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Environmental Engineering (EE);
Innovative energy storage technology for stationary use;
Part 1: Overview

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Environmental Engineering (EE).

The present document introduces an open series of documents for different families of technologies (battery systems, super-capacitors systems) that will be enriched progressively as new technologies emerge that may significantly impact the field of energy storage.

With the increase of new technologies in energy storage there is need for a global overview of an energy storage system for use in stationary information and communication technology (ICT) installations in networks, data centres and customer premises equipment (CPE), and simple evaluation of acceptable duration and characterization methods for this specific purpose.

The present document is part 1 of a multi-part deliverable covering "Innovative energy storage technology for stationary use", as identified below:

Part 1: "Overview";

Part 2: "Battery technology";

Part 3: "Super-capacitor technology".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Until early 2000, the battery technology has been dominated by Lead-acid for stationary uses and motive uses (factory fork lifts, engine starters). NiMH and Lithium have been used for mobile devices, portables tools and partially for electric vehicles. There have also been used for highly reliable and secure applications in fields such as industry, transport, etc.

The recent and relatively fast evolution of batteries, in particular lithium-ion has been driven by the rapid development of electric cars for urban use in fleets and more recently for popular commuter use in vehicle for public and private transport. The latest battery research has been directed toward technology enhancements that support an increase in distance travelled by vehicle using a single charge and a reduction in the time taken to re-charge the battery. Vehicle battery technology is rapidly expanding to include other battery technology areas offering product advantage in terms of reduced cost, safer usage, higher energy density levels and quicker charging. These include solid state batteries, aluminium ion, lithium sulphur and metal air. These strong developments of battery technologies can be applied in stationary Information and Communication Technology (ICT) industry.

An energy storage and generation technology that appears to move in and out of the battery lime light is the fuel cell. This technology comes in various different assortments but is best known as the hydrogen fuel cell for which a very high power density at 0,7 Watt per cm^2 or higher is possible, depending on operating conditions. Car manufacturers are considering extending batteries range with general optimizing in hybrid solutions with fuel cell, or internal and external engine generators. Fuel cell technology remains a potential contender for future use by electric vehicle manufacturers. Fuel cells have also been used in several ICT site trials and installations by major telecom providers.

The European Union (EU) Renewable Energy Directive [i.24] states that the EU is to meet at least 20 % of its total energy needs with renewable energy by 2020 through individual national targets of its member states. In revision work of the directive, the EU indicates new target of at least 27 % Renewable Energy of its final consumption by 2030.

Depending on the energy mix, the existing electric grid can accept in average injection of up to 10 % to 30 %, of renewable energy by only adding regional big energy storages for example water Pump Hydro Storage (PHS) or Compressed Air Energy Storage (CAES) connected to the high voltage grid. Above this level of intermittent renewable energy in some places or more generally in regions or countries, there is a need for smaller local storages in general made of electro-chemical batteries. Statistical analysis carried out within the EU in 2014 showed that 25,4 % of its total primary energy production came from renewables. This was made up of 16 % biofuels, 4,2 % hydropower, 2,83 % wind and 1,55 % solar. These technologies were further augmented with large regional energy storage solutions such as PSH and CAES, both solutions offering peak time energy stability to the high voltage grid. Although the EU can boast of having very high levels of renewable energy solutions, there is a need to further support these solutions in some regions where large renewable energies are still in development or offer intermittent or limited energy supply. This point is particularly true in some countries outside of the EU borders where there is a need for smaller local storages solutions. In general these solutions comprise of electro-chemical batteries.

In attempts to make the ICT sites more autonomous or interactive with the local utilities e.g. by peak shaving, demand response, etc., local battery installations are offering 'self-consumption' of renewable energy. This is achieved by charging local battery stacks using solar technology and as such providing site power at night and in periods of bad weather. In these particular examples there is a need to move away from pure back-up use of battery often in charge floating mode to charge/discharge cyclic use and in addition where site power requirements dictate, short term storage solutions such as super- capacitors should be considered.

With the development of sectors such as Internet of Things (IoT) and Machine to Machine (M2M) technologies, uninterrupted stationary power supplies have become more and more important where energy consumption is too high for using primary batteries due to size, cost and frequency of replacement. Therefore, rechargeable batteries are necessary for resilience and energy harvesting.

Further information on all these subjects can be found in various studies on energy storage such as the IEC White paper [i.9] or other presentations and publications e.g. in [i.13], [i.14], [i.15], [i.16], [i.17] and [i.19].

The trend towards the use of more cyclic battery technologies and super capacitors can be observed on international battery market evolution presented in annex A.

To this end to facilitate the choice of adapted storage solutions for stationary use in the ICT sector, simple and effective methods are developed in this multi part deliverable. They should give results in reasonable time which is introduced in the present document "ETSI TS 103 553-1: Overview".

