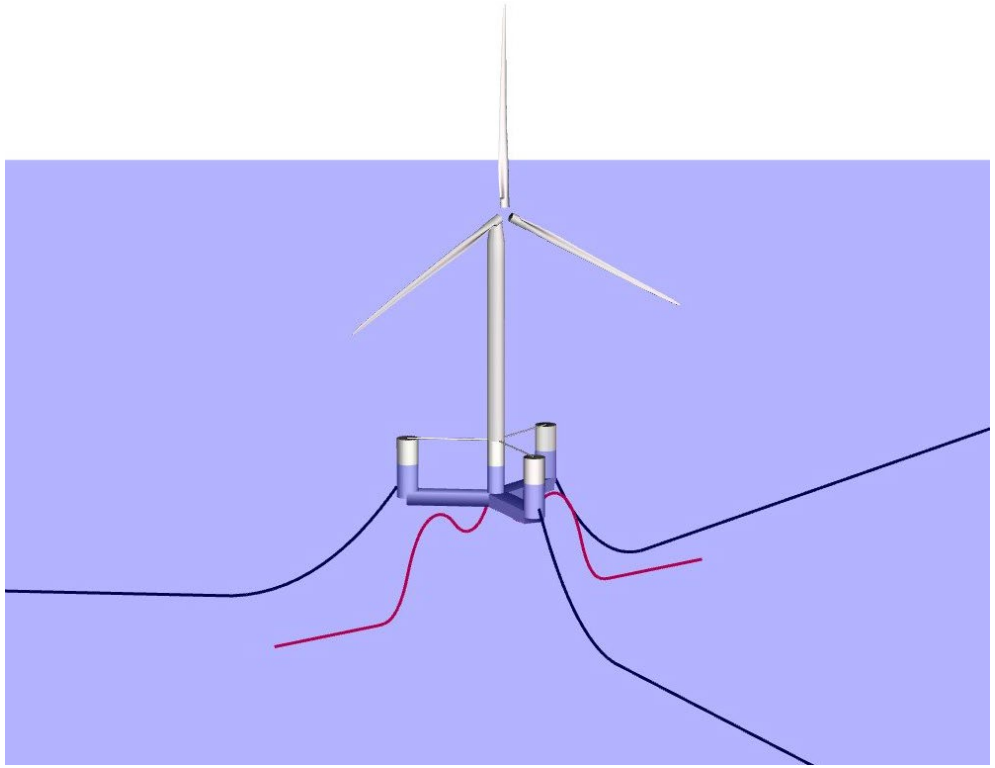


Standards and certification

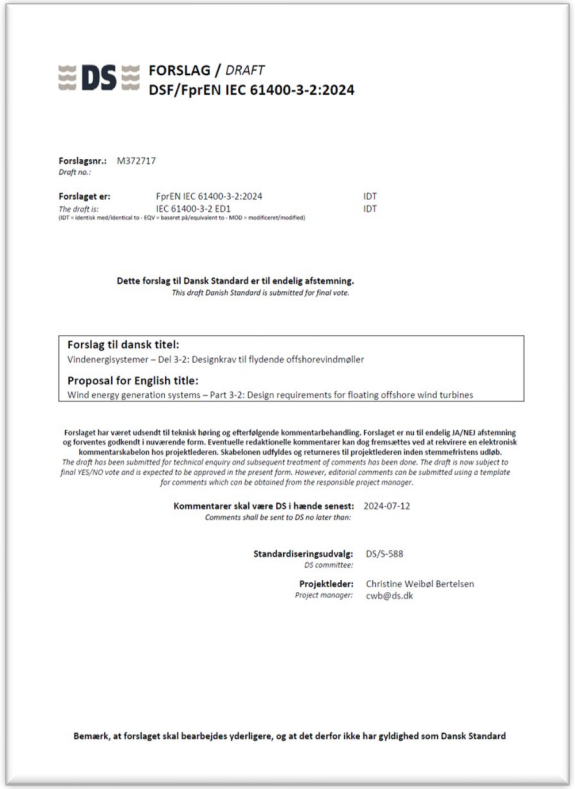
Kenneth Thomsen, Head of Wind Turbine Design division
David Verelst, Senior Researcher in REC, WTD

Research and Standards

- Aeroelastic response modelling of wind turbines.
- Area closely related to some parts of the IEC 61400 standards
- Vice chair of the S-588 (Danish mirror committee of TC88)
- Following activities in the –1 and –3 standards



Example of a wind turbine system standard



DS FORSLAG / *DRAFT*
DSF/FprEN IEC 61400-3-2:2024

Forslagsnr.: M372717
Draft no.:

Forslaget er: FprEN IEC 61400-3-2:2024 IDT
The draft is: IEC 61400-3-2 ED1 IDT
(IDT = identisk med/identical to - EQV = baseret på/equivalent to - MOD = modificeret/modified)

Dette forslag til Dansk Standard er til endelig afstemning.
This draft Danish Standard is submitted for final vote.

