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EVALUATION REPORT

SUBJECT / TEST METHOD / STANDARDS	:	**CUMULATIVE EFFECT OF LEEUWBERG AND ADJACENT WINDFARMS**
CLIENT / APPLICANT	:	**MAINSTREAM RENEWABLE POWER**
SITE EVALUATED	:	**Leeuwberg**
REPORT NUMBER	:	**R 7152/16**
REVISION	:	**0.5**
DATE ISSUED	:	**13/01/2017**
COPY	:	**Master**

CONFIGURATION CONTROL

ORIGINAL ONLY IF THIS NOTE IS IN RED INK

This test report was prepared by : ***Name:*** *CFH Fouchè*
Title: *Technical Director*

This test report was reviewed by : ***Name:*** *JJ Joubert*
Title: *Senior EMC Test Engineer*

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1.0	13/01/2017	C Fouche	All	N/A

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C:\Users\Admin\Documents\Projects\Renewable energy and SKA\Mainstream\	Cumulative effect

LIST OF EFFECTIVE PAGES								CONFIGURATION CONTROL
PAGE	**REV**	**PAGE**	**REV**	**PAGE**	**REV**	**PAGE**	**REV**	
1	1.0	9	1.0					
2	1.0	10	1.0					
3	1.0	11	1.0					
4	1.0	12	1.0					
5	1.0							
6	1.0							
7	1.0							
8	1.0							

CLIENT INFORMATION	
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ACRONYMS AND ABBREVIATIONS

AMN	Artificial Mains Network
AVE	Average
CDN	Coupling/ Decoupling Network
CSIR	Council for Scientific and Industrial Research
E-Fields	Electric Fields
EFT	Electrical Fast Transients
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
EUT	Equipment Under Test
H	Horizontal
HCP	Horizontal Coupling Plane
NIST	National Institute of Science and Technology
NMISA	National Metrology Institute of South Africa
OATS	Open Area Test Site
PC	Personal Computer
QP	Quasi-Peak
RF	Radio Frequency
SANAS	South African National Accreditation System
V	Vertical
VCP	Vertical Coupling Plane

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

The Karoo area is ideally suited for the installation and commissioning of renewable energy projects, but is also host to the Department of Science and Technology's SKA radio telescope project. Due to the sensitivity of the telescope receivers, there is a risk that unintentional emissions from the systems and associated equipment associated with renewable energy projects will desensitize or saturate the SKA receivers resulting in interference to celestial observations and/or data loss. Such interference is typically referred to as 'Radio Frequency Interference' (or 'RFI').

