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SUBJECT

RFI Assessment of the Proposed PV Plant Site and MTS Grid Connection applicable to: Paarde Valley PV2

KEYWORDS

Electrical Equipment, Electrical Infrastructure, EMI, RFI, OHL

DISTRIBUTION

Holland & Associates Environmental Consultants

SUMMARY

The purpose of this document is to report on the possible RFI from the PV2 substation and switching station and the Vetlaagte MTS grid connection to electrical/ communications services in the surrounding area and to assess whether any mitigation will be required to the PV2 switching- and substation equipment and grid connections if the grid connection is to be constructed.

According to the DFFE screening report (2022/06/10) there are no RFI sensitive services in the immediate area. A literature study reveals that there will be no interference from the PV2 switching- and substation or the grid connection to the surrounding areas assuming that the PV2 switching- and substation equipment comply to CISPR 11 class A specifications, and the grid connection cabling and connections adhere to general best practise installation methods.

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1. BACKGROUND

There is a newly proposed grid connection, substation and switching station from the PV2 plant site to the Vetlaagte MTS North from De Aar. The radio frequency interference (RFI) impact that the new PV2 switching station and PV plant grid connections will have on existing electrical equipment must be evaluated. The cabling and grid connections used to connect the PV plant to the power grid could cause unwanted levels of RFI. The Vetlaagte MTS grid connection as well as the Paarde Valley PV2 plant switching- and substation will be the focus of this report. RFI and electromagnetic interference (EMI) can influence sensitive facilities such as airport communications, RF high sites, railway line control equipment, cell phone towers, EMI sensitive equipment in the area, etc. If calculations show a PV plant's switching station or PV plant grid connection might influence existing infrastructure, EMI mitigation will have to be implemented.

The DFFE report did not flag any RFI sensitive areas close to the proposed grid connection or close to Paarde Valley PV2 switching- and substation. This report will note the separation distance required around a PV plant switching- and substation as well as methods to mitigate RFI from grid connections at the installation stage. The separation distance around a PV plant switching station is required to have minimal RFI from the switching station to surrounding EMI sensitive equipment, if no RFI mitigation will be implemented based on an assumed RFI profile.

2. DEFINITIONS AND KEYWORDS

Electrical equipment	Any electrical machinery, electrical systems, appliances, or devices, including any wireless data communication used for the operation of these facilities, used for construction, distribution and transmission power systems, exploration, farming, household, manufacturing, maintenance, or mining purposes
Electrical infrastructure	Any infrastructure or facility, including any wireless data communication used for the operation of the electrical infrastructure, to be used in any way for electricity generation, electricity distribution, electricity transmission, or for a distribution or transmission power system, and electrical facilities and equipment used for these applications
EMI	Electromagnetic Interference
RFI	Radio Frequency Interference
OHPL	Overhead Power Line

Table 1: Definitions

3. REFERENCED AND APPLICABLE DOCUMENTS

[1] EMC ADCO 6th EMC Market Surveillance Campaign 2014

[2] CR-NAVFAC-EXWC-PW-1504
Renewable Energy, Photovoltaic Systems Near Airfields: EMI (April 2015)

[3] REPO Electro-Magnetic Interference from Solar Photovoltaic Arrays (April 2017)

[4] RF DISTURBANCES PRODUCED BY HIGH-POWER PHOTOVOLTAIC SOLAR PLANTS
Lappeenranta University of Technology

[5] RADIO MOBILE
RF Propagation simulation program by Roger Coude'

[6] SPLAT – RF Signal Propagation, Loss, And Terrain analysis tool

[7] Noise and Vibration control TM 5-805-4
United States. Department of the Army.; United States. Department of the Air Force. 1995

4. AIM

The aim of this document is to provide a statement with motivation regarding the expected RFI from the PV2 switching station, substation and the PV2 Vetlaagte Grid Connection to EMI sensitive equipment in the area. The separation distance around the PV2 switching station, substation and associated grid connections will be noted and discussed.

The effects of adding intentional transmitters such as Wi-Fi to the proposed site location, falls outside the scope of this study/report, thus it will not be investigated or discussed.

