INPUT PAPER

Prepared for the Global Assessment Report on Disaster Risk Reduction 2015

Disaster impact mitigation through international standards

IEC (International
Electrotechnical Commission)

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Introduction

Millions of devices in hospitals, homes, offices, public administrations, transportation, customs bureaus, banks etc. are dependent on electricity and electronics. Over a third of the world's raw energy is today converted into electricity, tendency rising.

Electricity supply is often the first thing to go when disaster strikes. Electrical installations, devices and supply are generally directly and adversely affected by manmade disasters or natural phenomena such as hurricanes, extreme cold or heat, floods, earthquakes, lightning or solar storms.

In all of these cases, in addition to the injuries, loss of life and infrastructure damage caused by a disaster, the effects on everyday life, safety, education, health care, transportation, commerce and manufacturing and the related costs due to electricity outages can be massive. A 2011 EU Power Quality [i]survey estimates the financial loss due to power outages at around 50 billion Euros each year.

Outages not only cost billions yearly, they can also indirectly trigger human and environmental disasters.

Improving the preparation and response to disasters is a broad and diverse area of activity. It requires efforts in policy, regulation, standardization, conformity assessment and technology development.

IEC risk and impact mitigation

The IEC takes a two-prong approach with regard to disaster risk and impact mitigation:

1. Avoid or minimize the risk and impact of environmental or economic disasters related to the failure of electrical or electronic equipment. A number of IEC TCs (Technical Committees) prepare International Standards that include metrics, rating and testing methodologies, classification systems and other processes that support risk assessment or risk avoidance in the home, offices, manufacturing, public spaces and health facilities. Some IEC International Standards also control the use and management of hazardous substances, as well as end-of-life recycling and waste management.

2. Provide a wide variety of IEC International Standards, which together with conformity assessment ensure that devices and systems, including alarm and emergency systems, are designed and built to resist failure during extreme conditions. They increase overall dependability of devices or systems, providing parameters for measuring reliability as well as supporting maintenance of functionality and repairs.

A very broad scope

The IEC has over 170 technical fields covering all aspects of electronic and electrical systems, devices and components. IEC work covers all aspects of safety in energy generation, distribution and the use of electricity by millions of electrical and electronic devices and components. It also enables interoperability, which facilitates maintenance and repair; is the world leader for electromagnetic compatibility and helps reduce e-waste. IEC International Standards are always voluntary and consensus based and represent the combined state-of-the art know-how of often world-renowned experts. They respond to the needs of stakeholders from 165 countries. Since its inception in 1906, the IEC has been fundamental in the roll-out of all technologies related to electricity and electronics enabling their global trade and facilitating overall energy access.

In addition to standardization, the IEC also runs the only global standardized form of conformity assessment. The IEC CA (Conformity Assessment) Systems are among the most extensive and widely adopted working multilateral agreements in the world.

All of the IEC CA Systems provide services that directly or indirectly help to avert the risk or minimize the impact of disasters. Of these Systems the IECEE (IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components) establishes minimum levels of safety, compatibility and performance for electrotechnical products and equipment used in homes, offices, medical establishments and industry. IECEx (IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres) helps ensure the safety of explosive areas where there is a risk of fire and/or explosion due to flammable gases, liquids and ignitable dusts. IECQ (IEC Quality Assessment System for Electronic Components) provides supply chain management tools that help prevent the use of hazardous materials, non-compliant components and counterfeit parts in the manufacture of componentry and equipment for IT, aviation, automotive and manufacturing automation.

Disaster risk assessment

Disasters can come in many forms, some are man-made while others are the result of the fury of mother nature. The IEC together with ISO has developed a clear methodology for the assessment of risks associated with electrical safety with a view to minimize related disasters of both origins. The methodology, which is detailed in ISO/IEC Guide 51 allows to determine safety needs and minimum risk reduction requirements.

Identification of electrical hazards

The methodology aims to identify the risk and occurrence of electrical hazards that can impact life or property. Those include for example:

- electric shock
- fire and burns
- explosions
- biological or chemical effects
- magnetic and electromagnetic fields
- ionising and non- ionising radiation
- leakage of current or other incorrect functioning
- mechanical hazards
- environmental

This approach is extensively used in the development of safety standards in the IEC.

When equipment is designed, manufactured and installed in line with IEC International Standards it will provide adequate protection against leakage of current, stored charges, arcs, electric shock and burns. Ultimately IEC work helps protect the investment of governments, businesses and communities and the lives of workers and populations.

