Renewable Energies

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World energy consumption is expected to grow by 37% by 2040, according to the IEA energy markets forecast, which assumes the continuation of existing policies and measures and their implementation. Renewable energy production is expected to make up to 26% of total electricity production in 2020.

Essential to this will be electrical energy efficiency to keep costs low and quality of service high.

Large scale use of Renewable Energy, or RE, is important for the future for several reasons: to meet a growing gap between energy production and demand in many countries, eliminate dependence on fossil fuels, combat global warming, and to raise the living standard of people in developing countries.

Much of RE is a recent field of research, technology and manufacturing and a new industry is growing up. Aware of these issues many countries are pushing for a "green" agenda, with green research, green projects and green jobs earmarked as priorities.

The challenges in much of RE are – like for other emerging technologies – reliability, efficiency and high start-up and initial running costs. The reliability and efficiency of many RE systems, in particular in the wind energy and photovoltaic sectors, have greatly improved. Another important factor, the often higher initial comparative cost of producing electricity from certain RE sources, has fallen sharply, making them more competitive.

The production of hydroelectric power from rivers, which currently provides the largest share of energy from renewable sources, can be increased with new large projects as well as the installation of small, micro- and pico-hydro stations. The smaller systems have low installation and running costs. Hydroelectric stations present a significant advantage: that of being able to meet increased demand at short notice and to act as storage.

Regulating power output and storing energy from renewable sources, which by definition do not provide a constant or regular flow of energy, are other challenges in the RE field. These are being addressed by improving existing technologies and developing new ones, such as molten salts for solar energy, for instance, where standards are being developed.

Standardization helps all these technologies in the RE domain to become marketable by providing a foundation for certification systems, promoting international trade of uniform high quality products and supporting transfer of expertise from traditional energy systems. The very nature of the RE technologies means that standardization requires a dedicated effort to keep pace with developments in the various fields.

It is against this backdrop that the IEC is working to set the International Standards that can serve the planet in this market sector. Our mission is to provide technical performance and safety Standards in this field, as well as certification schemes when needed, thereby offering an essential tool for establishing a quality level to protect customers everywhere.

In standardization, we work in three areas concerned with RE: water, sun and wind. The following IEC Technical Committees (TCs) are involved:

- TC 4: Hydraulic turbines
- TC 82: Solar photovoltaic energy systems
- TC 88: Wind turbines
- TC 114: Marine energy – Wave and tidal energy converters
- TC 117: Solar thermal electric plants.

There is an additional area of activity, TC 105: Fuel cell technologies. Although not truly RE since fuel cells require a fuel supply of either hydrogen or a hydrocarbon to function, they are often considered as such. The IEC is committed to RE and coordinates the various interest groups to publish Standards at a rapid pace, very often in under 12 months.

In certification, the IEC System for Conformity Testing and Certification of Electrotechnical Equipment and Components (IECEE) is available and, for photovoltaics, includes an IECEE PV Scheme.

Technology	Standardization	Certification
Water power – rivers	TC 4: Hydraulic turbines	
Water power – oceans	TC 114: Marine energy – Wave and tidal energy converters	
Solar power – photovoltaic	TC 82: Solar photovoltaic energy systems	IECEE PV Scheme
Solar power – thermal electric	TC 117: Solar thermal electric plants	
Wind power	TC 88: Wind turbines	

Water power

Coming from the Greek word for “water”, hydro applies to rivers and oceans. IEC standardization work for the first covers both large-scale and small-scale river projects. Ocean power is relatively new for us as we began considering the subject recently for its potential to require Standards (the market for this is still largely in the research and development stage). Power generation from river flows and oceans is expected to grow more than seven fold between 2012 and 2017, from 760 MW to 5,5 GW.

