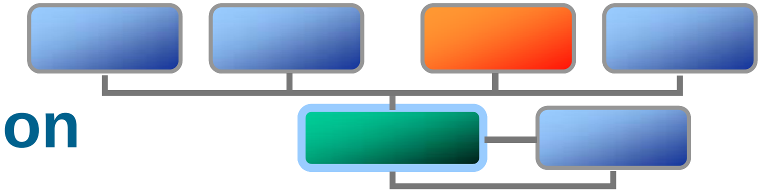
Site-specific Design Assessment

- Load Assessment

- Assessment the support structure
  - ULS (ultimate limit state)
  - FLS (fatigue limit state)
  - Investigation of details e.g. for grouting connection, 2nd-steel

- Assessment of the turbine including
  - are the loads higher than those assumed in the Type Certificate? (in such cases: reserve calculations necessary)
  - Is the turbine design to withstand site conditions? (corrosion, temperature,...)

Surveillance during Production



- inspection and testing of materials and components
- scrutiny of QM records, such as test certificates, tracers, reports
- surveillance of production, including storage conditions and handling
- structural steelwork, welding, inspection of NDT
- nacelle assembly
- inspection of the corrosion protection
- inspection of the electrical power system
- supervision of the final test

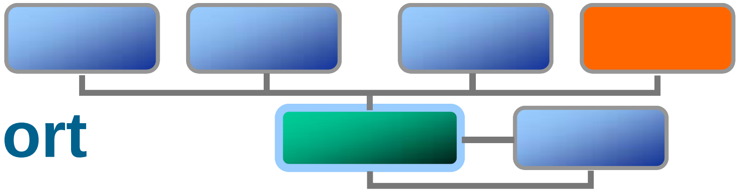
a1

The general objective is to verify, that the production is done according to the approved drawings, rules and specifications.

a1

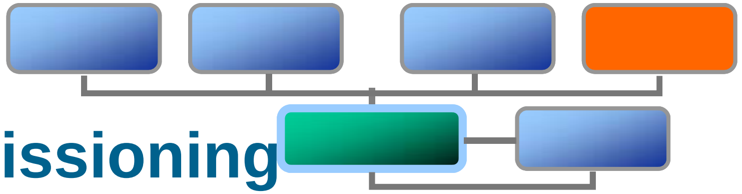
Qualification of welders, approval of weld shops
Geometry and corrosion protection
Traceability of components
alber; 23.09.2010

Manufacturing Surveillance (2)



Surveillance during Transport and Erection

- identification and allocation of all components to the wind turbine in question
- checking the components for damage during transport
- inspection of the job schedules (e.g. for welding, installation, bolting up)
- inspection of prefabricated subassemblies, and of components to be installed, for adequate quality of manufacture, insofar as this has not been done at the manufacturers' works
- surveillance of important steps in the erection on a random-sampling basis
- inspection of bolted connections, surveillance of non-destructive tests (e.g. welded joints)
- inspection of the corrosion protection
- inspection of the electrical installation (run of cables, equipment earths and earthing system)



Surveillance during commissioning

- functioning of the emergency stop button
- triggering of the brakes by every operating condition possible in operation
- functioning of the yaw system
- behaviour at loss of load (grid loss)
- behaviour at overspeed
- functioning of automatic operation
- visual inspection of the entire installation
- checking the logic of the control system's indicators
- general appearance
- corrosion protection
- damages
- conformity of the main components with the certified design and traceability / numeration of the components

Source: GE


Thank you
very much!

Present Status of CMS for Wind Turbines (1)

Application:

- Condition monitoring is used for many years in power plants and industrial facilities.
- At the beginning only little use in wind turbines due to skepticism of its advantages.
- With increasing power of wind turbines CMS is becoming more accepted.
- According to the GL RC's Offshore Guideline CMS is mandatory for Offshore wind turbines.