2. AREA OF INTEREST

Figure 1: Windfarm areas considered for REM OPT 7 evaluation

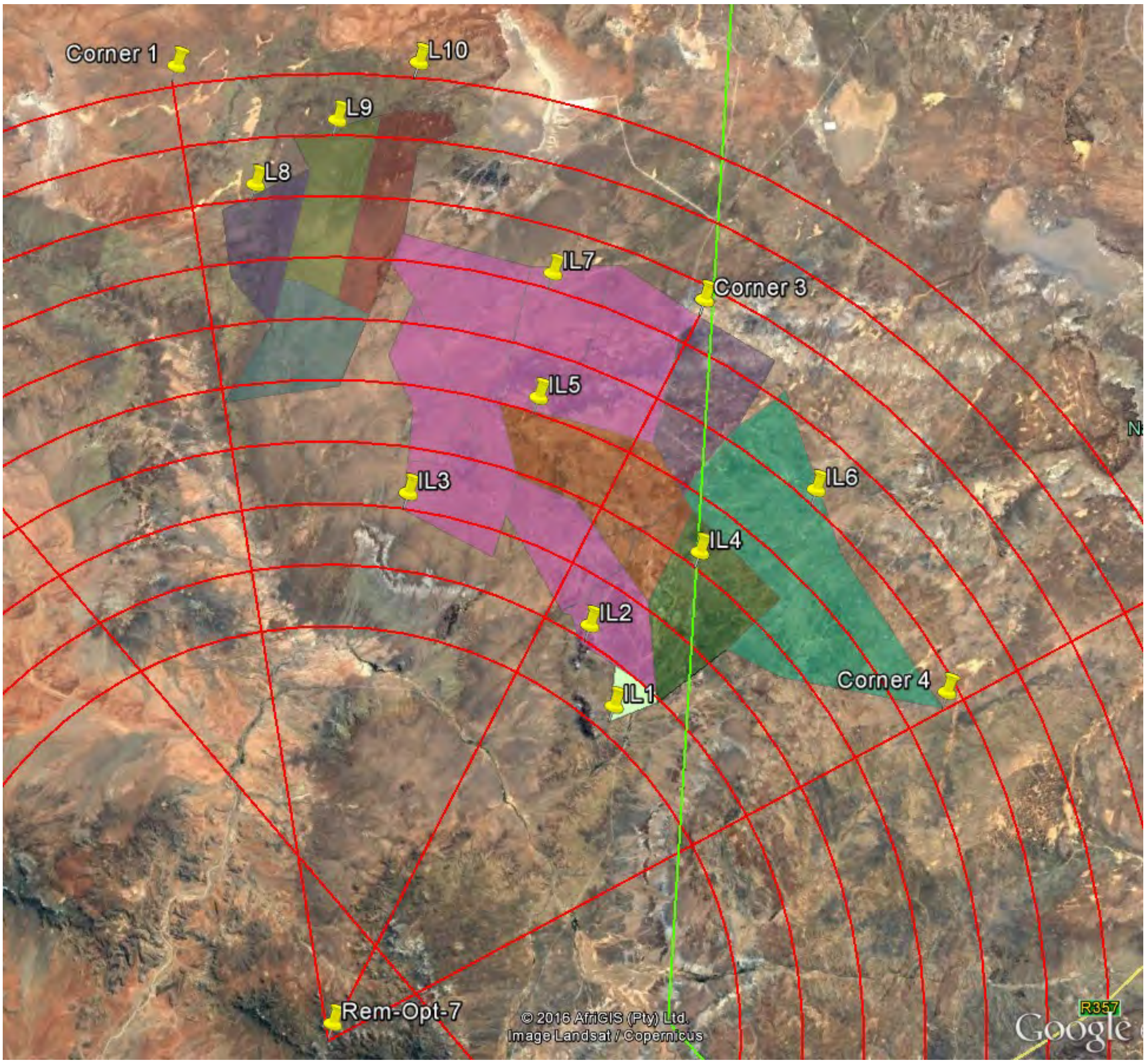


Figure 2: Windfarm areas considered for SKA ID 2377 evaluation

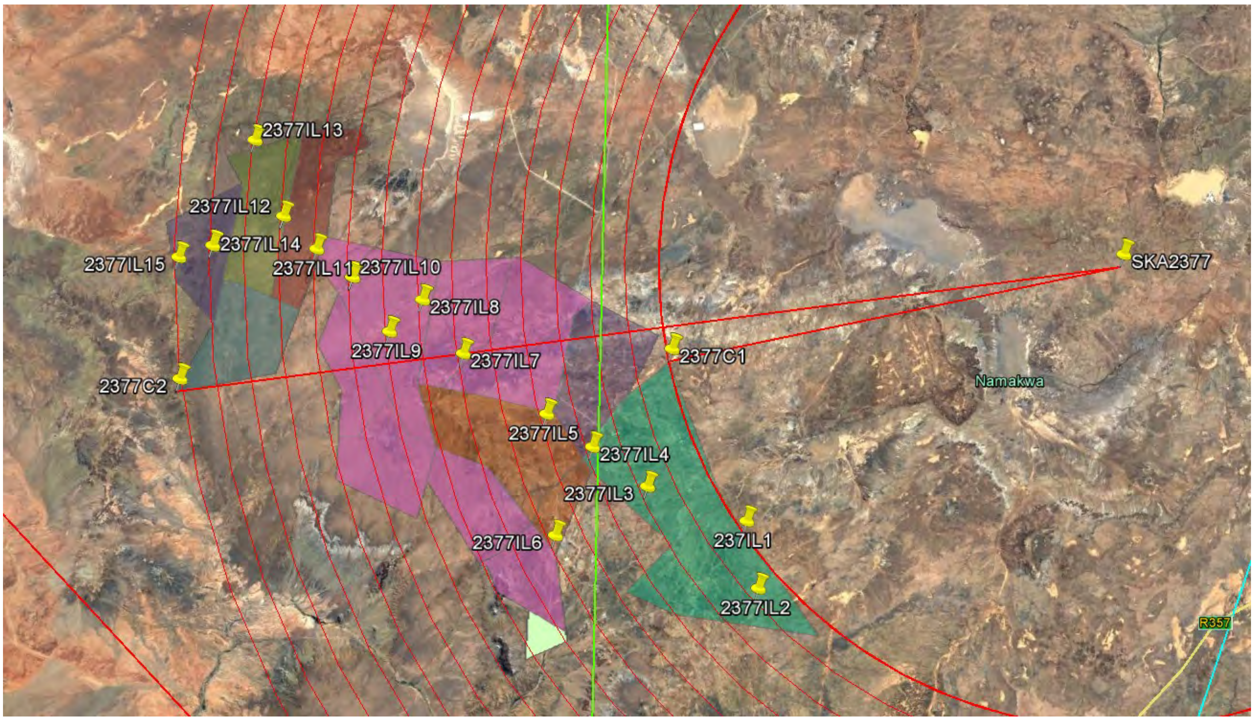


Table 1: Windfarm capacity and number of turbines

Development	Current status of EIA/development	Capacity	No. Turbines
Dwarsrug Wind Farm	Environmental Authorisation issued	140MW	70
Khobab Wind Farm	Environmental Authorisation issued/Approved under RE IPPPP	140MW	61
Loeriesfontein 2 Wind Farm	Environmental Authorisation issued/Approved under RE IPPPP	140MW	61
ACED Kokerboom 1 Wind Farm	EIA ongoing	240MW	60
ACED Kokerboom 2 Wind Farm	EIA ongoing	240MW	60
Graskoppies Wind Farm	EIA ongoing	140MW	47
Hartebeest Leegte	EIA ongoing	140MW	47
Ithemba Wind Farm	EIA ongoing	140MW	47
!Xha Boom Wind Farm	EIA ongoing	140MW	47

3. CALCULATION INFORMATION

A total of 500 mitigated Acciona model AW 125/3000 turbines with a 150m hub height was used for the NTIA TM-89-139 calculations with an inner ring of 30km and outer ring of 70km. This resulted in 10 rings with a spacing of 4.44km between rings.

Path loss was calculated with SPLAT! at 500MHz. Where the software reported parameters that were out of range, the ITU-R Recommendation P.452-15 model as contained in SEAMCAT was used.

4. DATA COMPARISONS

The following factors have an impact on cumulative emissions:

- Number of emitters (emitter density)
- Path loss due to distance and topography

To avoid tedious path loss calculations for 500 emitters and the exact location of each emitter not being known, the NTIA TM-89-139 [2] “Rings” method was used to calculate the expected cumulative amplitude. The source amplitude of all emitters was assumed to be Acciona mitigated. The levels as described in [1]. Path loss was calculated for each of the rings at the calculated distance from the receiver.

The following definitions apply to Business areas (City), Residential areas, Rural areas and quiet rural areas:

Business areas: any area where the predominant usage throughout the area is for any type of business eg. stores, offices, industrial parks, large shopping centers, main streets or highways etc.

Residential areas (urban or suburban): any area used predominantly for single or multiple dwellings with a density of at least two single family units per 4046 square meter (1 acre) and no large or busy highways.

Rural areas: primarily agricultural or similar purpose with no more than one dwelling per 20234 square meter (5 acres).

The statistical cumulative figure of 10*Log N where N = number of emitters is an overly conservative approach when the emitter number is >63 units. (18dB).

