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PM Number

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Date

2019-04-08

PM Title

Suðuroy, Faroe Islands

Porkeri. Production, noise and shadow flicker

Client

Elfelagið Streymoy-Eysturoy-Vágar (SEV)

Client Reference

Tórfinn S. Simonsen

Objectives

The Promemoria (PM) presents the expected production, noise emission and shadow flicker from a wind farm at Suðuroy close to Porkeri.

The co-ordinates of the turbines are received from the client. The wind data and wind map is based on the report KVT/UT/2017/R087.

Disclaimer

Although this PM, to the best of our knowledge, represents the state-of-the-art in wind energy assessment methods, and effort has been made to secure reliable results, Kjeller Vindteknikk (KVT) cannot in any way be held responsible neither to the use of the findings in this PM nor for any direct or indirect losses arising from such use or from errors of any kind in the contents.

Revision history

Rev. number	Date	Number of copies	Comment	Distribution
0	2019-02-21	Electronic file	First delivery	Client
1	2019-04-08	Electronic file	Updated layout with 7 turbines.	Client

	Name	Date and signature
Prepared by	Brian Broe	

In accordance to our QA system, a KVT PM is not internally reviewed, in contrary to a KVT report.

1 Summary

Production

The calculation of the expected production is based on the report KVT/UT/2017/R087. The report from 2017 used long-term corrected result based on 1 year and 2 months of data from the mast 18004 Suđuroy. The main results from the 2017 report is listed in the below table.

Long Term Corrected Wind Speed at site 18004

Annual mean wind speed @ 76.5 m AGL	9.6 m/s
Annual mean wind speed @ 45.0 m AGL	9.1 m/s

The CFD model WindSim is used to calculate the wind speed at each individual turbine location. The simulation domain also includes the position of the new mast Porkeri installed May 31, 2018.

To be able to present an expected net production, the wake losses is calculated and other losses estimated. For the wake losses the N.O.Jensen method is used with a Wake Decay Constant (WDC) of 0.072. The estimate of the WDC is based on the observed turbulence intensity at the mast 18004 Suđuroy. Other losses are just roughly estimated to 10 % in total. Other losses include unavailability, electrical losses, power curve imperfection, blade degradation, hysteresis and more. For a bankable report, all these losses must be calculated or estimated individually. The uncertainty is not calculated.

The wind farm consists of 7 Enercon E44 with a 45 m hub height. The main results are given below:

Main results for the wind farm

Total installed capacity	6.3 MW
Annual mean wind speed @ hub height for all the turbines	9.3 m/s
Gross energy production	24.4 GWh
Wake losses	7.5 %
Other losses	10.0 %
Annual expected new production	20.3 GWh

Noise

The following methodology and inputs are used:

- The Danish 2007 noise calculation model has been used in the calculations.
- The source for noise for the considered wind turbines are defined as:
 - A single source emission level (LwA,ref) is assigned for both 6 m/s and 8 m/s at the chosen hub height of 45 m.
 - The octave data has been estimated by WindPRO's generic calculation approach.
- In the current calculations noise map (isolines) are presented.

- The contour interval for the topographic map is 5 m outside the wind farm area and 2 m inside the wind farm area.
- The noise limit is 37 dB(A).

Shadow flicker

A map showing hours of shadow flicker around the wind farm area is calculated with the SHADOW module available in WindPRO. The following methodology and inputs are used:

- Worst case scenario is calculated with the assumption of the Sun is always shining (from sun rise to sun set; no clouds), turbine always running and rotor oriented perpendicular to neighbour.
- The height contours are described in the noise chapter.
- A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non-visible WTGs do not contribute to calculated flicker values.
- Topographic shadow is included in calculation

The following limits to the shadow flicker have been taken into account:

- Theoretical shadow flicker: < 30 hours per year. Worst case.
- Theoretical shadow flicker: < 30 minutes per day. Worst case.

