Review of technical decision for WorkSafe New Zealand

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Author:	**Graham Kenyon**
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G Kenyon Technology Ltd
15 Westmorland Ave,
Thornton-Cleveleys,
Lancashire. FY5 2LX.
United Kingdom.

t: +44 (0) 753 985 1252
w: www.gkenyontech.com

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Executive Summary

This report documents a review by an independent expert of the technical decision taken to list the deletion of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) in Schedule 2 to the New Zealand Electricity (Safety) Amendment Regulations 2025. The report concludes that the decision is justified, but that there are residual risks. Some of the residual risks are already mitigated by existing practices, standards and guidance, whilst others require additional industry guidance and/or standards to be implemented.

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1 Introduction

1.1 Formal details

1.1.1 This report has been prepared by Graham Harry Kenyon, Managing Director and Principal Consultant of G Kenyon Technology Ltd, 15, Westmorland Ave, Thornton-Cleveleys, Lancashire, FY5 2LX, United Kingdom.

1.1.2 I am a Chartered Engineer, Member of the Institution of Engineering and Technology, a registered European Engineer through Engineers Europe (formerly FEANI), and a Technical Member of the Institute of Occupational Safety and Health. My career history and experience exceeds 30 years. I practise as an independent international electrical engineering consultant with relevant experience in electrical installations, and electrical product assurance and safety. I have been in my current position for 10 years 10 months. my previous experience was engineering and technical assurance, for projects developing and implementing specialist systems for major infrastructure programmes. I have been actively involved with standardization in the electrotechnical sector for around 20 years, and have held formal qualifications in UK electrical installation design, installation and verification practice since 1992. I am the current Chair of joint IET/BSI Committee JPEL/64, which is the UK national committee responsible for a number of standards including BS 7671 *Requirements for Electrical Installations (IET Wiring Regulations, 18th Edition), and the international IEC 60364 series, and also the current Chair of UK technical committee GEL/600 responsible for BS 7430 Code of Practice for Earthing*. I am the author of an extensive range of electrotechnical industry guidance and training publications for the UK; a comprehensive list can be found at: https://www.gkenyontech.com/the-principal/publications/.

1.1.3 I have been engaged by WorkSafe New Zealand to conduct a technical review, which is outlined in the background to this report (Section 1.2).

1.2 Background

1.2.1 Schedule 2 to the New Zealand Electricity (Safety) Amendment Regulations 2025 [reference 1] deletes Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) [reference 2].

1.2.2 The provisions of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) [reference 2] relate to conditional requirements for switching neutral conductors in electrical installations, and requirements to limit switching of protective earthing conductors and combined protective earth and neutral (PEN) conductors. Specific provisions of these Clauses are examined in Appendix C to this Report.

1.2.3 The intent of deleting Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) [reference 2] for New Zealand was to 'future proof' the New Zealand Electricity (Safety) Amendment Regulations 2025 [reference 1], to facilitate:

(a) Improvements in the integrity of electricity supplies to homes as a result of power outages in the distribution network, by allowing switching arrangements to 'island' the installation to operate from a source of energy independent from the public distribution network (for example, temporary generators or renewable energy systems with battery storage); and

(b) The future use of protective devices that can operate to disconnect electric vehicles from all live conductors, and the protective earthing system, in the event of detection of conditions indicative of a broken PEN conductor upstream of the supply to the electric vehicle charging equipment. The Institution of Engineering and Technology (IET) in the UK published a standard for such devices, IET 01:2024 [reference 3].

1.2.4 WorkSafe New Zealand have received correspondence from the New Zealand Electrical Inspectors Association, which has been reviewed by myself after I formed an independent opinion.

1.3 Use of this report

1.3.1 Subsequent Sections of this report are intended to be considered as follows:

(a) Section 2 of the report summarizes the risks to be considered in achieving the aims.

(b) Section 3 of the report considers the residual risks that exist at the time of writing the report and provides a commentary on whether they are mitigated with provisions outside AS/NZS 3000 [reference 2] at the time of writing this report. It also provides a commentary on residual risk, and recommendations to address those risks.

(c) Section 4 of this report summarizes an overall conclusion of the review.

1.3.2 Appendices C to F inclusive provide further detail, referenced in Sections 2 to 4 inclusive, to provide technical background. In particular:

(a) Appendix C provides facts associated with the risks discussed in Section 2.

(b) Appendices D and E provide comparative provisions in BS 7671 and IEC 60364, as referenced in Sections 2 to 4and Appendix C.

(c) Appendix F provides a commentary on the timing of switching of the neutral conductor in relevant product standards, as referenced in Sections 2 to 4 and Appendix C.

2 Risks to be considered

2.1 Introduction

2.1.1 This Section of the report summarises the risks to be considered in relation to the removal of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 [reference 2], and the development of subsequent industry guidance and standards as listed in Table 2.1.

Table 2.1 Potential risks associated with the removal of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018

Ref	Removal of provision in AS/NZS 3000	Potential hazard	Cause	For hazard detail, see Paragraph
1	2.3.2.1.2 (b)(i) and 2.3.2.1.2 (c)	Electric shock	• Hazardous touch-voltages between simultaneously accessible exposed-conductive-parts connected to different earthing systems (IEC 60364-4-41, Clause 411.3.1.1)	2.4.1 and 2.4.2, and Appendix C Paragraphs C3-2, C3-3, C3-6, C3-7, C3-8, C3-9, C7-2
2	2.3.2.1.2 (b)(i) and 2.3.2.1.2 (c)	Electric shock	• Change of earthing resistances in 'global earthing' system. • Hazardous touch-voltages between simultaneously accessible exposed-conductive-parts connected to different earthing systems (IEC 60364-4-41, Clause 411.3.1.1)	2.4.3 and Appendix C Paragraphs C3-4, C7-2
3	2.3.2.1.2 (b)(i) **NOTE**: guidance for island switching in development	Electric shock (of those working on MEN network)	• Diverted neutral currents from islanded installation to distributor MEN if this is not switched (and PEN conductors are not precluded in islanded installations)	2.7.1 and 2.7.2, and Appendix C Paragraphs C6-1 to C6-5 inclusive
4	2.3.2.1.2 (b)	Electric shock during maintenance	• Failure to disconnect live conductors on operation of devices that ought to provide safe disconnection/isolation	2.5.1 and 2.5.2 and Appendix C Sections C3 and C4
5	2.3.2.1.2 (b)(ii), 2.3.2.1.2 (b)(iii) and 2.3.2.1.2 (b)(iv)	Damage to equipment	• Disconnected neutral in a three-phase system or circuit when active (line) conductors remain connected	2.5.1 and 2.5.2 and Appendix C Sections C3 and C4
6	2.3.2.1.2 (b)(ii), 2.3.2.1.2 (b)(iii) and 2.3.2.1.2 (b)(iv)	Fire/burns	• Disconnected neutral in a three-phase system or circuit when active (line) conductors remain connected.	2.5.1 and 2.5.2 and Appendix C Sections C3 and C4
7	2.3.2.1.2 (c)	Electric shock	• Disconnected protective conductor and high protective conductor currents	2.6.1 and 2.6.2 and Appendix C Paragraph C5-3
8	2.3.2.1.2 (c)	Electric shock	• Disconnected protective conductor and electrical fault that would normally conclude with automatic disconnection of supply	2.6.1 and 2.6.2 and Appendix C Paragraphs C5-4, C5-5

NOTE 1: In Table 2.1 electric shock generally means physiological harm, or death, from electric shock. Secondary effects of injury resulting from involuntary reactions due to contact with electricity, are not precluded.

NOTE 2: The term 'global earthing system' is defined in Clause 3.7.19 of IEC 61936-1. See Appendix B. In the context of this report, the safety advantages of multiple earth connections in the MEN system, and via connected installations and their extraneous-conductive-parts, is intended.

2.2 Clause 2.3.2.1.2 of AS/NZS 3000:2018 [reference 2]

2.2.1 Clause 2.3.2.1.2 of AS/NZS 3000:2018 [reference 2] concerns requirements for:

(a) provision of a device for isolating active conductors in AC circuits;
(b) preclusion of switching MEN and PEN conductors;
(c) conditions under which neutral conductors (other than MEN and PEN conductors) should be switched; and
(d) preclusion of switching protective (earthing) conductors.

2.2.2 There are risks associated with switching of neutral, earthing (protective) conductors and PEN conductors which Clause 2.3.2.1.2 of AS/NZS 3000:2018 [reference 2] aims to address.

2.2.3 Facts pertaining to Clause 2.3.2.1.2 of AS/NZS 3000:2018 [reference 2] are detailed in Section C1 of Appendix C to this report.

2.3 Reasons for deletion of 2.3.2.1.2 (b) and (c) of AS/NZS 3000:2018 [reference 2]

2.3.1 Switching for alternative sources of energy to improve resilience of electricity supplies

2.3.1.1 In order to facilitate switching arrangements to improve resilience of electricity supplies to homes, it will be necessary to implement switching arrangements (for example supply transfer arrangements and/or island mode switching arrangements).

