Project Title:

Innovative compact HYbrid electrical/thermal storage systems for low energy BUILDings

Project Acronym:

HYBUILD

Deliverable Report

Deliverable number:

D5.4

Report on existing standards and standardization landscape

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Lead beneficiary:	UdL
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Publishable executive summary

The EU Horizon 2020-funded project HYBUILD, led by COMSA, will develop two innovative compact hybrid electrical/thermal storage systems for stand-alone and district-connected buildings.

Deliverable D5.4 aims at collecting the existing standards related to the HYBUILD systems developed for both Mediterranean and Continental climates. The two systems are structured into sub-systems and specific components. The collection of the standards is finalized at defining the state-of-the-art on the norms regulating the identified components, and at understanding whether there are shortcomings to be integrated with new standards.

Therefore, the present deliverable is divided into three main sections.

In the first section, an introduction on the methodology is proposed and the list of components to be analysed is presented for both the HYBUILD systems developed for the Mediterranean (MED) and for the Continental (CONT) climates. The components are shown in Figure 1.

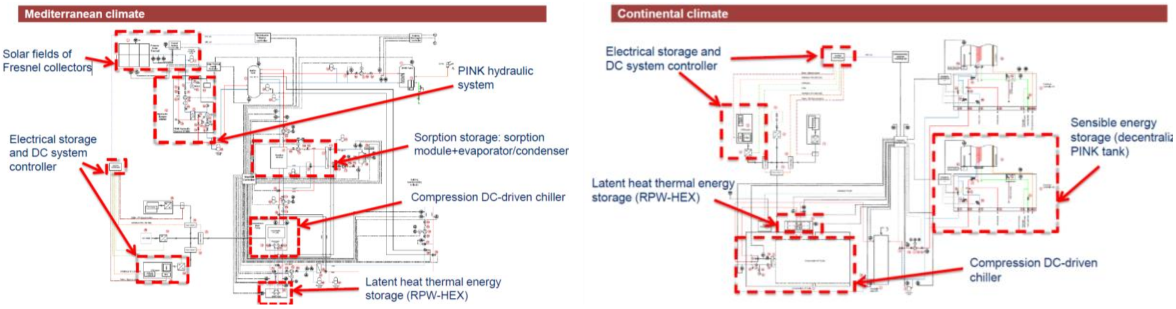

Figure 1. Identification of components for the MED and CONT HYBUILD systems

In the second section, the analysis of existing standards is provided, considering international, European and national regulations. A sub-section is dedicated to each component, i.e. sorption storage, latent thermal energy storage, electrical storage, DC system controller and PV panels, heat pumps, solar fields, and sensible heat storage.

According to the analysis carried out and described in this deliverable, it can be concluded that:

- there are no relevant standards related to sorption storage; however, multiple standards have been set-up for sorption heating and cooling systems;
- there are several standards covering the use of PCMs in latent thermal energy storage, nevertheless no distinction is made between low- and high-temperature latent storage;
- there are few codes and standards focused on DC devices: indeed, without standards and codes, electrical manufacturers have no explicit criteria to design DC products or ensure product compatibility;
- very few standards exist regarding building integrated PV (BIPV);
- standards for Fresnel solar fields are currently quite rare, and those for building applications even more;
- standards for specific hydraulic storage systems involved in solar application are currently poorly developed; they are included in larger packages such as solar thermal standards. Moreover, a distinction between groups, such as DHW tank and buffer tank, is difficult;
- several standards and ad-hoc technical committees exist regarding electrical storage, PV panels and heat pumps.

In the last section, conclusions and indications on the following activities of Task 5.4 are provided. Indeed, based on the performed investigation, it can be concluded that, for some components, the existing standards are quite exhaustive (e.g. for the heat pumps), but for others (e.g. sensible heat storage, sorption storage, and others) a deep development of standards is needed. In addition, there is a lack of standards at the building scale; moreover, a normative framework concerning solar fields based on Fresnel collectors in the building context is currently missing.

Building on these conclusions, the second part of Task 5.4, which will be finalised in the D5.5 “Full standardization proposals”, will be dedicated to the definition of the optimal standardization strategy for the HYBUILD systems and/or components. The activities will start with the involvement of the consortium partners that are connected with relevant standardisation organisations and technical committees in order to define the standardization strategy: to understand, considering the complexity of the HYBUILD hybrid storage solution, whether an ad-hoc certification or standard would be required or if standards related only to the innovative components could be proposed.

Acronyms and Abbreviations

AHRI	Air-conditioning, Heating and Refrigeration Institute
ANSI	American National Standards Institute
ASHREE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials International
BIPV	Building-integrated Photovoltaics
CEN	Comité européen de normalisation
CENELEC	Comité européen de normalisation en électronique et en électrotechnique
CONT	Continental
CSP	Concentrated Solar Power
DC	Direct Current
DHW	Domestic Hot Water
DIN	Deutsches Institut für Normung
EC	European Commission
EN	European Norms
EU	European Union
HEX	Heat Exchanger
HP	Heat Pump
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
MED	Mediterranean
NBK	Nobatek, Institut National pour la Transition Énergétique et Environnementale du bâtiment
NTUA	National Technical University of Athens
PCM	Phase Change Material
prEN	Draft European Standard
PV panel	Photovoltaic panel
RAL	German Institute for Quality Assurance and Certification
R2M	Research to Market Solution
RPW-HEX	Refrigerant-PCM-Water HEX (latent storage integrated in the refrigerant cycle of a compression heat pump)
STE	Solar Thermal Electric
STRESS	Sviluppo Tecnologie e Ricerca per l'Edilizia Sismicamente Sicura ed ecoSostenibile
TC	Technical Committee
UDL	Universidad de Lleida
VDI	Verein Deutscher Ingenieure
WP	Work Package

1 Introduction

1.1 Aims and objectives

Task 5.4 aims at facilitating the acceptance and utilization by the market of the developed HYBUILD solutions. Moreover, it aims at providing starting information for other WPs, ensuring compatibility and interoperability with market available systems through standards and regulations, as well as using the standardization system as a tool for dissemination of the project results and interaction with the market stakeholders.

The activities planned in T5.4 to fulfil the above objectives are developed under three specific subtasks, which are mutually linked:

1. the identification and analysis of related existing standards,
2. the collaboration with the relevant standardization Technical Committees, and
3. the contribution to the on-going and future standardization developments from the results of the project.

In the present deliverable - D5.4 – the first subtask is discussed by analysing existing standards for HYBUILD systems components.

Two HYBUILD systems, for the Mediterranean (MED) and the Continental (CONT) climates, have been defined and designed in WP2 and WP3.

The HYBUILD systems are shown in Figure 2 and Figure 3; the figures show specific sub-systems and their components listed hereafter.

- Mediterranean system
  - Sorption storage (sorption module + evaporator condenser)
  - Low temperature latent thermal energy storage (RPW-HEX)
  - Electrical storage, DC system controller and PV panels
  - Compression DC-driven chiller (DAIKIN heat pump)
  - Solar fields of Fresnel collectors + sensible heat storage (PINK hydraulic system, buffer tank and DHW tank)

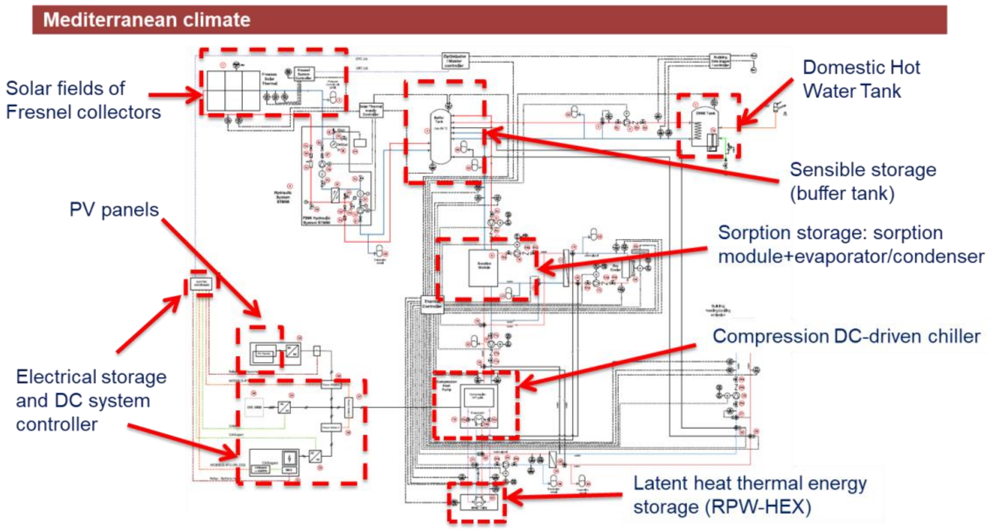

Figure 2. Components of MED HYBUILD system

- Continental system
  - High temperature latent thermal energy storage

- Electrical storage, DC system controller
- Compression DC-driven chiller (OCHSNER heat pump)
- Sensible heat storage (decentralized PINK tank)