Forslag til dansk titel:
Vindenergisystemer – Del 3-2: Designkrav til flydende offshorevindmøller

Proposal for English title:
Wind energy generation systems – Part 3-2: Design requirements for floating offshore wind turbines

Forslaget har været udsendt til teknisk høring og efterfølgende kommentarbehandling. Forslaget er nu til endelig JA/NEJ afstemning og forventes godkendt i nuværende form. Eventuelle redaktionelle kommentarer kan dog fremsættes ved at rekvirere en elektronisk kommentarskabelon hos projektlederen. Skabelonen udfyldes og returneres til projektlederen inden stemmefristens udløb.
The draft has been submitted for technical enquiry and subsequent treatment of comments has been done. The draft is now subject to final YES/NO vote and is expected to be approved in the present form. However, editorial comments can be submitted using a template for comments which can be obtained from the responsible project manager.

Kommentarer skal være DS i hænde senest: 2024-07-12
Comments shall be sent to DS no later than:

Standardiseringsudvalg: DS/S-588
DS committee:

Projektleder: Christine Weibøl Bertelsen
Project manager: cwb@ds.dk

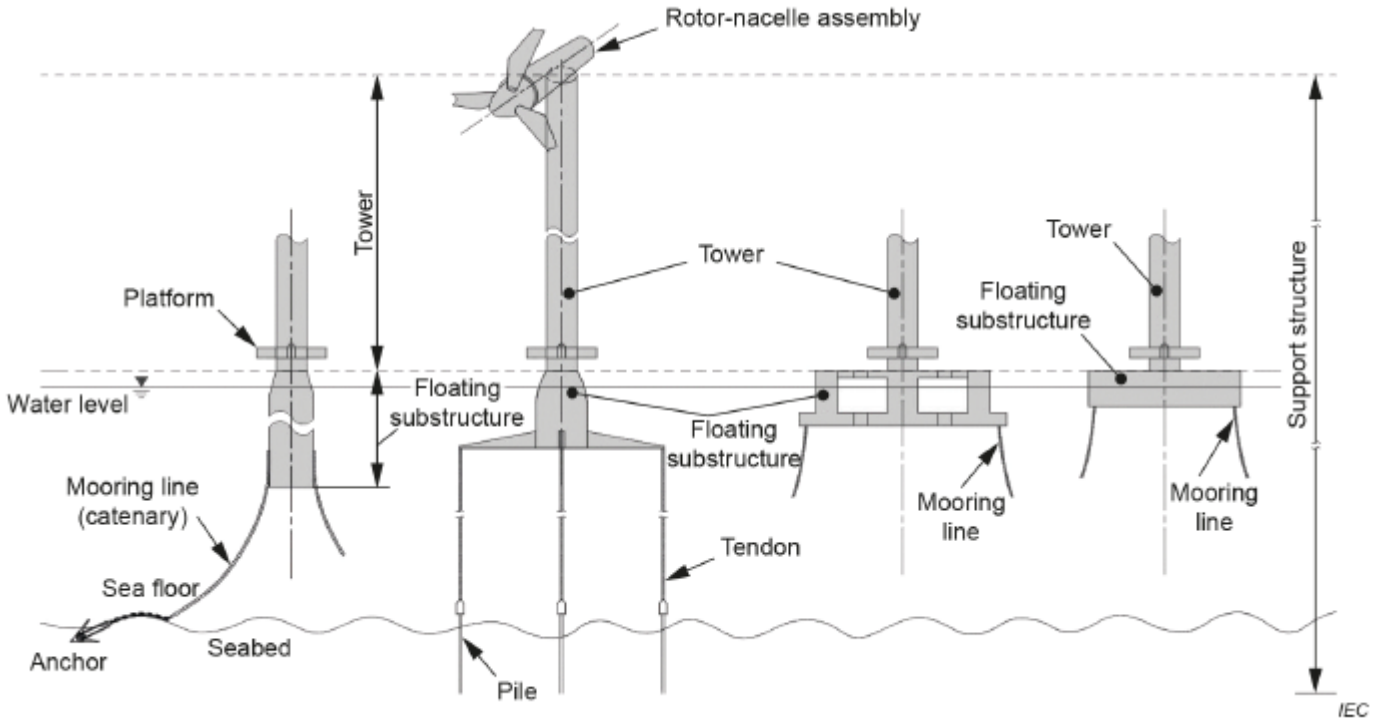
Bemærk, at forslaget skal bearbejdes yderligere, og at det derfor ikke har gyldighed som Dansk Standard

An example from the IEC 61400 series

Wind energy generation systems – Part 3-2: Design requirements for floating offshore wind turbines