2.3.1.2 Switching between the MEN system and alternative sources of energy will involve switching active conductors, along with neutral and protective conductors.

2.3.1.3 Existing guidance for connection of temporary generation (WorkSafe New Zealand Technical Bulletin *Connecting a generator to the wiring of a house or building following an emergency* [reference 4]) involves the manual disconnection of the MEN conductor at the installation, along with ensuring the neutral of the installation is connected to an earth electrode as a means of earthing.

2.3.1.4 If the existing guidance (WorkSafe New Zealand Technical Bulletin *Connecting a generator to the wiring of a house or building following an emergency* [reference 4]) were to be translated directly to guidance for switching, this would necessitate switching of the MEN conductor, and along with neutral and protective conductors for the alternative form of energy.

2.3.1.5 Facts associated with this type of switching arrangement are provided in Appendix C to this report, Paragraphs C2-1 to C2-6 inclusive and Section C7.

2.3.2 Improvements in protection of electric vehicle charging installations

2.3.2.1 In order to facilitate the use of open-PEN detection devices (OPDDs), for example to IET 01:2024 [reference 3] (see NOTE to this Paragraph), it is necessary to not preclude the switching of earthing (protective) conductors. OPDDs operate to disconnect all live conductors (active and neutral) along with the protective conductor, to facilitate a situation similar to removing a plug from a socket-outlet. It is necessary to disconnect the earthing (protective) conductor, because it is that conductor which transfers the MEN neutral potential rise to the exposed-conductive-parts of a vehicle during an open PEN fault in the MEN network.

NOTE: At the time of writing this report, the only product standard for OPDDs is IET 01:2024 [reference 3]. It is not a UK national standard, but an industry standard published by the Institution of Engineering and Technology (IET), developed with industry participation and public consultation. The provisions of Regulation 722.411.4.1 of BS 7671 refer to to other provisions in BS 7671 that address the conditions under which the protective conductor can be switched; however, there are not adequate provisions in BS 7671 to facilitate a product standard. Examples of the missing provisions in BS 7671 include those for classification, marking, durability and verification.+

2.3.2.2 Facts associated with the implementation of OPDDs are provided in Appendix C to this report, specifically paragraphs C2-7 and C2-8.

2.4 Risks associated with switching a PEN conductor

2.4.1 If the PEN conductor is switched (or broken) and the line (active) conductors remain connected, then:

(a) If the PEN conductor is associated with a single-phase system, in circuits downstream of the open-circuit PEN conductor, exposed-conductive-parts can attain a voltage up to the line to Earth voltage with respect to the general mass of the Earth.

(b) If the PEN conductor is associated with a three-phase system, in circuits downstream of the open-circuit PEN conductor, exposed-conductive-parts can attain a voltage exceeding the line to Earth voltage with respect to the general mass of the Earth.

2.4.2 The actual touch-voltage experienced depends on a number of factors, including, in three-phase systems, the balance of loads across the phases. Within buildings, main protective bonding helps reduce the available touch-voltage. Outside buildings, only additional earth electrodes, with (usually impracticably) low values of earth electrode resistance, can reduce the available touch-voltage.

2.4.3 There can also be situations in which switching the incoming MEN conductor can lead to simultaneously accessible exposed-conductive-parts that are connected to different earthing systems. This can lead to situations where hazardous touch voltages exist without faults being present.

2.4.4 More detailed facts relating to these risks can be found in Sections C3 and C7 of Appendix C to this report.

2.5 Risks associated with switching a neutral conductor other than a PEN conductor

2.5.1 In a single-phase system, if a neutral conductor is switched, or broken, then the neutral conductor downstream of the switch or break will be at the same voltage as the line (active) conductor. This can present a shock risk to persons working on the installation, although this can be mitigated by safe working practices and properly proving dead before starting work.

2.5.2 In a three-phase system:

(a) If a neutral conductor is switched, or broken, but the line (active) conductors are not simultaneously switched, the neutral conductor downstream will attain a voltage, with respect to the line (active) conductors that depends on the balance of loads on the phases. This often leads to overvoltages that damage equipment connected downstream of the broken or switched neutral. Fires can also result.

(b) Damage to equipment due to overvoltage can also be experienced with multipole switching of all live (active and neutral) conductors, if the line (active) conductors are opened after, or closed before, the neutral conductor.

2.5.3 More detailed facts relating to these risks can be found in Section C4 of Appendix C to this report.

2.6 Risks associated with switching an earthing conductor (protective conductor) other than a PEN conductor

2.6.1 If a protective conductor is switched, and the live conductors, and in particular the line (active) conductors are not switched, then there is a risk of electric shock at exposed-conductive-parts downstream of the switched, or broken, protective conductor arising from:

(a) Protective conductor currents of energized equipment; or

(b) Inability for a fault current to return to the source via the protective conductor, meaning the provisions for automatic disconnection of supply in a fault are ineffective.

2.6.2 Except for plug and socket-outlet combinations, or where the switching of part of equipment that has appropriate durability requirements and tests according to a relevant product standard, there are concerns in the industry that switching devices in protective conductors could fail, leading to a permanent loss of the protective conductor until a repair can be effected. Such a fault might go undetected.

2.6.3 More detailed facts relating to these risks can be found in Section C5 of Appendix C to this report.

2.7 Risks associated with leaving the MEN conductor connected to an installation which has other PEN conductors connected in energized circuits in island mode

2.7.1 It is possible for neutral currents in PEN conductors to be diverted through other conductive parts in connection with the general mass of Earth, especially where these are connected via earthing or bonding to the PEN conductor in the installation. This can lead to currents being returned through the MEN system neutral as illustrated in Figure C.1 (page 28). These currents can be hazardous to persons working on the MEN network.

2.7.2 This risk could be mitigated by precluding the use of PEN conductors in energized parts of installations operating in island mode.

2.7.3 More detailed facts relating to these risks can be found in Section C6 of Appendix C to this report.

3 Existing mitigation in place for the risks outlined in Section 2 of this report

3.1 During my investigation, there was evidence that specific risks summarized in Section 2 of this report are mitigated, at least in part, by other provisions already in place.

3.2 The mitigation and recommended residual risk actions are summarized in Table 3.1.

Table 3.1 Potential mitigation already in place of risks associated with the removal of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018

Ref	Removal of provision in AS/NZS 3000	Potential hazard	Cause	For hazard detail, see Paragraph	Mitigations already in place	Recommended residual risk actions
1	2.3.2.1.2 (b)(i) and 2.3.2.1.2 (c)	Electric shock	• Hazardous touch-voltages between simultaneously-accessible exposed-conductive-parts connected to different earthing systems (IEC 60364-4-41, Clause 411.3.1.1)	2.4.1 and 2.4.2, and Appendix C Paragraphs C3-2, C3-3, C3-6, C3-7, C3-8, C3-9, C7-2	Installing this type of switching is highly likely to involve licensed workers/inspectors. Regulations 13 and 14 of the New Zealand Electricity (Safety) Regulations apply, and prescriptive controls in place do not appear to preclude switching of PEN conductors.	A. Switching of PEN conductors appears to be permissible at present. Guidance or standards are necessary to prevent switching of PEN conductors. B. It is advisable, for the implementation of island mode switching, to not switch MEN/PEN conductors in parts of electrical installations that are to be islanded. This is necessary to prevent diverted neutral (PEN) currents from within an islanded installation being conducted through the general mass of the Earth.
2	2.3.2.1.2 (b)(i) and 2.3.2.1.2 (c)	Electric shock	• Change of earthing resistances in 'global earthing' system (see Note 2). • Hazardous touch-voltages between simultaneously accessible exposed-conductive-parts connected to different earthing systems (IEC 60364-4-41, Clause 411.3.1.1)	2.4.3 and Appendix C Paragraphs C3-4, C7-2	Installing this type of switching is highly likely to involve licensed workers/inspectors.	C. Standard arrangements for automatic switching of island mode are yet to be addressed. D. In a global market, not all products meet every country's national requirements, and without industry guidance, other countries have found particular safety issues associated with islanding. IEC 63445 [reference 12] could be considered for the system referencing conductor switching.

<table>
<tr><th>Ref</th><th>Removal of provision in AS/NZS 3000</th><th>Potential hazard</th><th>Cause</th><th>For hazard detail, see Paragraph</th><th>Mitigations already in place</th><th>Recommended residual risk actions</th></tr>
<tr><td>3</td><td>2.3.2.1.2 (b)(i)
NOTE: guidance for island switching in development</td><td>Electric shock (of those working on MEN network)</td><td>• Diverted neutral currents from islanded installation to distributor MEN if this is not switched (and PEN conductors are not precluded in islanded installations)</td><td>2.7.1 and 2.7.2, and Appendix C Paragraphs C6-1 to C6-5 inclusive</td><td>Manual disconnection of MEN conductor in existing guidance (see Section C7 of this report).</td><td>E. Consider implementing requirements so that PEN conductors are not used in islanded installations. See also residual risk action B.</td></tr>
<tr><td>4</td><td>2.3.2.1.2 (b)</td><td>Electric shock during maintenance</td><td>• Failure to disconnect live conductors on operation of devices that ought to provide safe disconnection/isolation</td><td>2.5.1 and 2.5.2 and Appendix C Sections C3 and C4</td><td rowspan="3">Installing this type of switching is highly likely to involve licensed workers/inspectors.

