SUMMER 11 ISSUE 39

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Energy efficiency of low-voltage electrical installations

Requirements for the design of new installations and the improvement of existing installations

By Geoff Cronshaw

THE IEE WIRING Regulations (BS 7671:2008) are based on European Standards, which in turn are usually based on international standards.

The UK participates in both European and international standards work. One new area of possible development within international standards is to integrate requirements for energy efficiency into IEC 60364.

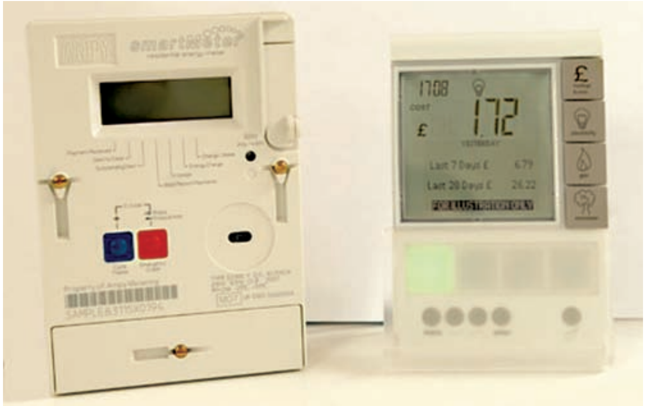
Electrical energy efficiency is intended to obtain the highest possible service from an electrical installation from the lowest energy consumption. Proposals include requirements for the design of new installations and the improvement of existing installations.

Basic concepts

Some key points when designing a new installation include determination of the load demand. This means establishing the type of application the electricity is used for.

A typical installation may include lighting, heating, ventilation, air conditioning etc. The design of the electrical distribution system needs to be carried out in such a way that will allow the metering and control of the various electrical loads.

Therefore, in order to make improvements we need to be able to measure the amount of electrical energy consumed and monitor and control energy effectively. For example in the UK the department of energy and climate change are planning to start a roll-out programme to introduce smart electricity meters into consumers' homes starting in 2014, which is expected to run through until 2020 with the ▶



Smart meter and consumer display unit

◀ aim of helping customers to reduce their energy bills. The smart meter will give customers information on energy consumed via a visual display and be capable of sending metering information to the energy supplier regarding the electricity consumed by the customer without the need for a meter reader. This should put an end to estimated bills. It will also allow the consumer to sell energy back to the energy supplier where the customer has a microgenerator installed such as a wind turbine or solar panels.

A smart meter is an electricity energy meter that incorporates a communications unit. The meter will measure the energy consumed and also measure any energy exported to the electricity network (where the consumer has micogeneration, such as a wind turbine or solar panels). The big difference is that the smart meter does not require a meter reader to visit the premises to read the meter.

Smart meters could use a number of communication options such as wireless, or data wire, or power line transmission (PLT), or mobile phone technology to transmit the meter-reading data to the energy supplier; it is not clear at this stage which option will be used. A smart meter may also be capable of controlling the consumers' load in the future by sending signals to consumer appliances to switch off at peak times, etc. It is also expected that the smart meter will be capable of providing flexible tariffs. It is expected that energy suppliers will be responsible for the installation of the smart meters.

Current-using equipment

Current-using equipment efficiency is based on control of the loads (the right energy at the right time).

Motor control

In the UK BEAMA have identified that most pump and fan applications are driven by very simple control systems where the motor runs at constant speed and the required flow variation is obtained by using a valve or damper to restrict the flow. This means that the energy consumption falls very little when the flow decreases. At 80 per cent of the nominal flow the energy consumption remains almost the same.

A more efficient option is to use a Variable Speed Drive (VSD) to adjust the speed of the motor or fan to deliver the required flow. For fans, savings can be in the region of 50 per cent and for pumps about 30 per cent savings are seen.

Lighting

Lighting can represent over 35 per cent of energy consumption in buildings depending on the application. Solutions for lighting control may save up to 50 per cent on the electricity compared to a traditional installation. These systems should be flexible and designed for the comfort of the users. The solutions can range from very small and local controls such as occupancy sensors, up to sophisticated customised and centralised solutions that are part of complete building automation systems.

Lighting controls for residential buildings are easy-to-install devices which are able to detect the presence of people and only switch on lights when required. Lighting controls eliminate wasted energy and save energy simply by switching lights off when not required. Lighting controls for commercial, public and industrial buildings are again easy-to-install devices that are able to automatically switch off lights when no occupants are detected or there are suitable levels of natural light.

When considering the design and installation of lighting controls there are a number of important points to consider. First, it is important to take ▶

IET Electrical excellence

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	Type	Overall luminous efficacy (lm/W)	Overall luminous efficiency
Incandescent	5w tungsten incandescent	5	0.7%
	40w tungsten incandescent	12.6	1.9%
	100w tungsten incandescent	13.8	2.0%
	200w tungsten incandescent	15.2	2.2%
	100w tungsten glass halogen	16.7	2.4%
	200w tungsten glass halogen	17.6	2.6%
	500w tungsten glass halogen	19.8	2.9%
	Tungsten glass halogen	24	3.5%
	Photographic and projection lamps	35	5.1%
Light-emitting diode	White LED	10 - 150	1.5 - 2.2%
Arc lamp	Xenon arc lamp	30-50	4.4 - 7.3%
	Mercury-xenon arc lamp	50-55	7.3 - 8.0%
Flourescent	9-26W compact flourescent	46 - 72	8 - 11%
	T12 tube with magnetic ballast	60	9%
	T5 tube	70 - 100	10 - 15%
	T8 tube with electronic ballast	80 - 100	12 - 15%
Gas discharge	Metal halide lamp	65 - 115	9.5 - 17%
	High pressure sodium lamp	85 - 150	12 - 22%
	Low pressure sodium lamp	100 - 200	15 - 29%

General luminous efficacies and efficiencies of common lamp types

◀ into account the type of space, how it is used and the amount of daylight available. The type and use of space will determine the type of sensor and therefore the control used.

Safety is also an important consideration. The operation of lighting controls should not endanger the occupants of the building. This may happen if a sensor switches off all the lighting in a space without daylight. It is therefore important that lighting controls are designed correctly to ensure the safety of occupants and save energy.

Commissioning should be included as an essential part of the installation of lighting controls. Commissioning could include calibrating photoelectric controls, checking that occupancy sensors are working, and setting a suitable delay time for occupancy sensors.

Energy efficiency of lamps

This section looks at the energy efficiency of lamps and is extracted from a previous *Wiring Matters* article. Incandescent lamps offer a low efficacy as the majority of energy consumed is converted into heat. A typical range would be 8-14 lumens per watt (lm/W). Luminous efficacy is a figure of merit for light sources and is the ratio of luminous flux (in lumens) to power (usually measured in watts).

As most commonly used, it is the ratio of luminous flux emitted from a light source to the electrical power consumed by the source and, therefore, describes how well the source provides visible light from a given amount of electrical power. This is also referred to as luminous efficacy. The table above shows general luminous efficacies and efficiencies of common lamp types.

