QUICK GUIDE - SITE COMPLIANCE

Purpose:

To check if a particular IEC turbine class (e.g. IIA) complies with the site and layout conditions.

SITE COMPLIANCE calculates the seven main checks required in IEC 61400-1 ed. 3 (2010) site assessments:

- Terrain Complexity
- Extreme Wind
- Effective Turbulence
- Wind Distribution
- Wind Shear
- Flow Inclination
- Air density

Three additional IEC checks are also included:

- Temperature range
- Seismic hazard
- Lightning rate

Note: IEC61400-1 ed. 4 (2018) will be released with the release of the standard, planned for June 2018.

WEng 4.0 is required for including effect of obstacles.

Outline of Guide:

- 1. Data and models needed in SITE COMPLIANCE
- 2. Setup input data in SITE COMPLIANCE
- 3. IEC Main calculations in SITE COMPLIANCE
- 4. Re-calculate for a different WTG class
- 5. Calculation of Other IEC checks

1. DATA AND MODELS NEEDED IN SITE COMPLIANCE

SITE COMPLIANCE can be used at various levels of input data and external software licenses.

Full functionality is obtained in projects with site mast(s) with multiple heights, a long-term reference series and valid external licenses for both WAsP and WAsP Engineering (WEng 4.0).

Minimum data level is a site mast with multiple measuring heights but no external model licenses.

Projects with no on-site mast require valid external licenses for both WAsP and WEng and a wind statistics (lib file) to complete all seven IEC main checks.

Make sure that your project at least contains following data/licenses before you start SITE COMPLIANCE:

- 1. A layout of WTGs
- 2. A digital elevation model, line or grid (TIN)
- 3A. A site mast with multiple heights
- 3B. A site data object (with a wind statistic)A valid WAsP licenseA valid WEng 3.0 or 4.0 license

In the following guide we assume a project allowing full functionality in SITE COMPLIANCE, i.e. a project with a site mast with multiple measuring heights and valid WAsP and WEng 3 licenses. We also assume that a longterm corrected wind statistics has already been created from MCP, although this is not a general prerequisite.

2. SETUP INPUT DATA IN SITE COMPLIANCE

Start Site compliance from the main menu.

M	odules
۲	Basis
۲	Energy
Ó	Environment
١	Visual
۲	Economy
۲	Optimization
è	Electricity
ģ	Loads
	SITE COMPLIANCE (WTG suitability for site and layout)
	 IDAD RESPONSE (WTG load estimation)
۲	Operation
۲	Cluster Services
۲	Other

Main - tab

In this example we have both **mast and flow models** available so we check this option.

Mark the flow models available: **WEng** (check) and **WAsP** (check). In this example we have a site data object with a **long-term corrected wind statistics** available (check).

For the WTG positions in this example we wish to test an IEC class of IIB. You may select this class specifically via **overrule WTG design class with** IIB (dropdown box).



Alternatively, the WTG class may be defined individually in each WTG object prior to starting SITE COMPLIANCE.

Mast data - tab

Here you see a list of all the Meteo objects in the project. Check the site mast(s) you want to use and it will expand and show the heights to be selected.

Purpose should be **Site mast** (default) and you must define the **Main height** (check) and the heights to be **used in shear calculations** (multiple checks).

😽 SIT	E COMPLIANCE Beta (WTG suitat	aility for site and la	yout)										
Mair	Main Mast data Layout Mast-WTG 🗸 WAsP 🗸 WEng Calculations Description												
Name		Purpose	Main height	Used in shear calc	Sample rate [min]	Duration (enabled) [years]	Recovery (enabled) [%]	First	Last				
- 2	MERRA	Long term ref											
۲	50.0m -		•		60.0	30.3	99.9	31/12/1981 18:0	30/04/2012 17:0				
•	NCAR												
•	Quick Mast	Site mast 🛛 💌											
۲	40.0m -		•	V	10.0	1.0	100.0	01/07/2001	30/06/2002 23:51				
÷	30.0m -		0	2	10.0	1.0	100.0	01/07/2001	30/06/2002 23:51				
ė	10.0m -		0	¥	10.0	1.0	100.0	01/07/2001	30/06/2002 23:51				

Note:

Any red data fields might indicate potential problems with the data, like too short data period, too low recovery rate or non-standard sample rate and should be investigated further in the Meteo object!