Product standards, such as IEC 60947 series, IEC 60947-6-1 and IEC 60669 series, contain requirements that mimic AS/NZS 3000 Clause 2.3.2.1.2 (b)(ii) and (iii). See Appendix F to this report.</td><td rowspan="3">F. Standards or guidance for other products, and installation arrangements, to replace the provision of AS/NZS 3000 Clause 2.3.2.1.2 (b)(ii) and (iii) is necessary.</td></tr>
<tr><td>5</td><td>2.3.2.1.2 (b)(ii), 2.3.2.1.2 (b)(iii) and 2.3.2.1.2 (b)(iv)</td><td>Damage to equipment</td><td>• Disconnected neutral in a three-phase system or circuit when active (line) conductors remain connected</td><td>2.5.1 and 2.5.2 and Appendix C Sections C3 and C4</td></tr>
<tr><td>6</td><td>2.3.2.1.2 (b)(ii), 2.3.2.1.2 (b)(iii) and 2.3.2.1.2 (b)(iv)</td><td>Fire/burns</td><td>• Disconnected neutral in a three-phase system or circuit when active (line) conductors remain connected.</td><td>2.5.1 and 2.5.2 and Appendix C Sections C3 and C4</td></tr>
</table>

<table>
<tr><th>Ref</th><th>Removal of provision in AS/NZS 3000</th><th>Potential hazard</th><th>Cause</th><th>For hazard detail, see Paragraph</th><th>Mitigations already in place</th><th>Recommended residual risk actions</th></tr>
<tr><td>7</td><td>2.3.2.1.2 (c)</td><td>Electric shock</td><td>• Disconnected protective conductor and high protective conductor currents</td><td>2.6.1 and 2.6.2 and Appendix C Paragraph C5-3</td><td>Installing this type of switching is highly likely to involve licensed workers/inspectors.

For non-automatic arrangements, AS/NZS 4509.1 applies.</td><td rowspan="2">G. Consider implementing necessary requirements similar to BS 7671 with regard to switching of protective conductors (see Appendix D, D6). This will facilitate the use of OPDDs as well as transfer switching that also transfers the protective (earthing) function between sources of supply, and preclude switching of protective conductors where live (active and neutral) conductors are not switched.

H. Consider mandating standards for open-PEN detection devices (OPDDs), for example IET 01:2024 [reference 3], that contain provisions for durability. It is noted that automatic transfer switching is covered by IEC 60947-6-1 [reference 8], which is already listed in the legislation. IEC 63445 [reference 12] could also be considered.</td></tr>
<tr><td>8</td><td>2.3.2.1.2 (c)</td><td>Electric shock</td><td>• Disconnected protective conductor and electrical fault that would normally conclude with automatic disconnection of supply</td><td>2.6.1 and 2.6.2 and Appendix C Paragraphs C5-4, C5-5</td><td>Installing this type of switching is highly likely to involve licensed workers/inspectors.</td></tr>
</table>

NOTE 1: In Table 3.1 electric shock generally means physiological harm, or death, from electric shock. Secondary effects of injury resulting from involuntary reactions due to contact with electricity, are not precluded.

NOTE 2: The term ‘global earthing system’ is defined in Clause 3.7.19 of IEC 61936-1. See Appendix B. In the context of this report, the safety advantages of multiple earth connections in the MEN system, and via connected installations and their extraneous-conductive-parts, is intended.

4 Conclusion

4.1 This Section of the Report provides a conclusion summarizing the opinion of the expert who conducted the review.

4.2 Changes to the Electricity (Safety) Regulations were necessary to safely implement renewable technologies and consider provisions for supply continuity under certain circumstances. Specifically, and with reference to Paragraph 1.2.3 of this report, it should be noted that:

(a) Switching of protective (earthing) and neutral conductors is necessary to facilitate supply changeover/transfer; and to facilitate protection by OPDDs.

(b) Switching of PEN conductors would not, in ideal circumstances, be considered; however, unless the use of PEN conductors in installations is to be restricted, there are risks to persons working on the MEN distribution system.

4.3 The deletion of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) [reference 2] for New Zealand was put in place to achieve the aim outlined in Paragraph 1.2.3 of this report.

4.4 Table 3.1 outlines specific residual risks that result from the decision (see Paragraph 4.3 of this report), some of which are mitigated as identified in the table.

4.5 The residual risks identified in Table 3.1 can be summarised as follows, each of which should be addressed by subsequent guidance and/or future relevant standards:

(a) PEN conductors should not be switched under all circumstances and applied in conjunction with item 4.5(b). (Residual risk action A in Table 3.1.)

(b) It is recommended that PEN conductors are not used in parts of installations energized in island mode. (Residual risk actions B and E in Table 3.1.)

(c) Standards or guidance for manual or automatic island mode switching arrangements should be provided. (Residual risk actions B, C, D and E in Table 3.1.)

(d) Not all product standards include timing arrangements for switching neutral conductors in conjunction with other live conductors. IEC 63445 [reference 12] could be considered for the system referencing conductor switching. (Residual risk actions D and F in Table 3.1.)

(e) Provisions should be put in place in standards or guidance, and relevant product standards mandated where appropriate, to cover situations in which it is necessary to switch an earthing (protective earth) conductor. (Residual risk actions D, G and H in Table 3.1.)

4.6 To address the residual risks associated with switching the PEN conductor outlined in 4.5(a), provision of guidance on, or standards for, switching this protective conductor is recommended. This in turn would introduce a risk associated with islanding installations that themselves contain PEN conductors that are intended to remain energized in island mode. This is addressed in this report by recommending PEN conductors are not used in parts of installations energized in island mode, see Paragraph 4.5(b) of this report.

4.7 With respect to the correspondence received from the New Zealand Electrical Inspectors Association discussed in Paragraph 1.2.4, I have reviewed the correspondence following for formation of an initial opinion, and, in my view, the hazards raised in that correspondence have been described in Appendix C of this report, and any residual risks outlined in Section 3 of this report.

4.8 The review concluded that, on balance, the decision to deletion of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) [reference 2] for New Zealand is technically justifiable, when the following is taken into account:

(a) In terms of the switching of PEN conductors, see Paragraph 4.5 item (a), there is a residual risk with existing installations operating in island mode, regardless of whether the decision is taken to either:

(i) switch PEN conductors, specifically the MEN neutral, with the aim of protecting those working on an MEN distribution network (see Paragraphs C6-1 to C6-5 inclusive of this report), or

(ii) to not switch PEN conductors, specifically the MEN neutral, whilst PEN conductors in the installation remain energized (see Appendix C Paragraphs C3-1 to C3-9 inclusive, Paragraphs C6-6 to C6-10 inclusive, and Section C7, of this report).

(b) Guidance and standards are being developed to address the residual risks outlined in Paragraph 4.5 items (b) to (e) inclusive of this report.

(c) The application of guidance and standards (yet to be developed), relating to island mode and supply transfer switching, and the use of open-PEN disconnection devices (OPDDs), would be limited or impeded if Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 (including Amendments 1, 2 and 3) [reference 2] had been retained in their present form.

