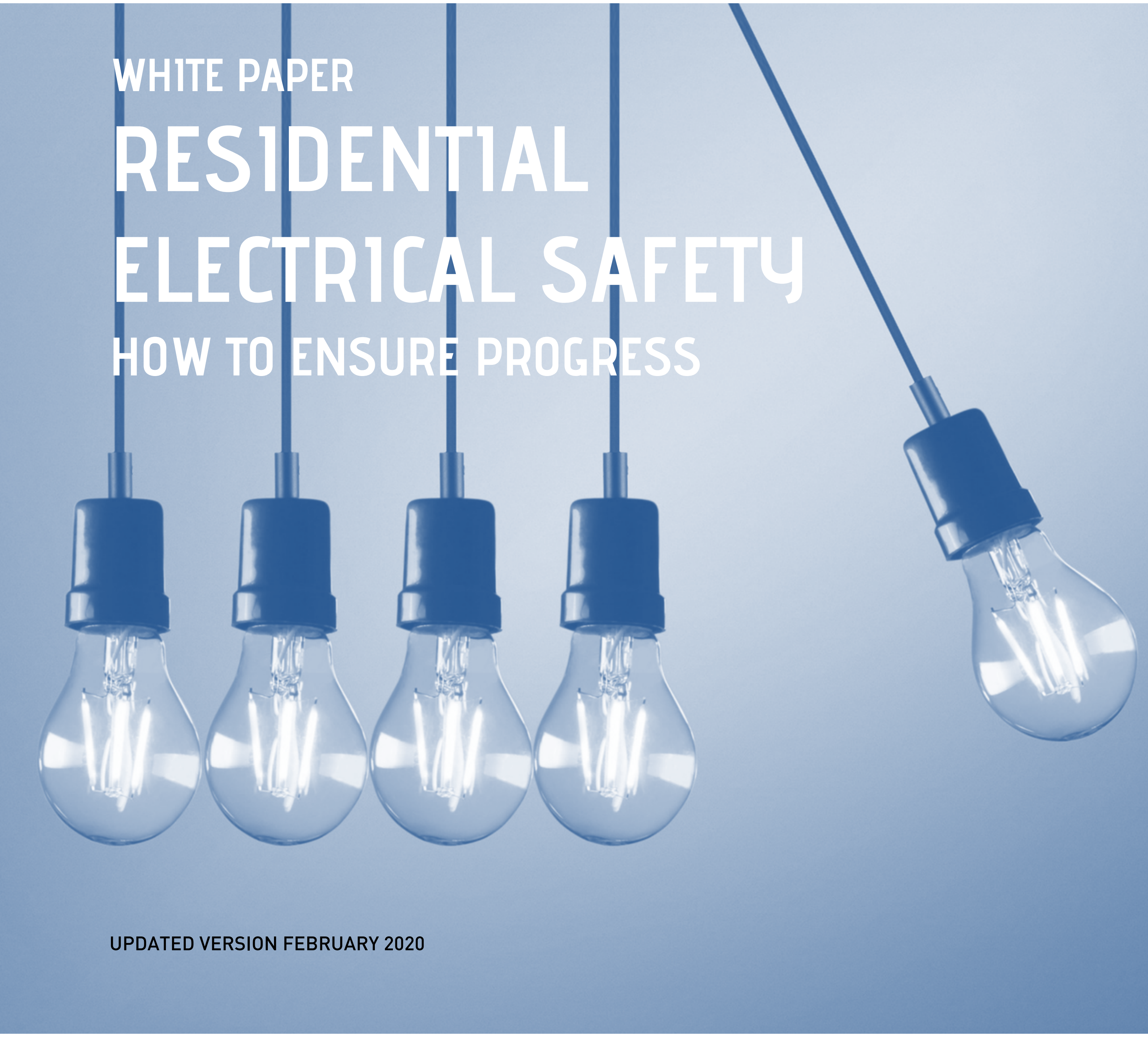
FEEDS

Forum for European Electrical Domestic Safety



WHITE PAPER

RESIDENTIAL ELECTRICAL SAFETY

HOW TO ENSURE PROGRESS

UPDATED VERSION FEBRUARY 2020

Available on www.feedsnet.org

Disclaimer

While this publication has been prepared with care, FEEDS and other contributors provide no warranty with regards to the content and shall not be liable for any direct, incidental or consequential damages that may result from the use of the information or the data contained.

CONTENTS

About FEEDS **5**

Executive summary **7**

Introduction — Why does it matter? **8**

Electrical safety: what are the risks and who is affected? 10

Emerging trends with potential negative impact on electric safety 14

List of common electrical safety issues 19

The hazards of an unsafe electrical installation **22**

Fires of electrical source 23

Property and other damage by fires 31

Electrification and electrocution 32

Enforcing electrical safety **36**

Types of action in Europe 38

Conclusion 48

Annex 1 : Emerging trends with potential negative impact on electric safety **49**

On the medium term 49

On the longer term 52

Annex 2 : Electrical Safety Checklists **53**

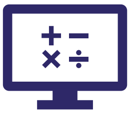
FISUEL Manual — Essential requirements for electrical safety 53

References **58**

ABOUT FEEDS

The Forum for European Electrical Domestic Safety (FEEDS) is a think-tank and a do-tank that brings together organizations aiming to improve electrical safety in dwellings.

The Forum aims to contribute to a safe, just and ambitious Energy Transition mainly focused on electrification by:



Providing harmonized data on domestic fires from electrical source at European level and contributing to improve data collection in each country,

Promoting proven solutions at European level to reduce electrical fires from electrical source in dwellings,

Putting electrical safety as a pre-requisite to the deep renovation and deployment of decentralized production (e.g. PV), energy storage and increased electrical demand of 132 million dwellings across Europe with obsolete electrical installations,

Drawing attention at all policy levels on the close connection between energy poverty and electrical safety for vulnerable communities,

Participating in the achievement of the Green Deal targets.

The results of the work of the FEEDS Forum are available to all stakeholders involved in household electrical safety in Europe. Stakeholders are free to make use of it to support their case and facilitate action in the different Member States of the European Union.

FEEDS MEMBERS

European organizations

- European consumer voice in standardization (ANEC)
- European Committee of Electrical Installation Equipment Manufacturers (CECAPI)
- Europacable
- European Association of Electrical Contractors (EuropeOn)
- European Copper Institute (ECI)
- European Fire Safety Alliance (EFSA)
- Federation of the European Union Fire Officer Associations
- International Federation for the Safety of Electricity Users
- Insurance Europe – Prevention Forum

National organizations

- Confédération Nationale du Logement (CNL – France)
- Electrical Safety First - The UK's Electrical Safety Experts (ESF – United Kingdom)
- Groupe de Réflexion sur la Sécurité Electrique dans le Logement (GRESEL – France)
- Dutch Burns Foundation (NBS – Netherlands)

EXECUTIVE SUMMARY

In the past 120 years, electricity has become the predominant energy source in our everyday life. Its applications have improved our comfort and safety, multiplying the means of entertaining and communicating.

However, domestic electricity can be dangerous. Specifically, the safety of older electrical installations is a concern in the countries of the European Union, given the low renovation rate of dwellings and their electrical installations. At the same time, the uses of domestic electricity continue to diversify and develop, posing increasingly important challenges in terms of quality and safety.

The safety deficiencies of obsolete electrical installations generally result from the aging of their components, the lack of maintenance and inappropriate usage. The dangers they represent are also clearly identified. The risks of electrification and electrocution are well known and reduced during last decades, but fires of electrical source and their consequences are the most worrying today.

Statistics from a number of European countries reveal that **electrical fires account for 25-30% of all domestic fires, an increase of 5-10% in the last 10 years**. The total number of fires of electrical origin in the EU is estimated to be 273,000 per year. Their consequences are dramatic in terms of fatalities, injuries and the economic cost to society.

Although Europe and European countries have advanced standards to ensure the safety of domestic electrical installations, their application is generally reserved for new electrical installations. In order to improve the safety of old electrical installations, the solutions observed so far are to establish reference guides and methods for safety and to carry out awareness campaigns and periodic inspections informing occupants about the risks of their old electrical installations. More rarely, countries have opted for regulations that directly empower homeowners with regard to the safety of their electrical installation.

European Union countries therefore face a major challenge in regard to domestic electrical safety, especially as, in practice, the number of hazardous installations is expected to continue to rise if nothing is done. In response to this, models of cooperation have emerged in some countries. The effectiveness of the resulting solutions is still subject to an important preliminary step: to improve the statistical knowledge on the state of the old domestic electrical installations and their consequences, particularly in terms of fires. Out of such knowledge, suitable solutions can then be developed.

Recently, the European Commission sent a strong signal to the Member States with its revised Energy Performance of Buildings Directive (July 2018). It advocates the development of national policies for safety inspections and upgrading domestic electrical installations as part of more extensive programs to renovate old buildings.

INTRODUCTION — WHY DOES IT MATTER?

In a time span of only 120 years, electricity has become such a vital part of our daily life that is hard to imagine living without. Electrical applications have brought additional efficiency, comfort, entertainment, safety and security to our homes. But as is the case with many good things, the advantages do not come without a downside. Electricity, if managed wrongly, can be dangerous. We are all familiar with the danger of electrocution. Less evident is the danger of electricity to start a fire. In Europe, 25 to 30% of all domestic fires have an electrical source.

Electrically induced fires cause 1,000 to 1,200 fatalities and 6.25 billion euro of property damage in the EU each year.

In some countries, e.g. the US and Japan, this danger has been recognized:

In the **US**, the number of fires per year has gone down from 3.3 million (or 44,000/million dwellings) to 1.3 million (or 11,000/million dwellings) between 1977 and 2015. In the same period, the number of fire deaths has decreased from more than 7,000 (94/million dwellings) to roughly 3,000 (26/million dwellings). A major contributor to this success story is the electrical safety promotions of the National Fire Protection Association (NFPA). [1]

In **Japan**, an inspection of the electrical installation every 4 years has been mandatory for all dwellings since the early 1960s. A similar law is in force in South Korea since the early 1970s. Fire statistics in both countries demonstrate the positive effect of this measure: the number of fires has been reduced by close to 90% since inspections became mandatory. Moreover, the regulation solved the problem of electrical safety in old buildings.

In a recent congress on the matter in the US, the NPFA president Jim Pauley warned of the new challenges in electrical safety that are facing us, due in no small measure to technology and life-style changes [1].

"If we do not step up with additional measures to improve domestic electrical safety soon, the issue is likely to become even more urgent in the future."

The downward trend of fatal accidents might sputter and even be reversed if we do not take further action. This is the case for the following reasons:

- In the short term, there is the acute problem of the old housing stock with ageing electrical installations. **The annual renovation rate for EU dwellings is low** (around 1%), and significantly lower than the growth of the building stock aged 25 years and older (1.75% on the average). As a result, the average age of the electrical installations in EU dwellings is increasing at a speed of 0.75% per year.

- In the medium term, there is the issue of new types of electrical applications that are entering the domestic environment and that require a new approach to safety.

    - **Europe's population is ageing rapidly**. Thanks to technological assistance (electric stair lifts, remote doctor consultation, safety alarms, et cetera) an increasing number of people can remain in their homes to a much higher age. These technologies create an extra challenge for the electrical installations in what are often old houses.

    - Thanks to government support and market development, **the generation of local electricity through PV panels** has become popular in many EU countries. This radically changes the concept of the residential electrical installation, introducing new hazards and in the process demanding new safety requirements.

    - Residential heating and private vehicle transport, which have in the past relied primarily on fossil fuels, are expected to be gradually electrified in the coming decade. **Heat pump compressors and electric vehicle charging points** are additional to the normal growth of domestic electrical applications, including the ever-growing number of rechargeable devices and the market breakthrough of domestic batteries. These new applications substantially increase the load on residential electrical installations, demanding an increased emphasis on electrical safety.

The Grenfell Tower disaster in North Kensington, London, on 14 June 2017 has revived discussion of domestic fires in Europe. According to the latest investigations, the fire may have started with an electrical appliance malfunction and caused 72 deaths, while a further 70 people were injured. Since the fire, the issue of fire prevention has gradually grown in importance.

ELECTRICAL SAFETY: WHAT ARE THE RISKS AND WHO IS AFFECTED?

OLD HOUSING STOCK AND SLOW RENOVATION RATE LEAD TO OBSOLETE ELECTRICAL INSTALLATIONS

Once dwellings surpass the age of 15 to 20 years, a regular inspection and — if necessary — renovation of the electrical installation starts to be required to prevent electrical safety issues from developing.

The EU has an old housing stock. According to the *OTB Research Institute for the Built Environment* in the Netherlands [2, p.54], the age distribution of houses in the EU is as follows on Table 1. **We see that 86% of the houses in the EU are more than 25 years old and 51% are more than 45 years old.** 35% of houses in the EU date from the period between 1970 and 1990, which are typically the houses requiring a first entire renovation today. The average annual building rate in this period, relative to the total numbers of dwellings today, was 1.75% (= 35%/20 years).

