

Wind Energy Courses Overview – 2025

Different training options provided by JEHO BV

Essential: preventing aeroelastic issues

- **Avoiding resonance is never enough to avoid all possible issues**
- For every design the aeroelastic stability should be checked
- This evaluation is currently **NOT** part of the design process, it is done only implicitly through load calculations, this does not suffice!!!
- Knowledge of possible instabilities is vital (what you do not know, you cannot prevent)
- Know enough about resonances, including relevance of change in frequency due to whirling!

It causes the instability makes it possible to develop the

turbine aeroelasticity

Current size wind turbines can suffer from different instabilities

- Most important ones are:
 - Classical flutter (overspeed)
 - Damping of edgewise mode (shape edgewise mode becomes more and more complicated with coupling to e.g. torsion)
 - Pitched/twisting instabilities
- It would be wise to perform a full aeroelastic evaluation of the design:
 - Check aerodynamic damping in constant settings, different values around supposed operating conditions, excite the modes and see what happens.
 - Check for resonances
 - Check idling situations

HAWTs Upwind or Downwind

- Upwind or downwind
- Most common: upwind

Advantage Upwind	Advantage Downwind
Tubulartower: smaller tower shadow	Tower tip clearance not an issue (flexible blades)
	Passive yaw possible (though you will still need a yaw mechanism to keep cables in place)

Upwind or downwind

Large vibrations in your wind turbine measurements or in simulations (in blades and/or tower)?

Yes

No

Is the vibration frequency close to a natural frequency?

Yes

No

Is it also at an nP value? (1P= rpm/60)

Yes

No

Is it at an nP value?

Yes

No

Solutions:

- Add damping to mode
- Change natural frequency
- Change rpm
- Contact JEHO BV for expert advise

Solutions:

- Add damping to mode
- Change mode shape
- Change AOA
- Change aerofoil
- ...
- Contact JEHO BV for expert advise

Solutions:

- Find out how a mode is still involved and add damping to mode
- Reduce the excitation
- Contact JEHO BV for expert advise

Solutions:

- Contact JEHO BV for expert advise

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JEHO BV

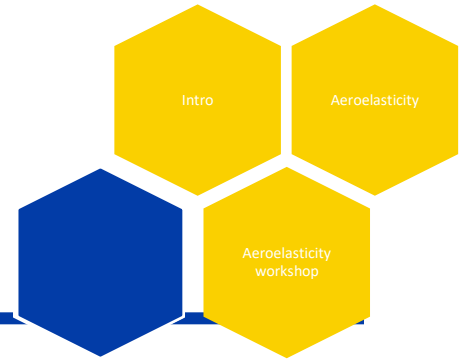
Wind energy courses



- Wind energy is a very successful industry at the moment, therefore every day there are people starting their new work in this field of expertise.
- We at JEHO BV provide different training options for those involved in the wind energy
- Our main expertise is wind turbine aeroelasticity and we provide several **unique** courses to cover this very complex area, but starting this year we will also provide a short introduction course for those new in wind energy.
- In this presentation we will shortly discuss the different courses we provide. For each course there is a leaflet available with a more detailed description.
- **We only provide on-line live web training which allows the training to be spread in time, which is much more efficient than fitting everything in a few long consecutive days.**



Courses we provide:



Wind energy introduction (2 sessions)

Basic aerodynamics for a wind turbine

Different concepts (2-3 bladed, Upwind, downwind, HAWT, VAWT, direct drive, offshore,...)

Cost of wind energy: how is it built up, where can we still improve,...

Turbine design: how, what, why,...