Present Status of CMS for Wind Turbines (2)

Intention:

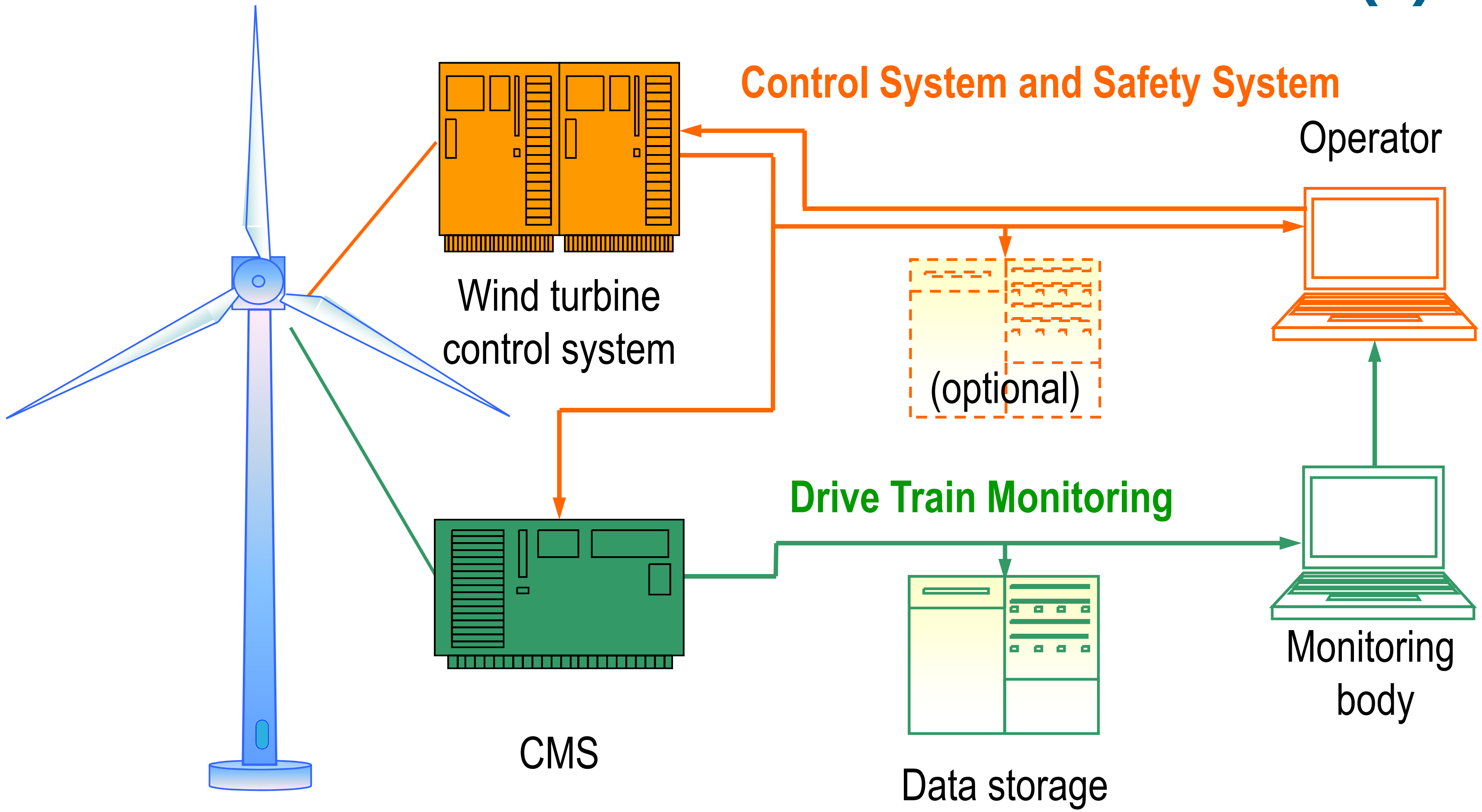
- Drive train monitoring with special focus on gears and bearings
- Detection of damages
- Condition based maintenance
- Predictable maintenance schedules
- Enhancing availability

Present Status of CMS for Wind Turbines (3)

Realization:

- Individual solutions are prevalent
- CMS are individually adapted to wind turbines as wind turbines are generally not prepared for CMS
- Monitoring by individuals, wind farm operators or Monitoring Bodies (MB)
- The CMS is independent from the control system and the safety system

Present Status of CMS for Wind Turbines (4)



Thank you very much for your attention

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