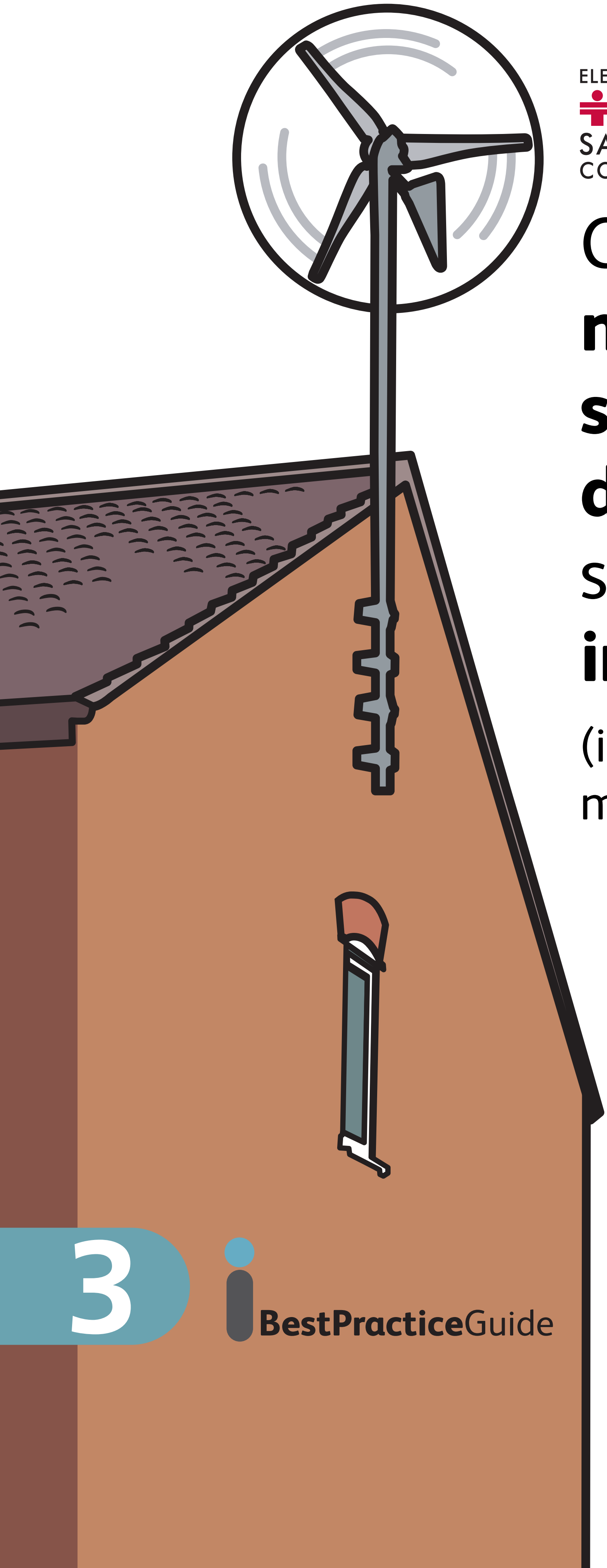
ELECTRICAL SAFETY COUNCIL

Connecting a **microgeneration system** to a **domestic** or similar **electrical installation**

(in parallel with the mains supply)



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BestPracticeGuide

BestPracticeGuide

This is one of a series of **Best Practice Guides** produced by the Electrical Safety Council* in association with leading industry bodies for the benefit of electrical contractors and installers, and their customers.

The Electrical Safety Council is indebted to the following organizations for their contribution to the development of this Guide:

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Connecting a **microgeneration system** to a **domestic** or similar **electrical installation**

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The aim of this Guide is:

- to provide an overview of microgeneration, otherwise known as small-scale embedded generation (SSEG),
- to provide information on the legal and contractual issues relating specifically to the installation of microgenerators with electrical rating up to 16 A per phase (including the relationship of the consumer with the electricity supplier and the electricity distributor), and
- to give guidance on the particular electrical issues, including electrical safety issues, that arise when installing or connecting a microgenerator.

