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Abstract

The main objective of this deliverable is to provides support regarding the standardization tasks included in the project. This document presents the standardization activity found relevant for GreenSoul project. In order to structure the search, a list of key concepts related to the project objectives was defined to be used as a starting point for those concepts and areas subject to be standardized: Energy Audits, Energy Management Systems, Energy Savings and Energy Efficiency, Energy performance, Life cycle assessment, Greenhouse gases, Internet of Things, Lighting. The included analysis covers European standardization developed by the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) and International standardization developed by the International Organization for Standardisation (ISO). The document also depicts the Technical Committees (TC) responsible for the elaboration of the identified standards which can be useful for the dissemination and exploitation purposes and aligned with the other tasks in the Work Package 7 of the project about Dissemination, standardisation and exploitation. For each specific key concept, the main standardization bodies are described and a structure of relevant standards is included. Each section is completed by a summary of the main link between the standards and the project GreenSoul. Finally, during project implementation, the partners have contributed to recommendations on new standards based on the know-how acquired during the project. A final section showed the standardization initiatives from GreenSoul after close collaboration with the Spanish Technical Committee 178.

Changes History

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v0.1	06/06/2019	Initial version	WSC
v0.2	17/10/2019	Completion of the Standardisation Landscape and next steps	4ER
v0.2	25/10/2019	Complete processing	4ER, UDEUSTO, CERTH, WEIZ, WSC
V0.3	31/10/2019	Final version	WSC
V0.4	12/12/2019	Reviewed version	WSC

List of Definitions and abbreviations

Abbreviation	Description
TCs	Standardization technical committees
AENOR	Spanish Association for Standardization and Certification
BLE	Bluetooth Low Energy
CEN	European Committee for Electrotechnical Standardization
CENELEC (CLC)	European Committee for Electrotechnical Standardization
CWA	CENELEC or CNC Workshop Agreements
ENs	European Standards
ETSI	European Telecommunication Standards
GHG	Greenhouse Gasses
IEC	International Electrotechnical Commission
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JWG	Joint Working Group
NMC	National Mirror Committee
NSB	National Standardization Body
MQTT	MQ Telemetry Transport
SAREF	Smart Appliances REFerence (SAREF) ontology
SC	Subcommittee
TCP/IP	TCP/IP, or the Transmission Control Protocol/Internet Protocol
TR	Technical Reports
TS	Technical Specifications
UNE	Spanish association of standardization
Wi-Fi	Wireless Fidelity Wi-Fi is simply a trademarked term meaning IEEE 802.11x.
WG	Working Group

Executive Summary

The present document is a deliverable of the GreenSoul project, funded by the European Commission's Directorate-General for Research and Innovation (DG RTD), under its Horizon 2020 Research and innovation programme (H2020), reporting the results of the activities carried out by T7.3, namely the "Standardisation activities.".

This deliverable contains a standardization landscape prepared under the direction of Wellness Smart Cities (WSC) to provide the partners with information about the state of the art in standardization, including published international standards and standards under development which can be interesting for the project objectives. This deliverable provided also basic information to help make decisions about further steps in the standardization process for the project results and inputs for the activities developed in other work packages of the project.

The analysis carried out also identified the standardization technical committees which could be useful for the project. A strategy for communication with them has been elaborated. In this deliverable also is shown initiatives to contribute to standards made by project partners. Following this strategy, a bidirectional relationship has been created with the objectives of using the standardization system as a fast and much-focused dissemination tool to the market stakeholders and also monitoring the technical committees works to propose future recommendations of standards based on the results of the project.

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1 Purpose of the document

This deliverable has been prepared to provide to the partners with basic information about standardization and the landscape of the published standards and standards under development which can be interesting for GreenSoul. This analysis has been completed to analyse the landscape and potential actions on standardization of hardware, software and/or communication protocols developed in GreenSoul. This deliverable also provides basic information to GreenSoul partners in order to support possible further steps in the standardization process of the project results and inputs developed within the different WPs. This analysis will also identify the standardization technical committees (TCs) which could be useful for the project. A strategy for communication with them has been devised in order to use the standardization system as a dissemination tool to the stakeholders and propose recommendations for the future elaboration of standards based on results of GreenSoul.