Wind turbine aeroelasticity (6 sessions)

Introduction course WT aeroelasticity

24 hrs of intensive training

Theory and practise are treated

Also possible to arrange confidential course for your company

The main issues are discussed: types of instabilities, their causes, their solutions as well as resonance issues

Participants will get hands on experience to identify some of the issues presented

Workshop (4 sessions)

Continuation of the initial course

Analyse your own turbine design to find possible issues

Or in an open setting an adjusted public design is evaluated

Step by step it is explained how issues can be found, identified and solved

A perfect course for people that have participated in the WT aeroelasticity course and want to refresh and extend their knowledge

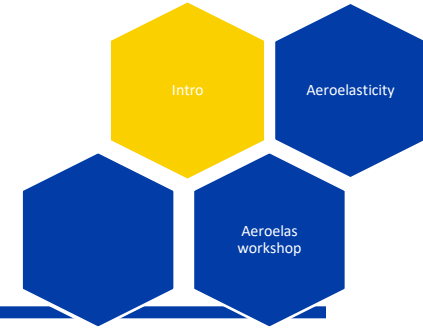
Evaluation training ($\approx$ 4 weeks)

We cooperate with one or more of your engineers and perform a complete aeroelastic evaluation of the design.

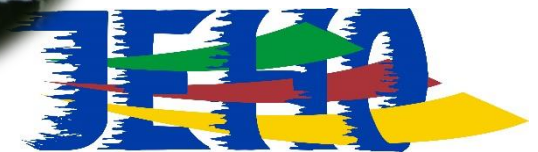
The engineers will gain significant experience and the design is checked for possible resonance and stability issues



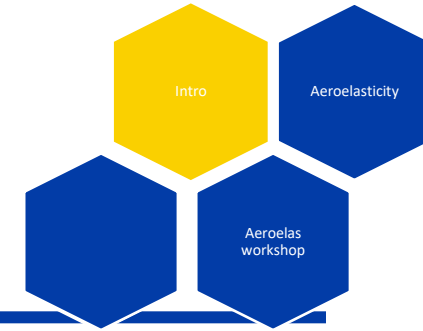
Wind energy introduction



- A very quick way to get acquainted with wind energy
- Different aspects are discussed:
 - Basic aerodynamics for a wind turbine
 - Different concepts (2-3 bladed, Upwind, downwind, HAWT, VAWT, direct drive, offshore,...)
 - Cost of wind energy: how is it built up, where can we still improve,...
 - Turbine design: how, what, why,...
- All this and more in just two sessions!



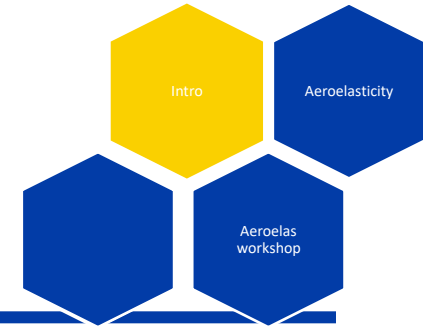
Wind energy introduction



- Get acquainted with the wind turbine
- Basic aerodynamics for a wind turbine
 - Why do turbines never generate all energy available from the wind?
 - How does a turbine generate energy?
 - Blade element and momentum theory in a nutshell
 - Power output of a wind turbine
 - Wind: shear flow, turbulence, Weibull
- Different concepts
 - What is HAWT, what is VAWT, different types of VAWT
 - Benefits of HAWT or VAWT
 - HAWT: why so often 3 blades?
 - Offshore: different possible support structures
 - Choice of drive train



Wind energy introduction



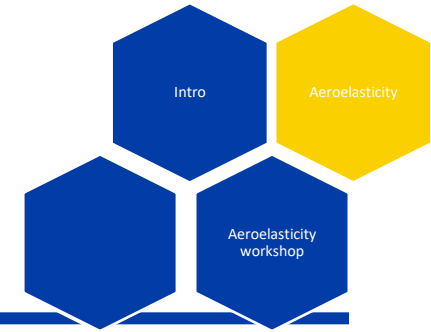
- Cost of wind energy:
 - Examples of cost built up
 - What has been done to get to current low costs?
 - Can we further reduce costs?
- Turbine design
 - How is a HAWT designed?
 - What calculations are needed and why (IEC, certification, fatigue and extreme loads)?
 - Small wind turbines vs large wind turbines

After completing this course you will be familiar with many of the basics of wind energy and understand why certain choices are made in the current designs. A great way to start your wind energy career!