PARK - Main Result

Calculation: Layout from SEV 4 MAR 2019 7 x E44-0p9MW HH 45 m

Wake Model N.O. Jensen (RISØ/EMD)

Calculation performed in UTM (north)-WGS84 Zone: 29

At the site centre the difference between grid north and true north is: 1.9°

Power curve correction method

New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Air density calculation method

Height dependent, temperature from climate station

Station: AKRABERG

Base temperature: 6.4 °C at 95.0 m

Base pressure: 1001.6 hPa at 95.0 m

Air density for Site center in key hub height: 249.5 m + 50.0 m = 1.223 kg/m³ -> 99.8 % of Std

Relative humidity: 0.0 %

Wake Model Parameters

Terrain type Wake decay constant

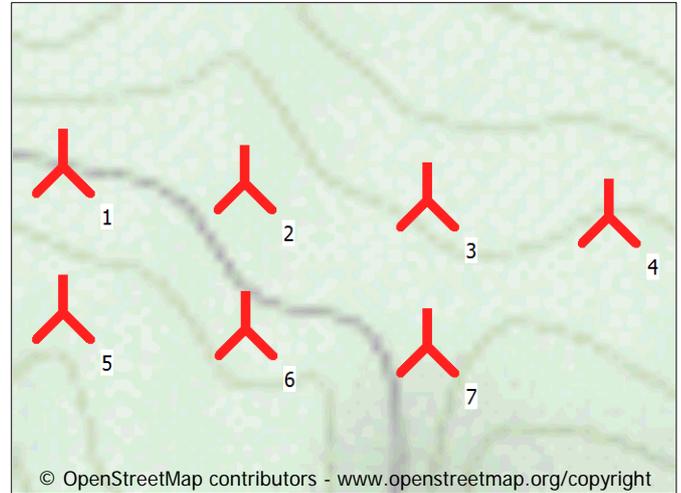
User defined 0.072

Wake calculation settings

Angle [°] Wind speed [m/s]

start end step start end step

0.5 360.0 1.0 0.5 30.5 1.0



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Scale 1:7,500

New WTG

Resource file(s)

\\kvt73\03.vindteknikk.local\kvt\KUNDER\180_SEV_Vindmaalinger_Torshavn_faeroyene\004_Suduroy\Analyses\2018_07_Alterative_west\03_WindPRO\02_Projects\wind_resources_clim_18004_SECBIN_H45m_D0_m_0045_int.wrg

Calculated Annual Energy for Wind Farm

WTG combination	Result		GROSS (no loss) Free WTGs	Wake loss	Specific results ^{a)}			Mean wind speed @hub height
	PARK	[MWh/y]			Capacity factor	Mean WTG result	Full load hours	
Wind farm	22,564.4	[MWh/y]	24,400.2	7.5	40.9	3,223.5	3,582	9.3

^{a)} Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 7 new WTGs with total 6.3 MW rated power

Links	WTG type		Type-generator	Power, rated	Rotor diameter	Hub height	Power curve		Annual Energy		
	Valid	Manufact.					Creator	Name	Result	Wake loss	Free mean wind speed
				[kW]	[m]	[m]			[MWh/y]	[%]	[m/s]
1 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,000.1	6.8	8.89
2 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,011.0	10.4	9.11
3 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,316.8	9.5	9.65
4 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,580.8	5.2	9.90
5 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,392.8	4.8	9.41
6 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,223.1	8.0	9.30
7 A	Yes	ENERCON	E-44-900	900	44.0	45.0	EMD	Level 0 - official - 900kW - 12/2014	3,039.8	8.2	8.97

Annual Energy results do not include any losses apart from wake losses. Additional losses and uncertainty must be considered for an investment decision.