The current renovation rates cannot keep up with the building rates that were shown at that time. In 2011, the *Building Performance Institute Europe (BPIE)* estimated **the annual renovation rate of the electrical installation in residential buildings across Europe to be 1%** [3, p.103]. This figure included all renovations others than those relating to a single energy saving measure. According to the BPIE, this figure is in line with a study carried out for the European Commission and led by the Fraunhofer Institute.

From these figures we can conclude that the number of European houses 45 years and older that have never seen a renovation of the electrical installations has risen at an annual rate of 0.75% of the total housing stock (= 1.75% minus 1%).

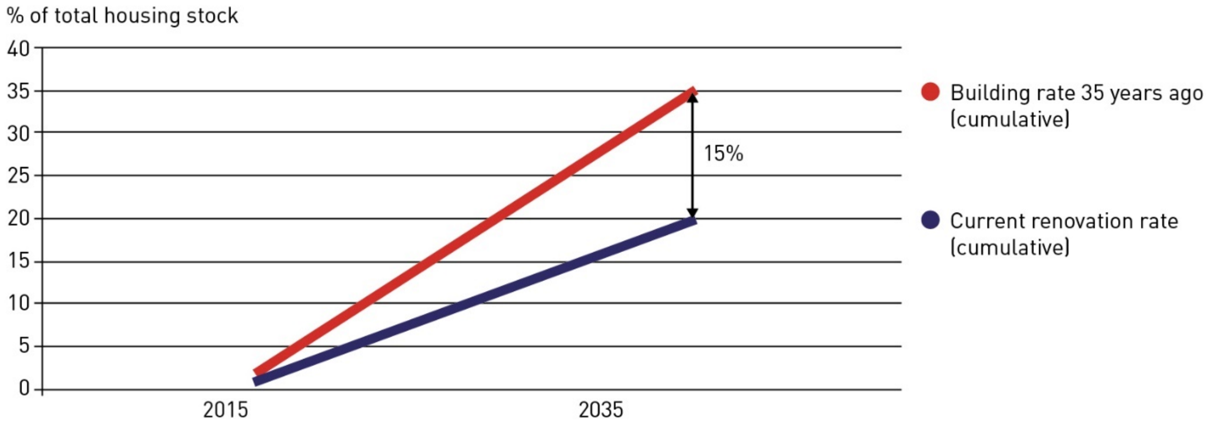


Figure 1 — The houses of 45 years and older that have not yet seen a renovation of the electrical installation will grow by 15% of the total housing stock over the next 20 years.

Per year	*# Dwellings*	Houses from before 1970 (%)	Houses from before 1970 (#)	Houses from before 1990 (%)	Houses from before 1990 (#)
Austria	3 778 180	51.4	1 941 985	78.10	2 950 759
Czech Republic	4 537 920	50.1	2 273 498	87.70	3 979 756
Denmark	2 790 751	62.2	1 735 847	87.90	2 453 070
Estonia	613 729	53.6	328 959	94.70	581 201
Finland	2 908 245	37.2	1 081 867	77.20	2 245 165
France	30 117 733	47.6	14 336 041	83.00	24 997 718
Germany	41 550 300	74.3	30 871 873	87.50	36 356 513
Greece	6 384 353	42.1	2 687 813	85.70	5 471 391
Hungary	4 246 045	48	2 038 102	88.90	3 774 734
Ireland	1 815 045	33.3	604 410	60.70	1 101 732
Italy	24 141 324	60.9	14 702 066	91.90	22 185 877
Latvia	915 871	49	448 777	88.60	811 462
Lithuania	1 124 929	62.6	704 206	93.70	1 054 058
Luxemburg	221 828	76.6	169 920	93.30	206 966
Malta	144 474	44.3	64 002	79.60	115 001
Netherlands	6 921 070	47.8	3 308 271	80.20	5 550 698
Poland	14 282 292	50.1	7 155 428	87.10	12 439 876
Portugal	5 661 637	39.3	2 225 023	74.20	4 200 935
Romania	7 769 601	52.7	4 094 580	91.30	7 093 646
Slovakia	1 775 079	45.1	800 561	91.70	1 627 747
Slovenia	710 061	50.6	359 291	89.80	637 635
Spain	25 382 000	46.6	11 828 012	84.30	21 397 026
Sweden	4 763 585	63.8	3 039 167	90.00	4 287 227
UK	27 864 444	55	15 325 444	96.80	26 972 782
Total	220 420 496	51.84	114 265 985	86.00	189 561 627

Table 1 — Distribution of house age across EU countries (Belgium is left out because no figures after 1990 are available; Bulgaria, Croatia and Cyprus are left out because of a general lack of figures).

Apart from the slow renovation rate, the quality of the renovations is another point of concern. Studies carried out in the UK by BSRIA [4] and the CFRL [5] at the end of the 1990s showed that in 25% of the renovations of the electrical installation at that time, no complete re-wiring was executed. If no new renovation was carried out since then, those houses — of which many were constructed before 1970 — have still never seen a complete rewiring. The wiring from before 1970 will have become inadequate in the large majority of cases taking today's domestic electrical applications and today's standards into account. Moreover, the wires themselves might be subject to ageing. The insulation material, for example, could show signs of wear causing leak currents or short circuits.

The objective enshrined in the recently revised Energy Performance of Buildings Directive (EPBD) to reach a "highly energy efficient and decarbonised building stock by 2050" in Europe should guarantee higher renovation rates in the future.

POPULATION WITH LOWER LIVING STANDARDS IS MORE EXPOSED TO ELECTRICAL HAZARD RISKS

Electrical safety and fire protection also have a social dimension. According to a UK survey [6], **demographic groups with lower social living standards and affected by energy poverty run more than average risk of accidents from electrical source**, while it is precisely these groups that tend to be disadvantaged already in other areas.

- A first cause behind this social gap is that **apartments** tend to be less safe than houses. In apartments, the maintenance of the electrical installation is often a joint responsibility between all the inhabitants and co-operative owners of the building. A disproportionate number of casualties from fires occur in high rise building (> 3 floors) without connected terraces or fire escapes. As a result, apartments represent 16% of all fires but 50% of the fire casualties [7].
- A second cause behind this social gap is that **rented** dwellings tend to be less safe than owner-occupied ones.

It is also important to note that **older people** are disproportionally at risk from electrical safety hazards due to their often poor housing conditions, the health issues they may have, or the lack of advice and practical help available to them [8].

Even if elderly people are house-owners, they still run a risk that is above the average. These houses are often old and the budgets for repair works, inspection or renovation small to non-existent. As a result, the houses lack the necessary features that can protect their occupants from electrical hazards.

The number of +65 people that rely on the private rented sector for their dwelling is predicted to double by 2035 [8] due to the ageing population, the preference of older people to remain in their own homes for as long as possible, and the lack of social housing (see also the sub-chapter "Changing demography and lifestyles" in Annex 1). Such privately rented dwellings have a safety record that is below the average. On top of that, older people are often vulnerable and open to exploitation by a landlord. Solutions to counter this are proposed in Chapter 5 ("Enforcing electrical safety") and more in particular in the sub-chapter "Inspection of existing electrical installations".

Finally, it is worth mentioning that **people with reduced mobility**, affected by physical disabilities or obesity, may not face higher electrical hazard risks per se, but may however face higher injury or death risks when their houses catch fire, as it may take them more time to leave their buildings compared to other people. Specific preventive measures should therefore be considered for them.

"The worst affected regions are the east and west Midlands, which features large numbers of Victorian homes, where about a quarter of a million rental properties suffer from category 1 hazards, according to the figures compiled by Labour based on the English Housing Survey. These hazards include exposed wiring or overloaded electrical sockets, dangerous or broken boilers, very cold bedrooms, leaking roofs, mould, vermin and broken stairs.

"Over a quarter of privately rented homes in the West Midlands are classified as unfit for human habitation."

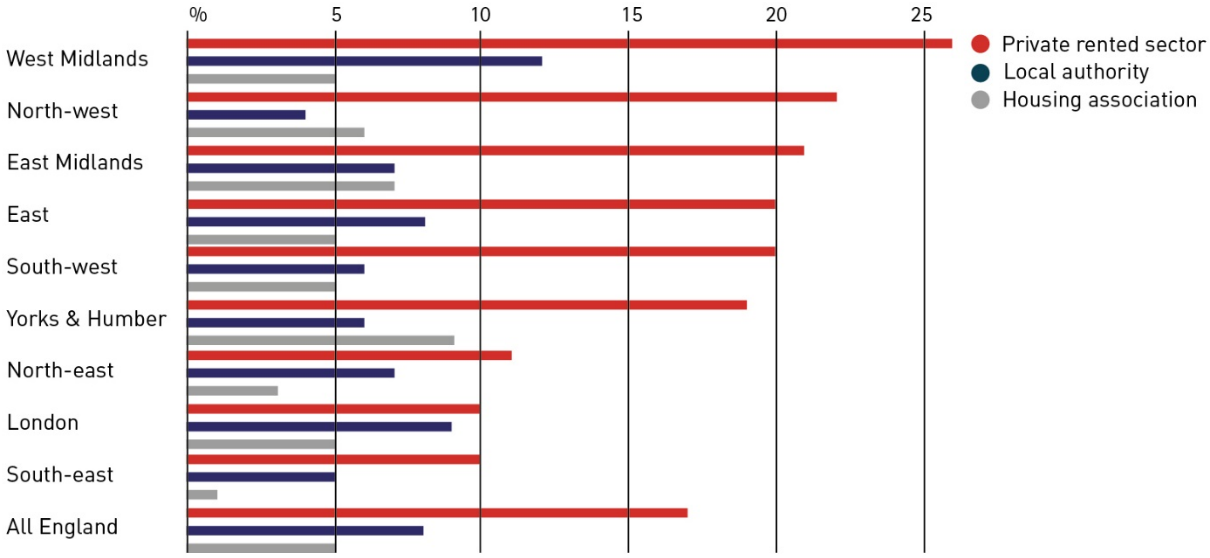


Figure 2 — Homes with category one hazards, percentage of total rental stock. Source: The Guardian newspaper article 'Hundreds of thousands living in squalid rented homes in England', 28 January 2018 [9].

EMERGING TRENDS WITH POTENTIAL NEGATIVE IMPACT ON ELECTRIC SAFETY

The ageing European housing stock, the slow renovation rates, and the related social dimension are compromising the efforts that have been made in the past decades to improve electrical safety in many countries throughout Europe. It requires a reaction in the short term to counter this trend.

Other changing conditions will put even more pressure on residential electrical safety in the near future. The energy transition and its technologies, as well as changing demography and life styles will demand a reaction in the medium term to avoid them abrogating the positive trend of increasing electrical safety.

THE ENERGY TRANSITION AND ITS TECHNOLOGIES

Thanks to favourable policy measures and reducing prices, rooftop solar PV panels have become popular among residential electricity consumers throughout Europe. In some EU countries, rooftop solar PV systems are increasingly being sold together with another electrical technology: battery storage. Another trend is the electrification of residential heating systems. The environmental balance is shifting in favour of electrical heating thanks to the decarbonisation of electricity generation and the development of clean electrical building technologies such as heat pumps. In the near future, private vehicle transport is likely to undergo a similar evolution.

All these new electrical devices in the house — PV panels, batteries, heat pumps, EV chargers — can represent a serious challenge for the domestic electrical system and its safety. All stakeholders should collaborate to make sure that the advantages of these new technologies do not get overshadowed by the appearance of previously absent safety hazards.

CHANGING DEMOGRAPHY

Europe's population is ageing and this will continue in the near future. A related trend is that older people will continue to live independent lives in their own home until a higher age. This will be partly because they prefer to do so and also partly out of necessity: having the elderly live safely at home for a longer time both takes the pressure off the increasing demand for care and reduces the costs to national health services. Many technological solutions exist to assist elderly people living at home, many of which are electrically operated. This means that the house and the electrical installation need to be adapted to carry out all those functions without introducing new safety hazards. An extra difficulty in this matter is that most elderly people live in houses of a considerable age that have often not seen renovation in a long time, if at all. Assisted living technology should therefore go hand in hand with a well-functioning program that enhances residential electrical safety and prepares dwellings for life-long-living.