Wind turbine aeroelasticity



- Wind turbines are flexible structures that have a strong interaction between elasticity and aerodynamics
- Therefore aeroelastic instabilities and resonance problems are a real risk
- This is often underestimated, until it happens
- The quickest way to get familiar with the risk, to gain knowledge of the most likely issues and how to prevent them, we provide several specialist courses/activities in this field.



A complete route



- Based on years of experience in wind turbine aeroelasticity as well as providing courses and workshops to the industry, we have set up a complete set of educational activities to effectively train wind turbine design engineers in finding and solving aeroelastic issues.
- The first step is a course of 6 weekly sessions. Then, preferably after a few months, this is followed by a workshop of 4 sessions. Finally during an evaluation training we can perform a full aeroelastic evaluation in close cooperation which will provide significant experience.
- All courses will always be for small groups (no more than 8 participants) to enable good interaction.
- When designing a new wind turbine (blade) a complete aeroelastic evaluation is an absolute must, to prevent many problems that are often not found until the prototype tests are performed.



Assume the reaction force to be:

- $F_{xR} = A \sin \omega t$; $F_{yR} = 0$

Transforming to non-rotating frame gives:

- $F_{xNR} = A \sin \omega t \cos \Omega t$
- $F_{yNR} = A \sin \omega t \sin \Omega t$

Using basic mathematics:

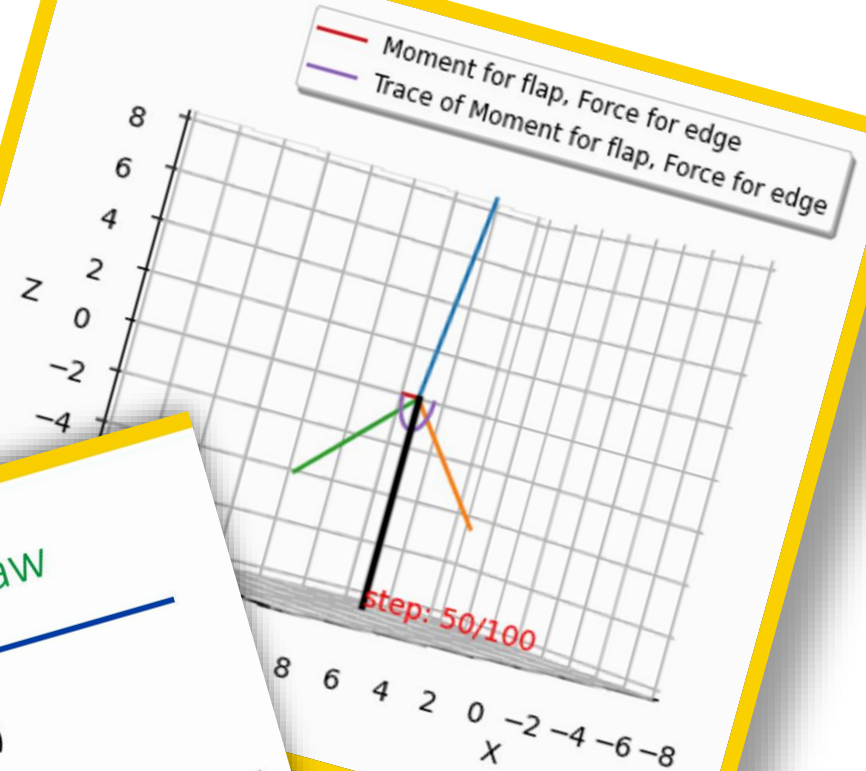
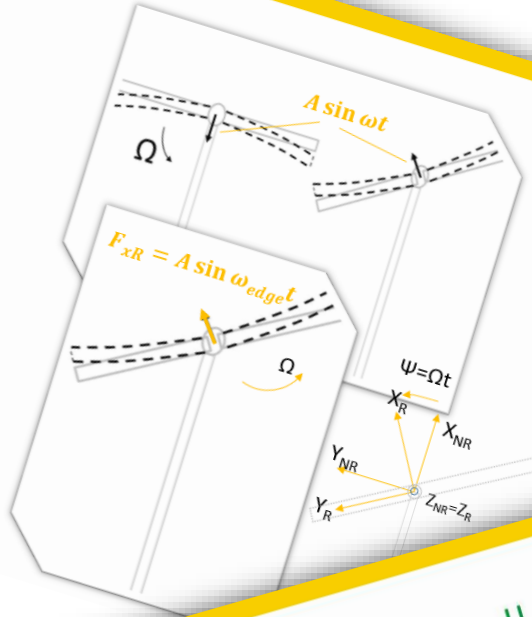
- $F_{xNR} = \frac{1}{2} A \sin((\omega - \Omega)t) + \frac{1}{2} A \sin((\omega + \Omega)t)$
- $F_{yNR} = \frac{1}{2} A \cos((\omega - \Omega)t) - \frac{1}{2} A \cos((\omega + \Omega)t)$

