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How to become a smart home installer

The tide is changing. The term 'smart home' can be heard more and more frequently and this is not just by people working within the electrotechnical industry. This shift is the result of consumers being confronted with products to turn their home into a smart home from all angles. There is a whole host of smart gadgets available for the house – smart thermostats, smart lights, smart TVs, smart kettles... the list goes on. We invited Philipp Schuster, MD of Loxone UK, to explain the route to becoming a smart home installer.

In the last five years the visibility and awareness of smart technology has increased dramatically but, unfortunately, the vast amount of information that is now flooding the Internet has not necessarily lead to a better understanding of what a smart home actually is. There are still many misconceptions, doubts, and even fears, about the benefits of smart technology. In this article, I aim to provide some clarity and explain how electricians and electrical contractors are perfectly placed to step into this emerging market to grow their business by offering smart home services.

What is a smart home?

Before we get stuck into why you should look at becoming a smart home installer, what customers want and what steps you ought to take, it's best to create a common understanding about what a smart home actually is and what all these devices that carry the word 'smart' actually do.

The Oxford dictionary defines a smart home as a *"home equipped with lighting, heating, and electronic devices that can be controlled remotely by smartphone or computer."*

It's no wonder that such a loose definition leads to confusion and doubt about whether a smart home is really of benefit. For the purpose of this article I prefer to define a smart home as a *home where tasks that a homeowner usually carries out manually are taken care of automatically through the intelligent use of technology.* Think of autopilot mode in an airplane: it assists the pilot by taking care of many menial tasks automatically. We believe that a smart home should be the same, improving the quality of life for the homeowner without much interaction required.

Hype and hot air, or a real opportunity?

There's clearly a lot of hype around the term 'smart home'. Apparently the UK smart home market is worth just under £1 billion per year and there are only 1,250 integrators in the UK. Doing the maths, we can see that this is equivalent to £800,000 per integrator. Well, sign me up! Or, maybe not... it seems that no one can agree on the actual value of the smart home market, or on how the overall market valuations can be broken down to the potential earnings for a smart home installer.



Smart Home
market value
forecasts

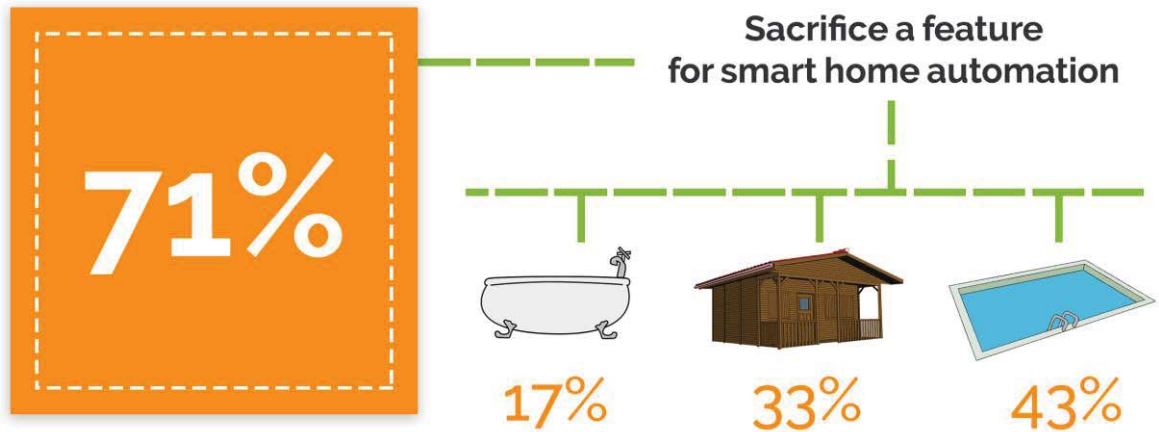


Depending on which report you read, the global market is forecast to be worth anywhere between £13 billion¹, £48 billion² or £120-billion³ by 2020, but this doesn't really matter. Whilst the likes of Ernst & Young and Frost & Sullivan also come up with different results and predictions, one thing is clear: the smart home market is still in its infancy and is growing rapidly. If you're an electrical contractor and want to grow your business then this is your best chance.

An all important question remains: "how do I get started?" To answer this, let's leave the financial forecasts and obscenely large sums of money behind and have a look at what consumer surveys reveal.

What do homeowners want?

To set yourself up as a smart home installer and to be successful you don't just need the technical skills, but also to know what your customers actually want. It's no good specialising in installing smart fridges that order the milk if nobody wants them, and believe us, they don't!⁴



Loxone UK Consumer Research

Recent consumer research conducted by Loxone revealed that 71 % of homeowners would sacrifice another feature in their home - such as a second bathroom or summer house - for smart home automation⁵. The Barclays Digital Homes Report determined that heating, lighting and security are the top three key growth areas for the so-called digital homes market.

Key Areas For Growth



Lighting



Heating

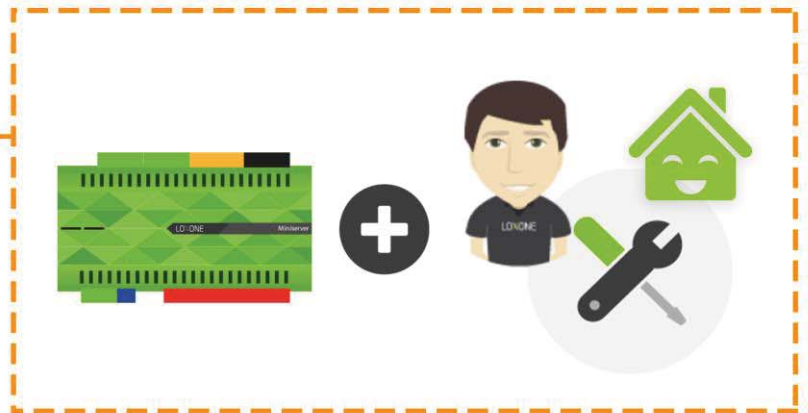


Security

Barclays Digital Homes Report

A surprising result – given all the smart home gadgets that are targeted directly at the consumer and the DIY market – is that the report also revealed that 66 % of homeowners are looking for a professionally installed system. So, it's time to get started!