This Guide does not provide installation guidance that is specific to any particular types of microgeneration.

When published, BS 7671: 2008 Part 712 will contain particular requirements for photovoltaic installations. For any microgenerator installation, the instructions of the manufacturer or supplier should be followed.

This Guide does not provide installation guidance where it is intended to install more than one microgenerator. In such cases it is necessary to consider the possibility of interaction between the protection and control equipment of the microgenerators and the specific advice of the manufacturers or suppliers of each of the microgenerators should be obtained and followed.

Microgenerator installations made as part of a Government programme are likely to require compliance with the UK Microgeneration Certification Scheme managed by BRE Certification and thereby an approved Code of Practice such as the REAL Code (www.realassurance.org.uk). Installers may wish to familiarise themselves with these requirements. Grants and subsidies are not addressed in this Guide.

Introduction

The UK Government is committed to encourage the wider use of renewable energy generation, and to technologies such as combined heat and power (CHP) that offer improved efficiency compared to traditional bulk generation in large power stations.

This commitment reflects undertakings made with the UK's partners in the European Union and internationally to reduce greenhouse gas emissions and reliance on fossil fuels.

Generation of electricity closer to the point of use avoids some of the losses that arise in the transmission and distribution of electricity to consumers. This currently amounts to up to 10% of units dispatched. Even for the most modern combined cycle gas generating stations with production efficiencies of 50-60%, the efficiency from the point of generation up to the point of use in a consumer's installation is generally well below 50%.

Decentralised generation, if sufficiently widely adopted, could also improve the reliability and resilience of the electricity supply system, though this clearly depends on the types and relative amounts of generation that are installed. For example, photovoltaic systems do not generate at night, and wind power does not function at very low or very high wind speeds.

Over the past few years, considerable attention has been given to the development of microgenerators that are intended to be installed in domestic and similar premises. Such microgenerators are rated at up to 16 A per phase.

A range of technologies has been emerging to take account of the rather different technical and operational challenges that the domestic environment presents compared to more traditional small generator designs.

Not least of these is the importance of providing simple, safe and reliable products at a price that is in proportion to the consumer's reduction in electricity purchase costs, so offering an attractive payback.

Photo Courtesy of Energy Saving Trust

Types of generation

It is, of course, possible to install and operate a generator and installation completely independently of the normal mains supply and to run certain appliances entirely on this separate system. This Guide, however, considers only generators that are intended to work in parallel with an existing mains supply, as this represents the most practical approach for most consumers.

The assumption is that consumers generally will wish to continue to use electricity as and when required at the throw of a switch without needing to be aware as to whether the generator is working or not.

Currently, the options can be divided into two broad classes from the point of view of connection into an existing installation:

- Renewable sources of electricity, powered by wind, light, or hydro-power, or fuel cells. Many of these generate at d.c. and are connected to the mains through a d.c. to a.c. inverter

Photo Courtesy of Energy Saving Trust

Photo Courtesy of Powergen

- Gas, oil and biomass fired micro-cogeneration (combined heat and power, or CHP) systems. The primary function of these systems is to provide for heating and hot water needs, in place of a traditional boiler or water heater. However, they include a small generator that provides electricity, powered by some of the heat energy produced for the water heating process. This Guide does not give guidance on the heat production aspects of microgenerators

- Renewable sources of heat using solar thermal panels, ground or air source heat pumps or biomass boilers that do not generate electricity are not covered by this Guide.

Photo Courtesy of Powergen

As previously mentioned, microgenerators are generally characterised as having an output of no more than 16 A per phase. In the case of micro-cogeneration (CHP) systems, because the electricity generation is ancillary to the heating of water and so represents only a part of the output of the system, the electrical output is typically in the range of 4 to 6 A.

Legal and related issues

An electrical installer working in premises, including domestic premises, is subject to relevant Health and Safety legislation, including the Electricity at Work Regulations.

Installers of microgenerators will need to be aware of the requirements of the relevant Building Regulations. In domestic premises in England and Wales, the installation of a microgenerator is notifiable under Part P. In Scotland, a Building Warrant may be required.

