MOTT MACDONALD

# Transmission Lines
# Solar Farm Clearances

Solar Farm Clearances

September 2017

Confidential

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# Issue and Revision Record

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# 1 Executive Summary

The Transmission line / Solar farm clearances working group was established by EirGrid in early 2017 to establish a policy in relation to the setback distance of solar panels from overhead transmission lines.

The working group have reviewed the practices of other Transmission System Operators (TSO) in relation to these clearances and have also considered the clearances from a domestic perspective and our obligations under health and safety and system security requirements.

This report has been produced to provide the solar industry with the background information and to outline the key considerations that have influenced the proposed setback distances. It will be used for consultation with external stakeholders as EirGrid are now seeking to engage with the solar industry on the proposed policy in advance of finalising and publishing the policy.

The proposed clearances are as per table 1 below:

**Table 1: Proposed Clearances from Solar Farms to Transmission lines**

| Setback | Condition |
|---|---|
| Within 10m of the outer conductors of a transmission line | Solar panels or solar farm infrastructure not allowed. |
| Between 10m of the outer conductor and 23m of the centreline of a transmission line | Solar panels and solar farm infrastructure limited to a height of 3 metres. |
| Beyond 23m of the centreline of a transmission line | No restriction in relation to clearance from transmission lines. |

Source: EirGrid

Note: The table above includes the proposed clearances for transmission lines only. Access routes for line maintenance will be required and additional clearances may be required around transmission line structures.

# 2 Introduction

Planning authorities in Ireland have seen a massive increase in applications for Photovoltaic (PV) or Solar Farms in recent years. As of October 2016, an estimated 594 Megawatts peak (MWp) of PV generation has been granted planning approval, under determination or on appeal for planning permission. More recent figures show that this could now be as high as 1000MWp.

As a typical MWp of PV panels uses around 2.2 hectares (ha) of land, the total land required to facilitate these PV farms exceeds 2200 ha. With such a large area of land required, it is likely some of these PV farms will be located on lands which have Overhead Lines (OHL) passing through them.

As a result, EirGrid has appointed a working group to investigate the potential impact PV farms may have on transmission lines. As part of this group, Mott MacDonald were tasked with producing this report to investigate what setback distances or clearances should be put in place for PV farms built near Transmission lines. It has been produced to provide the solar industry with the background information and to outline the key considerations that have influenced the proposed setback distances. It will be used for consultation with external stakeholders as EirGrid are now seeking to engage with the solar industry on the proposed policy in advance of finalising and publishing the policy.

# 3 Literature Review

Mott MacDonald undertook a review of documentation available through library sources, international contacts in other utilities, review of other utilities specifications, and through discussion with colleagues in other Mott MacDonald offices around the World. The following information was garnered from documentation, policies and specifications in relation to the clearances between overhead lines and photovoltaic farms.

## 3.1 UK Standards

### 3.1.1 ENA_TS43-8_Issue_3

UK – ENA_TS43-8_Issue_3, published by the Energy Networks Association is a technical specification which outlines overhead line clearances for the UK. It is based on The Electrical Safety, Quality and Continuity Regulations 2002, ESQCR, a legislative document which applies throughout the UK. Table 1.1 as shown below, gives the clearance from a line conductor to any object which is normally accessible. This has been adopted by NG in their TGN 287 document and also applied directly by Northern PowerGrid.

**Table 2: Clearances to objects**

| Item | Description | Nominal System Voltage (kV) / Minimum Clearance (metres) | | | | |
|---|---|---|---|---|---|---|
| | | <33 | 66 | 132 | 275 | 400 |
| 6.2.3 | Line conductor to that part of a tree under / adjacent to line and: (ii) Capable of supporting ladder / climber | 3 | 3.2 | 3.6 | 4.6 | 5.3 |

Source: Energy Networks Association TS 43-8 Table 6.2.3

### 3.1.2 Code of practice for grid connected solar photovoltaic systems – IET

The Code of Practice for Grid Connected Solar Photovoltaic Systems, published by IET London (ISBN: 9781849197212) sets out the requirements for the design, specification, installation, commissioning, operation and maintenance of grid-connected solar photovoltaic (PV) systems installed in the UK. There is no information of relevance in this book regarding clearances to overhead line clearances or setback distances.

## 3.2 UK TSO and DSO Policies

### 3.2.1 TGN 287-Third party guidance for working near NGET equipment

National Grid's Third Party Guidance for working near NGET equipment was published to give guidance to third parties who are proposing, scheduling or designing developments close to National Grid Electricity assets. The requirement of this document calls for a clearance of 5.3m from the highest point of the solar panel to the lowest OHL conductor on 400kV lines. This value has been adopted from table 6.2.3 of the ENA TS 43-8 specification. It should be noted that no new clearance distances have been put in place in this document. The solar requirements are based on existing criteria. National Grid permit PV panels to be located beneath their transmission lines provided that the minimum clearance above can be achieved. National Grid

also highlights the risks to the PV farm by location close to an OHL from conductor fall/failure and ice drop.

National Grid also reference the potential issues related to earthing, in particular, lightning strikes or earth faults. Strikes on the OHL or earth faults can cause a rise in the earth potential around the base of the tower. PV farm designers are reminded that earthing of their structures & equipment must be adequate.

It is also outlined that maintenance work areas and vehicular access must not be hindered by the solar farm. The TAO should have unrestricted access to the assets including, but not limited to, access through any compound gates.

### 3.2.2 Northern Power Grid NSP-004-011 Guidance on Overhead Line Clearances

With the rise in demand for solar PV farms, developers are increasingly enquiring about the placement of solar PV under overhead lines. As a result, Northern PowerGrid have specified minimum clearances/corridors from solar farms to overhead lines.

Northern PowerGrid have stated that their designers will require that solar farms maintain the same clearances / setback distances as those laid out for minimum horizontal distances to safety barriers in table 3.11.1 of their guidance document, (see below).

**Table 3: Minimum horizontal distance to safety barriers**

| Voltage type | All Wood pole lines | 66 & 132kV Tower lines | 275kV Tower lines | 400kV Tower lines |
|---|---|---|---|---|
| Minimum horizontal distance to safety barriers (metres) | 6.0 | 9.0 | 12.0 | 14.0 |

Source: Northern PowerGrid – Northern Power Grid NSP-004-011 Guidance on Overhead Line Clearances Table 3.11.1

Table 2 builds on the HSE guidance note GS6 for work near overhead lines. The GS6 guidance note is a similar guidance document to the ESBN Code of practice for Avoiding Danger From Overhead Electricity Lines, which is discussed in section 3.3. It sets out distances to safety barriers which are referred to as Hazard Zones in the ESBN code of practice.