As the project is still in early planning stage, no Technology Partner has been selected yet. It is therefore assumed that the switching station equipment to be used will comply to CISPR 11 Class A [1]. Possible receiver sensitivities from nearby areas are listed in Table 3.

5. GOOD PRACTISE RFI MITIGATION METHODS

There are some steps that can be considered when designing a new PV plant switching station and grid connections to minimise the amount of RFI or EMI. These are considered general best installation practises:

- Properly ground the switching modules and grid connection points to reduce common mode impedance.
- Ensure that there is proper electrical bonding on the grid connection cables as well as the cable trays, should they be installed.
- Avoid pigtail connections when installing the grid connections.
- Ensure all grid related connections are according to specification. (no gaps between connections)
- Use approved grid cable connectors to avoid unwanted corona and/or sparking.
- Avoid sharp edges at the end of cable connections.

The purpose of electrical bonding is to provide structural homogeneity with respect to the flow of electrical currents, including high frequency currents for proper operation of filters and fault current paths. Bonding prevents or safely discharges static charges. Sufficient bonding ensures a good ground connection. A good ground connection of equipment will prevent unintentional emissions to occur.

6. POTENTIAL NOISE SOURCES FROM THE GRID CONNECTIONS

In a high voltage environment, the RFI sources are generally arcing and sparking related. Corona from the lines are generally not associated with high frequency (above 30MHz) interference. Gap-type corona interference can extend to beyond 1GHz. Typical causes of RFI from grid connections are listed below.

- Corona discharge at the surface of the conductors, insulators, and fittings.
- Sparking at the insulators.
- Sparking at mounting hardware and contacts.
- Control equipment in the substation.
- Micro arcing.

Weather conditions has a 10 to 20 dB impact on the noise source with corona being worst during wet weather conditions and sparking/ arcing being worst during dry weather conditions.

6.1 CORONA DISCHARGE

Corona discharge occurs when the electrical field close to a conductor is higher than the electrical withstand capability of the air, resulting in an electrical break down. The breakdown occurs at a local level, hence no flash over will occur. The discharge energy will be fairly low and the frequency band of concern is also low.

Any equipment, fittings and insulators energised to high voltage may generate corona.

Corona is a normal effect and is worst during wet weather conditions.

6.2 SPARKING

Sparking occurs when there is sufficient voltage (> withstand capability of air) to cause electrical breakdown of the air between two metallic objects (avalanche ionisation) and the development of an arc. At least one of the metallic components is electrically floating. This is not necessarily a single event as the components can be charged again after the discharge. The discharge energy is much higher than for corona and the frequency range extends into the GHz domain.

Sparking (gap discharge) is mostly associated with bad contacts and inferior installation practises.

Sparking is worst during dry weather conditions.

6.3 ARCING

Arcing is when ionised air forms a conductive current path between an earthed component and component at line potential. Arcing is associated with a fault condition, of short duration and the arc will normally be interrupted by the protection circuits.

6.4 SWITCHING EVENTS

Switching events such as capacitor bank switching will cause voltage and current transients with frequency components into the GHz band due to steep dV/dt and dI/dt gradients.

7. LOCATION

Figure 1 - Paarde Valley PV2 Grid Connection, OHPL and Switching Station

Figure 2 - Paarde Valley PV2 Switching Station Location (Purple Area)

8. CLEARANCE ZONE

The clearance zone around a PV plant switching station and grid connection is the separation distance required, between the edge of the PV plant or switching station (source) to a specific EMI sensitive location or infrastructure (victim), for the PV plant switching station and grid connection to have no RFI on existing electrical infrastructure. It is assumed that the switching station equipment that will be used complies to CISPR11 Class A specification. (57 dBµV/m @ 3m). The recommended clearance zones are listed in Table 2.

To prevent the proposed infrastructure to have any RFI on surrounding EMI sensitive receivers, the clearance zone is the required distance from the new infrastructure to any existing EMI sensitive equipment.