Check your long-term reference series (if any) and set "Purpose" to "Long term reference" (dropdown) and define the "Main height" (check).

Layout - tab

Select the layer(s) with your layout (check).

Main	Mast data	Layout	Mast-WTG	🖉 WAs	P 🖉 WE	ing Calculations	🛛 Descri 🗹
Layers	3						
Gee Hei WT Cor WT Met Rou Rou Obs	eral data ght contours G Layout ntrol points G Area teorological ughness are ghness line stacles e data objec	data as is ts					
Use al	l objects fro	m select	ed layers				
Nev Nev	v WTG (20) sting WTG (7 01					

Mast-WTG - tab

Select which site mast is representative for each WTG, default is nearest site mast. With only one mast the choice is simple...

Main	Mast d	ata La	yout	Mast-	WTG	0 w	AsP	Ø WEr	ng	Calculations	Description
⊙ Us	e neare:	st mast					ΟM	lanual ma	ast-	WTG matrix	
WTG											Quick Mas
VEST	AS V80-	1.8MW	60H:	z 1800	80.0	!O! hub	70.0	m (TOT:	11	0.0 m) (56)	•
VEST	AS V80-	1.8MW	60H	z 1800	80.0	IOI hub	70.0	m (TOT:	11	0.0 m) (57)	•
VEST/	AS V80-	1.8MW	60H;	z 1800	80.0	IOI hub	70.0	m (TOT:	11	0.0 m) (58)	•
VEST/	AS V80-	1.8MW	60H;	z 1800	80.0	!O! hub	70.0	m (TOT:	11	0.0 m) (59)	•
VEST/	AS V80-	1.8MW	60H;	z 1800	80.0	!O! hub	70.0	m (TOT:	11	0.0 m) (60)	۲
VEST	AS V80-	1.8MW	60H:	z 1800	80.0	!O! hub	70.0	m (TOT:	11	0.0 m) (61)	۲
VEST	AS V80-	1.8MW	60H	z 1800	80.0	!O! hub	70.0	m (TOT:	11	0.0 m) (62)	۲
VEST	AS V80-	1.8MW	60H:	z 1800	80.0	IOI hub	70.0	m (TOT:	11	0.0 m) (63)	•
VEST/	AS V80-	1.8MW	60H;	z 1800	80.0	IOI hub	70.0	m (TOT:	11	0.0 m) (64)	•
VEST/	AS V80-	1.8MW	60H;	z 1800	80.0	IOI hub	70.0	m (TOT:	11	0.0 m) (65)	•

WAsP - tab

Match each mast in the list with the relevant site data object that contains the long-term corrected wind statistics based on that mast (dropdown).



Press the yellow **Run WAsP calculation** button. The red stop icon on the WAsP tab becomes a green tick mark when WAsP is done.

ſ	VITE COMPLIANCE Beta (WTG suitability for site and layout)	
	Main Mast data Layout Mast-WTG 🗹 WAsP 🖉 WEr	ng Calculations De

WEng - tab

Select a site data object (dropdown) to define the terrain and roughness files to be used by WEng.

Current WAsp Engin	neering version: WEng 3
Setup	
Select site data ob	aject (WAsP or Statgen purpose):
Site data for WAst	P V
Advanced	
Buffer around all m	nasts/WTGs
5,000 m	
Grid resolution	
50 m	
Number of grid poin	nts
North - south	263
East - west	226

Press the yellow **Run WEng (WAsP Engineering) calculation** button. The red stop icon on the WEng tab becomes a green tick mark when WEng is done. Note that WEng may take several minutes for large projects.

ſ	TITE COMPLIANCE Beta (WTG suitability for site and layout)
	Main Mast data Layout Mast-WTG 🗸 WAsP √ WEng Calculations Description

3. IEC MAIN CALCULATIONS IN SITE COMPLIANCE

The **Calculations** tab is where the calculation of the IEC checks takes place.