66%
of homeowners want a
professionally installed system



Barclays Digital Homes Report

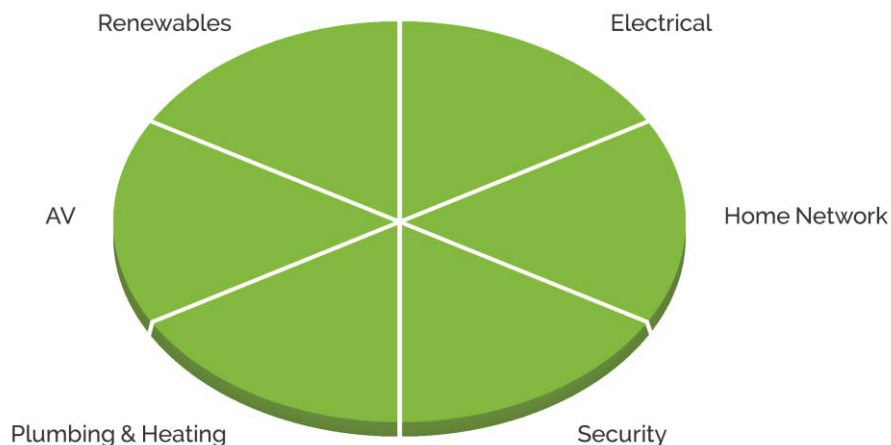
How can I get involved?

Now that you know why you should become a smart home installer and what the British public desires to have in their homes, let's take a look at how you can set your business on course to ride the wave.

Build on your existing skills

Firstly, don't be scared of something new or of not knowing all the answers. Smart homes are still new to most people and there are very few companies that already have all the skills required to jump straight into this market. Creating a smart home requires various skills and as you can see from the following pie chart, there are many elements that contribute equally to a feature-rich, holistic smart home.

Elements of a holistic smart home



Most companies that are becoming smart home installers come from one of these areas and are now branching out of their original area of expertise to offer smart home solutions that incorporate several of the above elements. This doesn't mean that a company that used to install burglar alarms will now, as part of their smart home offering, start to install the plumbing for a heating system. You have to imagine the smart home solution to be more like a layer that sits on top of all the different areas. You can let the plumber do the pipework and commission the heating system, and only take control over the system once the plumbing is done.

As an electrician or electrical contractor, you are in the perfect position to do so, since you already have a sound understanding of the electrics in many of the areas shown on the pie chart. You can build on this foundation to learn new skills and expand those aspects of a smart home you offer as you go along. You don't need to know everything at once and you don't need to be an expert at everything. Which leads us to the second point ...

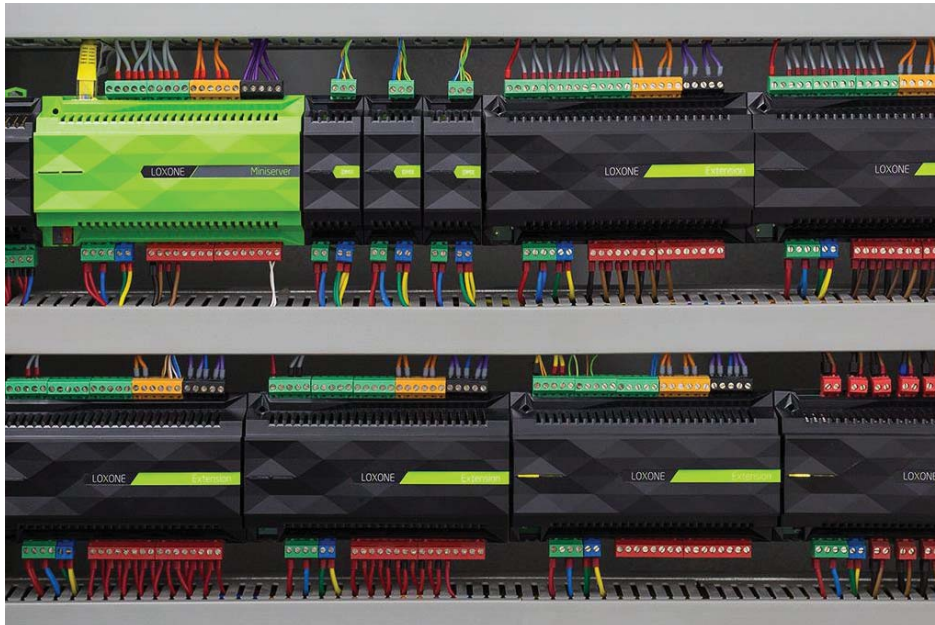
Start small – finish big

Don't bite off more than you can chew. Over-promising and then not being able to deliver is never good for business. If you're newly getting into smart homes then start with what you know. If you are familiar with small electrics, then maybe start out by offering smart lighting systems, but initially refrain from offering full AV streaming and multi-room audio, since these require advanced networking skills. Setting clear expectations with a customer and being able to meet or exceed these will set you on the right path. Since this is still a very small industry it is important to make a good name for yourself and instil confidence in your clients. This will lead to more business and larger installations with more smart home features. At the same time, your own skills and confidence will continue to grow.

Educate yourself and pick your tools

As mentioned right at the start of this article, this industry is growing – and so is the amount of information and products out there. When starting out, this can be very overwhelming since every solution promises to be 'THE' best thing ever. You cannot possibly know how to install every single system and it is thus important to pick which one(s) you want to work with and become an expert in them. To help you sift through the options, first decide which area of smart home automation you want to get started with. Is it lighting, heating or security, etc.?

Next decide if this is all you ever want to do, or if – rather than looking at a dedicated solution for one aspect of smart homes – you prefer a solution that will grow with you and covers multiple aspects of a smart home. This should narrow down your list of possible manufacturers and products. Then consider contacting the manufacturer to find out about their support for installers and the training that they offer. If a manufacturer does not offer the chance for you to see their products, or doesn't provide technical support, a clear installers' program or training, then we would advise to stay well clear of them since you will be left on your own when installing their products.