2 Introduction

Standards are defined by technical specifications or benchmarks for a specific item, material, component, system or service, or describe in detail a particular method, procedure or best practice. These specifications are defined in order to facilitate that the products or services gain access to the market while meeting the demands of authorities and consumers for save and quality. The technical standards are mainly applied to a repeatable technical task that usually is a formal document that establishes uniform engineering or technical criteria methods, processes and practices. A technical standard may be developed privately or unilaterally, for example by a corporation, regulatory body, military, etc. or by groups (e.g. trade unions, trade associations or standards organizations). Several organizations participate in setting standards at different levels around the world, that usually involves the formal consensus of technical experts. Although the standards are led by international organisations, in many cases, regional standards contribute to the international and global environment. A selection of the most significant standardization bodies relevant to GreenSoul is shown below:

- The International Organization for Standardization (ISO) is an organism responsible for promoting the definition of international standards. This institution has reached a broad agreement on the classification of its services based on the experience of the European Union, Japan, the United States and other places in several Working Groups (WG) organized under different Technical Committees (TC).
- The International Electrotechnical Commission (IEC) is the world's leading organization that prepares and publishes International Standards for all electrical, electronic and related technologies. When appropriate, IEC cooperates with ISO (International Organization for Standardization) or ITU (International Telecommunication Union) to ensure that International Standards fit together seamlessly and complement each other. Joint committees ensure that International Standards combine all relevant knowledge of experts working in related areas.
- The International Telecommunication Union (ITU) is the specialized agency of the United Nations for information and communication technologies. ITU carries out its work standards in its radio communications division and other ITS communication

standards. This group focuses on establishing a worldwide harmonized set of communication standards.

- The European Committee for Standardization (CEN) is an association that brings together the National Standardization Bodies of 34 European countries. At European level, CEN is one of three European Standardization Organizations (together with CENELEC and ETSI) that have been officially recognized by the European Union and as responsible for developing and defining voluntary standards.
- The European Committee for Electrotechnical Standardization (CENELEC) is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field. CENELEC prepares voluntary standards, which help facilitate trade between countries, create new markets, cut compliance costs and support the development of a Single European Market.
- The European Telecommunication Standards (ETSI) is a European Standard Organization recognized regional standards body dealing with telecommunications, broadcasting and other electronic communications networks and services. ETSI supports European regulations and legislation through the creation of Harmonised European Standards. Only standards developed by the three European Standard Organizations (CEN, CENELEC and ETSI) are recognized as European Standards (ENs).

For the development and definition of standards, there is a common process of sharing knowledge and building consensus among technical experts nominated by interested parties and other stakeholders. This can include businesses, consumers, environmental groups, etc. These experts are organized in Technical Committees (TCs), which are subdivided in different Subcommittees) or Working Groups (WGs). These TCs are included in the structure of the Standardization Organizations (National, EU and International, with the corresponding counterpart committees) and work following internal regulations.

Along with these Regional (ETSI, CENELEC, CEN) and International (ISO, IEC, ITU) standardization bodies, there are other organisations that operate at National level (AENOR in Spain, AFNOR in France, BSI in the United Kingdom, DIN in Germany, etc.). In occasions, there are different standardization bodies at the same level, but covering different fields. This

is the case of ISO (general issues) and ITU (telecommunications) at International level, or CEN, CENELEC and ETSI at European level.

The standardization bodies produce different types of standardization documents. The standards are the official document collecting the elaborated contributions of a group of people with expertise in their subject matter and who know the needs of the organizations they represent (i.e. manufacturers, sellers, buyers, customers, trade associations, users or regulators). Standards are designed for voluntary use and are considered powerful tools that can help drive innovation and mainly increase productivity. They have different codes, depending on the organization that elaborate it. For instance, EN for European Standards, ISO or IEC for International standards. Other types of documents are Technical Specifications (TS), Technical Reports (TR) and Workshop Agreements (CWA). The Technical Specifications are documents that are usually produced when various alternatives that do not gather enough as to make an agreement on a European Standard (EN) or need to coexist in anticipation of future harmonization. In other cases, they provide specifications in experimental circumstances or in technologies that are under evolution or rapid change. A Technical Specification is established by a CEN Technical Body and approved through a weighted vote by the CEN national members. The Technical Specification shall be announced at the national level. It may be adopted as a national standard, but conflicting national standards may continue to exist. However, always when a European Standard is published, subsequently the Technical Specification under conflict is withdrawn. All the Country members of CEN and CENELEC shall adopt EN standards as national standards and have to withdraw any existing standard which could conflict with them. A Technical Report (TR) provides information on the technical content of standardization work. It is usually prepared when it is considered necessary or advisable to provide additional information to the national members, the European Commission or any governmental agencies or outside bodies.

