IEC work for energy storage
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IEC, the International Electrotechnical Commission covers the large majority of technologies that apply to energy storage, such as pumped storage, batteries, supercapacitors and flywheels.

More information about the work IEC does in electrical energy storage (EES) can be found in the following White Papers:

**Electrical Energy Storage**, analyzes the role of energy storage in electricity use and identifies all available technologies. It summarizes present and future market needs for EES technologies, reviews their technological features, and finally presents recommendations for all EES stakeholders.

[www.iec.ch/whitepaper/energystorage](http://www.iec.ch/whitepaper/energystorage)

**Grid integration of large-capacity Renewable Energy sources and use of large-capacity Electrical Energy Storage**, provides a global view on the latest and future directions for grid integration of large-capacity RE sources and the application of large-capacity EES for that purpose. It identifies challenges for grid operators and producers of electricity, and provides insights into current and potential methods for addressing these difficulties.

[www.iec.ch/whitepaper/gridintegration](http://www.iec.ch/whitepaper/gridintegration)
Energy storage is key to renewable energy

The growing penetration of wind power and solar photovoltaic farms is a positive consequence of government incentives and industries working together in a worldwide context. This has succeeded in bringing down the cost of the technologies and greatly increased their deployment. However, the implication of large volumes of power emanating from variable and intermittent renewable sources being fed into conventional grid structures is often the reason why the use of these forms of energy is curtailed in favour of grid stability. Smart grid solutions can only partially adapt electricity demand to these unpredictable patterns. In order to avoid installed capacity and clean primary energy going to waste, it is crucial to be able to store the electricity produced from these renewable sources. Using water electrolysis to produce hydrogen is a weight-efficient (compared to batteries) and location-flexible (compared to pumped hydro) method to convert and store surplus electricity.

Hydrogen offers multiple benefits

Hydrogen can be converted back to power effectively in commercial, low-temperature FCs. It is particularly suited to mobile applications in fuel cell electric vehicles (FCEV), where the electricity that has been stored as hydrogen can add value by supplying energy for transportation.

Similarly, hydrogen is a highly valuable primary substance for the chemical industry, when used in conjunction with fuel cell technology.
with industrial processes to produce substances such as ammonia, chlorine and steel. It is also used in the refining of fossil fuels as well as in the food industry.

The electrochemical production of hydrogen has enormous potential for the profitable matching of large-scale renewable energy generation and economic development. Although it requires the hydrogen handling infrastructure to be set up, the use of fuel cell systems in reversing mode for alternating power storage and power generation within a unique system boundary is a readily available engineering solution to the issues currently connected with distributed energy management. Furthermore, the interesting prospect of using high-temperature, solid oxide cells which are capable of being operated directly as both power generators and power storing devices simply by inverting polarity, has prompted IEC Technical Committee (TC) 105: Fuel cell technologies, to look into the need for standardizing developments in this direction.

**Bringing FC and electrolysis operation standardization together**

The present standardization work on FC and electrolysis operation does not yet cover reversing FCs. Similarly, systems designed to meet power storage and power generation needs within a unique solution – even if composed of separate FC and electrolysis modules – are not currently within the mantle of standardization. Given the potential of the application, this represents a promising area for standardization. A generic system approach is advisable (power in, power out, by-product heat and grid connections) for industry use. It should be noted that power-to-gas-to-power systems could combine different FC technologies for hydrogen and power generation, but a specific task on test procedure development for reversing FCs needs to be undertaken as this currently constitutes a gap in the standardization portfolio.

**FC-based reversing power storage and generation systems already deployed**

Across the world, industries are already demonstrating systems based on FCs for the reversing
storage and generation of renewable power. In Japan, Toshiba has had a system for buffering solar PV in operation since April 2015 (polymer electrolyte membrane, or PEM, electrolyzer, hydrogen storage and PEMFC at throughputs of 1-2.5 m3/h of hydrogen). In Germany, Sunfire is developing reversing (or regenerative) solid oxide fuel cell (SOFC) systems of 10-500 kWe. In addition to these, FuelCell Energy is ramping up SOFC/SOEC (SOEC = solid oxide electrolyzer cell) installations for energy storage in the US and, in Italy, ElectroPower Systems has already deployed a significant number of PEM-based systems for remote, off grid, constant powering of telecom masts with PV hybridization.