Design requirements for floating offshore wind turbines

- Definitions
- External conditions
- Design methodology
- Design load cases
- Load analysis
- Control
- Mechanical system
- Electrical system
- Anchor system
- Assembly, installation, transport
- Commissioning, operation and maintenance



External conditions

IEC61400-1

plus offshore elements

Table 1 – Basic parameters for wind turbine classes

Wind turbine class		I	II	III	S
V_{ave}	(m/s)	10	8,5	7,5	Values specified by the designer
V_{ref}	(m/s)	50	42,5	37,5	
	Tropical (m/s) $V_{ref,T}$	57	57	57	
A+	I_{ref} (-)	0,18			
A	I_{ref} (-)	0,16			
B	I_{ref} (-)	0,14			
C	I_{ref} (-)	0,12			

The parameter values apply at hub height and

- V_{ave} is the annual average wind speed;
- V_{ref} is the reference wind speed average over 10 min;
- $V_{ref,T}$ is the reference wind speed average over 10 min applicable for areas subject to tropical cyclones;
- A+ designates the category for very high turbulence characteristics;
- A designates the category for higher turbulence characteristics;
- B designates the category for medium turbulence characteristics;
- C designates the category for lower turbulence characteristics; and
- I_{ref} is a reference value of the turbulence intensity (see 6.3.2.3).

Design situation	DLC	Wind condition	Waves	Met ocean directionality (Wind, waves, currents)	Sea currents	Water level	Other conditions	Type of analysis	Partial safety factor
1) Power production	1.1	NTM $V_{in} < V_{hub} < V_{out}$ rotor-nacelle assembly	NSS $H_s = E[H_s \mid V_{hub}]$	MIS, MUL	NCM	MSL	For extrapolation of extreme loads on the rotor-nacelle assembly	U	N (1,25)
	1.2	NTM $V_{in} < V_{hub} < V_{out}$	NSS Joint prob. distribution of H_s, T_p, V_{hub}	MIS, MUL	NCM	NWLR or ≥ MSL		F	*
	1.3	ETM $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E[H_s \mid V_{hub}]$	COD, MUL	NCM	MSL		U	N
	1.4	ECD $V_{hub} = V_r - 2$ m/s, V_r, $V_r + 2$ m/s	NSS $H_s = E[H_s \mid V_{hub}]$	MIS, wind direction change, MUL	NCM	MSL		U	N
	1.5	EWS $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E[H_s \mid V_{hub}]$	COD, MUL	NCM	MSL		U	N
	1.6	NTM $V_{in} < V_{hub} < V_{out}$	SSS $H_s = H_{s,SSS}$	MIS, MUL	NCM	NWLR		U	N

Specifications are given as general terms:

7.4.2 Power production (DLC 1.1 to 1.6)

In this design situation, a FOWT is running and connected to the electric load. The assumed wind turbine configuration shall take into account rotor imbalance. The maximum mass and aerodynamic imbalances (e.g. blade pitch and twist deviations) specified for rotor manufacture shall be used in the design calculations.

In addition, deviations from theoretical optimum operating situations such as nacelle yaw misalignment and control system tracking errors shall be taken into account in the analyses of operational loads.

Design load cases (DLCs) 1.1 and 1.2 embody the requirements for loads resulting from atmospheric turbulence (NTM) and stochastic sea states (NSS) that occur during normal operation of a FOWT throughout its lifetime.

Design load cases

Onshore design load cases given in IEC61400-1:

Design situation	DLC	Wind condition	Other conditions	Type of analysis	Partial safety factors
1) Power production	1.1	NTM $V_{in} < V_{hub} < V_{out}$	For extrapolation of extreme events	U	N
	1.2	NTM $V_{in} < V_{hub} < V_{out}$		F	*
	1.3	ETM $V_{in} < V_{hub} < V_{out}$		U	N
	1.4	ECD $V_{hub} = V_r - 2$ m/s, V_r, $V_r + 2$ m/s		U	N
	1.5	EWS $V_{in} < V_{hub} < V_{out}$		U	N
2) Power production plus occurrence of fault	2.1	NTM $V_{in} < V_{hub} < V_{out}$	Normal control system fault or loss of electrical network or primary layer control function fault (see 7.4.3)	U	N
	2.2	NTM $V_{in} < V_{hub} < V_{out}$	Abnormal control system fault or secondary layer protection function related fault (see 7.4.3)	U	A
	2.3	EOG $V_{hub} = V_r \pm 2$ m/s and V_{out}	External or internal electrical fault including loss of electrical network	U	A
	2.4	NTM $V_{in} < V_{hub} < V_{out}$	Control system fault, electrical fault or loss of electrical network	F	*
	2.5	NWP $V_{in} < V_{hub} < V_{out}$	Low voltage ride through	U	N
3) Start-up	3.1	NWP $V_{in} < V_{hub} < V_{out}$		F	*
	3.2	EOG $V_{hub} = V_{in}$, $V_r \pm 2$ m/s and V_{out}		U	N
	3.3	EDC $V_{hub} = V_{in}$, $V_r \pm 2$ m/s and V_{out}		U	N
4) Normal shutdown	4.1	NWP $V_{in} < V_{hub} < V_{out}$		F	*
	4.2	EOG $V_{hub} = V_r \pm 2$ m/s and V_{out}		U	N
5) Emergency stop	5.1	NTM $V_{hub} = V_r \pm 2$ m/s and V_{out}		U	N
6) Parked (standing still or idling)	6.1	EWM 50-year return period		U	N
	6.2	EWM 50-year return period	Loss of electrical network connection	U	A
	6.3	EWM 1-year return period	Extreme yaw misalignment	U	N
	6.4	NTM $V_{hub} < 0{,}7\ V_{ref}$		F	*
7) Parked and fault conditions	7.1	EWM 1-year return period		U	A
8) Transport, assembly, maintenance and repair	8.1	NTM V_{maint} to be stated by the manufacturer		U	N
	8.2	EWM 1-year return period		U	A