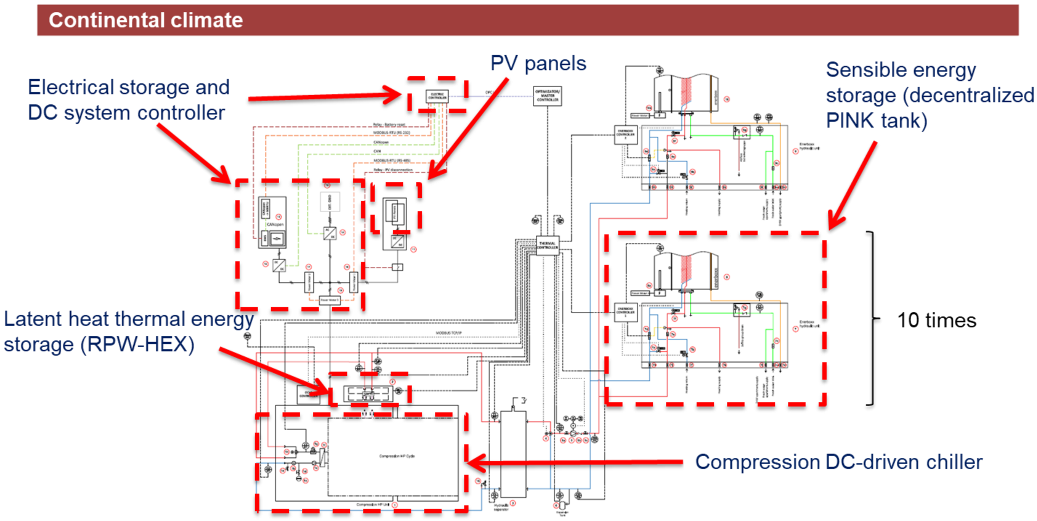

Figure 3.Components of CONT HYBUILD System

The analysis of existing standards has started at international and European level. When relevant, standards at national level have also been considered. The list of standards here presented derives from a deep bibliography research, but should be considered not totally exhaustive, since some existing standards could be missing. The collected standards are updated at January 2021.

1.2 Relations to other activities in the project

Task 5.4 is strictly connected to WP2 and WP3 packages, since they provide the information on the technology used in the HYBUILD project. Moreover, it is connected to the activities of WP7 "Dissemination and exploitation" and WP8 "Communication", because it ensures that the results of the project can be disseminated and that the interaction with the market stakeholders can take place.

1.3 Report structure

This report describes the existing codes and standards related to each component of both the Mediterranean and Continental HYBUILD systems. European standards are taken into account; if relevant, national standards are also considered.

Therefore, the report is structured as follows:

- In Section 2, the existing standards for the components of HYBUILD systems have been analysed, one for each sub-section:

  1) Sorption storage (sorption module + evaporator condenser)
  2) Latent thermal energy storage

3) Electrical storage, DC system controller and PV panels
4) Compression DC-driven chiller (heat pump)
5) Solar fields of Fresnel collectors
6) Sensible heat storage (hydraulic system, buffer tank, DHW tank, decentralized tank)

- In Section 3, conclusions and general information on following T5.4 activities are given.

1.4 Contributions of partners

Each partner involved in T5.4 has provided its contribution to task development, according to the effort distribution. It was decided to assign to partners the analysis of existing standards of HYBUILD systems components, considering their respective knowhow. Therefore, the following components assignment to partners has been defined:

- NBK has analysed the standards related to solar fields of Fresnel collectors and sensible heat storage
- R2M has analysed the standards related to heat pumps, DC system controllers, solar PV and electrical energy storage systems
- NTUA has analysed the standards related to the sorption storage, low temperature latent storage and high temperature latent heat storage
- STRESS has coordinated the task activities, structured the document, integrated and reviewed partners' contributions.

2 Existing standards for HYBUILD Systems Components

2.1 Sorption storage

2.1.1 Overview

Currently, there are no effective standards regarding sorption storage systems. However, multiple standards have been set-up for sorption heating and cooling systems. The main information of these standards is summarized in the following table.

Standard	
EN 12309 (EU)	Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70 kW - Part 1: Terms and definitions, Part 2: Safety, Part 3: Test conditions, Part 4: Test methods, Part 5: Requirements, Part 6: Calculation of seasonal performances, Part 7: Specific provisions for hybrid appliances
EN 13203-6 (EU)	Gas-fired domestic appliances producing hot water - Part 6: Assessment of energy consumption of adsorption and absorption heat pumps
ANSI/AHRI 560 (US)	Standard for Absorption Water Chilling and Water Heating Packages
ANSI/ASHRAE 182 (US)	Method of Testing Absorption Water-Chilling and Water-Heating Packages
VDI 4650-2 (DE)	Simplified method for the calculation of the annual coefficient of performance and the annual utilisation ratio of sorption heat pumps - Gas heat pumps for space heating and domestic hot water
RAL-UZ 118 (DE)	Basic criteria for award of the environmental label- energy-efficient heat pumps

EN 12309

EN 12309 consists of seven parts. Appliances covered by this European Standard include one or a combination of the following: gas-fired sorption chiller; gas-fired sorption chiller/heater; gas-fired sorption heat pump. EN12309 applies to appliances designed to be used for space heating or cooling or refrigeration with or without heat recovery. Furthermore, it applies to appliances having flue gas systems of type B and C (according to CEN/TR 1749) and to appliances designed for outdoor installations. EN 12309 does not apply to air conditioners, it only applies to appliances having: integral burners under the control of fully automatic burner control systems, closed system refrigerant circuits in which the refrigerant does not come into direct contact with the water or air to be cooled or heated, mechanical means to assist transportation of the combustion air and/or the flue gas. The above appliances can have one or more primary or secondary functions (i.e. heat recovery - see definitions in prEN 12309 1:2012). In the case of packaged units (consisting of several parts), this standard applies only to those designed and supplied as a complete package. The appliances having their condenser cooled by air and by the evaporation of external additional water are not covered by EN 12309. Installations used for heating and/or cooling of industrial processes are not within the scope of EN 12309.

EN 13203-6

EN 13203-6 is the sixth part of standard EN 13203, which is applicable to gas-fired appliances producing domestic hot water. EN 13203 applies to both instantaneous and storage appliances; water-heaters and combination boilers that have: heat input not exceeding 70 kW and hot water storage capacity (if any) not exceeding 500 l. In the case of combination boilers, with or without storage tank, domestic hot water production is integrated or coupled, the whole being marketed as a single unit. Overall, EN13203 sets out in qualitative and quantitative terms the performance in delivery of domestic hot water for a selected variety of uses. It also outlines a procedure for presenting the information to the user.

The scope of EN 13203-6, in particular, is the assessment of energy consumption of adsorption and absorption heat pumps connected to or including a domestic hot water storage tank. It applies to a package marketed as single unit or fully specified that have: a heat input not exceeding 400 kW and a hot water storage tank capacity (if any) not exceeding 2000 l. In the case of combination boilers, with or without storage tank, domestic hot water production is integrated or coupled, the whole being marketed as a single unit. EN 13203-6 sets out a method for assessing the energy performance of the appliances. It defines a number of daily load profiles for each domestic hot water use, kitchen, shower, bath and a combination of these, together with corresponding test procedures, enabling the energy performances of different gas-fired appliances to be compared and matched to the needs of the user. Where other technologies are combined with a gas-fired boiler or a water heater to produce domestic hot water, specific parts of EN 13203 apply. Horizontal ground heat sources are not covered by the scope of the present European Standard.

DIN 33830-4

DIN 33830-4 describes test conditions and scope of testing of performance and operational tests of absorption heat pump units for heating. The standard is applicable for water, ground or air source units; on the heat sink side, both water and air can be the heat transfer medium.

ANSI/AHRI 560

This standard applies to water/LiBr water chilling machines. It includes indirectly-fired single effect chillers (both steam- and hot water-fired), indirectly-fired double effect chillers (both steam- and hot water-fired), and directly-fired double effect chiller/heaters. It does not apply to machines that are air-cooled, exhaust gas-fired, or used only for heating.

ANSI/ASHRAE 182

This standard prescribes a method of testing absorption water-chilling and water-heating packages to verify capacity and thermal energy input requirements at a specific set of operating conditions. It applies to absorption packages used to chill and/or heat water and testing that will occur where proper instrumentation and load stability can be provided. This standard is not intended for testing typical field installations. The ANSI/ASHRAE 182 standard is a method of test (MOT) standard meant to be used in conjunction with a rating procedure such as ARI 560. The standard applies only to water-cooled units. It applies to chillers using water/LiBr, ammonia/water, and other working fluids, both single- and double-effect. The chiller can be direct-fired by natural gas, LP gas, oil, or other fuel; or it can be indirectly fired by steam, hot water, a hot gas stream, or other hot heat transfer fluids. It covers three modes of operation: cooling-only, heating-only, and combined cooling and heating.