Techniques to assess risk

The IEC has also published a double logo, double prefix International Standard on risk assessment techniques, IEC/ISO 31010, Risk management – Risk assessment techniques, which is a supporting standard for ISO 31000 Risk management -- Principles and guidelines, and provides guidance on selection and application of systematic techniques for risk assessment. This International Standard was developed by IEC TC (Technical Committee) 56: Dependability.

Dependability is the ability of a product to do its job as and when required without encountering problems. Being dependable means that a product has earned the user's trust and can be relied upon to perform its intended task. Product dependability does not happen by itself but needs to be designed and built into products.

Properties of dependability

- Reliability – how long the product can do its job without failing
- Maintainability – how easy it is to keep the product in good running condition
- Maintenance Support – the ability to have the product fixed when failure occurs at acceptable expense and timeliness

The standards developed by TC 56 apply anything from components, to products, to systems. They provide systematic methods and tools for assessment of dependability and management of equipment, services and systems throughout their life cycles. IEC International Standards cover generic aspects of reliability and maintainability, programme management, testing and analytical techniques, software and system dependability, life cycle costing, technical risk analysis and project risk management.

Functional safety – essential to overall safety

Another area that is fundamental to IEC work is functional safety.

Functional safety describes the part of overall safety that relies on a system or equipment operating correctly in response to its inputs. For example, you would want a safety valve to open or close precisely when it is given the instruction to do so. By extension, when such a security-device fails to operate as it should, for example during deep-sea oil drilling or during the filling of a chemical tank, major disasters can ensue.

The concept of functional safety is applicable across all industry sectors and is fundamental for most safety-related systems. The oil and gas industry, nuclear plants, the manufacturing sector, to name but a few, all rely heavily on functional safety to achieve safety for equipment that can give rise to hazards. IEC 61508: Functional Safety, considers the whole lifecycle of electrical, electronic or programmable electronic systems and products. This IEC International Standard includes specific steps that must be carried out by manufacturers to ensure the absence of unacceptable risk due to hazards caused by the mal-functional behaviour of products and systems.

Mitigating explosion risks

To avoid disasters, safety standards and conformity assessment need to work hand in hand. Functional safety as well as the assessment and mitigation of risks are at the core of the work of IECEx. IECEx not only provides services that verify that devices are able to function safely in explosive areas, it also enables the Ex industry to ensure that design, installation, maintenance, repair and inspection services are of equipment are undertaken by personnel competent to execute them in accordance with the relevant IEC International Standards.

Disaster avoidance

There are multiple examples that illustrate what happens when electric devices and explosive materials meet in an uncontrolled way, without taking into account the safety measures that are built into IEC International Standards and IEC CA Systems.

Equipment failure

In explosive areas, seemingly small failures to perform can have disastrous effects:

> *In the early hours of Sunday, 11 December 2005, a number of explosions occurred at Buncefield Oil Storage Depot, Hemel Hempstead, Hertfordshire, UK. At least one initial explosion was of massive proportions and there was a large fire, which engulfed most of the site. Over 40 people were injured; fortunately there were no fatalities. Significant damage occurred to both commercial and residential properties in the vicinity and a large area around the site was evacuated on emergency service advice. The fire burned for several days, destroying the entire site, emitting large clouds of black smoke into the atmosphere.*

Buncefield UK explosion Photocredit: Getty Collection

The event was caused by the failure of a level switch in a tank. This lead to an overflow of fuel. The presence of an ignition source (possibly the emergency generator or the fire pump system) ignited the fuel and led to the explosion. This is a typical situation that the IECEx System aims to avoid.

Dust: small but deadly

Many forms of dust found in industry are combustible but, to the surprise of many, so too are grain, sugar, cotton and wood dust or particles. Dust explosions can occur in any enclosed area and unfortunately are a frequent occurrence in underground coal mines in the absence of proper precautions and without the use of suitable equipment.

A dust explosion is generally the result of a draft of air that swirls up a layer of dust in a confined area (the dust layer doesn't have to be thick for this to happen). When this dust/air (oxygen) combination comes into contact with an ignition source a violent and expansive explosion can, under certain conditions, occur. The force of the explosion swirls up more dust, which may, in turn, be ignited. In some cases chain reactions such as these sweep through entire buildings or facilities, destroying them. Ignition sources include sparks from electrical or mechanical processes, arcs, open flames, ESD (electrostatic discharge), and electromagnetic waves among others.