Keep up to date with the industry – advise your client

There are many off-the-shelf or DIY smart home products out there and it's these products that are fuelling the industry. Companies like Google and Amazon and even British Gas are investing huge sums in advertising to make sure that homeowners hear about their brands. It is their products (Hive, Nest, Echo, etc.) that have probably sparked your client's interest and they'll likely look to you for answers. It is therefore important that, even if you do not install these products, you ensure that you are well informed about them, so that you can advise your clients appropriately.

Urging your clients to keep an open mind about these trendy products and explaining the limited functionality or lack of integration in contrast with a professional system will put you in good stead, likely resulting in larger jobs for your company.

Following this information and pieces of advice will help you make a successful start as a smart home installer and make the most of the opportunities in a growing market.

Sources:

¹ www.channelbiz.co.uk/2016/10/04/smart-home-products-market-worth-16-2bn/

² www.ironpaper.com/webintel/articles/smart-home-market-size-trends-projections/

³ www.pwc.co.uk/industries/power-utilities/insights/energy2020/connected-home.html

⁴ The Barclays *Digital Homes Report* smart fridges is the technology homeowners would least likely be tempted by to spend extra money on a property (at 4% of those surveyed).

⁵ Loxone Consumer Research May 2016 - www.loxone.com/enen/71-percentage-of-brits-would-make-sacrifices-for-a-smart-home/

⁶ Barclays Digital Homes Report - www.barclays.co.uk/journal/digital-homes/

About the author

Philipp is the founding MD of Loxone UK. He holds a first class degree in MEng Electronic Engineering and Cybernetics and has proven his talents for project management, embedded systems and control engineering. He is a member of CEDIA, the Institute of Electrical and Electronics Engineers (IEEE) and the Institution of Engineering & Technology (IET).

If you would like to find out more about the Loxone Smart Home solution, as well as the Partner Program, in-house training and UK-based technical support offered by Loxone then please contact 01183 130 140 or visit loxone.com/become-partner

Loxone is a leading manufacturer of a holistic smart home solution for lighting, heating, security and more. The company is changing the way people live in their homes for the better through an international network of installation partners.

Do you work with smart applications?

The IET is considering undertaking work in this area and we would be interested to [hear from you](#).

LOXONE



Energy management: the foremost challenge for facilities managers

With energy costs persistently rising, continuing concerns over resilient energy supplies, and increasing levels of statutory obligations connected to emissions and climate change policies, facilities managers and their colleagues will have to face many energy management challenges. Authors Cameron Steel and Andy Lewry discuss how facilities managers can prepare for these challenges.

How energy management is undertaken, with its associated responsibilities and roles, can vary depending on the type of organisation and on the lifecycle of the installation. Larger estates and corporations, for instance, will have a duty-holder with a clearly defined role for managing energy. However, within smaller companies it is typically the case that energy management will fall into the facility manager's or other professional's role as an additional responsibility.

For successful outcomes, coordination within the different parts of the business is crucial. To keep overhead costs down an energy manager may be tempted to turn the lights and equipment off wherever possible. However, for a business to operate successfully, it is essential to provide staff with conditions that promote efficient and effective working practices. Such dilemmas are not uncommon in most businesses but short-sighted cost cutting should not be allowed to prevail as this will affect productivity and profits.

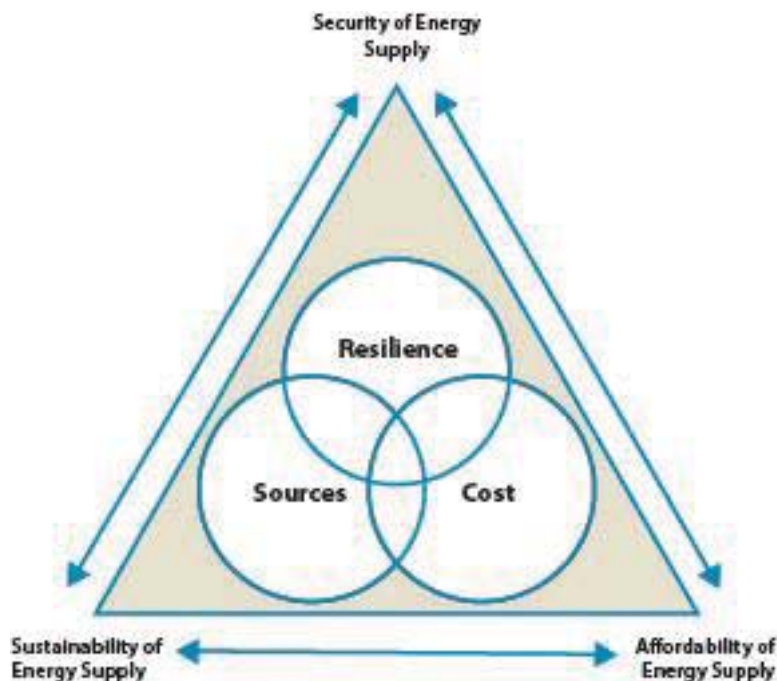


Figure 1 Energy trilemma - reproduced from the IET's Guide to Energy Management

Despite the complexity of some of the issues involved, doing nothing and carrying on as normal – typically classified as 'business as usual' – is not an option when considering energy

management. Rising energy prices and security of supply now pose major risks to business and need to be managed. So, what exactly are the challenges that need to be overcome?

Energy management: the challenges

Ownership

Who actually owns the problem of energy management? Who is driving the agenda and why do they need to?

An organisation must have a plan to effectively address any challenges that might be encountered. Sometimes these plans are driven by compliance – to meet statutory requirements and adhere to policies, for instance, health and safety, environmental management, and equal opportunities policies.

