IMP/001/107 - Code of Practice for Point of Connection assessment using Standard Design Rules for Low Voltage connections up to 60kVA

1. Purpose

The purpose of this document is to provide standard design rules for determining the point of connection for new Low Voltage (LV) connection(s) to the existing LV distribution systems of both Northern Powergrid (Northeast) Limited and Northern Powergrid (Yorkshire) plc. The maximum total diversified connection capacity is 60kVA with any individual single or three phase connection limited to 80A per phase.
The standard design rules are for use by both Northern Powergrid employees and accredited Independent Connection Providers when self-determining a point of connection to underground three phase LV systems only.

This document supersedes the following documents, all copies of which should be destroyed.

Reference	Version	Date	Title
IMP/001/107	3.0	Aug 2017	Code of Practice for point of Connection assessment using Standard Design Rules for Low Voltage connections up to 60kVA

2. Scope

This document applies to the determination of point of connections for the following:

Service Line	Reporting Code
One low voltage single phase **domestic or non-domestic** service connection, where there is no requirement to extend the low voltage network	ECGS2A
Two to four low voltage single phase **domestic** service connections, where there is no requirement to extend the low voltage network	ECGS2B
One to four low voltage single phase **domestic** service connections involving an extension to the low voltage network	ECGS2B
One low voltage three phase domestic or non-domestic **whole current metered connection**, where there is no requirement to extend the low voltage network	ECGS2B
One low voltage three phase domestic or non-domestic **whole current metered connection**, involving an extension to the low voltage network.	ECGS3A
Up to 20 low voltage single phase gas heated domestic service connections which could involve an extension to the Low voltage Network	ECGS3A
Two to six new low voltage single phase **domestic** service connections, with G83 compliant PV Installations.	ECDGS3A
Two to six low voltage single phase **domestic** service connections, with heat pumps up to 32A/phase and compliant with BS EN 61000-3-2 and BS EN 61000-3-3 involving an extension to the Low voltage Network.	ECGS2B
One low voltage single or three phase whole current metered, service connection where the Load to be connected includes disturbing loads that comply with either BS EN 50160 or can be connected without assessment under P28	ECGS2A/ECGS2B

2.1. General

This document provides the Standard Design Rules (SDRs) for the self-determination of a Point of Connection (PoC) and is applicable for new connections to the existing distribution system, and for the permissible modifications specified within this code of practice only. This document does not cover any modifications or additional load requirements to any existing connections where such modifications will result in the maximum diversified supply requirements of that connection exceeding 80A per phase.

The standard service length for all new connections is 20m as per Code of Practice for Economic Development of LV Systems, IMP/001/911. However where this standard length can't be achieved, in exceptional cases and following additional checks, the service can be extended up to a maximum length of 40m. The SDRs limit the scope of acceptable service cable lengths to a maximum of 30m, for metered connections only, without the requirement for any additional checks. This service length has been matched with the maximum lengths of mains cables and transformer impedances to allow a 30m service length whilst ensuring that the maximum impedances will not exceed the requirements of IMP/001/911. Due to unmetered connections using 16mm^{2}Cu service cables the maximum length for unmetered connections is limited to 20m.
The minimum transformer rating considered in the code of practice for one to six single phase domestic connections, one single phase commercial connection and up to twenty single phase unmetered connections, is 315kVA. A minimum 500kVA transformer is required for all other connections covered by this code of practice.

Connections are only allowed to be made to three phase underground cable networks with no overhead line sections in circuit between the source substation and the PoC to be used. The minimum size cables that can be used to comply with the SDRs are specified for both metered and unmetered connections. The minimum sizes specified ensure compliance with the maximum earth loop impedance to provide fault clearance within 30 second disconnection to the end of the mains cable and minimises the risk of a supply being provided outside of statutory limits.

Where records and data are unclear, or the criteria determined in the SDRs cannot be met; a higher level design engineer[1] shall be consulted or refer to Northern Powergrid for further information.
This document applies to:

- The Low Voltage (LV) distribution systems of Northern Powergrid (Northeast) Ltd and Northern Powergrid (Yorkshire) plc;
- All extensions to the LV distribution system for new connections.; and
- All assets with a nominal operating voltage of 230/400V ac three phase, at a HV to LV substation including the HV to LV transformers.

It is not a requirement to apply this Code of Practice retrospectively, but when work is being carried out on the LV system, the opportunity shall be taken to improve sections of system to comply with the Code of Practice when it is practicable and economic to do so.

Connection arrangements, including those for multi-occupancy premises and embedded 'independent' networks, are covered in the Code of Practice for Standard Arrangements for Customer Connections IMP/001/010.

[1] As defined in section 3.9

2.2. Table of Contents

3. Standard design rules (SDRs)

3.1. Introduction

A subset of point of connections can be determined using Standard Design Rules (SDRs). This code of practice provides the following:

- the process to be applied when self-determining a LV point of connection to the existing LV distribution system;
- the standard design rules that will assist in assessing the capacity that can be connected to the existing LV distribution system;
- guidance in identifying whether the connection to the LV system can be designed utilising the SDRs;
- guidance as to which type, and capacity, of low voltage connection can be connected under certain conditions;
- points to consider before connecting under the SDRs; and
- Limitations under SDRs and additional assessments that should be made prior to establishing the point of connection and completion of the design.

3.2. Standard design guidance flow charts

The appendices to the code of practice, detailed below document the considerations behind the SDRs including the flow charts. They provide guidance as to the suitability of the LV system to accept a connection.

- Appendix 1 – Connection limits for single phase metered connections for one to six domestic supplies (including Low Carbon Technologies) or one single phase commercial supply;
- Appendix 2 – Connection limits for single phase metered connections for seven to twenty non electrical heated domestic supplies or up to six single phase electrically heated domestic properties (including Low Carbon Technologies), two to four single phase commercial supplies or a single three phase connection, domestic or non-domestic;
- Appendix 3 – Unmetered connections;
- Appendix 4 – Equivalent cable spreadsheets;
- Appendix 5 – Earthing; and
- Appendix 6 – Justification for values utilised within the SDR guidance flowcharts.

3.3. Design loads – Metered Connections

3.3.1. General domestic connections

General domestic connections are premises that are typical centrally gas heated and do not have any form of electric heating installed, or have a requirement for an Electric Vehicle (EV) charging point.