Where this cannot be achieved and it is practical to de-energise the line during the construction phase, then the minimum safety clearance shall be as detailed in table 3 (see below), using the clearance appropriate to the operating voltage of the adjacent line.

**Table 4: Clearances to objects at max. conductor temperature, hanging vertically in still air or deflected up to 45 degrees.**

| Item | Description | Minimum Clearance (m) /System Voltage (kV) | | | | |
|---|---|---|---|---|---|---|
| | | <33 | 66 | 132 | 275 | 400 |
| 3.6.1.1` | Line conductor to any object which is normally accessible (including permanently mounted ladders and access platforms) or to any surface of a building | 4.3 (3.0) | 4.3 (3.2) | 4.3 (3.6) | 4.6 | 5.3 |

Source: Northern PowerGrid – Northern Power Grid NSP-004-011 Guidance on Overhead Line Clearances Table 3.6.1.1

These clearances are in line with those in the ENA standard and as required by National Grid.

### 3.2.3 Scottish Power and Scottish and Southern Electricity

Scottish Power (SP) also reference the GS6 guidance document. They state that any work within a horizontal distance of 15*[1] metres of an overhead line on steel towers, and 9 metres on wooden poles requires consultation with the line owner for safe working advice.

Scottish and Southern Electricity (SSE) use the same parameters as Scottish Power for work near overhead lines.

Neither SP nor SSE have clearance requirements specifically for solar farms.

## 3.3 National Electrical Safety Code (NESC) C2-2012 IEEE publication (USA)

NESC provides clearances to buildings which are readily accessible to pedestrians which has a Horizontal and Vertical component. (Table 234-1). This document is a voluntary standard which is widely specified by American utilities for overhead line clearances. This standard does not directly deal with solar farm clearances. The USA adopts similar criteria to UK and Ireland.

Although standards do not prohibit PV panels to be located under overhead lines, it is generally not done, except where the utility itself is installing the panels, i.e. not 3rd parties. In this case, there is no need for the utility to require the SF operator to dismount the panels in case of urgent requirement for access, as the operator is the utility, their own operators can carry out the work.

## 3.4 Solar Farm Clearances from Overhead Power Lines – AECOM for ISEA

AECOM were commissioned by the Irish Solar Energy Association (ISEA) to investigate the required setback distance or clearances of solar farms from overhead lines. This report looked at practices in a number of countries and found that there were two main ways for treating solar farm clearances to overhead lines:

- No development allowed under lines (with varying set back distances) and
- Development allowed under lines
  - *Areas around towers need to be kept clear*
  - *Clear access to towers and pole sets required*
  - *Clear access not required but must be facilitated if needed.*

This document indicates that most international utilities prefer a horizontal corridor but that there are examples where the utility is flexible to consider alternative approaches.

It is stated in this document that;

> *"The width of the corridors proposed in Ireland is the largest that can be found from all of the countries considered, and some of the technical considerations within the ESBN documentation such as earthing do not seem to be a major consideration for other utilities, with the exception that developers are required to install adequate and appropriately designed earthing systems, including 3rd party fences"*

It is noted in this document that ESBN had outlined setback distances for transmission lines in a previous revision of their solar clearances document, however these were removed in the latest version. These distances were given as shown in the table below.

[1] *Is a minimum distance, if plant can reach 20 metres then the barrier becomes 35 metres.

**Table 5: ESBN minimum corridor width over solar farms (withdrawn)**

| | 110kV | 220kV | 400kV |
|---|---|---|---|
| Corridor width over solar farms (metres) | 46 | 60 | 70 |

Source: 2.3.2 Solar Farm Clearances from Overhead Power Lines – AECOM for ISEA

While the table above has now been withdrawn, the document states that ESBN and its contractors need permanent access routes to the overhead lines at all times. This differs from other utility companies who only need permanent access to structures or like National Grid, only need temporary access to structures.

## 3.5 Summary

See table below for a summary of the findings in this chapter:

**Table 6: Summary of clearances**

| | Minimum Clearance (m) /System Voltage (kV) | | | | | |
|---|---|---|---|---|---|---|
| | 33 | 38 | 66 | 132 | 275 | 400 |
| NGUK | 3 | - | 3.2 | 3.6 | 4.6 | 5.3 |
| Northern Powergrid | 4.3 | - | 4.3 | 4.3 | 4.6 | 5.3 |
| SSE | - | - | - | - | - | - |
| Scottish Power | - | - | - | - | - | - |
| NESC | - | - | - | - | - | - |
| ESB | - | 17m* | - | - | - | - |

Note: * 34 metre corridor

# 4 Existing Clearance Requirements / Setback

## 4.1 Electricity (Supply) (Amendment) (no.2) Act, 1934

The Electricity (Supply) (Amendment) (No.2), 1934 outlines the required distances for buildings or structures from transmission lines.

Section 20.-(1) states:

> *" No person shall erect or construct or begin to erect or construct any building or structure of which any part is within or projects over or will, when such building or structure is completed, be within or project over the relevant area of any transmission wire unless he has, at least two months before beginning such erection or construction, given to the Board notice in writing stating his intention to erect or construct such building or structure and stating all relevant particulars of such building or structure."*

Where in section 20. -(3) it states:

> *"the expression "relevant area of any transmission wire" means the area within twenty-five yards on either side of the straight line joining the centres of the bases of any two consecutive posts, pillars, or other erections supporting such transmission wire, and the expression "transmission wire" means a wire or line carrying electricity above ground and forming part of the transmission system or of the distribution system."*

The 25 yards clearance either side of the centre line equates to about 23 metres or a 46 metre corridor.

## 4.2 National Normative Aspects EN 50341-3-1:2011

Clearance to ground, trees and residential/other buildings are outlined in section 5 of EN 50341-3-11:2011 National Normative Aspects (NNA) for Ireland. It should be noted that the requirements outlined in this document (EN 50341-3-11:2011) only apply to new build HV transmission lines but can be used as a guidance for clearances to existing lines. The NNA document lists the following clearances for OHL:

**Table 7**
**Clearances to ground in unobstructed countryside**

| | 110 kV | 220 kV | 400 kV |
|---|---|---|---|
| Maximum design temperature | 7 m | 8 m | 9m |

Source: EN 50341-3-11:2011 Table 5.4.4/IE.1.1

**Table 8**
**Clearances to trees**

| Condition | Clearance from conductor | | | Conditions for conductor position | | |
|---|---|---|---|---|---|---|
| | 110 kV | 220 kV | 400 kV | Temp | Ice | Wind |
| 1 | 1,5 m | 2,5 m | 4,0 m | Max design | 0 | 0 |
| 2 | 1,0 m | 2,0 m | 3,0 m | 15 ºC | 0 | 40 m/s |
| 3 | 1,0 m | 2,0 m | 3,0 m | 0 ºC | 1,5 cm | 20 m/s |

| Condition | Clearance from conductor | | | Conditions for conductor position | | |
|---|---|---|---|---|---|---|
| 4 | 1,0 m | 2,0 m | 3,0 m | 0 ºC | 2,5 cm | 0 |

Source: EN 50341-3-11:2011 Table 5.4.4/IE.1.2 – NOTE: No tree in falling to contact any overhead line conductor in its undisturbed position or any part of any support.