Table 2 - Clearance Zone Distances [2, 3]

EMI sensitive location/ service	Distance Between the Edge of a PV plant switching station / grid connection and an EMI sensitive location in meter
Existing Radar equipment ex. Weather radar	152.4 m
Navigational and communication equipment	45.72 m
Equipment sensitive to EMI	45.72 m
Airfield/Airport Radar system	76.20 m

8.1 COVERAGE MAP AND TYPICAL SENSITIVITIES

A coverage map generated using Radio Mobile RF software [5] is shown below in figure 3. The coverage map shows that the RF signals emitted from the PV2 switching station and grid connection (starting point) have a sharp decrease in power vs distance. The average receiver sensitivity is around -107dBm, thus if the clearance zone around the PV2 switching station, substation and the entire grid connection as per Table 2 is adhered to, it will not cause unwanted RFI to equipment in the area. Typical sensitivities of receivers are listed in Table 3.

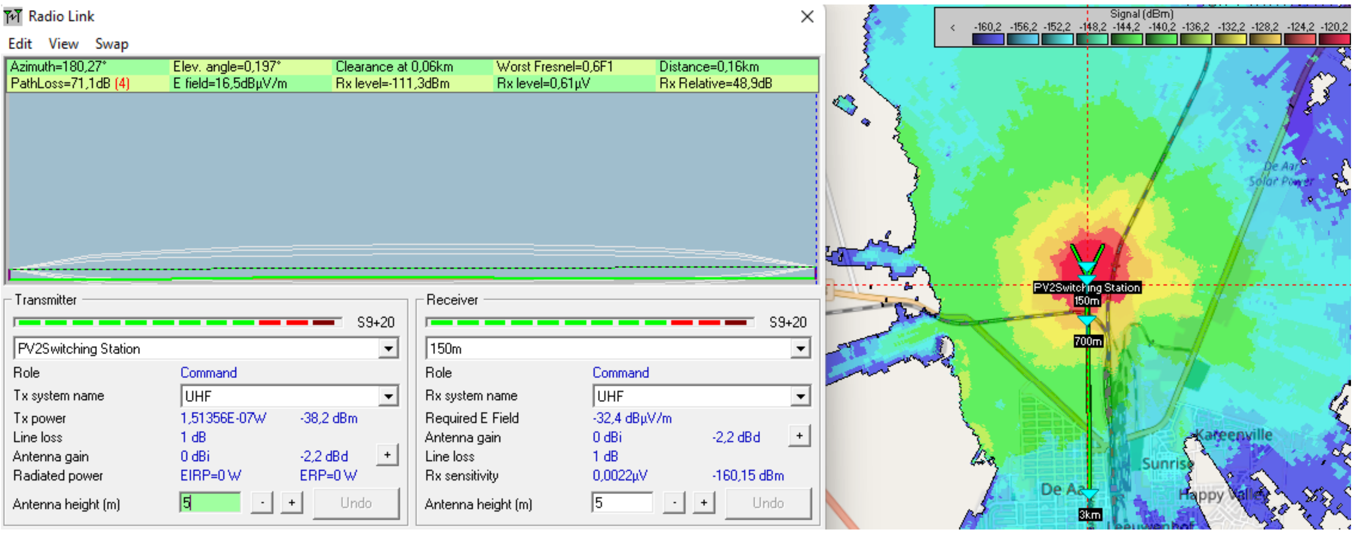

Figure 3 - Signal strength Coverage Map from the PV plant to the edge of the clearance zone (150m)

Table 3 - List of typical sensitivities from EMI sensitive equipment

Receiver	Sensitivity
Pulse Radar	-94 dBm
Wifi (common 802.11g)	-85 dBm
GSM/LTE/GPRS	-102 dBm
UHF	-100 dBm
Bluetooth	-82 dBm

9. CUMULATIVE EFFECT

Non-correlated noise sources such as PV plant inverters or wind turbines in close proximity could increase the clearance zone required around a specific renewable energy plant site, as the level of unintentional radiated emissions will be higher. A standard factor of $10 \log_{10} N$, where N = amount of renewable energy plants in the direct vicinity, is used to account for the increased radiated emission levels [7]. For Paarde Valley PV2 switching station there are 44 renewable energy facilities within a 35 km radius.