For general domestic connections the SDRs use the ADMD formula specified in Section 3.4.2.1 of the Code of Practice for the Economic Development of the LV System, IMP/001/911, for assessing the number of connections that can be connected to the LV system without the requirements to undertake LV system studies. The formula calculates the nth customer ADMD and consequentially the design demand (kW) for the maximum permissible number of connections that can be connected to the LV system ensuring the projected capacity does not exceed 60kVA. The maximum permissible number of single phase general domestic properties across a three phase supply, that can be connected using the SDRs is twenty. The maximum diversified demand for each individual connection shall be limited to the service cut-out fuse rating of 80A per phase.

The SDRs shall only be used for developments where the total number of general domestic connections on completion of the development will not exceed twenty connections. Multiple connections of ≤ 20 for one development (i.e. possibly happening as a phased development) shall not be allowed under the SDRs.

3.3.2. Electrical heated properties

This section covers conventional resistive forms of heating only (for heat pumps see section 3.3.3). These include but are not exclusive to:

- Storage Heaters, using off peak electricity;
- Direct Acting Space Heating (DASH), panel heaters available for use 24 hours a day; and
- Flow Boilers (up to 9kW only[2]).

These devices will result in higher demands on the LV system than those using gas heating systems covered in General domestic connections section 3.3.1. The SDRs allow a maximum of six electrically heated connections to be made. The maximum diversified demand for each individual connection shall be limited to the service cut-out fuse rating of 80A per phase. This ensures that the quality of supply to both existing and new connections is maintained within statutory limits.

3.3.3. Heat pumps (HPs)

SDRs in this code of practice only allow heat pumps compliant with both BS EN 61000-3-2 (Harmonic distortion) and BS EN 61000-3-3 (Voltage fluctuation - flicker) standards to be connected to the LV system without further technical assessment.

Any requests for the connection of heat pumps under the SDRs must be submitted using the appropriate application form and be duly signed by the applicant. Multiple heat pump connections with similar characteristics could be submitted with a single form.
The SDRs allow for the connection of up to six heat pumps that are fully compliant with the required standards. However because clusters of heat pumps on the LV system could potentially cause power quality and thermal issues, connections under SDRs shall only be made if the additional requirements detailed below are met:

- Any heat pump connected to an individual property shall not result in the maximum demand of the property exceeding the service cut-out rating up to a maximum of 80A per phase;
- No more than one compliant heat pump shall be connected to an individual premise; and
- The total electrical load of each individual heat pump, including boost and back up[3], should not exceed 16A per phase; or
- If the total electrical load of the heat pump is between 16A and 32A per phase these can be connected following further checks to ensure that the total number of heat pumps connected on the feeder is no more than six. If checks suggest that the total number of heat pumps (including the new one) exceeds six, the connection falls outside the SDRs and a full PoC design shall be carried out.

The above requirements will ensure that the total load connected to the LV system will not exceed 60kVA. The nth customer ADMD and consequentially the design demand for a property with a heat pump and general domestic load is calculated using the formula in Section 3.4.2.2 of the Code of Practice for the Economic Development of the LV System, IMP/001/911.

[2] Based on IMP/001/911 – Other electric heating = 1kW + 100% on installed load 6 units at 1kW + 9kW = 60kW. SDR limit is based on assumption of unity power factor.

[3] Consideration in regards to operation of additional heating elements like back up or boost should be given i.e. if this heating comes on very infrequently, once for 5 minutes/week, then the rating of the additional heating can be ignored.

3.3.4. Domestic electric vehicle (EV) chargers

The SDRs allow the connection of a combination of 16A and/or 32A per phase domestic EV chargers as per Table 1, provided that the following conditions are met:

- The total number of EV chargers connected on the network (including those that are already connected) does not exceed those mentioned in Table 1 otherwise their connection falls outside the SDRs and a full PoC design shall be carried out;
- The maximum demand, including the general domestic load, for each individual connection shall not exceed the service cut-out rating up to a maximum of 80A per phase;
- Where the application is for connection of an EV charger to an existing supply, checks shall be made to ensure the adequacy of the existing cut-out for the new load required and;
- No more than one EV charger (16A or 32A) is installed to an individual premise connection.

32A EV Chargers		16A EV Chargers							
		0	1	2	3	4	5	6	7
	0		YES	YES	YES	YES	YES	YES	NO
	1	YES	YES	YES	YES	YES	NO	NO	NO
	2	YES	YES	YES	NO	NO	NO	NO	NO
	3	YES	YES	NO	NO	NO	NO	NO	NO
	4	YES	NO	NO	NO	NO	NO	NO	NO
	5	NO	NO	NO	NO	NO	NO	NO	NO

Table 1: Combination of domestic EV chargers

The above requirements will ensure that the total new load connected to the LV system will not exceed 60kVA. The nth customer ADMD and consequentially the design demand for a property with an EV charger and general domestic load is calculated using the formulae in section 3.4.2.3 of the Code of Practice for the Economic Development of the LV System, IMP/001/911.

3.3.5. Public electric vehicle charging points (EVCP)

As per IMP/001/911, public EVCP can be both metered and unmetered and provided from dedicated charging points or street lighting columns with a charging outlet. The SDRs only allow the connection of dedicated public metered EVCP. Any unmetered street lighting EVCPs fall outside the SDRs and a full PoC design shall be carried out.
The SDRs allow the connection of a combination of 16A and/or 32A per phase public EV charging points as per Table 2.

32A EV Chargers		16A EV Chargers						
		0	1	2	3	4	5	6
	0		YES	YES	YES	YES	YES	NO
	1	YES	YES	YES	YES	NO	NO	NO
	2	YES	YES	NO	NO	NO	NO	NO
	3	NO	NO	NO	NO	NO	NO	NO

Table 2: Combination of public EVCP

As per IMP/010/011 Code of Practice for Earthing LV Networks and HV Distribution Substations (section 3.15.15), Public EVCP shall always have a TT earthing system by installing a separate earth electrode and fitting appropriate protection in accordance with BS 7671 (e.g. an RCD).

3.3.6. Photovoltaic (PVs)

Under the SDRs up to six PVs compliant with EREC G83 can be connected. Any application containing units with an output that exceeds 16A per phase will fall outside the SDRs.
When assessing the numbers of compliant PV systems that can be connected to the LV system under the SDRs, the diversity factors and minimum demand as per IMP/001/911 have been used.
The selection of the maximum circuit lengths as per section 3.5 ensures that any voltage rise created by the installation of six 16A per phase PV systems will not exceed the maximum statutory voltage limits at times of minimum demand.