**Table 9**
**Clearances to residential and other buildings**

| Condition | Clearance from conductor | | | Conditions for conductor position | | |
|---|---|---|---|---|---|---|
| | 110 kV | 220 kV | 400 kV | Temp. | Ice | Wind |
| 1 | 5,0 m | 6,0 m | 7,35 m | Max. design | 0 | 0 |
| 2 | 5,0 m | 6,0 m | 7,35 m | 30 ºC | 0 | 17,5 m/s |
| 3 | 1,5 m | 2,25 m | 3,15 m | 30 ºC | 0 | 45 m/s |
| 4 | 3,0 m | 3,75 m | 4,65 m | 0 ºC | 5 cm | 0 |
| 5 | 1,5 m | 2,25 m | 3,15 m | 0 ºC | 5 cm | 20 m/s |
| 6 | 3,0 m | 4,0 m | 5,35 m | 30 ºC | 0 | 22,5 m/s |
| 7 | 1,5 m | 2,25 m | 3,15 m | 30 ºC | 0 | 40 m/s |
| 8 | 1,5 m | 2,25 m | 3,15 m | 0 ºC | 2,5 cm | 22,5 m/s |
| 9 | 1,0 m | 2,25 m | 3,15 m | 0 ºC | 4 cm | 0 |

Source: EN 50341-3-11:2011 Table 5.4.5.2/IE.1

NOTE:
Conditions 1, 2, 3, 4, and 5 apply for High Security lines (urban areas) and lines designed to reliability level three and the notes below apply.
Conditions 1, 2, 3, 5 and 6 apply for Normal Security lines.
Conditions 1, 2, 7, 8 and 9 apply in respect of buildings not normally occupied.
Specific Gravity of ice is 0,9 except for conditions 4 and 5 where it is 0,8.
Final conductor conditions should be used to calculate the conductor positons.

The NNA standard also advises that

> *"No building shall be permitted within 23 m of the centre of any overhead line support having earthed crossarms unless it has been established that there will be no undue risk of injury to those using the building in the event of an earth fault on the line at that support".*

## 4.3 ESBN Code of Practice for Avoiding Danger from Overhead Electricity Lines

ESB's Code of Practice for Avoiding Danger from Overhead Electricity Lines was developed with the help of the Health and Safety Authority (HSA) to improve the level of safety and minimise the dangers when working near overhead lines.

This code of practice outlines Hazard Zone clearances. A Hazard Zones is defined as

> *"an area in the vicinity of an overhead electricity line which must normally be isolated from the work site by the use of physical barriers, in order to minimise the risk of accidental contact or near contact with the overhead line by plant, equipment, scaffolding or other materials while carrying out construction work"*

These hazard zones are measured from the outermost conductor and run parallel to the overhead line. This is given as 10 metres from the outer conductors for transmission level overhead lines.

Exclusion Zones are defined in the code of practice as

*"a region around a live overhead electricity conductor which must never be breached in order to avoid electrical arcing or flashover"*

The distance for exclusion zones are shown in the table below:

**Table 10**
**Exclusion Zone in Metres**

| | 110kV | 220kV | 400 kV |
|---|---|---|---|
| Exclusion Zones (metres) | 4.5 | 6.0 | 8.0 |

Source: ESBN Code of Practice for Avoiding Danger from Overhead Electricity Lines

## 4.4 EirGrid Overhead Line Functional Specification LDS-EFS-00-001-R0

In EirGrid's functional specification for new overhead lines, minimum vertical clearance over different areas are outlined in section 6.4. These clearances, shown in the table below, could be applied to solar farms.

**Table 11**
**Overhead Line Clearances**

| Feature | 110kV | 220kV | 400kV |
|---|---|---|---|
| Over Normal Ground | 7.0m | 8.0m* | 9.0m* |

Source: Overhead Line Functional Specification LDS-EFS-00-001-R0 Section 6.4.1

EirGrid note normal corridor distances for growing trees in their functional specification for 110, 220, and 400 kV lines. EirGrid mention in this document that, although they do not generally object to growing trees to a maximum height of 3 metres within these corridors, a corridor of 4 metres must be kept totally clear for maintenance access.

## 4.5 Easements

As part of the planning for a new HV overhead line, it is ESBN's policy to secure easements or wayleaves for all overhead lines or underground cables crossing lands which is not a public highway / railway or tramway. Easement widths are provided by the CER as follows:

***Forestry:***

- *MV and 38kV Lines – 20m corridor (10m either side of the line)*
- *110kV Lines – 61m corridor (30.5m either side of the centerline)*
- *220kV Lines – 68m corridor (34m either side of the centerline)*
- *400kV Lines – 74m corridor (37m either side of the centerline)*

*Within these corridors trees are allowed grow to a maximum height of 3m (as per the ESB/IFA Agreement). However, a 4m maintenance access corridor directly under the line must be left clear at all times to allow ESB access. Any trees which grow above 3m are to be cut or lopped by the landowner at his expense or, if not, by ESB and the cutting costs recovered from the landowner.*

***Building:***

*Generally building easements are only purchased under 110kV lines and upwards. The widths can vary but the following widths usually apply:*

- *110kV Lines – 46m corridor (23m either side of the centerline)*
- *220kV Lines– 60m corridor (30m either side of the centerline)*

- *400kV Lines – 70m corridor (35m either side of the centerline)*

CER also provide the following standard wording for the deed:

> "*The Grantor hereby covenants with the Grantee, to the intent that such covenant shall bind and run with the Lands and any part thereof, not to erect any building structure or erection or to place any concrete or similar surface or foundation or to carry out any excavation or development under, or on, or within a distance of _____ metres on either side of the straight line joining the centres of the bases of any two consecutive posts pillars or other erections nor within a distance of _____ metres on either side of the centre of any installation placed on the lands"*

It should be noted that easements may not be in place for all lands which overhead lines span.

## 4.6 ESB Standard Clearances for Solar Panel Farms From LV, MV and 38 kV Overhead Power Lines

The DSO, ESB Networks (ESBN) published their company standard for clearances between Solar Farms and overhead lines in June 2016. The clearances ESBN use for solar farms are outlined in the table below.