Like each of these issues, increasing levels of legislation governing energy consumption, reporting mechanisms and the need for business efficiency mean that facilities managers should acknowledge that energy management also needs similar levels of ownership and responsibility throughout the organisation – from board level to the shop floor. In addition, visitors also need to understand how to play their part in reducing unnecessary use of energy. The strategy and plan need active boardroom support or the initiative will stall at the technical level and not result in organisational culture change. The aim should be to ensure that the strategy is embedded in the management practices and becomes the 'new' 'business as usual'.



Figure 2 – The components of the continuous process of ISO 50001 that are an integral part of a much wider picture – reproduced from the IET's Guide to Energy Management

System

For energy management to succeed there must be a process-driven system to facilitate change supported by technology that closely assesses what, where, why and how the energy is used. Careful monitoring and analysis will identify areas and opportunities for improvement.

The international standard ISO 50001 – *Energy Management* provides a framework for an energy management system using the universal model of ‘plan, do, check, act’ that is often adapted to manage improvements in the engineering world.

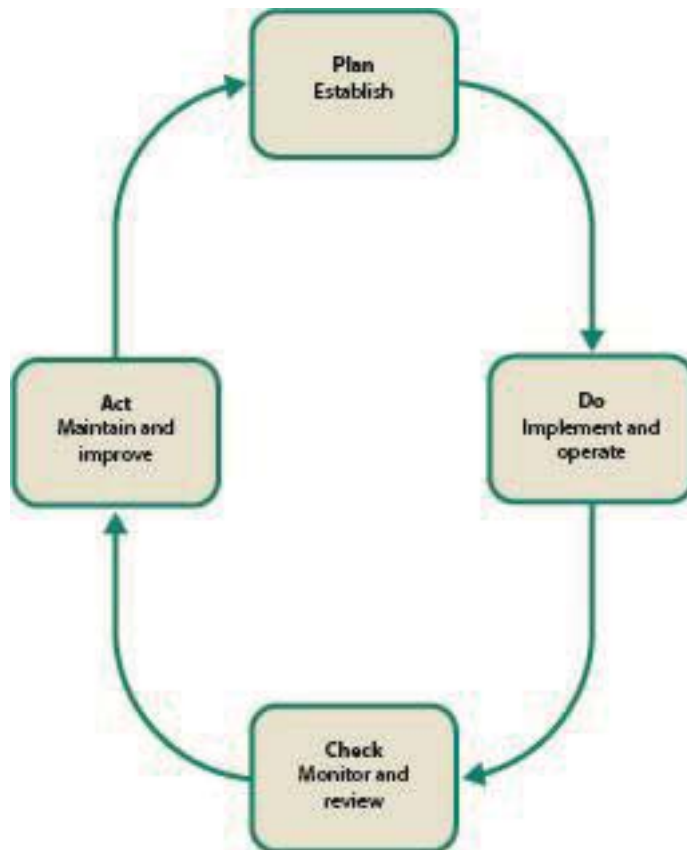


Figure 3 – Plan, Do, Check, Act cycle – reproduced from the IET’s Guide to Energy Management

However, facilities managers need to be aware that there is no single solution. A robust energy management system should:

- have appropriate policies in place and include processes that employ a wide variety of tools, all of which have been adapted for the local needs of the business;
- reflect strategic direction;
- include procedures that make the best use of resources;
- have clear aims and objectives that are quantifiable and are ‘SMART’ in nature; and
- be flexible enough so that it is adaptable in response to changes in use, changes to the overall size of the estate, or changes to occupancy.

However, it is important to recognise that any changes need careful recording so that data can be compared and realistically analysed.

Energy sources

What sources of energy is the installation actually connected to? Is the capacity large enough? Is the business about to grow with demands that are greater than the local infrastructure can provide?

The sources of energy that an organisation uses will depend very much on where they are located, the availability of grid connections and what the particular needs of the organisation are. Costs will vary too depending on the size of supply required, both in terms of average and peak loads. Legislation changes mean that there are increasing challenges in understanding what the commodity prices are, what the legislative costs are and what scope there is for influencing any of it through careful energy management, and therefore reducing energy costs as an overhead to the organisation's activities.

Local renewable energy sources are increasingly being deployed. These can assist with reducing the costs of importing energy to a site but they do bring their own strategic issues, such as storage, consistency and resilience, in addition to ensuring there is adequate cover during essential maintenance periods.

An energy management strategy needs to be carefully linked to the overall business strategy so that it does not become a constraint; after all "process is king" and this activity should support good business practice.

User behaviour

Spending a fortune on energy saving equipment and associated controls technology may well save energy, but are there quicker wins to be had? Could the technological investment be undermined by the activities of the occupants? People are energy management's biggest and best resource, but if badly managed can also be the biggest obstacle. Technology is only an enabler and for energy management to really work the management and staff need to be on-board.

Within any space, environment or building, modifying the behaviour of occupants with respect to the use, and potential wastage, of energy is generally recognised as the quickest way to reduce energy consumption. It does not really matter if the technology in your estate is old and tired or brand new and state of the art. Where the working culture is to override controls and leave the lights on even when they are not required, then energy will be wasted. It must be recognised that this is not the staff's fault; all they want is a comfortable working environment and this has been shown to lead to staff productivity being maximised. The aim is to provide that environment and not just turn off systems to cut energy usage.

Site induction, education, training, feedback and updates will all assist. Directors should champion energy management and the associated initiatives; managers should own the procedures; and users should be incentivised. The challenge in reducing energy demand is keeping people engaged in the drive to keep reducing energy consumption while maintaining an environment that allows the business to prosper.

Measures for achieving good energy management

So, what technologies should be applied and where? Are your buildings the energy equivalent of a sieve trying to hold water?

Passive measures – design and building fabric

Modern building designs are governed by regulatory parameters (for example, UK Building Regulations and similar design criteria); these have back stop values for the thermal performance of building elements (u-values) and the efficiency of HVAC and lighting. However, the building needs to reach an overall building energy performance that can be achieved by passive design, and the use of low carbon technologies and renewables.

