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Environmental Engineering (EE); Interfacing of renewable energy or distributed power sources to 400 VDC distribution systems powering Information and Communication Technology (ICT) equipment

Reference

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

The up to 400 VDC power solutions feeding the power interface to ICT equipment as defined by ITU-T (Recommendation ITU-T L.1200 series [1], [2], [3], [i.1], [i.3]) and ETSI [8], are well adapted to straight forward use of renewable energy or distributed power sources through new simple DC nano or micro grids. This series defines the coupling of local or remote renewable energy into an up to 400 VDC power system without reducing DC performances defined in Recommendation ITU-T L.1202 [2] mainly for efficiency and reliability. The main advantages are saving of fossil fuel (as a source of primary energy consumption), reduction of GHG emission and increase of resilience. Additional site interconnection by DC grid can even bring more optimization. One other big benefit is that compared to AC, on 400 VDC there is no synchronization required between the various inputs, which keeps the architecture simple.

Modal verbs terminology

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Introduction

The up to 400 VDC power feeding solution for ICT sites (datacenters, telecom centers) and other building using the up to 400 VDC power interface Recommendation ITU-T L.1200 [1], are well adapted to straightforward use of renewable energy or distributed power sources through new DC nano or micro grid, most of them being more complex in AC than in DC. The DC would allow great simplification by avoiding frequency and phase synchronization of AC generators or inverters.

The present document aims at defining interface and architecture for injecting renewable energy into an up to 400 VDC power system in charge of providing power to ICT and facilities equipment with an interface compliant to Recommendation ITU-T L.1200 [1], and with a DC power architecture as defined in Recommendation ITU-T L.1204 [i.3], without reducing DC performances defined in Recommendation ITU-T L.1202 [2] mainly for efficiency and reliability.

The addition of local renewable energy will reduce energy consumption from the public utility, and possibly fossil primary energy consumption and the corresponding high GHG emission.

It can also provide more resilience in case of public electric grid interruption.

In addition, energy exchange is simple with distributed green power sources e.g. photovoltaic, wind power, fuel cell (FC) or engine generator using green fuel through a DC nano or micro grids at the level of a multi-building site or between different sites. These sites can be any type of ICT sites such as network access or nodes, data-centers, customer premises including IoT devices, etc.). Such an inter-buildings or sites power interconnection is called "site grid" by opposition to public electric utility.

These DC energy exchanges through site grid can bring higher level of optimization such as:

- exploit green-energy sources more efficiently by optimal location of renewable energy generator (e.g. for wind system in windy places and for PV system, in places out of shadow);
- complement local back-up power system e.g. battery;
- share local renewable energy excess of one site with other sites;
- ensure remote powering of distributed ICT site in the neighbourhood (e.g. by dedicated remote DC power cables or hybrid optical and DC power cables).

Injection of the renewable energy into the legacy AC public utility should consider the use of electricity for ICT services, and avoids undetermined use in the neighbourhood that can be inefficient. Key performance indicators could be used for reducing inconsidered use by accounting for efficient use of renewable energy on one ICT site or interconnected sites through a nano grid.

Many documents provided in bibliography are elaborating on the benefit and the need of coupling REN energy to local installation or to nano grid [i.7], [i.14] to ICT installation and the advantages of doing it in DC [i.8], [i.9], [i.10], [i.11], [i.12]. LCA approach is more detailed in [i.13].

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.1205 [i.1] and ETSI ES 203 474 (the present document), which are technically equivalent.

1 Scope

The present document defines interconnection of site power installation feeding up to 400 VDC interface, to site renewable energy or to distributed DC power. The covered aspects are:

- general power architectures for:
  - connection of a site renewable energy source (PV, wind generator, fuel cells, etc.) to a site power plant and especially the DC power system, (the site sources being on the buildings or around);
  - exchange of power to and from a DC nano or micro grid for use and production out of the site (this includes dedicated remote powering network built for ICT access equipment but also more general purpose DC electric grids);
  - conditions required to keep specified performance for the up to 400V power system:
    - electrical stability;
    - reliability and maintainability;
    - proper battery charge and management;
    - lightning protection coordination;
    - EMC and transient limits;
  - specification of proper power sizing, Requirement for control-monitoring and power metering;
  - assessment of performances (AC grid energy saving, reliability, flexibility, environmental impact, etc.).