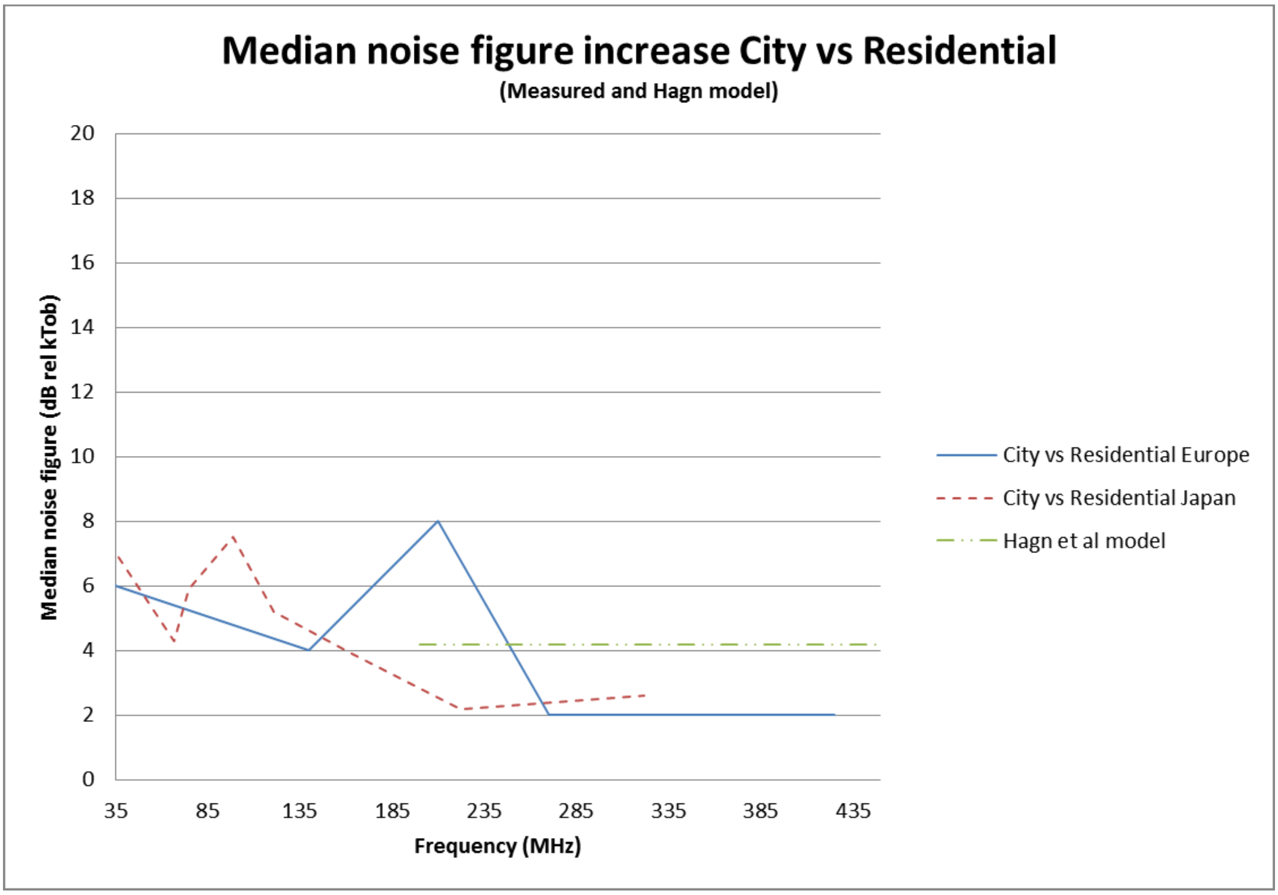
4.1 NTIA TM-89-139 [2]

The 500MHz calculation for the REM Opt 7 location showed an expected increase of 17.9dB when comparing one emitter to 500 emitters and 18.3dB for the SKA ID 2377 location.

4.2 ITU-R P.372-13: RADIO NOISE

When comparing the City (high emitter density) with residential and rural data from ITU-R P.372-13 *Table 3: Outdoor man-made noise measurements in Europe (2006-2007)*, the median noise figure increase for the City environment compared with the residential environment is shown in Figure 3 below. The City median noise figure compared with the residential noise figure as measured in Japan (2009-2011) is also included. Added to Figure 3 is the Hag et al model [3] that is in line with the measured values presented.