Because the effort of defining and producing standards is shared by many organisations around the world, there is an agreement established between European and International Organizations in order to avoid duplication of efforts and promote global relevance of standards, which allows to adopt or develop in parallel each other's standards with the same content and code. Moreover, in this line, national standards can also be proposed as a base

for new European or International standards, as it is the case for the Spanish National Standard UNE 178104, on the "Comprehensive systems for smart city management. Requirements of interoperability for a Smart City Platform". Specifically, Standard UNE 178104, whose first edition dates from 2015, has resulted in ITU-T Y.4200 recommendations: Interoperability requirements for Smart City platforms, and ITU-T Y.4201: High-level requirements and frame of reference of the Smart Cities Platforms, which have acquired international relevance.

3 Standardization landscape related to GreenSoul

3.1 Introduction

Considering the context and the tasks conducted in the different WPs within GreenSoul, a relevant group of keywords has been selected as a starting point in order to research the standards could be of interest for the consortium. These standardization areas related to GreenSoul have been considered:

- Energy Audits
- Energy Management Systems
- Energy Savings & Energy Efficiency
- Energy performance
- Life cycle assessment
- Greenhouse gases
- Internet of Things
- Lighting

The study covers International standards defined by the International Organization for Standardization and European standards produced by the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC). For each keyword, the following relevant technical committees and the published

standards and work in progress under their responsibility have been identified and detailed in the following sections.

The Technical Committee ISO/TC 301 (Energy management and energy savings), formerly ISO/TC 242 for standardisation of energy management systems, has been identified as one of the most important for **Energy Management**, with strong relevance for GreenSoul. At EU level, CEN/CENELEC Joint Working Groups for Energy Management were created with the aim to identify those main standardization priority items dealing with energy management. In this sense, three different CEN/CENELEC Joint Working Groups exist operating within the field of energy management which its results can serve as a reference for GreenSoul project:

- Joint Working Group 1 “Energy audits”
- Joint Working Group 3 “Energy management systems”
- Joint Working Group 4 “Energy efficiency and saving calculations”

Many standards are developed in joint working groups (JWG), so that experts from around the globe can be used to set the best standards for Europe. CEN/CENELEC (European Committee for Standardization / European Committee for Electrotechnical Standardization).

Moreover, other areas have been identified with relevant impact on GreenSoul. This is the case for **Environmental Management**. In this field, the standardization work is mainly developed at the international level, therefore, the ISO standards have been adopted identically as European Standards (EN-ISO). Under this area, we have identified Life Cycle Assessment (ISO/TC 207/SC 5 Life cycle assessment) and Greenhouse Gases (ISO/TC 207/SC7 Greenhouse gas management and related activities)

Because GreenSoul is focused on IoT devices and platform to increase the energy-awareness of the users of public buildings to improve the energy performance of the building, a special emphasis has been provided to the areas of **Internet of Things** and **Lighting**, as well as **Energy Performance**.

3.2 Energy Audits

In order to be able to test GreenSoul in other pilots in the future, the implementation of an energy audit was necessary in order to be able to make statements about energy savings. For the standardization of GreenSoul, the standardized calculation of energy savings is of great importance.

A standardized energy audit was carried out before GreenSoul installation in the GreenSoul project. An energy audit is necessary to capture the energy needs of all consumers (heat, cold and electricity) under standardized conditions. Since the GreenSoul system was sometimes not used in the hole area of the pilots, but measured energy data was sometimes only available for the entire building, the impact of GreenSoul cannot be directly calculated. Furthermore, the measured energy data were often only available on an annual basis or similar resolution. Since the pilots were only a few months in operation during the research project, calculating the direct energy benefits of GreenSoul was further complicated. Furthermore, many energy data depend on the weather, the number of people in the buildings, or other factors. The problem can be solved by creating a baseline based on the standardized energy audit.

3.2.1 Standardization bodies

At European level, there are three CEN/CLC Joint Working Groups operating in the area of energy audits and energy management whose work could serve as a reference for the project. There are also some ISO/TC providing documents in this field.

CEN/CENELEC/JWG1: Energy Audits specifies the process requirements, the common methodology and the deliverables for carrying out an energy audit in relation to energy performance. It takes into account all forms of establishments and organizations and all forms of energy and uses of energy. JWG 1 also specifies the competence requirements of the energy auditors. Joint Working Group 1 has been convened to draft a European Standard on energy audits. The JWG began with a state-of-the-art study which seeks to draw on the experience of energy auditing in as many member states as possible.