CHANGING LIFE-STYLES

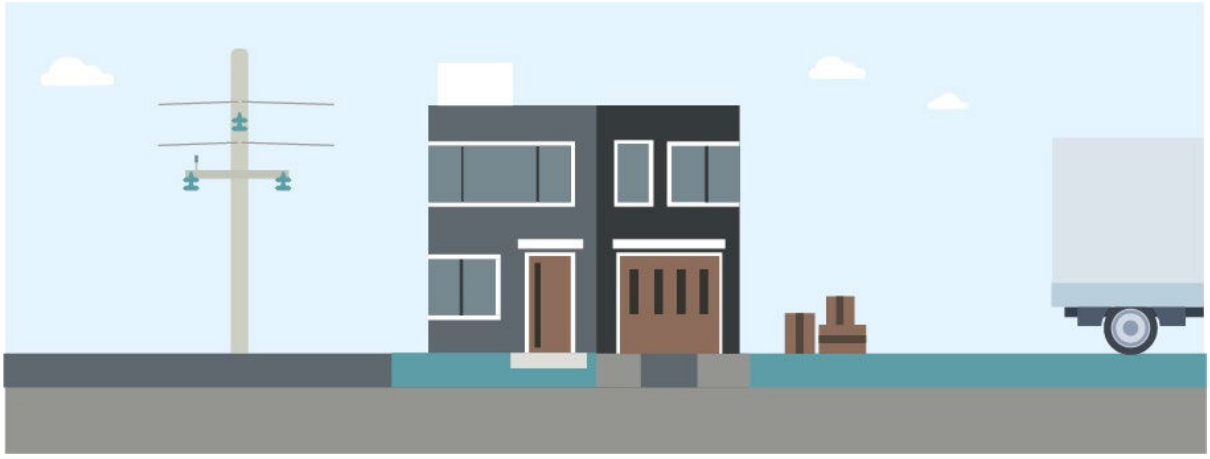
Life-styles are continuously changing and houses need to be adaptable to cope with those changes. One of the main issues is that most dwellings suffer from a lack of sockets—even relatively new houses. This problem has grown bigger with the increase in electronic devices used at home and with the increasing trend to work from home. To compensate for the lack of sockets, occupants use extension cords.

In the longer term, other additional electrical safety issues await us. With an increasing number of electricity sources providing **DC power** (PV panels, batteries), as well as an increasing number of appliances that are using DC power (ICT infrastructure, LED lighting, EV charging, et cetera), some people wonder why we still need an AC network in between. A growing number of electricity experts are indeed convinced that we should evolve towards a DC electrical system for residential and office buildings. One of the main problems with such a transition to DC could be that electricity experts are absolutely not familiar with it and are often unaware of the **related safety issues**.

For a more detailed overview of these changing conditions that are affecting electrical safety, see Annex 1.

ILLUSTRATION: TYPICAL ELECTRICAL SAFETY ISSUES THAT HAVE ADDED UP OVER THE YEARS

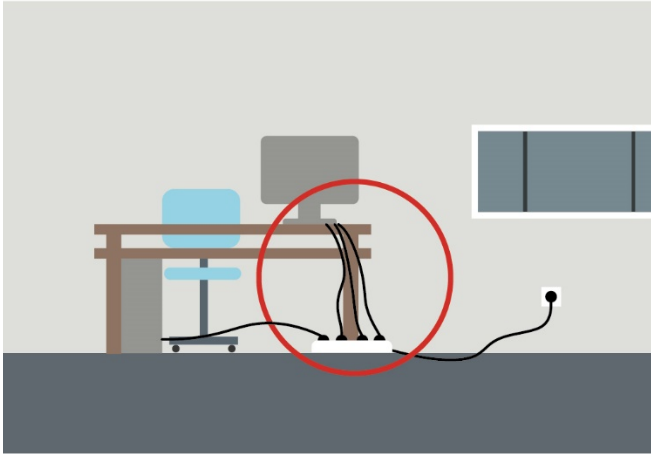
The following is a typical story of how electrical safety problems can add up over the years in a house that was inspected and declared safe after construction 40 years ago, but never saw a periodic inspection or a renovation of the electrical installation.

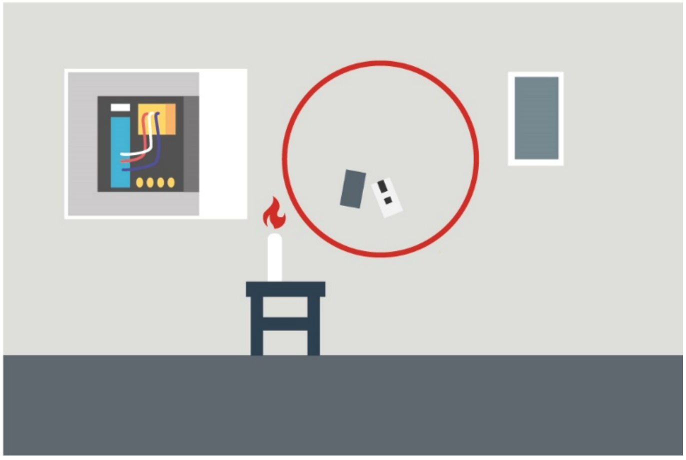


1979 – Alex is 35 years old and has constructed a new house for the family. The electrical installation is inspected and declared safe before being connected to the electricity grid.

1984 – Following new insights in electrical safety, an RCD becomes mandatory on circuits that go through wet areas (bathrooms etc.). Alex is unaware and no adaptation of the electrical installation is made.

1988 – In the second part of the eighties, many new devices are being introduced in the house. Alex bought a microwave oven, his son a computer and several adjoining auxiliary devices. Since the house now lacks the necessary power sockets, Alex goes to buy cheap extension cords in the DIY shop around the corner, without verifying whether these products are actually carrying a CE mark...



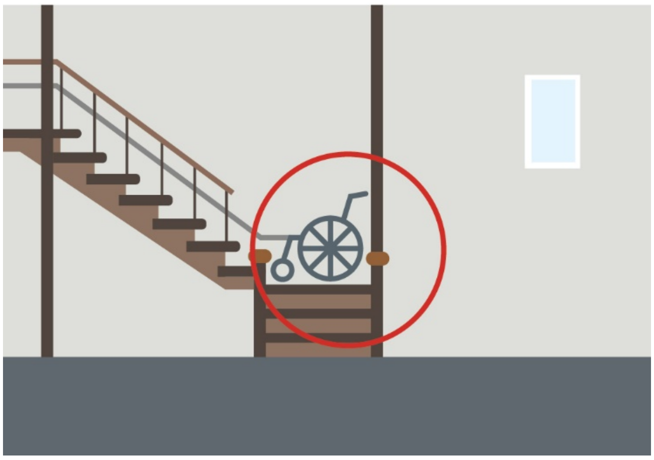


1996 – Some of the fuses are blowing all the time, apparently without any reason. This is very annoying. Alex learns from one of the neighbours how to fix the fuses with pieces of metal.

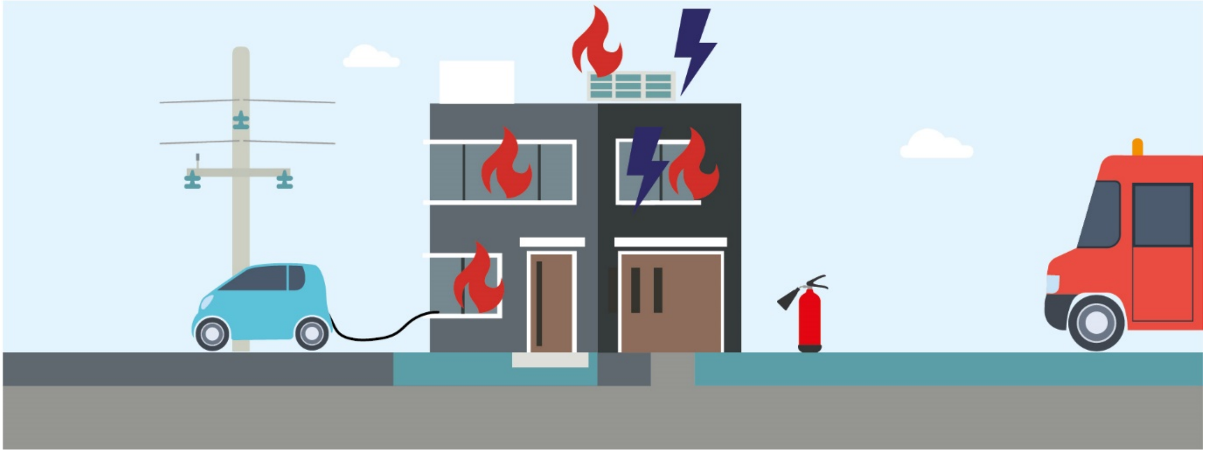
2000 – The house is starting to show wear and tear. One of the sockets that is used very often came loose from the wall. Another socket, continuously connected to one of the extension cords, shows burn marks. Alex doesn't notice.

2008 – Now being 67 years old and on a pension, Alex wants to install PV panels on the roof. Being a fan of DIY work and having plenty of time, he/she decides to carry out the installation without any assistance. He/she does not realize that the DC conductor sections that are being used are insufficient and that measures for avoiding leak currents are lacking.

2014 – At t he age of 73. Alex has an accident that impairs his/her mobility. A wheelchair is the solution. To be able to stay in his/her own house, an electric chairlift is installed. Are the electric circuit and the corresponding safety measures sufficient for such a heavy duty device? Nobody asks the question.



2015 – Alex's son is an early adapter and has bought an Electric Vehicle. At home he has his own charging station, but where can he charge his car when he is visiting his parents' house? Via an extension cord through the window, he plugs it into one of the ordinary sockets in the living room…



2019 – 40 years after the construction of the house and the initial verification of the electrical installation, the place is full of dangers…

Figure 3 — A typical story of how electrical safety problems can add up over the years.

LIST OF COMMON ELECTRICAL SAFETY ISSUES

The deficiencies found in the residential electrical installations differ from country to country. The following examples of critical problems are therefore not always applicable to all countries. It is in any case a non-exhaustive list that only has the intention to demonstrate how much can go wrong in the electrical installation of today's dwellings. For examples of lists on what to verify during installation and inspection, see Annex 2.

INSIDE DWELLINGS

DUE TO INAPPROPRIATE DESIGN OF THE ELECTRICAL INSTALLATION:

- ✓ Power sockets or lighting points that are not earthed
- ✓ Absence of a proper earthing electrode
- ✓ Mains supply that is not protected by a Residual Current Device (RCD) (often the case in old dwellings)
- ✓ Bathroom and wet areas that are not protected by an RCD
- ✓ No RCD protection for circuits supplying power to appliances outdoors

- Inappropriate installation of PV panels (often the result of a Do-it-Yourself (DIY) practice):
  - Insufficient sizing of conductors
  - DC wires that are not separated at their entrance into the house
  - Leak currents in the metal parts of the roof and the metal water pipes in the house
  - The use of switches that are not adapted to DC

DUE TO LACK OF PROPER MAINTENANCE OF FIXED INSTALLATIONS:

- Wear and tear of the electrical equipment, holding the risk of causing electric shocks
- Frequent, tripping of circuit breakers considered as unexplained by the end user. With the increase of electrical appliances in the house, the load on some circuits may become higher than it was originally designed for, causing circuit breakers to trip.
- Sockets, switches and panels that become hot or even display black burn marks. This indicates over-loading or bad contacts and requires immediate action.

DUE TO INAPPROPRIATE USE OF THE INSTALLATION

(often related to older installations lacking the required functionality for today's electrical equipment and life style):

- Frequent use of extension cords due to insufficient socket outlets. When these are routed under carpets, the leads may be damaged and are a fire risk.
- Overloading of sockets using multi-way adapters, resulting in a fire risk.
- All kinds of 'Do-it-Yourself' (DIY) modifications carried out by untrained people without knowledge of standards.

- EV charging at a regular household socket without additional protection, holding the risk of overheating wires and switches after several hours of charging at maximum power. Even if the circuit is designed according to the safety standards, components might still get dangerously overheated in those circumstances. If other appliances are connected to the same circuit simultaneously, circuit breakers might trip.

IN COMMON PARTS OF APARTMENT BUILDINGS

A point of concern in apartment buildings is the *rising mains*. These are the cables that run from the grid connection in the basement up to the various building floors, where they are used to connect the individual apartments. In older apartment blocks, a discrepancy can grow between the load capacity of the rising mains and the increasing number of electrical devices that are used inside the apartments. If this discrepancy grows too big, the rising mains will hold insufficient capacity. Overloading, material wear, insufficient maintenance and ageing of the rising mains can result in repeated electrical failures and a potential source of fire. Moreover, the electricity connections in the common parts are often lacking an earthing conductor. If that is the case, the earthing wires that exist inside the apartments cannot be connected to a proper earthing network and become useless. Another attention point is the behaviour of the rising mains in case of fire.

France and the UK are intensively investigating all of these issues related to the electrical safety of rising mains.

WIRING

Studies carried out in the UK by BSRIA [4] and the CFRL [5] at the end of the 1990s showed that in 25% of the renovations of the electrical installation at that time, no complete re-wiring was executed. If no new renovation was carried out since then, those houses — many of which were constructed before 1970 — have still never seen a complete rewiring. When taking today's domestic electrical applications and today's standards into account, the conductor cross sections used in the wiring from before 1970 will have become inadequate in the large majority of cases. Moreover, the wires might be subject to ageing:

The insulation material could show signs of wear. Weak points in the insulation can be the cause of leak currents or short circuits.	Some types of electrical conductors — for example some types of Aluminium (Al) alloys — age badly. Aluminium (Al) oxide is not an electrical conductor and can create sparks inside the conductor material. Moreover, with older types of Al there could be problems with micro fretting and arcing at Al wiring connectors (e.g. at connections between the wire and devices at switches or outlets) which can cause overheating. The connections can become hot enough to start a fire without even ever tripping a circuit breaker. The problem of inadequate Al wiring is an issue mainly — but not limited to — certain Eastern European regions.