This change in frequency occurs only if the reaction force is in-plane

$$\sin(a)\cos(b) = 0.5(\sin(a+b) + \sin(a-b))$$

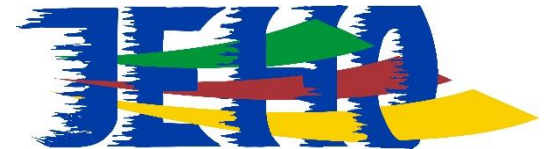
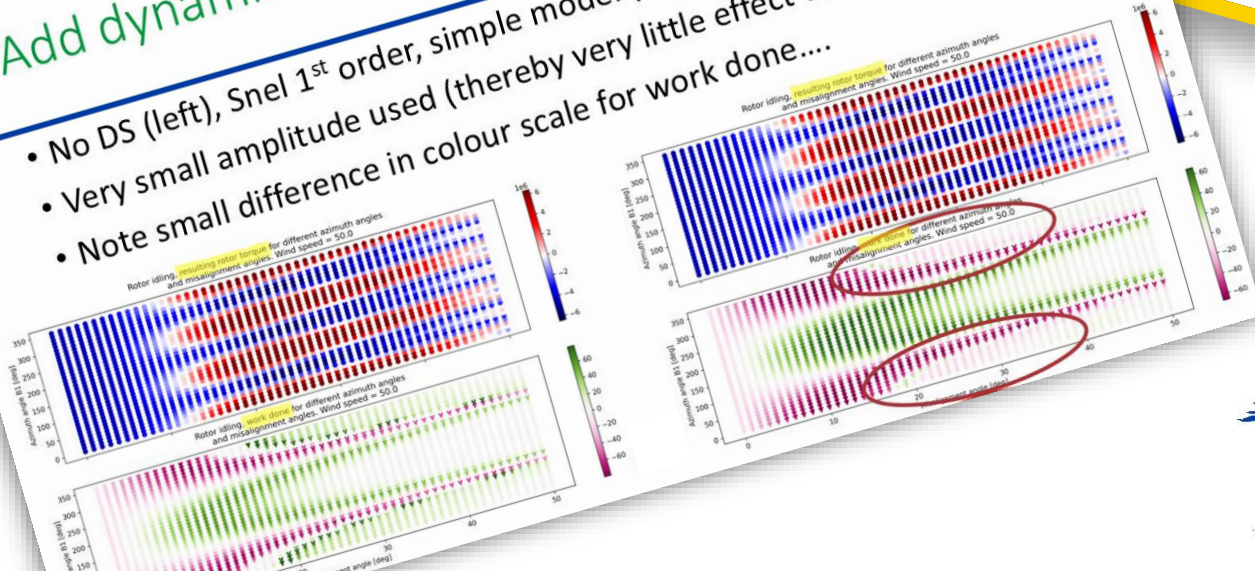
$$\cos(a)\sin(b) = 0.5(\cos(a-b) - \cos(a+b))$$

$$\cos(a)\cos(b) = 0.5(\cos(a+b) + \cos(a-b))$$



Add dynamic stall and smaller steps in yaw

- No DS (left), Snel 1st order, simple model (right)
- Very small amplitude used (thereby very little effect of DS)
- Note small difference in colour scale for work done....