The present document does not cover:

- renewable energy dimensioning;
- power injection into the legacy AC utilities which is already covered by many standards (e.g. from IEC);
- some of the smart power management possibilities through exchanges with DC nano or micro grid.

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

[2] Recommendation ITU-T L.1202 (2015): "Methodologies for evaluating the performance of up to 400 VDC power feeding system and its environmental impact".

[3] Recommendation ITU-T L.1203 (2016): "Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems".

[4] ETSI EN 301 605 (V1.1.1): "Environmental Engineering (EE); Earthing and bonding of 400 VDC data and telecom (ICT) equipment".

[5] ETSI ES 202 336 (all parts): "Environmental Engineering (EE); Monitoring and Control Interface for Infrastructure Equipment (Power, Cooling and Building Environment Systems used in Telecommunication Networks)".

[6] IEC 60364 series: "Low-voltage electrical installations".

NOTE: Available at https://webstore.iec.ch/searchform&q=IEC%2060364.

[7] IEC 62368-1: "Audio/video, information and communication technology equipment - Part 1: Safety requirements".

[8] ETSI ES 203 408 (V1.1.1) (2016-12): "Environmental Engineering (EE); Colour and marking of DC cable and connecting 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 (October 2016): "Interfacing of renewable energy or distributed power sources to up to 400 VDC power feeding systems".

[i.2] ETSI EN 302 099 (V2.1.1): "Environmental Engineering (EE); Powering of equipment in access network".

[i.3] Recommendation ITU-T L.1204 (2016): "Extended architecture of power feeding systems of up to 400 VDC".

[i.4] Recommendation ITU-T L.1302 (2015): "Assessment of energy efficiency on infrastructure in data centres and telecom centres".

[i.5] Recommendation ITU-T L.1350 (2016): "Energy efficiency metric of base station site".

[i.6] Recommendation ITU-T L.1410: "Methodology for environmental life cycle assessments of information and communication technology goods, networks and services".

[i.7] K.K. Nguyen et al. (Projet GreenStar) (2011): "Renewable Energy Provisioning for ICT Services in a Future Internet" Future Internet Assembly, LNCS 6656 (open access at SpringerLink.com), pp. 421-431.

[i.8] IEEE/Intelec 2013 (Hamburg): "DC power wide spread in Telecom/Datacenter and in home/office with renewable energy and energy autonomy", Didier Marquet and al. Orange Labs; Toshimitsu Tanaka et al. NTT.

[i.9] Vicor White paper: "High-voltage DC distribution is key to increased system efficiency and renewable-energy opportunities", Stephen Oliver.

NOTE: Available at http://www.vicorpower.com/documents/whitepapers/wp-High-voltage-DC-Distribution.pdf.

[i.10] STARLINE: "Phasing Out Alternating Current Directory: An Engineering Review of DC Power for Data Centers", David E. Geary.

[i.11] 400 VDC Power Solutions from Emerson Network Power: "Innovative Power Architecture for Data Center and Telecommunications Sites".

NOTE: Available at https://www.vertivco.com/globalassets/products/critical-power/dc-power-systems/400v-dc-power-solutions-brochure.pdf.

[i.12] IEEE/Intelec 2014 (paper quoted on Emerge Alliance): "Three Case Studies of Commercial Deployment of 400V DC Data and Telecom Centers in the EMEA Region", Sara Maly Lisy, Mirna Smrekar Emerson Network Power.

NOTE: Available at http://www.emergealliance.org/portals/0/documents/events/intelec/TS01-2.pdf.