3.3.7. Commercial loads

Commercial loads generally have a higher demand profile than general domestic therefore under the SDRs the maximum commercial connections have been limited.
The SDRs allows for only one single phase 80A connection to be provided if the source transformer is a 315kVA unit. Up to four single phase 80A commercial connections or a one three phase 80A per phase connection can be connected but will require a minimum distribution transformer size of 500kVA. Where developments have a requirement for a number of connections above this level, the connection shall be referred to a higher level designer.
The full development must be considered as one application, multiple applications for one development shall not be allowed.

3.3.8. Connection of welders and motors without assessment

Planning Limits for Voltage Fluctuations Caused by Industrial, Commercial and Domestic Equipment, EREC P28-Addendum 1 covers electric motors that can be connected without prior agreement. Table 3 below is an extract from P28 and covers single phase and three phase motors which can be connected to the LV system that don't start more frequently than once a minute. The following table has been extended for the SDRs:

Type	Normal running rating expressed in terms of either:		Values used in NPg Standard Design Rules
	OUTPUT (kW)	INPUT (kVA)	INPUT (kVA)
Single-phase 240V	0.75	1.7	3.87(3.68kW)
Single-phase 480V	3.00	4.5	Not considered within the Standard Design Rules
Three-phase 415V	4.50	6.0	6.0
Three-phase 415V (star delta/ soft start/VSD)	Not considered in P28	Not considered in P28	10.0

Table 3: P28 (1989) Addendum 1 – Motors (Direct on Line) Table B

The single phase values shown above, extracted from P28 are based on an earth loop impedance of 0.4 + j0.25 (Z = 0.47Ω). The 1.7kVA value is considered too conservative, given many domestic appliance motors are above this value and

Northern Powergrid experience has shown these sized motors rarely cause issues. Therefore, this value was scaled up using an earth loop impedance of 0.2Ω giving a value of 3.87kVA for DOL single phase motors.

For three phase DOL motors the value of 6kVA from the table in P28 was taken directly, as experience has shown DOL motors above this size usually require more analysis. Given their lower starting currents, it has been decided, star delta and VSD connected motors up to 10kVA[4] can be connected without further studies as per Table 4 below.

Equipment	Rating
Welders	16A
Single Phase Motors	3.87kVA (3.68kW) Direct on line start
Three Phase Motors	6kVA Direct on Line start
Three Phase Motors	10kVA Star Delta Start, soft start and VSD

Table 4: Maximum input welder and motor ratings allowed under the SDRs

3.3.9. Transformer ratings

The addition of demand to smaller transformers without undertaking a load assessment on the transformer is a risk that has been assessed when deciding on the minimum sizes of transformer to be used within the SDRs. The risks associated with connecting any load to transformers with a capacity of less than 315kVA is deemed unacceptable due to the potential for overloading the transformer and the additional impedance it inserts in the circuit.

The use of 315kVA transformers is acceptable but only for additional loads that will add a total diversified load to the transformer of no more than 12% of the transformer rating. It has therefore been calculated that up to six single phase domestic connections (max diversified load for six EV's = 33kVA) or one single phase commercial connection (18.4kVA) or twenty unmetered connections can be added with a minimal risk of creating an unacceptable overload on a 315kVA transformer.

The connection of any three phase metered connection, or two to four single phase commercial connections, or seven to twenty domestic connections pose an unacceptable risk of overload to a 315kVA transformer and therefore any system to which connections of these types are made will have to be supplied by a transformer with a minimum capacity of 500kVA.

3.3.10. Unmetered connections

This section covers new supplies to all unmetered connections including unmetered connections to street lighting columns. Unmetered connections may include street lighting columns with charging outlet for electric vehicle. However, the connection of such unmetered connections falls outside the scope of this CoP and will not be discussed in the SDRs. For further guidance on such connections refer to the Code of Practice for the Economic Development of the LV System.
For street lighting connections only, the SDRs cover both new connections, and the replacement of existing lighting columns. This section of the SDRs therefore caters for;

- New unmetered connections;
- Transfer of existing lighting columns; and
- The replacement/transfer of columns fed via a looped service or 5th core network.

[4] Flicker calculations for a star delta start 10kW motor indicates a potential 1.24% flicker on starting at the point of common coupling for the maximum circuit impedance allowed under the SDRs. This allows a starting frequency of approximately once every 40 seconds.

Street lighting authorities have a number of existing connections from networks that were designed prior to the current requirements of IMP/001/911 and the replacement of those networks to meet IMP/001/911 is not always economically viable when changing a street lighting column.
Requirements for the replacement of existing looped or 5th core street lighting networks are detailed in Section 3.3.10.2 below.

3.3.10.1. New unmetered connections

When connecting any new unmetered supply whether to a pillar, cabinet or a lighting column they shall be provided via a direct service fed from a mains cable as per IMP/001/911. The SDRs provide both maximum mains and service cable lengths, along with the minimum sizes, that can be used whilst ensuring compliance with the requirements of IMP/001/911.

The maximum number of new unmetered connections that can be made to a dedicated LV main shall be 20. Mains extensions to facilitate new unmetered connections are allowed providing the extended mains cable does not exceed the maximum lengths permitted in section 3.5.2 Table 6 for unmetered connections.

Code of Practice for the maximum load of unmetered supplies, CNN/006/001 allows for a maximum capacity of 1.38kW for unmetered connections. No diversity exists for street lamps and therefore calculations have been made with each potential connection being at a maximum of 1.38kW.

Twenty unmetered connections at 1.38 kW = 27.6kW.

3.3.10.2. Replacement or transfer of existing lighting column services

When replacing any existing street lighting column the replacement shall have a dedicated direct service from a passing main wherever practicable. This is to minimise the earth loop impedance and operational issues surrounding the use of switched control lamp systems.

A transfer is deemed to be the replacement of an existing column by a new column situated within 3 metres of the existing column. This minimises the risk of any significant increase in the potential earth loop impedance of the original network whilst allowing for the erection and connection of a new column with minimal delays in the transfer of the service.

Where no main exists within close proximity, (less than 20metres) then the existing looped network may be maintained provided the following rules are complied with:

- The first column on the looped network supplied from the LV mains shall be used as a control column[5] and the total power consumption of all the columns on the looped service cable should be under 1.38kW. A sub-fuse rated at 25A shall be installed in the first (control) column and co-ordinated with the impedance to the last lighting column such that a fault shall be cleared in 5s to protect the outgoing looped cable. A 25A first column fuse will so protect loop impedance up to 1Ω.
- Only transfers of existing lighting columns are permitted and no additional columns can be installed.
- A service can be classified as a transfer on a looped or 5th core system, only if it is within 20metres of the position of the existing column; and the new column should not be located further away from the route of the looped service cable than the original column.
- The maximum length of the looped service cable shall not be extended beyond the existing last column. This means that the last column can only be relocated closer to the supplying LV mains cable and not moved further away.