Some forms of microgenerator may be subject to planning law and to the non-electrical aspects of the Building Regulations, in particular structural considerations.

Although an electrical installer might not be involved in such issues on behalf of his client, they may impact on an unwary electrical installer in carrying out his work.

Before commencing work, it is advisable to consider the issues covered below:

(a) The installation of renewable energy sources may be subject to planning consent and Building Regulations. If the building is in a conservation area or is a listed building, planning consent will always be necessary.

In other cases, exemptions from planning requirements and Building Regulations are in force for photovoltaic systems up to certain sizes, provided they do not extend substantially outside the envelope of the existing building. Details of this exemption should be checked with the local Planning Authority and Building Control body.

At the time this Guide was published, planning exemptions were being considered (though were not currently generally in force) for wind turbines up to certain sizes and in certain locations on a building.

Photo Courtesy of Encraft Ltd

Before fixing microgeneration equipment to a building, consideration should be given by the installer to the structural condition of the building. This may involve a structural survey.

Hydro turbines may require planning consent and will also require a water abstraction licence.

Photo Courtesy of Energy Saving Trust

(b) The Electricity Safety, Quality and Continuity Regulations 2002 contain in Regulation 22 requirements for the installation and operation of generators in parallel with the distributor's network. These generally prohibit the connection of a generator without prior consent of the distributor (typically the relevant regional distribution network operator (DNO)), and contain requirements concerning design and operation that are likely to prevent parallel operation of generators in domestic premises.

However, an exemption is given in Regulation 22(2) for the installation of generation rated up to a total of 16 A per phase, provided:

- it has protection which will disconnect from the mains supply automatically in the event of the loss of the mains supply
- the installation complies with the current edition of BS 7671(Requirements for Electrical Installations), and
- the installer notifies the distributor before or at the time of commissioning the microgenerator.

Details of the characteristics for the protection scheme necessary to provide automatic disconnection following loss of mains, and the requirements for notification, are contained in the Energy Networks Association's Engineering Recommendation G83/1 or in BS EN 50438.

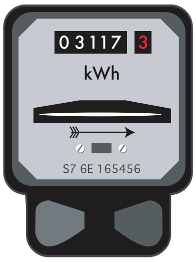
The installer should refer to the manufacturer's documentation to confirm that the microgenerator complies with the relevant requirements of G83/1 or BS EN 50438.

In addition to the notification to the distributor before or at the time of commissioning a microgenerator, the installer must also provide the distributor with an Installation Commissioning Confirmation Form, a copy of the circuit diagram showing the circuit wiring, and the manufacturer's Verification Test Report, all within 30 days of the microgenerator being commissioned.

Where generation exceeding 16 A output in total is to be provided in a single installation, it is necessary to obtain the permission of the distributor in advance.

Contract with the electricity supplier

Generators rated at up to 50 MW are exempted from licensing under the Utilities Act, so microgenerators covered by this Guide are exempt.



Energy users will have a contract with an electricity supplier for the purchase of electricity. Invariably the supply is provided through a meter. The meter will be either a prepayment meter (the customer pays in advance with cash or tokens) or a credit meter (the meter is read and the customer is billed retrospectively). In either case, the contract is for the supply of electricity to the premises.

If at any time the consumer's microgenerator generates more electricity than is being used in the premises, the surplus will go back into the mains. The exporting of electricity from the premises in this way is unlikely to be covered by the consumer's contract with the electricity supplier.

The reverse flow of energy can have an impact on the customer's meter in one of the following ways:

- some meters will be fitted with a 'backstop' which prevents the energy register from running backwards, so the consumer will be exporting electricity but will receive no compensation for it
- some meters with backstops may have a flag that is tripped by reverse power flow, which could result in the consumer being accused of stealing energy
- a prepayment meter may have an internal contactor that cuts off the mains supply if the energy flow is reversed
- some older meters may not have a backstop and the register will run backwards while energy is being exported, effectively 'crediting' the consumer with energy at the rate at which they normally pay for the electricity. This could be treated by the electricity supplier as a form of theft.