[i.13] IREED 2011 (Lille 23-24 March 2011, 7 p): "Wiring design based on Global Energy Requirement criteria: a first step towards an eco-designed DC distribution scheme", C. Jaouen, B. Multon, F. Barruel.

[i.14] Micro grids: "A bright future".

NOTE: Available at http://www1.huawei.com/enapp/198/hw-110948.htm.

3 Definitions and abbreviations

3.1 Definitions

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

back-up power system: power system providing energy to equipment of an ICT site in case of downstream electric unavailability

distributed power source: local electrical power source where energy is produced close to the user and distributed by a nano or micro grid by opposition to a centralized power plant with a long distance electricity transport grid

NOTE: This local power source can be an individual user power system or a small collective energy power plant for a group of customers. It can include energy sources or storage or cogeneration of heat and electricity using any primary energy renewable or not.

distributed power system: system of distributed power source and possibly other function such as energy conversion, interconnection, safety system, energy storage and corresponding management

ICT equipment (Recommendation ITU-T L.1200 [1]): information and communication equipment (e.g. switch, transmitter, router, server, and peripheral devices) used in telecommunication centres, data-centres and customer premises

Interface P (Recommendation ITU-T L.1200 [1]): interface, physical point, at which power supply is connected in order to operate the ICT equipment

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

NOTE: It can be in AC or DC. 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.

renewable energy: energy which can be obtained from natural resources that can be constantly replenished

NOTE: Source: Australian Renewable energy Agency.

renewable energy source: source producing electrical energy from renewable energy

site grid: DC nano or micro grid between ICT sites by opposition to public electric utility

3.2 Abbreviations

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

AC	Alternating Current
BMS	Battery Management System
CHP	Combined Heat and Power
CT	Current Transducer
CU	Control Unit
DC	Direct Current
EE	Energy Efficiency
EMC	Electro-Magnetic Compatibility EMC
FC	Fuel Cell
GHG	Green House Gas
HV	High Voltage
HVAC	High Voltage AC
ICT	Information and Communication Technology
IoT	Internet of Things
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LVAC	Low Voltage AC
LVDC	Low Voltage DC
MW	Megawatt
PDF	Power Distribution Frame
PDU	power Distribution Unit
Ppeak	Peak power
Pu	Used power
PV	Photovoltaic
PWM	Pulse Width Modulation
REN	Renewable Energy
RF	Rectifier Function
TCO	Total Cost Ownership
VDC	Volt DC

4 Architecture of up to 400 VDC power with REN coupling

4.1 Overview

In existing buildings, AC grid (HVAC or LVAC) and LVAC distributions are powering ICT equipment, cooling systems, back-up power systems, control/monitoring, lighting, office computers, Ethernet switches routers and many other equipment in the building such as ventilation, heater, lifts, etc. A part of the equipment is DC powered by the DC power feeding systems, and this part is mainly using 400 VDC rather than -48 VDC because of the higher power density of equipment in order to reduce cable cross-section area and distribution losses.

ICT sectors work on the reduction of the non- renewable primary energy use by reducing direct electricity consumption and producing more Renewable Energy (REN).

The REN generators are generally in LVDC and so power arrangement up to 400 VDC power systems is much more convenient for injecting REN.

NOTE: REN generators that are in AC are generally producing variable frequency and voltage requiring precise synchronization for connection to AC grid.

DC REN generators allow easier consumption of locally generated energy or generated by a group of close sites through DC nano or micro grid compared to solution with local AC generator synchronized with AC grid.

Due to the wide use of AC in ICT buildings, the REN coupling solutions should consider a progressive swap from AC injection to DC. Figure 1 gives the general principle of energy flow of the renewable energy or distributed DC power to the existing power system of the building integrating an up to 400 VDC system.