**Table 12**
**ESBN Clearances to solar panels**

| Voltage of Overhead Power Line: | Minimum Corridor required to be kept clear of solar panels, equipment and underground services: | Maximum height of solar panels above ground level that will be located at the extremities of the minimum corridor: |
|---|---|---|
| LV Line | 18m or 2 times Height of Pole + 2 m whichever is higher | 4m* |
| 10/20 kV | 18m or 2 times Height of Pole + 2 m whichever is higher | 4m* |
| 38 kV Line (Single Circuit & Double Circuit) | 34m (if wind stays are used on poles then apply 40m) | 4m* |

Source: ESB Standard Clearances For Solar Panel Farms From LV, MV and 38 kV Overhead Power Lines, 2016

> **This is a guide height for solar panels above original ground level. If proposed vertical type solar panels are to be installed on the site adjacent to live ESB overhead power lines then a separate study will be required by Asset Management Section ESBN, Leopardstown Road, Foxrock, Dublin 18 in advance of the solar panel farm owner/designer applying for planning permission.*

It is a requirement of ESBN's standard that the solar farm owner/developer ensures that all cable/ducting and metal palisade fencing and conductive fencing has a minimum radial clearance of greater than 23m measured from all steel tower legs.

ESBN state that permanent access is required to the overhead line at all times, requiring that access in addition to the corridor under the line us designed in from an early stage.

# 5 Working Group Considerations affecting Clearances

## 5.1 OHL Operation and Maintenance

EirGrid's licence as the Transmission System Operator requires that they "*operate and ensure the maintenance of and, if necessary, develop a safe, secure, reliable, economical and efficient electricity transmission system".* Maintenance is at the core of ensuring the existing system continues to function into the future.

Wayleave agreements endeavour to ensure sufficient access is in place to ensure maintenance can be carried out on tower/support structures and the OHL itself. The DSO company standard clearly outlines the access requirements both under the line and to each structure within the solar farm, including noting the requirement for access through site gates.

Maintenance activities on transmission overhead lines are generally carried out following inspections or assessments such as:

- Sag Inspection;
- Climbing Patrol;
- LCA
- Heli-patrol

From these inspections/assessments, a set of corrective maintenance works are recommended to take place on order to maintain the integrity of the OHL. These works may include:

- Replace Insulator;
- Replace Poles only (Set);
- Replace Pole & Hardware;
- Replace Jumpers;
- Replace Joints;
- Replace Pole Bolt;
- Replace Arcing Horns;
- Replace Vibration Dampers (110 & 220 kV);
- Cross Arm Replacement;
- Shackles (400 kV);
- Straighten Pole;
- Repair Earth Straps / Leads;
- Bird Nest Removal;
- Painting / Corrosion Treatment
- Reconductoring &
- Foundation Refurbishment.

### 5.1.1 Access Maintenance Equipment and Vehicles

For the maintenance activities outlined above, a range of vehicles and equipment need access to the line, especially the tower or poles. The vehicles and equipment can include:

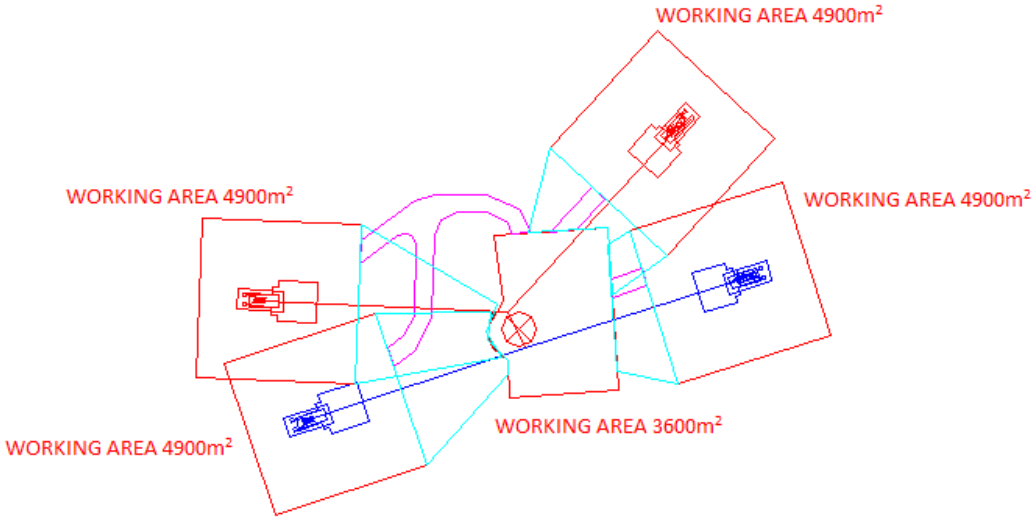
- Cars / Vans / 4x4's / ATV's
- Unimogs
- Hiabs
- Generators / Compressors
- Backhoe / Tracked excavator
- Articulated lorry and low loader
- Puller / Tensioner Machines
- Ready mix concrete lorry

As noted in ESBN's Standard Clearances for Solar Panel Farm, ESBN it is required that adequate gate site entrance be provided such that trucks and cranes can access the site with ease, access routes to be kept as short as possible, a minimum width of 6m while avoiding sharp bends. This is to permit trucks, track machines and cranes access to the lines without difficulty.

### 5.1.2 Access for construction or re-stringing

In the case of upgrade works, maintenance requiring conductor replacement or construction of new sections of overhead line, working areas around the structures / towers will be required, in addition to any clearances. Figure 4.1 shows potential stringing and working areas for a 400kV OHL with indicative Puller/Tensioner machine positions. The relative locations of these working areas will be specific to each structure and are driven by the angle of the direction of conductors with respect to the structure.

**Figure 1**
**Potential stringing and working areas for 400kV OHL with Puller/Tensioner machine positions**




Source: Mott MacDonald PLSCADD model

### 5.1.3 Heli-patrol and reflection

The working group raised the concern that glare from solar panels and its potential impact on the annual Heli-patrol. It was noted that increasing the distance from OHL's may not mitigate glare during these patrols.

The Federal Aviation Administration (FAA) in USA published "Technical Guidance for Evaluating Selected Solar Technologies on Airports" in 2010. There are many such installations through the US and they continue to be installed since the publication of the guidance. FAA note that they continue to examine the issue of glare and reflectivity and caution against the use of the document as the sole source for decision making however they state "*Today's panels reflect as little as 2% of the incoming sunlight depending on the angle of the sun and assuming use of anti-reflective coatings".* It is understood that this level of reflectivity is about the same as a body of water. There does not appear to be strong evidence that this adversely affects the piloting of aircraft however in the case of heli-patrols, we have not found reports of the impact of solar farm glare on the effectiveness of the overhead line inspection.