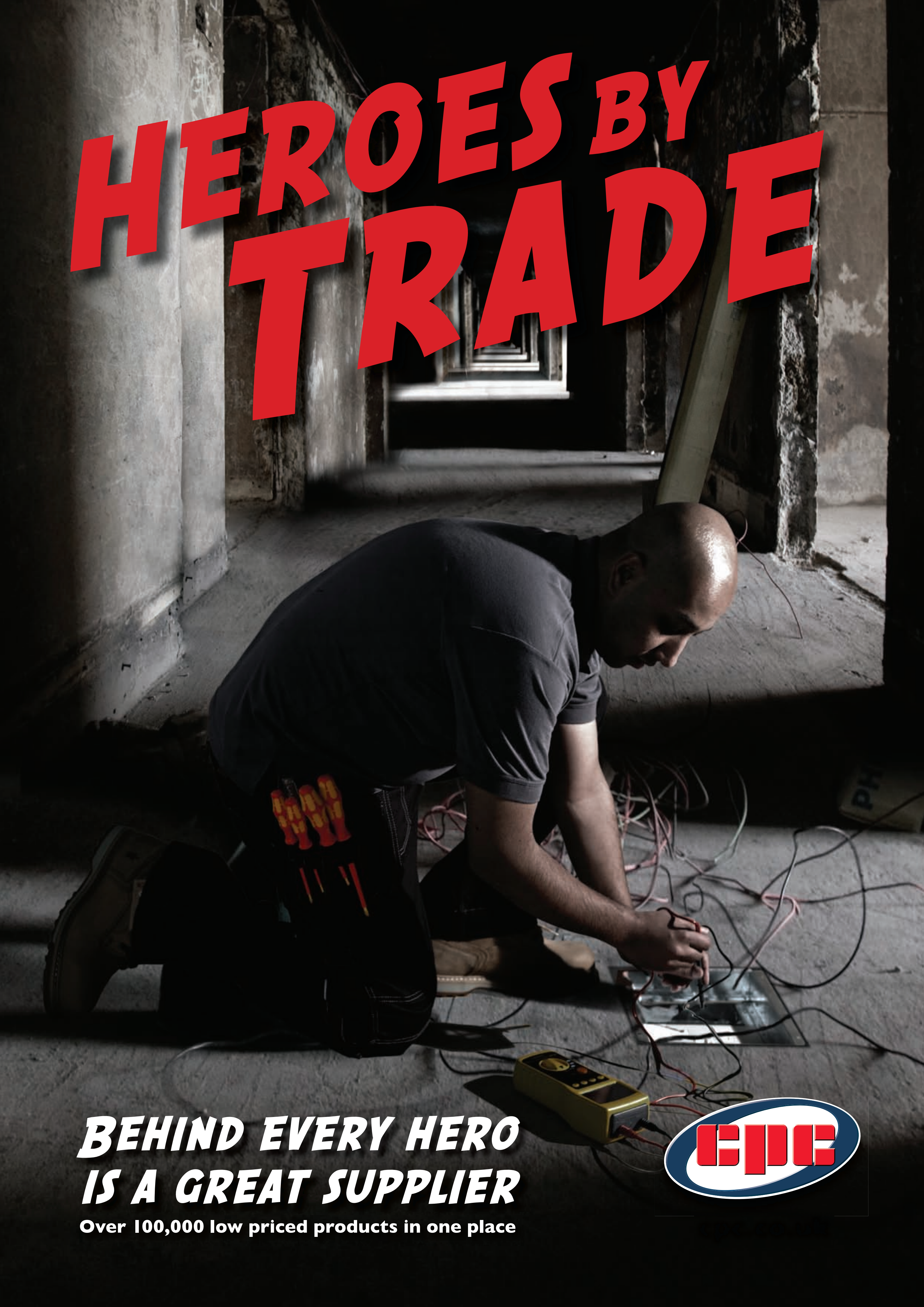
Power-factor correction

A poor power-factor is undesirable for a number of reasons. Power-factor correction technology is used mainly on commercial and industrial installations to restore the power factor to as close to unity as is economically viable. Low power-factors are caused by reactive power demand of inductive loads such as induction motors and fluorescent lights. A poor power-factor reduces the effective capacity of the electrical supply, since the more reactive power that is carried the less useful power can be carried, also causes losses at transformers, and can cause excessive voltage drops in the supply network and may reduce the life expectancy of electrical equipment.

For this reason electricity tariffs encourage the user to maintain a high power-factor (nearly unity) in their electrical installation by penalising a low power-factor. There are a number of ways in which power-factor correction can be provided. The most common way that this can be achieved is by the installation of power factor correction capacitors. These can be installed in bulk at the supply position or at the point of usage on motors, for example. Persons involved in this type of work are recommended to seek advice from specialists on the most economic system for a given installation.

The future: LVDC distribution

A future area of possible development within international standards is LVDC distribution. More and more ▶



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Consumer display unit

◄ electronic equipment is being introduced in buildings which use dc. There is also a wide range of micro generation technologies – including solar photovoltaic (PV) and wind turbines – being installed which generate dc. One of the main reasons for the proposal to introduce LVDC distribution in a building is to improve energy efficiency by reducing losses in the conversion of ac to dc for electronic loads and conversion of the dc output from micro generation to ac for mains distribution.

The challenges.

There are a number of challenges when designing a LVDC installation. Persons involved in dc installations need to have the necessary expertise. Electrical equipment used on a dc installation must be suitable for direct voltage and direct current.

Equipment approved to normal ac standards may not be suitable, especially switchgear. For example, the use of plugs and socket outlets for use on dc need careful selection depending on the current rating.

Given the nature of dc, additional requirements need to be taken into account when disconnecting a dc load by withdrawing a plug from a socket outlet. This is because an arc can occur when disconnecting a load, which is more difficult to extinguish compared with an ac load because there is no natural zero point on dc compared to ac.

It is understood that one possibility being considered is to use a switched socket outlet with a plug that is interlocked with the socket outlet. The plug and socket outlet is then designed in such a way that the plug cannot be withdrawn from the socket outlet while the plug contacts carry current.

Arc quenching

Circuit breakers for overcurrent protection is another area that needs special consideration. The arc produced when disconnecting a fault on a dc installation is more difficult to extinguish. Designers of dc installations will need to liaise with manufacturers of equipment and exercise careful consideration when selecting a circuit breaker for use on dc to ensure that the circuit breaker has suitable arc-quenching capabilities and are suitable for the operating voltage.

Cables for use on dc again need special consideration. A cable is given a voltage rating which indicates the maximum circuit voltage for which it is designed, not necessarily the voltage at which it will be used. For example, a cable designated 600/1000V is suitable for a circuit operating at 600Vac phase to earth and 1000Vac phase to phase. This cable is traditionally used in areas where mechanical strength is required such as industrial installations. For light industrial circuits operating at 230/400Vac it would be normal to use cables at 450/750Vac, and for domestic circuits operating at 230/400Vac, cable rated at 300/500Vac would often be used. The traditional rating of the cable 300/500V is the ac rating of the cable. The dc rating of this cable for core to earth is 300×1.5 (450V dc max) and the core to core voltage is 500×1.5 (750V dc max). Therefore, designers of dc installations need to give careful consideration when selecting a cable for use on dc to ensure it is suitable for the operating voltage and are recommended to seek advice from the manufacturer.

Note: It is important to consult the Building Regulations in the UK when designing electrical installations. The Building Regulations contain requirements for lighting controls etc. Please note this article is only intended as a brief overview of issues that are being considered at a very early stage and therefore may not become international standards. ■

Smart-meter installation

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Renewable sources of electricity – a brief overview

How to ensure the safe connection of low-voltage generating sets including small scale embedded generators and solar photovoltaic (PV). This article is repeated from a previous edition of Wiring Matters, and clarifies important issues.
By Geoff Cronshaw

THE SCOPE of the 17th Edition is wider and contains many new requirements, including additional requirements to ensure the safe connection of low-voltage generating sets including small-scale embedded generators and solar photovoltaic (PV) power supply systems. In this article we look at the new Regulations in Section 551 and Section 712.

Chapter 55 – Other Equipment. Regulation 551 – Low Voltage Generation Sets

This set of Regulations now includes additional requirements contained in Regulation 551.2 to ensure the safe connection of low-voltage generating sets including small-scale embedded generators.

A new Regulation, 551.4.2, ▶


A wind generator

◀ regarding the use of RCDs, has been added. Regulation 551.4.2 states:

"The generating set shall be connected so that any provision within the installation for protection by RCDs in accordance with Chapter 41 remains effective for every intended combination of sources of supply."

Notes have been added including one to Regulation 551.1 stating that the procedure for connecting generating sets up to 16 A in parallel with the public supply is given in 'The Electricity Safety, Quality and Continuity (Amendment) Regulations 2006'. For sets above 16 A the requirements of the distributor must be ascertained. The 17th Edition recognises that there are two connection options:

(i) Connection into a separate dedicated circuit

(ii) Connection into an existing final circuit

Connection into a dedicated circuit is preferred. Regulation 551.7.2 sets out the requirements for the two options. The Regulation requires that a generating set used as an additional source of supply in parallel with another source shall either be installed on the supply side of all protective devices for the final circuits of the installation (connection into a separate dedicated circuit) or if connected on the load side of all protective devices for the final circuits must fulfil a number of additional requirements.

These additional requirements are:

(i) the current carrying capacity of the final circuit conductors shall be greater than or equal to the rated

current of the protective device plus the rated output of the generating set, and

(ii) A generating set shall not be connected to a final circuit by a plug and socket, and

(iii) A residual current device providing additional protection of the final circuit in accordance with Regulation 415.1 shall disconnect all live conductors including the neutral conductor, and

(iv) The line and neutral conductors of the final circuit and of the generating set shall not be connected to earth, and

(v) Unless the device providing automatic disconnection of the final circuit in accordance with Regulation 411.3.2 disconnects the line and neutral conductors, it shall be verified that the combination of the disconnection time of the protective device for the final circuit and the time taken for the output voltage of the generating set to reduce to 50 V or less is not greater than the disconnection time required by Regulation 411.3.2 for a final circuit.

PV Installation

Section 712 of BS 7671:2008 is concerned with the safe installation of solar photovoltaic (PV) power supply systems. A PV system is a collection of interconnected PV cells that turn sunlight directly into electrical energy.