Possible courses



Wind turbine aeroelasticity (6 sessions)

Introduction course

Six intensive 4-hour sessions

Theory and practise are treated

Also possible to arrange confidential course for your company

The main issues are discussed: types of instabilities, their causes, their solutions as well as resonance issues

Participants will get hands on experience to identify some of the issues presented

Workshop (4 sessions)

Continuation of the initial course

Analyse your own turbine design to find possible issues

Or in an open setting an adjusted public design is evaluated

Step by step it is explained how issues can be found, identified and solved

A perfect course for people that have participated in the WT aeroelasticity course and want to refresh and extend their knowledge

Evaluation training (≈ 4 weeks)

We cooperate with one or more of your engineers and perform a complete aeroelastic evaluation of the design.

The engineers will gain significant experience and the design is checked for possible resonance and stability issues



Wind turbine aeroelasticity course



- A course with 6 lessons
- Start with the relevant aerodynamics, this includes a discussion of engineering models that are included in many codes, how do they work, are there possible issues with these.
- The whirling of wind turbines will be explained, why does the frequency change its value when measured in rotating frame compared to fixed frame?
- Wind turbine aeroelasticity issues such as resonance and instabilities will be explained, covering all instabilities and resonances currently known to be relevant
- In several interactive sessions participants will try to find and identify issues as well as solve them efficiently by changing design
- Participants will become aware of possible issues, how to find issues and how to solve them
- This can result in significant load reductions as well as preventing loss of prototypes.



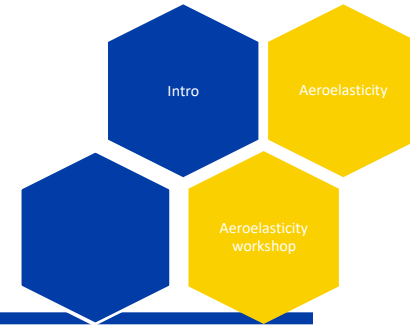
Workshop



- A workshop of 4 sessions
- Wind turbine aeroelasticity issues such as resonance and instabilities will be explained
- Your own wind turbine design can be analysed by the participants under the supervision of an expert
- Participants will become able to find issues and increase their capabilities on identifying the causes. This will allow them to find out how to solve them
- This can result in significant load reductions as well as preventing loss of prototypes.



Evaluation training ($\approx$ 4 weeks)



- Together with one or a few engineers, a full aeroelastic evaluation of your wind turbine design will be performed
- The engineers will learn by closely following the process and by actually helping during the evaluation. At the same time your design will be evaluated and the results presented by JEHO BV in a report or presentation.
- Performing a full aeroelastic analysis of a wind turbine is a typical job that actually requires many years of experience. However by following the process closely, your engineers will become more and more able to do at least large parts of the evaluation themselves.
- JEHO BV also provides the service of performing a full aeroelastic evaluation, please contact us for more information or look on our website: www.jeho.nl



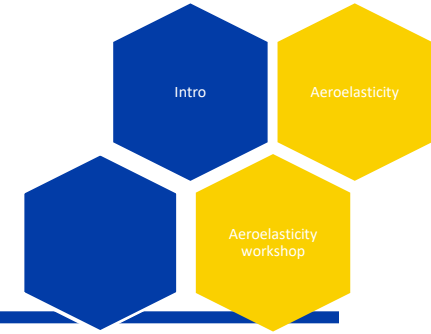
Who should participate in these training opportunities?