IEC leads standardization work

The IEC is keeping abreast of this rapidly evolving scenario, and TC 105 has approved new work proposals for the development of International Standards on energy storage systems using FC modules in reverse mode. IEC TC 105 ad hoc Group (ahG) 6 will be responsible for this, encompassing the prenormative activities on the definition and validation of testing and characterization procedures of these modules being carried out in the European collaborative project SOCTESQA (Solid Oxide Cell and stack Testing and Quality Assurance, supported by the Fuel Cells and Hydrogen Joint Undertaking).

The objective is to develop performance test methods for power storage and buffering systems based on electrochemical modules (combining electrolysis and fuel cells, in particular reversing fuel cells), taking into consideration the options of both re-electrification and substance (and heat) production for the sustainable integration of renewable energy sources.

The proposed Standards which are considered the most important and will come under IEC 62282-8 for energy storage systems using fuel cell modules in reverse mode, are:

IEC 62282-8-101, Solid oxide single cell and stack performance including reversing operation

IEC 62282-8-102, PEM single cell and stack performance including reversing operation

IEC 62282-8-20, Power-to-power systems performance

The call for experts for these projects is open. The project leaders are Dr Stephen McPhail (Italy) for IEC 62282-8-101, Prof Hongmei Yu (China) for IEC 62282-8-102 and Dr Tsuneji Kameda (Japan) for IEC 62282-8-201.

The convenor of AHG 6 is Stephen McPhail, assisted by Dr Kazuo Shibata (Japan) as Secretary.

Target dates for the first Committee Drafts and finalized International Standards are the end of 2016 and mid-2019, respectively.

Boeing’s fuel cell energy storage system uses a technology called a “reversible solid oxide fuel cell” to store energy from renewable resources (Photo: Boeing via UAS Vision)
Everywhere from pocket to grid
The cellular telephone in our pocket constitutes one tiny part of the world’s biggest consumer of battery technology – portable electronics.

Smartphones, tablets and laptops are a massive market, but while the lithium- or nickel-based battery within may power that latest gadget, it does not necessarily represent the latest in battery technology development. Designed to supply just milliwatts of power, ideally for a period of several days, with a focus on lightweight and sustained low output, such technology is not necessarily ideal for most of today’s emerging battery applications.

Professor David Greenwood at the University of Warwick in the UK, outlines the key market drivers: “Mobile energy for things like electric vehicles and large-scale energy storage for operating with the grid and the electrical distribution network. What those two growth sectors need is a bit different to the consumer electronics industry, which has driven battery development”.

This is a point echoed by Phil Hare, management consultant with analysis firm Poyry: “These are auspicious times for storage. Batteries actually seem to be coming to the fore, and I think are coming to the fore in part because of the crossover from developing electric cars. So costs are coming down enormously”.

IEC Technical Committee (TC) 21: Secondary cells and batteries, develops International Standards for all secondary cells and batteries, irrespective of type and chemistries (i.e. lithium-ion, lead-acid, nickel-based) or application (i.e. portable, stationary, traction, electric vehicles or aircraft). They cover all aspects such as safety, performance and dimensions and labelling, a new battery technology. Chemistry for flow batteries – another potential candidate for large-scale electrochemical energy storage – is now part of the TC’s remit.

Big batteries, big business
Big batteries are expected to become big business. Just how big is indicated from a recent report by US-based analysis firm Navigant which concludes that annual revenue for the commercial and industrial (C&I) energy storage industry is expected to reach USD 10.8 billion by 2025, from less than USD 1 billion in 2016.

As Alex Eller, research analyst with Navigant Research, explains: “Despite early challenges, global C&I energy storage system power capacity deployments are expected to grow from 499.4 MW in 2016 to 9.1 GW in 2025”.

A major driver of the demand for increased energy storage capacity has been the high penetration of variable output renewables, particularly wind and solar photovoltaic (PV). As an example, in 2013, regulators in California in the USA, which has a significant proportion of renewables, mandated the state’s three major utilities – Pacific Gas and Electric, Southern California Edison and San Diego Gas & Electric – to procure collectively 1325 MW of energy storage by 2020, with installation by the end of 2024.

And in February this year, AES UK & Ireland commissioned its Advancion 48V lithium-ion battery for so-called mild hybrid vehicles (Photo: Thomas Content, Milwaukee Wisconsin Journal Sentinel)
storage array at Kilroot power station in Carrickfergus in Northern Ireland, which provides 10 MW of grid-connected energy storage. Globally, AES owns and operates 116 MW of operational storage with a further 268 MW under construction or late stage development.