VDI 4650-2

The scope of VDI 4650-2 is to define a method to estimate seasonal performance figures of a gas fired thermally driven heat pump based on measurements under part load laboratory conditions. It is defined for monovalent gas fired sorption heat pumps up to a heating power of 70 kW. As ambient heat sources ground water, boreholes, air and solar radiation gained by a solar collector are considered. The heat is used for domestic hot water preparation and space heating.

RAL-UZ 118

RAL-UZ 118 is issued by RAL, the German Institute for Quality Assurance and Certification, governs the labelling of the environmental certificate "Der Blaue Engel" for gas driven heat pumps. RAL-UZ 118 is a collection of minimum standards a gas driven heat pump has to fulfil to gain the labelling. It is valid for absorption type and adsorption type thermally gas fired heat pumps as well as for combustion engine driven compressors. The maximum heating power should not surpass 70 kW at a heating temperature of 40°C.

2.1.2 Summary

Although the aforementioned standards cover sorption heat pumps and not specifically sorption storage appliances, their main principles could provide a framework for the development of standards for the evaluation of the performance of the latter, as they are technologically very similar.

2.2 Latent thermal energy storage-phase change materials (PCMs)

2.2.1 Overview

There are currently several standards covering the use of PCMs in force. The main information on these standards is summarized in the following table. It should be noted that in these standards, no distinction is made between low- and high- temperature latent heat storage.

ANSI/ASHRAE Standard 94.1	Method Of Testing Active Latent-Heat Storage Devices Based On Thermal Performance
ASTM C1784 - 20	Standard Test Method for Using a Heat Flow Meter Apparatus for Measuring Thermal Storage Properties of Phase Change Materials and Products
VDI 2164:2016-12	PCM energy storage systems in building services
RAL-GZ 896	Phase Change Materials Quality Assurance
EN 16806-1:2016	Textiles and textile products - Textiles containing phase change materials (PCM) - Part 1: Determination of the heat storage and release capacity
EN 16806-2:2016	In part 1 description, there is "This part of EN 16806 does not apply to the determination of the heat transfer properties of textile fabrics (woven and knitted fabrics, nonwovens) containing phase change materials, for which part 2 of EN 16806 applies"

ANSI/ASHRAE Standard 94.1

This standard applies to latent thermal energy storage devices in which a transfer fluid enters the device through a single inlet and leaves the device through a single outlet. The purpose of this standard is to provide a standard procedure for determining the thermal performance of latent thermal energy storage devices used in heating, air-conditioning, and service hot water systems. This standard is not applicable to those configurations in which there is simultaneous flow into the storage device through more than one inlet or simultaneous flow out of the storage device through more than one outlet. The transfer fluid can be either a liquid or a noncondensing gas.

ASTM C1784 - 20

Materials used in building envelopes to enhance energy efficiency, including PCM products used for thermal insulation, thermal control, and thermal storage, are subjected to transient thermal environments, including transient or cyclic boundary temperature conditions. This test method is intended to enable meaningful PCM product classification, as steady-state thermal conductivity alone is not sufficient to characterize PCMs.

VDI 2164

This standard defines the fundamentals for the use of latent-heat storage systems in building services. Recent developments in the field of phase-change-materials (PCMs) open the way to new systems and components allowing energy savings and increases in energy efficiency. As the use of regenerative energies expands, demand and generation no longer coincide, requiring the temporary storage of energy in the building. Based on the fundamentals specified in this standard, PCM systems are described, their planning and calculation explained, and performance parameters are identified. The standard comprehensively covers: passive surface heating and cooling systems (such as building materials, components), active surface heating and cooling systems (such as chilled ceilings), local ventilating systems for cooling purposes, centralised ventilating systems for heating and cooling, energy storage systems.

RAL-GZ 896

These quality and testing specifications set out the general principles for PCM including PCM composites, PCM objects and PCM systems, in particular for authoritative parameters, requirements, as well as content and scope of monitoring measures. Continuous in-house monitoring and external monitoring ensure permanent compliance with the quality requirements. The applicable version of the implementation regulations and the applicable version of the detailed regulations complementing the quality and testing specifications according to the sample status March 2018 must also be applied. The detailed regulations are adapted to the state-of-the-art on a regular basis. The most recent version is published on the web page of the Quality Association PCM (www.pcm-ral.org).

EN 16806-1

This part of EN 16806 specifies a test method for the determination of the heat storage and heat release capacity and the phase change temperatures of textile fibres, yarns and fabrics (woven and knitted fabrics, nonwovens) containing phase change materials (PCM). The test method can also be applied for pure or micro-encapsulated PCM. This part of EN 16806 does not apply to the determination of the heat transfer properties of textile fabrics (woven and knitted fabrics, nonwovens) containing phase change materials, for which part 2 of EN 16806 applies. This part of EN 16806 does not apply to determining the heat transfer between the user and the product for textile products, e.g. garments, mattresses, etc. made with PCM containing materials, for which part 3 of EN 16806 applies.

2.2.2 Summary

There are currently existing standards on the efficiency assessment of PCMs by various standardization organizations and agencies, which could be readily utilized for establishing standards for the HYBUILD components with minimal modifications.

2.3 Electrical storage, DC system controller and PV panels

2.3.1 Electrical storage

The European technical committee working on standards related to electrical energy storage and more specifically on batteries is:

- **CLC/TC 21X** “Secondary cells and batteries”, mirror committee of the IEC TC21/SC21A.

The Cenelec TC addresses the requirements covering the aspects of safety installation principles, performance, applications, dimensions, labelling and testing.

In addition, the EES system should contain components which are in compliance with the EC Regulation 1907/2006 (REACH) and directive 2011/65 (ROHS).

CLC/TC 31 – Electrical apparatus for potentially explosive atmospheres	Status
EN IEC 62932-1:2020 (pr=63527) Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects	Published
EN IEC 63056:2020 (pr=64887) Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems	Published

Other international standards	Status
IEC 61427-1	Published

Secondary cells and batteries for renewable energy storage – General requirements and methods of test – Part 1: Photovoltaic off-grid application Stability date: 2021. At this date, the publication will be either reconfirmed, withdrawn, replaced by a revised edition or amended 2021	
IEC 61427-2 Secondary cells and batteries for renewable energy storage – General requirements and methods of test – Part 2: on-grid applications Stability date: 2021. At this date, the publication will be either reconfirmed, withdrawn, replaced by a revised edition or amended 2021	Published
IEC 62485-2 Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries Stability date: 2021. At this date, the publication will be either reconfirmed, withdrawn, replaced by a revised edition or amended 2021	Published
IEC 62485-5:2020 Safety requirements for secondary batteries and battery installations – Part 5: Safe operation of stationary lithium ion batteries	Published
IEC/TS 62257-9-1 Recommendations for renewable energy and hybrid systems for rural electrification - Part 9-1: Integrated systems - Micropower systems Forecast publication date: 24-FEB-22	Published
IEC/TS 62257-9-2 Recommendations for renewable energy and hybrid systems for rural electrification - Part 9-2: Integrated systems - Microgrids	Published
IEC/TS 62257-9-7 Renewable energy and hybrid systems for rural electrification - Part 9-7: Recommendations for selection of inverters	Published
IEC 62933 Part 1-4 Electrical energy storage (EES) systems	Not published yet

IEC 62281 Safety of primary and secondary lithium cells and batteries during transport	Published
IEC 62934 Grid integration of renewable energy generation – Terms and definitions Forecast publication date: 2021-05	Not published yet
Functional Requirements for Electric Energy Storage Applications on the Power System Grid, Electric Power Research Institute (EPRI)	Interesting reference
PNNL 22010: Protocol for Uniformly Measuring and Expressing Performance of Energy Storage Systems (2012)	Interesting reference

2.3.2 DC system controller

In March 2017, the IEEE European Public Policy Initiative (IEEE EPPI) calls on European Union policy makers to take actions that will lead to greater efficiency in the supply of Direct Current (DC) electric power for the rapidly growing range of products and equipment that require DC power, commonly found in private homes and businesses. Standards will be an essential part of the solution.

The IEEE Standards Association has already developed some of the most important standards required to consolidate the large-scale deployment of DC power, and has launched an initiative called the Indian Low Voltage DC Forum, which is conducting research in India to "evaluate LVDC impacts for emerging and developed markets and recommend appropriate global standards." To walk towards the adoption of a DC solution, some steps need to be followed. Standardization should be promoted, following successful experiences already available in industrial applications, such as data centres. It is important to clearly define the DC voltage levels that show the optimal combination of efficiency and safety. Legislation concerning energy efficiency of household and office appliances should be updated, to promote the production of more efficient DC appliances [1].