It should be noted that glint and glare has been raised as a concern in the Irish context. In February 2017, An Bord Pleanála upheld a decision by Wexford County Council to refuse an application for the development of a solar farm spanning more than 200 acres. The council noted that it was not satisfied that residential properties would not be adversely affected by glint and glare from the solar panels and further, the council also noted concerns for public safety, noting *"particular concern from a traffic-safety perspective".*

## 5.2 Earthing

The working group considered earthing issues that may arise in the case of solar farms siting close to overhead line infrastructure.

The group also discussed the impact of transmission system fault levels on the solar farm and its earthing system. In case of system faults, the potential of the transmission system earth will rise, including the earthing mat surrounding the structures of the overhead line. Overhead lines are designed and constructed to ensure safe touch and step voltages in the area surrounding the towers. The working group found that the solar farm would not be adversely affected by this provided the solar farm is designed to safely manage this earth potential rise. Further the group suggested that this report propose text for inclusion in connection offers stating that it is the customer's responsibility to ensure that the solar park development is designed to safely withstand the effect of faults at nearby transmission assets.

## 5.3 Potential Physical Damage to PV farms due to OHL proximity

The group considered two main risks for damage to solar farms arising from their close proximity to overhead lines:

- Conductor ice drop: while it may be considered that this is similar to overflying buildings, PV panels may be more fragile therefore there may be possible damage.
- Conductor dropping: although unlikely and rare, the risk exists of a conductor or fitting falling from the overhead line.

## 5.4 Potential Physical Damage to OHL due to PV farms proximity

The group considered the risk of physical damage to the overhead line related to the proximity of solar panels. The potential for increased ambient temperature is discussed in section 4.5 below. Concerns were also raised that in high winds or storm conditions, panels could cause

damage where they may break free from ground mountings. It is known that PV panels are lightly fixed using loose concrete blocks in other countries however the group's visit to a windfarm in Northern Ireland found the PV panels to be well fixed to a solid ground mounting.

## 5.5 Ambient Temperature Increase

In their report for ISEA, AECOM identified that Réseau de Transport d'Électricité (RTE), the TSO of France, mention in their general requirements specification for overhead lines in section 4 – 2.4 that when an overhead line transverses a solar farm, there is a potential risk of temperature increase from the PV panels. They have recommended the addition of 10 degrees Celsius to the ambient temperature when either designing the overhead line or positioning the PV farm under the line.

EirGrid's standard overhead line specification designs the line to the conductor's maximum operating temperature of 80ºC. An increase in the ambient temperature would have the knock-on effect of limiting the heat dissipation and consequently, increasing operating temperature for the same power flow. Increased conductor temperature could increase sag (potentially breaching minimum clearances) and exceeding the maximum rated operating temperature for the conductor could have damaging effects on the conductor (burning off grease) and limit its life. Conductor temperature monitoring could improve the best management of maximum permissible power flows however should a 10ºC ambient increase in temperature be achieved, it should be expected that maximum power flow will be limited. A similar approach is already taken in the implementation of summer/winter ratings where the lower temperature during winter months permits a higher power flow.

## 5.6 Cleaning/Maintaining PV farm Equipment

Recommendations for the frequency of cleaning of solar PV panels varies across manufacturers and will be affected by local environment, dust levels, local bird life, etc. Common approaches include the use of telescopic brushes and water, hydraulic brush attachment for a propelled machine. We have also found examples of front mounted tractor attachments being used. During operation, this attachment appears to be no higher than the tractor itself, approximately 3m in height.

As there are dangers with working in close proximity to overhead lines, as was outlined in section 3.3, ESB have addressed PV panel cleaning directly in the solar clearances document referenced in section 2.3. It states:

> *"The Solar Panel Farm owner/operator shall agree the safe method of cleaning the panels with the EO (Engineering Officer ESBN) at design stage. The safe method must be agreed in writing and the EO or its Consultant shall keep a copy of this agreement on file.*
>
> *The EO or its consultant shall explain the dangers with using jet water or liquids in close proximity to Overhead Power Lines. It is strongly recommended that adequate large signage be erected in appropriate places along the width of the required corridors". The machine operator shall be briefed of such dangers and a method statement shall be agreed and issued to the EO before the cleaning work commences on site."*

## 5.7 Other Influences

### 5.7.1 Solar Gain

Solar gain was raised as a concern by the working group however having reviewed through PLSCADD, it was found to have negligible effects.

### 5.7.2 EMF

The working group discussed the issue of EMF and noted that overhead lines are designed to operate within ICNIRP / EU levels. The Working Group do not foresee any issues from an EMF perspective, if solar farms are located close to transmission lines.

## 5.8 Conclusions

The assessment of issues that may affect the current clearances standards for solar farms identified that the following are of concern to the TSO:

- Permanent and unrestricted access for maintenance and fault restoration and restringing;
- Personnel and public safety in case of transmission fault;
- Damage to the overhead line in case of high winds causing PV panels to be blown onto the line;
- Safety of solar farm personnel during PV cleaning;
- Impact of glare on effectiveness of heli-patrol;
- Impact of increased ambient temperature and,
- Future development of network infrastructure.

# 6 Proposed Policy

## 6.1 General clearance requirements to Transmission lines and Structures

Following due consideration of the general factors affecting transmission line clearances and taking into account the nature of solar farm installations the working group has proposed the following clearances for inclusion in the future policy document:

**Table 13: Proposed Clearances from Solar Farms to Transmission lines and Structures**

| Setback | Condition |
|---|---|
| Within 10m of the outer conductors of a transmission line. | Solar panels or solar farm infrastructure not allowed. |
| Within 23 metres of the centreline of a transmission line for a distance of 23 metres on either side of an intermediate type structure. | Solar panels or solar farm infrastructure not allowed. |
| Within 23 metres of the centreline of a transmission line for a distance of 50 metres on either side of an angle or tension type structure. | Solar panels or solar farm infrastructure not allowed. |
| Within 10 metres of a stay anchor. | Solar panels or solar farm infrastructure not allowed. |
| Between 10m of the outer conductors and 23m of the centreline of a transmission line. | Solar panels and solar farm infrastructure limited to a height of 3 metres. |
| Within 100 metres radius from the centre of an angle or tension type structure. | All panels to be demountable type to allow for easy removal for restringing activities. |

Source: EirGrid

Please refer to drawing MMD-373966-E-SK-00-XX-0001 in Appendix A for an illustration of the above requirements.

## 6.2 Access requirements

Access needs to be maintained to the transmission line corridor for maintenance and emergency requirements. The solar farm developer shall ensure that a 4.5 metre wide access road to the transmission line corridor is provided for ESB crews at all times including throughout the solar farm construction phase.