WTG siting

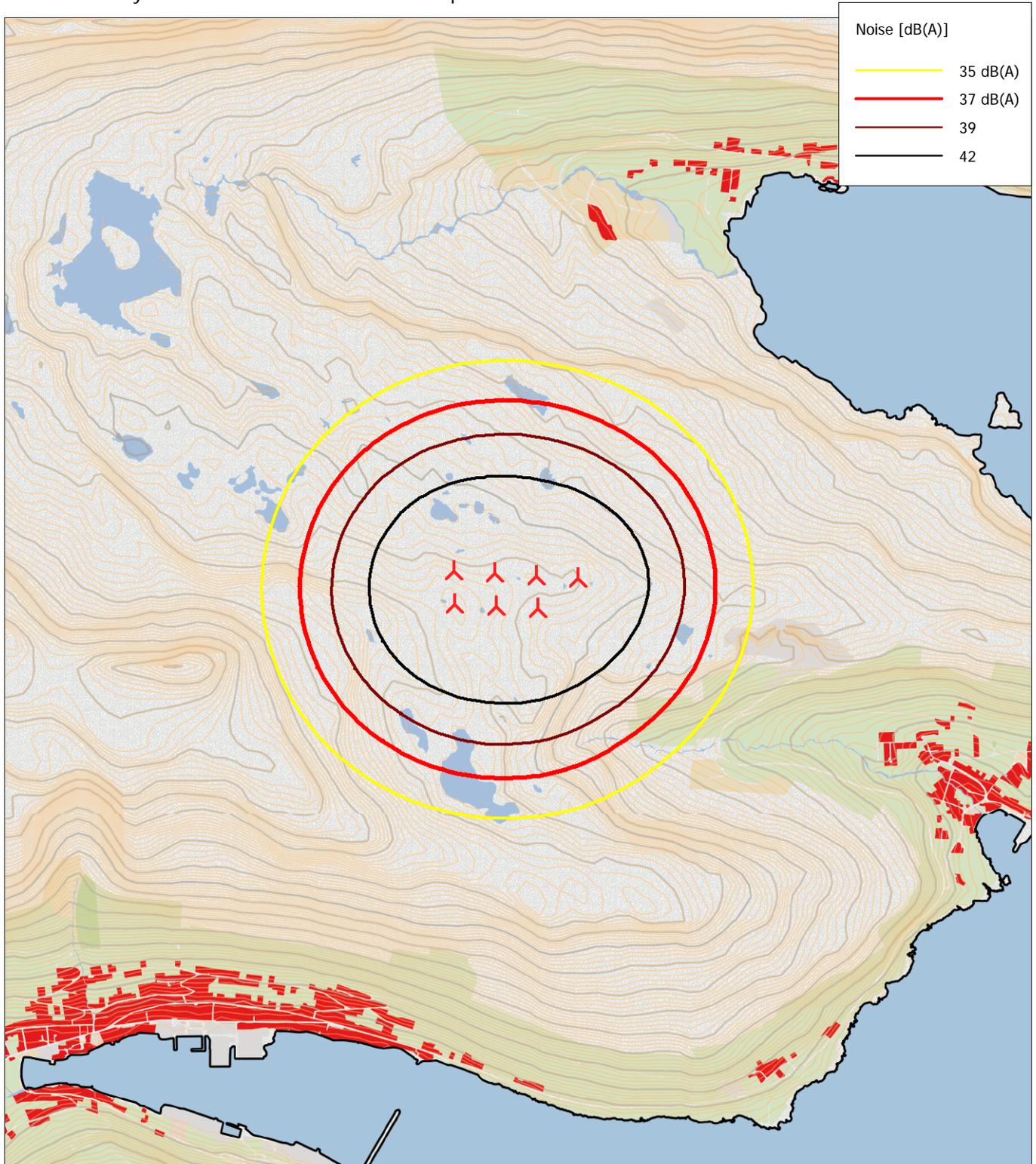
UTM (north)-WGS84 Zone: 29

Easting Northing Z Row data/Description
[m]

1 New	617,759	6,819,474	259.9	PH101
2 New	617,940	6,819,463	255.1	PH102
3 New	618,121	6,819,453	256.0	PH103
4 New	618,301	6,819,442	252.4	PH104
5 New	617,764	6,819,328	274.0	PH108
6 New	617,945	6,819,318	262.0	PH109
7 New	618,126	6,819,307	244.0	PH110