> *On February 7, 2008, a huge explosion and fire occurred at the Imperial Sugar refinery northwest of Savannah, USA, killing 14 and injuring 38 others. Although the exact cause of ignition is unknown, the explosion started in a conveyor running underneath sugar silos. The primary explosion raised sugar dust that had accumulated on the floors and elevated horizontal surfaces, propagating more dust explosions through the buildings. Secondary dust explosions occurred throughout the packing buildings, parts of the refinery, and the bulk sugar loading buildings. The pressure waves from the explosions heaved thick concrete floors and collapsed brick walls, blocking stairwells and other exit routes. The resulting fires destroyed the packing buildings, silos, palletizer building and heavily damaged parts of the refinery and bulk sugar loading area.*

Imperial Sugar Refinery explosion Photocredit: fotogalerieindegewelven.nl

Explosions are also a leading hazard at grain elevators. According to the US Occupational Safety and Health Administration, there have been more than 600 explosions over the last 40 years, killing over 250 and injuring in excess of 1 000 people. Because of the explosion hazard that dust represents, all equipment – electric cables and motors, enclosures, isolators and vents, lamps and switches, control systems and many, many more should have the relevant level of dust explosion protection. The use of devices that are certified for hazardous environments together with safety precautions during installation, use, maintenance and repair, as well as inspection allows plants to operate safely, protecting lives of workers and surrounding populations.

The IECEx System has been endorsed by the UN via the UNECE regulatory platform as the recommended global best practice model for verifying conformity to International Standards in explosive areas. The IECEx System is supported by the efforts of the IEC Technical Committee IEC TC 31: Equipment for explosive atmospheres, that prepares and maintains International Standards that aim to avoid such explosions.

Mitigation of future disasters

April 20, 2010. The explosion and fire on the MODU (Mobile Offshore Drilling Unit) DEEPWATER HORIZON results in the biggest environmental disaster in history. The oil-spill in the Gulf of Mexico was caused by the failure of a blowout preventer. It resulted in deep and long-lasting environmental damage and enormous financial and economic impact for the whole region. This disaster underscores the need to address electrical equipment that may present an ignition source for gases or vapours encountered during oil drilling exploration.

Deepwater Horizon Disaster, Gulf of Mexico oil spill view from space, Photocredit : en.wikipedia.org

Deepwater Horizon Disaster, rescue operation Photocredit : valleygreenspace.com

On September 9, 2011 the Coast Guard published the Final Action Memo (FAM) by the Commandant on the recommendations of its investigation into the explosion, fire, sinking and loss of eleven crew members on the MODU DEEPWATER HORIZON. (viewable online: http://uscg.mil/hq/cg5/cg545 and clicking on the Deepwater Horizon-exhibits-transcripts-video link).

The FAM called for the Coast Guard to evaluate whether MODUs engaged in U.S. OCS (Outer Continental Shelf) activities should be subject to independent testing and certification of electrical equipment installations in hazardous areas. In February 2013 the US Coast Guard adopted a rule that is applicable to all foreign-flagged MODUs: Henceforth equipment that is certified to IECEx requirements under the IEC 60079 International Standards Series do not need additional hazardous location assessment.