[5] Drawing C1010662 Termination Arrangement for a public lighting control column

- Where the looped service arrangement is supplied from a mains network that has been converted to PME then the neutral conductor shall be bonded to an earth electrode at the following positions:
    I. The first column (control column) supplied from the mains cable;
    II. The last column on the looped service arrangement.
- Where the existing service cable extends beyond the last column then the service cable shall be disconnected and abandoned at the last column.

3.4. Earthing

Code of Practice for Earthing LV Networks and HV Distribution Substations, IMP/010/011 states that we should normally provide all new customers with an earthing terminal. As part of the design work to identify the point of connection an assessment of the existing network, and the customers' requirements shall be undertaken to identify the type of earth that can be provided. The proposed earthing arrangement shall be provided on all designs submitted for approval. Guidance as to the type of earthing systems employed and the earths that can be offered is detailed in Appendix 5.

It is accepted that in few special circumstances further consideration needs to be given before offering an earth, these special circumstances are also identified in Appendix 5. If connections are to be made to these premises referral to a higher level designer shall be made.

3.5. Permitted cable lengths and sizes

Relative to the impedance of long cable lengths the impedance of ground mounted transformers becomes negligible. For example a 315kVA transformer can be connected with 190m of 95mm2 Wf Al/Cu cable before reaching maximum limits; however this cable length only increases to 220m when the transformer is changed to 1000kVA. Given these marginal increases in lengths, for simplicity it has been assumed the maximum cable lengths should be based on the smallest ground mounted transformer size of 315kVA.

The maximum lengths and minimum sizes of cables for both metered and unmetered connections in the SDRs have been set so that the statutory voltage limits are not breached and hence do not affect the quality of supply. This also ensures that a 400A fuse will blow within 30 seconds to the end of any newly installed main, or 60 seconds to the service position at any metered cut out.

3.5.1. Maximum service cable lengths and minimum sizes

The standard type and size for service cables differs between metered connections and unmetered connections. The standard size cable for all metered connections is 35mm^{2}Al/Cu cable. Unmetered connections require the use of a 16mm^{2}Cu cable due to the terminal size available in a 25A cut out which is used for unmetered connections. In order to maintain the earth loop impedance limits, to ensure adequate fault clearance times, the maximum permitted service lengths are;

- Metered connection – 30 metres
- Unmetered connection – 20 metres

These lengths have been selected to maintain the maximum flexibility between service length and mains cables.

3.5.2. Maximum mains cable lengths for existing systems

The tables below show the maximum equivalent circuit length of existing cables to which a service can be connected for both metered and unmetered connections under the SDRs.

300mm^2 Wf Al/Cu	185mm^2 Wf Al/Cu	95mm^2 Wf Al/Cu
400m	340m	190m

Table 5: Maximum equivalent circuit length for metered connections

300mm^2 Wf Al/Cu	185mm^2 Wf Al/Cu	95mm^2 Wf Al/Cu
510m	430m	240m

Table 6: Maximum equivalent circuit length for unmetered connections

3.5.3. Mains extensions

Low voltage mains extensions are permitted under the SDRs providing that the maximum earth loop impedance from the substation to the end of the new extended main will not exceed those provided by the maximum permitted lengths in Table 5 for metered connections and Table 6 for unmetered connections. If a mains extension is installed and the distance from the source substation to the end of the extended main is of the maximum lengths then this will enable the installation of the maximum service lengths given in section 3.5.1at the end of the new main.

The only LV mains cables permitted for extensions to the LV system is 300 mm^{2}Wf Al/Cu for all mains extensions, other than for short tail end spurs (e.g. cul-de-sacs) where 95 mm^2 Wf Al/Cu is acceptable, as per IMP/001/911.

3.5.4. Minimum cable sizes and their equivalents

Metered Connections - The minimum size cable that can be in circuit on an existing system for metered connections is 95 mm^2 Wf Al/Cu and its equivalents which are 70 mm^2 Cu, 0.1 inch^2 Cu, and 0.15 inch^2 Al.

Unmetered Connections – The minimum size cable that can be in circuit on an existing system for unmetered connections is 70 mm^2 Wf Al and its equivalents which are, 0.06 inch^2 Cu, and 0.1 inch^2 Al.

Existing LV systems are typically made up of multiple cable types and therefore the individual cables have to be converted to an equivalent circuit length of one of the principal cable sizes shown in Table 5 and Table 6.
Table 7 below shows the three principal cable types that are referenced in the SDRs and some of their typical equivalent cable sizes.

Standard Cable sizes referred to on flow charts/rules	Copper Equivalent metric (sq. mm)	Copper Equivalent imperial (sq. in)	Aluminium Equiv. imperial (sq. in)
95mm^2 Wf Al / Cu	70	0.1	0.15
185mm^2 Wf Al/Cu	95	0.15	0.25
300mm^2 Wf Al/Cu	185	0.25	0.4

Table 7: Approximate equivalent cables sizes for the SDRs

All cable sizes within the system will have to be converted to an equivalent length of either 95 mm^2, 185 mm^2 or 300 mm^2 Wf Al/Cu to ensure the equivalent circuit does not exceed the maximum permitted lengths.

Appendix 4 provides further guidance.

3.6. Installation of cables in the public highway

All cables shall be installed in the footpath/verge where possible. However, this may not always be reasonably practicable and where this is the case the installation of both mains and service cable in the public highway should be kept to a minimum. All cable installations must comply with Policy for the Installation of Distribution Power Cables, NSP/002.

3.7. Situations requiring special consideration

- Within urban networks, there are low voltage mains cables that are not three-phase, when considering any connection point if there is any doubt about the number of live phases in the mains cable advice should be sought from a higher level designer to validate the point of connection;
- Where a feeder already supplies a large three phase customer, or multiple small three-phase customers, guidance should be sought from a higher level designer to validate the point of connection;
- For any connections on triple concentric or two-phase cable network, guidance from a Higher Level Engineer should be sought; and
- Only 3 phase cable networks that have no overhead lines in circuit between the source substation and the point of connection can be connected to using the SDRs

3.8. Maximum number of connected customers

IMP/001/911 states that the average number of customers connected to feeders supplied from a distribution substation shall not exceed 100. To ensure this average is complied with whilst minimising the potential risk of overload on connections being made to an LV feeder, without load checks, the following restrictions must be adhered to;

- The total customer numbers on any feeder shall not exceed 100, existing plus new; and
- The total customer numbers supplied by small section[6] cables shall not exceed 70, existing plus new.