DECIBEL - Map 6.0 m/s

Calculation: Layout from SEV 4 MAR 2019 7 x E44-0p9MW HH 45 m



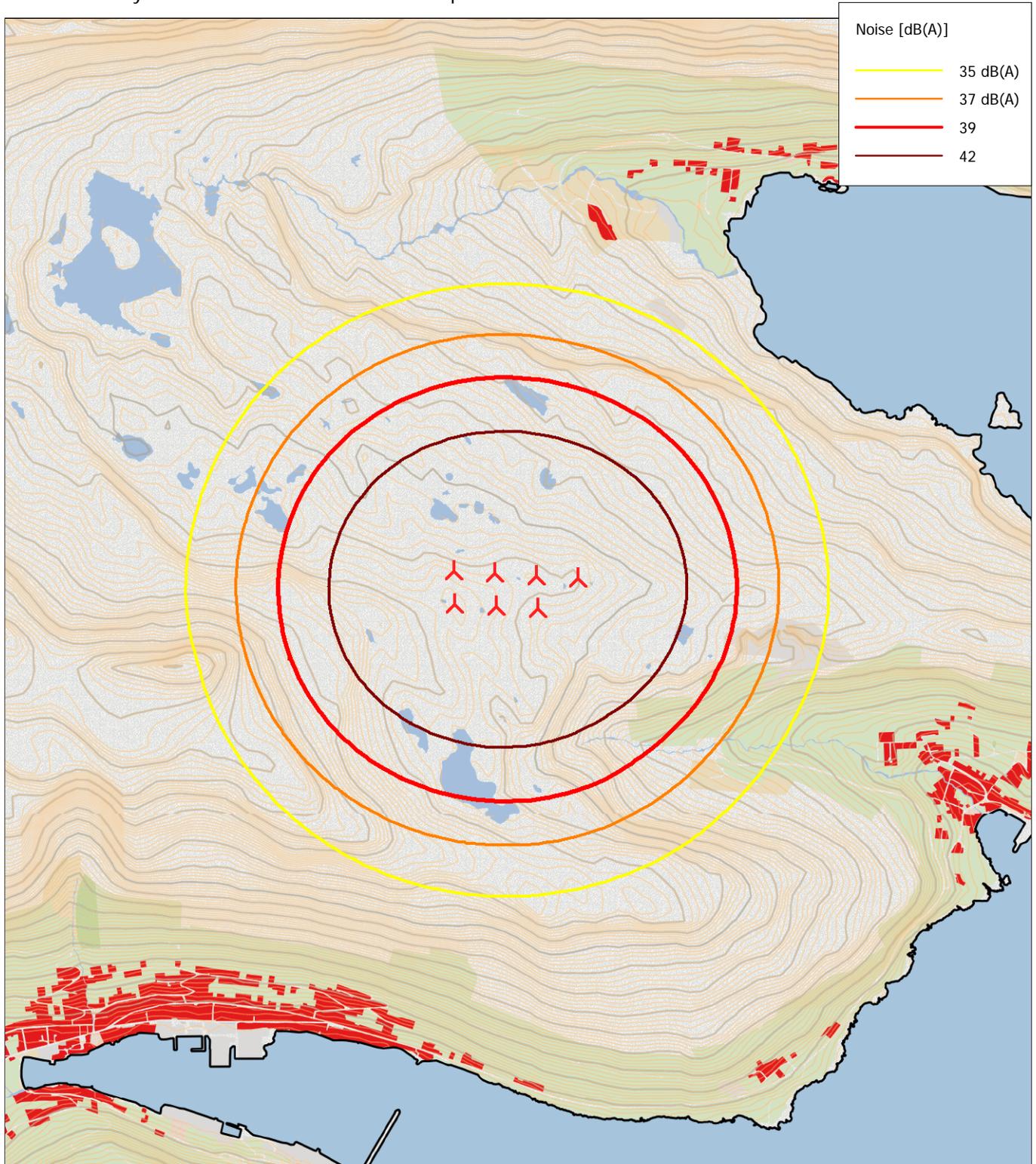
0 250 500 750 1000m

Map: Suduroy_landcover_overview_map , Print scale 1:25,000, Map center UTM (north)-WGS84 Zone: 29 East: 618,030 North: 6,819,391
New WTG

Noise calculation model: Danish 2007. Wind speed: 6.0 m/s
Height above sea level from active line object