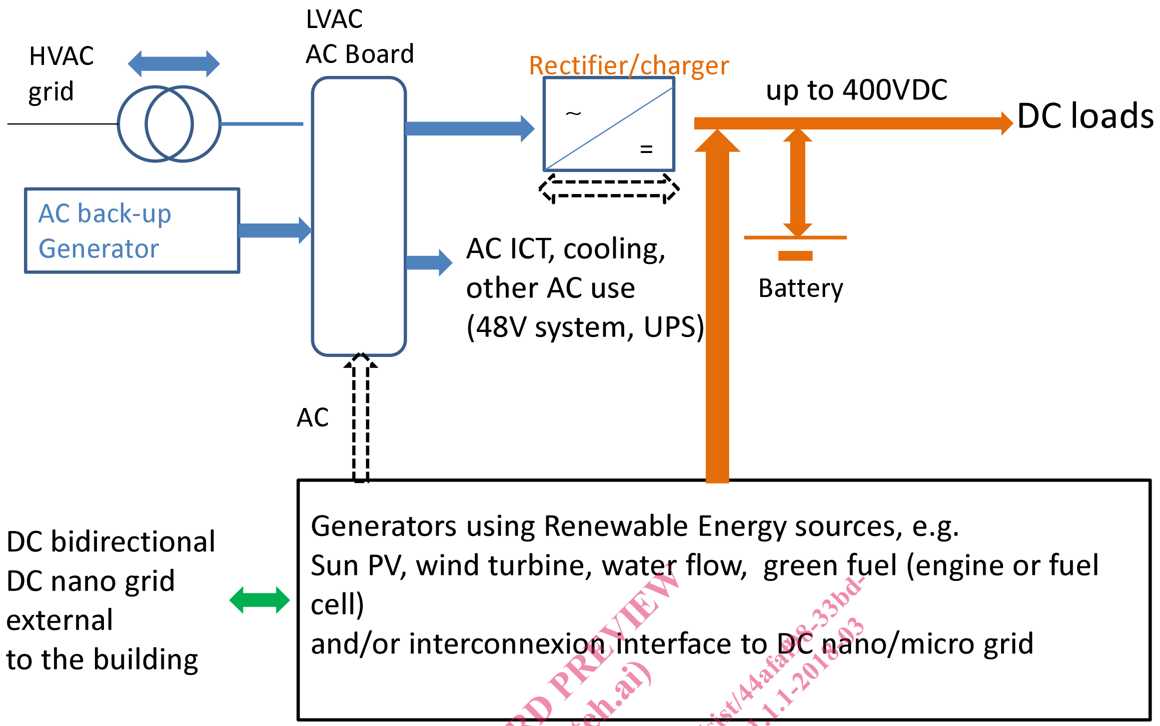

Figure 1: General energy flow principle for coupling renewable or distributed DC site grid to an up to 400 VDC power system in a building of a site

The flow direction is indicated by the arrow and reverse direction from REN to grid depends on excess of power not used by the sites for powering ICT equipment, cooling and air conditioning equipment and building use could be sent to the AC or DC grids. This is to avoid loss of productivity and to contribute to the local or regional nation electric mix and CO_2 reduction effort and to obtain a better TCO for the user.

Combined Heat and Power generation (CHP) and storage can be also alternatives, but they are not covered in the present document focused on injection of electricity in DC and partly in AC.

4.2 Local and distant Renewable Energy coupling architecture to sites with up to 400 VDC

There are different architectures for interconnections of local REN or distributed power systems or DC nano and micro grid up to 400 VDC power systems in buildings or sites. It includes local renewable power sources:

- connected to AC and/or DC distribution:
  - for local consumption;
  - for local injection of excess of production into external grid;
- connected to an external DC nano or micro grid:
  - for injection of excess of DC production towards other buildings or sites;
  - for remote interconnection to the AC grid e.g. for mutualized injection of DC energy excess on one single point;
  - for islanding the group of sites when running on own distributed power production capacity (e.g. pure or hybrid renewable energy source with energy storage).