Evolving battery technology

New requirements for battery system performance characteristics may be emerging, but that does not necessarily indicate that lithium-ion or even older technologies like lead-acid are played out.

Greenwood highlights the evolving nature of battery technologies: “You have this family of chemistries around lead and lead-acid. There is another family of chemistries around nickel, the first of which was nickel-cadmium, while nickel metal hydride is the more modern version and then you have got a further family of chemistries which are around lithium and lithium-ion. There are many different flavours of lithium-ion, more than 40-odd; they are not all the same and they behave quite differently in places.”

He continues: “A lot of the new technologies that we are starting to look at are still lithium-based, but they’re not working on transporting lithium ions, they’re working on different reactions”. Greenwood cites a number of promising chemistries, including lithium-air, lithium iron phosphate and nickel cobalt manganese.

Indeed, in March 2016, sodium-ion battery technology company Faradion announced a partnership with WMG, University of Warwick and energy storage specialists Moixa Technology in a bid to commercialize this battery chemistry. By using highly abundant sodium salts rather than lithium, sodium-ion cells are anticipated to be 30% cheaper to produce. Alongside endeavours to explore novel battery chemistries in more detail, the influence that the physical structure of the cell can have on performance is also driving research into new materials such as solid electrolytes or novel electrode structures.

Says Greenwood: “Typically the amount of energy that is held inside a battery cell is directly related to the amount of electrochemical material inside it, whereas the power that you get out of that cell is determined effectively by the active surface area inside the cell over which those reactions can take place”.

Ideally then, highly porous materials are used which allow rapid reactions for high power and can simultaneously pack in a large ratio of active material to support sustained reactions for high energy density. Graphene and other nanomaterials are showing promise in this area. IEC TC 113: Nanotechnology standardization for electrical and electronic products and systems is developing, for instance, Technical Specifications for “electrode nanomaterial used in nano-enabled energy storage devices such as lithium-ion batteries”, and is also developing a range of publications related to this and to graphene-related applications.

The search for life

Lifespan is perhaps the major challenge for any emerging battery technology.

“The basic reactions are reasonably well understood, but like anything, it is the things that that you didn’t want to happen that are harder to control. There are many degradation mechanisms that come into play; the active sites in the electrochemical material effectively get clogged up with lithium deposits, or you can get problems with the electrochemical materials fracturing and coming away,” says Greenwood.

This degradation process has a significant impact on the size and mass of the current generation of battery technologies. In order to compensate for degradation over the eight or 10 years of an electric vehicle (EV) battery’s life, additional capacity is required initially if the system
is to achieve design performance parameters after multiple charge and discharge cycles.

Furthermore, as some of these degradation processes are accelerated at states of very high or low charge, ‘buffer’ capacity is typically designed into battery systems to enable required performance whilst maintaining the charge state between, say, 10% - 90%.

All this adds weight, volume and cost.

“A lot of the work that is going on around battery development nowadays is about really understanding those degradation modes, working out how to manage the battery in the best possible way so as to get the best out of it.”

**Crash diet**

One way battery performance may be improved is by reducing the mass of ‘ancillary’ components. Says Greenwood: “For your typical automotive battery at the moment, only about 40% of the mass of the battery is the electrochemically active material, the rest of it is all the support structure, the cooling structure, the control system, the electrical interconnects.”

“There’s a lot you can do to understand how to better package that whole lot and get to a point where a great percentage of that battery pack is the chemically-active material, which is actually delivering on the primary purpose of the battery.”

Industry standards have a clear role to play here, explains Greenwood: “The standards really come in when we start to talk around applications for energy storage, because many of the sectors we have been talking about are relatively new to using electrical energy storage systems.”

Standard cell formats are one area of interest for consumers: “Manufacturers have their own proprietary standards that they are working to and that makes it incredibly difficult for users of those batteries to be able to standardize,” says Greenwood, in particular noting pouch and prismatic types of construction.

IEC TC 21 develops Standards for cell formats as part of its scope.

**The power of chemistry**

Looking forward, Greenwood envisages a number of developments over the coming decade or so. Within the five-year horizon: “It is all about being able to use much better the chemistry that we have got around us, to build electrode structures that give us the right mix of power and energy and which give us the durability that we need”.

Over the next 10 and more years: “That is when you start looking at things like lithium-air chemistries, which are still very much at laboratory scale. Typically these are operating with quite short life times at the moment. There is a lot of development work left to understand how we get the very best out of those chemistries and get them to a point where they can all be industrialized.”