The risks

Modules produce electricity when exposed to daylight. This needs to be taken into account during design, installation, use and maintenance. Also, the electrical installation which incorporates a PV system has a second source of energy which needs to be isolated before starting work. A further risk involves working at height ▶

PV installations require expertise in dc wiring and fault protection for d.c. side of the installation

◀ on a roof, for example together with the manual handling associated with a PV installation. Finally, PV installations require expertise in dc wiring and fault protection for d.c. side of the installation.

Scope
Section 712 of BS 7671:2008 applies to the electrical installations of PV power supply systems including systems with a.c. modules. Section 712 does not apply to PV power supply systems which are intended for standalone operation.

The Electricity Safety, Quality and Continuity (Amendment) Regulations 2006
Solar photovoltaic (PV) power supply systems are required to meet the Electricity Safety, Quality and Continuity (Amendment) Regulations 2006 (ESQCR) as they are embedded generators. These are mandatory requirements.

However, where the output does not exceed 16 A per line they are small-scale embedded generators (SSEG) and are exempted from certain of the requirements provided that:

(i) the equipment should be type tested and approved by a recognised body,

(ii) the consumer's installation should comply with the requirements of BS 7671,

(iii) the equipment must disconnect itself from the distributor's network in the event of a network fault, and

(iv) the distributor must be advised of the installation before or at the time of commissioning.

See 'Engineering Recommendations G83/1, for PV systems up to 16A (5kw) and G59/1', published by the Energy Networks Association (ENA) for larger systems and generators, etc. Further information can be obtained at: www.ena-eng.org.

Protection for safety
General requirements
Regulation 712.410.3 requires that PV equipment on the dc side must be considered to be energised, even when the system is disconnected from the a.c. side. This is because modules produce electricity when exposed to daylight. Regulation 712.410.3.6 states that the protective measures of non-conducting location and earth-free local equipotential bonding are not permitted on the d.c. side.

Protective measures
Regulation 712.41 recognises three methods of protection. Regulation 712.411 gives requirements for the protective measure, automatic disconnection of supply. Where this method of protection is used on the a.c. side, the PV supply cable shall be connected to the supply side of the protective device for automatic disconnection of circuits supplying current using equipment.

Regulation 712.412 gives requirements for the protective measure, double or reinforced insulation and states that protection by Class II or equivalent insulation shall preferably be adopted on the d.c. side. Regulation 712.414 gives requirements for the protective measure, extra-low voltage provided by SELV or PELV. Where this method of protection is used Uoc STC replaces Uo and must not exceed 120 v dc.

Protection against overcurrent and electromagnetic interference
Regulation 712.433 gives a relaxation, and allows overload protection on the d.c. side to be omitted when the current carrying capacity of the cable is equal to or greater than 1.25 times Isc STC (short-circuit current under standard test conditions) at any location.

Regulation 712.434 requires that the PV supply cable on the a.c. side shall be protected against fault current by an overcurrent protective device installed at the connection to the a.c. mains.

Regulation 712.444 deals with Protection against electromagnetic interference (EMI) in buildings. The Regulation recognises that in order to minimise voltages induced by lightning, the area of all wiring loops shall be as small as possible.

Selection and erection of equipment

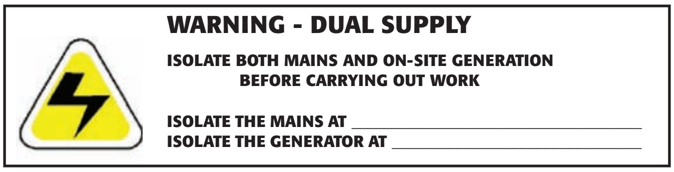
Compliance with standards
Regulation 712.511 requires that PV modules shall comply with the requirements of the relevant equipment standard, e.g. BS EN 61215 for crystalline PV modules.

Operational conditions and external influences
Electrical equipment on the d.c. side must be suitable for direct voltage and direct current as required by Regulation 712.512. Equipment approved to normal a.c. standards may not be suitable, especially switchgear. It is therefore essential that PV systems are installed by competent persons to an approved design. The designer must clarify the standards and performance requirements with the equipment manufacturers as part of the design process. It must also be remembered that as PV systems are often installed on a roof or other location external to the building they will be subject to external influences such as heavy rain, high winds, etc. and therefore need to be designed and installed to withstand such conditions. Also, it must also be remembered that planning and building regulations approval may be required.

Accessibility
Regulation 712.513 requires that the selection and erection of equipment shall facilitate safe repair and maintenance.

Wiring systems
Regulation 712.522 requires that PV string cables, PV array cables and PV d.c. main cables shall be selected and erected so as to minimise the risk of earth faults and short-circuits. Cables should be selected that are suitable for their environment and conditions of use and the expected equipment temperatures. The Regulations require that wiring systems must be able to withstand the expected external influences such as wind, ice formation, temperature and solar radiation.

Isolation, switching and control
Regulation 712.537.2.1.1 recognises the need for maintenance and requires that a means of isolating the a.c. and d.c. sides of the PV convertor needs to be provided.



Regulation 712.537.2.2 has requirements for the selection and erection of isolation and switching devices. The Regulation states that the selection and erection of devices for isolation and switching to be installed between the PV installation and the public supply, the public supply shall be considered the source and the PV installation shall be considered the load.

Earthing arrangements and protective conductors

Regulation 712.54 requires that where protective bonding conductors are installed, they shall be parallel to and in as close contact as possible with d.c. cables and a.c. cables and accessories.

Labelling

Labels are required at the:

- supply terminals (fused cut-out)
- meter position
- consumer unit, and at all the points of isolation to indicate the presence of the SSEG within the premises

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

Conclusion

There are a wide range of microgeneration technologies including: Solar photovoltaic (PV), wind turbines, Small scale hydro and Micro CHP (Combined heat and power). Microgeneration systems such as solar PV installations should always be carried out by a trained and experienced installer. For example, the roof must be strong enough to take their weight, especially if the panel is placed on top of existing tiles. It is also important to note that there are mandatory requirements concerning the parallel connection of generators with the supply network.

For further information refer to 'BS 7671:2008, Engineering Recommendations G83/1 and G59/1' published by the Energy Networks Association and the Department for Business, Enterprise & Regulatory Reform (BERR).

Further information

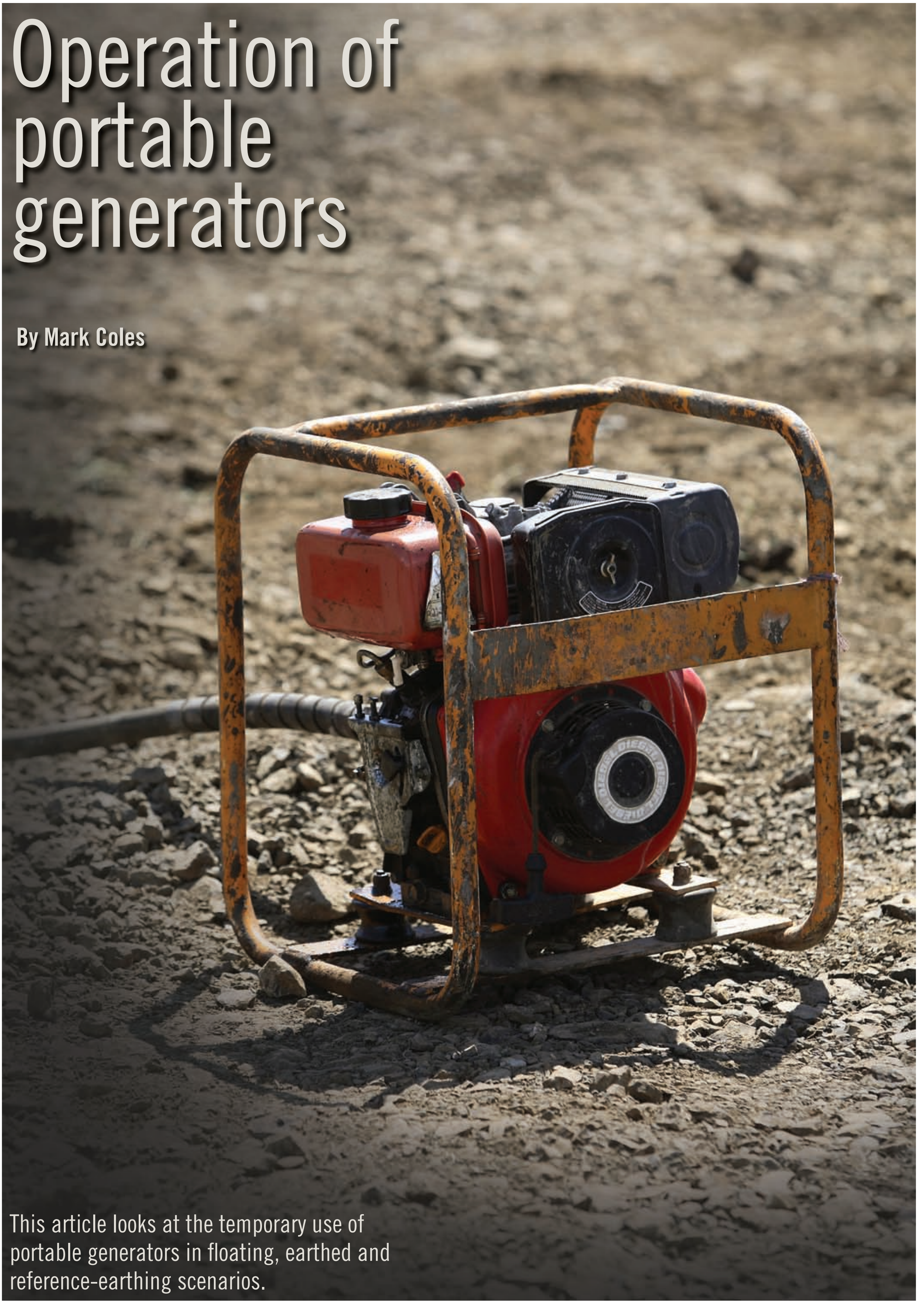
England and Wales – the Department of Communities and Local Government www.communities.gov.uk