Some of the standards developed by the IEEE Standards Association related to this domain are:

- IEEE P946 - Approved Draft Recommended Practice for the Design of DC Power Systems for Stationary Applications
- IEEE 1899-2017 - Guide for Establishing Basic Requirements for High-Voltage Direct-Current Transmission Protection and Control Equipment

IEC is working on the Standardization for Low-Voltage DC Systems Committee LVDC (SyC LVDC) involving different Subcommittees and Working Groups [2]. Amongst the several domains under analysis, the Working Group 8 of the TC 23 is working on guidelines and standards for Electrical Accessories for household and similar purposes intended for use in direct current circuits. Their publications include:

- IEC 63044-4 ED1 General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 4: General functional safety

requirements for products intended to be integrated in Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS);
- IEC TS 63236 ED1 Direct current (DC) appliance couplers for information and communication technology (ICT) equipment installed in data centres and telecom central offices - Part 1: 2.6 kW system.

At international level, a study [3] has been made by the National Electrical Manufacturers Association (NEMA) based on a survey with vendors, technical experts, research laboratories, standards development organizations, and other stakeholders to explore the existing landscape and future scenarios for DC in buildings. Amongst others, the lack of DC standards is one of the barriers to the use of DC in buildings at broad scale (Figure 4).

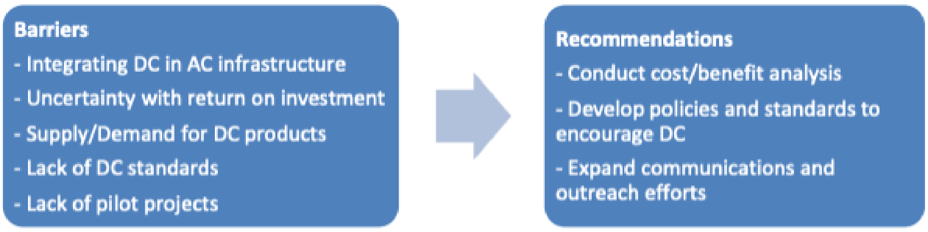

Figure 4. Examples of barriers and recommendations from increased deployment of DC in buildings [3]

There are few codes and standards today that give specific treatment of DC. They are mostly in the area of data centres and Power over Ethernet. Without standards and codes, electrical manufacturers have no explicit criteria to design DC products or ensure product compatibility.

Insufficient DC products are one of the primary barriers to promote DC distribution. These products range from generation and storage to end-use appliances, **as well as control system** and fundamental hardware such as connectors, wiring and circuit breakers. Manufacturers should develop DC products and control systems that have at least the same capabilities as equivalent AC products.

The EMerge Alliance, a consortium that includes product manufacturers, has developed a standard for 24V DC power distribution in occupied spaces as well as a standard for 380V DC power distribution in data/telecom centres and is **on the way to develop DC standards for residential and commercial buildings** and campus microgrids. The majority of DC deployment has occurred with high-voltage electricity transmission, telecommunication facilities and towers and low voltage electricity service such as Power over Ethernet (PoE). **However, medium-voltage DC distribution, which is usually deployed in residential, commercial and industrial buildings, has potential for growth.**

At the national level, interesting trends can be observed in relation with DC. For instance, in France, the Smart Building Alliance for Smart Cities - through its dedicated DC & Digital commission - advocates to rethink our buildings in DC. It estimates that it could lead to 25% energy savings (between the savings made in terms of energy conversion, the savings made for cooling the spaces subject to heat release and the savings in transport), between 10 and 20% savings on the cost of basic equipment thanks to the absence of power supply, at least 25% savings on the cost of electrical installation (less wiring, simplification and less equipment), and an increased durability of more than 25% of the equipment [4].

Recent research [5] also highlights that DC networks for residential consumers have gained attraction in recent years, primarily due to building-integrated photovoltaics and increasing electronic loads coupled with the decreasing prices of DC appliances (Figure 5).

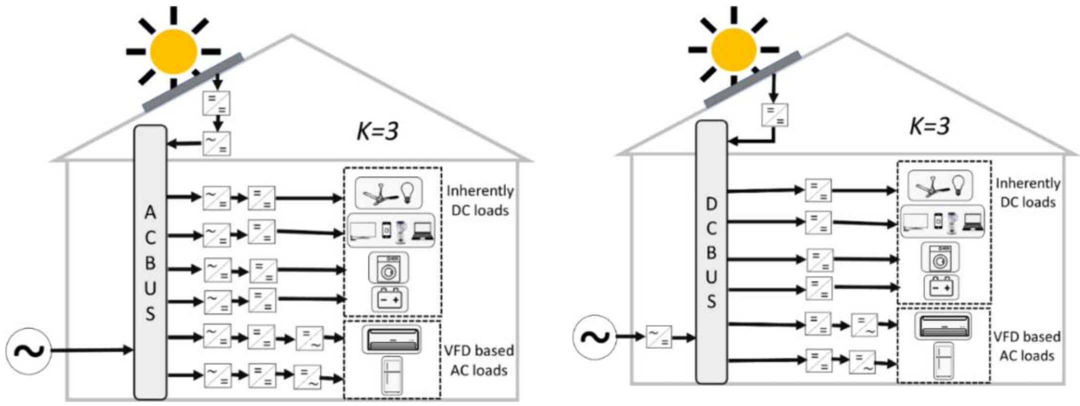

Figure 5. The layout of (a) an AC distribution-based home catering modern VFD based appliances and (b) a DC distribution-based home catering modern VFD based appliances [5]

However, unlike AC (110V, 60Hz, or 220 V, 50Hz), the paper reminds that existing standards for DC distribution are disjoint, ranging from 48V to 380V with distribution voltage selection affecting the system efficiency.

2.3.3 Solar PV panels

The European technical committee working on standards related to solar photovoltaic energy systems is:

- **CLC/TC 82** Solar photovoltaic energy systems

The CLC/TC 82 cooperates closely with IEC TC 82 and the National Committees.

CENELEC TC 82 is organized in two working groups: WG1 and WG2. The scope of the WG1 "Wafers, cells and modules" is to develop international standards for wafers, solar cells and terrestrial photovoltaic modules and for related components. The scope of WG2 "BOS components and systems" is to develop international standards for balance of systems (BOS) components, interfaces of PV systems and system integration.

The main sources used for this section are a 2019 report [6] from the H2020 project BIPVBOOST and a 2018 JRC Science for Policy Report [7] on photovoltaic energy systems.

- **Relevant standards for PV modules**

CLC/TC 82 Solar photovoltaic energy systems	Status
EN IEC 61215-1:2016 Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements	Published
EN IEC 61215-2:2016 Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures	Published

EN IEC 61730-1:2016 Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction Under review. Forecast publication date: 28-JAN-22	Published
EN IEC 61730-2:2016 Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing Under review. Forecast publication date: 28-JAN-22	Published

IEC/EN 61215:2016 is a qualification for PV modules, regardless of the technology. Officially, it “lays down requirements for the design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in general open-air climates”, as defined in **IEC 60721-2-1**. The objective of this standardized testing is to determine the electrical and thermal characteristics of the module and to show, as far as possible within reasonable constraints of cost and time, that “the module is capable of withstanding prolonged exposure in climates described in the scope.” It covers the parameters which are typically responsible for the ageing of PV modules. This includes all forces of nature:

- Sunlight including UV
- Climate (changing of climate, coldness, warmth, humidity)
- Mechanical load (hail, wind suction, wind pressure, snow; parameters which are responsible for the ageing of PV modules).

IEC/EN 61646, which was highly identical to IEC/EN 61215 but specific to thin-film PV modules, has been withdrawn. Currently, only IEC/EN 61215 still exists and covers all PV technologies, whereas it was used to be exclusively related to crystalline silicon modules.

For the HYBUILD demo sites, crystalline silicon modules are being used.

IEC/EN 61730-1:2018 “specifies and describes the fundamental construction requirements for photovoltaic (PV) modules in order to provide safe electrical and mechanical operation. Specific topics are provided to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses. This part of IEC 61730 pertains to the particular requirements of construction, whereas IEC 61730-2 defines the requirements of testing. This standard is intended to apply to all terrestrial flat plate module materials such as crystalline silicon module types as well as thin-film modules.

This standard includes a specific reference to BIPV (Building Integrated Photovoltaic systems - see the following sub-section), in its **“Part 1: Requirements for construction”**. PV modules are considered to be Building Integrated if the PV modules form a building component providing additional functions such as:

- Mechanical rigidity or structural integrity
- Primary weather impact protection: rain, snow, wind, hail
- Energy economy such as shading, daylighting or thermal insulation
- Fire protection
- Noise protection.

The BIPV module is thus a prerequisite for the integrity of the building's functionality. If the integrated BIPV module is dismounted, the PV module would have to be replaced by an appropriate building component. Multiple cross references exist within these standards, referring to multiple standards such as IEC 60364-4-41 relative to the protection against electric shock or others like IEC 60891, IEC 60904, IEC 61853 and IEC 61724, regarding qualification of PV modules and systems characteristics and performances, for example. These are not listed and detailed here but must be of course fulfilled as well by (BI)PV modules manufacturers.