On older structures this is not always as straightforward. To reduce energy demand, one of the main challenges then becomes dealing with the building fabric and its constituent elements. Although building science dictates that the fabric should be dealt with first, the economics don't usually add up unless you have already planned an upgrade and all you're doing is upping the specification – this is normally a comfort decision (i.e. maintaining the working environment) or protecting the asset. Both are a legitimate part of the business case as they ensure the value of the asset and, if rented out, maintain rental values and reduce void times. If the project is standalone often the only cost effective measures are controls and pipe insulation. Plant comes into the picture only if it is at the end of its service life or an upgrade is planned.

A holistic approach to refurbishment is always advisable where all measures that will contribute to successful energy reduction are considered together, but be wary of creating other problems through ill-conceived initiatives.

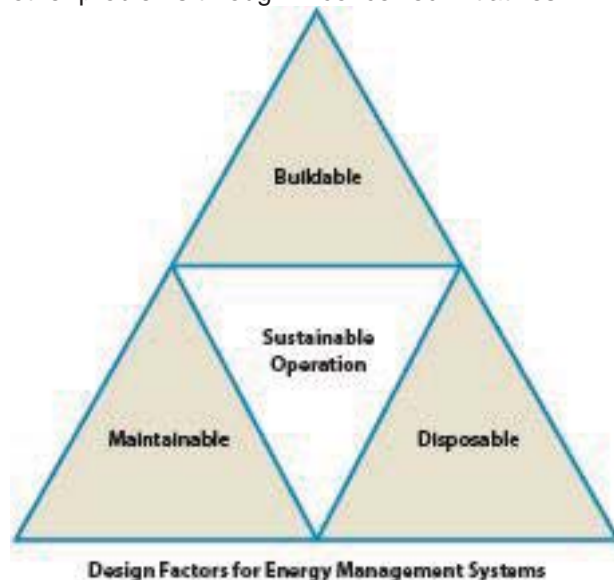


Figure 4 – Design factors for energy management systems – reproduced from the IET's Guide to Energy Management

Active measures

If the occupants are continually demonstrating poor user behaviour – for example, opening windows and using portable heaters – this is usually a sign of a poorly controlled building. The environment required is not being provided so what measures can be applied? Controls are normally the answer – but is the deployment of automated controls actually appropriate? The choice depends on the functionality required and whether there is requirement to provide manual overrides.

Again, regulatory parameters and national and international standards drive modern building designs towards the use of energy-saving technology and controls. The complexity of this approach will vary according to needs and budgets. Sustainability design tools such as the Building Research Establishment Environmental Assessment Method (BREEAM) will help shape new installations and refurbishment projects, but care needs to be taken that ‘green’ boxes are not simply ticked off. Consideration also needs to be made on user requirements, installation operation, potential maintenance issues, user interfaces and whole-life performance. Get any of these wrong and the expensive technology, designed to save energy, will simply not work in the manner envisaged on the design table – this is part of the so-called ‘performance gap’. Another possible downfall might arise if the operation, maintenance and commissioning issues are not considered. A proper assessment of the anticipated use of the installation and the holistic approach is vital; this can be completed using assessment methodologies such as BREEAM-In-Use

Challenges will also exist on retrospectively installing new technology within older buildings and on older infrastructures. It is important to ensure that the implementation of technology in a particular installation, often as a replacement for legacy, is an appropriate use of resources. The impact of new technology, such as variable speed drives, may reduce energy consumption at the point of use, but it could lead to other problems on a 40-50 year old electrical switchboard or cabling infrastructure.

When undertaking this assessment, looking at the whole installation is vital. Another consideration may be to ask whether all the required passive measures are in place before the active measures are taken. Although replacing the building’s ancient cast iron central heating boiler if there is a double height single-glazed atrium losing heat from the building is not logical in engineering terms; economics and/or the practicalities of the fabric solution may favour the installation of new plant and controls.

Checks and balances

How can you ensure that the measures already taken are actually working to justify the initial investment? What else should be done? Where are the priorities?

Without monitoring and analysing both the existing situation and the feedback that informs any subsequent improvements, a management plan will fail. Energy management, though, needs to be seen as more than just checking the meters and correlating the bills; although this may be essential to initially sell the philosophy and to generate subsequent savings.

Proactive processes to check meter readings and to observe the general patterns of use and operational energy consumption trends will help to highlight problem areas and any unusual energy activity or specific events. Ideally this should be done in real time if possible or very soon afterwards. If it is available, analysis of half-hourly readings, that document electrical energy consumption in more detail, can highlight wasted overnight energy or controls that

bring on heating too early in the working day. Spikes in the daily usage are also indicative of poor control and/or a failing plant.

Regular energy audit processes, using recognised methods, can highlight particular areas for improvement. These should be used to influence user behaviour and to implement passive measures, active measures or better working processes. The consumption of energy should not simply be accepted as it is – it needs to be challenged and improved where possible in a successful and robust energy management system.

Procurement

Procurement, as part of an energy management system, is often a challenge to get right and finance departments will always be looking to achieve best value for money. There are also many facets to getting procurement activities correct and high peak loads are expensive and need to be considered to be as important as the average usage. There are also penalty charges to be considered, which are imposed when you exceed these limits. Estimation of usage need to take into account usage patterns and the growth of the business while still minimising risk over the period of the contract.

The most immediate challenge might be choosing an energy supplier and getting the correct tariff. Trying to compare different energy suppliers and their respective tariffs to ensure the best deal can be bewildering. Matching the tariff to the business load profile can be difficult and estimating future needs may require outside expert help.

As energy management systems develop, and projects that will save energy are identified, further procurement challenges are likely to relate to ensuring that the best solution is purchased, whether that be user focused (such as training) or a technology offering. Enthusiastic sales representatives may focus only on their particular product or service, whilst not necessarily looking holistically at the overall installation and how it is used. Taking a short-term view or cut-price approach, i.e. value engineering, is normally a false economy.