Scotland – The Scottish Building Standards Agency www.sbsa.gov.uk

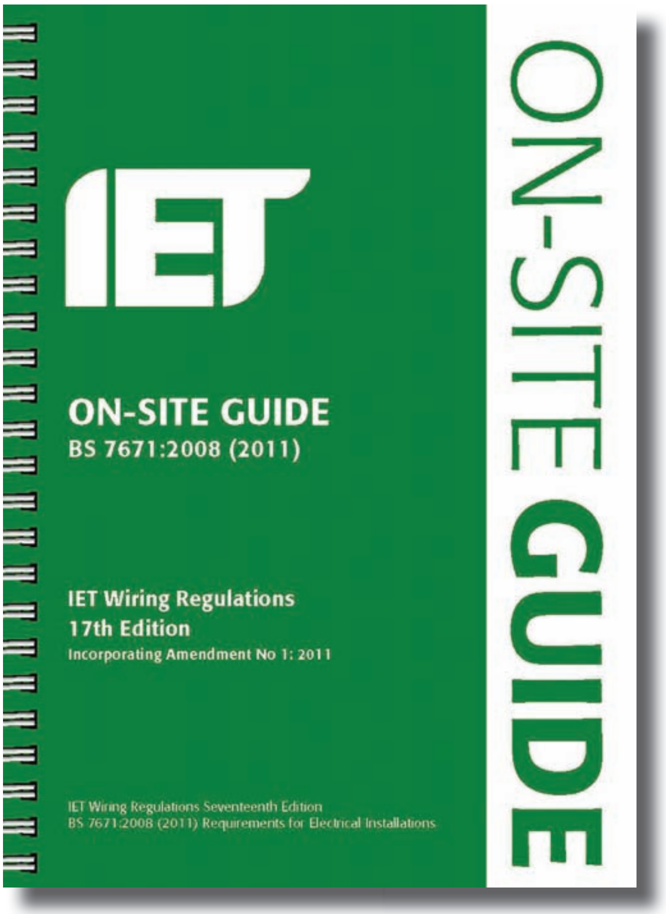
This article is repeated from a previous edition of Wiring Matters, and clarifies important issues.

Operation of portable generators

By Mark Coles



This article looks at the temporary use of portable generators in floating, earthed and reference-earthing scenarios.



A new version of the On-Site Guide is in preparation

BS 7671:2008(2011), the First Amendment to the 17th Edition of the IET Wiring Regulations, is due for publication on 1 July 2011. Accordingly, the IET's On-Site Guide is currently being aligned with the amended regulations, which itself, is due for publication in October 2011.

The On-Site Guide is intended to enable competent electrical installers to deal with smaller installations up to 100 A, single- or three-phase. The guide includes simple circuit calculations and provides essential information in a convenient, easy-to-use form, avoiding the need for detailed calculations.

One of the many new topics covered within the planned On-Site Guide is portable generators.

Types of generators for temporary use

It is often necessary to temporarily supply electrical equipment or electrical installations with a generator where the mains or usual supply is unavailable.

There is a difference between generators used for short periods, for example, for up to one day and those used for longer time scales. The main consideration when using generators temporarily is how the temporary system will be earthed. From this viewpoint, two classes of temporary generators emerge, i.e. portable generators and mobile generators. ▶

- portable generators with an electrical output rating of up to 10 kVA are used for small scale work for short term use, i.e. less than one day; and
- mobile generators are those used for longer periods and can be in excess of 10 kVA.

Portable generators

Portable generators will be used in the following situations:

- use on a construction site;
- used to supply stalls on street markets;
- external gathering or function attended by the general public, such as a country show.

Three scenarios will be considered:

- portable generator used with a floating earth;
- portable generator used without reference to the general mass of the earth;
- portable generator referenced to the general mass of the earth.

For permanent use of generators see The IET's Guidance Note 5 and Guidance Note 7 and Section 551 of BS 7671:2008(2011).

Where generators are used to supply concession vehicles, such as burger vans, see Section 717 Mobile and Transportable Units of BS 7671:2008(2011) and Guidance Note 7.

Portable generator with floating earth

Small portable generators, ranging in output from 0.3 kVA to 10 kVA single-phase often have a floating earth, i.e. there is no connection between the chassis and/or earth connection of the socket-outlet of the unit to the neutral of the generator winding. The ends of the generator winding are brought out to one or more three-pin socket-outlets which should conform to BS EN 60309-2. The earth socket-tube of the socket-outlet(s) are usually connected internally to the frame of the generator only.

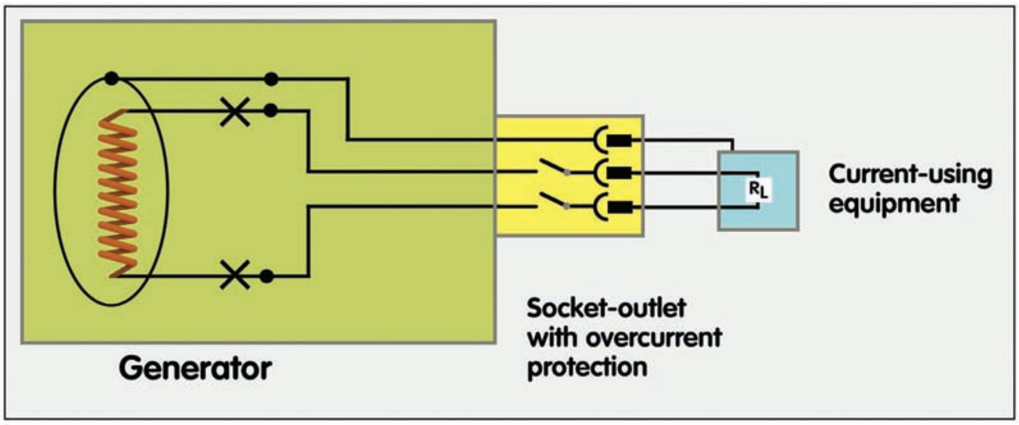


Fig 2: Portable generator with floating output – no connection from winding to chassis or earth socket-tube of the socket-outlet

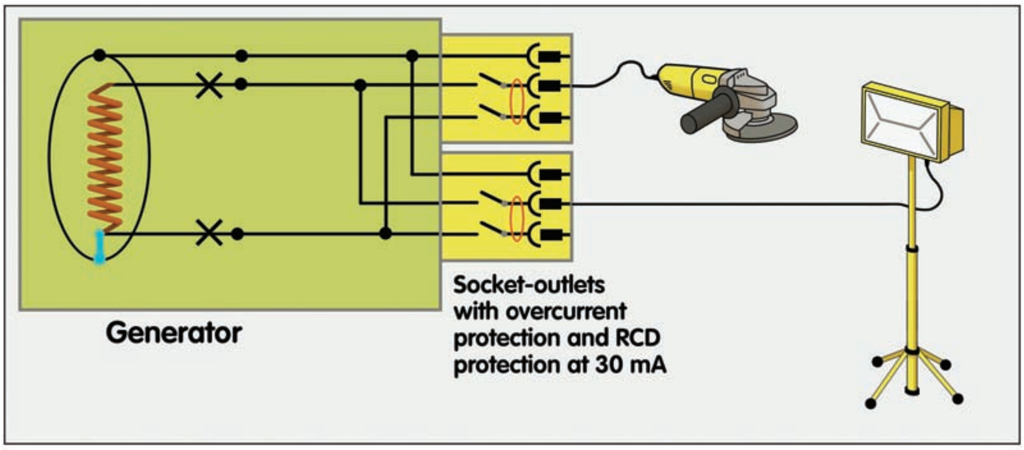


Fig 3: Generator supplying more than one item of equipment

This arrangement is a form of electrical separation, where basic protection is provided by basic insulation of live parts and fault protection is provided by simple separation of the separated circuit from other circuits and from Earth.