Where either of the above conditions cannot be met then referral to a higher level designer will be required.

[6] Small section cables are classed as 0.1Cu, 0.15Al, 95 mm^{2}Wf Al, 95 mm^{2}Wf Al/Cu for metered connections and 0.06Cu, 0.1Al and 70 mm^{2}Wf for unmetered connections.

3.9. Roles

The SDRs refer to two key roles; these roles are fulfilled by individuals who are deemed competent to self-determine points of connection.

ICPs accredited under the NERS are deemed competent to determine the point of connection.

3.9.1. Low level designer

A Low level designer is a person deemed competent to use the SDRs for self-determining a point of connection. Where the SDRs does not cover the point of connection the Low level designer will refer to a designer with a higher level of technical competence to determine the Point of Connection and guidance for the outline design.

3.9.2. Higher level designer

A Higher level designer is a person deemed competent to assess the asset records and standards to achieve a point of connection that can be used. ICPs accredited under the NERS Point of Connection Self Determination are deemed competent to determine the Point of Connection as well as all Northern Powergrid design engineers and design technicians.

4. References

4.1. External Documentation

Reference	Title
ENA Engineering Recommendation P28	Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom
Engineering Recommendation G83 Issue 2	Recommendations for the Connection of Type Tested Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with Low-Voltage Distribution Systems
BS EN 61000-3-2 (harmonic distortion)	Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16A and ≤ 75A per phase
BS EN 61000-3-3 (Voltage fluctuation - flicker)	Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems. Equipment with rated voltage current ≤ 75 A and subject to conditional connection

4.2. Internal documentation

Reference	Title
IMP/001/911	Code of Practice for the Economic Development of Low Voltage Networks
IMP/001/010	Code of Practice for Standard Arrangements for Customer Connections
IMP/010/011	Code of Practice for Earthing LV Networks and HV Distribution Substations
NSP/002	Policy for the Installation of Distribution Power Cables

4.3. Amendments from Previous Version

Reference	Title
Document	Minor editorial changes
3.3.1	Removed formula and reference IMP/001/911
3.3.3	Deleted reference to Form A and minor editorial changes
3.3.4	Edited section to refer to domestic EV chargers only, added 32A chargers and added a table that shows the permitted combination of 16A and 32A chargers. Deleted EV ADMD formula and reference IMP/001/911.
3.3.5	Added new section on public EV charging points.
3.3.10	Reference to street lighting columns with charging outlet for EV

5. Definitions

Reference	Title
SSEG	Small-scale embedded generation
Service cut-out	Service cut out consists of the service cable feeding the premise, the cut out and the cut-out fuse.
Large three phase	Greater than 80 amps per phase
NERS	National Electricity Registration Scheme
Accredited	Accreditation means accreditation awarded to an ICP under the National Electricity Registration Scheme (NERS)
DOL	Direct on Line
ADMD	After Diversity Maximum Demand
Point of Connection (PoC)	This is the point (or points) of physical connection between the extended network and the existing Distribution System
LCT	Low Carbon Technologies like heat pumps, electric vehicles and photovoltaic systems
VSD	Variable Speed Drive

6. Authority for issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Sign	Date
Andy Leggett	CDS Administrator	Andy Leggett	12/09/2018

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
Yes	Period: n/a	Reason: n/a
Should this document be displayed on the Northern Powergrid external website?		Yes

		Sign	Date
Paris Hadjiodysseos	Smart Grid Development Engineer	Paris Hadjiodysseos	26/11/2018

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Sign	Date
Phil Jagger	Design Team Manager	Phil Jagger	17/09/2018
Derek Fairbairn	System Design Manager	Derek Fairbairn	21/09/2018

6.4. Authorisation

Authorisation is granted for publication of this document.

		Sign	Date
Mark Nicholson	Head of Smart Grid Implementation Unit	Mark Nicholson	17/09/2018

Appendix 1 – Connection limits for metered connections – up to six single phase domestic or one single phase commercial metered connections

Design selection criteria

- **Appendix 1 covers the following connections**

  I. Up to 6 x single phase domestic connections (electrically or non-electrically heated or LCT); or
  II. 1 x single phase commercial connection.

- **Each individual connection can include;**

  I. A single Heat Pump conforming to FORM A no larger than 16A per phase, (without network checks); or
  II. A single Heat Pump conforming to FORM A >16A and ≤ 32A per phase, where a network check show that the new HP will not result in more than 6 heat pumps on the feeder.
  III. An Electric Vehicle Charger up to 16A per phase;
  IV. A G83 compliant Photovoltaic system up to 16A per phase;
  V. A Welder up to 16A per phase ; and
  VI. A Single phase motor up to 3.68kVA or 16A per phase
  VII. Or a combination of the above up to the maximum of 60kVA

- **Maximum service cable length**

  I. Maximum service length should be no more than 30m

- **Maximum mains cable length**

  I. 95 mm^2 Wf Al/Cu – maximum length of 190m
  II. 185 mm^2 Wf Al/Cu - maximum length of 340m
  III. 300 mm^2 Wf Al/Cu – maximum length of 400m