Appendix A References and related documents

No.	Reference[*]
1.	New Zealand Electricity (Safety) Amendment Regulations 2025, last accessed 18 February 2026 from: https://www.legislation.govt.nz/regulation/public/2025/0225/latest/whole.html
2.	AS/NZS 3000:2018 (including Amendments 1, 2 and 3) *Electrical installations "Wiring Rules"*
3.	Institution of Engineering and Technology Standard IET 01:2024 *Open combined protective and neutral (PEN) conductor detection devices (OPDDs)* (IET, London, ISBN 978-1-83953-885-8)
4.	WorkSafe New Zealand Technical Bulletin *Connecting a generator to the wiring of a house or building following an emergency*, last accessed 18 February 2026 from: https://www.worksafe.govt.nz/dmsdocument/57543-technical-bulletin-connecting-a-generator-to-the-wiring-of-a-house-or-building-following-an-emergency/latest/
5.	AS/NZS 4509.1:2009 *stand-alone power systems part 1: Safety and installation*
6.	BS 7671:2018+A2:2022+ A3:2024 *Requirements for Electrical Installations. IET Wiring Regulations Eighteenth Edition*
7.	IEC 60947-6-1:2005+AMD1:2013 *Low-voltage switchgear and controlgear – Part 6-1: Multiple functional equipment – Transfer switching equipment*
8.	IEC 60947-6-1:2021 *Low-voltage switchgear and controlgear – Part 6-1: Multiple functional equipment – Transfer switching equipment*
9.	IEC 60947-1:2007+AMD1:2000+AMD2:2014 *Low-voltage switchgear and controlgear – Part 1: General rules*
10.	IEC 60947-1:2020 *Low-voltage switchgear and controlgear – Part 1: General rules*
11.	IEC 60669-1:2017 *Switches for household and similar fixed-electrical installations - Part 1: General requirements*
12.	IEC 63445:2025 *System referencing conductor switching device (SRCSD)*
13.	IEC 60364-5-53:2015 (HD 60364-5-57:2017) *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*
14.	Institution of Electrical Engineers *General Rules Recommended for Wiring of the Supply of Electrical Energy*, Fourth Edition, 1903
15.	Institution of Electrical Engineers *Wiring Rules*, Seventh Edition 1916
16.	Institution of Electrical Engineers *Regulations for the Electrical Equipment of Buildings*, Fourteenth Edition 1966
17.	linked switch. (n.d.) McGraw-Hill Dictionary of Architecture and Construction. (2003). Retrieved 17 February 2026 from https://encyclopedia2.thefreedictionary.com/linked+switch
18.	BIPM The International System of Units (SI) 9th Edition 2019 (updated to 2024)
19.	NIST Special Publication 811 *Guide to the International System of Units (SI)*
20.	NIST Technical Note 1297 *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results* 1994 Edition
21.	IEC 61936-1:2021 *Power installations exceeding 1 kV AC and 1,5 kV DC. Part 1: AC*
22.	IEC 60364-1:2025 Ed 6.0 *Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, and definitions*

[*] References which are without a date or revision / version are intended to refer the reader to the latest revision / version.

Appendix B Abbreviations and specialist terms

Abbreviations for SI Units, SI Derived Units, and related Non-SI Units are not listed here due to their widespread use and standard application. Details of these units can be found in references 18 and 19.

Term	Meaning
AC	Alternating current **Note:** 'a.c.' is used in AS/NZS 3000, and in older IEC, CENELEC and British standards. In the text of this Report, 'AC' is used, following current IEC usage, unless quoting parts of such standards verbatim.
AS/NZS	Australian Standard/New Zealand Standard (National Standards jointly published by Standards Australia and Standards New Zealand)
BIPM	Bureau International des Poids et Mesures (International Bureau of Weights and Measures)
BS	British Standard (UK National Standards)
DC	Direct current **NOTE:** 'd.c.' is used in AS/NZS 3000, and in older IEC, CENELEC and British standards. In the text of this Report, 'DC' is used, following current IEC usage, unless quoting such standards directly.
Diverted neutral current	Load currents that return to the electrical energy source via conductive paths other than a protective earth and neutral (PEN) conductor. Such conductive paths include extraneous-conductive-parts, earth electrodes, and the general mass of the Earth.
EN	Euro-Norm (European Union Regional Standard Standard)
IEC	International Electrotechnical Commission
IET	Institution of Engineering and Technology (formerly the IEE)
IEE	Institution of Electrical Engineers
Global earthing system	See IEC 61936-1 [reference 21] Clause 3.7.19, which is as follows: **3.7.19** **global earthing system** Equivalent earthing system created by the interconnection of local earthing systems that ensures, by the proximity of the earthing systems, there are no dangerous touch voltages NOTE 1 to entry Such systems permit the division of earth fault current in a way that results in a reduction of the earth potential rise at the local earthing system. Such a system could be said to form a quasi-equipotential surface. NOTE 2 to entry The existence of a global earthing system may be determined by sample measurements or calculations for typical systems. Typical examples of global earthing systems are in city centres, urban or industrial areas with distributed low- and high-voltage earthing.
Island mode	Operating mode of an electrical installation in which it is disconnected from the public distribution network, temporarily or permanently, and loads within the installation are supplied by one or more local sources of energy. **NOTE**: sometimes, the term 'grid independent' is used for an electrical installation that is permanently disconnected from the public distribution network.
MEN	Multiple earthed neutral
ISO	International Organisation for Standardisation
NIST	National Institute of Standards and Technology (United States of America)
PEN	Protective earth and neutral (combined)
SI	Système Internationale (International System of Units)
SRCSD	System referencing conductor switching device
System referencing conductor	A conductor between a live part and an earthing arrangement, enabling the live part to be substantially at the same potential as the earthing arrangement. The system referencing conductor is neither a neutral conductor nor a protective conductor. *See IEC 60364-1:2025 [reference 22] Clause 1.8.4.*
UK	United Kingdom

Appendix C Facts associated with removal of Clauses 2.3.2.1.2 (b) and (c) from AS/NZS 3000:2018 and associated risks

C1 Clause 2.3.2.1.2 of AS/NZS 3000:2018 [reference 2]

C1-1 Clause 2.3.2.1.2 of AS/NZS 3000:2018 [reference 2] is as follows (highlights are made for clarity in later Paragraphs of this review report):

2.3.2.1.2 *Alternating current systems*

Provisions for isolation of conductors in a.c. systems are as follows:

(a) *Active conductors* All active conductors of an a.c. circuit shall be capable of being isolated by a device for isolation.

(b) *Neutral conductor*:

(i) No switch or circuit-breaker shall be inserted in the neutral conductor—

(A) of consumer mains; or

(B) where the neutral conductor is used as a combined protective earthing and neutral (PEN) conductor for protective earthing of any portion of an electrical installation.

NOTE: This requirement applies to situations such as an earth sheath return (ESR) system or a submain neutral used for earthing of an electrical installation in an outbuilding in accordance with Clause 5.5.3.1.

(ii) A switch or circuit-breaker may operate in the neutral conductor of circuits other than those in Item (i) where—

(A) the neutral pole of a multi-pole switch or circuit-breaker, having an appropriate short-circuit breaking and making capacity, is linked and arranged to switch substantially together with all active poles; or

(B) the switch or circuit-breaker is linked with corresponding switches so that the neutral contact cannot remain open when the active contacts are closed.

A switched neutral pole shall not open before and shall not close after the active pole(s).

(iii) Where an item of switchgear is required to disconnect all live conductors of a circuit, it shall be of a type such that the neutral conductor cannot be disconnected or reconnected without the respective active conductors also being disconnected or reconnected.

NOTE: The manual disconnection and connection of neutral conductors should be as follows:

(a) The active conductors should be disconnected before the neutral conductors.

(b) The neutral conductors should be connected before the active conductors.

Refer to AS/NZS 4836 for safe work practices.

(iv) A switch in the control circuit of a fire pump shall operate in the neutral conductor in accordance with Clause 7.2.5.6.4.

In accordance with Clause 2.5.1.1, no fuse shall be inserted in a neutral conductor.

(c) *Switching of earthing conductor prohibited* An earthing conductor shall not be isolated or switched.

A conductor used as a combined protective earthing and neutral (PEN) conductor shall not be isolated or switched.

C1-2 Clause 2.3.2.1.2 (b) of AS/NZS 3000:2018 [reference 2], highlighted with a blue outline in Paragraph C1-1 of this report, divided into four sub-clauses, numbered 2.3.2.1.2 (b)(i), 2.3.2.1.2 (b)(ii), 2.3.2.1.2 (b)(iii) and 2.3.2.1.2 (b)(iv). The sub-clauses deal with conditions for, or limitation of, switching of, neutral conductors, including PEN conductors, and are analysed in subsequent Sections of this report as follows:

(a) Section C2 summarizes facts regarding the reasons for deletion of 2.3.2.1.2 (b) and (c) of AS/NZS 3000:2018 [reference 2].

(b) Section C3 summarizes facts regarding risks associated with switching a PEN conductor that 2.3.2.1.2 (b) (i) and the second paragraph of 2.3.2.1.2 (c) intend to prevent.

(c) Section C4 summarizes facts regarding the risks associated with switching a neutral conductor other than a PEN conductor, without opening the line (active) conductors, that 2.3.2.1.2 (b) (ii) and (iii) intend to prevent.

C1-3 Clause 2.3.2.1.2 (c) of AS/NZS 3000:2018 [reference 2], highlighted with a green outline in Paragraph C1-1 of this report, requires that no switching is provided in an earthing conductor (protective conductor in IEC 60364 series and BS 7671) including a PEN conductor. These are analysed in subsequent Sections of this report as follows:

(a) Section C3 summarizes facts regarding risks associated with switching a PEN conductor that 2.3.2.1.2 (b) (i) and the second paragraph of 2.3.2.1.2 (c) intend to prevent.

(b) Section C5 summarizes facts regarding the risks associated with switching of an earthing conductor that 2.3.2.1.2 (c) of AS/NZS 3000:2018 [reference 2] intends to prevent.

C1-4 The deletion of Clause 2.3.2.1.2 (b)(iv) of AS/NZS 3000:2018 [reference 2] was, on review, considered inconsequential, as it simply makes reference to two other Clauses, 7.2.5.6.4 and 2.5.1.1, neither of which are deleted by the Electricity (Safety) Amendment Regulations 2025 [reference 1].