THE HAZARDS OF AN UNSAFE ELECTRICAL INSTALLATION

The use of electricity comes with two main safety risks: an indirect and a direct one.

The indirect risk of electricity is that it may start a fire, causing substantial human and financial damage. A major share of domestic fires in Europe has been shown to be of electrical source (25 to 30% according to the numbers of those EU members for which reliable statistics are available). Moreover, the causes for 50% of the fires remain unknown. It cannot be ruled out that many of these could be of electrical source as well [10]. Ensuring a safe and sound electrical installation is therefore a vital part of maintaining fire safety in the home.

The direct risk of electrification or electrocution due to contact with live parts is a better known risk among the general public. We all learned from a young age that we should be careful with touching parts of the electrical installation in the house. Measures are usually taken to avoid making such a contact possible, as well as minimizing the consequences should it happen. Despite this awareness and measures, accidents still occur.

In this chapter we will discuss the causes and consequences of both types of hazards.

FIRES OF ELECTRICAL SOURCE

CAUSES

For a fire to start, three basic elements need to come together in the so called "triangle of fire":

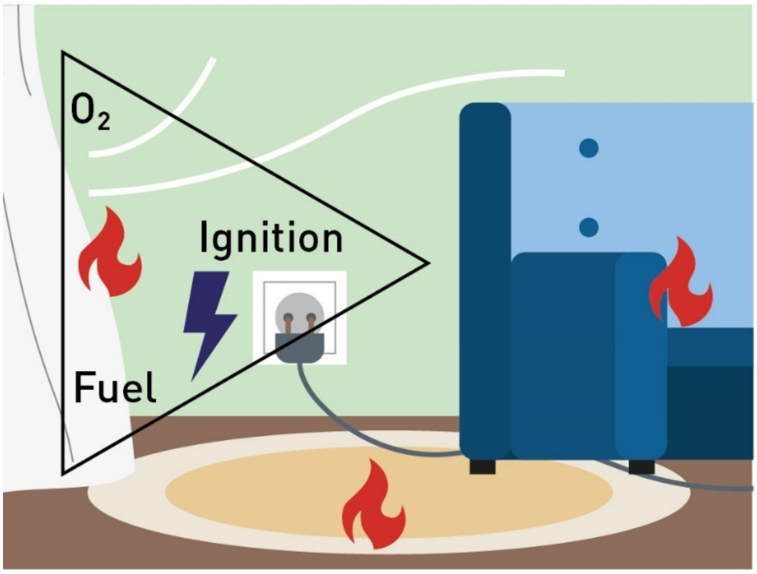


Figure 4

Every house contains the first two elements: oxygen and combustible material. Electricity can be the origin of the heat source that ignites the fire if it has not been properly installed.

When an electric current is flowing through a conductive material, the electrical energy is partly converted into heat — more so if the resistivity of the material is high. This is called the Joule effect. Use is often made of this effect in applications such as electric heating systems and furnaces, but it occurs in every wire and in every device through which an electric current is flowing. In normal conditions, the temperature rise due to the Joule effect in electrical wires and devices is too modest to be hazardous.

Under some fault conditions, however, the local temperature can rise to dangerous levels; namely:

1. **If the current surpasses the current-carrying capacity of the conductor not protected by a circuit breaker.** This can lead to a dangerous situation very quickly, since the amount of heat that is generated rises with the square of the current intensity. Over-currents can be caused by a circuit overload. They can also be caused by short circuit conditions, in which they can reach dramatically high levels.

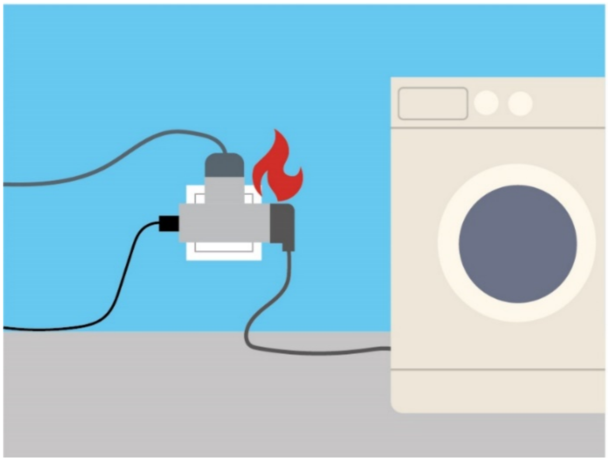


Figure 5 — Overusing adapters or using them for connecting heavy duty appliances can lead to overload: the current becomes higher than what the adapter was designed for. The adapter will heat up excessively and becomes a potential source of fire.

2. **If the resistivity of the electrical installation surpasses standard values.** Loose or bad contacts and degraded conductors are typical causes of increased electrical resistivity. Inappropriate design or installation can be another cause.

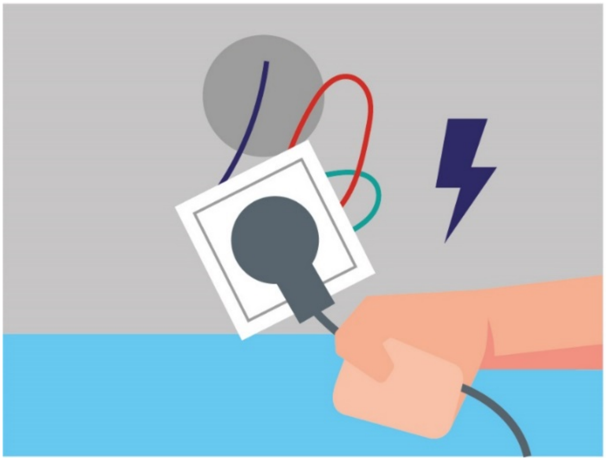


Figure 6 — Loose contacts, e.g. with a loose socket that was kept on being used, can increase the resistivity, leading to a hot spot and a potential source of fire.

3. **If the heat dissipation to the environment is too slow.** This will make the local temperature rise faster. The cause can be an inaccurate design of the installation, in which heat dissipation was not taken into account. In short circuit conditions, the thermal energy that is generated can be so high that timely heat dissipation becomes difficult.

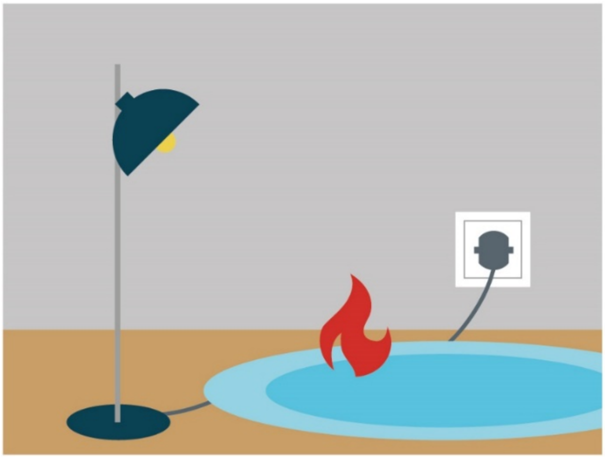


Figure 7 — Preventing the heat from dissipating from electric cables or devices can be dangerous. A common example is a cable hidden under a carpet which might heat up excessively. Moreover, the carpet might be the perfect combustible material to start a fire.

One of those three conditions, or a mixture of those three, can result in high temperature spots in the electrical installation. Such elevated temperatures can act as an ignition source causing fire, depending upon the environmental conditions in the room and the materials in contact with the installation.

CONSEQUENCES

NUMBERS OF FIRES AND FIRES FROM ELECTRICAL SOURCE

In some EU countries, statistics were published that represent the number of fires of electrical source. They all show that this number is substantial.

According to the French ONSE (Observatoire National de la Sécurité Electrique) [11], there was an average of 82,100 reported fires per year between 2010 and 2013. By "reported" we mean that there was an intervention of the fire brigade. The same document estimates the total number of fires to have reached an average of 200,000 per year over the same period. This means that 2 out of 5 domestic fires required an intervention by the fire brigade. According to the ONSE report, 25% of the fires in France are of electrical source. This was concluded after the investigation of 6 different independent studies that cover the period from 1995 to 2014. From this we can ascertain that France sees an annual average of 50,000 domestic fires of electrical source, reported or not.

The figures from the UK show similar tendencies. The UK Electrical Safety Council [12] counted an annual average of 20,000 reported domestic fires of electrical source. If we suppose that the number of reported fires compared to the total number of fires is the same in the UK as in France (2 out of 5), we can conclude that the UK also has an annual average of 50,000 domestic fires of electrical source, reported or not.

The total number of dwellings in France and in the UK is almost similar (27,260,000 in France versus 27,765,000 in the UK), which means that we can detect a strong coherence between the figures of both countries.

In Germany, an assessment by the German Fire Brigades calculated a total of 26,100 reported fires from electrical source per year in the country. Using the same key as for France and the UK concerning the share of reported fires (2/5), the total number of residential fires of electrical source in Germany (reported or not) is estimated to be 60,000 per year.

Similar statistics exist in Poland [13]. In this country, the State Fire Service reported an average of 22,319 fires per year in residential buildings (figures from 2007-2009). Using the same key as for France and the UK concerning the share of reported fires (2/5), the total number of residential fires in Poland (reported or not) is estimated to be 55,800 per year. According to the statistics of the State Fire Service, 11% of all domestic fires had defect or incorrect operation of electrical equipment as a cause. Fire causes categorized as "unknown" or "other" accounted for 24% of the domestic fires.

Supposing a similar division of causes for the unknown cases as for the known cases, an additional 3.5%[1] has to be added to the reported figure, bringing the total number of fires from electrical source to 14.5% of all domestic fires, or 8,090 fires per year.

Spain sees 7,300 reported fires of electric source in dwellings, according to the IFSA and FISUEL [14]. Using the same key as for France and the UK concerning the share of reported fires (2/5), the total number of residential fires of electrical source in Spain (reported or not) is estimated to be 18,250 per year.

Nordstat provides data from five European countries (Denmark, Finland, Sweden, Estonia and Norway) who all collect fire statistics on the same basis. The total number of electric fires in these countries (whether reported or not) is estimated at 10,690 per year from a total of 13 million dwellings. [15]

INTERPRETATION AND EXTRAPOLATION OF THE FIGURES

Some of the statistics presented above (e.g. those of France and the UK) were gathered after extensive research by a network of collaborating expert stakeholders and can be considered to be highly reliable. They clearly show that electrical safety issues constitute a substantial problem regarding fire safety.

Starting from the reliable figures, we constructed conservative extrapolations for other countries in the Northwestern EU. We continued this exercise with the slightly less consolidated data to make even more prudent extrapolations for Southern, Eastern and Central Europe. Even though the resulting figures are not confirmed by assessments in the field, they do provide an idea of the probable size of the problem in those countries. The authors of this document would be eager to collaborate with stakeholders (fire brigades, insurance companies, et cetera) to collect more actual and consolidated numbers for those countries.

[1] Of the 76% known fire causes, 11% had an electrical source, or one out of 6.91 (= 76/11). Applying the same division for the 24% of unknown causes, then 24/6.91 = 3.47% of those unknown causes would be electrical.

NORTHWESTERN EU

For the Northwestern EU, we combined the French, German and UK figures. Taking the average of both figures, we calculate that **one out of 636 dwellings experiences a fire of electrical source each year**. Extrapolating this to the other countries of this region, we come to the following results:

Per year	*# Population*	Number of dwellings	Electrical fires (reported or not)
Austria	8 665 550	3 778 180	2 580
Belgium	10 449 361	4 372 881	7 430
France	66 259 012	27 259 012	50 430
Germany	80 854 408	41 550 300	60 000
Ireland	4 892 305	1 815 045	3 090
Luxemburg	570 252	221 828	380
Netherlands	16 947 904	6 921 070	11 770
United Kingdom	64 088 222	27 767 000	51 370
Total	252 727 014	113 685 316	187 050

Table 2

NORDIC COUNTRIES

For the Nordic EU countries (Denmark, Finland, Sweden, Estonia) we could use the figures provided by Nordstat, so no extrapolation was required [15].