“The different chemistries of batteries are still waiting in the wings,” concludes Hare, “and interestingly, lithium-ion batteries I think have a massive momentum behind them. We’ve already looked at lithium batteries, but the prospect of tuning those to meet the static applications is very intriguing.”

Hare envisages the prospect of lowering costs significantly by focusing on static applications, rather than requirements for lightness and power density.

He also posits another way to improve the lifetime performance of existing battery technology, using end-of-life EV batteries in static applications as well. With the performance specifications on EV batteries so much higher than required for, say, an average domestic static application, such as a solar PV system, the residual performance of an ‘end-of-life’ EV battery could be sufficient for many years.

“I think that’s at an early stage, but there’s a definite thought about that, and that’s going to require all sorts of interesting questions about standardization.”
TC work underpins mobile and stationary energy storage

Batteries are driving growth in mobile devices, e-mobility and stationary energy storage

**Different applications, similar restricting issues**

As IT and CE mobile and wearable devices employ ever more advanced processors, displays and audio systems and offer connectivity to an ever growing range of wireless networks and other devices, they are becoming more and more power hungry.

Likewise, the wider adoption of full or hybrid electric drives in electric vehicles (EVs) is seen as hinging on the availability of more advanced batteries (and charging systems), which will allow them to overcome the limitations of range and charge they currently face.

**Different chemistries for different applications**

Today’s batteries for mobile applications are based mainly on Li-ion (lithium-ion) chemistry, which offers the key advantage of being able to store large amounts of energy in comparatively light, compact and purpose-made packages. However, while these batteries may provide a reliable power supply, they can no longer keep up with the growing demands placed on them in their current form.

**New trends in automotive applications**

Although attention has been focusing on storage for mobile applications for a few years, trend in the automotive sector are no less interesting.

EVs rely extensively too on Li-ion batteries, but may use also nickel-metal hydride batteries. As for vehicles powered by internal combustion engines (ICEs), they depend on rechargeable sealed lead-acid starter batteries, increasingly of the valve-regulated type (VRLA).

International Standards for batteries used in automotive applications, including "for the propulsion of electric road vehicles" are developed by IEC TC 21 and its Subcommittee (SC) 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes.

As car manufacturers are striving to manufacture cars that will meet tighter emission laws in many countries and regions from 2025-2030, some are now prioritizing so-called 48 V mild hybrids as an interim solution before achieving pure electrification of vehicles. Mild hybridization relies on lithium-ion batteries and consists in adapting 48 V devices and interconnects to existing ICE powertrains.

**Morand Fachot**

In recent years consumers have benefited from the introduction of countless mobile and wearable IT and consumer electronics (CE) devices and systems. Meanwhile, public and individual means of transportation everywhere are increasingly relying on electric drives and storage for part or all of their propulsion systems. Large stationary energy storage is another area where batteries are playing a growing role. Standardization work by IEC Technical Committee (TC) 21: Secondary cells and batteries, is central to future advances in all energy storage domains.

Electric superchargers used in 48 V mild hybrid vehicles cut emissions and fuel consumption (Photo: Valeo)
This technology has already been tested for a number of years and offers, among many others, the following benefits, according to IDTechEx Research and manufacturers’ data.

- CO2 emissions reduced by 10-20%, depending on test cycles
- cheaper (50-70%) than full hybrids, according to automotive equipment manufacturer Valeo
- unlike existing 12 V and 24 V vehicles, they can accept charging from regenerative braking and other regeneration (thermoelectric, exhaust heat, suspension, etc.); and they can drive the wheels electrically and provide additional power.

Stationary applications matter too
Batteries are not just central to mobile and automotive applications, but increasingly also to stationary energy storage.

Electricity being consumed as it is produced there must be sufficient supply to meet variations in demand. At times of peak demand extra capacity must be available to respond rapidly. If demand cannot be met, the stability and quality of the power supply suffer and may result in brownouts or worse. To balance demand and supply additional generation a certain amount of storage may also be necessary. It currently mainly takes the form of pumped hydro, which makes up the bulk of electricity storage.

Advanced batteries are set to play a major role in the future global electrical energy storage landscape and in grid management, in particular as the share of Renewable Energies (REs) grows.

A new generation of advanced safe, low-cost and efficient enough batteries to allow for storage on the grid has paved the way to the first instances of large-scale energy storage for the electric distribution network. The next-generation advanced batteries include Li-ion, sodium metal halide, NaS (sodium sulphur), advanced lead-acid and flow batteries.