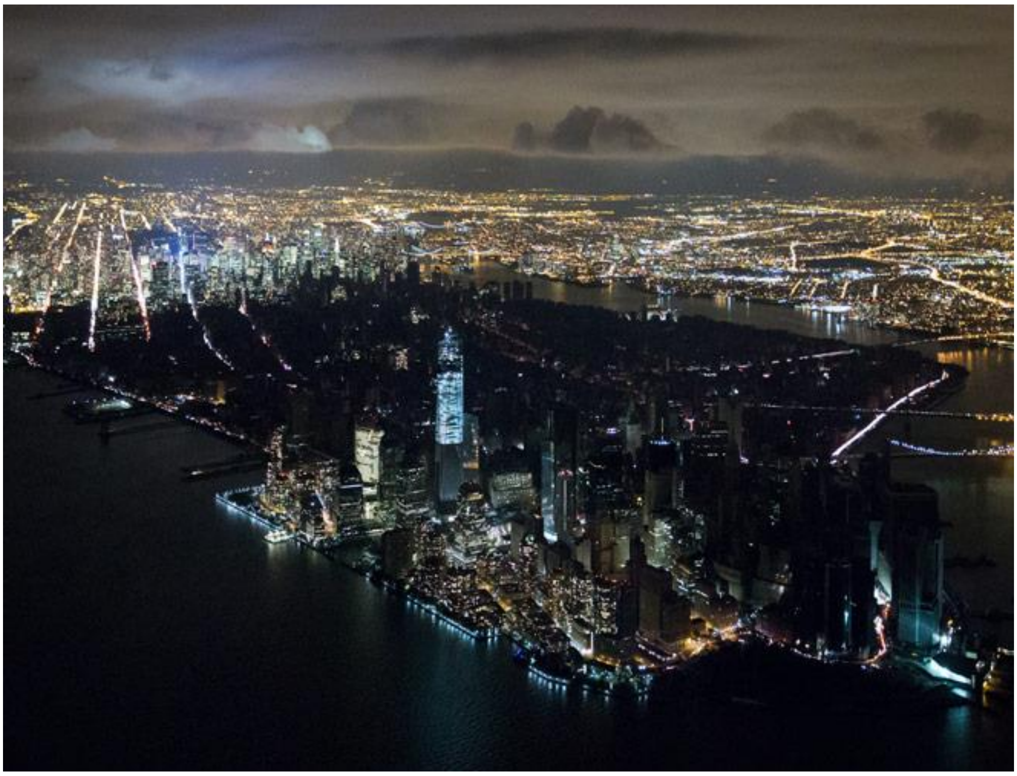
The US Coast Guard (USCG) have indicated their acceptance of IECEx Certificates issued by IECEx bodies on their list of approved bodies for installations under their jurisdiction for other areas.

Offshore drilling is a particularly dangerous activity in which a harsh environment is combined with hazardous substances - the IECEx System seeks to ensure that operational equipment is not able to cause fires or explosion. Safety on offshore installations relies largely on the proper and safe interaction of equipment and human factors. Proper electric installations are absolutely central to the safe operation of offshore units; IEC TC 18 develops International Standards for such installations in collaboration with IMO (International Maritime Organization). The seven Standards in the IEC 61892, *Mobile and fixed offshore units - Electrical installations* series are intended to enable safety in the design, selection, installation, maintenance and use of electrical equipment in offshore units.

Resisting disasters

Today, the impact of disasters is significantly worsened by power outages that paralyze essential services and rescue infrastructures alike. IEC International Standards help increase the disaster resistance of essential infrastructure and make it easier to rebuild.

> *Hurricane Sandy hit the US Eastern seaboard in late October 2012, after having wreaked devastation in many countries and islands in the Caribbean region. Sandy destroyed transformers, downed overhead power lines and flooded underground cables and other systems. Storm-related power cuts left more than 7,4 million homes and businesses without electricity in and around New York City, and knocked out mass transit transportation along a wide swathe of the eastern US. Damage in the US alone was estimated at over USD 71 billion.*



Hurrican Sandy NYC blackout Photocredit : www.whenfallsthecoliseum.com

Ensuring highest reliability and dependability

Environmental conditions, including those resulting from extreme weather are the focus of the work of IEC TC 104: Environmental conditions, classification and methods of test. Devices such as measurement – and alarm equipment must be able to function under all circumstances and resist the ingress of dust or water, high or low temperatures, air velocity, etc. The safety and dependability of components in nuclear plants, as well as rescue machinery need to have the highest degree of reliability and dependability. TC 104 provides Standards with Horizontal Safety Function and maintains internal liaisons with 7 different IEC TCs and SCs, as well as with ACOS (IEC Advisory Committee on Safety).

Protection

Another domain where prevention is better than cure is that of lightning protection, as damage to buildings and other installations can be severe. The role of IEC TC 81: Lightning protection, is to prepare guides or, where possible, International Standards, for lightning protection for structures and buildings as well as for persons, installations and contents in or on them.

Its International Standards cover general principles (design and installations) of lightning protection, physical damage to structures and life hazard, electrical and electronic systems within structures, as well as risk management.

Disaster recovery

Repair

The best standards cannot prevent equipment and installations sustaining serious or total damage in case of severe adversity. Repairing infrastructure often means technicians and engineers having to work on live installations. IEC TC 78: Live working, prepares the International Standards that are needed to protect the workers and citizens during disaster recovery when live parts such as downed pylons or torn electrical wires need to be repaired.

Temporary power

Live working is not only used in case of damage to installations, but also to deploy temporary systems such as mobile transformers. IEC International Standards in this area are prepared by TC 14: Power transformers.

