QUICK GUIDE – LIFETIME ANALYSIS

Purpose:

The following quick guide shows you how to perform a lifetime analysis according to DNVGL-ST-0262 (2.2 Analytical part) using the LOAD RESPONSE module in windPRO 4.0. This fatigue lifetime calculation provides indicative results and is intended as an initial analysis of the potential for a lifetime extension of the WTG asset.

Outline of Guide:

- 1. Prerequisites for the analysis
- 2. Setting up the analysis
- 3. Reviewing results

1. PREREQUISITES FOR THE ANALYSIS

The lifetime analysis in windPRO 4.0 is performed using the LOAD RESPONSE module. As a result, you must ensure that both the SITE COMPLIANCE and LOAD RESPONSE modules are installed, and you have valid licenses for both.

From the "Settings & Help" tab clicking "Show window" all your installed modules can be viewed. If both SITE COMPLIANCE and LOAD RESPONSE are installed and licensed properly you should see the same as shown below.

М	Iodules	푸	\times
>	Basis	 	
>	Energy		
>	Environment		
>	Visual		
>	Economy		
>	Optimization		
>	Electricity		
Ý	Loads		
	SITE COMPLIANCE (WTG suitability for site and layout)		
	LOAD RESPONSE (WTG load and lifetime estimation)		
>	Operation		
>	Cluster Services		
>	Other		

2. SETTING UP THE ANALYSIS

Firstly, a SITE COMPLIANCE analysis must be performed, where LOAD RESPONSE must be included in the main tab.

SITE COMPLIANCE (WTG suitability for site a	nd layout)	
Main Mast data WTGs Mast-WTG Long te	rm correction 🖌 WASP 🗸 WASP-CFD 🖌 WEng 📒 IEC checks 🖉 LOAD RESPONSE D	Descriptio
Name Mast and flow model + Load respons		
Site and layout check using: Mast data & flow model(s) Mast data only No mast data Jrd party WTG results (*.sml) Ambient site result (*.siteres) Offhore site	How models: Wing Wing Wing Wing Wash-CPD Wing Mast directly Noverse CFD results Downscaling	
Load calculation / curtailment:		
Include LOAD RESPONSE		
Design standard: IEC61400-1 ed. 3 (201	0) -	
 Use design class from WTG object 		
 Overrule WTG design class with 	IA -	
Basic design parameters		
Wind speed class	1 II III	
Vref [m/s]	50.0 42.5 37.5	
Vmean [m/s]	10.0 8.5 7.5	
k [-]	2.0 2.0 2.0	
Turbulence class	А В С	
Iref [-]	0.16 0.14 0.12	
Certification history of SITE COMPLIANC	E / LOAD RESPONSE: Version notes	
ok Canad		
<u>U</u> K Cancel		

In the LOAD RESPONSE tab, the lifetime analysis is included by checking the "Include "DNVGL-ST-0262 Lifetime analysis" box.

SITE COMPLIANCE (WTG suitab	ility for site and layout)						×
Main Mast data WTGs Mast-W	/TG Long term correcti	ion 🖌 WAsP 🖌 WAsP-0	FD 🖌 WEng	IEC checks	O LOAD RESPONSE	Descrip	tior
Design standard: IEC61400-1	ed. 3 (2010)						
WTG design class: IA							
Select WTG response file							
Show only type/name:	Generic models	Carbon i acturer Direct D	n blades ('Carbor ive ('DD')	י)			
 Select for all WTGs 	EMD Generic RD>=9	0m	*				
 Select individually 	Select	Define load r	argins				
Result legend	2" Lifetime analysis eric turbine design: [No WTGs ex	High similarity (low uncerta	nty) - 🕫				
Cri	tical ≥1 WTG exc	ceed IEC loads					
Load Include Setup	/Calculate Result	Load Index	WTG	Comment			
(Re)calculate all	Show	result as: Ioad Index	Fatigue L	ifetime			
Note: - LOAD RESPONSE does - LOAD RESPONSE appro - The estimated loads fro - Fatigue life does not inc - The accuracy of suitabil - Consult the manufacture	not include the effect of ximates WTG loads usin im the response surface dude other degradation ity analysis based on a er for final verification of	special operation modes. ng a response surface meth a are, thus, subject to a sm processes like e.g. corrosi generic WTG depends on t of suitability.	od based on pre- all model uncerta n. le representativit	run aero-elasti inty. y of the WTG a	c simulations. nd load margins.		
Qk Cance	I						