To prepare International Standards for rechargeable batteries used in RE storage, IEC TC 21 and IEC TC 82:

Solar photovoltaic energy systems, set up a Joint Working Group, JWG 82: Secondary cells and batteries for renewable energy storage.

Finding the right chemistry for the right use
IEC TC 21 lists the key areas of battery standardization as starting, lighting, ignition (SLI) also named “starter” batteries, which supply electric energy to motor vehicles; automobile hybrid/electric vehicle cells; traction batteries; and the stationary batteries of the VRLA type.

IEC TC 21 has broadened its scope to include technology and chemistry for flow batteries, which are starting to be deployed in the market and, as such need international standardization regarding performance, performance tests and safety.

Flow batteries are rechargeable batteries in which electroactive chemical components dissolved in liquids (electrolytes) stored externally in tanks and pumped through a membrane convert chemical energy into electricity.

To develop Standards for flow batteries that cover safety, performances, installation, terminology and other necessary requirements, IEC TC 21 set up JWG 17: Flow battery systems for stationary applications, with IEC TC 105: Fuel cell technologies, as flow batteries and fuel cells share certain characteristics.

IEC TC 21 was created in 1931 and currently brings together 25 participating countries and 17 Member countries. Around 215 experts are active in its standardization work.

In view of the fast expanding energy storage needs from mobile, e-mobility and stationary applications, IEC TC 21 and IEC SC 21A are unlikely to see any reduction in their workload in the foreseeable future.
Tackling energy efficiency from the start

Better energy efficiency is central to our future energy supply and to sustain growth

Morand Fachot
Energy Efficiency represents the biggest source of untapped energy in the world and, by helping slowing down final energy consumption, one of the main contributors in the reduction of noxious gases emissions. Improved electrical Energy Efficiency is made possible by standardization work performed by many IEC Technical Committees (TCs) and starts with electricity generation, distribution and storage.

Covering all areas
Energy intensity, the measure of energy consumption per unit of gross domestic product (GDP), can be an imperfect indicator [1] of energy efficiency in general. In recent years, despite relatively low energy prices, energy intensity has improved greatly, contributing significantly to a slowdown in energy-related emissions of greenhouse gases (GHG), CO2 in particular.

“Increasing mandatory Energy Efficiency regulation, which now covers 30% of global final energy use, played a key role in moderating the effect of low energy prices on energy use,” according to an International Energy Agency (IEA) report. The report indicates that some 1.5 billion tonnes (GtCO2) of GHG were not released in 2015 and 13 GtCO2 cumulatively since 2000, thanks to Energy Efficiency (EE).

Electrical Energy Efficiency (EEE), which is central to overall energy efficiency, ranges from electricity generation, improved electricity distribution and storage infrastructure, to the introduction of more energy efficient equipment and systems in industry, buildings, transport and consumer goods.

Generation first...
EEE starts with energy generation, the conversion of primary energy (from hydropower, fossil fuels, nuclear, renewables, such as wind, solar, marine or geothermal sources) into electricity.

Hydropower was the first source of electricity, it represents now some 15% of electricity production in OECD countries, which is 75% more than the share of electricity generated by other renewable sources. Modern hydro turbines can convert 90% of all available energy into electricity.

IEC TC 4, established in 1913, develops International Standards for hydraulic turbines. IEC TC 4 develops and maintains publications that assess the “hydraulic performance of hydraulic turbines, storage pumps and pump-turbines.” Hydropower installations are robust and reliable but they need rehabilitation after 30 to 50 years of operation. IEC TC 4 works on a new edition of a Standard that deals with the various options to increase power and efficiency in rehabilitation projects.

PS10 CSP Power Plant near Seville (Spain)
Burning fossil fuels – coal or oil – in thermal power plants is the second oldest form of generating electricity. The share of electricity generated from fossil fuels was 67% in 2014, according to the IEA. A significant amount of primary energy is wasted in the conversion of fossil fuels into electricity in thermal plants (up to 60–65%). One way of reducing waste is to recover waste heat in cogeneration Combined Heat Power (CHP) installations to use in industry or for urban heating systems.

Thermal power plants use steam turbines to convert heat and steam into power. International Standards for steam turbines, which are used also in nuclear power plants, geothermal installations, solar thermal electric and CHP plants are developed by IEC TC 5.