Per year	*# Population*	Number of dwellings	Electrical fires (reported or not)
Denmark	5 581 503	2 790 751	2 280
Estonia	1 265 420	613 729	520
Finland	5 476 922	2 908 245	2 160
Sweden	9 801 616	4 763 585	3 840
Total	22 125 461	11 076 310	8 800

Table 3

EASTERN & CENTRAL EU

For the Eastern & Central EU, we used the figures from Poland. In this country, **one out of 1,401 dwellings experiences a fire of electrical source each year**. Extrapolating this to the other countries of this region, we come to the following results:

Per year	*# Population*	Number of dwellings	Electrical fires (reported or not)
Bulgaria (1)	7 186 893	2 874 757	1 630
Croatia (1)	4 464 844	1 785 938	1 010
Czech Republic	10 627 448	4 537 920	3 060
Hungary	9 897 541	4 246 045	2 400
Latvia	1 986 705	915 871	520
Lithuania	2 884 433	1 124 929	640
Poland	38 562 189	14 282 292	13 950
Romania	21 666 350	7 769 601	3 870
Slovakia	5 445 027	1 775 079	1 000
Slovenia	1 983 412	710 061	400
Total	104 704 842	40 022 493	28 480

Table 4

(1) *No figures available for number of dwellings. The figure used here was derived from the average number of dwellings per 1,000 inhabitants of the other 9 Eastern & Central EU countries and then multiplying this figure (namely 400) by the number of inhabitants of Bulgaria and Croatia respectively.*

SOUTHERN EU

For the Southern EU, we used the figures from Spain. We calculate that **one out of 1,272 dwellings experiences a fire of electrical source each year.** Extrapolating this to the other countries of this region, we come to the following results:

Per year	*# Population*	Number of dwellings	Electrical fires (reported or not)
Cyprus	1 189 197	493 517	350
Greece	10 775 643	6 384 353	4 590
Italy	61 855 120	24 141 324	17 360
Malta	413 965	144 474	100
Portugal	10 825 309	5 661 637	8 250
Spain	48 146 134	25 382 000	18 250
Total	133 205 368	62 207 305	48 900

Table 5

CONCLUSION FOR THE EU

Per year	*# Population*	Number of dwellings	Electrical fires (reported or not)
Northwestern EU	252 727 014	113 685 316	187 050
Nordic countries (minus	22 125 461	11 076 310	8 800
Eastern and Central EU	104 704 842	40 022 493	28 480
Southern EU	133 205 368	62 297 305	48 900
Total	512 762 685	227 072 424	273 230

Table 6

We can conclude from the above figures that approximately **273,000 domestic fires of electrical source occur in the EU each year** (reported or not) representing more than 0.12% of the entire housing stock.

PROPERTY AND OTHER DAMAGE BY FIRES

ESTIMATED COST OF FIRES IN EUROPE

According to the ONSE report on electrical safety in France of 2015 [11], the insurance cost for property damage was on the average € 10,000 per fire in the period between 2010 and 2013[2]. The total number of fires in this period was 200,000 per year on the average. As a result, the total annual property damage caused by fire in France can be estimated to be € 2 billion. Since the EU has 5.6 times the number of fires of France (see tables 2 and 5) and the GDP per capita in France was 107% the EU average in 2014 (source: Eurostat), the total annual property damage caused by fire for the entire EU can be estimated to be more than € 10 billion.

ESTIMATED COST OF FIRES FROM ELECTRICAL SOURCE IN EUROPE

ONSE makes a rough estimate by supposing that the property loss due to electrical fires is one quarter of the total property loss. This is a linear extrapolation from the conclusion (mentioned above) that the number of fires of electrical source is one quarter of the total number of fires. It was thus estimated that the cost of property damage is € 2.5 billion.

However, strong indications exist that fires from electrical source have a cost that is a multiple of the average fire cost. This assumption is confirmed by the UK study "Fires in the home: findings from the 2000 British Crime Survey" by the *UK Department for Transport, Local Government and Regions* [6]. According to this study, the mean cost of an electric fire is 5 times the average fire cost. This figure is consistent with the one in [16], based on studying fire statistics in 8 EU countries.

Based on these assumptions, the total annual cost of property damage due to fires of electrical source in residential buildings in the EU would be € 6.25 billion. Given the approximate character of this figure, we can assume a fork for this total **annual property damage between € 5 and 7 billion**.

---

[2] In the UK, RISC Authority reported an average insurance cost for domestic fires of £13,250 in the period between 2000 and 2014, which is in the same order of magnitude as the figures of France.

INJURIES AND DEATHS THROUGH FIRES

Only a few countries have complete data concerning injuries and fatalities caused by fires. According to the French ONSE report, domestic fires in France caused 310 fatalities and 15,830 people injured on the average per year between 2010 and 2013 [11]. This means there was an average of 4.68 deaths per million people.

In the UK, domestic fires caused 268 fatalities and 7,776 people injured in 2010 [12]. This means there was an average of 4.18 deaths per million people.

In Poland, an annual average of 450 fatalities and 24,690 people injured due to domestic fires were counted between 2007 and 2009 [13]. This means there was an average of 11.67 deaths per million people.

In Spain [14], an annual average of 150 fatalities and 1,600 people injured due to domestic fires of electrical source was reported; or 625 fatalities and 6,667 injuries per year if all types of domestic fires are taken into account.

Fire Safe Europe [17] estimates that the entire EU counts 4,000 deaths due to fire per year, or 11 death per day. A quarter of the fires is estimated to be from electrical source, leading to an estimation of 1,000 to 1,200 deaths annually due to domestic electrical fires throughout the entire EU, or between 2 and 3 death per day.

ELECTRIFICATION AND ELECTROCUTION

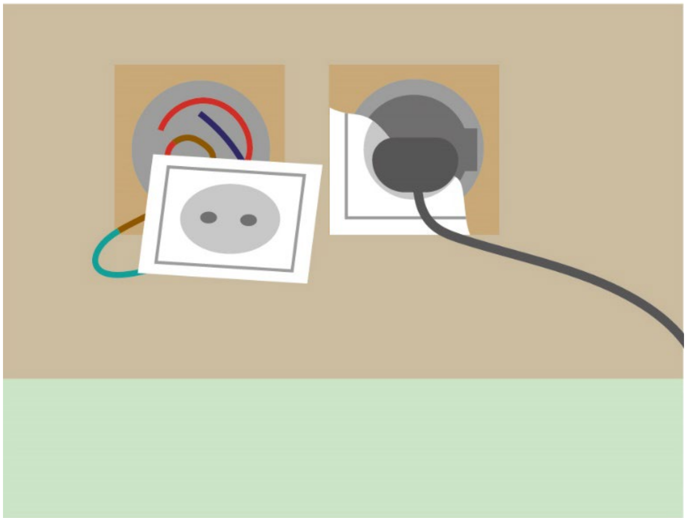
CAUSES

The term electrification is used to indicate an event where a person is subjected to electrical current. The term electrocution refers to electrification with *lethal* consequences.

An electrification incident can occur due to either of the following:

Electrically live parts of the installation are accidently exposed to human contact (e.g. damaged power cables with exposed conductor cores, power outlets with missing protective covers, et cetera)

Figure 8



Exposed, non-electrical parts of the installation are accidently electrically charged (e.g. the metal housing of a device with faulty insulation)

Figure 9

A special case can occur in case of a lightning strike on or near the residential building. The dispersion of the electrical current followed by the strike can create substantial voltage gradients in the ground or in the building structure, which can be dangerous when touched.

EFFECTS

During electrification, the resistance of the person's body is part of the electric circuit. The physiological effects of a 50 Hz current applied to a body vary with the current amplitude, the contact points on the body, and the length of time the current flows through the body. It does not depend directly on the applied voltage, but for a given path the current is almost proportional to the voltage. Current densities in the body are determined by the resistance of the tissues in the path of the current. The skin has the highest resistance — in the order of several kΩ. Once inside the body, the resistance to the current is affected by the density, shape, orientation and size of the tissue cells. The resistance between two limbs is typically a few 100 Ω. Currents paths between both arms and between a leg and an arm are the most hazardous because the current can pass through the heart zone as well as through the muscles controlling breathing.

The following table gives an overview of the effects of electrical currents on the human body at common power frequencies (50Hz and 60Hz) [18]. Minor differences can exist between persons, as well as between the results of various studies, but the general tendencies are consistent.

Current	Reaction
< 1 mA	Generally, not perceptible
1 mA	Faint Tingle
5 mA	Slight shock felt. Not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6 to 25 mA (women)	Painful shocks. Loss of muscle control.
9 to 30 mA (men)	The freezing current or so-called let go range. If extensor muscles are excited by shock, the person may be thrown away from the power source. Strong involuntary reactions, however, can render an individual unable let go. In either event, this can lead to other injuries.
1.0 to 4.3 A	Rhythmic pumping action of the heart ceases (fibrillation). Muscular contraction and nerve damage occur. Death is likely.
0 to 150 mA	Extreme pain, respiratory arrest, severe muscle reactions. Death is possible.
10.00 A	Cardiac arrest, severe burns. Death is probable.

Table 7 — Indicative effects of electrical current on the human body (common power frequency).

Allowing currents of over 30 mA to travel through a person can never be considered safe and even currents as low as 5 mA can constitute a hazard to persons, depending on circumstances.

For France, this trend is illustrated by the following timeline:

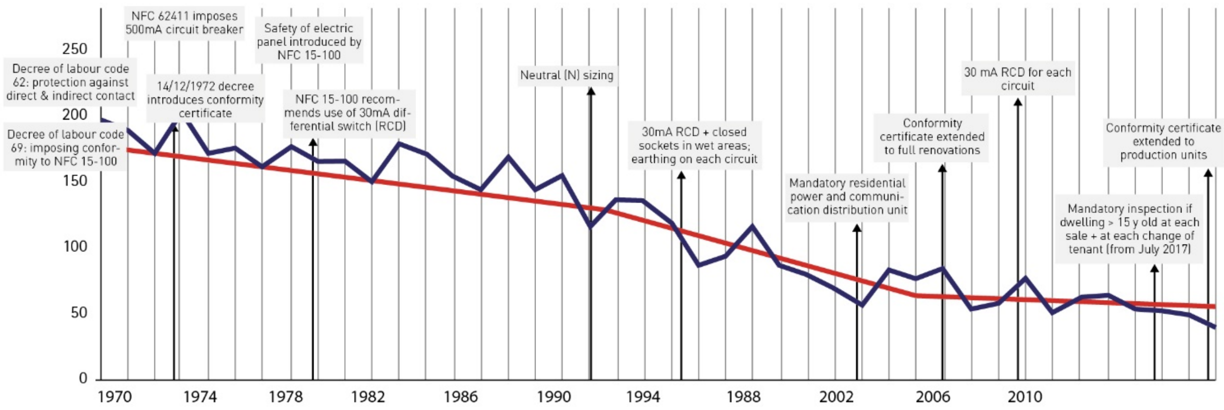


Figure 10 — The total number of fatal electrocutions in dwellings per year between 1970 and 2015, in France. The positive influence of regulation and standardization is clearly visible.

CONSEQUENCES

According to figures from the *World Health Organization* and the *UK Health and Safety Executive*, 78% of the fatalities due to electrocution in the UK in 2010 happened at home or during leisure activities and only 12% happened at work [12]. The *Electrical Safety Council* estimates that every year, an estimated 2.5 million (or 5% of the 50 million adult population) receive a 230 V electric shock in their home or garden in the UK. Of these, 350,000 are significantly injured [12].

In France, InVs and ONSE calculated an average of 60 fatalities due to electrocution per year [11]. Also in France, ANAH (*Agence Nationale pour l'Amélioriation de l'Habitat*) calculated that about 200,000 individuals suffer burns due to electrification in their home each year [19].

Taking the average of the figures of the UK and France, we calculate an annual rate of 0.6 deaths due to electrocution per million persons. Extrapolation leads to **an annual average of 300 fatalities due to electrocution in the EU**.

Again taking the average of the figures from the UK and France, we estimate the number of injuries due to electrification per million persons per year to be around 4,000. Extrapolation leads to **an annual average of 2,000,000 injuries due to electrification in the EU**.

CONCLUSION ON ELECTRIFICATION, ELECTROCUTION AND FIRES OF ELECTRICAL SOURCE

Our investigation shows that numbers of electrocutions and injuries due to electrification differ significantly from country to country but show a consistent evolution over the years throughout the entire EU. The introduction of ever more stringent electrical safety standards and regulation has clearly resulted in a positive, downward trend of these figures in all countries, as the mandatory installation of Residual Current Devices.

The same trend cannot be witnessed in the figures of fires from electrical source. **Electrical safety standardization measures without periodic inspections have proven to be insufficient in this respect.** As we will discuss in the next chapter, **periodic inspections that verify whether the electrical safety standards are actually applied could create a similar positive downward trend in the number of fires.**

ENFORCING ELECTRICAL SAFETY

ELECTRICAL SAFETY STANDARDS

The international standard of the **IEC (International Electrotechnical Commission)** with number IEC 60364 treats "Low voltage electrical installations and protection against electric shock". This standard has been entirely taken over by the European standardization body **CENELEC (*Comité Européen de Normalisation Electrotechnique*)**[3] under the code number HD384. The IEC and CENELEC define a solid basis on which the individual countries can inspire themselves to gradually adapt and improve their own historically grown safety standards.

[3] CENELEC (European Committee for Electro-technical Standardization) was created in 1973 as a result of the merger of two previous European organizations: CENELCOM and CENEL. CENELEC is a non-profit making technical organization set up under Belgian law and composed of the National Electro-technical Committees of 27 European countries. In addition, 8 National Committees from Central and Eastern Europe are participating in CENELEC work with an affiliate status. CENELEC members have been working together in the interests of European harmonization since the 1950s, creating both standards requested by the market and harmonized standards in support of European legislation, which have helped to shape the European internal market.