When using a generic WTG response file, you must further specify the similarity of your WTG with the generic turbine model.

Choosing e.g., high similarity results in a lower amount of uncertainty included in the lifetime assessment. As a result, this decision should be considered carefully to include appropriate uncertainty

Quick Guide – Lifetime Analysis

in the fatigue life assessment. The generic turbine model to compare your WTG with is a standard 3-bladed with standard nacelle/hub, steel tower and collective pitch, similar to e.g., NREL 5MW or DTU 10MW.

SITE COMP	LIANCE (W	TG suitabi	ility for site a	nd layout)						×
Main Mast da	ta WTGs	Mast-W	TG Long te	erm correction	✓ WAsP ✓ WAsP-C	D 🗸 WEng	IEC checks	O LOAD RESPONSE	Descri	ptio
Design stan	dard: IE(61400-1	ed. 3 (2010))				-		
WTG design	dass: 14									
Select WTG	response	e file								
Show or	nly type/na	ime:	Gener	ic models ic to manufactur	rer Direct Dri	blades ('Carbi /e ('DD')	on')			
Selection	ct for all W	/TGs	EMD Gen	eric RD>=90m		-				
O Selection	ct individua	ally	Select		Define load m	argins				
Result legen	nd	Ok Crit	tical	lo WTGs e Low ≥1 WTG exceed	similarity (low uncertain ium similarity (medium usimilarity (high uncertain IEC 10805	ity) incertainty) nty)				
Load	Include	Setup/	Calculate	Result	Fatigue Lifetime [yea	rs] WTG	Comment			
atigue loads										
	(Re)calc	ulate all		Show resul	It as: 🛛 Load Index	Fatigue	Lifetime			
Note:										
- LOAD - LOAD - The e - Fatig - The e - Cons	D RESPON D RESPON estimated gue life doe accuracy o sult the ma	SE does n SE approx loads fro es not ind of suitabili nufacture	not include t dimates WT m the respo lude other o ity analysis er for final y	he effect of spe G loads using a onse surface are degradation pro- based on a gene verification of su	cial operation modes. response surface metho e, thus, subject to a sma cesses like e.g. corrosio eric WTG depends on th itability.	d based on pr II model uncer n. e representativ	e-run aero-elas tainty. ity of the WTG	ic simulations. and load margins.		
Qk		Cancel								

Access the calculation setup by clicking the "Edit" button as shown below.

钉 SITE COMP	LIANCE (W	TG suitability for site	and layout)						×
Main Mast da	ta WTGs	Mast-WTG Long	erm correction	✓ WAsP ✓ WAsP-CFD	✔ WEng	IEC checks	O LOAD RESPONSE	Descrip	ption
Design stan	dard: IEC	61400-1 ed. 3 (201	0)						
WTG design	dass: IA								
Select WTG	response	file							
Show or	ily type/na	me: Gene Speci	ric models fic to manufactu	er Direct Drive (des ('Carbon 'DD')	')			
Selection	t for all W	TGs EMD Ger	eric RD>=90m		-				
Selection	t individua	elly Selec	t	Define load margi	ns				
WTG Result legen	similarity i	Ok Critical	design: High No WTGs exceed ≥1 WTG exceed	similarity (low uncertainty) I IEC loads IEC loads	- 0				
Load	Include	Setup/Calculate	Result	Fatigue Lifetime [years]	WTG	Comment			_
atigue loads	2	Edit							
	(0-)	data all	ch		0.5454	fettere a			
	(Re)calc	ulate all	Show resu	t as: 🔘 Load Index	 Fatigue L 	fetime			
Note: - LOAD - LOAD - The - Fatig - The - Cons	RESPONS RESPONS estimated ue life doe accuracy o ult the ma	SE does not include SE approximates W loads from the resp is not include other if suitability analysis nufacturer for final	the effect of spe IG loads using a onse surface are degradation pro based on a gen verification of su	cial operation modes. response surface method b t, thus, subject to a small m sesses like e.g. corrosion. rric WTG depends on the re tability.	ased on pre- odel uncerta presentativity	run aero-elas nty. r of the WTG	tic simulations. and load margins.		
Qk		Cancel							