The requirements for electrical separation can be found in Section 413 of BS 7671 where one item of equipment is supplied and Regulation Group 418.3 where more than one item of equipment is supplied.

It is extremely important to note that the portable generator should only be used to supply equipment in the following permutations:

- one or more items of Class II equipment;
- one item of Class I equipment;
- one or more items of Class II and one item of Class I equipment.

"The use of only Class II equipment, however, is preferable."

More than one item of Class I equipment should not be used simultaneously as faults can be presented as voltages and operatives can provide a path for current flowing between exposed-conductive-parts of faulty electrical equipment.

Portable generator used without reference to the general mass of the earth

Where more than one item ▶

◀ of Class I equipment is to be supplied by a single-phase portable generator, it is important to ensure that the earth connections of the socket-outlets at the generator are connected to the neutral of the generator winding in addition to the chassis or frame of the generator.

RCD protection at 30 mA is required for all circuits supplied in this manner.

Such a configuration will provide a return path for any fault current caused by contact between live parts and exposed-conductive-parts of the connected equipment.

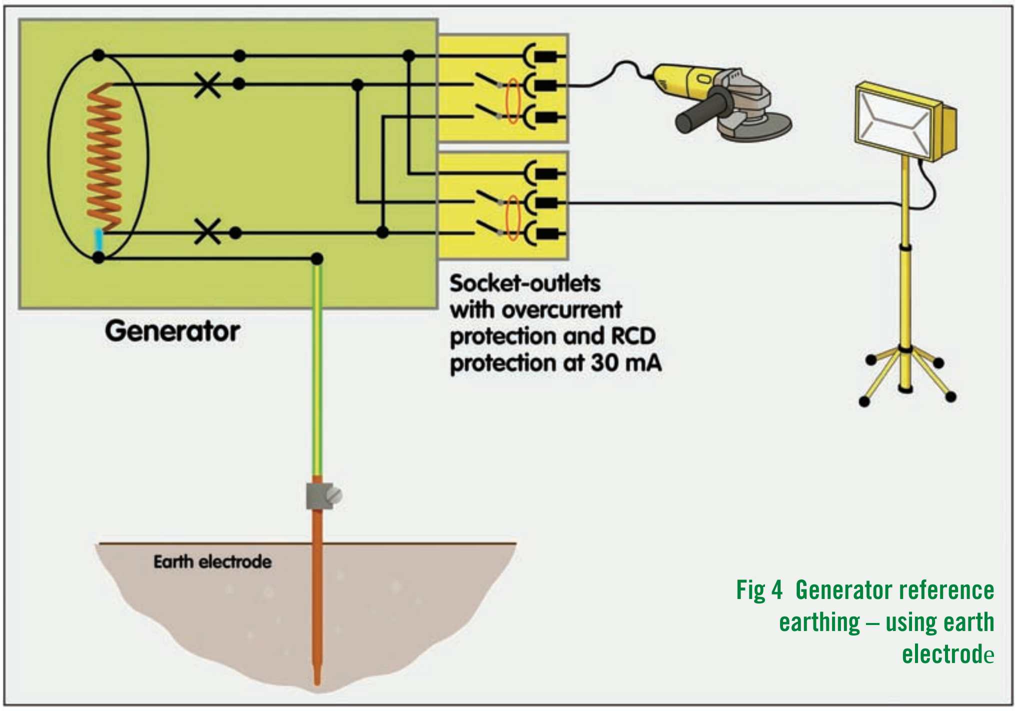


Fig 4 Generator reference earthing – using earth electrode

If this method of supply is used, extreme care should be taken to ensure that there is no intended or casual interconnection with any other electrical systems, such as, extraneous-conductive-parts or exposed-conductive-parts from other electrical systems.

Portable generator referenced to the general mass of the earth

Where there are extraneous-conductive-parts or exposed-conductive-parts from other electrical systems present, generator reference earthing by means of an earth-electrode to the general mass of earth, should be installed.

Note that this does not create a TT arrangement; the supply will be TN-S from the generator but the neutral or star point will be referenced to the general mass of Earth.

Where an earth electrode is supplied it will need to be ▶

◀ tested by the standard method using a proprietary earth electrode resistance tester. Note that an earth-fault loop impedance tester cannot be used for this test as the earth electrode is not used as a means of earthing it used to reference the portable generator to the general mass of the Earth. As the earth-electrode is used for referencing and not as a means of earthing, the resistance should, ideally, be less than 200 Ω.

If buried, generator reference earthing and/ or bonding conductors should be sized in accordance with Table 54.1 and suitably protected in accordance with Regulation 543.3.1.

Where restrictions, such as concreted/paved areas or the portable generator is being used some distance above ground level, make it impossible to install an earth electrode, simultaneously accessible metal parts, i.e. accessible extraneous-conductive-parts or exposed-conductive-parts from other electrical systems, may be bonded to the main earthing terminal of the generator; see below.

Where separate accessible extraneous-conductive-parts or exposed-conductive-parts from other electrical systems are connected together, protective conductors can be sized in accordance with Regulation 544.1.1.

Further discussion

Care must be taken to ensure

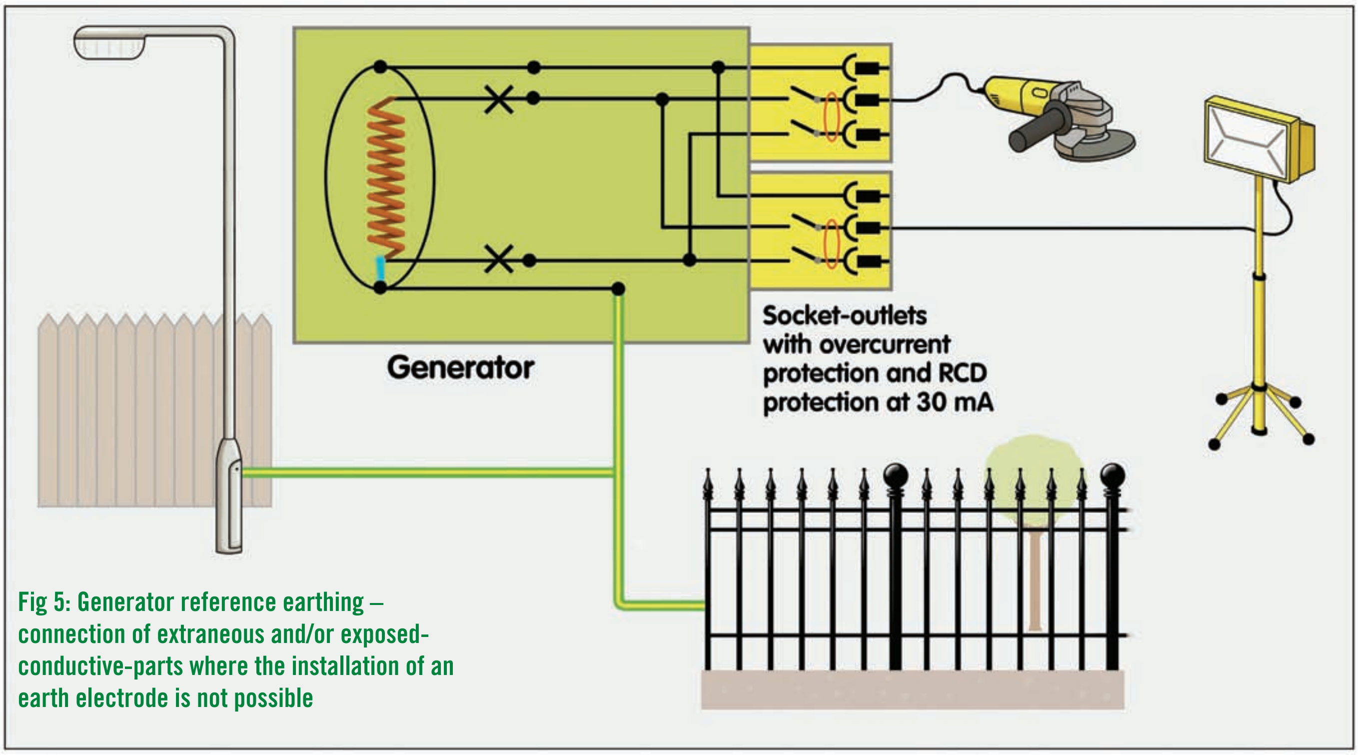


Fig 5: Generator reference earthing – connection of extraneous and/or exposed-conductive-parts where the installation of an earth electrode is not possible

that the generator and the cables connected to it are used and installed safely. It is extremely important to ensure that all equipment is inspected before each use.