Countless other IEC TCs also prepare International Standards for components, systems and installations that are essential to the prevention, mitigation or reparation of adverse effects of extreme natural or man-made phenomena. They, together with those mentioned in this overview ensure that power can be maintained or re-established in the shortest possible timeframe.

Planning for disaster

While business continuity planning and dependability remain a relatively new domain, uptake has been particularly successful in the information technology industries. Here, coping with major electricity outages – whether from communication infrastructure failures or cyber-attack – is a key consideration in risk management for organizations such as data centres. Consequently, a significant amount of work has been undertaken in this area, including standardization activities that provide guidelines and codes of practice for planning against major interruptions. Relevant International Standards here include:

ISO/IEC 27001:2005*, Information technology – Security techniques – Information security management systems – Requirements*

ISO/IEC 27002:2005, *Information technology – Security techniques – Code of practice for information security management*

ISO/IEC 27031:2011, *Information technology – Security techniques – Guidelines for information and communication technology readiness for business continuity*

ISO/IEC 24762:2008, *Information technology – Security techniques – Guidelines for information and communications technology disaster recovery services*

Even bigger challenges for developing countries

In developing countries often equipment that is used is aging and not compliant with the safety requirements defined in IEC International Standards. Because verifying conformity remains a challenge in some parts of the world, the IEC Affiliate Country Programme is helping developing countries to use its International Standards to ensure quality, performance and safety of electrical equipment at the national level. The IEC also offers the Affiliate Conformity Assessment Status (ACAS) to educate its Affiliates to understand, use and benefit from its conformity assessment systems. A few examples illustrate the challenges faced by IEC Affiliates regarding their electrical installations:

Sudan, aging equipment

On March 9, 2013, a generator in the Sennar Hydroelectric Power Station, 300 km south of the capital Khartoum in Sudan exploded. The power station supplies 15MW of power to the Sudan main national grid. The voltage transformer, installed since 1963, was subjected to an overvoltage and this resulted in the destruction of the 11kV busbar and switchgear, cutting power to Sudan's national power grid. Sudan considers that the use of the relevant IEC International Standards for safety and performance in combination with an IEC conformity assessment approach could have helped avoid such an accident.

Democratic Republic of Congo, inadequate equipment in Ex area

In 2009 a fire in the industrial bakery UPAK (Usine de Panification de Kinshasa) near Kinshasa, the capital of the Democratic Republic of Congo (DRC) destroyed two storehouses with 10 000 bags of flower as well as machinery. The factory, which produces up to 75 tons of flour each day employs more than 500 people.

The fire was caused by a short circuit due to combustible dust that covered the contacts of the electrical equipment located in an open electrical power box. Periodical inspections and the use of Ex certified equipment would have permitted to prevent the accident. The installation of automatic fire detection devices certified according to IECEx or IECEE CA System requirements would have allowed to better manage the disaster, locating the fire faster and stopping its propagation.

The implementation of IEC International Standards and the use of IECEE and IECEx CA Systems would have allowed for quantitative and qualitative risk analysis as well as verification of conformity of installed equipment. The use of appropriate equipment certified according to i.e. IEC 61508 as well as regular periodical inspections could have helped to prepare for and respond to such disasters.

Ghana, faulty electrical installations

On October 21, 2009 in Accra, Ghana, a major fire completely destroyed the 10-story Ministry of Foreign Affairs building and several big markets in its vicinity. The disaster was due to ineffective grounding and aging cables. IEC 60364 on Low-voltage electrical installations , including protection against electric shock, thermal effects and overcurrent as well as the use of resistant cables could have avoided such a tragedy. This disaster shows that there is a real need to educate practitioners in electric wiring of building so that they adhere to the requirements of the relevant IEC International Standards, which are referenced in the Ghana National Wiring Code.

Côte d'Ivoire, faulty electrical installations

Côte d'Ivoire experienced several disasters caused by faulty electrical installations. The table below gives an overview of what caused the accidents and resulting damages.