New areas to be standardized under TC 88

Already started:

- Probabilistic design measures for wind turbines
- Through life management and life extension
- Decommissioning and preparation for recycling

To be started:

- Tower and foundation for offshore wind
- LCA methods
- Airborne wind



Material from Danish Standard/IEC secretariat

Research and standard development

- Scientific experts can bring new findings and understanding to the standard community based specific output from various projects.

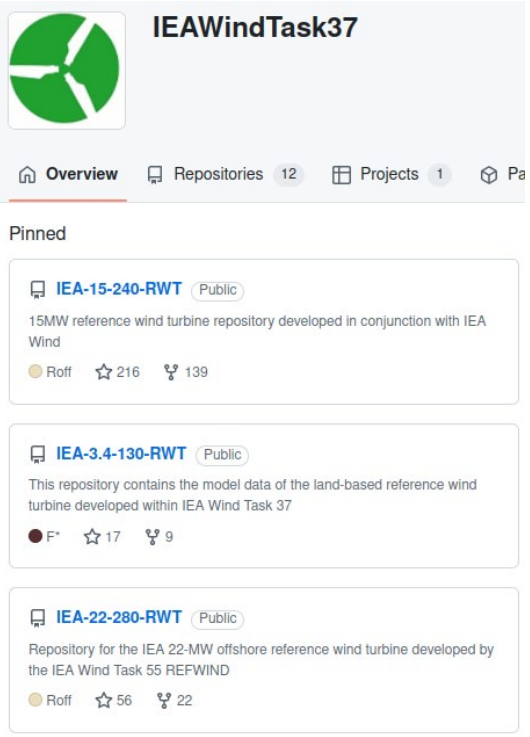
- Standards create a level playing field.
- Standards help researchers understand what an industrial context looks like.
- A competitive environment can cause practical challenges:
  - Some actors could prevent specific knowledge form entering the standard to protect their IP and maintain an advantage over others.
  - Academic experts are encouraged to push out findings that have a positive impact beyond single actors.

Academic reference models and standards

- How does a change in a standard affect a real product?
- Challenging in competitive environment with sensitive IP.

- Solution: academic/public reference models.
  - NREL5MW, DTU10MW, IEA10, 15, 22MW, … reference turbine models.

- Reference models ease entry for new (small) players:
  - Company designing generators can "easily" estimate impact on the rest of the wind turbine system.
- Open set of models that set a common denominator.
- Not the same as a detailed industrial grade design.



Academic reference models and standards

IEA reference wind turbine models

- Prevent sharing sensitive IP from commercial partners when discussing impact of the standards for example on specific products.

- Working on reference models not always obvious from an academic point of view. Overlap with product design.
- Participating in IEA activities not obvious funding wise.
- Who takes long term ownership: maintenance, improvements, coordination?

Thoughts on Standard development

- What should a standard contain?
  - Handbook: good for new actors
  - General principles: good with inhouse experience

- Politics that form the standard: agents have different strategical objectives:
  - Agent maintaining detailed set of handbooks.
  - Agent short on cash just want to keep things the same.
  - Agent innovating in which an element in a standard causes a disadvantage.

- Competitive advantage in detailed understanding what drives a design.
- Very specific/explicit standards: increased risk it hinders innovation.

Thoughts on Standard development

- How to fund the long-term efforts required for highly trained experts to support the standard developments in the academic context?
- Academic experts can act as "neutral" agents by providing impact analysis of what changes in the standards mean for different perspectives.
- Wind turbine standards are increasingly complex. Who has overview, the time, and can manage changes across documents?

Questions?



Thank you!