IEC TC 2: Rotating machinery, develops International Standards for rotating electrical machines, including motors, used, for instance in “generators driven by steam turbines or combustion gas turbines”. This work includes aspects aimed at improving the EE of motors.

Renewable sources are set to play a central role in Electrical Energy Efficiency (EEE) efforts, by reducing the share of fossil fuels. All IEC TCs involved in renewable sources installations work on developing new more EE systems and in improving the EE of existing ones. These TCs include:

- **IEC TC 82**: Solar photovoltaic energy systems, which develops also International Standards for various measurements and performance parameters of PV devices.
- **IEC TC 88**: Wind energy generation systems, prepares, for instance, International Standards “for power performance measurements of electricity producing wind turbines”.
- **IEC TC 82**: Wind energy generation systems, prepares, for instance, International Standards “for power performance measurements of electricity producing wind turbines”.
- **IEC TC 88**: Wind energy generation systems, prepares, for instance, International Standards “for power performance measurements of electricity producing wind turbines”.
- **IEC TC 114**: Marine energy – Wave, tidal and other water current converters, is a recent IEC TC, but the potential of harnessing marine energy is very promising. Much of the work of this TC focuses on power performance assessment of these converters.
- **IEC TC 117**: Solar thermal electric plants, also covers a fairly recent area, which is fast expanding and showinga significant potential.

...followed by distribution

Electricity distribution is also an area where EE is addressed by developing new technologies and systems or improving existing ones.

Electrical energy produced by power plants in medium (MV 20 000 V) or low (LV 1 000 V) voltage is elevated to HV (up to 400 kV) by a step-up substation before being transmitted across long distances by high-tension power lines. A step-down station converts HV to MV to transport it to feed MV or LV transformers for use by households, factories, commercial buildings, etc. The efficiency of large transformers in step-up and step-down substations is very high and can reach 99%. The efficiency of MV and LV transformers may range between 90% and 98%. IEC TC 14 develops International Standards for power transformers.

Losses in cables are higher than in transformers, but EE is improving there as well. IEC TC 20 develops and maintains International standards for electric cables and incorporates improved efficiency and durability in its maintenance procedure. Ultra high voltage (UHV) distribution of both DC and alternating current (AC) is seen as allowing the EE transmission of power generated by renewable energy sources in sites far away from the main load centres, e.g. in offshore wind farms, large hydro power plants or large solar installations in deserts with acceptably low transmission losses.
International Standards for HV and UHV transmission systems for DC and AC are being developed by IEC TC 115 and IEC TC 122, respectively.

Storing electricity for later use
Energy storage is an important component of EE projects. It helps reduce transmission losses and help balance power from intermittent RE sources. By allowing electricity to be stored for later use it can eliminate the need for the expensive (and polluting) use of generators and idling power plants. It is also an essential ingredient in so-called microgrids and off-grid rural electrification. Energy storage International Standards for electricity storage systems are developed by:

- IEC TC 4: Hydraulic turbines. Hydropower, in addition to generating electricity, makes up some 90% of installed storage capacity worldwide, in the form of pumped storage hydro (PSH) installations. In PSH water is pumped in a reservoir uphill when electricity is cheap and plentiful (excess electricity from wind or solar power installations) and released downhill to generate electricity, when needed. It is highly efficient (80% or more). IEC TC 4, prepares also International Standards for “storage pumps and pump-turbines”.
- IEC TC 21: Secondary cells and batteries, prepares International Standards for all types of batteries used in energy storage, including stationary (lead-acid, lithium-ion and NiCad/NiMH) batteries and flow batteries.

Into the future...
In many countries, electricity grids were designed based on technology that was modern more than 100 years ago. Standardization work by several IEC TCs makes it possible to update these legacy systems in order to transform them in “Smart Grids”. This is essential to reduce distribution losses and identify energy efficiency opportunities. This means updating the ageing infrastructure to allow the integration of intermittent Renewable Energy sources, ensure the security of supply and increase in energy use.

[1] “For instance, a small service-based country with a mild climate would have a lower intensity than a large industry-based country in a cold climate, even if energy was used more efficiently in the latter country.” (IEA)
Smart Cities to boost energy efficiency
A wide range of technologies will help cities optimize energy use

Peter Feuilherade
In hundreds of Smart City projects around the world, governments, municipalities and private stakeholders are investing in Smart Grids, open data platforms and networked transport systems to meet the challenges of environmental sustainability, population growth and urbanization.

Smart Cities drivers
The continuing influx of people to cities, especially in Asia, Africa and Latin America, is predicted to add 2.5 billion people to the world’s urban population by 2050.