Figure 3: Man-made noise measured results (ITU-R P.372-13 Table 3 and Table 4, Hagn eq 8 and 9)

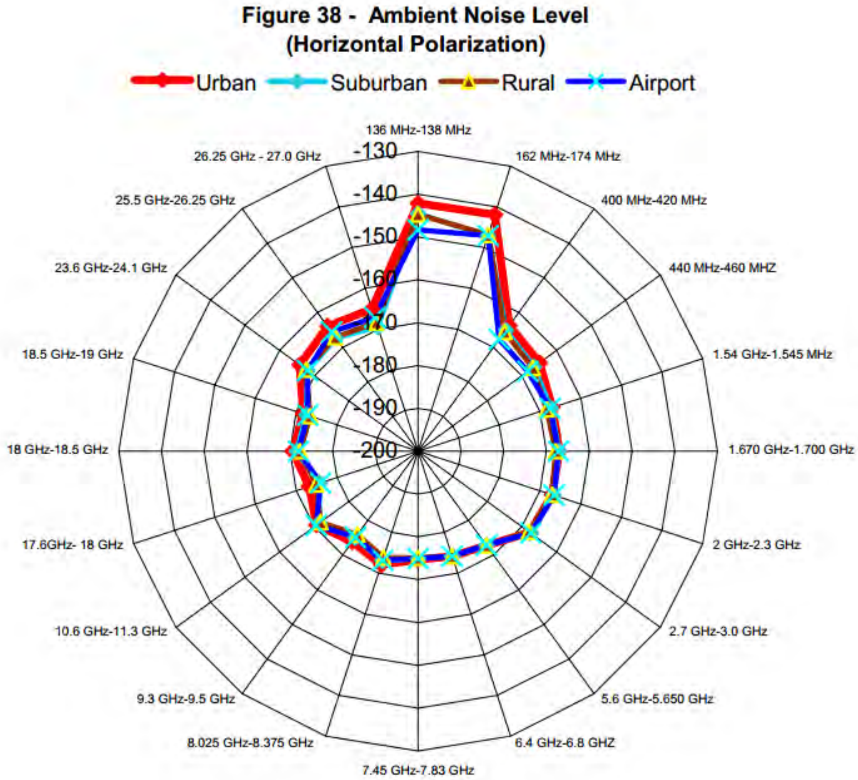


4.3 MEASURED URBAN, SUBURBAN, AIRPORT AND RURAL AMBIENT EMISSIONS

The emitter density in rural areas is much lower than the urban environment.Tthe urban environment ambient level are the highest as expected, however the increase in the measured bands is <10dB for both vertical and horizontal polarisation as shown in [4]