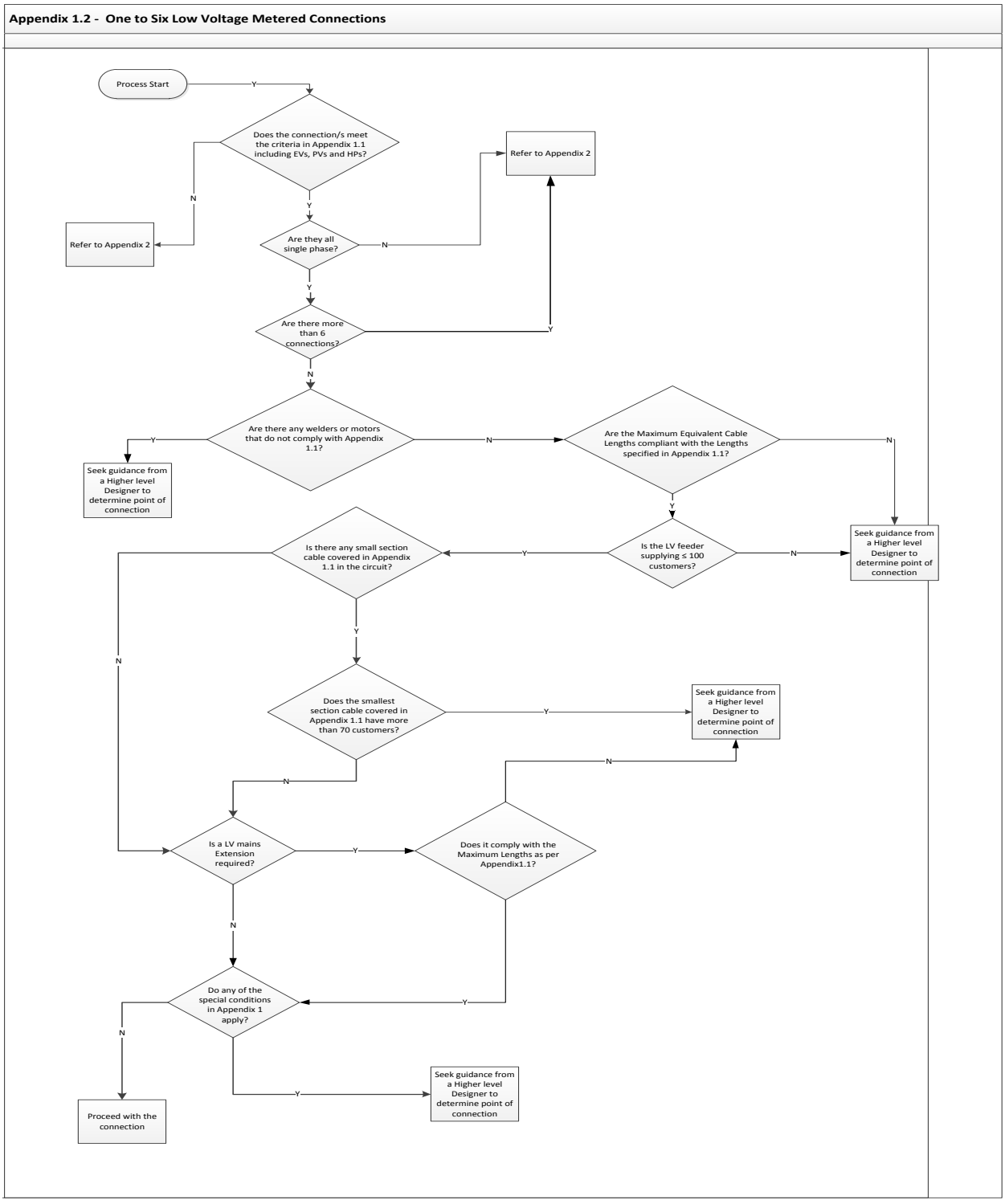
- **Minimum transformer rating**

  I. 315kVA is the minimum transformer size

- **Special conditions where appendix 1 does not apply;**

  I. The LV System is not 3 phase
  II. The new load requires a 3 phase supply
  III. Overhead network is in circuit between the supplying substation and the connection point
  IV. Connection is to be made on triple concentric or two phase cable network
  V. Loads requirements for individual connections exceed 80A per phase
  VI. Total number of customers on the LV feeder after connection of the new supplies exceeds 100 customers.
  VII. Total number of customers supplied by the small section cable (0.1Cu, 0.15Al, 95 mm2wf Al) exceeds 70 customers.
  VIII. The LV feeder already supplies large, or multiple small, 3 phase connections.

One to six LV metered connections flowchart



NOTE – Minimum transformer required is 315kVA – Max service length 30 metres.

Appendix 2 – Connection limits for metered connections – seven to twenty single phase domestic (non-electrically heated), or two to four single phase commercial, or a single three phase connection

Design selection criteria

- **Appendix 2.1 covers the following connections**

  I. Up to 20 x single phase non electrically heated domestic connections.; or
  II. Up to 6 x single phase electrically heated domestic or LCT connections; or
  III. Up to 4 x single phase Commercial connections; or
  IV. 1 x three phase connection Commercial or Domestic up to 80 A per phase

- **The installation can include up to a maximum of:**

  I. Up to 6 x Heat Pumps conforming to FORM A no larger than 16A per phase[7]; or
  II. Up to 6 x Heat Pumps conforming to FORM A >16A and ≤ 32A per phase, where a network check shows that the new HP will not result in more than 6 heat pumps on the feeder.
  III. Up to 6 x Electric Vehicle Chargers no larger than 16A per phase;
  IV. Up to 6 x Photovoltaic systems no larger than 16A per phase;
  V. Welders - Three phase up to 16A per phase
  VI. Motors - One single phase motor up to 3.68kVA or 16A per phase; or
  VII. One DOL three phase motor up 6kVA; or
  VIII. One Star Delta or Soft start three phase motor up to 10kVA; or
  IX. Or a combination of the above up to the maximum of 60kVA

- **Maximum service cable length**

  I. Maximum service length should be no more than 30m

- **Maximum mains cable length**

  I. 95 mm^2 Wf Al/Cu – maximum length of 190m
  II. 185 mm^2 Wf Al/Cu - maximum length of 340m
  III. 300 mm^2 Wf Al/Cu – maximum length of 400m