Mark all the **Main checks** (check) to prepare a full site assessment. This enables an "Edit" button for each check which is ready for calculation. Notice that **Terrain complexity** check is required by some checks.

Notice the "Result legend":

Red = Critical

Issues likely to hamper the project - must be approved by the manufacturer.

Yellow = Caution

Issues not likely to threaten the project, but should be discussed with the manufacturer.

Green = OK

Unlikely to cause problems to the project.

Terrain complexity - check

Start the Terrain complexity check by pressing Edit.

You only have one active elevation model, the Active DEM (Digital elevation model).

Terrain complexity	HORE - MICONSTRUCTS MICONS	000100	
Setup			Active DEM
Name			
Active DEM			
Active elevation model (Line or Elevation grid object)	Grid resolution: 100	m	
			Selected O Shown
			Add new Remove
			Calculate
Qk Cancel			

Press Calculate (lower right).

This enables more tabs showing the results of this IEC check. Notice the green square in the upper right corner indicating that in this case the overall result of the check is "OK". The reason is that all WTG positions are "not complex".

etup	Results (Table)	Results (Graphics)		 Actin 	DEM
and a		Result Terrain complexity indicator	- Complex - Not complex		
in completely in	8			Selected Shown	G
Terra				Add new	Remove
-	2 4	B B 10 12 14 16 1 WTG number (Mouse over point to view name)	18 20	Calc	ulate

Extreme wind - check

Start the **Extreme wind** speed calculation by pressing **Edit**.

Default **Statistical model** with this setup is the **POT-N & Gumbel** method. **N** is the number of extracted storm events and can be adjusted, but 10-20 events is usually a good choice. Δt is the minimum time separation required for storm events to be independent. Four days is a typical value for synoptic events (extratropical storms).

Setup		POTA	K_WENG
lama			
OT.N_WEAG			
Statistical model			
POT-N & Gumbel N = 20 & & = 4 days	(quality: B)		
D Webull parent (EWTS/Bergstotm) N = 2.307	(quality: C)		
Rise NCEP/NCAR estreme wind atlas	(quality: C)		
Eurocoda EN1991-1-4 Base wind speed # 81 m/s Octomer * Octomentar Oldmentar	(quality: -)	8	
Propagation model			
WEng (sector-exise mast-to-etg speedup)	(quality: A)		
) WAsP (sector-wise speedup)	(quality B)		
D Shear (sector-wise vertical extrapolation only)	(quality C)		
O No model (mast assumed representative)	(quality C)		
Additional model settings			
C Index connect POTH & Gambel ")			
Air density @ high wind speed p = 1025 kg/m*			
Nchide 3s gust estimate Kb = 31		Salacted	
Distactor pre-conditioning k = 10 Delaut is mean k for all WTGs		Shewn	Ě
manes 25 years data		Add new	Remove
assumes base height and roughness as defined Weng advanced setup		Calo	ulate
		1	

Press calculate.

Results (Table) summarizes the 50 year extreme wind speed result for each WTG and the IEC limit for the WTG class. In the case shown all WTGs are OK (green), and hence the overall result for the park (see square in upper right corner) is also green (OK).