C2 Reasons for deletion of 2.3.2.1.2 (b) and (c) of AS/NZS 3000:2018 [reference 2]

C2-1 Guidance is under preparation for switching arrangements for operation of electrical installations in New Zealand in island mode. Guidance exists for carrying out the operation manually at present (see Paragraph C2-6 of this report).

C2-2 Island mode is the mode of operation of an electrical installation in which installation is disconnected from the grid, and supplied from a local source of energy within the installation, for example a rotary generator, or inverters supplied by batteries, wind, and/or solar PV.

C2-3 For safety of those operating on a public supply network, it is known that operation of an installation in island mode will involve disconnection of live (active and neutral) conductors within the installation from the grid.

C2-4 A complicating factor is the multiple earthed neutral (MEN) arrangements can be extended to other parts of an installation such as an outbuilding. There are two key aspects that might affect the use of MEN arrangements within an installation with renewable energy systems in island mode:

(a) Due to low fault currents associated with renewable technology inverters, RCDs are often necessary, and these are not compatible with PEN conductors.

(b) It is generally considered dangerous practice to recombine neutral and protective (earthing) functions once they are separated. BS 7671 requires that PEN conductors cannot be formed by recombining neutral and protective conductors (see D5 of Appendix D of this report).

C2-5 It is not known at this stage precisely how island mode switching arrangements will be achieved in standards and guidance in New Zealand, especially given the complicating factors outlined in Paragraph C2-4 of this report.

C2-6 However, standards and guidance are already in place for the manual temporary connection of a generator by licensed electrical workers, see:

(a) WorkSafe New Zealand Technical Bulletin *Connecting a generator to the wiring of a house or building following an emergency* [reference 4];

(b) AS/NZS 4509.1 *Stand-alone power systems part 1: Safety and installation* [reference 5].

C2-7 Consideration was also given to the possible future use of protective devices that can operate to disconnect electric vehicles from all live conductors, and the protective earthing system, in the event of detection of conditions indicative of a broken PEN conductor upstream of the supply to the electric vehicle charging equipment. The Institution of Engineering and Technology (IET) in the UK published a standard for such devices, IET 01:2024 [reference 3], termed 'open PEN detection devices' (OPDDs).

C2-8 During a fault resulting from a broken PEN conductor, touch-voltages on conductive parts of electric vehicles connected to a charging point can, under certain circumstances, exceed the line-to-Earth voltage if the break in the PEN conductor is in a three-phase portion of the distribution system. OPDDs remove the danger by disconnecting all live (active and neutral) conductors, and, at the same time, the protective (earthing) conductor to the charging point, which would otherwise continue to transfer the raised PEN conductor potential to conductive parts of the vehicle. This necessarily requires switching of the earthing conductor.

C3 Risks associated with switching a PEN conductor

C3-1 Sub-clause 2.3.2.1.2 (b)(i) of AS/NZS 3000:2018 [reference 2] requires that neither a neutral conductor of the consumer mains, nor a PEN conductor, are switched.

C3-2 The effect of switching a PEN conductor is to remove both protective earthing and neutral functions from exposed-conductive-parts downstream of the switch. The risks associated with switching a PEN conductor depend on whether the circuit (or service) associated with the PEN conductor is single-phase or three-phase, and whether multiple earthing (MEN) provisions are available downstream of the disconnected PEN conductor.

C3-3 It is not desirable to switch a PEN conductor under any circumstances. Not all countries enable switching of protective conductors in their national wiring codes. The UK is one country that does, but even in the UK, switching of PEN conductors is precluded (see Appendix D Section D4 of this report).

C3-4 If a PEN conductor is switched at the same time as the other live conductors:

(a) The earthing resistances on an MEN distribution network as a whole are changed.

(a) Touch-voltages can develop between exposed-conductive-parts, and earthing (protective) conductors, on both sides of the switched conductor.

C3-5 If a PEN conductor is switched and line (active) conductors are not also disconnected, the resulting impact depends on the following factors:

(a) whether the circuit or system is single-phase or three-phase; and

(a) if the PEN conductor is part of an MEN system, or there is bonding or fortuitous contact with the Earth either directly or indirectly through extraneous-conductive-parts, so that there is a PEN return path around the switched PEN conductor due to low effective earth electrode resistance.

C3-6 In single-phase circuits and systems with PEN conductors, exposed-conductive-parts downstream of an open-circuit PEN conductor can have a touch-voltage of up to the line-to-Earth voltage with respect to the general mass of Earth. This risk can be reduced inside buildings where main protective bonding is in place.

C3-7 In three-phase circuits and systems with PEN conductors, the PEN conductor downstream of the open-circuit PEN conductor is a neutral, and will assume a voltage dependent on the balance of loads connected downstream of the open-circuit PEN conductor, which appears as a touch-voltage with respect to the general mass of the Earth at exposed-conductive-parts and, if applicable, bonded extraneous-conductive-parts downstream of the open-circuit PEN conductor. The touch-voltage, in some conditions, can exceed the line-to-Earth voltage with respect to the general mass of Earth, and in rare conditions could approach the line-to-line voltage.

C3-8 The touch-voltages described in Paragraphs C3-6 and C3-7 of this report can be reduced, to an extent, by:

(a) Provision of earth electrodes with very low values earth electrode resistances, connected to the PEN conductor downstream of the disconnection. The values of earth electrode resistance that reduces the possible touch-voltages to a level that might be considered generally safe in dry conditions depends on the connected load. Based on calculations carried out for electric vehicle charging installations supplied by protective multiple earthing (PME) systems in the UK, the values of earth electrode resistance are generally only considered practicable in cases where there is extensive metallic contact with the ground (for example, buildings with a piled steel-framed buildings). The calculated resistances are:

(i) In single-phase systems, values of earth electrode resistance of less than 1 Ω would be needed to maintain touch-voltages below 70 V AC for supplies up to 100 A.

(ii) In three-phase systems the touch-voltage developed depends on phase unbalance. Similar values of earth electrode resistance would be required to maintain touch-voltages below 70 V AC for supplies up to 100 A, unless phase unbalance can be guaranteed to be better than 0.60 per unit and 0.37 per unit in the second and third largest line currents respectively both with respect to the largest line current (being 1.00 per unit).

(b) Inside buildings, by provision of main protective bonding, although note that conductive parts connected to the protective bonding, that are accessible outdoors, will then be subject to a potentially dangerous touch-voltage.

C3-9 In the case of a dangerous touch-voltage described in Paragraphs C3-6 and C3-7 of this report, neither overcurrent protective devices nor residual current devices (RCDs) will operate to provide automatic disconnection of the touch-voltage.

C4 Risks associated with switching a neutral conductor other than a PEN conductor

C4-1 Sub-clauses 2.3.2.1.2 (b)(ii), 2.3.2.1.2 (b)(iii) and 2.3.2.1.2 (b)(iv) of AS/NZS 3000:2018 [reference 2] relate to conditions that must be satisfied for switching a neutral conductor (other than a PEN conductor). These can be summarized as follows:

(a) The neutral is not to be switched without also switching the associated active (line) conductors.

(b) When switching all live (active and neutral) conductors, the switching is to be arranged so that either:

(i) all live (active and neutral) poles are linked so that all live contacts make and break at substantially the same time; or

(ii) all live (active and neutral) poles are linked so that the neutral contact does not open before the active (line) contact(s), and the neutral contact does not close after the active (line) contact(s).

C4-2 In single-phase systems and circuits, disconnecting a neutral conductor without switching the associated line conductors generally disconnects power from loads; however, all live conductors downstream of the disconnected neutral conductor remain live. This could post a shock risk to anyone maintaining the installation, including removal of lamps at general lighting service points.

C4-3 In three-phase systems and circuits, disconnecting a neutral without also disconnecting the active (line) conductors means that the neutral is 'floating' and will assume a voltage, relative in the phasor world to the live conductors, based on the balance of the loads downstream of the disconnected neutral. In this case, the voltage between any line and neutral could attain a voltage of up to the line-to-line voltage, or in rare cases with non-unity power factor, exceed the line-to-line voltage.

C4-4 Undervoltage is often experienced by equipment in general; however, due to the magnitude of overvoltage experienced by single-phase equipment connected between a line and neutral downstream of the switched neutral, serious overvoltage can be experienced. Overvoltage from broken neutrals in three-phase systems has been known to not only damage equipment, but also lead to fire. The situation in a real open neutral situation is often exacerbated by the fact that, as modern equipment with internal electronic and control circuitry becomes inoperative or is damaged by overvoltage, the balance of loads is continually shifting.

C4-5 Where the timing arrangements summarized in Paragraph C4-1(b) of this report are not met, the neutral can be disconnected when the live conductors are connected. This can lead to the risks described in Paragraphs C4-2 to C4-4 inclusive of this report; however, in this case, the risk of fire resulting is generally less because of the short time involved. Damage to equipment, however, can still result, particularly if a three-phase circuit is being switched.