The IEC/CENELEC standard consists of 5 parts[4].

PART 1	PART 4	PART 5	PART 6	PART 7
Discusses fundamental principles, definitions and the assessment of the general characteristics	Describes technical protection measures for a safe electrical installation	Describes how to select and install electrical equipment	Tackles the inspection of the electrical installation (initial and periodic verification)	Treats specific installations (e.g. medical installations, marinas, bathrooms, photovoltaic installations, et cetera)

In Part 6, the IEC 60364 recommends an **initial inspection** after the installation comes into use or after an addition or alteration is made to an existing installation. The goal is to verify whether the other parts of IEC 60364 have been met. The standard describes which visual inspections and measurements should be executed, how often, and how the results should be reported.

Part 6 of IEC 60364 **also recommends periodic inspections of the electrical installation**. Such verifications should "*take into account the results and recommendations of former inspections as much as possible*" (6.5.1.1). Moreover, "*All details of damage, wear, faults or dangerous conditions of the installation should be written down in the report*" (6.5.1.4). And "*The inspection should be executed by a qualified person with expertise in the field of periodic inspections*" (6.5.1.5).

Concerning the frequency of inspections, it stipulates that "*the maximum interval between periodic inspections may be laid down by legal or national regulations.*" **A 10-year inspection interval for residential dwellings is mentioned as a good practice.** It furthermore mentions that "*a verification of the electrical installation is strongly recommended with each change of building occupancy*" (6.5.2.1) [20] [21].

[4] Parts 2 and 3 no longer exist. The former "Part 2—Fundamental principles" (1970) and "Part 3—Assessment of general characteristics" (1993) were replaced by a new "Part 1 fundamental principles, assessment of the general characteristics, definitions" in 2001.

The EU Commission Recommendation on building modernization accompanying the revised EPBD also refers to regular inspections of household electrical installations as good practice [22].

Despite EU recommendations, only a minority of EU countries have a system in place for periodically inspecting domestic electrical installations.

The national standards that exist in all EU countries are based on the IEC and CENELEC standards, but differ significantly in their implementation. Updates of those standards generally apply only to new buildings, and sometimes to large renovations. They are, however, **almost never applied retroactively**. As in most EU countries there is also no system of periodic inspections in place, installations continue to contain features that are considered to be unsafe according to the latest standards. A major proportion of the EU housing stock does not yet have the safety features that were introduced in the standards in the 1970's and 1980's, such as circuit breakers and Residual Current Devices (RCD's)[5].

TYPES OF ACTION IN EUROPE

THE IMPORTANCE OF DATA GATHERING

Each regulatory action or adjustment should be based on a thorough knowledge of the actual situation. Two types of data are essential:

- **Statistics about electrical fires** and the fatalities, injuries and property loss they are causing, and similar figures about electrification incidents.

The UK provides some of the most detailed fire statistics in the EU. Nevertheless, the Fire Safety Platform expressed its concern in relation to the current data recording systems. They are often "insufficiently integrated, disparate in nature, and not sufficiently accessible to stakeholders". The platform recommends **setting up a National or EU System in place to record the incidence of fires** involving electrical installations, in order to provide robust evidence of performance. [23]

- **The results of inspections**, namely the number of installations that were considered unsafe, the type of anomalies that were recorded, and the number of corrective measures that were taken following the inspection.

[5] Cf. a survey of 16,000 dwellings on electrical safety in Europe (www.electric-safety.org). On average, 67% of dwellings do not have mains protection by RCD, a safety device which has been available for over 20 years.

PREVENTIVE ACTIONS

To ensure electrical safety in dwellings, the first important aspect is to make sure that electrical installations are designed and installed according to proper safety standards right from the beginning.

The following measures have been observed across Europe:

- An established system for **life-long training of electrical installers**. Whether access to the profession is regulated or not, installers need continuous training in the changing requirements and safety standards of an electrical installation.
- A **qualification system for electrical installers**. Hiring a qualified installer should give people the guarantee that works will be executed according to the latest standards. If the work doesn't meet the requirements, the client should have access to a formal complaint procedure.
- **New installations and major renovations should be the work of certified installers, or verified by certified experts, or both.**
- Demanding that all the small electrical works in the domestic environment are carried out by certified electrical installers would be exaggerated. **Continuous information and awareness campaigns** should improve the electrical safety knowledge of do-it-yourself workers that carry out small jobs on the electrical installation.
- Installers, and even more so do-it-yourself workers, can be misled into buying counterfeit, poor quality or faulty electrical cables and products. A system of **product registration and manufacturer recall arrangements** with the active support of retailers could be a remedy.

The residential electrical safety regulation in the UK can serve as a good example on how to organize these actions. It makes a difference between "non-notifiable" and "notifiable" work. For the latter, a registered installer or an inspection by a third party certifier is mandatory. By keeping the second option, access to the profession of electrical installer is kept open, stimulating free competition. This is not the case in Germany, where all electrical installers need to be registered.

Also in the UK, new research by *Electrical Safety First*, a leading consumer safety charity, shows that **do-it-yourself (DIY) work is gaining in popularity** among the younger generation. Electrical Safety First launched a TV and internet video spot (called *DIY Nation*) to warn DIY's about the dangers of electrical work. [24]

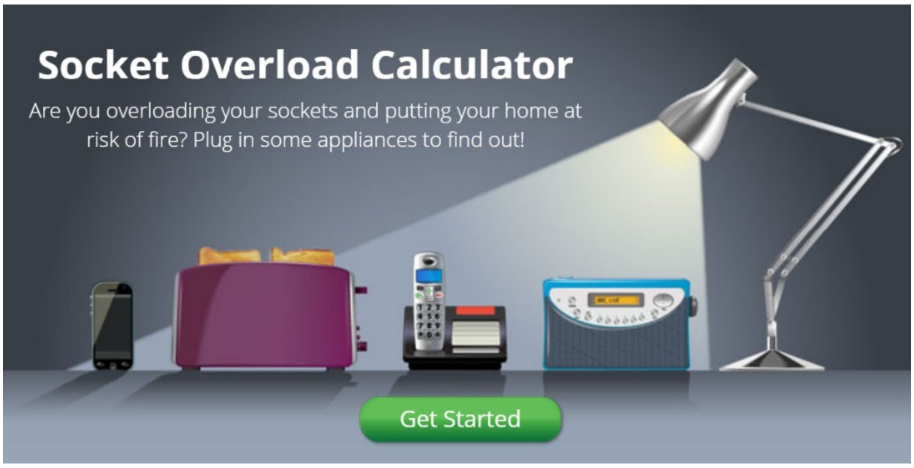


Figure 11 — An online Calculator provided by Electrical Safety First helps consumer to check if sockets are exceeding maximum load [25].

A system of **product registration for electricity products** can enable a recall of products from the moment they are discovered to be counterfeit, non-spec or illegal. However, such a system did not have the desired results in the UK. A major cause could be privacy issues; consumers might not like the idea of registering their purchases in a data bank. The system is currently under evaluation. Stressing more clearly that data are only used in case of product recalls could be one way to improve the system.

In France, a **national information campaign on electrical safety** [26] was launched in March 2015, organized by GRESEL (*Groupe de Réflexion sur la Sécurité Electrique dans le Logement*) with the support of the national consumer association INC (*Institut National de la Consommation*). It is another good example of how to make people aware of the dangers of the domestic electrical installation, the regulatory obligations and the necessity to contact professionals for inspections as well as for all renovation jobs.

Figure 12 — A YouTube campaign by PROMOTELEC and FASE foundation in France warns of the danger of an unsafe electrical installation [27].

REGULATION

VARIOUS TYPES OF EXISTING REGULATIONS THROUGHOUT THE EU

INITIAL VERIFICATION OF THE ELECTRICAL INSTALLATION

In the majority of the EU countries, **an initial third-party verification of the electrical installation** in new residential buildings is mandatory [28, 29][6]. Who coordinates and who executes those inspections depends upon the country and the type of building. The majority of the inspections in the EU are executed by private inspection companies or third party authorized electricians. In some cases, a central government department, the distribution network operator or the electricity supplier play a role. Municipal inspection regimes, which are common in North America, hardly exist in Europe. An exception is Italy, where the local public authorities can assign private installers to organize the inspections.

In some countries (e.g. Germany, Finland, Norway), third-party inspection of the installation is not mandatory, but **the work on the installation needs to be executed by certified electrical contractors**.

In the Netherlands, the initial inspection of the electrical installation in new buildings are included in the standards but not enforced by public law. As a result, it is often not carried out for small residential installations [28].

Verification that the inspection (or certified installation) has been executed is in the hands of distribution network operators or public authorities. In most EU countries, distribution network operators request an inspection report before connecting the new electricity meters to the grid.

INSPECTION OF EXISTING ELECTRICAL INSTALLATIONS

The majority of European countries do not have regulation for verifying domestic electrical installations after the initial inspection. Among countries that do require periodic inspections, the protocols vary greatly. The following four strategies can be roughly distinguished:

[6] The input from Bulgaria, Latvia and Slovenia on this subject is missing.

PERIODIC INSPECTIONS AT FIXED INTERVALS

CENELEC (*Comité Européen de Normalisation Electrotechnique*) recommends a periodic inspection of the electrical installation **at least every 10 years and at each change of occupancy** (owner or tenant). [21]

INSPECTIONS WITH EACH CHANGE OF OCCUPANT

In this system, an inspection of the electrical installation is mandatory at each change of owner and/or tenant. An inspection report has to be presented to the (potential) buyer or tenant, increasing the transparency of the transaction. Usually, this only applies to buildings of a certain age, and an exemption is being made if such an inspection has been carried out in recent years.

ALL MAJOR WORKS MUST BE EXECUTED OR VERIFIED BY A QUALIFIED INSTALLER

In this system, the emphasis is placed upon certification of professional skills which obliges the installer to follow the prevailing safety standards. In some cases, non-certified installers are allowed to carry out work if it is verified by a certified third party. Often this system is combined with a voluntary regime of periodic inspections.

OWNER'S RESPONSIBILITY

In some countries, the responsibility for ensuring the safety of the electrical installation is left to the owner.

RECOMMENDATIONS

EUROPEAN LEGISLATION

The revised Energy Performance of Buildings Directive (EU) 2018/844 opened the possibility for EU Member States to introduce measures aimed at improving fire safety in their Long-Term Renovations Strategies (LTRSs).

In its Recommendation (EU) 2019/786 of 8 May 2019, the European Commission specifies that a building renovation could include "*renovations to improve accessibility for people with reduced mobility, to improve building safety (e.g. for fire, flood, seismic or faulty electrical risks) or to remove asbestos*".

In the same Recommendation the Commission also specifies that "*less expensive housing tends to be older with obsolete electrical installations, making energy-poor consumers particularly vulnerable. Measures such as regular inspections and upgrades to electrical systems up to safety standards can dramatically improve electrical safety. The safety inspection of electrical installations and appliances is also to be encouraged. In the EU, degraded or faulty electrical installations cause 32 home fires every hour (20-30% of all domestic fires).*" [30]

FEEDS RECOMMENDATIONS

FEEDS analysed the general framework, putting special focus in the regulatory framework, regarding the renovation of electrical installations in dwellings in various countries. It also studied actions to promote domestic electrical safety throughout Europe and identified which countries have good practices and their key characteristics. The following list of recommendations is aimed at countries looking to initiate or strengthen national initiatives in this area.

General framework	
To have mandatory technical requirements for domestic electrical installations at national level ("wiring rules")	
To regularly verify whether European standards pertaining to electrical installations have been updated, and to update national rules accordingly	
Initial safety inspections at every new installation, carried out by qualified persons.	
Periodic inspections of existing installations, ideally at least every 10 years, or triggered by a change in owners or tenants, or by insurance companies. Inspections should be carried out according to a reference checklist and carried out by qualified persons. The checklist must target the key safety elements of the installations with the objective of protecting persons and property. It should aim for simplicity, favouring visual inspection over measurement, to mitigate the economic cost of the inspection.	
Inspection reports to be provided to the owner identifying any unsafe parts of an installation. Reports should remain on the premises as official documents.	
Other actions for promotion	
The involvement of all stakeholders, including fire services, insurance companies, consumer associations, tenants' associations, manufacturers, wholesalers, installers and public authorities. This is already a reality at EU level thanks to FEEDS.	
Awareness and prevention campaigns to...	... disseminate facts and statistics on electric shocks and electrically induced fires
	... provide information on the risks of an unsafe electrical installation
	... promote qualified electrical installers
Support for independent organizations dealing with the safety of electrical installations (e.g. Electrical Safety First in the UK, GRESEL and Promotelec in France and PROSIEL in Italy).	
Maintenance of domestic energy renewable installations	
Support for the work of market surveillance authorities who focus on eliminating unsafe electrical products from the market.	

Table 8 – FEEDS recommendations.