Figure 4: Measured ambient data comparison – Horizontal polarisation

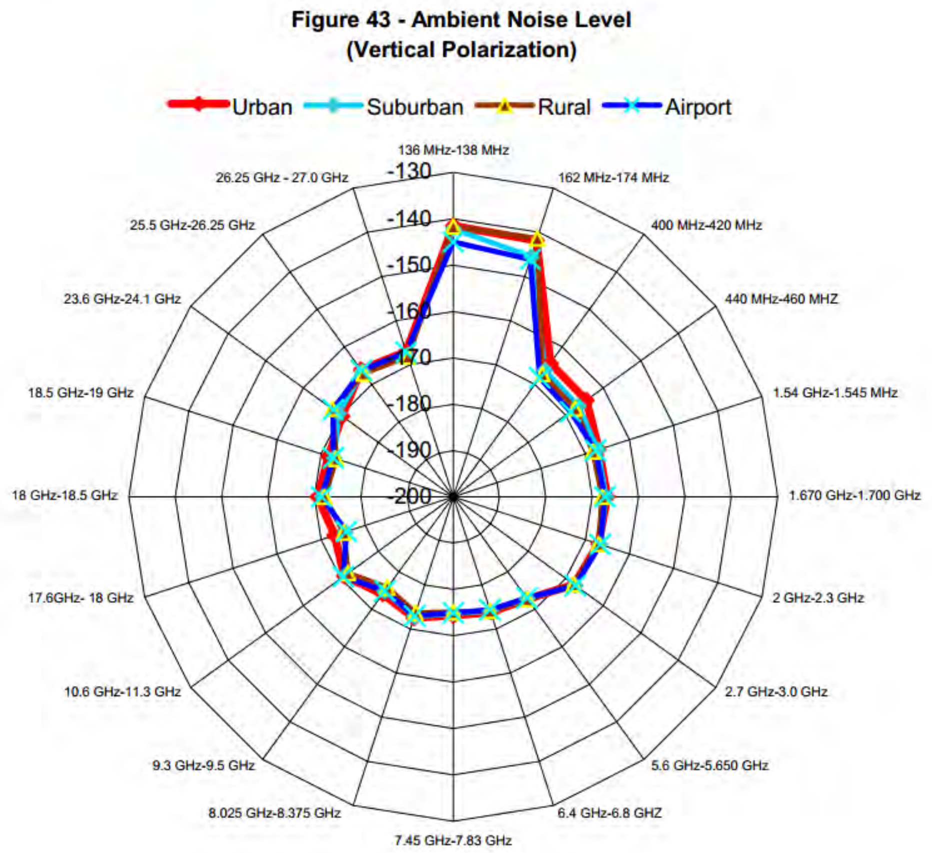
Figure 38 compares the ambient noise levels of each of the sites from an environmental perspective. (The radial axis represents the measured frequency band. The circular axis represents the ambient noise level.)



Source: CBS/SG-RFC 2005/Doc. 5(1) WORLD METEOROLOGICAL ORGANIZATION

Figure 5: Measured ambient data comparison – Vertical polarization

Figure 43 compares the ambient noise levels of each of the sites from an environmental perspective. (The radial axis represents the measured frequency band. The circular axis represents the ambient noise level.)



Source: CBS/SG-RFC 2005/Doc. 5(1) WORLD METEOROLOGICAL ORGANIZATION

4.4 MOBILE COMMUNICATION RADIO BASE STATIONS.

From "*Comparative international analysis of radiofrequency exposure surveys of mobile communication radio base stations*" it was noted that the installation of more base stations did not result in a marked increase in ambient RF levels as shown in Figure 6 below. Although often quoted when investigating cumulative effect of multiple sources, it cannot be used as a case study for wind turbine generators as the service quality that consumers expect requires certain signal strength and the signal strength is regulated by the service providers. This would be a driving factor from industry to maintain ambient levels. The base station density per square kilometer is also less than the WTG sites.