3.2.2 Structure of relevant standards

CEN and CENELEC have published a series of European Standards that set out requirements and provide guidance on how to carry out energy audits. The EN 16247 series of standards is intended to help companies throughout Europe comply with the requirements of the European Union's Energy Efficiency Directive (2012/27/EU) [1].

The Energy Efficiency Directive (2012/27/EU) [2] sets out a series of measures to help the EU reach its targets for reducing energy consumption by ensuring more efficient use of energy at all stages of the energy chain. According to this Directive (Article 8), each Member State should ensure that large companies undergo energy audits carried out by qualified and/or accredited experts or implemented and supervised by independent authorities. Every large company (with more than 250 employees) should undergo an energy audit by 5 December 2015 and then on a regular basis (at least once every four years). Furthermore, Member States must develop programmes to encourage smaller companies (SMEs) to undergo energy audits and implement the recommendations from these audits.

The European Standards of the EN 16247 series were developed by a JWG1, which included experts from business and industry, public authorities and other stakeholders, in accordance with an official standardization request (M/479) from the European Commission. The first standard in the series (EN 16247-1), specifying the general requirements, common methodology and deliverables for energy audits, was adopted by CEN and CENELEC in June 2012. Three further standards, addressing the specific requirements, methodology and deliverables of energy audits in relation to buildings (EN 16247-2), processes (EN 16247-3) and transport (EN 16247-4), were adopted by CEN and CENELEC in May 2014.

The fifth and final standard in the series (EN 16247-5), which relates to the competences of energy auditors and will support the development of national qualification schemes for energy auditors, was approved by CEN and CENELEC in March 2015. All of the European Standards in the EN 16247 series are published and distributed by the National Members of CEN and CENELEC.

An overview of all parts of this standard is shown in Table 1.

Reference	Tittle	Standardization bodies
EN 16247-1:2012	*Energy audits - Part 1: General requirements*	*CEN/CENELEC JWG1*
EN 16247-2:2014	*Energy audits - Part 2: Buildings*	*CEN/CENELEC JWG1*
EN 16247-3:2014	*Energy audits - Part 3: Processes*	*CEN/CENELEC JWG1*
EN 16247-4:2014	*Energy audits - Part 4: Transport*	*CEN/CENELEC JWG1*
EN 16247-5:2015	*Energy audits - Part 5: Competence of energy auditors*	*CEN/CENELEC JWG1*

Table 1: Parts of the energy audit standard EN 16247

Following the publication of the EN 16247 series of European Standards on Energy Audits, including part 5 which specifies the competence requirements of energy auditors, CEN published in 2016 a Technical Report with examples of national requirements on qualification, training and experience of energy auditors (prepared by the CEN/CENELEC JWG1)

Only EN 16247-1 and EN 16247-2 are important for the standardization of GreenSoul. EN 16247-5 must be kept when selecting the energy auditor.

3.2.3 Energy audits in GreenSoul

An energy audit basically consists of an analysis of the energy usage within a building or facility and its contained equipment to assess how much energy the building and its users consume and to evaluate what measures can be taken to make it more energy-efficient.

The energy audits carried out within the GreenSoul project collected the data required to establish the baseline and identify variables that significantly affect energy consumption. The energy audits basically fulfil the baseline data collection and analysis requirements on the basis of the EN16247-2. The evaluation of the building includes all the technical systems and its envelope in this standard. The energy used, the evaluation of the systems to provide a cosy indoor climate and all the other services related to the use of the building within its performed activities are investigated [3].

A holistic view of the building and its systems is necessary to represent the energy flows within the system in a realistic dimension. The generation and the consumption of the energy are identified in size, type and usage. Furthermore, it is necessary to define a boundary for the system. The delivered energy is separated by different sources of energy and is compared to the different energy demands of the building. Furthermore, it states if there is an on-site production from renewable energy technologies as well as solar gains through windows and heat load from people.

3.3 Energy management systems

GreenSoul is an energy management system. For the exploitation of GreenSoul, certain standards regarding the system itself must be considered. The following explains the standardization bodies and the various standards regarding energy management systems.

3.3.1 Standardization bodies

CEN/CENELEC/JWG3 was created to elaborate EN standards in the energy management and related services field.

ISO identified energy management as one of the top five fields for the development of International Standards and in 2008 created a project committee, ISO/TC 242 “Energy management”, to carry out the work. In 2016 it was a merge between the ISO/TC 242 “Energy management” and the ISO/TC 257 “Energy Savings” to create **ISO/TC 301 “Energy management and energy savings”**, the scope of the TC’s energy efficiency standardization work has substantially increased. The “new” ISO/TC 301 counts 65 full country members and 14 observer country members.