Rivers

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According to the World Energy Council, in 2016 hydropower generated over 16% of the world’s electricity from all sources. There are three hydropower plants larger than 10 GW in the world, in Brazil, China and Venezuela. Some of the world’s biggest hydroelectric power plants, in terms of both total installed capacity and annual average power generation volume, produce millions of kilowatts and billions of kilowatt hours. At the other end of the scale are small, micro- and pico-hydro stations. For us, “small” means up to 15 MW.

Micro-hydro schemes can be as large as 500 kW and are generally run-of-the-river developments for villages and communities far from industrial centres. Pico-hydro systems have a capacity of 50 W to 5 kW and are generally used for individuals or clusters of households. The World Small Hydropower Development Report 2016, by the United

Nations Industrial Development Organization (UNIDO), said that approximately 78 GW of small hydro were installed worldwide. SHP represents approximately 1.9% of the world's total power capacity. However, small hydro is likely to expand in coming decades as heavily populated countries like India keep expanding rural electrification.

IEC TC 4: Hydraulic turbines, set up in 1911, prepares Standards and Technical Reports for designing, manufacturing, commissioning, testing and operating hydraulic machines. Its focus has been, and at present remains, river projects. These include turbines, storage pumps and pump-turbines of all types, as well as related equipment, such as speed governors and performance evaluation and testing. For now it focuses on river power.

IEC TC 114: Marine energy – Wave and tidal energy converters, was created in 2011 to prepare International Standards for devices and systems that convert wave, tidal and other current into electrical energy.

The two main forces driving much of IEC TC 4 work are, on one hand, new large-scale hydroelectric river projects in Asia, Russian Federation and South America and, on the other, refurbishment and up-rating of existing plants in North America and Europe. As a result, the work programme focuses on turbine runners and pump impellers, acceptance tests of hydro turbines, control systems testing, and evaluating both cavitation pitting and discharge measurement methods, as well as hydraulic turbine efficiency, vibration, stability, upgrading and rehabilitation. Particle erosion is a potential future topic for IEC TC 4.

Oceans

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Ocean energy devices work with tides or with waves, although ocean currents and ocean thermal technologies are other huge potential sources of power. These devices are either floating or fixed and, to generate electrical energy, they tend either to oscillate or to rotate. Research appears to have started in Japan in the 1940s, the technology for it has been around since the 1970s and functioning units have been deployed in various countries in the 1990s, mostly as prototypes. In 2007 the IEC created IEC TC 114: Marine energy – Wave and tidal energy converters, to begin preparing Standards for this emerging field of technology.

IEC TC 114 is responsible for marine energy which includes wave, tidal and other water sources able to convert current energy into electrical energy with the exception of tidal barrage and dam installations which are covered by IEC TC 4.

Standards produced by IEC TC 114 aim to address:

- → System definition
- → Performance measurement of wave, tidal and water current energy converters
- → Resource assessment requirements, design and survivability
- → Safety requirements
- → Power quality
- → Manufacturing and factory testing
- → Evaluation and mitigation of environmental impact

Solar power

The conversion of sunlight into electricity, either using photovoltaic (PV) modules, or concentrated solar power systems (CSP) in solar thermal electric (STE) plants is occupying a growing share of electricity production worldwide. Unlike PV technology that uses semiconductor material to convert sunlight directly into electricity, STE plants use reflective material to concentrate the sun's heat to drive steam or gas turbines, or other engines, to produce electricity.

Photovoltaic systems
Off-grid

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So far, solar panels have mostly been used as standalone systems for energy. These systems are now being deployed throughout the industrialized and developing world on a commercial scale. The PV industry is expected to total more than USD 1,2 trillion in global revenues between 2015 and 2024, according to Navigant Research. The market for PV has developed in both industrialized countries and in the developing countries where off-grid and hybrid village grid electrical services are now becoming available to thousands of remote villages. Such rural populations of developing countries without the benefits of grid connections can enjoy an electrical supply from standalone PV systems with their inherent advantages of modularity and independence from imported fuels.