Detailed information and methods are given in next parts for each family of technologies:

- ETSI TS 103 553-2 battery technology [i.25];
- ETSI TS 103 553-3: super-capacitors technology [i.26].

Future possible parts could be other storage technologies (e.g. fuel cells, mechanical storage).

With an increase in the selection of different manufacturers offering energy storage systems with different battery and super-capacitor technologies it has become increasingly difficult for the designer and the user to make the correct selection for their end system.

The intention of these evaluation methods is not to substitute but to complement the IEC standards on batteries for safety or factory tests such as [i.12] for Stationary lead-acid batteries or [i.10] and [i.11] for alkaline batteries or other non-acid electrolytes batteries or any new IEC standard on new energy storage technologies e.g. batteries, fly-wheel, etc.

The present document was developed jointly by ETSI TC EE and ITU-T Study Group 5 and published respectively by ITU and ETSI as Recommendation ITU-T L.1220 [i.27] and ETSI TS 103 553-1 (the present document), which are technically equivalent.

1 Scope

The present document identifies the main needs and applications of stationary electrical energy storage for ICT sites such as back-up on different grid quality and cyclic use of renewable energy systems. It also provides possible selection criteria for the correct choice for the end system. The topics considered are:

- families of electrical energy storage such as batteries or super-capacitors;
- technologies types and their main properties;
- adaptation to requirements (functionalities, technology availability, electrical characteristics, environmental adaptation, maintenance type, cost, etc.);
- national or regional rules and regulations.

The present document highlights the need of evaluation methods that are complementary to existing battery standards as they allow different time frame including shorter tests compared to common energy storage industry tests.

The present document introduces a series of subparts that covers energy storage technologies (battery, super-capacitor, etc.) applicable to stationary Telecom/ICT equipment used in telecom networks, data centres and customer premises (CPE).

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 2: -48 V Direct Current (DC)".

[2] Recommendation ITU-T L.1001 (11/2012): "External universal power adapter solutions for stationary information and communication technology devices".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-T L.1205 (12/2016): "Interfacing of renewable energy or distributed power sources to up to 400 VDC power feeding systems".

[i.2] ETSI EN 300 132-3-1 (V2.1.1): "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 1: Direct current source up to 400 V".

NOTE: An ongoing work should result in ETSI EN 300 132-3 replacing ETSI EN 300 132-3-1.

[i.3] ETSI EN 302 099 (V2.1.1): "Environmental Engineering (EE); Powering of equipment in access network".

NOTE: Annex C refers to ongoing revision work.

[i.4] ETSI TR 102 532 (V1.1.1) (2009-06): "Environmental Engineering (EE) The use of alternative energy sources in telecommunication installations".

[i.5] RSE (Ricerca Sistema Energetico) report (2011): "L'accumulo di energia elettrica".

[i.6] CEER (Council of European Energy Regulators) (2015-02): "Benchmarking Report 5.2 on the Continuity of Electricity Supply".

NOTE: Available at https://www.ceer.eu/documents/104400/-/-/cbc48e6a-5d5e-a170-ae1d-7b7b298d46a4.

[i.7] AEEGSI Report (2015-05).

NOTE: Available at: https://www.autorita.energia.it/allegati/com_stampa/15/151116cs.pdf.

[i.8] IEC 60050-826 (2004): "International Electrotechnical Vocabulary - Part 826: Electrical installations".

[i.9] IEC WPstorage: "IEC Energy storage White paper".

NOTE: Available at http://www.iec.ch/whitepaper/pdf/iecWP-energystorage-LR-en.pdf.

[i.10] IEC 62619 (2017-02): "Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications".

[i.11] IEC 62620 (2014-11): "Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for use in industrial applications".

[i.12] IEC 60 896 series: "Stationary lead-acid batteries".

[i.13] IRES and ESE 2016-T&E (2016-03): "International IRES and European ESE Conference".

NOTE: Available at https://eurosolar.de/en/index.php/text-and-media/press-releases-eurosolar.

[i.14] ETSI EE 2015-Storage Solutions (2015-06): "Energy Storage Solutions Panorama for Telecom Stand-By applications", Campion 3Cprojects, Third ETSI Workshop on ICT Energy Efficiency and Environmental Sustainability, Sophia Antipolis.

NOTE: Available at https://docbox.etsi.org/Workshop/2015/201506_EEWORKSHOP.

[i.15] Elsevier 2016-ESS applications (2016-08): "Energy storage technologies and real life applications - A state of the art review".

[i.16] Battery University website.

NOTE: Available at http://batteryuniversity.com/learn/article/types_of_lithium_ion.

[i.17] ENEA Fact & Figures (2012-03): "Issues, Technical solutions and development opportunities".