- The aeroelasticity trainings are designed for engineers that already have some experience in wind energy, specifically wind turbine design or wind turbine loads
- Very basic knowledge of aerodynamics, dynamics and wind energy is expected
- The participants should have a laptop at their disposal
- Software that will be used during course or workshop will be supplied before the course. JEHO software is only to be used during the actual days of the course or workshop.



Tools



- Tools that are used in the aeroelasticity workshop/course:
 - Either your own licensed tool (e.g. Bladed, FOCUS Phatas,...)
 - Or the open-source tool OpenFAST from NREL can be used
- Together with a JEHO tool that is specifically developed for illustrational purpose (WAF1C)





Who will give the courses?

- Dr. ir. Jessica Holierhoek has well over 20 years of experience in wind turbine aeroelasticity, focussing on instability and resonance.
- Currently managing director of JEHO BV specialising in bringing this knowledge to the industry.
- Experience gained at Delft University of Technology (including PhD), at ECN and of course as director of JEHO BV
- Experience in research, tool development and teaching/training



Two options



- We provide the courses and the workshop in two different ways:
 - OPEN session: for all engineers, so engineers from different companies come and take part in the course or workshop. For the aeroelastic courses a ready model can be supplied, though it is also possible for the engineers can work on their own design, nothing will be shared with other participants
 - PRIVATE: organised for one company only. In this case the expert can provide more support in the analysis of the companies own design and discuss it more easily. It is also possible to add a certain focus to the course based on current issues relevant for the company.



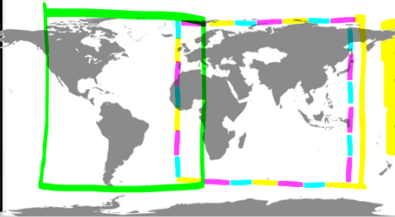
Schedule 2025 open courses ON-LINE

Online live web training sessions **wind turbine aeroelasticity course**. Small groups of participants, allowing pleasant interaction between instructor and participants.

Six times, each week a four-hour training session or eight times twice a week a three-hour training.

Scheduled training times are suitable for different locations, as indicated in the world map

February						
M	T	W	T	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		



8x3 hours: Mondays & Thursdays in February
Time: 9-12 CET

April						
M	T	W	T	F	S	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May						
M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

6x4 hours: Tuesdays April 15 – May 20
Time: 18-22 CEST

September						
M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October						
M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

6x4 hours: Thursdays
September 25 – October 30
Time: 9-13 CEST (Sep 25-Oct 23) & 9-13 CET (Oct 30)

November						
M	T	W	T	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December						
M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

6x4 hours: Fridays November 14 – December 19
Time: 9-13 CET

Interested in attending?
Contact us: workshop@jeho.nl



Costs for different options (2025)

- OPEN introduction to wind energy course on-line (2 * 4 hours), including lunch: €600 per person (not yet scheduled)
- OPEN Live web training aeroelasticity (six sessions, max 6 participants): €2040 per person ([schedule](#))
- PRIVATE Live web training aeroelasticity (six/eight sessions, max 8 participants): €8150¹
- OPEN Live web workshop aeroelasticity (4 * 4 hours): € 1450 per person (not yet scheduled)
- PRIVATE Live web workshop aeroelasticity for a max 6 participants: € 6800
- Evaluation training, costs depend on your requirements

All prices mentioned are excluding VAT and possible other taxes (e.g. withholding tax). Please contact us if you would like to receive a personal offer for any of these products.

¹ If you would like all participants to pass a test at the end of the training, to check if they have actively and effectively participated, we can provide individual (unique) final tests at €75 each



Interested?

- If you have any questions or are interested in any of the courses, workshops or training, please get in touch with us: workshop@jeho.nl
- If you want to receive a more detailed description of any of the products at offer in this leaflet, please contact us and we can send you a presentation for the specific product: workshop@jeho.nl



Thank you!