		Name			Mast	Class	u 50y (mis)	IEC max (Vivit) (m/s)	
UVESTAS VO	3-1.8MW 60H	1800 80.0 101 hub:	70.0 m (TOT)	110.0	Quick Mas	18	312	42.5	
VESTAS VO	D-1 BMW GDH:	1800 88.0 KM hub:	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
J VESTAS VO	0-1 SMW 60H	1800 80.0 KH hub	70.0 m (TOT:	110.0	Quick May	18		42.5	
J VESTAS VO	3-1.8MW 60H	1800 80.0 101 hub	70.0 m (TOT)	110.0	Quick Mas	18		42.5	
J VESTAS V8	D-1 SMW 60H	1800 80.0 101 hub	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
D VESTAS VO	D-1 BMW 60Hb	1800 80.0 KM hub:	70.0 m (TOT:	110.0	Quick Mas	10		42.5	2
D VESTAS VO	D-1.8MW 60Hz	: 1800 80.0 KH hub	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
J VESTAS VØ	3-1 SMW 60H	1800 80.0 101 hub	70.0 m (TOT)	110.0	Quick Mas	18		42.5	
VESTAS VO	1.1 MW GOH	1800 80.0 101 hub:	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
J VESTAS VO	D-1.8MW 60Hb	1800 80.0 101 hub.	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
# VESTAS V8	1-1.8MW 60Hz	1800 80 0 KOI hubr	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
J VESTAS V9	D-1 BMW 60Hb	1900 80.0 101 hub	70.0 m (TOT)	110.0	Quick Max	18		42.5	5
J VESTAS VB	3-1 BMW 6DH	1800 80.0 KM hub:	70.0 m (TOT:	110.0	Quick Mas	10		42.5	
VESTAS VØ	D-1.8MW 60Hs	1800 80.0 101 hub:	70.0 m (TOT:	110.0	Quick Mas	18		42.5	
J VESTAS VØ	D-1.8MW 60H	1800 80.0 KH hub	70.0 m (TOT:	110.0	Quick Max	18		42.5	and the second second
J VESTAS VO	D-1.8MW GDHs	1800 80.0 KM hub:	70.0 m (TOT:	110.0	Quick Mas-	#3		42.5	Selected
VESTAS VØ	1.1.8MW GDH	: 1800 80.0 10f hub:	70.0 m (TOT)	110.0	Quick Mas	18		42.5	Shown
J VESTAS VØ	3-1.8MW 60Hz	1800 80 0 101 hub	70.0 m (TOT:	110.0	Quick May	18		42.5	And share 1 man
J VESTAS VO	D-1 BMW 60H	1800 80 0 101 hub	70.0 m (TOT)	110.0	Quick May	18		42.5	NOU THIN T YOU
J VESTAS V8	3-1.8MW 6DH	1800 80.0 KOI hub:	70.0 m (TOT:	110.0	Quick Mas	16		42.5	Calculate

You may click Add new (lower right corner) to add another calculation setup for extreme wind to compare the results. Select "Weibull e.g. parent (EWTS/Bergström)" and press Calculate. Now you have two result options you can compare. Try also "Risø NCEP/NCAR extreme wind atlas" which covers most of Europe and US. Each calculation adds a line in the right pane. Click on a calculation in the pane to highlight it and view its setup and results tabs. The calculation which is checked defines the result to be used in the site assessment.

Effective turbulence - check

The Effective turbulence check is maybe the most complex of the IEC calculations. This check does not result in a single result per WTG, but the effective turbulence must be calculated and checked for a range of wind speeds.

Press Edit to initiate the calculation.

Fortunately, the default settings will usually be a good choice. The setup is has three main decisions/sections. **Turbulence data**, defines ambient turbulence and it should be handled. **Propagation model**, defines how/if the turbulence data shall be transferred from the mast to each WTG position and hub height. **Frandsen model**, defines the parameters in the Effective turbulence calculation, mainly the **Wöhler exponent**, where m=10 represents fiberglass composites.

Setup			_						Mast	WEng
Mast WEng										
Turbulance d	Lut a									
 Ambient to 	urbulence from mast m	easurements						(quality: A)		
Mean of	sector wise	use bins N>	10	Use ft for all bins						
St.dev.o	weighted mean	use bins N>	50	E Use ft for all bins	O Auto	O Linear fit	O Robust fit			
Ambient to	urbulence from WEng r	esuit (no mast d	(etel	Call	bration constant	5.83		(quality: B)		
Deseasation	model									
 Scale turb 	sulence using:									
⊙ WEr	ng turbulence							(quality: A)		
O WAs	sP sector speed-up							(quality: B)		
Scaling	g method.									
	 Asymptotic 	O Consta	int σ-i	HIDE	O Uniform					
O No scaling	1									
Turbulence s	tructure correction								2	
Complex to	errain (ic>0) correction	from: O Com	plexit	y check O WEng	g turbulence comp	onents O No co	mection			
Frandson m	odel									
Wohler expo	ment 10									
Large wind f	arm correction O A	lutomatic	0/	d WTGs	O No WTGs				Selected Shown	4
Sector mana	agement		-						1 Add annual	Demo
Exclude '	WTG wakes within	Re		Hotor dameters					weit bew	- namo
									and the second sec	- Andre

Press calculate.