- **Relevant standards specific to BIPV**

We focus in this subsection on Photovoltaics Products for Buildings Applications which is relevant in the context of HYBUILD.

Building integrated PV (BIPV) has long been recognised as an important area, but also one in which the lack of standards is frequently cited as an issue. Given that in Europe the requirements of the Energy Performance in Buildings Directive are expected to push this market segment towards significant growth in the coming years, standards for BIPV products and systems are likely to be a priority area.

The publication of the **EN 50583-1** (Photovoltaics in buildings. BIPV modules) and **EN 50583-2** (Photovoltaics in buildings. BIPV systems) standards in January 2016 was a major step forward in this complicated area, which covers both building codes and standards as well as those standards aimed at PV devices.

EN 50583:2016 distinguishes between modules (part 1) and systems (part 2) by providing a definition for BIPV modules used as construction products and a definition for BIPV systems (e.g. BIPV curtain wall systems) that are integrated into buildings. To clearly distinguish between building-applied (BAPV) and building- integrated (BIPV), definitions of building-applied modules and systems are also provided.

In the HYBUILD demo sites, the installation is made of BAPV, however, BIPV could similarly be integrated with the overall HYBUILD system provided that they comply with the below standards.

CLC/TC 82 Solar photovoltaic energy systems	Status
EN 50583-1:2016 Photovoltaics in buildings - Part 1: BIPV modules This document addresses requirements on the PV modules in the specific ways they are intended to be mounted but not the mounting structure itself, which is within the scope of FprEN 50583- 2.	Published
EN 50583-2:2016 Photovoltaics in buildings - Part 2: BIPV systems This document addresses requirements on the BIPV systems in the specific ways they are intended to be mounted but not the BIPV modules as construction products, which is the topic of FprEN 50583-1.	Published

EN 50583-1 "BIPV modules": Photovoltaic modules are considered to be building-integrated if the PV modules form a construction product providing a function as defined in the European

Construction Product Regulation CPR 305/2011. Thus, the BIPV module is a prerequisite for the integrity of the building's functionality. If the integrated PV module is dismounted (in the case of structurally bonded modules, dis-mounting includes the adjacent construction product), the PV module would have to be replaced by an appropriate construction product.

The building functionality in the context of BIPV are one or more of the following:

- Mechanical rigidity or structural integrity
- Primary atmospheric agents protection: rain, snow, wind, hail
- Energy economy, such as shading, daylighting, thermal insulation
- Fire protection
- Noise protection
- Separation between indoor and outdoor environments
- Security, shelter or safety.

Inherent electro-technical properties of PV such as antenna function, power generation and electromagnetic shielding etc. alone do not qualify PV modules to be building-integrated.

EN 50583-2 "BIPV systems": Photovoltaic systems are considered to be building-integrated if the PV modules they utilize fulfil the criteria for BIPV-modules as defined in EN 50583 Part 1 and thus form a construction product providing a function as defined in the European Construction Product Regulation CPR 305/2011.

In this standard, 5 categories of BIPV mounting systems are identified:

A. Sloped (0° to 75°), roof-integrated, not accessible from within the building
B. Sloped (0° to 75°), roof-integrated, accessible from within the building
C. Non-sloped (75° to 90°) mounted not accessible from within the building
D. Non-sloped (75° to 90°) mounted accessible from within the building
E. Externally integrated, accessible or not from within the building (e.g. balconies, louvres, balustrades, shutters etc.).

This definition is a first step but still contains inaccuracies and neglects, mainly regarding the part related to construction product's characteristics. For example, BIPV as well as BAPV could be considered as construction products by the CPR (Construction Product Regulation). Indeed, the CPR does not define the functions of construction products. In addition, this standard does not consider the potential specific requirements necessary in certain countries for building components. These are only a few of the numerous remaining issues with this standard, which explains why it is not yet widely used. Updates are highly needed according to the BIPVBOOST report [6].

The multifunctional role of PV products in such applications leads to different standards requirements:

- Electrical performance and safety, via CENELEC/IEC standards and the Low Voltage Directive.
- Building energy performance via CEN/ISO standards (as required under the Energy Performance of Buildings Directive)
- Structural performance via Eurocodes. The EN Eurocodes are a series of 10 European Standards, EN 1990 - EN 1999, providing a common approach for the design of buildings and other civil engineering works and construction products. They are the recommended means of giving a presumption of conformity with the basic requirements of the Construction Products Regulation (CPR) for construction works and

products that bear the CE Marking, as well as the preferred reference for technical specifications in public contracts.

It is noted that several general issues regarding use of PV in the built environment remain open according to the JRC report [7]. The Energy Performance of Buildings Directive (EPBD) 2010/31/EC includes standards for assessing the output of energy generating systems. Specifically, the calculation of PV energy contribution to the building performance is covered by EN 15316-4-3. However, the application of the method requires location specific data, and that responsibility for reference climatic data is given to the Member States. Overall, while the EPBD requirements establish a framework, many details need to be clearly defined (e.g. system performance factors and degradation effects).

There are specific documents related to safety in building installations like the technical report CLC/TR 50670 “External fire exposure to roofs in combination with photovoltaic (PV) arrays - Test method(s)”.

CLC/TC 82 Solar photovoltaic energy systems	Status
CLC/TR 50670:2016 External fire exposure to roofs in combination with photovoltaic (PV) arrays - Test method(s)	Published
Abstract: This Technical Report provides test methods for the assessment of external fire exposure to roofs in combination with photovoltaic (PV) arrays which characterize potential impacts of PV arrays to an existing fire rating of roofs from an external fire exposure. The performance of roofs without PV to external fire exposure is defined in CEN/TS 1187. The test methods of CLC/prTR 50670 are only applicable to roof added installations. Building integrated PV is not covered by this standard. The test method refers to PV modules as test specimens without a specific mounting system as well as combinations of PV modules with particular mounting systems on tilted roofs and flat roofs.	

2.4 Compression DC-driven Chiller (heat pump)

Mandates, also called standardization requests, are the mechanism by which the European Commission (EC) and the European Free Trade Association (EFTA) Secretariat request the European Standards Organizations (ESOs) to develop and adopt European standards in support of European policies and legislation.

In the field of eco-design and energy labelling, CEN and CENELEC are mandated by the European Commission to develop Harmonized Standards in support of the various product specific Ecodesign Regulations (also known as ‘Implementing Measures’) implementing the framework Directive 2009/125/EC and Directive 2010/30/EU.

The standardization requests related to HYBUILD / HEAT PUMPS which support the above regulations are, for eco-design:

- M/488 on air conditioners and comfort fans;

- M/439 on standby and off modes power consumption measurement for energy using products;
- M/534 on water heaters;
- M/535 on space heaters;
- M/537 on ventilation unit.

And for energy labelling:

- M/534 on water heaters;
- M/535 on space heaters;
- M/537 on ventilation units;
- M/555 on standardization request with regard to use of flammable refrigerants in refrigeration, air conditioning and heat pump equipment.

The European technical committees working on standards related to heat pumps and air conditioning units are:

- CEN/TC 228 "Heating systems and water based cooling systems in buildings";
- CEN/TC 113 "Heat pumps and air conditioning units";
- CEN/TC 182 "Refrigerating systems, safety and environmental requirements";
- CEN/TC 109 “Central heating boilers using gaseous fuels”;
- CEN/TC 299 “Gas-fired sorption appliances, indirect fired sorption appliances, gas-fired endothermic engine heat pumps and domestic gas-fired washing and drying appliances”;
- CLC/TC 61 "Safety of household and similar electrical appliances";
- CLC/TC 31 "Electrical apparatus for potentially explosive atmospheres";
- ISO/TC 205 "Building Environmental Design".

At international level, the technical committee ISO/TC 86/SC 6 "Testing and rating of air-conditioners and heat pumps" would be the mirror committee of CEN/TC 113 mentioned above.

The table below summarizes the related standards per each Technical Committee.