C5 Risks associated with switching an earthing conductor (protective conductor) other than a PEN conductor

C5-1 Clause 2.3.2.1.2 (c) of AS/NZS 3000 [reference 2] requires that earthing (protective) conductors are not switched or disconnected.

C5-2 Risks associated with switching of a PEN conductor are summarized in Section C3 of this report.

C5-3 Switching earthing (protective) conductors without switching live conductors is generally considered dangerous as it removes the protective provision of automatic disconnection of supply. If a fault were to occur under these conditions, the fault would not be disconnected, and exposed-conductive-parts would be at a hazardous live voltage with respect to the general mass of the Earth.

C5-4 In many installations, protective conductor currents result from electromagnetic compatibility filters, and if the protective conductor is open-circuit, such currents can flow to Earth through someone in contact with exposed-conductive-parts. If the protective conductor is interrupted to a number of items of equipment, or a number of circuits, that remain live, the sum of protective conductor currents can, on their own, be lethal with no electrical fault, unless the protective conductor remains continuous.

C5-5 There is concern regarding switching of protective conductors (other than through the removal and reinsertion of a multi-pole plug and socket-outlet), that if a switching device has a protective conductor contact, this can, over time, fail. A user may be unaware of the damage, leading to permanent disconnection of the earthing (protective) conductor. Such risks can be alleviated by only enabling switching of the protective conductor by dedicated equipment to an appropriate product standard that includes durability tests, and/or where there is monitoring of the earthing system through the protective conductor.

C6 Risks associated with the use of PEN conductors and remote system referencing connections in electrical installations operating in island mode

C6-1 In system with TN-C or TN-C-S earthing arrangements, diverted neutral current is a term used to describe neutral current, that would normally flow back to the source of energy via the PEN conductor, but instead are diverted through other low resistance paths, including:

(a) fortuitous connection of protective (earthing) conductors, including PEN conductors, with the ground, or conductive parts in contact with the ground;

(b) bonded extraneous-conductive-parts that form an effective low resistance earth electrode (for example metallic non-electrical service pipework, or the steel frame of a building);

(c) exceptionally low resistance earth electrodes (for example where the steel frame of a building is used as an earth electrode).

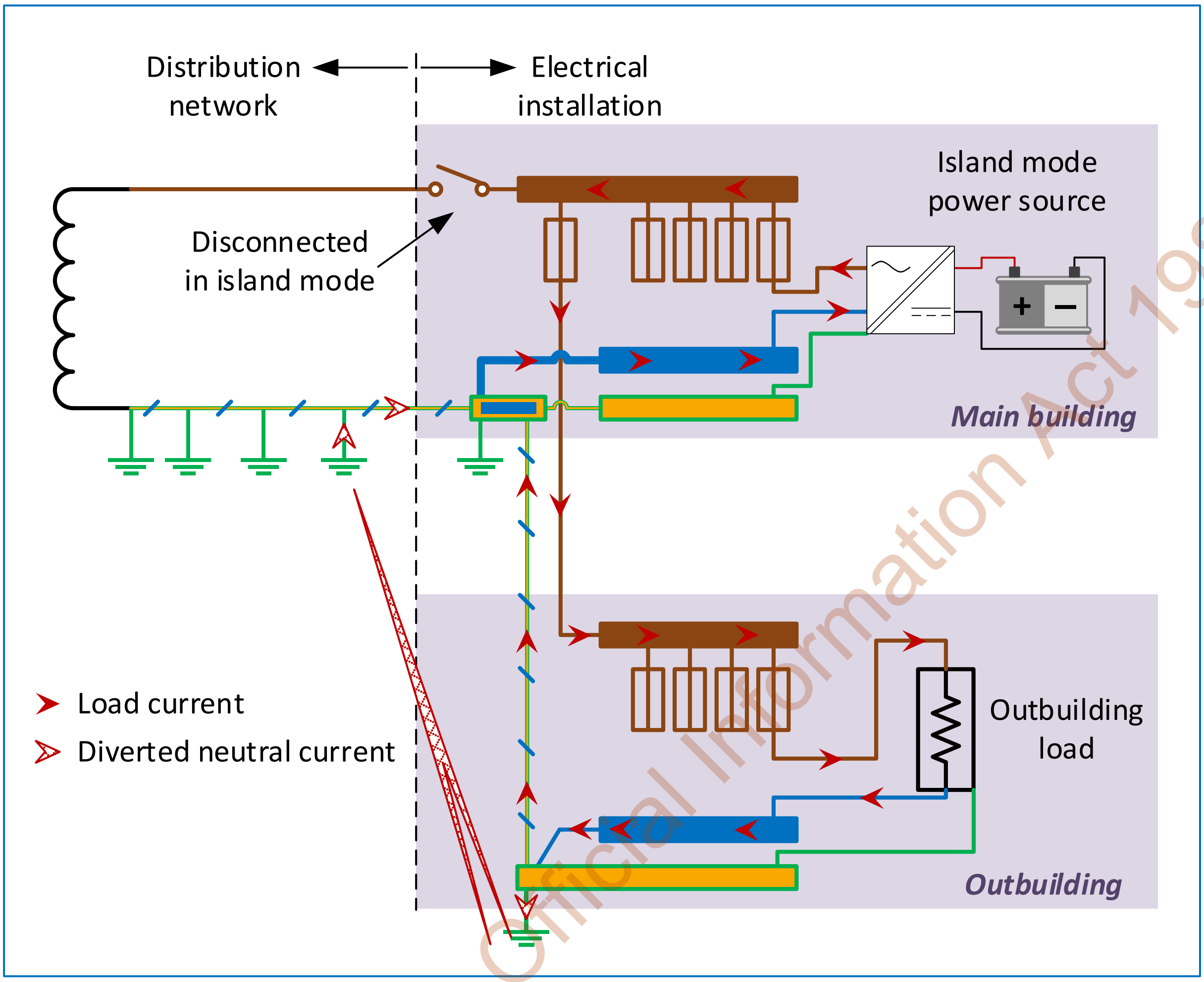
C6-2 The proportion of diverted neutral current depends on the earth electrode resistances, soil resistivity, and presence of conductive material in the ground. It is not something that is easy to predict without extensive investigation for a given site.

C6-3 If the PEN conductor of the MEN network remains connected to an electrical installation operating in island mode, diverted neutral currents from PEN conductors in the installation can return to the island mode source via the MEN network as a parallel path, as illustrated in Figure C.1. This can provide a risk to persons working on the supply distribution network (MEN distribution system), even where the distribution system is de-energized for the work to be carried out.

C6-4 Whilst the proportion of diverted neutral current in many cases is likely to be small with respect to load current, currents of only a few milliamperes can be fatal.

C6-5 If the diverted neutral current results from shared metalwork (for example, metallic non-electrical service pipes) between two separate electrical installations, however, a large proportion of diverted neutral current can be expected.

Figure C.1 Example of path of possible diverted neutral currents



NOTE 1: See Paragraph C6-10 of this report regarding the earthing arrangement for connecting the island mode power source.

NOTE 2: Figure C.1 is intended to illustrate a principle, and is not specific to supply and installation arrangements any particular country.

C6-6 'System referencing' is a term that is recently appearing in IEC standards, see IEC 60364-1 [reference 22], to mean the connection of a live part or conductor to Earth for the purpose of forming a suitable earthing arrangement associated with protection against electric shock. The system referencing conductor is the conductor that connects the live part to an earthing conductor to enable the live part to be substantially at the potential of the earthing arrangement.

C6-7 The location of the system referencing conductor is important to the operation of certain protective devices.

C6-8 In installations where small-scale embedded generators are used to provide power to the installation in island mode, the available fault currents can be insufficient to operate overcurrent protective devices, and residual current devices (RCDs) are necessary to provide protection against electric shock.

C6-9 If the system referencing conductor is not provided immediately after the grid-forming embedded generator, the generator connecting circuit might not be effectively protected against electric shock by automatic disconnection of supply, as an RCD in that circuit will not operate for a fault in the embedded generator circuit.

C6-10 The arrangement shown in Figure C.1 effectively includes a ‘combining’ of neutral and protective conductors from the perspective of the island mode source of supply at the point where the PEN conductor to the outbuilding is connected. The neutral bar connection from the combined neutral and earth terminal acts as a system referencing conductor. This is effectively precluded in IEC 60364-5-54:2011+AMD1:2021 (see Paragraph E6-1 in Appendix E of this report). It is not clear how such a conflicting requirement might be interpreted in multi-source, or switchable-source, systems. Ideally, the system referencing conductor should be as close as possible to the island mode source of supply (see Paragraph C6-9).

C7 Existing guidance for connecting temporary generators

C7-1 The existing guidance for connecting temporary or stand-alone generators [references 4 and 5] address the risks outlined in Paragraphs C6-1 to C6-5, by temporarily disconnecting the MEN connection to the installation.