## 6.3 Solar Farm requirements

### 6.3.1 Earthing

Solar farm developers shall ensure that their installations are adequately designed from an earthing perspective. Solar farms shall carry out earthing design studies to ensure safety to the public and to personnel in the case of short circuits on the transmission system. Such studies should consider touch and step voltages and any transferred potentials, including through metallic fencing etc. The solar developer should engage with EirGrid to agree the requirements for each instance and afford EirGrid the opportunity to review the earthing design.

### 6.3.2 Maintenance and Cleaning

Solar farm developers shall agree the cleaning and maintenance practices for any panels within 23 metres of the centreline of the overhead line with the TSO. Responsibility shall reside with the solar farm operator to ensure the safety of his personnel (reference can be made to the Code of Practice for working under overhead lines). The working group have highlighted their concern in relation to the use of high pressure washers near transmission lines.

### 6.3.3 Air Temperature

Solar farm developers shall provide studies to EirGrid in relation to local air temperature changes because of the solar farm installation. An increase in the local air temperature will reduce the transmission line rating.

### 6.3.4 Risk Assessment

The solar farm developer shall provide a risk assessment that considers the risks associated with the installation with particular focus on the proximity of the transmission line. The risk assessment shall address all such risks for the lifetime of the installation and shall follow the general principle of Eliminate Reduce Inform & Control (ERIC). A sample risk assessment has been provided in Appendix B.

# 7 Reference Documentation

**Table 14: References**

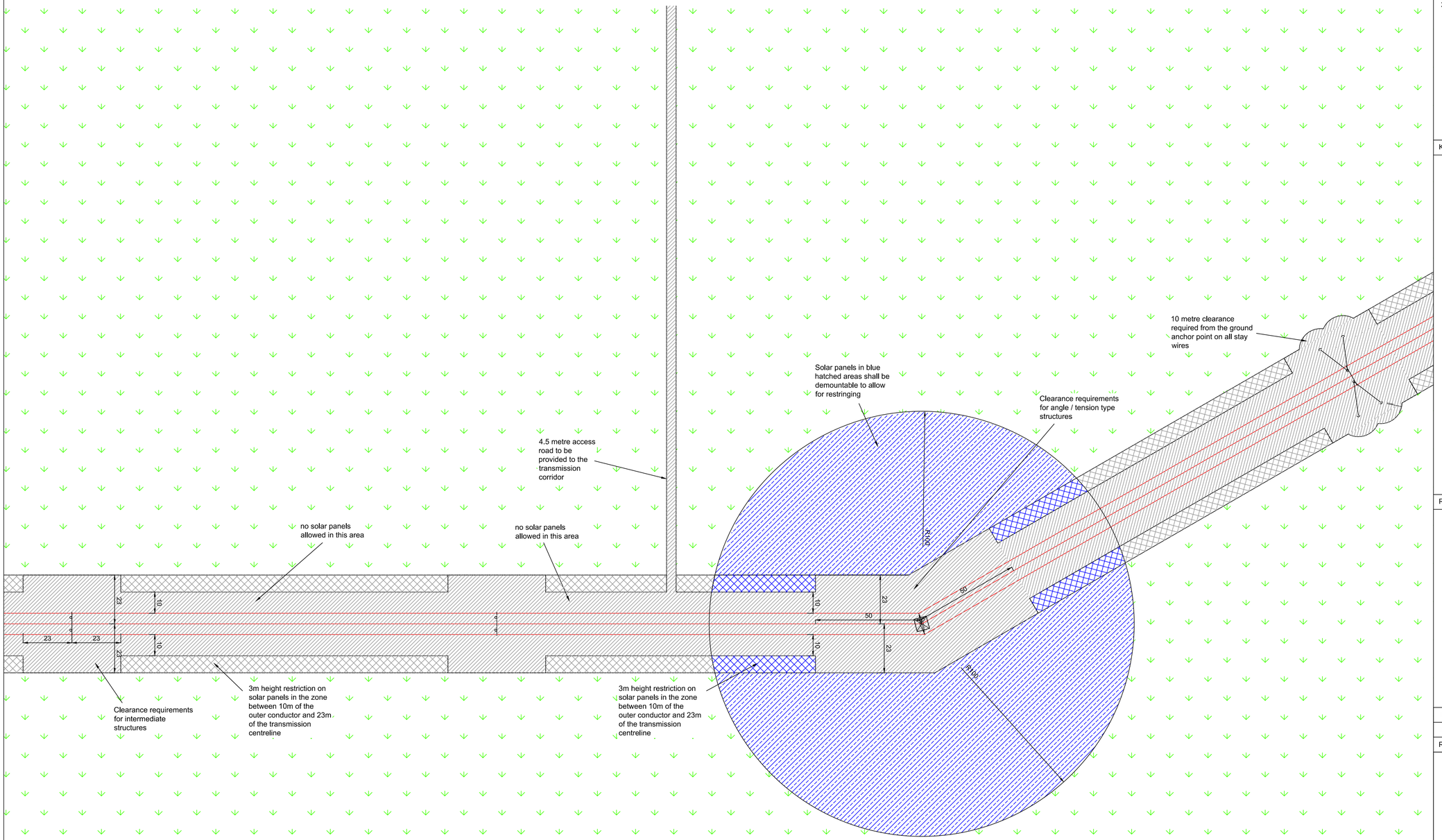
| | | |
|---|---|---|
| EN 50341 -1 | Overhead electrical lines exceeding AC 1 kV<br>Part 1: General requirements — Common specifications | 2012 |
| EN 50342-3-11 | National Normative Aspect (NNA) Ireland | 2001 |
| ENA_TS_43-8_Issue 3 | Energy Networks Association, UK – Overhead Line Clearances | 2004 |
| TGN 287 | National Grid Electricity Transmission, UK<br>Third party guidance for working near NGET equipment. | 2016 |
| Northern Power Grid NSP-004-011 | Northern PowerGrid: Guidance on Overhead Line Clearances | April 2014 |
| NESC C2 - 2012 | National Electrical Safety Code C2-2012 IEEE publication (USA) | 01/08/2011 |
| ISBN: 9781849197212<br>Published by the IET London, | Code of practice for grid connected solar photovoltaic systems | |
| HSE GS6 (Fourth Edition) | Avoiding Danger From Overhead Lines | |
| ISEA, AECOM | Solar Farm Clearances from Overhead Power Lines | December 2016 |
| ESBN, HSA | Code of Practice for Avoiding Danger from Overhead Electricity Lines | September 2008 |

Source: MM

# Appendices

A. Drawing MMD-373966-E-SK-00-XX-0001 20
B. Sample Risk Assessment 21

# A. Drawing MMD-373966-E-SK-00-XX-0001




Notes

1. All dimensions are in metres.
2. Arrangement based on typical 110kV conductor spacings and spans.

Key to symbols

- Transmission line
- Transmission tower
- Wood pole set
- Stay Wire
- No panels permitted
- 3 metre height restriction on panels
- Panels to be demountable
- 3 metre height restriction and panels to be demountable
- No restrictions on solar panels