Where items of equipment supplied from different generators are used in close proximity then the main earthing terminals of the generators should be interconnected; this method may be in addition to the scenarios shown in figs 4 and 5.

Where required, warning signs related to the presence or use of electricity should be provided, particularly where members of the public are present. All signs are expected to confirm to the Health and Safety (Safety Signs and Signals) Regulations and BS 5499-11:2002 (AMD 16783)

Possible weather conditions should be taken into account when planning the operation of a portable generator. Some thought must also be given to the positioning of distribution units, plug and socket connectors, for example and cable runs should not be placed in a gutter, gully or depression serving as a drain or elsewhere that might fill with water.

It is important to emphasise that generators must be used in accordance with the manufacturers' instructions. Where generators are hired from plant-hire companies, it is the responsibility of the plant-hire company to provide the hirer with information regarding the safe use of their equipment. Under no circumstances should hirers attempt to change the internal electrical connections of hired equipment.

Where doubt exists as to the internal earthing connections of the generator, a continuity test between neutral and earth socket-tubes at the socket-outlet can be undertaken; a very low reading, i.e. less than 0.1 Ω, would indicate that it is not a generator with floating earth. ■

Further reading

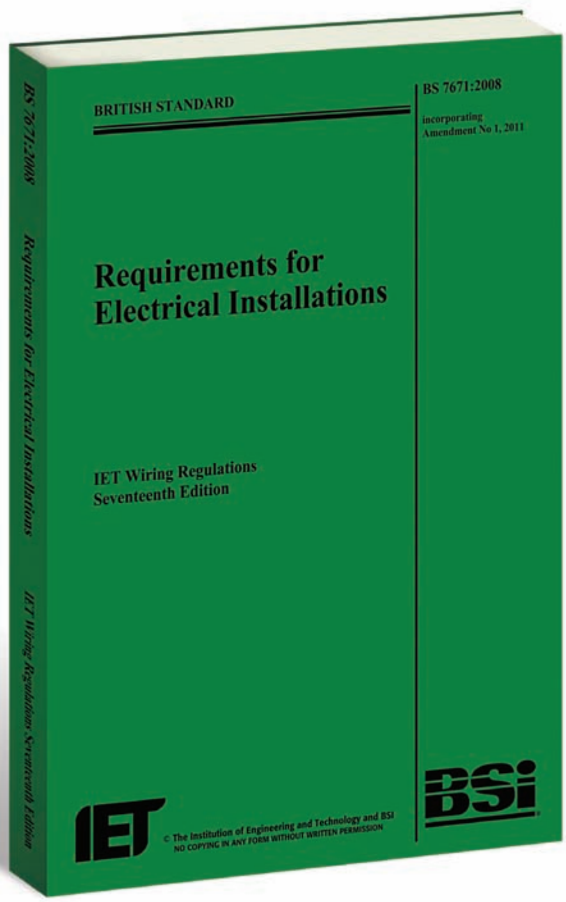
- IET Guidance Note 3 - Inspection and Testing
- IET Guidance Note 7 – Special Locations
- BS 7909:2008(+A1) Code of Practice for temporary electrical systems for entertainment and related purposes
- Health and Safety Executive document OC 482/2, Electrical Safety of Independent Low-Voltage AC Portable and Mobile Generators and Connected Systems.
- BS 7375:2010 Code of Practice for distribution of electricity on construction and building sites
- BS 7430:1998 Code of Practice for Earthing.

Thanks:
Bill Allan, NAPIT
Paul Sayer, BEAMA
Ken Morton, HSE
Roger Lovegrove

Frequently Asked Questions

This article answers some of the frequently asked questions related to the publication of BS 7671:2008 incorporating Amendment No 1

By Paul Bicheno



Why is BS 7671:2008 being amended?

The development of BS 7671 is carried out in conjunction with the standard BS 0: A standard for standards (refer to the article 'Development of Standards' in *Wiring Matters* issue 37 Winter 2010 for more information) and is the responsibility of joint IET/BSI committee JPEL/64. As part of the maintenance of standards requirement the committee decided that an amendment was required to align with recent developments of the associated European standards since the publication of 17th Edition as well as other amendments that were deemed necessary.

What are the key amendments?

As mentioned above the alignment to European standards has resulted in four NEW sections being included:

- 444 – measures against electromagnetic disturbances;
- 534 – devices for protection against overvoltage;
- 710 – medical locations;
- 729 – operating or maintenance gangways.

In addition there are a number of other amendments across parts 1 to 7 and the ▶

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◀ appendices such as:

- A new '100' numbering system for some 'UK'-specific regulations to embody future IEC and CENELEC changes. E.g. Regulation 522.6.5 will become 522.6.100.
- Updates to Part 2 Definitions including a number of new definitions related to the new Sections 444, 534 and 710.
- The 'Periodic Inspection Report' has been changed to 'Electrical Installation Condition Report' along with associated schedules of inspection model forms in Appendix 6.
- Appendices 11 and 12 have been deleted and the content incorporated in Appendix 4. A new Appendix 16 'Devices for protection against overvoltage' has been included for information and relates to Section 534.
- Updates to Chapter 41, Chapter 43, Chapter 53 and Appendix 3 have been made due to the fuse standards BS 88-2.2, BS 88-6 being withdrawn and replaced by a single standard BS 88-2 and fuse standard BS 1361 being withdrawn and replaced by BS 88-3. (Reference can be made to the appropriate entries in Appendix 1.)

Will there be a separate Amendment 1 document?
In addition to the four new sections there are a number of other amendments across all parts of the Wiring Regulations. Therefore the decision was to publish a complete new document (Green cover).

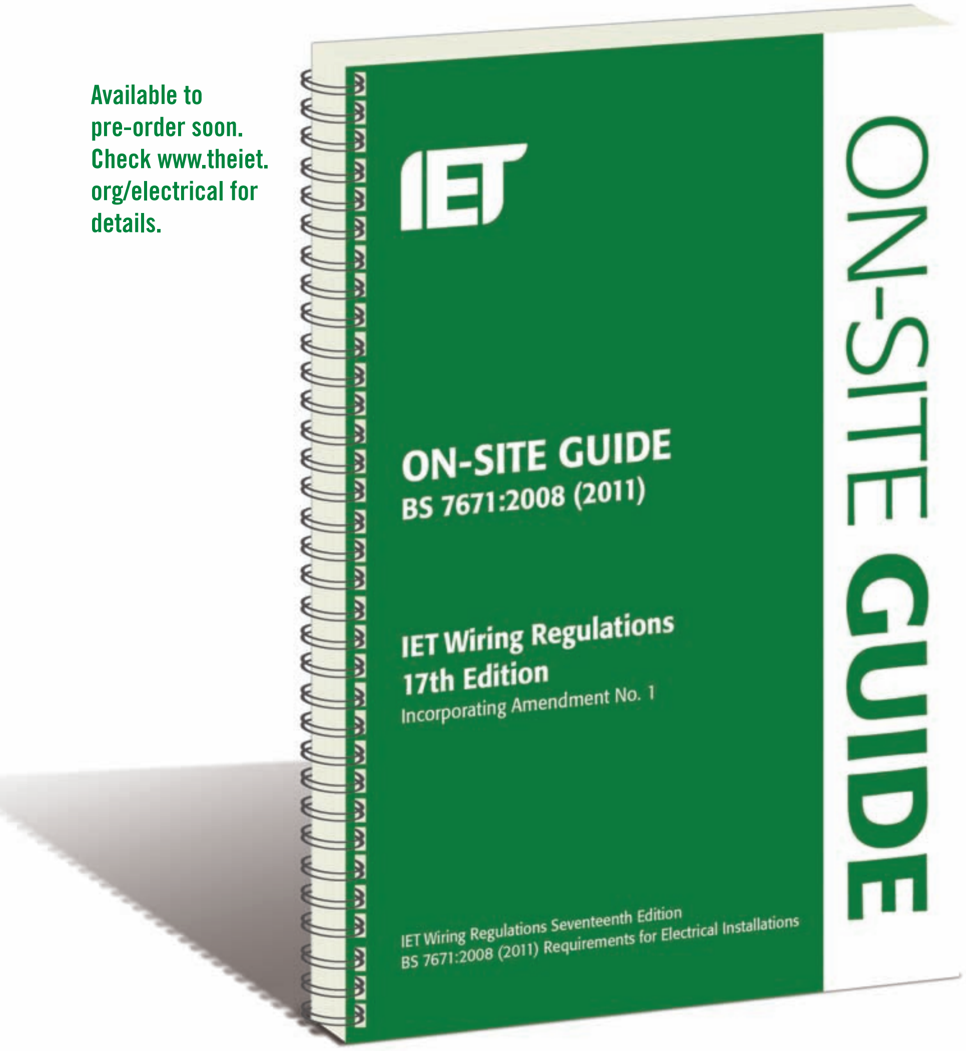
When do new installations have to comply with Amendment No 1 requirements?
Amendment 1 will be published on 1 July 2011 and will come into effect on 1 January 2012. This means that installations designed after 1 January 2012 will need to comply with the Amendment 1 requirements. Prior to 1 January 2012 installations should be designed and certified to the 17th Edition requirements.