- **Minimum transformer rating**

  I. 500kVA is the minimum transformer size

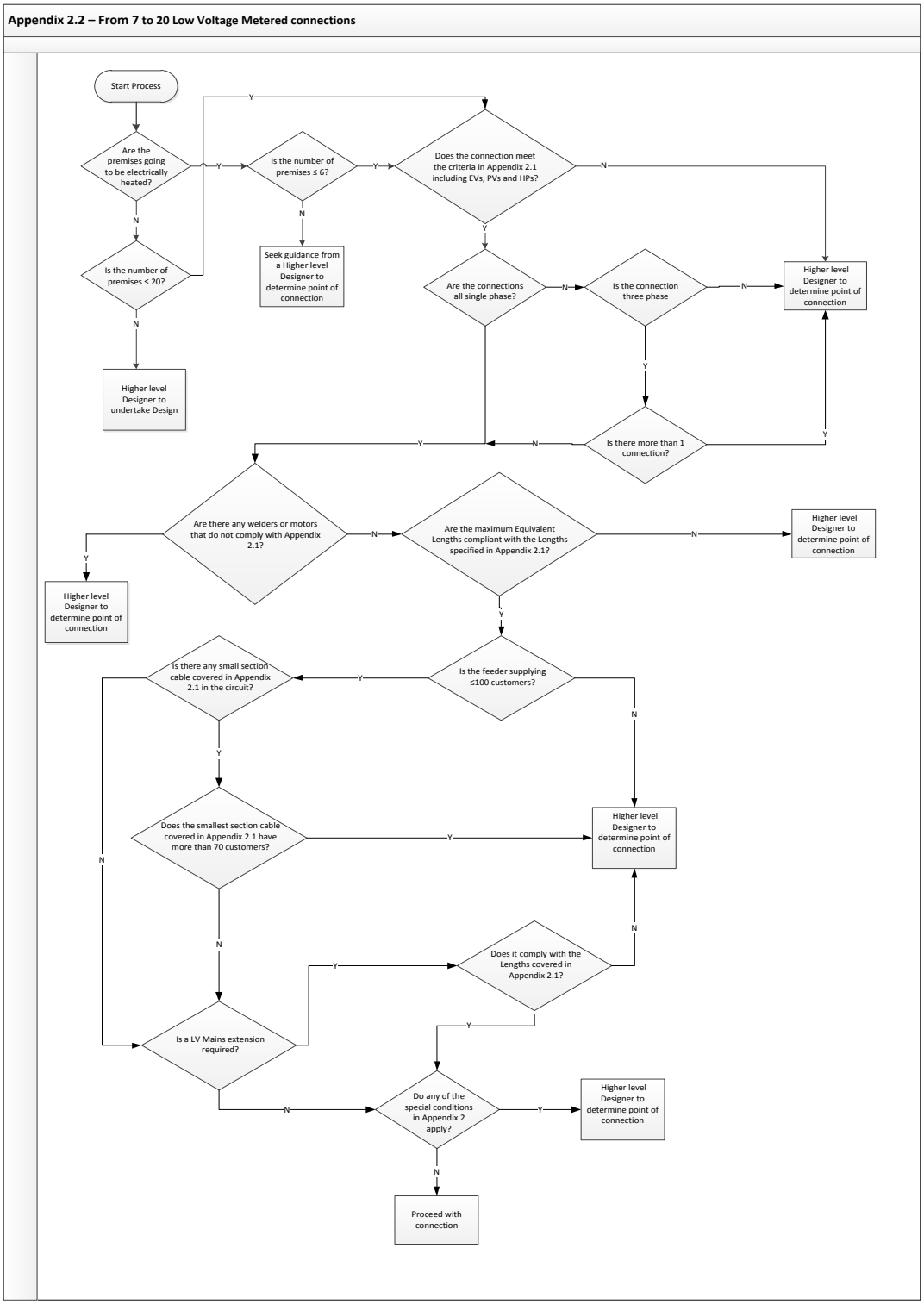
- **Special conditions where appendix 2 does not apply**

  I. The LV System is not 3 phase
  II. Overhead network is in circuit between the supplying substation and the connection point
  III. Connection is to be made on triple concentric or two phase cable network
  IV. Loads required are greater than 80A per phase
  V. Total number of customers on the LV feeder after connection of the new supplies exceeds 100 customers
  VI. Total number of customers supplied by the small section cable (0.1Cu, 0.15Al, 95 mm2wf Al) exceeds 70 customers

[7] Subject to only 1 installation of HP, EV, PV per property

VII. The LV feeder already supplies large, or multiple small, 3 phase connections.

Seven to twenty LV metered connections flowchart



NOTE – Minimum transformer required is 500kVA – Max service length 30 metres.

Appendix 3 - Connection limits for new unmetered connections

Design selection criteria

- **Appendix 3.1 covers the following connections**

I. Up to 20 x single phase unmetered connections

Unmetered connections may only be provided in line with the guidance contained within the Electricity (Unmetered Supply) Regulations 2001 and the guidance contained within the Balancing and Settlement Code. These requirements are explained in more detail in Code of Practice for the maximum load of unmetered supplies (CNN/006/001). The key requirement of both these documents is that, subject to other conditions, an unmetered supply may be given where the electrical load is of a predictable nature, and no greater than 1.38kW

- **Maximum service cable length**

II. Maximum service length should be no more than 20m

- **Maximum mains cable length**

III. 95 mm^2wf Al/Cu – maximum length of 240m
IV. 185 mm^2wf Al/Cu - maximum length of 430m
V. 300 mm^2wf Al/Cu – maximum length of 510m

- **Minimum transformer rating**

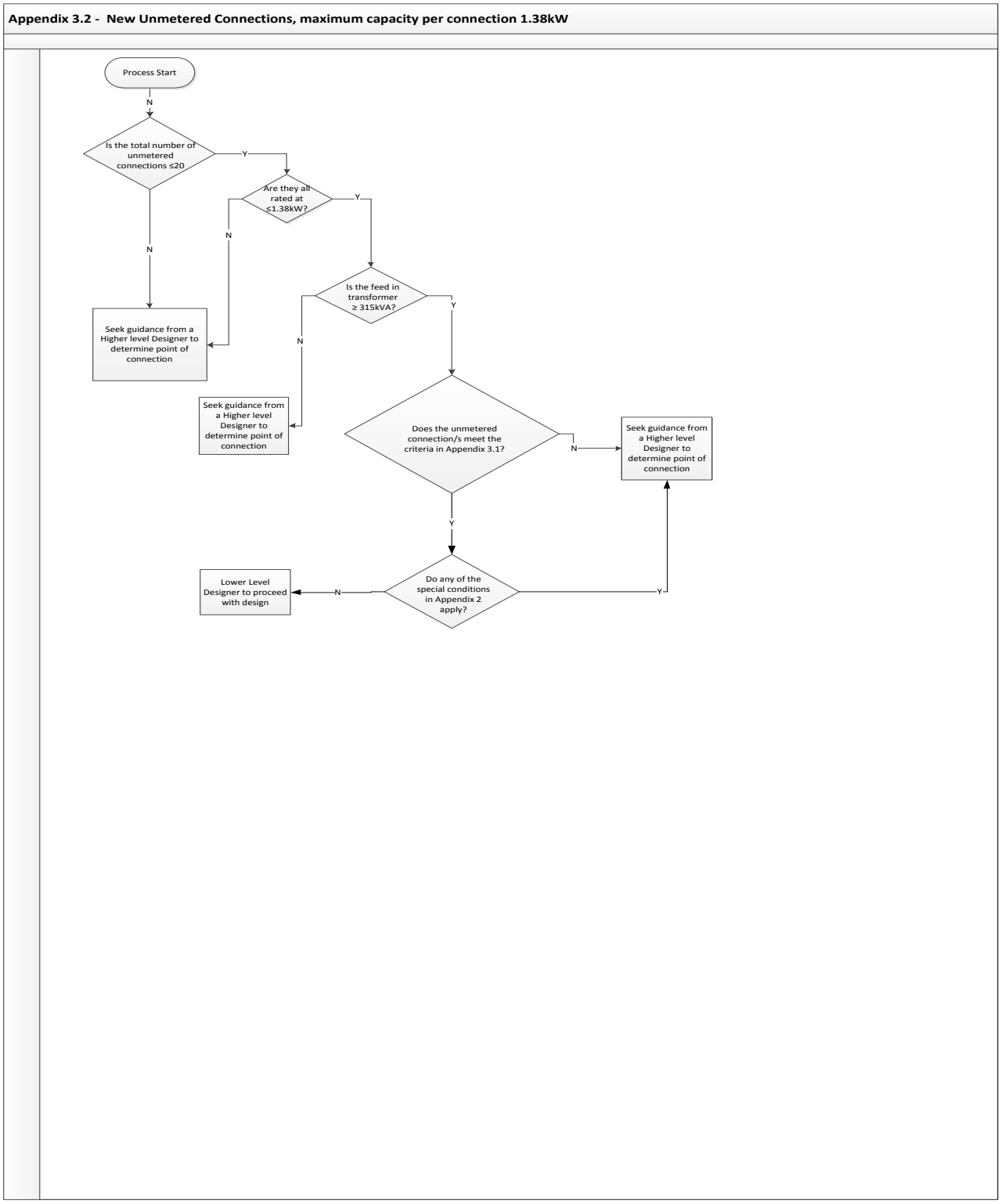
VI. 315kVA Transformer is the minimum transformer size