CEN/TC 228 - Heating systems and water based cooling systems in buildings	Status
(WI=00228082) Heating systems and water-based cooling systems in buildings - Heat recovery from waste water	Under Drafting
(WI=00228083) Heating systems and water-based cooling systems in buildings - Design for water-based cooling systems	Under Drafting
EN 12831-1:2017, Part 1,3 Energy performance of buildings - Method for calculation of the design heat load	Published

Part 1: Space heating load, Module M3-3 (WI=00228049) Part 3: Domestic hot water systems heat load and characterization of needs, Module M8-2, M8-3 (WI=00228050)	
CEN/TR 12831:2017, Part 2, 4 Energy performance of buildings - Method for calculation of the design heat load. Part 2: Explanation and justification of EN 12831-1, Module M3-3 Part 4: Explanation and justification of EN 12831-3, Module M8-2, M8-3	Published
EN 15316, Part 1,2,3,4-2,4-3,4-5,5 Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies Part 1: General and Energy performance expression, Module M3-1, M3-4, M3-9, M8-1, M8-4 Part 2: Space emission systems (heating and cooling), Module M3-5, M4-5 Part 3: Space distribution systems (DHW, heating and cooling), Module M3-6, M4-6, M8-6 Part 4-2: Space heating generation systems, heat pump systems, Module M3-8-2, M8-8-2 Part 4-3: Heat generation systems, thermal solar and photovoltaic systems, Module M3-8-3, M8-8-3, M11-8-3 Part 4-5: District heating and cooling, Module M3-8-5, M4-8-5, M8-8-5, M11-8-5 Part 5: Space heating and DHW storage systems (not cooling), Module M3-7, M8-7	Published
CEN/TR 15316-6 :2017, Part 1,2,3,5,6,8,10 Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies. Explanation and justification.	Published
EN 15378 Energy performance of buildings - Heating systems and DHW in buildings Part 1: Inspection of boilers, heating systems and DHW, Module M3-11, M8-11 Part 3: Measured energy performance, Module M3-10, M8-10 CEN/TR 15378 :2017 Part 2, 4 Energy performance of buildings - Heating systems and DHW in buildings Part 2: Explanation and justification of EN 15378-1, Module M3-11 and M8-11	Published

Part 4: Explanation and justification of EN 15378-3, Module M3-10, M8-10	
EN 15459-1:2017 (WI=00228056) Energy performance of buildings - Economic evaluation procedure for energy systems in buildings - Part 1: Calculation procedures, Module M1-14 CEN/TR 15459-2:2017 (WI=00228066) Energy performance of buildings - Economic evaluation procedure for energy systems in buildings. Part 2: Explanation and justification of EN 15459-1, Module M1-14	Published
EN 12170:2002 (WI=00228010) Heating systems in buildings - Procedure for the preparation of documents for operation, maintenance and use - Heating systems requiring a trained operator	Published
EN 12171:2002 (WI=00228011) Heating systems in buildings - Procedure for the preparation of documents for operation, maintenance and use - Heating systems not requiring a trained operator	Published
EN 12828:2012+A1:2014 (WI=00228079) Heating systems in buildings - Design for water-based heating systems	Published
EN 14336:2004 (WI=00228009) Heating systems in buildings - Installation and commissioning of water based heating systems	Published
EN 15450:2007 (WI=00228014) Heating systems in buildings - Design of heat pump heating systems	Published
prEN 14336 rev (WI=00228088) Heating systems and water based cooling systems in buildings - Installation and commissioning of water based heating systems	Under Drafting

prEN 15450 rev (WI=00228090) Heating systems in buildings - Design of heat pump heating systems	Preliminary

CEN/TC 113 - Heat pumps and air conditioning unit	Status
prEN 17625 (WI=00113091) Roof-top units	Under Enquiry
CEN ISO/TS 16491:2012 (WI=00113058) Guidelines for the evaluation of uncertainty of measurement in air conditioner and heat pump cooling and heating capacity tests (ISO/TS 16491:2012)	Published
EN 12102-1:2017 (WI=00113073) Air conditioners, liquid chilling packages, heat pumps, process chillers and dehumidifiers with electrically driven compressors - Determination of the sound power level - Part 1: Air conditioners, liquid chilling packages, heat pumps for space heating and cooling, dehumidifiers and process chillers	Published
EN 12102-2:2019 (WI=00113080) Air conditioners, liquid chilling packages, heat pumps, process chillers and dehumidifiers with electrically driven compressors - Determination of the sound power level - Part 2: Heat pump water heaters	Published
EN 12900:2013 (WI=00113052) Refrigerant compressors - Rating conditions, tolerances and presentation of manufacturer's performance data	Published
EN 13215:2016 (WI=00113068) Condensing units for refrigeration - Rating conditions, tolerances and presentation of manufacturer's performance data	Published
EN 13215:2016+A1:2020 (WI=00113095) Condensing units for refrigeration - Rating conditions, tolerances and presentation of manufacturer's performance data	Published
EN 13771-1:2016 (WI=00113069) Compressors and condensing units for refrigeration - Performance testing and test methods - Part 1: Refrigerant compressors	Published

EN 13771-2:2017 (WI=00113067) Compressors and condensing units for refrigeration - Performance testing and test methods - Part 2: Condensing units	Published
EN 1397:2015 (WI=00113054) Heat exchangers - Hydronic room fan coil units - Test procedures for establishing the performance	Published
EN 1397:2015/AC:2016 (WI=00113C05) Heat exchangers - Hydronic room fan coil units - Test procedures for establishing the performance	Published
EN 14511-1:2018 (WI=00113077) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors. Part 1: Terms and definitions	Published
EN 14511-2:2018 (WI=00113075) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 2: Test conditions	Published
EN 14511-3:2018 (WI=00113076) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 3: Test methods	Published
EN 14511-4:2018 (WI=00113074) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 4: Requirements	Published
EN 14825:2018 (WI=00113081) Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance	Published
EN 15218:2013 (WI=00113062) Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling - Terms, definitions, test conditions, test methods and requirements	Published

EN 16147:2017 (WI=00113071) Heat pumps with electrically driven compressors - Testing, performance rating and requirements for marking of domestic hot water units	Published
EN 16147:2017/AC:2017 (WI=00113C06) Heat pumps with electrically driven compressors - Testing, performance rating and requirements for marking of domestic hot water units	Published
EN 16583:2015 (WI=00113055) Heat exchangers - Hydronic room fan coils units - Determination of the sound power level	Published
EN 810:1997 (WI=00113016) Dehumidifiers with electrically driven compressors - Rating tests, marking, operational requirements and technical data sheet	Published
prEN 12102-1 rev (WI=00113089) Air conditioners, liquid chilling packages, heat pumps, process chillers and dehumidifiers with electrically driven compressors - Determination of the sound power level - Part 1: Air conditioners, liquid chilling packages, heat pumps for space heating and cooling, dehumidifiers and process chillers.	Under Drafting
EN 12102-2:2019 (WI=00113080) Air conditioners, liquid chilling packages, heat pumps with electrically driven compressors – Measurement of airborne noise – Determination of the sound power level - Part 2: Heat pumps water heaters	Published
prEN 1397 (WI=00113083) Heat exchangers - Hydronic room fan coil units - Test procedures for establishing the performance	Under Approval
prEN 14511-1 rev (WI=00113088) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 1: Terms and definitions	Under Drafting
prEN 14511-2 rev (WI=00113086) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors- Part 2: Test conditions	Under Drafting
prEN 14511-3 rev (WI=00113087)	Under Drafting

Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 3: Test methods	
prEN 14511-4 rev (WI=00113092) Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 4: Requirements	Under Drafting
prEN 14825 rev (WI=00113090) Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance	Under Enquiry
prEN 16583 (WI=00113093) Heat exchangers - Hydronic room fan coils units - Determination of the sound power level	Under Enquiry

CEN/TC 182 - Refrigerating systems, safety and environmental requirements	**Status**
EN 12178:2016 (WI=00182073) Refrigerating systems and heat pumps - Liquid level indicating devices - Requirements, testing and marking	Published
EN 12263:1998 (WI=00182017) Refrigerating systems and heat pumps - Safety switching devices for limiting the pressure - Requirements and tests	Published
EN 12284:2003 (WI=00182014) Refrigerating systems and heat pumps - Valves - Requirements, testing and marking	Published
EN 12693:2008 (WI=00182023) Refrigerating systems and heat pumps - Safety and environmental requirements - Positive displacement refrigerant compressors	Published
EN 13136:2013+A1:2018 (WI=00182081) Refrigerating systems and heat pumps - Pressure relief devices and their associated piping - Methods for calculation	Published
EN 13313:2010 (WI=00182041) Refrigerating systems and heat pumps - Competence of personnel	Published