Can you certify an electrical installation to the 17th Edition that is completed after 1 January 2012?
An installation that was designed to the 17th Edition before 1 January 2012 but gets completed after this date should be certified to the 17th Edition.

What are the amendments to Inspection and Testing?
The major change for inspection and testing is to the Periodic Inspection Report. This will now be called an 'Electrical Installation Condition Report' so that the report is more meaningful to the client. This includes a specific condition report inspection schedule for smaller installations (domestic and similar up to 100A supply) and a recommended list of items requiring inspection for larger installations. The coding system has been reduced from four code options to three (C1 – Danger present, C2 – Potentially dangerous and C3 – Improvement recommended). There have also been some updates to the generic schedule of test results sheet to enable improved recording of various test results.

What are the amendments to Special Installations and Locations?
There are two new Part 7 sections. Section 710 Medical locations apply to electrical installations of hospitals, private clinics, medical and dental practices, health-care centres and dedicated medical rooms in the workplace. Section 729 Operating and maintenance gangways applies particular requirements of basic protection and other aspects to the operation or maintenance of switchgear and controlgear in areas that are restricted to skilled or instructed persons. Amendments have been made in Sections 702, 704, 705, 708, 709, 711, 717 and 740 to specifically refer to the appropriate use of Protective Multiple Earthing (PME).

What are the amendments to the Appendices?
The Committee decided that the content of Appendices 11 and 12 was related to Appendix 4; therefore these two appendices have been deleted and incorporated into Appendix 4. Appendix 3 has been updated to reflect the changes needed for the withdrawal of BS 88-2.2, BS 88-6 and BS 1361 fuses. The model forms in Appendix 6



Available to pre-order soon. Check www.theiet.org/electrical for details.

have been updated to reflect the new electrical installation condition report and associated inspection schedules.

Is there a minor works exemption for the installation of RCDs?
After altering a series of regulations to exempt the installation of RCDs for minor works a decision was taken to remove these amendments.

Do you have to update your training?
At present anyone who has completed a 17th Edition course does not have to do any new training as there is no formal update qualification like there was for the transition from the 16th to the 17th Edition. The IET 17th Edition course will be updated to reflect the Amendment 1 requirements.

Are there any courses available?
The IET Electrical Courses Unit offer both public and in-company courses for the 17th Edition and as of July 2011 the course content will include the requirements of Amendment 1. Details are available from the electrical website: www.theiet.org/courses. Anyone who has already completed their 17th Edition training may be interested in the IET Amendment 1 public seminars www.theiet.org/first-amend; potential additional dates will be added here so check for updates. The seminar can also be provided in-company on your premises. Please contact the Courses Unit on 01438 767289 or email coursesreg@theiet.org.

How do you get a copy?
Prior to publication on 1 July the quickest way to receive a copy is to sign up to the pre order service, currently being offered at £60 for non-members and £52 for IET members, available via the IET electrical website http://electrical.theiet.org/books/regulations/17th-edition-amd1.cfm. Post publication, visit the bookstore http://electrical.theiet.org/books/.

Are there any changes to the IET On-Site Guide and Guidance Notes?
The IET will be updating the content of the On-Site Guide, Electrician's Guide to the Building Regulations and Guidance Note series to align to the amendment 1 requirements. Guidance Note 8 Earthing and Bonding will also include 17th Edition updates as well as Amendment 1 updates.

Wiring Regulations Digital?
The Wiring Regulations Digital (WRD) packages (Industrial and Domestic) will also be included in the Amendment 1 update programme. Any WRD package that is purchased before 30th June 2011 will be entitled to receive **FREE UPDATES** in e-book format for the titles included in the purchased package when they are updated to the Amendment 1 requirements. The domestic package is currently offered at a price of £136.50 for IET members (£210 full price) and the industrial package is £273 for IET members (£420 full price). Prices are inclusive of VAT. Visit the IET electrical website http://electrical.theiet.org/books/e-books/index.cfm. ■

The Institution prepares regulations for the safety of electrical installations for buildings, the IET Wiring Regulations (BS 7671), which has now become the standard for the UK and many other countries. It has also prepared the Code of Practice for Installation of Electrical and Electronic Equipment In Ships (BS 8450) and recommends, internationally, the requirements for Mobile and Fixed Offshore Installations. The Institution provides guidance on the application of BS 7671 through publicationsfocused on the various activities from design of the installation through to final test and certification with further guidance formaintenance. This includes a series of eight Guidance Notes, two Codes of Practice and model forms for use in wiring installations.

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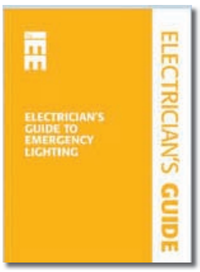

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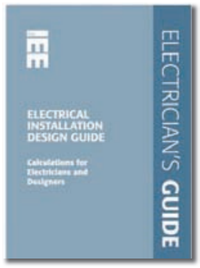

This book provides step-by-step guidance on the design of electrical installations, from domestic installation final circuit design to fault level calculations for LV/ large LV systems.
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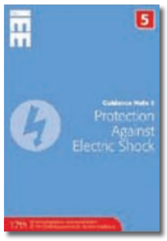

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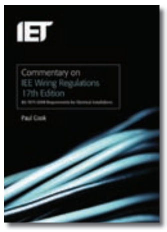
P. Cook



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The battery pack for the 2008 Tesla Roadster is composed of 6,831 individual cells

Plug-in power

Ask yourself: 10 years from now, will you be driving an electric vehicle? Many people hope you will – but the electricity networks are not so sure.

By Mark Venables

THE ROLE of Electric Vehicles (EVs) in delivering a sustainable transport system is beset by controversy. To critics, the vehicles represent a poorly conceived plan to reduce emissions, while to supporters they are an essential component of a sustainable transport mix. It comes as no surprise then, that there is such a disparity between predictions of how readily drivers will rush to purchase the new breed of car: forecasts for new-car sales share ten years from now fluctuate wildly between 2 per cent for the most pessimistic and 10 per cent for the most optimistic.

A report from the influential Deloitte Consulting published last spring set the bar at 5 per ▶

A BYD e6 all-electric vehicle sits next to a charging station

◀ cent, while global consulting company PRTM are slightly less optimistic at a point lower. Then you have manufacturers such as Nissan predicting in excess of 10 per cent sales.

Critics point to the fact that it has taken hybrids ten years to garner a miserly 3 per cent of new car sales: but even if EVs only captured 3 per cent of the market that would be a significant amount of cars. Sales figures for 2010 are predicted to top 80 million, and despite the global financial crisis this figure is expected to grow by around 4 per cent a year, fuelled primarily by the growing markets in China and India. That would set the sales for 2020 at 118 million, and a 3 per cent slice of that would be 3.45 millions cars, not sales to be sniffed at.

How will we use electric vehicles?

If the more optimistic predictions hold true then 10 per cent of sales would see 12 million new EVs on the road. "The automotive industry is bedevilled by fundamental questions of how consumers will accept and use electric vehicles," John Gartner, senior analyst at Pike Research, says. "There is still uncertainty about the issues of price sensitivity, range anxiety and the importance of charging station networks, the length of time required to charge EVs, and other important matters. These questions can only be answered through real-world experience that is gained from commercial launches. 2011 is the year in which many of these answers will come into greater focus."

"In the UK the plug-in car grant and company car tax incentives will facilitate a move towards ultra-low carbon transport in many commercial fleets," Ian McDonald, technical director of future transport systems, member of the IET transport policy group and chair of the IET EV Infrastructure technical group, explains.

"With most of the major automotive manufacturers poised to introduce EVs and E-REVs [Extended Range Electric Vehicles] over the next two years, it is reasonable to expect a second surge in uptake in around three years when previously-used fleet vehicles exit their commercial lease period and are in reach of the private market."