STE plants can provide energy for water desalination, heating or the production of chemicals. To lessen problems arising from varying electricity demand and solar radiation STE plants can use storage tanks and hybrid solar-fossil fuel systems to deliver electricity throughout day and night, at base and peak times, ensuring grid stabilization.

Grid-connected

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It is now technically possible to connect solar panels to the electricity grid, meaning those who own them could sell excess energy back to their power company. Three developments show how important this branch is becoming:

→ The world's largest solar PV power plant, a 200 MW facility in Golmud, Qinghai Province, China, went on stream in October 2011

→ The world's largest roof-top PV installation, a 12 MW roof-integrated

design of about 85 000 solar panels, is now operating at a General Motor plant in Zaragoza, Spain

- Also during 2005, a leading American manufacturer started marketing a 3 kW Grid Tie Solar Inverter for home use

STE plants present significant benefits when connected to the grid:

- High degrees of predictability and reliability of production as installations are located in zones enjoying large and constant amount of sunshine
- Good dispatchability – that is, a good capacity to increase or reduce power generation, or to be brought on line or shut down as required, due to proven and highly cost-effective storage, and to the potential integration of backup firing
- Efficient storage and backup possibility
- Grid stability due to inertial features of STE power blocks
- Long-term supply security and independence from oil and gas supplies and prices
- Potential for significant technological progress

PV grid-connected systems are rapidly increasing in numbers supported by government-sponsored programmes in Australia, Europe, Japan and the US. Most of these systems are located on residences and public/commercial/industrial applications. Installations of large scale centralized PV power stations, typically owned by utilities, continue at a very slow rate.

IEC TC 82 prepares International Standards for systems of photovoltaic conversion of solar energy into electrical energy and for all the elements in the entire photovoltaic energy system. In this context, the concept "photovoltaic energy system" includes the entire field from light input to a solar cell to, and including, the interface with the electrical system(s) to which energy is supplied. IEC TC 82 has prepared Standards for terms and symbols, salt mist corrosion testing, design qualification and type approval of crystalline silicon and thin-film modules It also has methods to evaluate PV module performance over a range of irradiances, temperatures and time periods spread over the year, and characteristic parameters of stand-alone systems, among others.

In the future, IEC TC 82 work will include:

- System commissioning, maintenance and disposal.
- Characterization and measurement of new thin film photovoltaic module technologies such as CdTe, CIS, CuInSe2, and so forth.
- New technology storage systems.
- Applications with special site conditions, such as tropical zone, northern latitudes and marine areas.

IEC TC 82 also expects to address several system and component safety issues, including grid-connected systems on buildings and utility-connected inverters, as well as various aspects of environmental protection. This consists of safeguarding the natural environment from such things as radiofrequency and electromagnetic pollution, disposal of toxic PV materials and atmospheric contamination from PV manufacturing processes, among other topics.

STE installations currently in operation, mainly in Spain and the United States, have an overall capacity exceeding 4,3 GW. Several large-scale projects in excess of 50 MW are now under construction in both countries as well as in the Middle East, North Africa and other regions. Various estimations forecast 140 GW of STE-generated capacity for 2020.

The Spanish standardization body, AENOR, established a specific STE subcommittee to start standardization procedures, a natural development given Spain's leading position in the development and deployment of the technology. AENOR was also behind the proposal to create an IEC TC to draft International Standards in the field of STE. IEC TC 117, established in 2011, prepares International Standards for solar thermal electric installations. It plans to set up three Working Groups (WGs) to cover the main needs for standardization: plant, components and storage.

Wind power

The global installed wind power capacity reached almost 487 GW in 2016, according to the Global Wind Energy Council (GWEC). A record 63 GW of new capacity was installed in 2015. China, already a world leader in the widespread use of solar water heaters, is set to become leader in wind power turbines also, and is already driving down wind turbine prices. One of the main trends in turbine development is increased size and rating for offshore installations; other continuing trends are variable-speed operation and the use of direct-drive generators. Principal associated developments are:

→ Resource evaluation (wind measurements, modelling)
→ Standards and certification
→ Improved aerodynamic efficiency
→ Cost reductions (value engineering, component development)
→ Advanced turbine development (new concepts)

In addition to increasing installation of turbines offshore in Europe, the development of offshore sites is advancing in the United States.