Low-cost projects may save proportionately more energy than more expensive projects and may be easier to justify in terms of payback times to keep the finance department happy. However, sometimes an organisation may need to bite the bullet and invest heavily in energy management projects. Also, no-cost or low-cost solutions such as behaviour changes are not silver bullets or single-shot solutions; they need to be continuously reinforced or the working culture will slip back to its previous state and savings will eventually be lost.

Conclusion

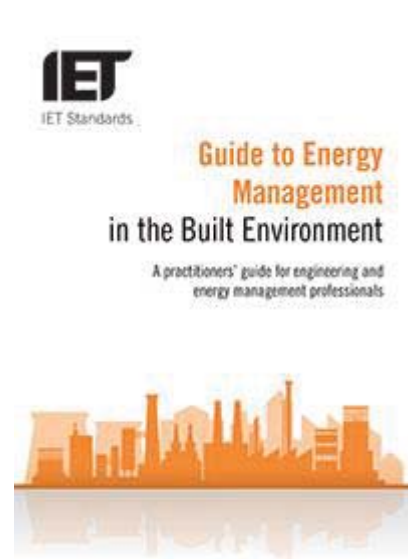
The reality is that the business may not always prioritise investment in energy saving measures. Such projects do cost money and may not provide obvious returns on the money invested. The business case needs to be robust and take into account reduced maintenance and increased productivity. Such factors will minimise risk to the owners by protecting the asset and, if the building is rented out, ensuring high rental values and low void times. From a commercial perspective, if the building is owner occupied, it may be tempting to invest the same amount of money in direct business, ignoring the subsequent waste of more energy, but in turn potentially generating more profit for the business.

However, proper planning and implementation of energy management systems provides real benefits to the wellbeing of staff and visitors, to an organisation's profitability, and to the organisation's environmental credentials.



The duties and responsibilities related to energy management are constantly evolving. Keeping the challenges in perspective requires professional advice and guidance. The principal aspects of standards such as ISO 50001 will apply to all installations, but other publications can provide more detail on specific areas, such as the built environment. These publications should assist the reader to understand the context of their own estates and adapt best practice processes to reduce the consumption of energy in a meaningful way.

Further reading



The [IET Guide to Energy Management](#) has been developed for those with specific or delegated responsibility for managing the procurement, consumption and control of energy. The Guide provides tools to assist energy managers and engineering staff to understand their own particular processes and responsibilities and the correlation between their respective duties. The Guide provides more detail about the framework required for successful energy management processes, the importance of better coordination with engineering design and also the interface activities with engineering maintenance throughout the life cycle of the installation or estate.

The aim of the [Building Research Establishment Environmental Assessment Method \(BREEAM\)](#) is to inspire developers and creators to excel, innovate and make effective use of resources at the design, refurbishment and operational stages.

[ISO 50001 - Energy management](#) is the international standard that supports organisations in all sectors to use energy more efficiently through the development of an energy management system (EnMS).

BS EN 15232: the Standard for building controls

In this issue we also explain how to prepare and introduce an [effective energy management strategy](#) and how to approach the opportunity of [smart installation work](#). Here, Karen Fletcher writes about how BS EN 15232 can guide your work in both these areas.

A well-planned and executed controls strategy can provide effective automation and control of heating, ventilating, cooling, hot water and lighting systems that in turn help create greater operational energy efficiencies and a far-improved working environment.

The Standard, BS EN 15232 *Energy performance of buildings. Impact of Building Automation, Controls and Building Management* may prove very useful for those looking for a simple approach to integration through the use of controls. Although the title of BS EN 15232 focuses on energy efficiency, its contents highlight the best approach to achieving occupant comfort through better control as well.

What does BS EN 15232 provide?

BS EN 15232 has, at its core, a structured list of controls and building automation technologies that have an impact on energy use in buildings. BS EN 15232 also includes a method to define minimum requirements for controls in different types of buildings, including offices, hospitals, schools, retail and restaurants.

BS EN 15232 assigns classes A, B, C or D to levels of control in a building and shows the resulting energy savings that can be expected. The elements of control included in each class are listed in detail, giving users a clear idea of what they get for their money in each class.

What are the benefits of using BS EN 15232?

One of the key benefits is that it assesses controls as a system while removing the effects of other factors such as building insulation from its calculations. This makes it a useful tool for quantifying the benefits of building controls at different levels and serves as a reliable method to calculate payback periods.

But perhaps one of the main advantages of using BS EN15232 is that it can aid the clear specification of building energy management systems (BEMS) in a commercial building if the client identifies what class of control is required for each individual project.

Whether clients are looking for enhanced energy performance, or a more integrated and enhanced building, electrical installation specialists are well-placed to offer sound advice and to make the most of this market opportunity.

Inspection and testing of earth electrodes

Leon Markwell, Senior Engineer at the IET, discusses the inspection and testing of earth electrodes.

An earth electrode and earth electrode resistance are defined in BS 7671 as:

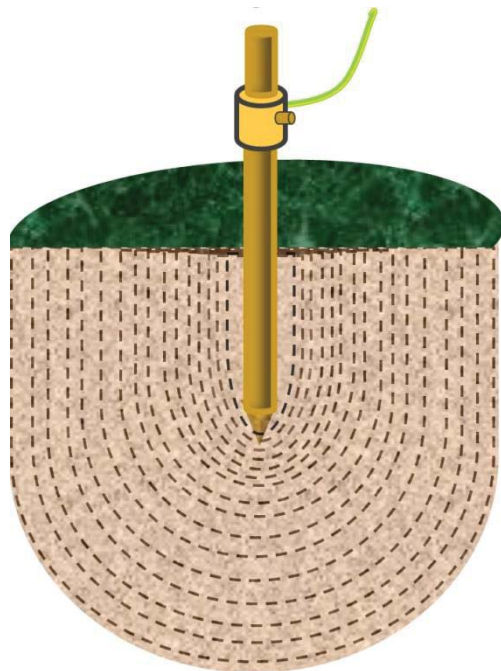
Earth electrode – *conductive part, which may be embedded in the soil or in a specific conductive medium, e.g. concrete or coke, in electrical contact with the Earth.*

Earth electrode resistance – *the resistance of an earth electrode to Earth.*

In a TT system where a connection to earth is not provided by the supply authority it is still necessary for an LV final circuit protective device to disconnect an earth fault within 0.2 s. In order to achieve this, suitable maximum earth fault loop impedance must be provided, as noted in Regulation 411.5.4 of BS 7671. It is generally not possible to comply with this Regulation using only an earth electrode earth return so a residual current device (RCD) is usually installed. Regulation 411.5.3 details the requirements for RCD performance and Table 41.5 provides values of the maximum earth fault loop impedance for different RCD rated residual operating currents.