- **Special conditions where appendix 3 does not apply**

VII. Overhead network is in circuit between the supplying substation and the connection point;
VIII. Any supply exceeds 1.38kW.
IX. Any replacement or transfers of existing lighting columns must comply with the requirements of section 3.3.10.2 of this CoP.

New unmetered connections up to 1.38kW

Appendix 3.2 - New Unmetered Connections, maximum capacity per connection 1.38kW



NOTE – Minimum transformer required is 315kVA – Max service length 20 metres.

Appendix 4 - Total cable equivalent spreadsheets

Two equivalent cable spread sheets have been developed to assist individuals in assessing the total equivalent circuit length when a feeder is made up of multiple cable types. The spread sheets are located on our external website and the links are provided below.

For Metered Connections - http://www.northernpowergrid.com/downloads/3052

For Unmetered Connections - http://www.northernpowergrid.com/downloads/3053

The appropriate spread sheet must be used whether for metered or unmetered connections. Additional cable length, and smaller section cables, can be allowed within the unmetered connections that are not permissible for use on metered connections, because of the lower demand requirements of unmetered connections.

The spread sheets assist with the calculation of the maximum permissible lengths of mains cable only. The service cable lengths are additional and a maximum service length of up to 30m of 35 Al/Cu can be added to the mains lengths.

NORTHERN POWERGRID	Table for use with **METERED** Connections		
	Version 1.0 06/03/2017		
	Equivalent length rebased to specific size reffered to in SDR's		
Cable Size / Conductors	Cable length	**Wf95**	**Wf185**	**Wf300**
95Al		0	0	0
120Al		0	0	0
185Al		0	0	0
300Al		0	0	0
0.15Al		0	0	0
0.2Al		0	0	0
0.25Al		0	0	0
0.3Al		0	0	0
0.5Al		0	0	0
0.1Cu		0	0	0
0.15Cu		0	0	0
0.2Cu		0	0	0
0.25Cu		0	0	0
0.3CU		0	0	0
0.5Cu		0	0	0
Total Equivalent lengths to be used		0	0	0
Max Equivalent Lengths permitted.	**For Metered Services**	190	340	400

Table 8: The blank template for the metered equivalent cable lengths

- The yellow boxes are the input cells - Enter the cable length for appropriate cable size
- The light grey cells indicate cables with Al Conductors
- The dark grey cells indicate cables with Cu Conductors
- The pink cells are the set limits for each cable (95Al/Cu,185Al/Cu,300Al/Cu waveform)
- The light blue boxes show the total equivalent lengths; these boxes will turn RED when the equivalent lengths are exceeded.

Appendix 5 – Earthing

NPg's underground cable network employs two different types of earthing systems, these are

- A Separate Neutral and Earth system (SNE)
- A Combined Neutral and Earth system (CNE) which employs PME earthing.

When providing any new connections from an existing network the earth provided to the customer must be appropriate for the network providing the supply to the connections.
In general this means that;

- Connections provided from CNE system, or a SNE system converted to PME, must be provided with a CNE/PME earth.
- Connections provided from SNE systems that have not been converted to PME must be provided with a SNE Earth.

Where it is not clear what earthing system is applicable a referral to a higher level designer will be required.

In addition to the above, Code of Practice for Earthing LV Networks and HV Distribution Substations IMP/010/011 provides a list of situations that need special consideration. Where any supplies are provided to any of the following sites referral to a higher level design will be required to decide on whether an earth can be provided or not. Where an earth can be provided they will have to specify the type of earth to be used.

- Construction Sites and Quarries
- Farms, Milking Parlours, Pig Sty's etc.
- Swimming Pools and Sports Pavilions
- Petrol Filling Areas
- Caravans, Mobile Homes, Temporary Site Offices, Boat Installations etc.
- Fairgrounds and Showgrounds
- Roadside and other Housings Accessible to the public.
- Railway Service Areas
- Multiple supplies to Steel Framed Buildings.

Appendix 6 - Justification for values in SDR flowcharts

Transformer Rating (kVA)	Cable Size (mm^2)	Maximum Mains Cable Length (m)	Maximum Service Cable Length ($35mm^2$Al/Cu) (m)	Total Impedance at cut out Z(Ohms)
315	95	**190**	30	**0.193**
315	185	**340**	30	**0.1943**
315	300	**400**	30	**0.1924**

Table 9: Metered Single Phase and Three Phase connections Up to 80A per phase design impedances

Transformer Rating (kVA)	Cable Size (mm^2)	Maximum Mains Cable Length (m)	Maximum Service Cable Length ($16mm^2$Cu) (m)	Total Impedance at Cut out Z(Ohms)
315	95	**240**	20	**0.249**
315	185	**430**	20	**0.2490**
315	300	**510**	20	**0.239**

Table 10: Unmetered Connections