

# Energipark Veddem Kær

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## Bilag 7A

Produktionsberegning for  
vindmøller fra EMD

Project:

**Veddum Kær (19021)**

Description:

Disclaimer

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 Calculated:  
 2021-01-05 12:27/3.3.294

**Loss&Uncertainty - Main result**

**Calculation:** 9 x V136, med skyggestop

**Main data for PARK**

PARK calculation 3.3.201: Scenarie 1, 9 x V136  
 Count 9  
 Rated power 36.0 MW  
 Mean wind speed 6.8 m/s at hub height  
 Sensitivity 2.0 %AEP / %Mean Wind Speed  
 Expected lifetime 20 Years

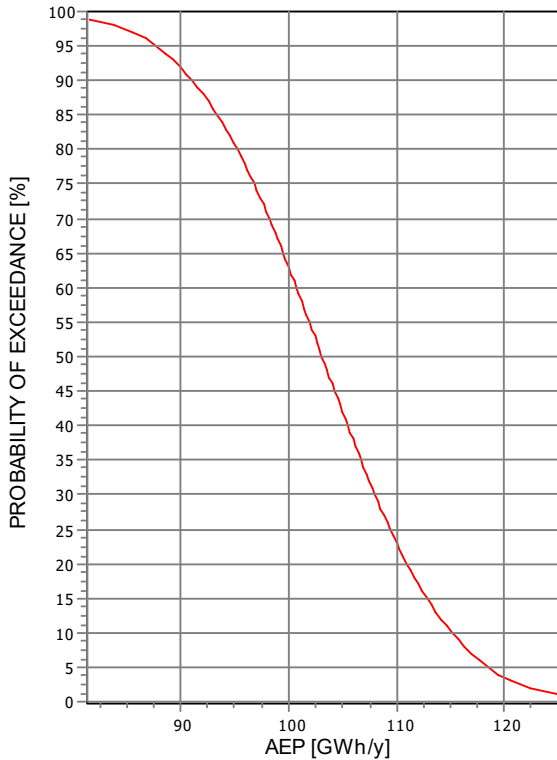
**RESULTS**

		P50	P84	P90
<b>NET AEP</b>	<b>[GWh/y]</b>	<b>103.1</b>	<b>93.8</b>	<b>91.1</b>
Capacity factor	[%]	32.7	29.7	28.9
Full load hours	[h/y]	2,864	2,605	2,530



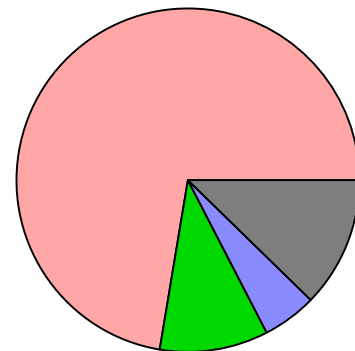
**Result details**

	P50		Uncertainty
GROSS AEP *)	125.3 GWh/y		8.3 %
Bias correction	1.5 GWh/y	1.2 %	0.3 %
Loss correction	-23.7 GWh/y	-18.7 %	3.7 %
Wake loss		-14.1 %	
Other losses		-5.3 %	
<b>NET AEP</b>	<b>103.1 GWh/y</b>		<b>9.1 %</b>



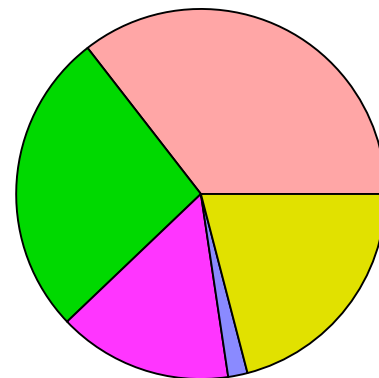
Scale: 25,000

**Loss: 18.7 %**



1. Wake effects	14.1 %	2. Availability	2.0 %
3. Turbine performance	0.0 %	4. Electrical	1.0 %
5. Environmental	0.0 %	6. Curtailment	2.4 %
7. Other	0.0 %		0.0 %

**Uncertainty: 9.1 %**



A. Wind data	6.3 %	B. Wind model	4.7 %
C. Power conversion	2.7 %	D. BIAS	0.3 %
E. LOSS	3.7 %		

\*) Calculated Annual Energy Production before any bias or loss corrections  
 Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

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## Loss&Uncertainty - Assumptions and results

**Calculation:** 9 x V136, med skyggestop

### ASSUMPTIONS

#### BIAS

	Method *)	Correction, wind speed [%]	Correction, AEP [%]	Std dev**) [%]	Comment
Wind data correction	Estimate	0.6	1.2	25.0	Indeholdt el og rådighedstab i reference mølle prd.
<b>BIAS, total</b>			<b>1.2</b>	<b>0.3</b>	

#### LOSS

	Method *)	Loss [%]	Loss [GWh/y]	Std dev**) [%]	Comment
1. Wake effects					
Wake effects, all WTGs	Calculation	14.1	17.9	25.0	
2. Availability					
Turbine availability	Estimate	2.0	2.5	50.0	
3. Turbine performance					No input
4. Electrical					
Electrical losses	Estimate	1.0	1.3	50.0	
5. Environmental					No input
6. Curtailment					
Flicker	Calculation	2.4	3.0	0.0	
7. Other					No input
<b>LOSS, total</b>		<b>18.7</b>	<b>23.7</b>	<b>3.7</b>	