This will potentially coincide with a self-sustaining market where government incentives are no longer offered (or indeed required) as oil prices reach a tipping point and electric and plug-in vehicles are considered as viable financial alternatives to conventional engine vehicles. "Market penetration will ultimately be dependent on the availability of a range of vehicle types offering different options to different customers," McDonald adds.

Grid under pressure

The launch this year of serious models from major manufacturers is likely to see an initial surge of EVs, especially in key urban areas and regions such as California, where legislation is making them an attractive option.

According to official state estimates there will be in excess of 5,000 EVs and plug-in hybrids sold in California alone next year. This rapid growth is viewed as both an opportunity and a challenge by many utilities.

Southern California Edison, the power utility, explains that it feels the most popular charging option will be a 240v home charge that will charge the battery in around three hours and will draw around 6.6kW from the grid. Plugging three cars in on a single street is equivalent to adding three new homes to the neighbourhood. Press reports have suggested that turning on more than a handful at once will put great pressure on street level transformers that are traditionally considered to be the weakest link on the grid.

"There will be pressure on the grid, but utilities are more than aware of the need to upgrade their infrastructure, particularly at a local level, and plans are in place to do this at whatever speed is required to match public demand for EVS," Sunil Chhaya, senior manager of OEM PHEV programmes at Electric Power Research Institute, explains.

So what are the big challenges when it comes to charging electric vehicles? According to McDonald, they are manifold.

Currently the undefined 7kW connector standard tops his list, but he expects a UK position will resolve this soon. He also includes the time it will take to install recharging posts including installation of cables and metering.

"Another thing is traffic regulation orders for road markings, and not forgetting connect times for the unit from the distributed network operator," he adds. "Charging times and the need to reduce them, as well as a real need to manage when vehicles charge using smart technologies to avoid peak demand."

There is agreement that smart technologies are essential to ensure that EVs do not create a peak demand. There is an expectation that users will charge cars overnight, taking advantage of cheap electricity, but recent research has cast doubts on this with many believing that most EV owners will simply plug their vehicles in when they return from work, putting stress on the grid during its busiest early evening period.

"Smart technology can negate some unnecessary energy supply network upgrades and importantly align charging with renewable embedded generation," McDonald adds. "Low-carbon transport will also stimulate innovation, new technologies and services that are essential in sustaining a lower-carbon lifestyle. In the last decade we have transitioned to a plug-in society, it therefore comes as no surprise to the new multimedia-enabled generation that transport should be any different."

Home or away

Another debate raging in EV circles is one about the charging habits of users. There is a great rush, and plenty of government money, being ploughed into providing a charging infrastructure at various key points around major cities and roads.

But are they the way forward? With charging times currently measured in hours, rather than minutes, many believe that most charging will be carried out at home, although to extend the limited range of the first wave of cars some fast-charge points will be required. ▶

EV charging - Connection standards

There are several standards for EV charging that cover connection

SAE (Society of Automotive Engineers)

The SAE Recommended Practice on electric vehicle charge connectors is SAE J1772, which was revised and re-issued in January 2010. It contains specifications for vehicle inlet and vehicle connector to be used for the conductive AC charging of EVs and plug-in hybrid EVs.
Specifications for a conductive DC charge coupler are still under development.
The vehicle inlet and vehicle connector specification contained in SAE J1772 is designed to be compatible with two levels of conductive charging, which are defined within the Recommended Practice as:
AC Level 1 – Single phase, 120V AC, 12A/ 16A, and AC Level 2 – Single phase, 208-240V AC, ≤ 80A.

IEC (International Electro-technical Commission)

The IEC standard covering the overall electric vehicle conductive charging system is IEC 61851, which covers equipment for charging electric road vehicles at standard AC voltages up to 690V and at DC voltages up to 1,000V. This standard is published in separate parts under the general title 'Electric Vehicle Conductive Charging System'. The main parts of this standard are:
Part 1: General requirements.
Part 21: Electric vehicle requirements for conductive connection to an AC/DC supply.
Part 22: AC electric vehicle charging station.
Part 23: DC electric vehicle charging station.
IEC 61851 Parts 1, 21 and 22 have been published and are available, but Part 23 is still under development.

Japan

In Japan a standardised DC charging system has already been adopted which allows DC charging at up to 500V DC at up to 125A. The vehicle inlet and vehicle connector for this DC charging system is covered by Japan EV Standard (JEVS) G 105-1993 – Eco-system connector for electric vehicle charging station, which has been published by the Japanese Automotive Research Institute (JARI). This was developed by a number of Japanese automotive manufacturers in association with the Tokyo Electric Power Company.
This DC charging system is known as CHAdeMO and in March 2010, Toyota, Nissan, Mitsubishi, Fuji Heavy Industries and the Tokyo Electric Power Company formally established a "CHAdeMO Association" to "increase quick charger installations worldwide" and "standardise how to charge

Tried and tested

Around the globe there are numerous programmes underway to test both the charging technology available along with the habits of electric vehicle users. In the United States Ford has teamed up with the New York Power Authority (NYPA) to share information on charging needs and requirements to ensure the electrical grid can support customers' needs. One of the key areas they are collaborating on is fast charging station permitting.

"Ford plans on bringing five new electrified vehicles to market over the next two years including the Transit Connect Electric later this year and the Focus battery electric in late 2011," says Sherif Marakby, director of electrification programmes and engineering at the Ford Motor Company. "We know there is an incredible excitement for electric vehicles in the New York area and across the country. To support the rollout and acceptance of these vehicles, it is crucial to work with utilities to make sure the necessary infrastructure is ready."

In the UK, the east of England's EValu8 project will begin to install a major network of 1,200 electric charging points across the region starting in Spring. Retail outlets, public car parks, railway stations, local businesses and residential streets have already been identified as prime locations for plug-in points to be installed across the east, particularly focused in hot-spots in and around Bedford, Luton, Cambridge, Ipswich, Norwich, Peterborough and Hertfordshire.

◄ "Not everyone will be able to charge at home; in fact a study carried out for the [east of England's] EValu8 plugged-in places suggests that a sizeable percentage of early private adopters will live in properties without garages," McDonald says. "I do believe however that there is an optimal level of street-side recharging – a level yet to be defined – but it is also worth remembering that a mix of free parking and free charging are part of the current decision matrix for some considering switching to an EV.

"To tether an EV to its own home-charge unit is under-utilising the capacity of the EV to commute and extend its overall range through the use of publicly accessible recharging point at various charge rates."

One thing is readily apparent: there are still more questions than answers when it comes to EVs. Some, such as common connection standards, may soon be settled, but others will only become clearer once EVs begin to be used in larger numbers allowing stakeholders to make decisions about future investment based on real experience of consumer habits. ■

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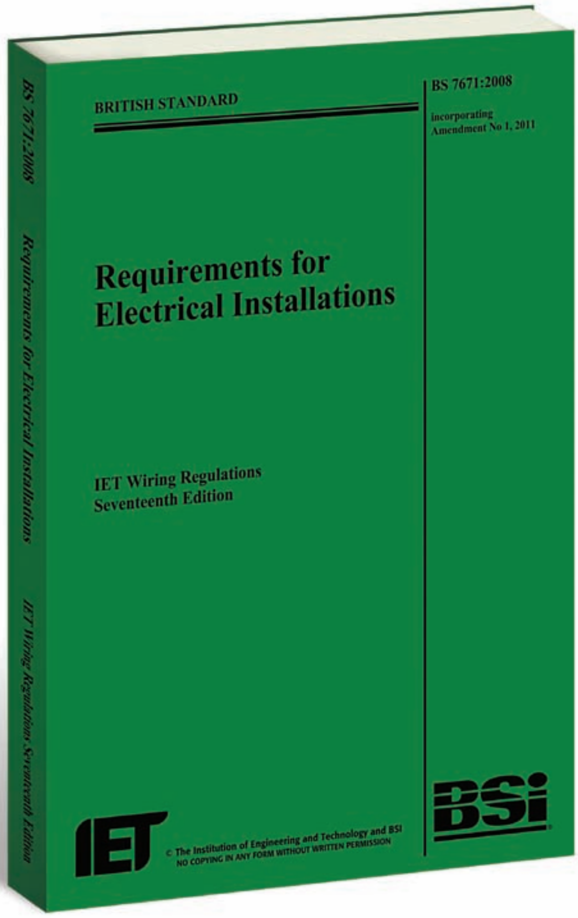

Requirements for Electrical Installations, the IET Wiring Regulations 17th Edition (BS 7671:2008 incorporating Amendment Number 1: 2011) publishes in July.

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