	Designation	Type	Nature	Date	Location	Cause	Damages
1	ORCA DECO	Big store over 5000m2	Fire	January 2013	TREICHVILLE (Abidjan district)	Short circuit in electrical installation	The store BATI PLUS as well as SNC Finances Western Union located near ORCA DECO were destroyed. Nothing could be saved. 238 jobs lost and a financial loss reaching 4 billion CFA
2	GANDOUR	Perfume factory	Fire	July 2013	YOPOUGON (Abidjan district)	Short circuit in electrical installations	2 persons injured, premises, and the factory totally burnt down. Over 1 500 jobs lost as well as goods and equipment
3	Electrical grid	225 kV substation	Break of the 225 kV cable	May 2013	ABOBO (Abidjan district)	Default not eliminated	Interruption of electricity supply in Abidjan and in several cities as well as impact on interconnections with Mali and Burkina Faso
4	AZITO thermal plant	Electricity generation	Fire	December 2012	YOPOUGON (Abidjan district)	Dysfunction of a turbine	Loss of the thermal plant
5	Electrical grid	225 KV line	Broken lightning protection wire	May 2013	ADJAME (Abidjan district)	Default not properly eliminated	Complete black out. Interruption of electricity supply on national territory
6	ERT VRIDI-BIA-SUD 1	Electrical energy transportation	Broken lightning protection wire	May 2013	VRIDI	Fall of the lightning protection wire on the conductors	Break of three conductors. A taxi cab damaged due to the cable fall. Fire in nearby barracks, no access to neighbouring companies due to the interruption of

							road traffic.

The AZITO site disaster resulted from the malfunction of one of the turbines in an explosive environment. Periodical inspection would have avoided this explosion. Implementation of IEC 60079-1 which covers factors relating to inspection and maintenance, could have helped to prevent such a disaster. The use of IEC 60079-10-1 and IEC 60079-14 could have helped the selection of appropriate equipment compliant with IEC 60079-1 to be installed in such an environment. Repairing the turbine in accordance to IEC 60079-19 and other relevant IEC International Standards could have helped to prevent this accident.

Faulty electrical installations which are not complying with international safety standards are a major cause for fires in public markets in Cote d'Ivoire. In view of the population density of these markets, proper installation of electrical equipment is of utmost importance to avoid similar disasters going forward. Such installations need to comply with IEC International Standards including IEC 60227, IEC 60 245, IEC 60502, IEC 60669.

Uganda, inadequate safety protocols

In 2013 in the Kampala North substation in Uganda a fire at UETCL (Uganda Electricity Transmission Company Limited) destroyed the control of the 11kV and 33kV feeder cables of the Umeme substation, part of the 11kV bus bar section as well as all the cables to the series reactors and one of the reactors. Four people were injured at the Mulago School where conductors of the outgoing Nakulabe feeder snapped (the line runs through the school's compound). As a result of this incident around 80 000 customers lost power.

Cause of the fire was the failure of the DC supply system that controls the overall fault protection system. Furthermore, the back-up protection system was not set into automatic mode and therefore didn't come into action. The fault cascaded through the 132kV network and this eventually led to the tripping of the Bujagali hydro power station, causing a total collapse of the Uganda grid system. Proper training of the control room staff and the respect of safety protocols would have helped minimize damages and avoid injuries.

Afghanistan, faulty electrical installations

- In 2013 in Afghanistan 288[ii] fires in commercial and residential places were reportedly due to faulty electrical installations. Electrical short circuits due to poor quality electrical products or substandard electrical installations were the main reasons identified. The following is a list of the main causes of these disasters:

  - Poor quality cables used for wiring purposes
  - Extension of external wiring systems without particular conduits
  - Usage of poor quality plugs and socket outlets
  - Usage of a single socket outlets for multiples users
  - Overloading of the electrical system
  - No safety protection

Such disasters could be avoided if e.g. the influx of low quality electrical products were controlled and their market entry prevented. This can be achieved through import inspection and market surveillance activities based on IEC International Standards. In the framework of the Afghanistan Energy Programme, ESRA (Renewable Energy Supply for Rural Areas) will make the necessary recommendations to the companies that provide electrical installation services and make them aware that standardized products and services not only reduce the occurrence of such incidents but also permit to speed up the response to disasters and reduce the risk of their occurrence.

Conclusion

IEC International Standards and CA Systems promote safety and help increase the resiliency of electrical and electronic systems and devices. IEC work helps directly reduce the number and severity of certain categories of disasters and to speed up disaster recovery in others.

[i] Consequences of Poor Power Quality – An Overview, Sharmistha Bhattacharyya and Sjef Cobben (2011). Power quality, Mr Andreas Eberhard (ed.), ISBN: 978-953-307-180-0.
[ii] Source: Ministry of Interior – Anti Disaster Department.