There is at present no legal duty for notifying the electricity supplier of the connection of a microgenerator, as is the case with the distributor. However, electricity suppliers may require notification as a condition of the supply contract. In addition, many electricity suppliers have contracts, called 'buy back' contracts available, that pay customers for any surplus electricity fed back into the mains.

It is therefore important that the installer encourages the customer to notify the electricity supplier of the installation of a microgenerator.

Customers should also be advised to check with their electricity supplier concerning any costs associated with the microgenerator connection, for example the provision of a new meter.

The contractual conditions, costs and buy back tariffs may vary between electricity suppliers. It may be that for some forms of microgeneration, or for some electricity suppliers, the buy back option may not be economic.

The availability of buy back contracts and the provision of the necessary metering are currently subject to a review by the Government, which may result in new arrangements being put in place in due course.

Electrical installation

Safety issues

Installing a microgenerator brings particular additional electrical safety concerns which include:

- Persons must be warned that the electrical installation includes a microgenerator so that precautions can be taken to avoid the risk of electric shock. Both the mains supply and the microgenerator must be securely isolated before electrical work is performed on any part of the installation

- Adequate labelling must be provided to warn that the installation includes another source of energy

- It must be remembered that photovoltaic (pv) cells will produce an output whenever they are exposed to light, and wind turbines are likely to produce an output whenever they are turning. Additional precautions such as covering the pv cells or restraining the turbine from turning will be necessary when working on those parts of the circuit close to the source of energy and upstream of the means of isolation. Reference should be made to the manufacturer's instructions.

In some respects, microgenerators can be considered to be similar to any current using appliance, for example:

- live parts will invariably be insulated or have an earthed or insulating enclosure
- the metallic enclosure of a Class I microgenerator will need to be connected to the circuit protective conductor.

However, there are other aspects that require care to ensure that the existing level of electrical safety is maintained for the users following the installation of a microgenerator.

As mentioned previously, the exemption to the requirement for prior consent of the distributor, contained in Regulation 22(2) of the Electricity Safety, Quality and Continuity Regulations 2002, requires compliance with the current edition of BS 7671. Prior to commencing the installation of a microgenerator, the installer must confirm such compliance, for example, by examining a recent Periodic Inspection Report for the existing installation (if available), or by carrying out a Periodic Inspection.

In order for a microgenerator to be placed on the market, the manufacturer or supplier of the microgenerator is required to declare compliance with the Electrical Equipment (Safety) Regulations and the Electromagnetic Compatibility Regulations. The microgenerator will be CE marked to confirm this.

This should ensure that the microgenerator will be satisfactory in an installation in terms of the power factor, generation of harmonics, and voltage disturbances arising from starting current and synchronisation.

Any synchronising system should be automatic and of a type that considers frequency, phase and voltage magnitude. The microgenerator should also have documentation confirming, amongst other things, the acceptability of the means of protection against operation in the event of loss of the mains supply, as required by G83/1 or BS EN 50438.

In designing a connection for a microgenerator, the electrical installer has to consider all the issues that would need to be covered for a conventional final circuit, including:

- the maximum demand (and the generator output)
- the type of earthing arrangement
- the nature of the supply
- external influences
- compatibility, maintainability and accessibility
- protection against electric shock
- protection against thermal effects
- protection against overcurrent
- isolation and switching
- equipment selection and installation issues.

The electrical installer will recognise that some of these issues can be changed by the connection of a microgenerator to an existing installation.

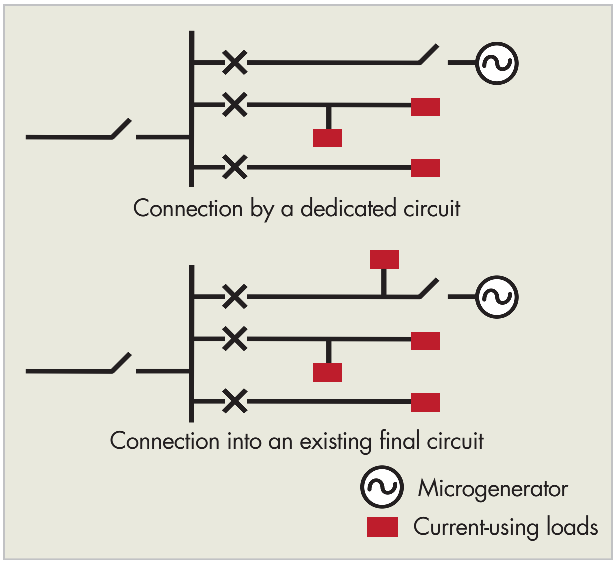
It is unlikely with the size of microgenerators covered by this Guide that the prospective fault current would change sufficiently to exceed the fault rating of existing protective devices, but this should be confirmed.