Verify that the design life in the WTG information window corresponds to your specific WTG. By default, this is set to 20 years.

Consider including the DLC other in the IEC design load case (DLC) window. Since excluding the contributions from start-up, shut-down and parked conditions would result in an overestimation of the lifetime assessment.



After reviewing the remaining load calculations setup options perform the lifetime analysis by clicking the calculate button.

3. REVIEWING RESULTS

After the calculations are performed (typically only a few seconds) several results tabs will be available.

The lifetime estimates for each WTG can be viewed at the "Results (Map)" tab. The figure visualizes how the fatigue lifetime estimates of the WTGs vary across the site.



In the "Results (Table)" tab the fatigue life and the standard deviation of the fatigue lifetime can be viewed for each sensor included in the WTG response model.

Fatigue loa	ds									
Setup Result	s (Table) Results (G	raphics) Result	ts (Map) Li	fetime Extension						
 Name 	Design Class	Component	Sensor	Sensor descript	w	L	L	Fatigue lifetime [y]	Fatigue lifetime st.dev. [y]	Visualize damage matri
> 724	Class IA	Blade	BirMx1	Root in-plane bendi			1.0	28.8	3.0	
> T26	Class 1A	Blade	BirMtx1	Root in-plane bende		-	1.0	28.3	2.9	
> T27	Class IA	Blade	BirMtd	Root in-plane bendi		1.04	1.0	27.8	2.9	
> T28	Class 1A	Blade	BirMtx1	Root in-plane bendir			1.0	28.6	3.0	
> T29	Class IA	Blade	BirMtx1	Root in-plane bendli			1.0	27.2	2.8	
> T30	Class IA	Blade	BirMtx1	Root in-plane bendi			1.0	25.6	2.6	
> T32	Class IA	Blade	8krMtx1	Root in-plane bendir		1.6.4	1.0	26.7	2.8	
> T34	Class IA	Blade	BirMoxI	Root in-plane bendir		100	1.0	26.4	2.7	
> T35	Class IA	Blade	8lrMx1	Root in-plane bendi			1.0	26.7	2.7	
> T37	Class IA	Blade	BirMtx1	Root in-plane bendir			1.0	27.6	2.9	
> T38	Class IA	Blade	BirMtk1	Root in-plane bendir			1.0	28.0	2.9	
> T39	Class IA	Blade	BirMtc1	Root in-plane bendir			1.0	26.7	2.8	
> T40	Class 1A	Blade	Birthut	Root in-plane bendi			1.0	29.2	3.0	

Finally, the "Lifetime Extension" tab presents general information about the lifetime analysis. Furthermore, it outlines main assumptions and uncertainties related to the calculations and summaries the expected lifetime extension potential of the WTGs.

7	
	7

It should be noted that the calculation only covers the analytical part of the DNVGL-ST-0262 lifetime assessment which states that there must always be a practical part, with detailed physical inspections of the WTGs in any lifetime extension of a WTG.

Nevertheless, this simple fatigue lifetime assessment can be indicative of the potential of a lifetime extension. As a result, it would provide valuable input to the planning process of any WTG park or as an initial analysis of the potential of a lifetime extension of an existing park.

For more detailed information about the theorical background for the lifetime analysis please refer to LOADS manual.