Results (Graphics) presents the results graphically and the relevant check interval, here from 9 to 25 m/s. Light red highlights where the calculated WTG effective turbulence exceeds the IEC limit (here at low wind speeds) within the check interval.

VESTALE VER-1 BANK 6565 SEE B Marc 1 EX C	E E O' Nali: TE E III (707: 148 E III) (60) David Haat David Ba	Official statutes Official statutes Official statutes	
u .			
11 11 11 11 11 11 11 11 11 11 11 11 11	****	0.00.04	Selucted C Stean

Click OK and the turbulence calculation gets an overall yellow result. Thus, the WTG effective turbulence

Quick Guide - SITE COMPLIANCE

exceeds the IEC limit for some wind speeds, but not in a critical way.

Wind distribution – check

Press **Edit** to initiate the Wind distribution check.

Setup			WAsf	Weibulks
Name				
WAsP Weibulls				
	(marker A)	ŝ		
WASH sector-laise vielouis Mast sector Weibull PDEs deaths (shear peopled)	(quality A)	1		
Mast Weibull directly	(quality: C)	l		
		2	Selected	
			Add new	Remove
			Calci	ulato

Default with this setup is **WAsP**. Press **Calculate**.

In this case the check is overall not passed. In **Results** (Graphics), light red highlights wind speeds within the check interval where the IEC limit is exceeded.



Flow inclination check

Press Edit to initiate the Flow inclination check.

Setup	-	 WEn 	9
lame			
NEng			
WEng (WAsP Engineering), flow modelling results (quality)	A)		
D Terrain fitting (5xHH disc) from complexity check (quality:	C) ,	Selected Shown	0
		Add new	Remove
		Calc	ulate

The inflow angles may be estimated using either the flow result from **WEng** or from the **Terrain complexity** calculation. We use **WEng** as it is the default option and hence expected to produce the best results. On the **Result (Graphics)** we can see that all angles are within the IEC limits of +/-8 degrees; all the dots are green (OK) and the overall result marker in the upper right corner is also green.

Heready	Results (Table) Results (Graphics)	_	 WEng
	istaw		
	• Official		
7.4	• · · · · · · · · · · · · · · · · · · ·	1	
logo o			
anda -		,	Selected .
-6			Shown
-			Add new Remove
	WTO number (Nouse over poet to view name)		Calculate

Wind shear - check

Press Edit to initiate the Wind shear check.

betyp		O Max	WEng
Name		1000	
Meet WEng			
	design at		
O Mant and any series a solution and vocal (vocal) calls and a solution of a soluti	(quarty A)	1	
Contract and the state and the state and the state and the state and the	Anality ID		
OWEre Miller Enserted their	dqueity: C)		
Mast measurements assemed representative for all WTOs	(quality C)	Selected	
		Shown	
J sectors religits mind a real estically and screek re-		Add range	Remo
		Cal	ulate .
		-	

Default selection is shear calculation using a combination of mast and WEng results.

Air density - check

Press Edit to initiate the Air density check.

Calculation of this check may be based on temperature (and pressure if available) measurements on the **site mast** or using statistical data from the GHCN Climate database.

Setup		Mast_Quick Ma
Name		
Mast_Quick Mast		
 Site or climate mast with Temperature (and Pressure) 	(quality: B)	
Quick Mast		0
O GHCN Climate database	(quality: C)	
Climate database Science/ MAPQLEXXV		>
		Selected Shawn
		Add new Remov
		Colorista

Press Calculate.

tup Base data	Results (Table)	Results (Graphics)	Mast_Guick M
13 120 120 121 15 15		Ar resulty	and God John S
1.00			Selected Shown
		10 17 10 10 10 10	Add new Remove
	WTG number	(Minute over point to view mane)	Calculate

All WTGs are within the IEC limit of 1.225kg/m³.