BEYOND EUROPE: THE INTERNATIONAL PERSPECTIVE

USA

According to the US National Fire Protection Association (NFPA), fires in the US decreased from 3.3 million to 1.3 million between 1977 and 2015, and the number of fire deaths fell from over 7,000 to roughly 3,000. However, the president of the NPFA John Pauley warned of the new challenges in electrical safety that are coming to us, not the least of which are due to technology and life-style changes. In recent years, the NFPA has shifted its focus from writing codes and standards to an information and knowledge centred organization in order to be better equipped to face these new challenges. **Acquiring and analysing data** to better focus its campaigns became one of primary points of emphasis, as well as targeted campaigns to provide users with reliable information on codes, standards and best practices.

Figure 13 — Example of an information campaign by the NFPA in the US.

JAPAN

In Japan, an inspection of the electrical installation every 4 years has been mandatory for all dwellings since the early 1960s. Fire statistics demonstrate the positive effect of this measure: the number of fires has been reduced by close to 90% since inspections became mandatory [29].

SOUTH KOREA

A similar law requiring mandatory periodic inspections of the electrical installation has been in force in South Korea since the early 1970s. As in Japan, the number of fires has been reduced by close to 90% since inspections became mandatory [29].

THE WORLD SAFETY BAROMETER

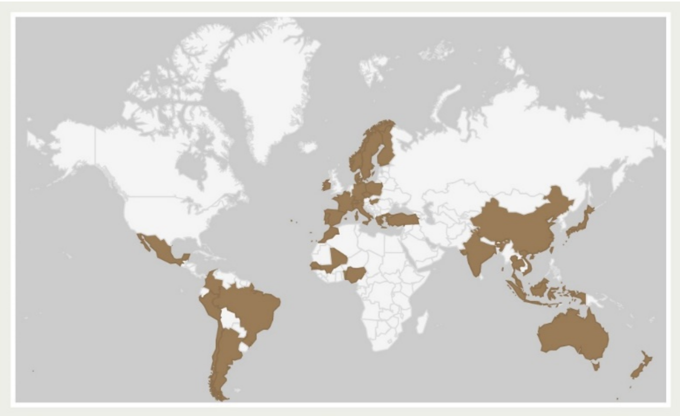


Figure 14 — Countries that are currently covered by the World Safety Barometer.

Before taking regulatory action, it is essential to understand and fully appreciate the gaps in current regulations and practice. The *World Safety Barometer* aims to provide a benchmark to policy makers as well as guidance on how they can improve the situation. It is an initiative of the Copper Alliance, supported and endorsed by FISUEL (the World Association for Electrical Safety) and AIE (the European Association of Electrical Contractors).

The barometer uses 13 criteria that are essential in achieving residential electrical safety. Each criterion is given a weighting factor, which is then used to calculate an overall score. The criteria range from product standards and manufacturer engagement, through inspection practices and the qualification of installers, to an adequate regulatory framework. The final barometer score demonstrates how far a country's actual situation is from best practices. It also functions as a benchmark for comparing the situation with other countries. With the assistance of local experts, the barometer is applied in an increasing number of countries. The results are published on the website and are publicly available. [31]

CONCLUSION ON ENFORCING ELECTRICAL SAFETY

In the best practice case, standardization and regulation of the electrical installation are organized according to two feedback circles of continuous improvement.

Data gathering and periodic inspections are at the centre of the entire system. Unfortunately, it is precisely these two functions that are underdeveloped in most EU countries. They are made all the more essential given the old housing stock and slow renovation rate of EU dwellings, a situation which is creating an increasing deviation between electrical safety standards and the reality throughout the EU.

Therefore, standardization and electrical safety inspections for new buildings alone will not suffice to counter the degradation of residential electrical safety in the EU.

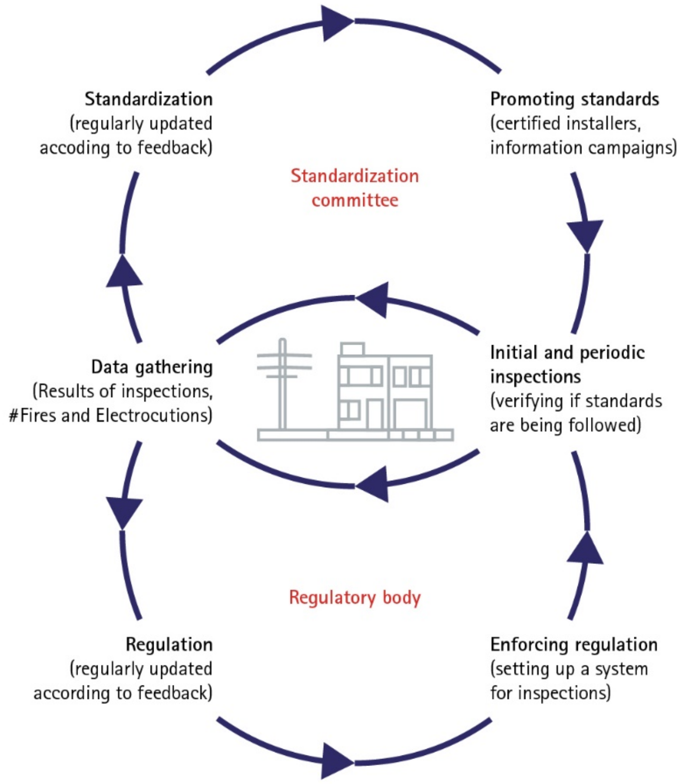


Figure 15

A strong collaboration between the crucial stakeholders will be the shortest way to move towards this best practice.

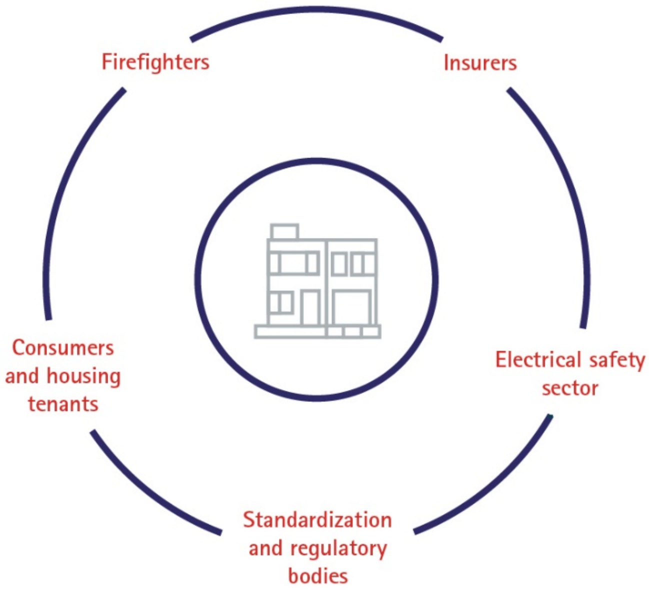


Figure 16 — The stakeholders in the electrical safety regulation debate.

CONCLUSION

The fight against hazardous domestic electrical installations is far from being won in all EU countries. Especially since the trends are towards an amplification of the phenomenon while the uses of domestic electricity continue to develop and diversify.

The major issue of domestic electrical fires is not yet sufficiently taken into account in most EU countries. The lack of reliable statistical tools partly explains this situation.

In any case, the first positive results regarding the improvement in rate of renovation or safety of old electrical installations appear in the countries where the statistical quantification of the phenomenon has been carried out. In those countries, measures have been taken to generalize the condition assessment of the old electrical installations and to inform their owner about this condition.

Where public policies in that direction have been the subject of a cost-benefit assessment, they have in any case proved positive, both for the parties concerned and for the community as a whole.

Recently, the European Commission sent a strong signal to the EU Member States with the revised Energy Performance of Buildings Directive (July 2018). It advocates the development of national policies for safety inspections and upgrading domestic electrical installations as part of more extensive programs to renovate old buildings.

ANNEX 1: EMERGING TRENDS WITH POTENTIAL NEGATIVE IMPACT ON ELECTRIC SAFETY

ON THE MEDIUM TERM

THE ENERGY TRANSITION AND ITS TECHNOLOGY

The electrical energy system is rapidly changing. The EU Renewable Energy Directive targeted 20% renewable energy by 2020. This has stimulated national governments of the Member States to set up various support mechanisms for distributed renewable energy systems, including rooftop PV panels for residential electricity consumers. To continue promoting the development of renewables after 2020, the European Council decided in 2018 on a binding renewable energy target of at least 32% of final energy consumption by 2030 [32].

Another trend is the electrification of residential heating systems. In the past, local fossil fuel burners enjoyed a better environmental assessment when compared to electricity. This made policy makers reluctant to support electrical heating. This balance is now shifting in favour of electricity, thanks to the decarbonisation of electricity generation and the development of technologies such as heat pumps and low energy houses that enable greater efficiency out of limited amounts of electrical energy.

In the near future, private vehicle transport is likely to undergo a similar evolution. Electric Vehicles (EVs) still have to exhibit a major market breakthrough in most EU countries, but a country like Norway demonstrates where we could be heading to in the coming decade. EVs are considered to be a priority for the EU 2030 Energy Program.

All these new electrical devices in the house — PV panels, heat pumps, EV chargers, et cetera — comprise a serious challenge for the domestic electrical system and its safety. All stakeholders should collaborate to make sure that the advantages of those new technologies do not get overshadowed by the appearance of previously absent safety hazards.

PV INSTALLATIONS

The number of residential PV plants, mostly rooftop panels, has been rising steeply over the past ten years. The total installed PV capacity in the EU increased from 1.9 GWp in 2005 to 80.7 GWp in 2013 [33, p.14]. IEA-REDT estimates the share of residential PV systems to vary between 25% and 35% of the total PV capacity in the EU Member States, or 30% on the average [34, p.11].

This means that the total residential PV capacity in the EU in 2013 was close to 25 GWp. Assuming an average residential PV system of 2.5 kWp, we can conclude that approximately 10 million houses in the EU have their own PV installation. This figure is expected to keep on growing in the coming decade.

A residential PV installation poses new challenges to the electrical safety. When a PV panel is integrated into the domestic network, the grid connection will be subjected to bi-directional power flows. This demands a different safety approach. If the grid connection is cut off, the PV panel should switch off as well, or the domestic network might still carry power. Another, albeit technically more complicated option, is to set up the network in such a way that the PV panel can serve as an Uninterruptable Power Supply (UPS) in case of network black outs.

Another point of attention is that the PV panel will produce DC electricity, which is only converted into AC by the inverter inside the house. The DC line going to the inverter brings along new kinds of safety issues. A short circuit happens much faster with DC, requiring a larger gap between the poles of switches. Cables should be separated to avoid short circuits in case of fire. Other potential issues are leak currents that might flow through the metal parts of the roof and through water pipes in the house, or the differential switch that might not work properly.

ELECTRIC VEHICLE (EV) CHARGING

In the first quarter of 2019, more than half of new passenger cars sold in Norway were fully electric (BEVs) [35]. In 2019, there were only about 1.2 million registered electric and plug-in hybrid vehicles in the EU [36], a little less than 0.5% of the total passenger car fleet [37], but rapid market growth is expected over the coming decade, stimulated by the EU 2030 program. Bloomberg expects that 5% of all passenger car sales in the EU will be fully electric in 2022 and 65% by 2040 [38].

The EV charging station is often a challenge for the residential electrical installation. Residential EV charging can take many forms:

1. The non-recommended practice is to simply connect the car to an extension cord. The primary problem with this set-up is many older houses have an electrical installation that does not meet current safety standards. But even if proper wiring, a proper earthing circuit, a residual current device (RCD) and an overload protection are in place, this situation is still not without issues. After several hours of charging the circuit at maximum power, the cable and switch can still overheat and start a fire. If other appliances are connected to the same circuit during the EV charging, the overload protection might trip and shut off the circuit.

2. Slightly better is the set-up with a special single or three phase charging cable instead of an ordinary extension cord. This charging cable has a built-in overload protection device and an earthing conductor. This improves safety, but charging will remain slow and may be interrupted due to cable overload.

3. A good practice would be to install a dedicated electrical circuit in the house with a dedicated wallbox to charge the EV. This circuit could then be designed for carrying higher currents (e.g. up to 40 A) than the usual household circuit (typically 16A). Adding such a circuit to the residential installation requires dedicated knowledge from the electrical installer.

4. A faster vehicle charge can be achieved through a DC connection with an external charging station. This charging station, containing an AC/DC converter and all the required control and protection devices, is installed on a dedicated electrical circuit of the residential network.

Even more popular than electric cars are the electric bicycles and motorbikes. Even though their battery power is lower than that from electric cars, the charging can still pose overload and safety problems on circuits that are already significantly loaded or poorly designed. DIY charging sockets that are installed for this purpose in the garage or on the outside of the house are often problematic.

HEAT PUMPS

Heat pump compressors have a high power load compared to the average residential application. They have to be connected through dedicated two or three phase circuits that will carry higher currents than the average residential circuit. This requires additional attention for electrical safety. Proper cable conductor sizing, a dedicated and well rated circuit breaker, an RCD and a proper earthing circuit are required. Therefore, the electrical works must be installed by a qualified person that is familiar with this kind of installations.