Photo Courtesy of Energy Saving Trust

From the specific perspective of a microgenerator, there are two connection options:

- connection into a separate dedicated circuit
- connection into an existing final circuit.

Examples of these two options are shown diagrammatically below.



Given the perceived constraint of financial viability on the development of the market for microgenerators, the second of these has been considered by some product developers to offer a simple solution with minimal disruption to the consumer's property.

From the perspective of the electrical safety of the installation however, this option can create design limitations for the installer of the microgenerator, and limitations for the user of the installation.

Connection into a dedicated circuit is preferred.

This option is technically simpler and creates least impact on existing use and hence on the user of the installation. The cost implication may not be significant when compared to the cost of the generator itself, and in some cases it may be less expensive in view of the need to meet the technical requirements detailed below for connecting into an existing final circuit.

Whichever of the two options is chosen, it is imperative that the safety of the electrical installation is not impaired by the installation of the microgenerator.

The essential criteria which must be met are given below for both options. In either case the following requirements must be met:

(i) The winding of an a.c. microgenerator must not be earthed. Note that a d.c. source or d.c. microgenerator could be earthed provided the inverter separates the a.c. and d.c. sides by at least the equivalent of a transformer providing simple separation. However, consideration would then need to be given to the avoidance of corrosion on the d.c. side.

(ii) The microgenerator must not be connected to an installation by means of a plug and socket.

(iii) Protection must be provided to disconnect the microgenerator from the mains automatically in the event of loss of the normal mains supply. This protection is incorporated in, or is supplied with, the microgenerator.

(iv) Where a microgenerator having a d.c. source does not incorporate the equivalent of a transformer providing simple separation between the d.c. and a.c. sides, an RCD installed for fault protection by automatic disconnection of supply must be of a type which will operate as intended in the presence of d.c. components in the residual current. Type AC RCDs do not fulfil this requirement.

Depending on the level and form of d.c. components, an RCD of Type A (to BS EN 61008 or 61009) or Type B (to IEC 607551 Amendment 2) will be required. This requirement does not apply where a microgenerator is, by construction, not able to feed d.c. currents into the electrical installation.

The need or otherwise for a Type A or a Type B RCD should be confirmed by reference to the installation instructions or to the supplier of the microgenerator.

(v) Where a microgenerator is installed within a special location covered by a specific section of Part 6 of BS 7671: 2001 (or, when published, Part 7 of BS 7671: 2008), the requirements applicable to that special location must also be applied as relevant to the microgenerator. For example, this might place limitations on the positioning of the microgenerator, involve additional protection with a 30 mA RCD, supplementary bonding, or the selection of a microgenerator with a specified IP rating.

The specific additional requirements for each of the two connection options are given below.

Connection of a microgenerator to a dedicated circuit

(i) The basic design parameters for the circuit are:

- $I_b \geq I_g$ where I_b is the design current and I_g is the rated output current of the microgenerator
- $I_n \geq I_b$ where I_n is the nominal current of the overload protective device
- disconnection of the circuit in the event of an earth fault on the circuit within 5 s for TN systems and 1 s for TT systems.

(ii) Where a microgenerator is connected on the same side of an RCD as final circuits protected by that RCD, the RCD must disconnect the line and neutral conductors.

(iii) The microgenerator must be provided with means of isolation and of switching off for mechanical maintenance.