Reference drawings

| Rev | Date | Drawn | Description | Ch'k'd | App'd |
|---|---|---|---|---|---|
| P2 | 19/09/2017 | SHY | Issued for Comment | AT | DMcC |
| P1 | 07/09/2017 | CHC | Issued for Comment | AT | DMcC |

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Client

EIRGRID

Title

# Transmission Line and Solar Farm Clearances

## Proposed Setback Distances

| | | | | | |
|---|---|---|---|---|---|
| Designed | A. Tighe | | Eng check | D. McCormack | |
| Drawn | S.Healy | | Coordination | G. McCarthy | |
| Dwg check | D. McCormack | | Approved | D. McCormack | |

| Scale at A1 | Status | Rev | Security |
|---|---|---|---|
| 1:1000 | PRE | P2 | STD |

Drawing Number

MMD-373966-E-SK-00-XX-0001

1:1000 0 20m 50m 100m



P:\Dublin\MPD\373966 EirGrid CE\Temp Cad\00 - Transmission Line & Solar Farm Clearances\MMD-373966-E-SK-00-XX-0001.dwg Sep 19, 2017 - 2:53PM hea38245

# B. Sample Risk Assessment

# Risk assessment for locating Solar Farms near Overhead Lines

| | |
|---|---|
| **PRODUCED BY:** | ESB Networks |
| **PROJECT TITLE:** | Risk Assessment for the location of Solar Farms near Overhead Lines |
| **CONTRACT** | |
| **REPORT TITLE:** | Examine risks associated with installing PV panels near Overhead Lines and categorisation of same. |
| **SUBJECT:** | Solar Farms |
| **PURPOSE OF REPORT:** | - To identify the risks of locating photovoltaic panels near overhead lines<br>- The Classification of each of the risks identified.<br>- Assess any possible mitigation measures that could be implemented to reduce risks |
| **SOURCES OF DATA:** | Transmission Lines - Solar Farm Clearances by Mott MacDonald |
| **REFERENCES:** | |
| **Report No.** | |
| **Revision No.** | 000 |
| **Latest Revision Summary:** | Initial issue |

| | Initiator | Date | Verifier | Date | Approver | Date |
|---|---|---|---|---|---|---|
| **ORIGINAL** | A.McGrath | 15/08/2017 | | | | |
| **CHANGE NO.** | | | | | | |
| **CHANGE NO.** | | | | | | |

QUALITY
ISO 9001:2008
NSAI Certified

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Telephone: +353-1-7038000

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CERTIFIED IQNet MANAGEMENT SYSTEM

| Design Risk Assessment | | L=Likelihood 1=Almost impossible 2=Very unlikely 3=Unlikely 4=Likely 5=Almost certain |
|---|---|---|
| Hazard Category | | S=Severity |
| 1 | Construction | 1=Length of Product Life Reduced 2=Product Incompatible 3=Some Structural Damage 4=Complete Component Failure 5=Fatality |
| 2 | Delivery/Storage | 1=Length of Product Life Reduced 2=Product Incompatible 3=Some Structural Damage 4=Complete Component Failure 5=Fatality |
| 3 | Environmental | 1=Localised Environmental Waste 2 =Controllable Environmental Waste 3=Minor Environmental Contamination 4=Major Environmental Contamination 5=Loss of Species/Life |
| 4 | Electrical | 1=Intermittent Electrical Activity 2=Length of Product Life Reduced 3= Some Structural Damage 4=Phase to Ground Fault 5= Fatality |
| 5 | Mechanical | 1=Slight Distortion 2=Length of Product Life Reduced 3=Some Structural Damage 4=Complete Component Failure 5=Fatality |
| 6 | Mechanical/ Electrical | 1=Slight Distortion 2=Length of Product Life Reduced 3=Some Structural Damage 4=Complete Component Failure 5=Fatality |
| 7 | Physical | 1=Minor injury 2=Lost time injury 3=Long term absence 4=Permanent Incapacity 5=Fatality |
| 8 | Installation | 1=Minor injury 2=Lost time injury 3=Long term absence 4=Permanent Incapacity 5=Fatality |
| 9 | Operational | 1=Minor injury 2=Lost time injury 3=Long term absence 4=Permanent Incapacity 5=Fatality |


| Prepared by | | Prepared Date | | Project Title | Solar Farm Clearances to Overhead Lines | Discipline | Overhead Lines | |
|---|---|---|---|---|---|---|---|---|
| Verified by | | Verified Date | | Report Title | Risk Assessment of the erection of Photo Voltaic Panels under Overhead Lines | Associated Report | | |
| Approved by | | Approved Date | | Document No. | PG567-F0000-R004-343-000 | Notes | Risk Assessment on Working in or about Overhead Lines | |

## All Hazards

| | | | | | | Risk Before Controls | | | | Risk After Controls | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref | Category | Activity | Key Hazard Identified | Spec Reference | Associated Risk | Likelihood (L) | Severity (S) | Risk = L*S | Decisions/Actions/Control Measures | Likelihood (L) | Severity (S) | Risk = L*S | Actionee |
| 1 | Construction Phase | Digging Foundations | Damage to underground Tower Potential Control Rings and counterpoise connection between towers | | **Risk Likelihood:** PV Installer would need to ensure sufficient distance is maintained from Tower Potential Control rings and Counterpoise<br><br>**Risk Severity:** Could cause issues with grounding of the system | 3 | 3 | 9 | Maintain distance and corridor from Overhead towers where Counterpoise connection exist | 1 | 3 | 3 | Set limits for digging underground |
| 2 | Construction Phase | Erection of PV Panels | Prolonged working near overhead lines - Working Criteria with respect to Health and Safety Authority with regard to working near overhead lines to be amended to working near or about lines:<br><br>Possibility for erection machinary / PV panels to come in contact with Overhead Conductors during installation maintenance. | | **Risk Likelihood: Likely** Erection of PV panels may require cranes, hoists to lift them into place. In such cases PV panels may come in contact with overhead lines<br><br>**Risk Severity:** PV panels / erection machinary coming into contact with an overhead conductors resulting in damage up to and including possible **fatality**. | 4 | 5 | 20 | Maintain distance and corridor from Overhead towers and use barriers where construction vehicles pass under Overhead lines | 1 | 5 | 5 | |
| 3 | Construction Phase | Land sterilisation | Is there scope to allow for station expansion and additional feeds from/to the station as surrounding population/loads grow into the future.<br><br>Stations near urban cities most likely to come under pressure in future years | | **Risk Likelihood: likely** Stations likely to come under pressure as surrounding population grows and load changes<br><br>**Risk Severity:** If sterilisation of the station occurs it will be difficult to future-proof the Network for additional ecomonic activity. | 4 | 1 | 4 | Maintain a set distance from stations and endmasts allow for additional feeds from stations to be made | 1 | 1 | 1 | |
| 4 | Construction Phase | Ground Clearance | Will the respective "ground level" clearances be adequate if PV panels are installed near Overhead Network - 80 / 120 degree sag limits be sufficient if solar panels up to 4 m high installed near Network where poles extend 9 - 10 m above ground (issue for both MV, 38 kV and HV) | | **Risk Likelihood: likely** If the top of PV panels are treated as the new ground level, resulting inspections could raise issues with clearances on Sag limits.<br><br>**Risk Severity:** Breech of Sag limit resulting in contact with Overhead Network conductors - risk of potential fatality and damage to Overhead Network. | 4 | 5 | 20 | Increase height of Network passing over PV Panels in the event panels are placed near overhead Network | 2 | 5 | 10 | |