Now all the main checks have been calculated and it is time to have a look at the overall result.

In this case five of the main checks are OK, one check is caution (Effective turbulence) and one check is critical (Wind distribution). Thus, an IEC class IIB wind turbine is possibly not suitable for this site and layout. It seems that a higher wind speed class is needed, perhaps IB?

4. CALCULATION OF OTHER IEC CHECKS

Check the three **Other checks**, **Seismic hazard**, **Temperature range** and **Lightning rate**.

These checks are more general and output a single value representative for the site and all WTGs. The IEC standard does not define specific limits for these checks but their result values serve as input parameters to the turbine manufacturer's evaluations.

Seismic hazard check

Click **Edit** to open the check and click **Calculate** to perform it. This check leaves no calculation settings to the user.



Result (Graphics) shows the variation of Seismic hazard around the site for an area of ca. 1000km by 1000km.



The **Result (Table)** illustrates that for this site the Peak Ground Acceleration (PGA) is very small and hence the Seismic hazard is very low.

Lightning rate check

Click **Edit** to open the check and click **Calculate** to perform it. This check leaves no calculation settings to the user.

Cupitning rate	
Sene Naka Goo Salad Hydrology and Cinnas Christe (SICC) lytheory data anto	O NASA GHOC
Activologenet The source of the data with in (MAA). Optical Hydrology and Chevine Center The source of the data with the source of the source of the source of the The probled data are complet using data from the types of analytic datatom: UII Suffering Imaging Sensor (set OTD) Capical Tenseed Defect(s)	Selected O Shown Add new Remove Calculate
Dk Cancel	

Result (Graphics) shows the variation of Lightning rate around the site for an area of ca. 1000km by 1000km.



The **Result (Table)** illustrates that for this site the Lightning rate is low.

Temperature range check

Click **Edit** to open the check. A site mast with temperature is needed for this calculation.

There are two fit options for the on-site temperature distribution **Gaussian fit** and **Tail Gaussian fit**.

The default WTG temperature ranges, Normal (operation) and Extreme (survival), represent the standard WTG classes WTGs. Custom (Class S) temperature limits may be defined too as user input.

After setup press Calculate.

			 Gaussian
Name			
Gaussian			
Select data and fit			
Temperature data (Site o	r Climate mast)		
Quick Mast			
Type of fit © Full Gaussian fit O Tail Gaussian fit	Fit upper and lower fraction		*
Temporature design limit			
Normal temperature Timin (PC)	Glandard limits Standard -10 40	Class S limits (insert below)	*
C. Longer (of	A	100 m	Selected
Catherine temperature	20	Care 5	Shown
Time (C)			TANKANG TRA
immet.cl	50		New York Car
	Cancel		
QK	Cancel]		
Setue Dass data Result	Cancel		
Setup Base data Result Chuck Trini [*2] 1	Cancel a (Table) Results (Draphics) Insk (CC) Asses - Tenin (Dysel) Asses >	Tmax (hiyuar) Tetal hours outside range (hi	year)
Importune range Satup Base data Read Oack Trim (C) Inormal range - 50 Internal range - 50	Cancel (Table) Results (Supplics) (Table) (Supplics) (Table) Results (Supplics) (T	Trax (hyse) 10 10	() () () () () () () () () () () () () (
V Terpenter sup Detail Terret Detail Terret Detail Terret Details Terret Details and sup Details and sup Detai	Gancel g (Table) Results (Strapfice) Trac ("C), here s - Trac (hyse) Trac ("C), here s - Trac (hyse) S - E - E - E - E - E - E - E - E - E -	The (boys) The form when any (r 4.) 4.1	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)

In this example the result is caution, as almost 40 hours per year are expected outside (below) the standard Normal temperature range. So this is a point to be aware of and consult the manufacturer if a low temperature version is available with extended operational temperature range.