Connection of a microgenerator to an existing final circuit

(i) The basic design parameters for the circuit are:

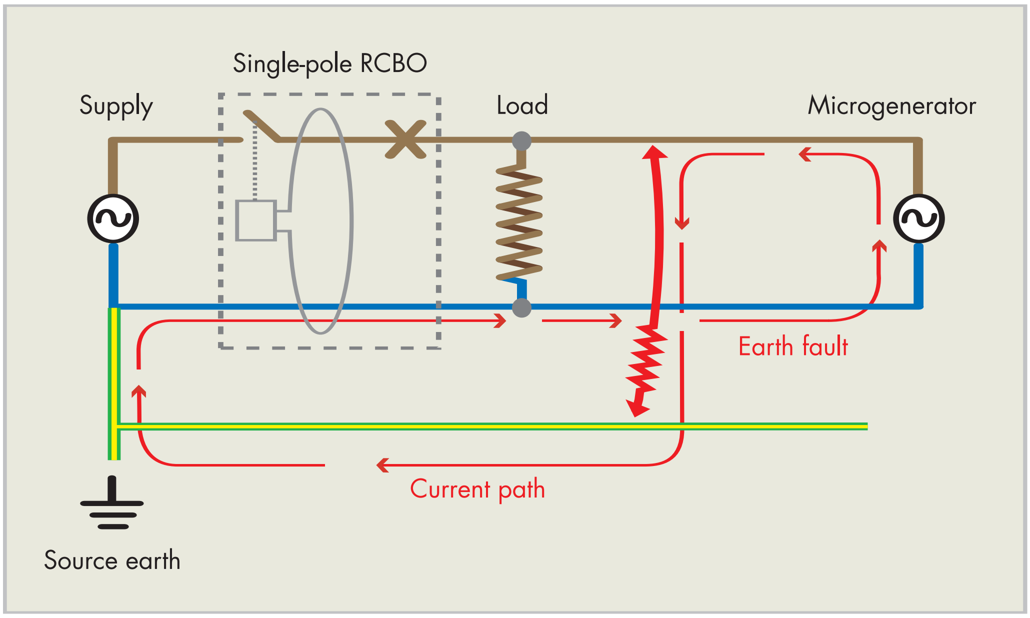
- $I_z > I_n + I_g$ where I_z is the current carrying capacity of the conductors of the final circuit, I_n is the nominal current of the overload protective device and I_g is the rated output current of the microgenerator. This may require the protective device to be replaced with one having a lower nominal current rating
- disconnection of the final circuit in the event of an earth fault on the circuit and de-energization of the microgenerator should both occur within an overall maximum time of 0.4 s for TN systems and 0.2 s for TT systems. However, if the protective device for automatic disconnection in case of an earth fault disconnects line and neutral conductors, it is not necessary to take account of the time taken for the microgenerator to de-energize.

(ii) An RCD providing additional protection for the final circuit must disconnect all line and neutral conductors.

(iii) The microgenerator must be provided with means of switching off for mechanical maintenance and of isolation from the remainder of the final circuit.

If the protective device does not disconnect the neutral, the effectiveness of the protection is no longer dependent solely on the operation of the protective device, but also on the shut down characteristics of the microgenerator.

The following diagram shows as an example an earth fault downstream of an RCBO with unswitched neutral. The earth fault causes operation of the RCBO, but the microgenerator can still supply current through the earth fault via the path shown in the diagram for a period until its own internal protection against loss of mains causes the microgenerator to shut down.



It should be noted that, if the RCD element of the RCBO has been provided for additional protection against electric shock, this arrangement is not permitted and the RCBO would need to switch both line and neutral conductors (see (ii) above).

Isolation and labelling

The microgenerator should have a means of isolation as close as practicable to its output terminals which disconnects all live conductors, including the neutral, from the mains supply.

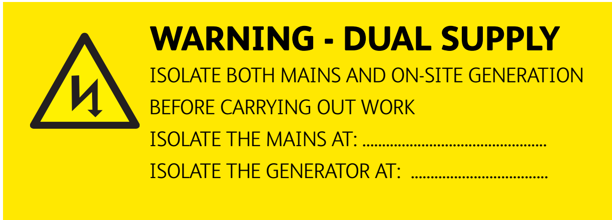
In all instances, the means of isolation, which must be manual, must be capable of being secured in the 'off' isolating position and must be located in an accessible position in the consumer's installation.