| All Hazards | | | | | | Risk Before Controls | | | | Risk After Controls | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref | Category | Activity | Key Hazard Identified | Spec Reference | Associated Risk | Likelihood (L) | Severity (S) | Risk = L*S | Decisions/Actions/Control Measures | Likelihood (L) | Severity (S) | Risk = L*S | Actionee |
| 5 | Operational Phase | E-field | PV panels near Overhead Network may experiencene additional insulation stresses due to the presence of e-fields, could result in a reduction of life of panels located under or near OHL.. | | **Risk Likelihood: Unlikely** PV panels likely to be sufficient distance from Overhead Network to cause an issue- Will be an issue for contractors to ensure that PV panels compatible with E-fields present in the vacinity<br><br>**Risk Severity:** Possibile requirement to install corona rings for e-field protection of insulators - additional members may need to be considererd for PV panels. | 2 | 1 | 2 | Ensure insulation of Network and panels is sufficient to withstand e-field stresses generated by low clearances and high e-fields - consider analysis to use corona rings on tower insulation | 1 | 1 | 1 | |
| 6 | Operational Phase | Earth faults | During electrical storms / system fault conditions there is a possibility that ground near Overhead Network will experience a rise in potential - This rise in potential could cause damage to neighbouring PV Panels / earthing systems for PV farms etc. | | **Risk Likelihood: likely.** Hazard(s) in relation to storms / earth faults will need to be taken in to account during design of farm<br><br>**Risk Severity: Complete failure** of panels and risk of exposure of onsite staff to rise in potential - possible step voltage issues - potential for fatality | 5 | 5 | 25 | Ensure sufficient earth separation between PV farm and Overhead Networks earthing<br><br>Avoid installing panels near counterpoise / tower potential control ring | 1 | 5 | 5 | |
| 7 | Operational Phase | Conductor drop | In the event of a conductor failure (line drop) there is a high propbability that the line will remain energised for a considerable period of time (up to 6 hours) during which conditions at the PV farm may become hazzardous to both staff working in the vacinity and neighbouring PV farms. | | **Risk Likelihood: Unlikely** line drops are rare occurance - usually during storm conditions.<br><br>**Risk severity: Complete component failure** potential for farm to suffer major equipment damage - possible risks to staff working in or about the farm during such faults | 3 | 5 | 15 | Avoid installing panels under overhead network and maintain current corridors | 1 | 5 | 5 | |
| 8 | Operational Phase | Ice drop | During winter periods, ice may develop around conductors, which may subsquently fall from Overhead Networkwith the possibility of damage to PV panels and possible risk to staff working underneath. | | **Risk Likelihood: likely** Ice falling on panels is likely to cause damage to the PV panel<br><br>**Risk severity: Complete component failure** of product(s) within its expected design life. | 5 | 1 | 5 | Avoid installing panels under overhead network and maintain current corridors | 1 | 1 | 1 | |
| 9 | Maintenance of Farm | Spray from washers | During cleaning of PV panels there is a risk that if pressure washers are used, subsequent spray could cause flashover from overhead networks to panels / machinary located underneath. | | **Risk Likelihood: likely** if power washers are used to clean panels there could be a risk of flashover if clearances are poor.<br><br>**Risk Severity: Potential for flashover** with risk to operators and staff operating cleaning machinary | 4 | 5 | 20 | Avoid the use of power washers / high humidity mist sprays for cleaning panels under / in close proximity to overhead lines | 2 | 5 | 10 | |
| 10 | Maintenance of Overhead Network | Tower uprate | Possibility that uprates will require longer outages due to the work involved in any foundation repair - during current works, ground anchors can be installed and works carried out during live line senarios. | | **Risk Likelihood: Likely** as farms are large in size and can result in difficult access to the Overhead Network<br><br>**Risk Severity:** Risk is on Netowrk revenue/ logistics side by requiring longer outages on overhead lines to uprate lines | 4 | 1 | 4 | Ensure sufficient clearance is maintained from towers to ensure that | 1 | 5 | 5 | |
| 11 | Maintenance of Overhead Network | Emergency repairs and restoration | If PV panels require removal for emergency repairs to be carried out to the Overhead Network it is likely that outages will be longer due to requirement for farm contractors to mobilise for panel removal to access the Overhead Network. | | **Risk Likelihood: Likely** if installed in such a manner there is a high risk to ongoing maitenance schedules / emergency restoration repairs<br><br>**Risk Severity:** Risk involves increased fines from regulator due to delays in restoration of service to customers | 4 | 1 | 4 | Ensure corridor is maintained and access / egress to the overhead line is available | 1 | 1 | 1 | |
| 12 | Maintenance / Installation | Ground Clearance | Will there be a requirement to treat the height of the panels as the "new Ground level" and surrounding structures raised to allow for the height o f solar panels (typically 3-4 metres) to take account of reduced sag clearance on all lines (MV - HV) ? | | **Risk Likelihood: likely.** Treatmeant of the Network to maintain clearances from equipment may require the erection of higher masts<br><br>**Risk Severity: Breach of clearances and risk of flashover** where a conductor breaches ground clearance during high load conditions possible risk of flashover if centre sag limit reduces over pv panels | 4 | 5 | 20 | Ensure corridor is maintained and access / egress to the overhead line is available | 1 | 1 | 1 | |

| All Hazards | | | | | | Risk Before Controls | | | | Risk After Controls | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref | Category | Activity | Key Hazard Identified | Spec Reference | Associated Risk | Likelihood (L) | Severity (S) | Risk = L*S | Decisions/Actions/Control Measures | Likelihood (L) | Severity (S) | Risk = L*S | Actionee |
| 13 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

ERIC

Eliminate Reduce Inform

Control
by others

**Change History of Form**

| Date | | New Rev | Author | Summary of Change |
|---|---|---|---|---|
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