NOTE: Available at http://www.enea-consulting.com/wp-content/uploads/2015/05/ENEA-Consulting-Energy-Storage.pdf.

[i.18] ESA (Energy Storage Systems) (2007-01): "Characteristics and Comparisons". Wind Energy Research Laboratory (WERL), Universite´du Quebec Canada.

NOTE: Available at https://www.researchgate.net/publication/223915340_Energy_storage_systems-Characteristics_and_comparisons.

[i.19] SooGREEN: The 2017 International Workshop on "Service-oriented Optimization of Green Mobile Networks".

NOTE: Available at http://dl.ifip.org/db/conf/wiopt/wiopt2017/1570349026.pdf.

[i.20] European Commission Smart Grid Mandate (source of definition in M490): "Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment".

NOTE: Available at ftp://ftp.cencenelec.eu/CENELEC/Smartgrid/M490.pdf.

[i.21] Source of definitions in IADC UBO / MPD Glossary, December 2011.Global Standards http://www.iadclexicon.org/load-shifting/ and in http://www.iadclexicon.org/peak-shaving/.

[i.22] Source of definition in https://cdn.eurelectric.org/media/1940/demand-response-brochure-11-05-final-lr-2015-2501-0002-01-e-h-C783EC17.pdf.

[i.23] Avicenne Energy (2017-02): "Evolution du marché mondial des batteries rechargeables, Impact sur la demande en Nickel, Cobalt et Lithium".

NOTE: Available at http://www.mineralinfo.fr/sites/default/files/upload/comes_presentation-_c._pillot_fevrier_2017_pour_diffusion.pdf.

[i.24] The European Union (EU) Renewable Energy Directive.

NOTE: Available at https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive.

[i.25] ETSI TS 103 553-2: "Environmental Engineering (EE); Innovative energy storage technology for stationary use; Part 2: battery technology".

[i.26] ETSI TS 103 553-3: "Environmental Engineering (EE); Innovative energy storage technology for stationary use; Part 3: super-capacitor technology".

[i.27] Recommendation ITU-T L.1220 (08/2017): "Innovative energy storage technology for stationary use, Part 1: Overview of energy storage".

[i.28] Recommendation ITU-T L.1200 (05/2012): "Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

-48 VDC: -48 Volt Direct Current voltage range

NOTE: As standardized in Recommendation ITU-T L.1200 [i.28].

400 VDC: up to 400 Volt Direct Current voltage range

NOTE: As standardized in ETSI EN 300 132-3-1 [i.2].

back-up energy storage: energy storage system able to feed electricity to equipment of an ICT site in case of electric grid or local source unavailability or insufficiency of power source (electric grid or local source) to match the load demand

demand response: utility demand to final consumers (households or businesses) providing response in manual or automatic mode giving flexibility to the electricity system by voluntarily changing their electricity consumption in reaction to price signals or to specific requests which lead to lower prices for consumers and for utility by avoiding grid over-load and decreasing the need of high-cost power generation often using fossil energy and emitting carbon emission

electrical equipment: item used for purposes like storage, generation, conversion, distribution or utilization of electric energy (e.g. electrical machines, transformers, switch gear and control gear, measuring instruments, wiring systems, current-using equipment, etc.)

NOTE: As standardized in IEC 60050-826 [i.8].

energy storage: action or mean to store energy for use in the future

lithium based battery: battery that uses Lithium in electrode

load shifting: moving an entire load from a peak time to an off-peak time

NOTE: As standardized in IADC UBO/MPD Glossary [i.21].

nano grid, micro grid: local area grid connecting some building together at relatively short distance

NOTE 1: As standardized in Recommendation ITU-T L.1205 [i.1].

NOTE 2: It can be in AC or DC.

NOTE 3: In general nano grid is lower than 100 kW, micro grid can be of higher power. "Nano or micro grid" will be used in the present document.

nickel based battery: battery that uses nickel in electrode

peak shaving: technique used to shift a portion of an electrical load at a peak time of day to a non-peak time, helping in that to meet peek demands using alternate power sources such as gas supplies or energy storage

NOTE: Definition based on IADC UBO/MPD Glossary [i.21].

renewable energy: mainly non-fossil fuel converted into electricity

NOTE: As standardized in Recommendation ITU-T L.1205 [i.1].

EXAMPLE: Solar energy, wind, water flow, biomass which can be obtained from natural resources that can be constantly replenished.

self-consumption: consumption by an electricity consumer of its own energy production

smart grid: electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety

NOTE: As standardized in the European Commission Smart Grid Mandate [i.20].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

A (interface)	name of ICT/Telecom equipment -48 VDC power interface in ETSI EN 300 132-2 [1]
P	power feeding interface of up to 400 VDC defined in ETSI EN 300 132-3-1 [i.2]

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternative Current
AGM	Absorbent Glass Material
Ah	Ampere hour