#### UNCERTAINTY

	Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment
A. Wind data				
Wind measurement/Wind data	Estimate	2.5	4.9	
Long term correction	Estimate		2.0	
Year-to-year variability	Estimate	4.0	7.8	
Future climate	Estimate	1.5	2.9	
Other wind related				
B. Wind model				
Vertical extrapolation	Estimate	2.4	4.7	
Horizontal extrapolation	Estimate	0.2	0.4	
Other wind model related				
C. Power conversion				
Power curve uncertainty	Estimate		2.7	
Metering uncertainty				
Other AEP related uncertainties				
D. BIAS, total uncertainty			0.3	
E. LOSS, total uncertainty			3.7	
UNCERTAINTY, total (1y average)			11.9	
<b>UNCERTAINTY, total (20y average)</b>			<b>9.1</b>	

#### VARIABILITY

Years	Variability (std dev) [%]	Total std dev [%]
1	7.82	11.9
5	3.50	9.6
10	2.47	9.3
20	1.75	<b>9.1</b>

### RESULTS

#### AEP versus exceedance level / time horizon

PXX [%]	1 y [MWh/y]	5 y [MWh/y]	10 y [MWh/y]	20 y [MWh/y]
50	103,098	103,098	103,098	103,098
75	94,844	96,428	96,654	96,770
84	90,928	93,264	93,597	93,767
90	87,414	90,425	90,853	91,073
95	82,968	86,832	87,382	87,664

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## Loss&Uncertainty - Assumptions and results

**Calculation:** 9 x V136, med skyggestop

\*) Calculation means that a calculation method available in the windPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

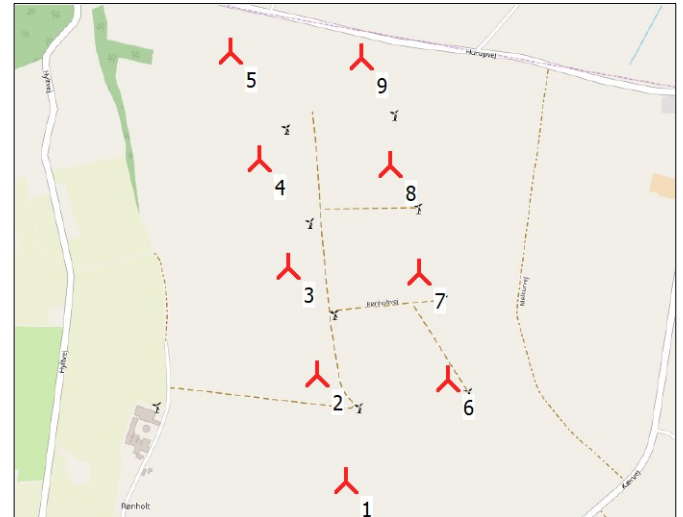
\*\*) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

## Loss&Uncertainty - WTG results

**Calculation:** 9 x V136, med skyggestop

### Main data for PARK

PARK calculation 3.3.201: Scenarie 1, 9 x V136  
Count 9  
Rated power 36.0 MW  
Mean wind speed 6.8 m/s at hub height  
Sensitivity 2.0 %AEP / %Mean Wind Speed  
Expected lifetime 20 Years



Scale: 25,000

### Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	User label	Calculated GROSS* [MWh/y]	20 years averaging					
			Bias [%]	Loss [%]	Unc. [%]	P50 [MWh/y]	P84 [MWh/y]	P90 [MWh/y]
1 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (1)	1	14,081.4	1.2	10.7	8.5	12,724.3	11,653.9	11,344.9
2 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (2)	2	14,019.8	1.2	15.1	8.8	12,045.4	10,992.3	10,688.3
3 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (3)	3	13,940.6	1.2	17.2	9.0	11,686.4	10,635.9	10,332.6
4 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (4)	4	13,419.4	1.2	17.1	8.8	11,258.3	10,271.4	9,986.5
5 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (5)	5	13,628.2	1.2	14.3	8.9	11,812.9	10,766.7	10,464.6
6 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (6)	6	14,175.0	1.2	20.6	9.2	11,394.7	10,352.8	10,052.0
7 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (7)	7	14,105.5	1.2	25.2	9.8	10,680.3	9,636.4	9,335.1
8 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (8)	8	14,018.9	1.2	25.7	9.9	10,544.6	9,502.0	9,201.1
9 VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (9)	9	13,920.6	1.2	22.2	9.6	10,957.8	9,914.5	9,613.3
<b>PARK</b>		<b>125,309.2</b>	<b>1.2</b>	<b>18.7</b>	<b>9.1</b>	<b>103,098.5</b>	<b>93,767.2</b>	<b>91,073.3</b>

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## Loss&Uncertainty - Flicker

**Calculation:** 9 x V136, med skyggestop

Calculated losses due to shadow (flicker) loss.

Used SHADOW calculation: 3.3.294: 9 x V136 (skyggestyring)

Assumptions:

Stopping specific turbines in SHADOW calculation

### Result

WTG	Calculated AEP GROSS [MWh]	Loss [MWh]	Percent of AEP [%]
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (1)	14,250.4	432.9	3.04
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (2)	14,188.0	321.6	2.27
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (3)	14,107.9	255.2	1.81
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (4)	13,580.4	247.4	1.82
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (5)	13,791.7	233.3	1.69
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (6)	14,345.1	445.1	3.10
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (7)	14,274.8	411.2	2.88
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (8)	14,187.1	393.2	2.77
VESTAS V136-4.0/4.2 MW 4000 136.0 !O! hub: 82.0 m (TOT: 150.0 m) (9)	14,087.6	304.5	2.16
<b>TOTAL</b>	<b>126,812.9</b>	<b>3,044.3</b>	<b>2.40</b>