EN 14276-1:2020 (WI=00182077) Pressure equipment for refrigerating systems and heat pumps - Part 1: Vessels - General requirements	Published
EN 14276-2:2020 (WI=00182076) Pressure equipment for refrigerating systems and heat pumps - Part 2: Piping - General requirements	Published
EN 1736:2008 (WI=00182042) Refrigerating systems and heat pumps - Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes - Requirements, design and installation	Published
EN 1861:1998 (WI=00182018) Refrigerating systems and heat pumps - System flow diagrams and piping and instrument diagrams - Layout and symbols	Published
N 378-1:2016+A1:2020 (WI=00182089) Refrigerating systems and heat pumps - Safety and environmental requirements - Part 1: Basic requirements, definitions, classification and selection criteria	Published
EN 378-2:2016 (WI=00182057) Refrigerating systems and heat pumps - Safety and environmental requirements - Part 2: Design, construction, testing, marking and documentation	Published
EN 378-2:2016/prA1 (WI=00182083) Refrigerating systems and heat pumps - Safety and environmental requirements - Part 2: Design, construction, testing, marking and documentation	Under Approval
EN 378-3:2016+A1:2020 (WI=00182090) Refrigerating systems and heat pumps - Safety and environmental requirements - Part 3: Installation site and personal protection	Published
EN 378-4:2016+A1:2019 (WI=00182085) Refrigerating systems and heat pumps - Safety and environmental requirements - Part 4: Operation, maintenance, repair and recovery	Published
EN ISO 14903:2017 (WI=00182072) Refrigerating systems and heat pumps - Qualification of tightness of components and joints (ISO 14903:2017)	Published

prEN 12693 rev (WI=00182093) Refrigerating systems and heat pumps - Safety and environmental requirements - Positive displacement refrigerant compressors	Under Drafting
prEN ISO 21922 (WI=00182078) Refrigerating systems and heat pumps - Valves - Requirements, testing and marking (ISO/DIS 21922:2018)	Under Approval
prEN ISO 22712 (WI=00182075) Refrigerating systems and heat pumps - Competence of personnel (ISO/DIS 22712:2018)	Under Approval

CLC/TC 61 - Safety of household and similar electrical appliances	**Status**
EN 60335-2-34:2013 (pr=23353) Household and similar electrical appliances - Safety - Part 2-34: Particular requirements for motor-compressors	Published
EN 60335-2-40:2003/A13:2012/AC:2013 (pr=24883) Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers	Published

CLC/TC 31 – Electrical apparatus for potentially explosive atmospheres	**Status**
EN IEC 60079-0:2018/AC:2020-02 (pr=71420) Explosive atmospheres - Part 0: Equipment - General requirements	Published
EN 60079-1:2014/AC:2018-09 (pr=67668) Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"	Published
EN 60079-2:2014/AC:2015 (pr=61059) Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p"	Published

EN 60079-5:2015 (pr=24472) Explosive atmospheres - Part 5: Equipment protection by powder filling "q"	Published
EN 60079-6:2015 (pr=24927) Explosive atmospheres - Part 6: Equipment protection by liquid immersion "o"	Published
EN 60079-7:2015 (pr=25319) Explosive atmospheres - Part 7: Equipment protection by increased safety "e"	Published
EN 60079-14:2014/AC:2016 (pr=62215) Explosive atmospheres - Part 14: Electrical installations design, selection and erection	Published
EN IEC 60079-15:2019 (pr=63176) Explosive atmospheres - Part 15: Equipment protection by type of protection "n"	Published
EN 60079-17:2014 (pr=24330) Explosive atmospheres - Part 17: Electrical installations inspection and maintenance	Published
EN 60079-18:2015/AC:2018-09 (pr=67848) Explosive atmospheres - Part 18: Equipment protection by encapsulation "m"	Published
EN IEC 60079-19:2019 (pr=62832) Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation	Published
EN 60079-20-1:2010 (pr=21991) Explosive atmospheres - Part 20-1: Material characteristics for gas and vapour classification - Test methods and data	Published
EN 60079-26:2015 (pr=24567) Explosive atmospheres - Part 26: Equipment with Equipment Protection Level (EPL) Ga	Published
EN 60079-30-1:2017 (pr=61144) Explosive atmospheres - Part 30-1: Electrical resistance trace heating - General and testing requirements	Published

EN 60079-30-2:2017 (pr=61145) Explosive atmospheres - Part 30-2: Electrical resistance trace heating - Application guide for design, installation and maintenance	Published
EN 60079-31:2014 (pr=24107) Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"	Published
CLC/TR 60079-32-1:2018 (pr=65613) Explosive atmospheres - Part 32-1: Electrostatic hazards, guidance	Published
EN 60079-32-2:2015 (pr=25135) Explosive atmospheres - Part 32-2: Electrostatics hazards - Tests	Published
CLC/TR 60079-33:2015 (pr=24967) Explosive atmospheres - Part 33: Equipment protection by special protection 's'	Published

ISO/TC 205 – Building Environmental Design	Status
ISO 13153:2012 Framework of the design process for energy-saving single-family residential and small commercial buildings	Confirmed
ISO 13612-1:2014 Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems	Confirmed
ISO 13612-2:2014 Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems — Part 2: Energy calculation	Confirmed
ISO 16484-1:2010 Building automation and control systems (BACS) — Part 1: Project specification and implementation	Confirmed
ISO 16484-2:2004 Building automation and control systems (BACS) — Part 2: Hardware	Confirmed

ISO 16484-3:2005 Building automation and control systems (BACS) — Part 3: Functions	Confirmed
ISO 16484-5:2017 Building automation and control systems (BACS) — Part 5: Data communication protocol	Published
ISO 16484-5:2017/AMD 1:2020 Building automation and control systems (BACS) — Part 5: Data communication protocol — Amendment 1	Published
ISO 16484-6:2020 Building automation and control systems (BACS) — Part 6: Data communication conformance testing	Published
ISO 16813:2006 Building environment design — Indoor environment — General principles	Confirmed
ISO 16814:2008 Building environment design — Indoor air quality — Methods of expressing the quality of indoor air for human occupancy	Confirmed
ISO 16817:2017 Building environment design — Indoor environment — Design process for the visual environment	Published
ISO 16818:2008 Building environment design — Energy efficiency — Terminology	Confirmed
ISO/TR 16822:2016 Building environment design — List of test procedures for heating, ventilating, air-conditioning and domestic hot water equipment related to energy efficiency	Published
ISO 23045:2008 Building environment design — Guidelines to assess energy efficiency of new buildings	Confirmed
ISO/WD 24359-1 Building commissioning process planning — Part 1: New buildings	Working draft

ISO 52031:2020 Energy performance of buildings — Method for calculation of system energy requirements and system efficiencies — Space emission systems (heating and cooling)	Published
ISO/DIS 52032-1 Energy performance of buildings — Energy requirements and efficiencies of heating, cooling and DHW distribution systems — Part 1: Calculation procedures	Enquiry
ISO/DIS 52120-1 Energy performance of buildings — Contribution of building automation and controls and building management — Part 1: Modules M10-4,5,6,7,8,9,10	Enquiry
ISO/TR 52120-2 Energy performance of buildings — Contribution of building automation, controls and building management — Part 2: Explanation and justification of ISO 52120-1	Under publication
ISO/DIS 52127-1 Energy performance of buildings — Building management system — Part 1: Module M10-12	Under publication
ISO/TR 52127-2 Energy performance of buildings — Building automation, controls and building management — Part 2: Explanation and justification of ISO 52127-1	Under publication

2.5 Solar fields of Fresnel collectors

The standards for Fresnel solar fields are currently quite rare, and those for building applications even more. The part taken of this standardization document is then to take stock of the actors and the existing standards for concentrated solar power, which includes the Fresnel solar field.

2.5.1 Ongoing activities on the International and on the European level related to the concentrated solar power (CSP)

- **International standardization**

International standardization is handled by two organizations, ISO, the International Organization for Standardization, and IEC, the International Electrotechnical Commission. Both organizations have committees for the solar field.

- **IEC:** IEC/TC 117 Solar thermal electric plants is responsible for the preparation of international standards for systems of Solar Thermal Electric (STE) plants for the conversion of solar thermal energy into electrical energy and for all the elements (including all sub-systems and components) in the entire STE energy system.

The main objectives of IEC/TC 117 will be to set the reference terms for the different systems, subsystems and components along with the most proper way to measure their respective performance [8].

The standards are to cover all of the current different types of systems in the STE field, as parabolic trough, solar tower, linear Fresnel, dish, thermal storage. The standards would define terminology, design and installation requirements, performance measurement techniques and test methods, safety requirements, and "power quality" issues for each of the above systems. The standards would also address issues of connectivity and interoperability with the power grid related to connections, bi-directional communicates and centralized control (smart grid) and environmental aspects.

Liaisons were proposed for IEC TC 5 Steam Turbines, IEC TC 82 Solar photovoltaic energy systems, **ISO TC 180 Solar Energy** and ISO TC 192 Gas turbines. A liaison has been established with ISO/TC 180.

- **ISO:** ISO/TC 180 Solar Energy was founded in 1983 and is responsible for standardization in the field of solar energy utilization in space and water heating, cooling, industrial process heating and air conditioning. It prepares International Standards for the development, testing, installation and servicing of equipment and systems related to solar energy. The committee's major activity is in relation to thermal applications for water heating [9].

  The business plan of ISO/TC 180 includes a list of current areas of priority interest:

    - Communication of information: standards for uniformity of terminology and climatic data, including instrumentation standards and measurement procedures, with particular reference to resource evaluation, monitoring of test conditions and traceability of calibration.
    - Uniformity of test methods: standard test methods to promote data exchange between different test sites, and to facilitate trade.
    - Provision of test methods and, where appropriate, specifications for materials for solar energy applications, as an aid to designers, consumers and government agencies providing support for market development.