To indicate the presence of a microgenerator in an electrical installation, labels are required at:

- the mains supply terminals (distributor's fused cutout)
- the meter position
- the consumer unit(s), and
- the output terminals of the microgenerator.

In the case of a renewable source, a notice must be placed at the microgenerator isolator to warn that the conductors on the microgenerator side may remain live when the isolator is open.

The Health and Safety (Safety Signs and Signals) Regulations 1996 stipulate that the labels should display the prescribed triangular shape and font size using black on yellow colouring. A typical label is shown below.

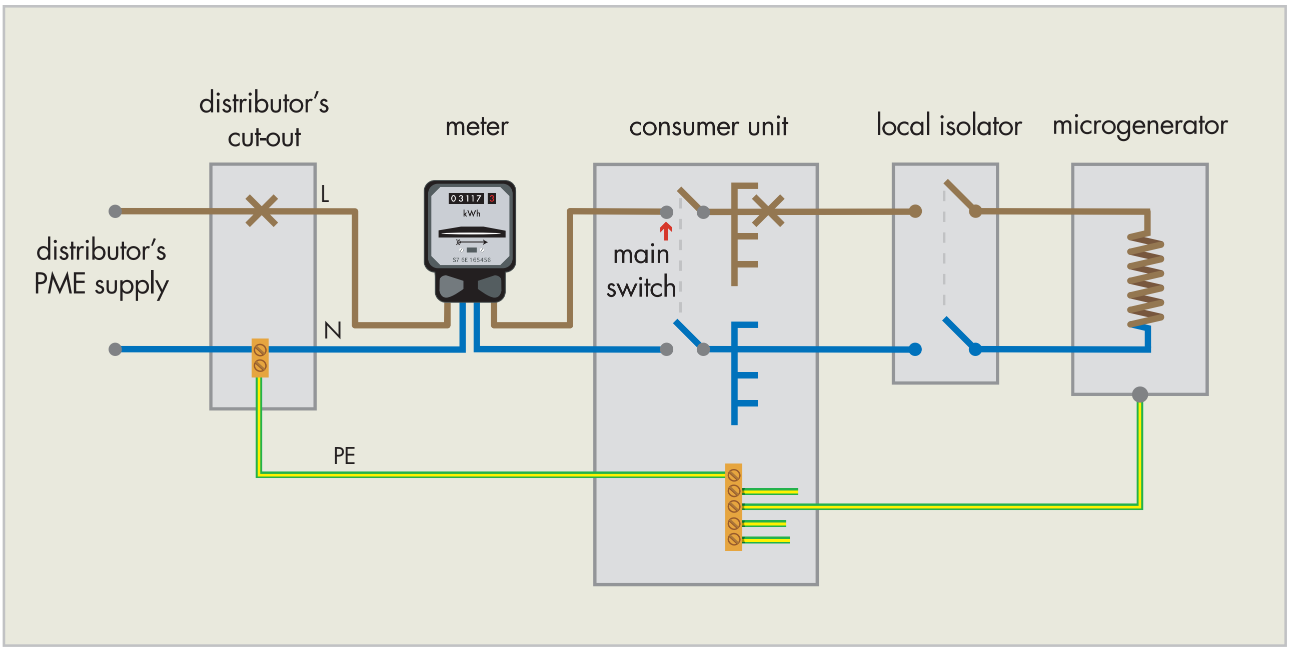


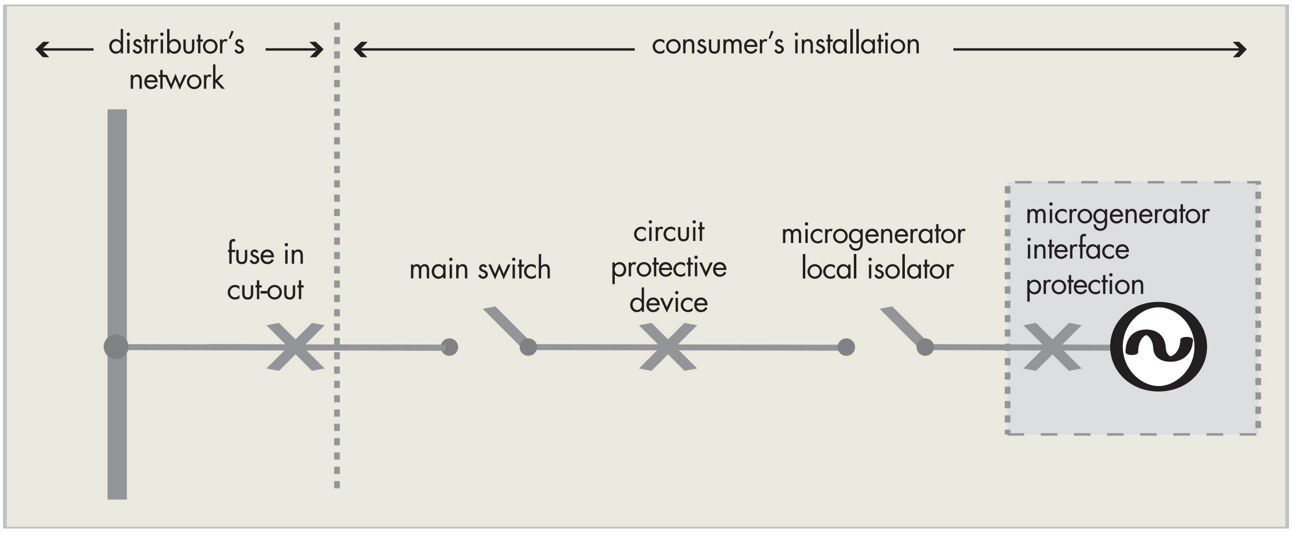
In addition, G83/1 and BS EN 50438 require up-to-date information to be displayed at the point of connection with a distributor's network as follows:

(a) A circuit diagram showing the relationship between the microgenerator and the distributor's fused cutout. This diagram is also required to show by whom the generator is owned and maintained

(b) A summary of the separate settings of the protection incorporated within the equipment. The figure below is an example of the type of circuit diagram that needs to be displayed. This diagram is for illustrative purposes and not intended to be fully descriptive.

Means of isolation for a microgenerator





Example of circuit diagram for a microgenerator installation

The installer is required to advise the customer that it is the customer's responsibility to ensure that this safety information is kept up to date.

The installation operating instructions must contain the manufacturer's contact details, such as name, telephone number and web address.

ANNEX

Glossary/Definitions:

Combined heat and power (CHP) Process that generates heat some of which provides the motive power to a microgenerator that is part of the heat generating device

Distributor (DNO) Owner or operator of low voltage electrical lines and equipment that are used to distribute electricity to consumers

Electricity supplier A person who supplies electricity to a consumer from a distributor's network

Microgenerator A device rated at up to 16 A per phase designed for the small-scale production of heat and/or electricity from a low carbon source (based on the definition in section 82 of the Energy Act 2004)

Network Low voltage electrical lines and equipment owned or operated by a distributor that are used to distribute electricity to consumers

RCBO An electromechanical protective device intended to provide overcurrent protection and residual current protection

SSEG (Small Scale Embedded Generation/Generator) microgenerator

Type AC RCD An RCD intended to operate for residual sinusoidal alternating currents, whether suddenly applied or slowly rising.

Type A RCD An RCD intended to operate for the following forms of residual current, whether suddenly applied or slowly rising:

- residual sinusoidal alternating currents
- residual pulsating direct currents
- residual pulsating direct currents superimposed on a smooth direct current of 6 mA.

Type B RCD An RCD intended to operate for the following forms of residual current, whether suddenly applied or slowly rising:

- residual sinusoidal alternating currents up to 1000 Hz
- residual alternating currents superimposed on a smooth direct current of 0.4 times the rated residual operating current
- residual pulsating direct currents superimposed on a smooth direct current of 0.4 times the rated residual operating current
- residual direct currents which may result from rectifying circuits.