IEC TC 88 prepares Standards that deal with safety, measurement techniques and test procedures for wind turbine generator systems. It has produced Standards for design requirements, performance, acoustic noise measurement techniques, measurement of mechanical loads, and communications for monitoring and control of wind power plants. Its current work programme includes both Standards and design requirements for offshore wind turbines, gearboxes and wind farm power performance testing.

IEC TC 88 plans to develop new Standards and specifications on power performance measurements, medium scale wind turbines, electrical simulation, rotor blades, and to upgrade its specifications on mechanical loads measurements and blade testing to full International Standards.

Reliability and safety of Renewables

IECRE – IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications

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IECRE has been created in recognition that the ever-increasing demand for electricity and the need to reduce the share of fossil fuels in power generation have led to rapid development and growth of the RE sector. Intending to provide testing, inspection and certification for sectors such as wind energy, marine energy and solar PV energy.

IECRE aims to facilitate international trade in equipment and services for use in Renewable Energy sectors while maintaining the required level of safety.

IECRE scope

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In practical terms, the IECRE System is being organized into Sectors and Schemes. Three Sectors have currently been defined:

→ Solar PV Energy
→ Wind Energy
→ Marine Energy

Each of these Sectors intend to operate Schemes that cover:

→ Products, e.g. components and systems
→ Services, e.g. installations and other related offers of the Sector
→ Personnel, e.g. covering the competence of those working in the Sector

Future potential

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While IECRE focuses on these three Sectors for now, the door remains open for consideration of other technologies such as CSP, geothermal energy and fuel cells.

More information: **www.iecre.org**

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Environmental policy

What is the link between IEC Standards and renewable energies? It has to do with the environment. We recognize the growing importance of preserving the environment and the role electrotechnical standardization has to play to foster sustainable development. It is our responsibility to contribute actively to the evolving Sandards framework for the benefit of the environment. For this purpose, the IEC cooperates with ISO and regional Standards development organizations. With respect to product related standards, our technical committees must continuously assess and improve new and existing standards in view of reducing adverse environmental impacts over the whole life-cycle of products.

It also has to do with electrical Energy Efficiency, which has been part of our work for more than 100 years. Ensuring efficient production, transmission, distribution and use of electrical energy brings positive results. In terms of electricity generated from burning fossil fuels or coal, it diminishes the overall impact on the environment. In terms of consumers, it helps to keep energy costs down. As electricity Energy Efficiency is a growing concern in societies worldwide, we are investing more time and resources in this question to ensure that our contribution has a positive impact.

The IEC established the Advisory Committee on Environmental Aspects (ACEA) to advise on questions concerning the environment. ACEA's principal task is one of coordination for our technical committees and subcommittees to help them address environmental issues when preparing their Standards. To carry out its mandate, ACEA keeps abreast of the issues in its field and remains up-to-date on regulatory developments.

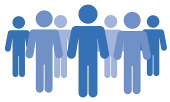
About the IEC

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).

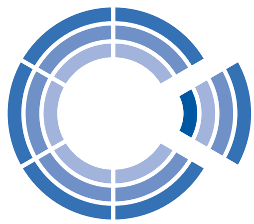
The IEC has served the world's electrical industry since 1906, developing International Standards to promote quality, safety, performance, reproducibility and environmental compatibility of materials, products and systems.

The IEC family, which now comprises 170 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.

170 countries | 83 members | 87 affiliates



99.1% of world population | 99.2% of energy generation



213 technical committees and subcommittees

1 500 working groups

More than 10 000 International Standards in catalogue

4 global Conformity Assessment Systems

>1 million conformity assessment certificates issued

More than 100 years of expertise

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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