ISO/TC 180 has a network of other technical committees it collaborates with, as ISO/IEC JPC 2 *Joint Project Committee – Energy efficiency and renewable energy sources - Common terminology* [10], ISO/TC 59 *Buildings and civil engineering works* [11], ISO/TC 61 *Plastics* [12], IEC/TC 82 *Solar photovoltaic energy systems* [13][6], IEC/TC 117 [14].

- **European standardization**

Standardization in Europe is handled by two organizations, CEN, the European Committee for Standardization, and CENELEC, the European Committee for Electrotechnical Standardization.

- **CENELEC**

CENELEC does not have a technical committee for solar applications, CLC/SR 117 Solar thermal electric plants provides information to the CENELEC Technical Board on any work of IEC/TC 117 which could be of interest for CENELEC.

- **CEN**

CEN/TC 312 [15] *Thermal solar systems and components* is developing standards covering terminology, general requirements, characteristics, test methods, conformity evaluation, certification and labelling of thermal solar systems and components.

Currently, CEN/TC 312 is focusing on solar thermal energy applications relevant for covering energy demand of buildings, such as solar heating for hot water production and space heating as well as cooling.

- American standardization
  - **ASME**

The American Society of Mechanical Engineers is a not-for-profit membership organization which develops standards related to all field of engineering. Among the working groups, the performance test codes 54 [22]analyses the gaps between the standards and real installations to propose ways to fill these gaps.

2.5.2 Relevant standard

Standard	Status
NF EN ISO 9806 - November 2017 Solar energy - Solar thermal collectors - Test methods	Revisions / corrigenda
EN 62925 – 2017 Concentrator photovoltaic (CPV) modules - Thermal cycling test to differentiate increased thermal fatigue durability	Published
EN 12975-1:2006+A1:2010 Thermal solar systems and components - Solar collectors - Part 1: General requirements	Revisions / corrigenda
FprEN 12975 (WI 00312039) Solar collectors - General requirements	Under approval (**will supersede EN 12975-1:2006+A1:2010**)
EN ISO 877-3 – 2018 Plastics - Methods of exposure to solar radiation - Part 3: Intensified weathering using concentrated solar radiation.	Published
ISO/CD 24194 Solar energy — Collector fields — Check of performance	Under development
ASME PTC 52 Performance Test Code for Concentrating Solar Power Plants	Under development

2.6 Sensible heat storage

Standards for hydraulic storage systems specific to the solar environment are currently poorly developed. They are included in larger packages such as solar thermal standards. Distinguishing between different applications (as DHW tank and buffer tank) is difficult to make.

2.6.1 Ongoing activities on the International and on the European level related to sensible heat storage

International standardization is handled by two organizations, ISO, the International organization for Standardization, and IEC, the International Electrotechnical Commission. Both organizations have committees for the solar field, which includes thermal storage systems.

- International standard
    - IEC

As before, IEC/TC 117 [14] is responsible for the international standardization of solar thermal electric systems. The standards are to cover all of the current different types of systems in the STE field, which includes **Thermal storage.**

Liaisons were proposed for IEC TC 5 Steam Turbines [17], IEC TC 82 Solar photovoltaic energy systems [13], ISO TC 180 Solar Energy [9] and ISO TC 192 Gas turbines [18].

- ISO

The scope of ISO TC 180 has been described above. Within this committee, **Subcommittee 4** is concerned with the technical performance, reliability and durability of solar systems and their components, including thermal storage systems.

ISO/TC 180 has a network of other technical committees it collaborates with, as ISO/IEC JPC 2 *Joint Project Committee – Energy efficiency and renewable energy sources - Common terminology* [10], ISO/TC 59 *Buildings and civil engineering works* [11], ISO/TC 61 *Plastics* [12], IEC/TC 52 *Solar photovoltaic energy systems* [13], IEC/TC 117 [14].

- European standardization
    - CENELEC

CENELEC does not have a technical committee for sensible heat storage.

- CEN

Sensible thermal storage is not covered by a specific working group but is within the scope of several other more general groups that we have tried to identify.

CEN/TC 57 - Central heating boilers [19]: establishes standards with respect to construction and performance requirements and efficiency tests for liquid and solid fuel-fired central heating boilers and boiler bodies of gas-fired central heating boilers to be equipped with forced-air burners, oil-fired air heaters, heat storage units and performance requirements (concerning efficiency) of storage tanks in a hot water storage system.

CEN/TC 228 - Heating systems and water based cooling systems in buildings [20]: technical bodies are scoped in standardization of functional requirements for all types of heating systems, including domestic hot water production, water based cooling emission and distribution systems in buildings and power generation systems in the direct environment of the building.

Even though it does not completely meet the needs of HYBUILD, CEN TC 265 [21] is related to metallic tanks for the storage of liquids at ambient and sub-ambient temperature. This is a standardization of metallic tanks, shop fabricated and site-built, for the storage of liquids with an internal gas pressure approximating to atmospheric pressure. The standardization may include performance requirements and product descriptions together with necessary test methods and requirements concerning the evaluation of conformity.

- American standardization
    - ASME

The performance test codes 53 [22] is a Draft Standard which establishes uniform test methods and procedures for conducting performance tests of mechanical or thermal energy storage systems.

2.6.2 Hydraulic system - Relevant standard

Standard	Status
EN 12977-1 – 2018 Thermal solar systems and components - Custom built systems - Part 1: General requirements for solar water heaters and combisystems EN 12977-2 – 2018 Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems	Published
ISO 9808 – 1990 Solar water heaters — Elastomeric materials for absorbers, connecting pipes and fittings — Method of assessment	Published
ISO/TR 10217 – 1989 Solar energy — Water heating systems — Guide to material selection with regard to internal corrosion	Published
FprEN 16480 Pumps - Rotodynamic pumps - Minimum required efficiency of water pumps and methods of qualification and verification	Under Approval

2.6.3 Buffer tank, DHW tank & Decentralized tank - Relevant standard

Standard	Status
EN 12977-3 Thermal solar systems and components - Custom built systems - Part 3: Performance test methods for solar water heater stores	Published
EN 12977-4	Published

Thermal solar systems and components - Custom built systems - Part 4: Performance test methods for solar combistores	
EN 15332:2019 Heating boilers – Energy assessment of hot water storage tanks	Published
EN 15316-5:2017 Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 5: Space heating and DHW storage systems (not cooling), Module M3-7, M8-7	Published
ISO 9459-4:2013 Solar heating — Domestic water heating systems — Part 4: System performance characterization by means of component tests and computer simulation	Published
ASME PTC 53 Mechanical and Thermal Energy Storage Systems (Draft Standard for Trial Use)	Published

3 Conclusions and Following activities of T5.4

Certifying new solutions like HYBUILD hybrid storage systems for energy efficient buildings will demonstrate that pioneering projects results are meeting the required safety, performance and reliability standards and providing the industry with confidence in the quality of its emerging new technologies. This will become even more essential when the Technology Readiness Level (TRL) of the overall solution will get close to the market. The importance of such certification and standardization approach is acknowledged for instance in an article [23] published in 2018 about an innovative grid-scale wind-battery hybrid energy storage solution developed by the Spanish group ACCIONA.

An article [24] published in 2017 discussing energy storage standardization and specifications looked at the steps being taken and where they can go further. It highlights that "*both governments and the private sector have identified several areas where further standardization is essential. First, to ensure that energy storage terms are referred to using a common language; while several standards committees are working on the issue, as it stands vendors and consumers in separate — and sometimes, even the same — markets can find themselves comparing apples to oranges*". There is also a challenge around standards that can be both too specific and not specific enough: when too highly focused on a particular technology — with new technology being developed every year, this way of issuing standards slows the adoption of new innovations.

The present deliverable analyses the state-of-the-art of standards for components included in the HYBUILD systems. From the analysis carried out, it can be concluded that there are some components which are fully standardised (e.g. the heat pumps) and others that need a deep development (e.g. sensible heat storage, given that the HYBUILD storage unit contains at the same time a water part and an electrical part). Moreover, there is a lack of standards at the building scale; indeed, e.g. for solar fields of Fresnel collectors, a normative framework for the adoption of this technology in the context of the building is missing.

Therefore, efforts should be made to prepare standardization proposals, a consortium proposal on components/systems to be standardized should be drafted and a procedure to achieve it during and after the project duration should be defined.

Therefore, the following activities of Task 5.4 should include:

- conducting an internal work to identify which HYBUILD consortium partners are already connected with relevant standardization organisations and technical committees;
- engaging discussions with relevant technical committees to understand whether an ad-hoc certification or standard would be relevant / required considering the complexity of the HYBUILD hybrid storage solution.

Results of following activities of Task 5.4 will be discussed in D5.5 "Full standardization proposals".

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