The primary drivers of Smart Cities are operational efficiency, cost reduction and environmental sustainability. Smart technologies have been most evident in sectors like energy, lighting, transport and water management.

Separate market studies in 2016 by consultancy firms Technavio and Frost & Sullivan estimate that the overall value of the global Smart Cities market will grow to between USD 1.4-1.5 trillion by 2020. Asia-Pacific and Europe are expected to dominate the market because of government initiatives to accelerate Smart City development.

IEC Standards promote integration
Electricity and electronics are indispensable for the operation of the myriad interconnected services in Smart Cities and buildings.

Many IEC Technical Committees (TCs) and Subcommittees (SCs) coordinate on the development of International Standards for the broad range of electrotechnical systems, equipment and applications used to build and maintain Smart Cities and smart buildings, with an emphasis on safety and interoperability.

The IEC White Paper, Orchestrating infrastructure for sustainable Smart Cities, stresses that cities can only achieve economic, social and environmental sustainability by integrating their infrastructures and services to improve urban efficiencies.

There are hundreds of IEC International Standards that enable the integration of smart solutions for energy, buildings and homes, lighting and mobility.

Optimizing energy consumption
One of the key drivers for integrating systems and making buildings more intelligent is the energy savings that can be achieved.

A report published in October 2016 by the International Renewable Energy Agency (IRENA) noted that cities account for 65% of global energy use and 70% of man-made carbon emissions. This makes optimizing energy consumption a fundamental objective of a Smart City.

IRENA’s director-general Adnan Z. Amin believes that renewable sources can meet most of the energy needs of commercial and residential buildings in cities “either in a centralized way (i.e. delivering renewables sourced elsewhere to buildings via energy distribution networks) or in a decentralized way (i.e. through solar thermal collectors and solar PV panels located at the site where energy is needed)”.

Energy research analysts at Technavio have identified the top three trends driving the global energy-efficient building market as increased government support and investments, rising energy prices and reductions in emission levels of greenhouse gases.

The IEC Systems Committee on Smart Energy (SyC Smart Energy) aims to create one international platform for a comprehensive portfolio of efficient and easy-to-use Standards that can be used by any project working on smart energy. The work of SyC Smart Energy includes wide consultation within the IEC community and a broader group of external stakeholders, in the areas of smart energy and Smart Grid, also including heat and gas.

IEC TC 8: Systems aspects for electrical energy supply, prepares and coordinates, in cooperation with other IEC TCs, the development of International Standards in these areas.

IEC TC 57: Power systems management and associated information exchange, deals with communications between the equipment and systems in the electrical power industry, a central element of smart buildings, cities and grid projects.

International Standards developed by IEC TC 82: Solar photovoltaic (PV) energy systems, and IEC TC 88: Wind turbines, (IEC 61400 series) are also central to smart energy.

In Smart Cities, both residential and commercial buildings are more efficient and use less energy. The consumption of energy is analyzed, data are collected and power production is optimized through different sources and distributed energy production. Proper energy management requires accurate metering. Multi-function, communicating smart meters that measurement energy exported and imported, demand and power quality, and management of load, local generation, customer information and other value-added functions are essential when creating Smart Grids to coordinate supply and demand.

IEC TC 13: Electrical energy measurement and control, develops International Standards for such meters, in liaison with other IEC TCs such as TC 8 and TC 57.

Another key component is the use of smart energy sensors with multiple functions to collect and share data for predictive analytics. These data can be used to detect and predict energy needs and provide valuable insights during times of peak demand.

IEC SC 47E: Discrete semiconductor devices, prepares International Standards for components used in a variety of sensors.

**Microgrids**

A new generation of low-carbon microgrids is changing the ways in which densely populated cities design and operate utility systems using the concept of locally generated and consumed energy. Microgrids allow predictive maintenance and are particularly promising for ensuring resilience in the energy demands of cities.

“Coupled with rapid declines in the cost of emissions-free Renewable Energy technology such as wind and solar photovoltaic, recent drops in the cost of advanced stationary battery storage technology have altered the technological make-up of microgrids dramatically,” in the view of the Microgrid Media website.

Another significant factor behind the growth in Renewable Energy microgrids is the global drive to reduce carbon and greenhouse gas emissions. Transparency Market Research forecasts that by 2020 the microgrid market worldwide will be worth more than USD 35 billion.