For this theoretical worst-case scenario, the theoretical increase in radiated emission levels will be 16.4 dB. This result in the clearance zone requirement to be extended from 152.4 m to 700 m. Thus, a new clearance zone of 700 m should be adhered to around the proposed Vetlaagte MTS grid connection as well as the PV2 switching- and substation where receivers with sensitivities of less than 107dBm should not be used.

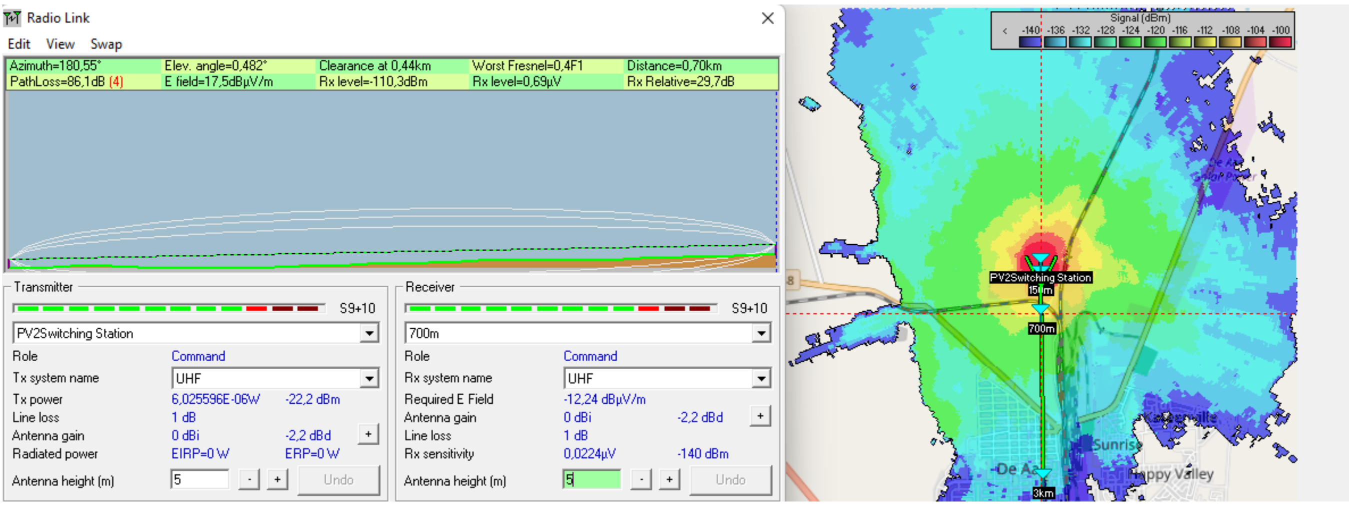

Figure 4 - Signal Strength Coverage Map with the Cumulative Effect Considered (700m)

10. CONCLUSION

The DFFE report did not flag any RFI sensitive areas close to the Paarde Valley PV2 Switching station, substation and the MTS Grid Connection. If the 700 m theoretical worst-case clearance zone from section 9 is adhered to, then the PV2 Switching station and associated Grid Connection will have no RFI impact on equipment in the surrounding area. Figures 5 and 6 use the switching station location as an example and the same clearance zone will apply around the whole grid connection.

Table 3 showcases possible EMI sensitive receivers with their respective sensitivities that could be encountered in the area. From the coverage map in Figure 5, it is seen that at 150 m the received power level is at -111.5 dBm if no cumulative effect is considered. When the cumulative effect of the nearby renewable energy plants is considered, the clearance zone is extended to 700 m where the receive power level is at -110.3 dBm as seen in Figure 6 (Consider the Rx level). CISPR 11 Class A + 16.4 dB radiated power level was used as the PV plant switching station and grid connection transmission power level. This is an assumed value as no technology partner has been selected yet. The 16.4 dB is the theoretical maximum level increase in power for a worst-case scenario. The theoretical worst-case scenario is highly unlikely to occur in practise.

Paarde Valley PV2 Switching Station as well as the Vetlaagte MTS Grid Connection pose a very low to no RFI or EMI risk to the surrounding equipment.

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