DECIBEL - Map 8.0 m/s

Calculation: Layout from SEV 4 MAR 2019 7 x E44-0p9MW HH 45 m



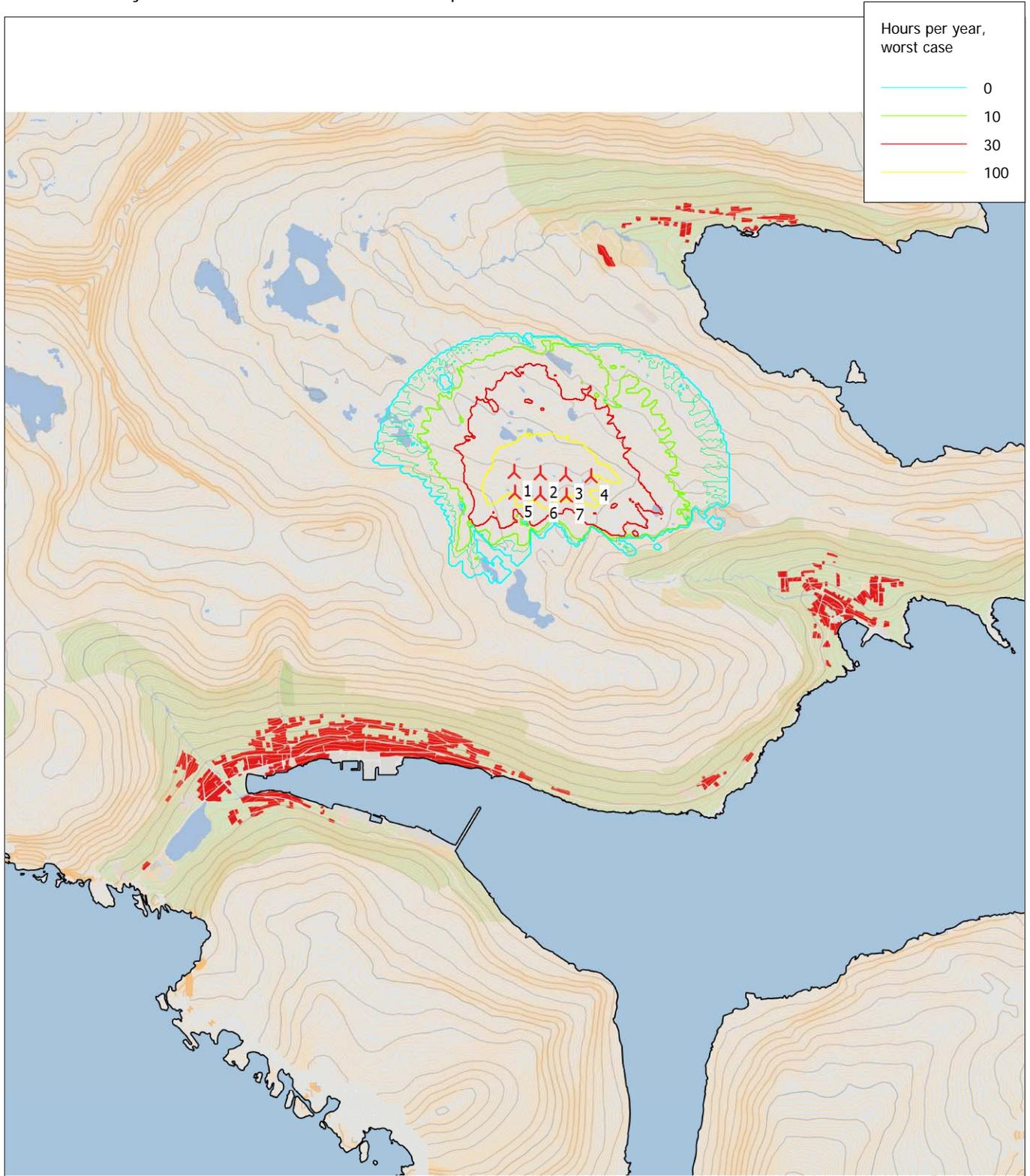
0 250 500 750 1000m

Map: Suduroy_landcover_overview_map , Print scale 1:25,000, Map center UTM (north)-WGS84 Zone: 29 East: 618,030 North: 6,819,391
New WTG

Noise calculation model: Danish 2007. Wind speed: 8.0 m/s
Height above sea level from active line object