It should be noted that the terms 'resistance' and 'impedance' are used rather interchangeably in earth fault loops – although they actually have different meanings – as most of the circuit is just resistance with inductive reactance only in the supply transformer and larger supply distribution cables.

Contact with Earth can also be made through other metalwork extraneous-conductive-parts associated with an electrical installation, such as structural steelwork, metal, water or gas supply pipes or other buried metalwork. The effect of this other metalwork may be seen to



reduce the overall earth electrode resistance, but it cannot be relied upon as an electrode as it could be removed or replaced at some future time. Regulation 542.2 of BS 7671 details what may be used as an earth electrode. An earth electrode may be in long-term contact with a corrosive environment and so allowance must be made for possible corrosion or the electrode made of material that can withstand corrosion.

When a new earth electrode is installed the installer will know its construction and location and some details of the surrounding soil condition, but its earth resistance can only be determined by a test measurement. During a periodic inspection of an existing earth electrode, the situation is less certain as there are unlikely to be details of its construction or its buried location. In addition, it may well have corroded to some degree and the inspector will have no knowledge of the underlying soil conditions so the resistance can only be ascertained by measurement.

Figure 1 – A simple earth electrode

The simplest earth electrode used in the UK is a straight rod driven into the ground (see Figure 1). Item 1 is the rod and item 2 identifies the rod/soil contact surface. Initially this contact surface area is quite small and is the surface area of the rod in contact with the soil, but it should be noted that as the current travels away from the rod the surface area 'layers' (item 3) of the soil can be considered to get larger in area. As the resistance at a point is inversely proportional to the area at that point, the electrode resistance can be considered to be in the form of:

$$R = \frac{\rho L}{A}$$

where:

R = electrode resistance in Ohms.

ρ = soil resistivity in Ohm meters (assuming a uniform soil).

L = length of electrode buried in soil in meters.

A = area in square meters.

From the above, if the soil resistivity is known then the theoretical resistance of a single vertically driven earth rod can be approximately calculated using the formula below.

$$R = \frac{\rho}{2\pi L} \left[1n \left(\frac{8L}{d} \right) - 1 \right]$$

Where:

d is the diameter of earth rod in meters

other terms are as noted above.

The derivation details of this and other electrode formulae can be found in BS 7430:2011+A1:2015 *Code of Practice for Protective Earthing of Electrical Installations*.

The above formula can only give an approximate value as there are always other factors to consider. For example, the soil resistivity is unlikely to be known with any accuracy and it may vary with depth. Seasonal changes in moisture content will also have an effect. The depth that the rod can be driven will depend on the soil conditions (rocks etc.) and the need to get to soil of suitable resistivity. For example, in the Middle East it is usual to drive a rod to below the level of the summer water table as the dry ground above has an extremely high resistivity.

It should also be noted that the length of the rod has significantly more effect on the electrode resistance value than the rod diameter. General data for a range of expected UK soil resistivities can be found in BS 7430:2011+A1:2015.

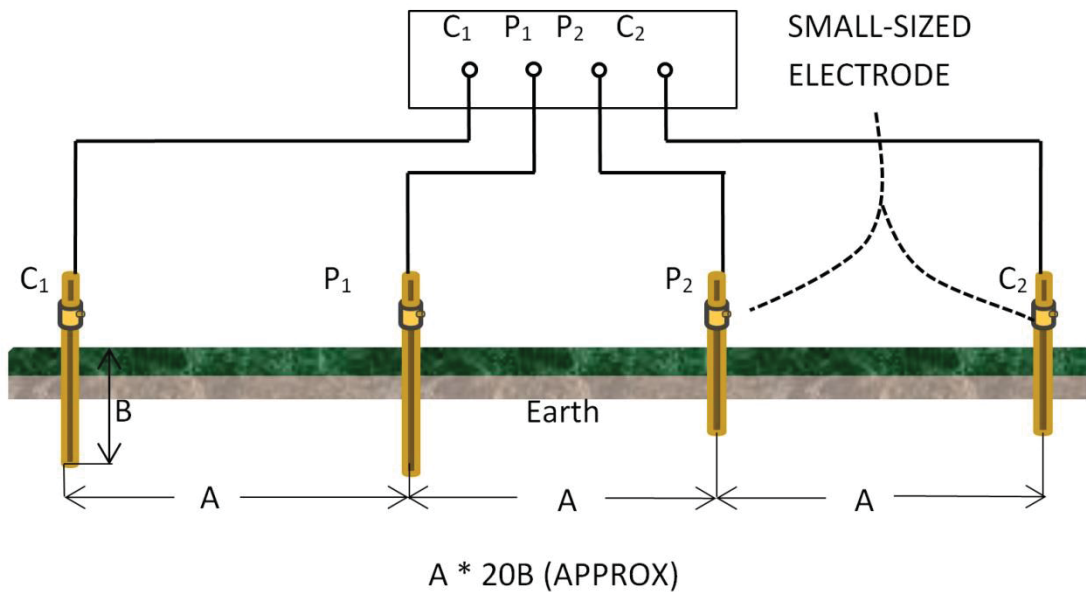


Figure 2 – Four-terminal method of measuring earth resistivity

From these basic electrode calculations it can be seen, as detailed in Figure 2, that if the spacing (A) between the actual installed electrode C₁, the temporary C₂ test electrode and the intermediate P₁ and P₂ test electrodes was large compared with the driven depth (B) of the installed electrode C₁ (say, A is more than 20 x B) the general soil resistivity can be calculated from:

$$\rho = 2\pi AR$$

where:

ρ is the resistivity in Ohm metres.