Figure 6: Comparison of ambient data for different years in different countries

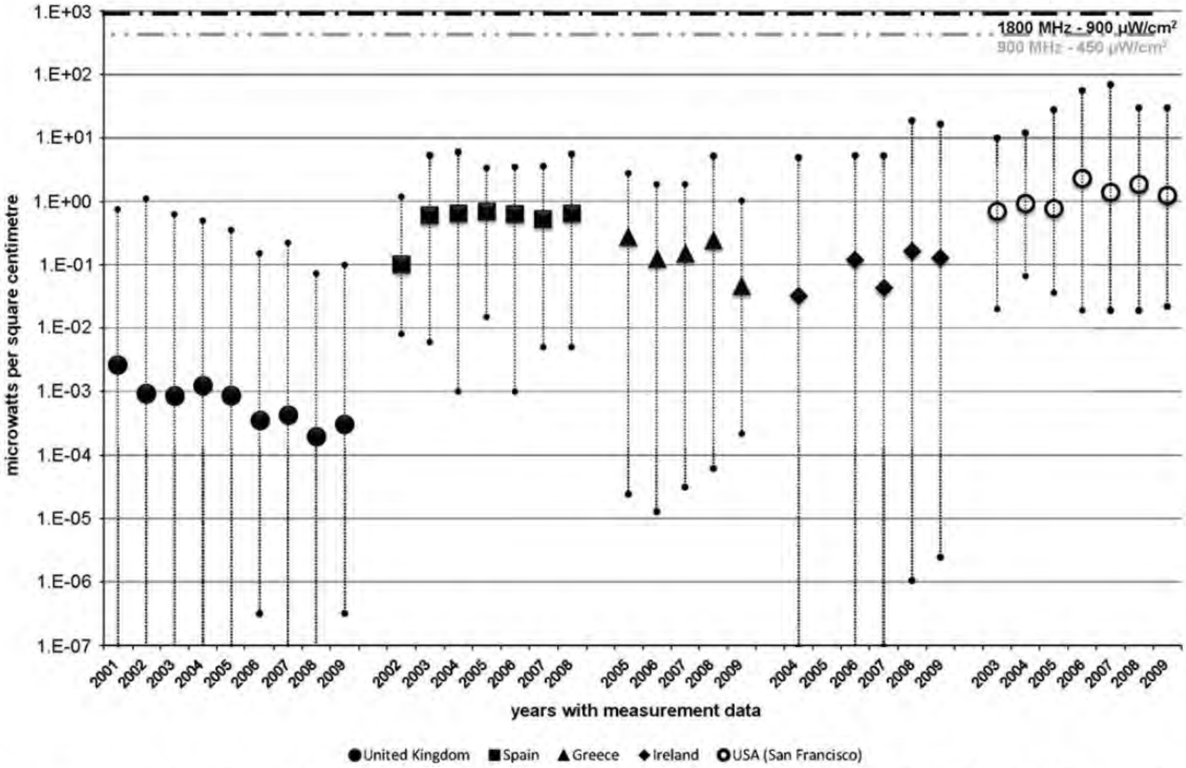


Figure 2. Minimum (●), maximum (●) and average of the narrowband measurements for the UK (●), Spain (■), Greece (▲) and Ireland (◆); and the broadband measurements for the US (○), with the year of measurement data on the horizontal axis. Note that not all years were available in all countries. For comparison, the ICNIRP reference level for the public at 900 MHz and 1800 MHz are included.

Source: Journal of Exposure Science and Environmental Epidemiology (2012), 304-315

5. CONCLUSION

- The NITIA TM-89-139 calculation of 17.9dB (REM OPT 7 location) and 18.4dB (SKA ID 2377 location) to be added to the emissions from a single unit to allow for the cumulative effect of 500 units appears to be conservative when compare to general man-made noise data (<10dB increase measured at various locations).

- The >60 degree beamwidth assumed during the NITIA TM-89-139 calculations will result in over estimation of the cumulative effect due to a higher number of emitters in the beamwidth.

- The 40dB mitigation is a border line figure when considering all the adjacent projects resulting in a relatively high emitter density

6. REFERENCES

[1] ITC Services CP 1609/16: EMISSION CONTROL PLAN THE AW125 TH100A WTG

[2] National Telecommunications and Information Administration NTIA TM-89-139: Single and aggregate emission level models for interference analysis

[3] Naval Ocean System Centre: Techniques for estimating the effects of man-made radio noise on distributed military systems

[4] World meteorological Organization: Results of Ambient RF environment and noise floor measurements taken in the U.S. in 2004 and 2005

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18 July 2017

RE: WIND TURBINE PERMUTATIONS

The risk of interference between wind turbines and the SKA radio telescope is primarily a function of the following factors:

- Radiated emission amplitude from turbine
- Turbine hub height
- Number of turbines
- Distance between turbine and SKA infrastructure
- Terrain between the turbine and the SKA infrastructure (line of sight or natural barriers between the installations)

The dB increase in the electromagnetic noise by increasing the number of turbines from 47 units to 70 units can be estimated with the standard 10 x Log (N), where N is the number of turbines, formula as a reasonable assumption. Changing the number of turbines from 47 to 70 will therefor result in a 13.6dB increase in electromagnetic noise.

Increasing the turbine hub height could result in the nacelle being elevated above the natural terrain barriers that provided a shield between the turbine and the SKA infrastructure at a lower hub height. The change in interference risk profile will have to be re-evaluated if the nacelle height is different from the initial proposed height to verify the line of sight/ terrain shielding conditions.

Please do not hesitate to contact me should you need further information.

CFH Fouche
Technical Director