**Internet of Things**

The Internet of Things (IoT) is the network of interconnected objects or devices embedded with sensors and mobile devices which are able to generate data and communicate and share that data with one another. The spread of IoT-related technologies including low-cost sensors and high-speed networking will accelerate the adoption rate of Smart City solutions over the next few years. IT research and analysis firm Gartner estimates that almost 10 billion connected devices will be in use in Smart Cities around the globe by 2020.

A major feature of a Smart City is the analysis and use of data collected by
IoT devices and sensors to improve infrastructure, public utilities and services, as well as for predictive analytics. In Malaga and Madrid, for example, environmental sensors fitted to bicycles and post carts monitor air pollution, uploading data to a publicly-accessible web portal. And London is just one of many cities trying to alleviate urban traffic congestion by enabling drivers to quickly locate parking spaces and pay for them via smartphone apps, without having to carry cash.

Intelligent lighting, too, can serve as enabling technology for a range of IoT uses beyond illumination, as manufacturers embed video cameras, acoustic sensors and data communications capabilities into LED fixtures and bulbs.

The IEC White Paper entitled Internet of Things: Wireless Sensor Networks surveys the role of wireless sensor networks in the evolution of the IoT. It also highlights the need for Standards to achieve interoperability among wireless sensor networks from different vendors and across varied applications, in order to unleash the full potential of the IoT.

As the IoT expands, so does the need for robust cybersecurity protection against malicious attacks on IoT-connected devices, applications and networks. This was demonstrated in October 2016 when hackers used software connected to tens of millions of commonly-used devices like webcams to launch a Distributed Denial of Service attack (DDoS) in the US which blocked some of the world’s most popular websites for several hours. The IEC is developing Standards and working on conformity assessment related to cybersecurity.

Self-learning buildings
A European consortium is developing ways to enable self-learning buildings to use wireless sensor technology and data mining methods to increase their energy efficiency over time by anticipating and meeting their occupants’ needs.

“As in practice this will involve collecting various data, such as temperature, humidity, luminance, and occupancy via wireless sensors. The software then learns to optimize heating and ventilation so that user comfort is satisfied but energy consumption is minimized,” according to the University of Salford in the UK, which is taking part in the three-year Europe-wide project.

As self-learning buildings become more widespread, technologically advanced buildings will be able to communicate electronically with each other to ensure that energy consumption is balanced.

The next generation
The next generation of Smart Cities will benefit from innovative ways to integrate Renewable Energy and energy-efficient and intelligent building technologies.

Researchers at the University of California Los Angeles (UCLA) have developed transparent solar panels that can be mounted on the windows of buildings in order to capture more sunlight than traditional roof-mounted panels.

Another innovation is a small, ultra-light wind turbine built into a building or other urban structure. These are already in use or undergoing trials around the world, from the Eiffel Tower in Paris to Bahrain’s World Trade Centre and the Pearl River Tower in Guangzhou, China.

The falling costs of sensors, controllers and gateways will see the IoT gain further traction in the smart buildings market, especially among owners of small and medium-sized buildings.

In these and many associated areas, the work of the IEC on standardization and conformity assessment as a fundamental principle in the development of future Smart City technology is set to play a central role.
Photovoltaic (PV) modules (Photo: Courtesy of DuPont)
The IEC, headquartered in Geneva, Switzerland, is the world’s leading organization that prepares and publishes International Standards for all electrical, electronic and related technologies – collectively known as “electrotechnology”.

IEC Standards cover a vast range of technologies from power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, flat panel displays and solar energy, to mention just a few. Wherever you find electricity and electronics, you find the IEC supporting safety and performance, the environment, electrical energy efficiency and renewable energies.

The IEC also administers international Conformity Assessment Systems in the areas of electrotechnical equipment testing and certification (IECEE), quality of electronic components, materials and processes (IECQ), certification of equipment operated in explosive atmospheres (IECEx), as well as Renewable Energy systems (IECRE).

The IEC has served the world’s electrical industry since 1906, developing International Standards to promote quality, safety, performance, reproducibility and environmental compatibility of materials, products and systems.

The IEC family, which now comprises 171 countries, includes all the world’s major trading nations. This membership collectively represents about 99.1% of the world’s population and 99.2% of the world’s electrical generating capacity.
Further information

Please visit the IEC website at www.iec.ch for further information. In the “About the IEC” section, you can contact your local IEC National Committee directly. Alternatively, please contact the IEC Central Office in Geneva, Switzerland or the nearest IEC Regional Centre.

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