SHADOW - Map

Calculation: Layout from SEV 4 MAR 2019 7 x E44-0p9MW HH 45 m



0 500 1000 1500 2000 m

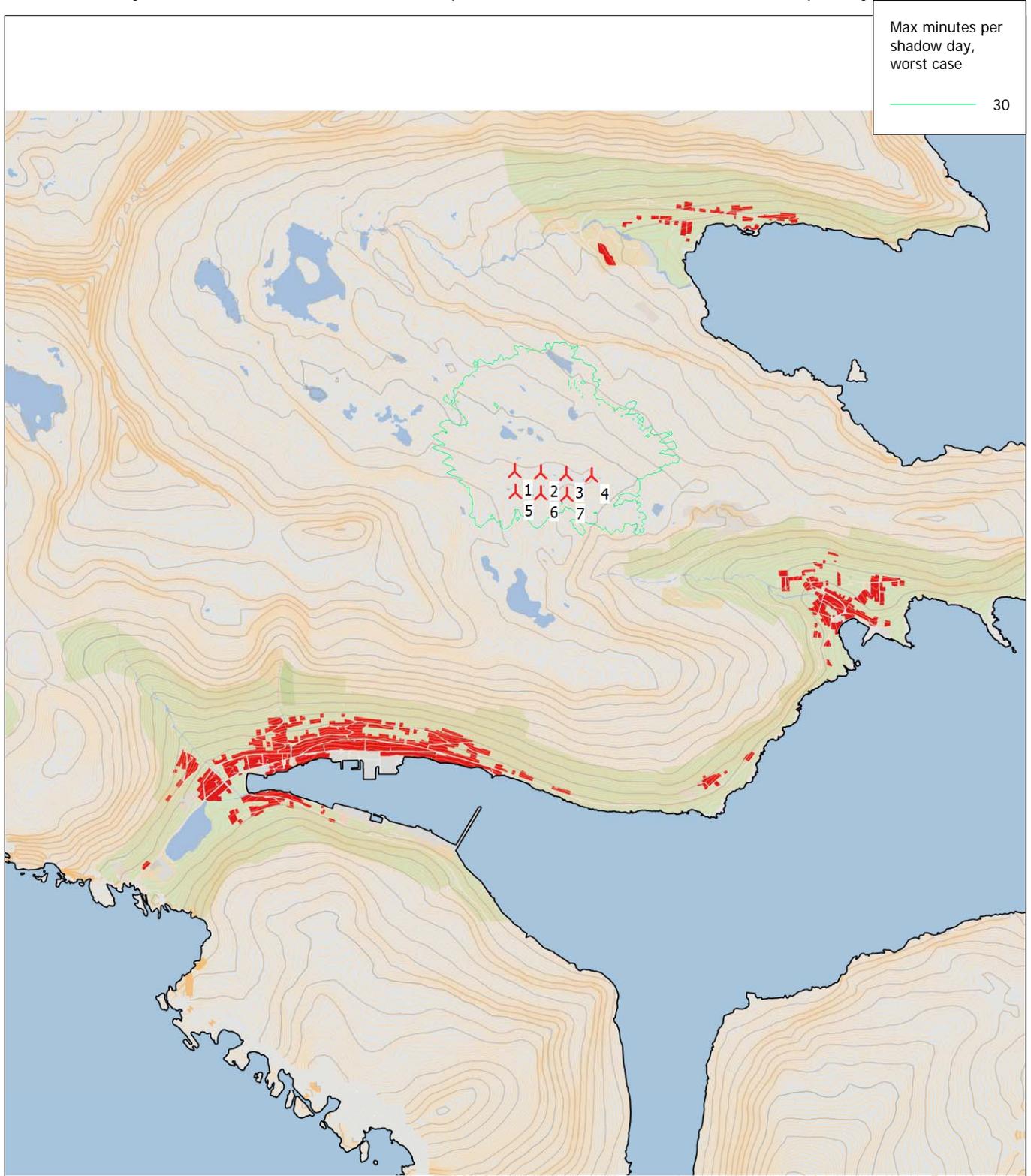
Map: Suduroy_landcover_overview_map , Print scale 1:40,000, Map center UTM (north)-WGS84 Zone: 29 East: 617,740 North: 6,818,600

▲ New WTG

Flicker map level: Height Contours: 2017_09_Suduroy_2m_5m_heightcontours.map (15)

SHADOW - Map

Calculation: Layout from SEV 4 MAR 2019 7 x E44-0p9MW HH 45 m worst case, Max minutes per day



0 500 1000 1500 2000 m

Map: Suduroy_landcover_overview_map , Print scale 1:40,000, Map center UTM (north)-WGS84 Zone: 29 East: 617,740 North: 6,818,600

 New WTG

Flicker map level: Height Contours: 2017_09_Suduroy_2m_5m_heightcontours.map (15)