C7-2 The existing guidance for connecting temporary or stand-alone generators [references 4 and 5] do not consider the fact that the MEN is to be disconnected. If this is not appropriately insulated, or there are exposed-conductive parts connected to the islanded installation that are simultaneously-accessible with exposed-conductive-parts connected to the MEN system outside the installation, then dangerous potential differences can be experienced.

Appendix D Provisions for and preclusions of switching protective, neutral and PEN conductors in BS 7671

D1 General

D1-1 The current national electrical installation standard in the United Kingdom is BS 7671:2018+A2:2022+A3:2024 [reference 6].

D2 Supply transfer arrangements

D2-1 The selection of switching and earthing arrangements for supply changeover, whether automatic or manual, is specifically covered by Regulation 537.1.5 of BS 7671 [reference 6] which has the following provisions:

> **537.1.5** Where an installation is supplied from more than one source of energy, one of which requires a means of earthing independent of the means of earthing of other sources and it is necessary to provide that not more than one means of earthing is applied at any time, a switching device may be inserted in the connection between the neutral point and the means of earthing, provided that the device is:
>
> (i) a multipole, linked switching device arranged to disconnect and connect the earthing conductor for the appropriate source at substantially the same time as the related live conductors, or
>
> (ii) a switching device interlocked with a multipole, linked switching device inserted in the related live conductors such that the earthing conductor for the appropriate source shall not be interrupted before the related live conductors and shall be re-established not later than when the live conductors are reconnected.
>
> Switching devices provided in accordance with (i) and (ii) shall meet the requirements of Chapter 46 for a device for isolation.

D3 Switching of the neutral conductor

D3-1 Regulation 132.14.2 is a general requirement of BS 7671 [reference 6] and contains the provision that only linked switches or circuit-breakers, either of which also breaks the line conductors, may be used in the neutral conductor:

> **132.14.2** No switch or circuit-breaker, except where linked, or fuse, shall be inserted in an earthed neutral conductor. Any linked switch or linked circuit-breaker inserted in an earthed neutral conductor shall be arranged to break all the related line conductors.

D4 Preclusion of switching a PEN conductor

D4-1 BS 7671 [reference 6] precludes switching of a PEN conductor, see Regulation 411.4.3:

> **411.4.3** In a fixed installation, a single conductor may serve both as a protective conductor and as a neutral conductor (PEN conductor) provided that the requirements of Regulation 543.4 are satisfied. No switching or isolating device shall be inserted in the PEN conductor.
>
> **NOTE**: Regulation 8(4) of the Electricity Safety, Quality and Continuity Regulations prohibits the use of PEN conductors in consumers' installations.

D5 Preclusion of forming a PEN conductor from separate neutral and protective conductors

D5-1 BS 7671 [reference 6] precludes the recombining of separate neutral and protective conductors to re-establish a PEN conductor, see Regulation 543.4.3:

> **543.4.3** If, from any point of the installation, the neutral and protective functions are provided by separate conductors, those conductors shall not then be reconnected together beyond that point. At the point of separation, separate terminals or bars shall be provided for the protective and neutral conductors. The PEN conductor shall be connected to the terminals or bar intended for the protective earthing conductor and the neutral conductor. The conductance of the terminal link or bar shall be not less than that specified in Regulation 543.4.5.

D6 Switching of the protective conductor (other than a PEN conductor)

D6-1 Regulation 543.3.3.101 of BS 7671 [reference 6] contains the following provisions:

> **543.3.3.101** No switching device shall be inserted in a protective conductor, except:
>
> (i) as permitted by Regulation 537.1.5
>
> (ii) a multipole, linked switching device in which the protective conductor circuit is not interrupted before the live conductors and is re-established not later than when the live conductors are reconnected
>
> (iii) a switching device interlocked with a multipole, linked switching device inserted in the live conductors such that the protective conductor circuit shall not be interrupted before the live conductors and shall be re-established not later than when the live conductors are reconnected, or
>
> (iv) a multipole plug-in device in which the protective conductor circuit shall not be interrupted before the live conductors and shall be re-established not later than when the live conductors are reconnected.
>
> Switching devices provided in accordance with (i), (ii), (iii) and (iv) shall meet the requirements of Chapter 46 and Section 537 for a device for isolation.
>
> Joints for test purposes that can be disconnected only by the use of a tool may be inserted in a protective conductor.

D6-2 Switching of a protective conductor (including an earthing conductor) is by a single-pole switching device inserted in the conductor, interlocked with a multipole linked switch that operates to disconnect live conductors, is therefore clearly facilitated by BS 7671 [reference 6], using the options in:

(a) indent (i) to Regulation 534.3.3.101, via the option in indent (ii) to Regulation 537.1.3; or

(b) indent (iii) to Regulation 534.3.3.101.

D7 Meaning of the term 'linked switch' in BS 7671

D7-1 The term linked switch has been used in BS 7671, and the predecessor UK industry standard commonly known as the 'IEE Wiring Regulations', published by the Institution of Electrical Engineers (IEE) for a period exceeding 120 years. A definition for the term first appeared in Regulation 100 of the Fourth Edition of the IEE Wiring Regulations [reference 14] which was published in 1903:

> 100. *Linked switches.–* Linked switches are single-pole switches fixed on conductors of different polarity linked together mechanically so as to operate simultaneously.

D7-2 The definition cited in Paragraph D7-1 of this Appendix remained in use in subsequent Editions of the IEE Wiring Regulations, from the Fourth to the Sixth, until the Seventh Edition [reference 15] was published in 1916, which contained the following definition introducing a 'definite sequence' of operation:

> **Switch, linked**. A switch the blades of which are so linked mechanically as to make or break all poles simultaneously or in a definite sequence.

The definition remained unchanged until the Fourteenth Edition [reference 16] published in 1966 (see Paragraph D7-3 of this Appendix).

D7-3 The current definition in Part 2 of BS 7671:2018+A2:2022+A3:2024 [reference 6] is:

> **Switch, linked.** A switch the contacts of which are so arranged as to make or break all poles simultaneously or in a definite sequence.

This definition has not changed since the Fourteenth Edition of the IEE Wiring Regulations, first published in 1966 [reference 16].

D7-4 There is no definitive statement in the current edition of BS 7671 [reference 6] that the poles of a 'linked switch' are required to be mechanically linked; however the following ought to be considered:

(a) It is generally considered in the industry that the term 'linked switch' refers to a multipole switch in which the linkages are mechanical in nature. For example, the McGraw-Hill Dictionary of Architecture and Construction [reference 17] defines the term 'linked switch' as:

> Two or more electric switches which are mechanically connected by operating arms or levers, so as to operate at the same time or in a desired sequence;

and

(b) BS 7671 [reference 6] uses the term 'interlocked' in relation to electrical linking in indent (ii) of Regulation 537.1.5, and indent (iii) of Regulation 543.3.3.101;

and

(c) BS 7671 [reference 6] implements the technical intent of the HD 60364 series published by CENELEC, as listed in the Preface. The facts regarding the technical intent in respect of multipole switching devices being required be mechanically linked are presented in Appendix E, E7 of this report.

Appendix E Provisions for and preclusions of switching protective, neutral and PEN conductors in IEC 60364 series

E1 General

E1-1 Relationship with AS/NZS 3000

E1-1-1 The preface to AS/NZS 3000:2018 [reference 2] states that one of the objectives of the revision from AS/NZS 3000:2007 was to 'maintain alignment with IEC 60364, *Low voltage electrical installations* (series)'.

E1-2 Relationship with BS 7671

E1-2-1 BS 7671:2018+A2:2022+ A3:2024 [reference 6] implements the technical intent of CENELEC harmonized documents (HDs) as shown in the Preface to the standard. HD 60364 series implements IEC 60364 series in CENELEC.

E2 Supply transfer arrangements

E2-1 IEC 60364 series appears to leave supply transfer switching to IEC 60947-6-1. It is not clear what conditions pertain when switching between supplies that have different, and separate, earthing arrangements.

E2-2 IEC 60364-1:2025 defines a 'system referencing conductor' to enable earthing of a live conductor to be established, preventing the need to switch a protective conductor, see Clause 1.8.4:

> **1.8.4 System-referencing-conductors**
>
> A system-referencing-conductor (SRC) is a conductor between a live part and an earthing arrangement, enabling the live part to be substantially at the potential of the earthing arrangement. The SRC is neither a neutral conductor nor a protective conductor.
>
> NOTE The application of SRC, shown in Figure 9, Figure 10, Figure 11, Figure 12 and Figure 13, is given to help define the characteristic behaviour of the electric systems.

E3 Switching of the neutral conductor

E3-1 Clause 530.3.2 of IEC 60364-5-53:2015 precludes switching of the neutral conductor unless the associated line (active) conductors are also switched:

> **530.3.2** Except as provided in 536.2.2.7, in multiphase circuits, single-pole devices shall not be inserted in the neutral conductor.
>
> In single-phase circuits single-pole devices shall not be inserted in the neutral conductor, unless a residual current device complying with the rules of 413.1 of IEC 60364-4-41 is provided on the supply side.