Joint working group 3 (Energy management and related services – General requirements and qualification procedures) was created to elaborate EN standards in the energy management and related services field. The use of energy benchmarks within companies is especially influenced by the harmonized international standard for energy management systems ISO 50001:2011. In addition, the energy efficiency benchmarking methodology described in EN 16231:2012 provides further guidance on how to implement and use energy benchmarks [4].

Table 2 lists relevant standards for energy management systems.

Reference	Tittle	Standardization bodies
EN ISO 50001:2011 (updated by the EN ISO 50001:2018)	*Energy management systems – Requirements with guidance for use*	*in collaboration of ISO/TC 301 and CEN/CENELEC JWG3*
EN 16231:2012	*Energy efficiency benchmarking methodology*	*CEN/CENELEC JWG3*
ISO 50015:2014	*Energy management systems - Measurement and verification of energy performance of organizations -- General principles and guidance*	*ISO/TC 301 "Energy management and energy savings"*

Table 2: Different standards regarding energy management systems

3.3.2 Structure of relevant standards

The **ISO 50001:2011 (updated by the ISO 50001:2018)** audit process was initiated in 2016 as the ISO reviews its standards over a five-year cycle. This is to ensure that the standards match the current social conditions and requirements. Under the supervision of the Technical Committee ISO/TC 301 (Energy management and energy savings), formerly ISO/TC 242, the revision of the standard was carried out after the usual revision processes, which also led to the standard versions ISO 9001:2015 and ISO 14001:2015 [5] Meanwhile, a new version of EN ISO 50001 has already been published (EN ISO 50001:2018).

Today, experts from the national standards bodies of 48 ISO member countries participate within ISO/TC 301, with another 17 countries as observers. This international TC operates within the field of energy management, including for instance: energy efficiency, energy performance, energy supply, procurement practices for energy-using equipment and systems, and energy use as well as measurement of current energy usage, implementation of a measurement system to document, report and validate continuous improvement in the area of energy management.

The ISO 50001 standard published in June 2011 sets the first international standard for an energy management system. ISO 50001 is a classic management system standard that is not

sector-specific and can be used by a wide range of organizations, from small and medium-sized enterprises to large corporations or government agencies. The standard sets a framework within which individual commitment of the standard user is required. The formal requirements for functions and tasks of systematic energy management naturally have to reflect a broad spectrum. It is, therefore, the task of the respective company to tailor the variety of design options of a management system, as described in the ISO 50001, to suit their own needs. The ISO 50001 can, therefore, be applied in companies and organizations of all industries and sizes.

ISO 50001 provides a framework for industrial plants; commercial, institutional, or governmental facilities; or entire organizations to manage energy. Targeting broad applicability across national economic sectors, it is estimated that the standard could influence up to 60 % of the world's energy use.

The structure of ISO 50001 is designed according to other ISO management system standards, in particular, ISO 9001 (Quality Management Systems) and ISO 14001 (Environmental Management Systems) and is therefore compatible with them. They are based on the PDCA cycle (Plan-Do-Check-Act) and share the same high-level structure.

EN 16231:2012 specifies requirements and provides recommendations for energy efficiency benchmarking methods in all energy-using sectors. The purpose of energy efficiency benchmarking is to determine the relevant data and indicators of energy consumption, both technically and behaviorally, qualitatively and quantitatively, to improve the energy performance of an organization, to acquire and develop knowledge about the use of energy by the organization Reduce energy costs and reduce greenhouse gas emissions.

Energy efficiency benchmarking can be applied both internally within a given organization and externally between organizations, including competitors. This standard describes how limits can be set for a benchmark, such as assets, processes, products, services and organizations. It provides guidance on the criteria to select an appropriate level of detail for data collection and processing appropriate to the benchmarking objective.

This standard itself does not specify any specific performance requirements for energy use. All activities related to a PDCA cycle (Plan-Do-Check-Act) must be related to an energy management system.

ISO 50015:2014 establishes general principles and guidelines for the process of measurement and verification (M&V) of energy performance of an organization or its components. ISO 50015:2014 can be used independently, or in conjunction with other standards or protocols, and can be applied to all types of energy.

To include the standards from the UNE 178108 and 178104 about smart buildings.