CHANGING DEMOGRAPHY AND LIFESTYLES

AGEING POPULATION, AGEING INHABITANTS OF DWELLINGS

Europe's population is ageing and this will continue in the near future. The base of the age pyramid is shrinking, while the elderly population increases. The proportion of the population above 65 years old in the EU is projected to rise from 17% in 2007 to 24.6% in 2030 [39, p.19].

A second, related trend is that older people will continue to live independent lives in their own home until a higher age. This is partly because people of 65 years old are increasingly in good health, partly because they prefer to do so, and partly also out of necessity. Indeed, a consequence of the ageing population pyramid is that there are going to be fewer people around to look after the elderly. The projected old-age dependency ratio for 2030 indicates that in Germany and Italy there might be only two persons of working age supporting one elderly person over the age of 65 [39, p. 31]. Having the elderly live safely at home for a longer time takes both the pressure off the increasing demand for care and reduces the costs to national health services.

Many of the various technological solutions that exist to assist elderly people living at home are electrically operated. Think about electric stair-lifts, various types of remote controls, safety alarms, tele-monitoring systems or a video link to the doctor, among other solutions [40]. This means that the house and the electrical installation need to be adapted to carry out all those functions without introducing new safety hazards. Many houses and their electrical installations will also need to be adapted for disabled people. An extra difficulty in this matter is that most elderly people live in houses of a considerable age that have often not seen renovation in several decades. Technology assisted living should therefore go hand in hand with a well-functioning program that enhances residential electrical safety and prepares dwellings for life-long-living.

OTHER FLEXIBILITY ISSUES

Life-styles are continuously changing and houses need to be adaptable to cope with those changes. One of the main issues that most dwellings suffer from is a lack of sockets. This is true of even relatively new houses. This problem has grown larger with the increase in electronic devices used at home and with the increasing trend to work from home. One of the problems is also that rooms are often changing function (e.g. a sleeping room becomes a work room) or new functions are added to it (e.g. computer, TV or gaming station in the sleeping room). To compensate for the lack of sockets, occupants often rely upon extension cords. This is a practice which can lead to dangerous situations, among other reasons because the extension cords are often not manufactured according to the standards or even blatantly counterfeited. Some countries (Germany, France) [41] have recognized this problem and created standards in an attempt to deal with this problem.

ON THE LONGER TERM

TOWARDS DC NETWORKS?

With an increasing number of electricity sources providing DC power (PV panels, batteries), as well as an increasing number of appliances that are using DC power (ICT infrastructure, LED lighting, EV charging…), some people wonder why we still need an AC network in between. A growing number of electricity experts are indeed convinced that we should evolve towards a DC electrical system for residential and office buildings. The first pilot projects of office buildings working on DC are already up and running in the Netherlands. One of the main problems with such a shift to DC could be that our electricity installation experts are absolutely not familiar with it and are often unaware of the related safety issues.

ANNEX 2 : ELECTRICAL SAFETY CHECKLISTS

FISUEL MANUAL — ESSENTIAL REQUIREMENTS FOR ELECTRICAL SAFETY

The organization for electrical safety FISUEL published a guide of 5 requirements that enable installers to quickly verify the compliance of an installation with the essential requirements for electrical safety [42].

REQUIREMENT 1

A manually operated switching and isolating device as well as a protecting device must be present at the origin of the installation.

WHY?

To enable the total electrical power supply to be cut off at a single, known and accessible point at the head of the installation during work on the installation or if an incident occurs.

REQUIREMENT 2

Protection against all risks of direct contact with electrically live parts must be ensured.

WHY?

To enable the total electrical power supply to be cut off at a single, known and accessible point at the head of the installation during work on the installation or if an incident occurs.

REQUIREMENT 3

Protection against indirect contact must be present, and it must be in accordance with the earth connection system of the installation. For example: contact with the metallic enclosure of class 1 equipment with an insulation fault will be dangerous if there is no suitable protective measure.

WHY?

To protect persons against injury and electrocution risks resulting from fault currents travelling through the human body.

REQUIREMENT 4

Special measures must be implemented in damp rooms, compliant with the rules related to the zones in these rooms.

WHY?

Wet rooms such as bathrooms, kitchens, laundries, et cetera present a special risk due to the presence of moisture, which increases the risk of electrocution (if no special measures are taken) due to the reduction of the body's resistance, deterioration of the insulation, et cetera.

REQUIREMENT 5

Protection against overcurrent in the customer unit/board must be installed, in accordance with the conductor cross-section of the cables. Protection against overvoltage must be installed as well.

WHY AGAINST OVERCURRENT?

To protect all circuits against overcurrent due to overloads or short circuits, which could damage equipment or even start a fire if no suitable measures are taken.

WHY AGAINST OVERVOLTAGES?

To protect circuits and sensitive appliances (computers, telecommunications, et cetera) against the effects of voltage surges (including the destruction of electronic circuits and fire). This is especially recommended in areas with high lightning risk and where distribution is by overhead lines. It should be noted that failure of the equipment concerned can have consequences for both personal safety and property.

18 INITIAL CHECKS OF ELECTRICAL INSTALLATIONS EVERY ELECTRICIAN MUST PERFORM (IET)

The UK Institution of Engineering and Technology (IET) has published clear guidelines regarding how to carry out an inspection of a residential electrical installation and what exactly must be inspected. [43, 44]

A first important point of attention is that certain information must be available to the inspector before he or she is able to carry out their job. This information should include at least a simple wiring diagram, but can also contain instructions from manufacturers and similar documents.

Before the actual testing procedure can start, the inspector must carry out a detailed physical inspection to verify whether the electrical installation and equipment is:

- ✓ Installed according to a relevant national standard (or harmonized European standard)
- ✓ Erected/installed in compliance with the IET regulations
- ✓ Not damaged or degraded in such a way that it could cause danger

IN ORDER TO COMPLY WITH THESE REQUIREMENTS, THE IET PROVIDES THE FOLLOWING CHECKLIST:

CHECK #1

CONNECTION OF CONDUCTORS

Are all terminations electrically and mechanically sound? Is the electrical insulation and sheathing removed only to a minimum to allow satisfactory termination?

CHECK #2

IDENTIFICATION OF CONDUCTORS

Are conductors correctly identified in accordance with the regulations?

CHECK #3

ROUTING OF CABLES

Are cables installed such that account is taken of external influences, such as mechanical damage, corrosion and heat?

CHECK #4

CONDUCTOR SELECTION

Are conductors selected for a current carrying capacity and voltage drop in accordance with the design?

CHECK #5

CONNECTION OF SINGLE POLE DEVICES

Are single pole protective and switching devices connected in the line conductor only?

CHECK #6

ACCESSORIES AND EQUIPMENT

Are all accessories and items of equipment correctly connected?

CHECK #7

THERMAL EFFECTS

Are fire barriers present where required and protection against thermal effects provided?

CHECK #8

PROTECTION AGAINST SHOCK

What methods have been used to provide protection against electric shock?

CHECK #9

MUTUAL DETRIMENTAL INFLUENCE

Are wiring systems installed so that they cannot have any harmful effect on non-electrical systems, and so that systems of different currents or voltages are segregated where necessary?

CHECK #10

ISOLATION AND SWITCHING

Are the appropriate devices for isolation and switching correctly located and installed?

CHECK #11

UNDER-VOLTAGE

Are there protective devices present where under-voltage may give rise for concern?

CHECK #12

PROTECTIVE DEVICES

Are protective and monitoring devices correctly chosen and set to ensure automatic disconnection in case of over-voltage and/or over-current?

CHECK #13

LABELLING

Are all protective devices, switches (where necessary) and terminals correctly labelled?

CHECK #14

EXTERNAL INFLUENCES

Have all items of equipment and protective measures been selected in accordance with the appropriate external influences?

CHECK #15

ACCESS

Are all means of access to switchgear and equipment adequate?

CHECK #16

NOTICES AND SIGNS

Are danger notices and warning signs present where necessary?

CHECK #17

SINGLE LINE DIAGRAMS/ WIRING SCHEMES

Are diagrams, instructions and similar information related to the installation available?

CHECK #18

ERECTION METHODS

Have all wiring systems, accessories and equipment been selected and installed in accordance with the requirements? Are fixings for equipment adequate for the environment?

REFERENCES

[1] YouTube Video: *NFPA President Jim Pauley talks about progress at the 2016 Conference & Expo in Las Vegas*.

[2] *Housing statistics in the European Union*, OTB Research Institute for the Built Environment, September 2010

[3] *Europe's Buildings under the Microscope*, Building Performance Institute Europe, October 2011

[4] Samuelson-Brown, G. Thornton, M. Repair, *Maintenance & improvement in housing - electrical supply, the supply side*, BSRIA, 1997 (see Reference 43 of *Towards improved electrical installations in European homes* [29])

[5] *The GB Private Home Improvement Market - the demand side for electrical & security system improvements*, Construction Forecasting and Research Limited, 1998 (see Reference 50 of *Towards improved electrical installations in European homes* [29])

[6] Aust, R, *Fires in the home: findings from the 2000 British Crime Survey*, UK Department for Transport, Local Government and Regions, 2001

[7] D. Phillips, Councillor Mid and West Wales Fire Authority, http://www.the-fic.org.uk

[8] *A Shock to the System / Electrical Safety in an Ageing Society*, George Holley-Moore and Jonathan Scrutton – The International Longevity Centre, UK, January 2015

[9] *Hundreds of thousands living in squalid rented homes in England*, The Guardian, 28 January 2018

[10] ISO/cd 17755-2 (= the international standard for how to define the sources of fire)

[11] *Les feux d'habitation et accidents d'origine électrique*, ONSE 2015

[12] M. Allen, *Safety of new and existing electrical installations*, FISUEL and the Electrical Safety Council, 2011

[13] S. Zajac, *Fire Statistics / Concerning fatalities and injured*, HQ of the State Fire Service Hazard Recognition Department

[14] *La revisión de las instalaciones eléctricas de los hogares reduciría 7.000 accidentes por instalaciones deficientes*, press release by the Spanish Copper Institute, 17 July 2012

[15] Nordstat – Nordic Fire Statistics

[16] J. Manson, *Improving electrical wiring safety standards, inspection periodicity and providing more effective controls*, European Copper Institute, 2000 (see Reference 75 of *Towards improved electrical installations in European homes* [29])

[17] Fire Safe Europe / Publications, Facts & figures

[18] B. Brouwers, *Design for electrical safety,* Egemin Consulting for Leonardo Energy, June 2014

[19] *Limiter les risques de brulures et d'électrocutions*, ANAH, 2001, 8 pages

[20] IEC 60364-6-61 and IEC 60364-6-62 at www.iec.ch. Standardization work in progress is not published. Information may be obtained from national standards committees (see members listing of IEC)

[21] ES 59009:2000, May 2000 (www.cenelec.org)

[22] Official Journal of the European Union, *Commission Recommendations (EU) 2019/786 of 8 May 2019 on building renovation*

[23] *Electrical Fire Safety, the UK Experience / A strategic approach to reducing electrical fire risk in the domestic environment*, Fire Safety Platform, December 2015

[24] Electrical Safety First DIY campaign

[25] Electrical Safety First / Overloading Sockets / Use our 'Socket calculator'

[26] GRESEL Electrical Safety leaflet

[27] Fonds d'Action pour la Sécurité Electrique (FASE) / *2018 – La sécurité, c'est aussi éléctrique*

[28] *Questionnaire on the inspection of LV electrical installations*, CENELEC TC 64

[29] *Towards improved electrical installations in European homes*, aie, Europacable, European Copper Institute, Fisuel and UIE, 2003

[30] EU Energy Poverty Observatory, *Addressing safety and energy poverty to better protect vulnerable consumers*, 1 June 2018.

[31] Leonardo Energy Electrical Safety Barometer

[32] European Commission – 2030 climate & energy framework

[33] *PV Status Report 2014*, European Commission, DG Joint Research Centre, Institute for Energy and Transport, November 2014

[34] *Residential prosumers – Drivers and policy options*, IEA – RETD, June 2014

[35] Norsk Elbilforening

[36] European Alternative Fuels Observatory – AF fleet electricity (2019)

[37] European Automobile Manufacturers Association / *Report: Vehicles in use – Europe 2018*

[38] BloombergNEF – Electric Vehicle Outlook 2019

[39] *The Ongoing Population Ageing*, Marija Mamolo and Sergei Scherbov, Vienna Institute of Demography of the Austrian Academy of Sciences, 2007

[40] *Living needs for the elderly*, Guy Kasier, Leonardo Energy, 2010

[41] D. Wijnants, *Advocating a more flexible electricity installation*, Leonardo Energy, 2015

[42] FISUEL Manual / Essential requirements for electrical safety (Existing installations in dwellings), FISUEL, 5 April 2007

[43] IET

[44] Electric Wiring: Domestic – Brian Scaddan IEng, MIET