R is the earth electrode resistance reading in Ohms.

A is the spacing in metres between the test electrodes.

This is known as the 'fall of potential' method and it can be seen in Figure 3 below that most of the voltage is dropped around the electrodes where, as outlined above, the soil 'layers' are small around the electrode and therefore holds the majority of resistance. In the area between the electrodes there are is multitude of current 'paths' and the area (A) is very large so the change in resistance is very small.

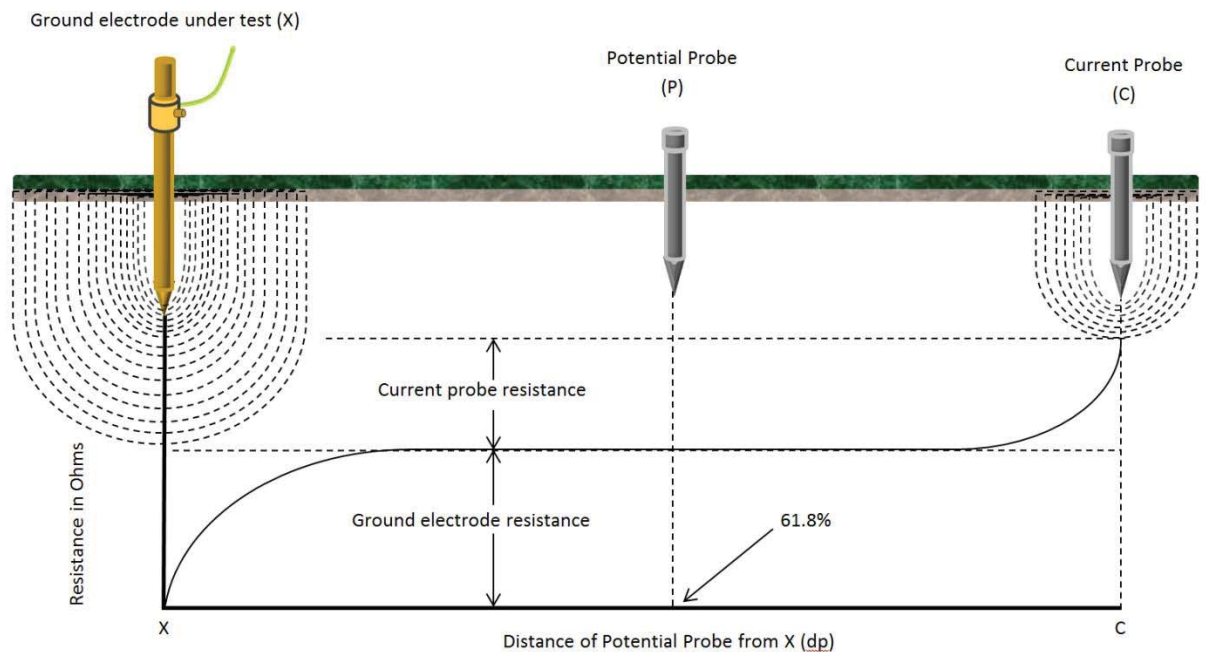


Figure 3 – Illustration of the fall of potential method of electrode resistance measurement

Modern testing equipment works on this principle but it is designed by instrument manufacturers to be more compact and easier to use.

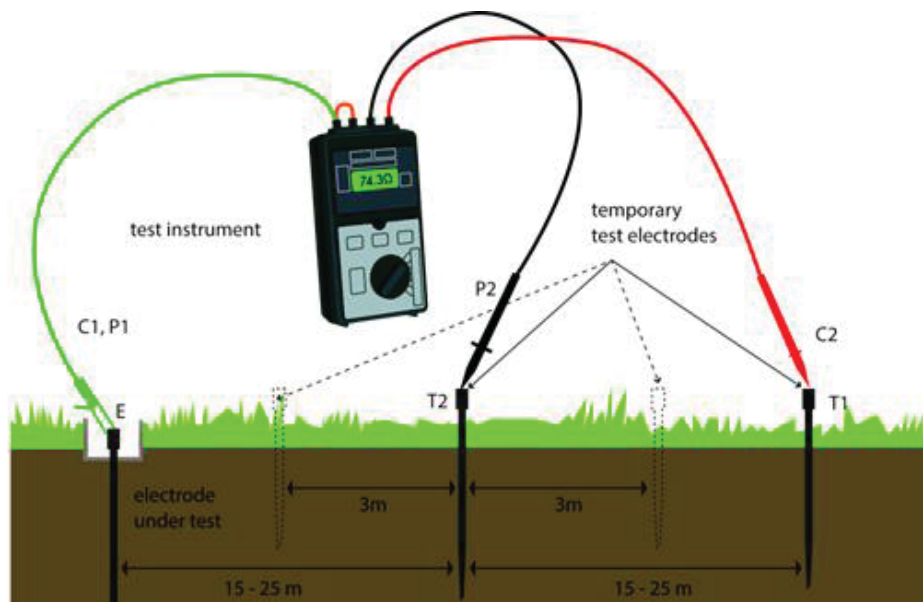


Figure 4 – Typical earth electrode test using a three or four terminal tester

New video – safe isolation procedure

We've published a new video which showcases the safe isolation procedure, as part of our Student's Guide initiative.



Student's Guide - Risk Assessment

Steven Devine, author of the *Student's Guide to the IET Wiring Regulations*, and presenter of the suite of technical Student's Guide videos, advised that knowing how to safely isolate a circuit is absolutely an essential skill – when undertaking electrical qualifications and especially when working in the electrical industry. When a circuit has been safely isolated it reduces the risk of electric shock to the electrician as well as any other persons that may come into contact with an electrical installation while work is being carried out.

Our full suite of videos aimed at all electricians – student or practicing – is available [here](#).