E4 Preclusion of switching a PEN conductor

E4-1 IEC 60364-4-41:2005+A1:2017 precludes the switching of a PEN conductor, see Clause 411.4.3:

> **411.4.3** In fixed installations, a single conductor may serve both as a protective conductor and as a neutral conductor (PEN conductor) provided that the requirements of 543.4 of IEC 60364-5-54 are satisfied. No switching or isolating device shall be inserted in the PEN conductor.

E5 Switching of the protective conductor (other than a PEN conductor)

E5-1 IEC 60364-5-54:2011+AMD1:2021 precludes the switching of a protective conductor, see Clause 543.3.3:

NOTE: Some countries, including the United Kingdom, allow switching of the protective conductor under specified conditions.

> **543.3.3** No switching device shall be inserted in the protective conductor, but joints which can be disconnected for test purposes by use of a tool may be provided.

E5-2 Similarly, IEC 60364-1, Clause 1.8.3, precludes switching protective conductors:

> 1.8.3 Protective conductors
>
> 1.8.3.1 General
>
> Protective conductors are those conductors used for protective purposes. Protective conductors are classified into:
>
> – protective earthing conductors;
>
> – protective bonding conductors.
>
> In a protective conductor the electrical continuity shall be maintained. Accordingly, no switching device shall be inserted.

E5-3 A distinction that needs to be raised in respect of Paragraph E5-2 of this Appendix, is that switching of a protective conductor need not occur, if the connection of a live conductor of the installation to Earth is not classified as a protective conductor, and a the term *system referencing conductor* is defined. See Section E2 of this Appendix.

E6 Preclusion of forming a PEN conductor from separate neutral and protective conductors

E6-1 IEC 60364-5-54:2011+AMD1:2021 precludes the recombining of separate neutral and protective conductors to re-establish a PEN conductor, see Clause 543.4.3:

> **543.4.3** If, from any point of the installation, the neutral/mid-point/line and protective functions are provided by separate conductors, it is not permitted to connect the neutral/mid-point/line conductor to any other earthed part of the installation. However, it is permitted to form more than one neutral/mid-point/line conductor and more than one protective conductor from the PEN, PEL or PEM conductor respectively.

E7 Requirements for linked switching in IEC 60364-5-53:2015

E7-1 Section 530.3 contains the following provisions:

530.3 General and common requirements

This part of IEC 60364 shall provide compliance with the measures of protection for safety, the requirements for proper functioning for intended use of the installation, and the requirements appropriate to the external influences foreseen. Every item of equipment shall be selected and erected so as to allow compliance with the rules stated in the following clauses of this part and the relevant rules in other parts of this standard.

The requirements of this part are supplementary to the common rules given in IEC 60364-5-51.

530.3.1 The moving contacts of all poles of multipole devices shall be so coupled mechanically that they make and break substantially together, except that contacts solely intended for the neutral may close before and open after the other contacts.

530.3.2 Except as provided in 536.2.2.7, in multiphase circuits, single-pole devices shall not be inserted in the neutral conductor.

In single-phase circuits single-pole devices shall not be inserted in the neutral conductor, unless a residual current device complying with the rules of 413.1 of IEC 60364-4-41 is provided on the supply side.

530.3.3 Devices embodying more than one function shall comply with all the requirements of this part appropriate to each separate function.

Appendix F Provisions for switching the neutral conductor in relevant product standards referenced in Schedule 4 to the New Zealand Electrical Safety (Amendment) Regulations 2025

F1 IEC 60947-1

F1-1 Clause 8.1.9 of IEC 60947-1:2020 [reference 10] has the following provisions in respect of the neutral pole:

> **8.1.9 Additional requirements for equipment provided with a neutral pole**
>
> When an equipment is provided with a pole intended only for connecting the neutral conductor, this pole shall be clearly identified to that effect by the letter "N" (see 8.1.8.4).
>
> A switched neutral pole shall break not before and shall make not after the other poles.
>
> If a pole having an appropriate short-circuit breaking and making capacity (see 3.7.14 and 3.7.15) is used as a neutral pole, then all poles, including the neutral pole, may operate substantially together.
>
> The neutral pole may be fitted with an overcurrent release.
>
> For equipment having a value of conventional thermal current (free air or enclosed, see 5.3.2.1 and 5.3.2.2) not exceeding 63 A, this value shall be identical for all poles.
>
> For higher conventional thermal current values, the neutral pole may have a value of conventional thermal current different from that of the other poles, but not less than half that value or 63 A, whichever is the higher.

F2 IEC 60947-6-1

F2-1 IEC 60947-6-1:2021 [reference 8] includes a clear, normative, requirement for the live conductor poles (lines and neutral) of multipole transfer switches to be mechanically coupled so they operate substantially at the same time. The same Clause also references IEC 60947-1:2020 Clause 8.1.9 in respect of the neutral pole (see Paragraph F1-1 of this Appendix).

> **8.1.5 Opening and closing of main contacts**
>
> The main moving contacts of all phase poles of the switching device of a multipole TSE shall be so mechanically coupled that they make and break substantially together, whether operated manually, remotely, or automatically.
>
> The manual actuator of the TSE shall be insulated. The requirements of 8.1.5.1 of IEC 60947-1:2020 applies.
>
> There shall be no path or opening which allows incandescent particles to be discharged from the area of the manual operating means.
>
> For TSE equipped with neutral poles, 8.1.9 of IEC 60947-1:2020 applies.
>
> For any TSE with manual operating means intended for on-load use, opening and closing of the main contacts shall be independent of the speed with which the manual operating means is operated.
>
> If the manual means is intended only for off-load use with all sources de-energized and is so marked according to Table 2 item 1.3, this requirement does not apply.

F3 IEC 60669-1

F3-1 IEC 60669-1:2017 [reference 11] Clause 14.4 contains provisions for the timing of switching of the neutral contact in three-pole plus switched neutral switches conforming to the standard. (See Paragraph F3-2 of this Appendix regarding classification of switches in terms of pattern numbers according to Clause 7.1 of the standard.)

> **14.4 Making and breaking**
>
> Switches of patter numbers 2, 3, 04 and 6/2 shall make and break all poles substantially simultaneously except that for switches of pattern number 03, the neutral shall not make after or break before the other poles.
>
> *Compliance is checked by inspection and by manual test when the switch is mounted with the cover, cover plates and actuating members installed as for normal use.*

F3-2 Switches to IEC 60669-1 are classified according to their pattern number as per Clause 7.1 of the standard (Figure 8 of the standard is reproduced in Figure F.1 on page 38 of this report):

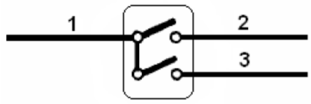
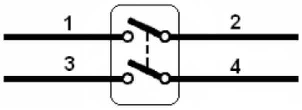
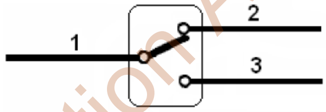
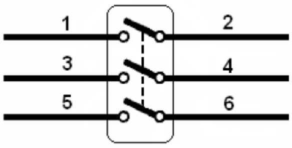
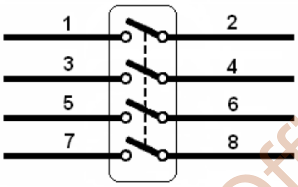
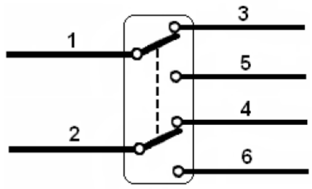
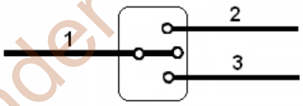
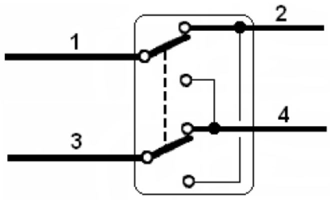
> **7 Classification**
>
> Switches are classified
>
> **7.1** according to the possible connections (see Figure 8)

	Pattern number
— single-pole switches	1
— double-pole switches	2
— three-pole switches	3
— three-pole plus switched neutral switches	03
— two-way switches	6
— two-circuit switches with a common incoming line	5
— two-way switches with one off-position	4
— two-way double-pole switches	6/2
— two-way reversing switches (or intermediate switches)	7

NOTE 1 Two or more switches having the same or different pattern numbers can be mounted on a common base.

NOTE 2 For the pattern number for which an off-position is considered, the above classification refers also to push-button switches and momentary contact switches.

Figure F.1 Figure 8 from IEC 60669-1:2017

Pattern number	Number of poles	Possible connections	Pattern number	Number of poles	Possible connections
1	1		5	1	
2	2		6	1	
3	3				
03	4		6/2	2	
4	1		7	1	

IEC

The figures indicating the terminals are given for test purposes only and are not those required to be marked.

Figure 8 – Classification according to connections