3.3.3. Energy Management Systems and GreenSoul

In order to design the GreenSoul system and especially the components for energy measurements and visualization, we followed the recommendations explained in ISO 50001:2011, updated in 2018. This standard allows organizations to establish systems and processes to continuously improve energy performance, including energy efficiency, use and energy consumption. In GreenSoul we used the specifications gathered in the standard regarding the requirements of an energy management system for an organization. Fundamentally these requirements have been considered as considerations or recommendations at the time of designing the energy consumption monitoring system and its subsequent visualization. The development and implementation of an energy management system include the definition of energy policy, objectives, energy goals and action plans related to energy efficiency, energy use and consumption. Here in GreenSoul we help the organisation to design its own Energy Management System. Together with the audit that we provided at the beginning of the project, we deliver a system to obtain performance indicators for energy consumption. With the GreenSoul system, the organisation can monitor the energy consumption of the elements with significant use of energy. With the GreenSoul system can help the organization to fulfil the requirements made by the standards in terms of operation. After the planning and design of the operational control stated by the standards, the organisation can use GreenSoul to collect data and pieces of evidence to demonstrate energy performance.

The GreenSoul system allows for continuous tracking and improved energy performance. The GreenSoul visualization tool allows you to observe the data needed for the energy review and the tracking, measurement, analysis and evaluation processes. The software allows data to be consolidated and delivered to an automatic analysis of the same (report, See deliverable D3.9 GreenSoul System [6]).

A building can be considered as producer and consumer of energy, thus it is a key element for energy efficiency. The information collected from the building is really valuable and should be able to adapt its behaviour taking into considerations the needs of the users and other parts of the neighbourhood or city. Specifically, the advances from the Universal Monitoring Device made by WSC during the project has been really useful for the development of new standards at National level [7]. UNE Standard 178104 (Spanish standards), the precursor of the ITU-T Y.4200 and ITU-T Y.4201 Recommendations of the International Telecommunication Union, sets out the interoperability requirements for a Smart City Platform. In it, as a use case, it discusses how to connect city objects to it. This is where the smart building such as Node IoT that reports data to the city is planned. The advances made in the Universal Monitoring Device has been used as a base for a future Node IoT and GreenSoul partners have contributed to the definition of the Standards for the definition of the Smart City Platform and Node IoT requirements [7].

3.4 Energy efficiency & energy savings

3.4.1 Standardization bodies

ISO/TC 301 "Energy management and energy savings" is responsible for standardization in the field of energy management and energy savings.

Standards from **CEN/CENELEC/JWG4** focus on common methods of calculation of energy consumption, energy efficiencies and energy savings and on common measurement and verification of protocol and methodology for energy use indicators.

3.4.2 Structure of relevant standards

Table 3 lists relevant standards for energy efficiency and energy savings.

Reference	Tittle	Standardization bodies
ISO/DIS 50049	*Calculation methods for energy efficiency and energy consumption variations at country, region and city levels: relation to energy savings and other factors*	*ISO/TC 301 "Energy management and energy savings"*
ISO/DIS 17743:2016	*Energy savings — Definition of a methodological framework applicable to calculation and reporting on energy savings*	*ISO/TC 301 "Energy management and energy savings"*
ISO 17742:2015	*Energy efficiency and savings calculation for countries, regions and cities*	*ISO/TC 301 "Energy management and energy savings"*
ISO/DIS 17747	*Determination of energy savings in organizations*	*joint with ISO/TC 242 "Energy management", ISO/TC 257 "Evaluation of energy savings" leading*
ISO/DIS 17741:2016	*General technical rules for measurement, calculation and verification of energy savings of projects*	*ISO/TC 301 "Energy management and energy savings"*
ISO/AWI 20619	*Calculation methods for energy savings*	*ISO/TC 257 "Evaluation of energy savings" leading*
EN 16212:2012	*Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods*	*CEN/CENELEC JWG4*
EN 16231:2012	*Energy efficiency benchmarking methodology*	*CEN/CENELEC JWG3*

ISO 50047:2016	*Energy savings - Determination of energy savings in organizations*	*ISO/TC 301 "Energy management and energy savings"*

Table 3: Different standards regarding energy efficiency and energy savings

ISO/DIS 50049 is under development.

ISO/DIS 17743:2016 establishes a methodological framework that applies to the calculation and reporting of energy savings from existing (implemented) and prospective measures and actions which intend to save energy. This framework standard will be applicable to other standards in the field of energy saving determination. ISO/DIS 17743:2016 addresses the following in the context of energy savings:

- terminology;
- definition of the system boundaries;
- principles for the determination of a baseline;
- principles for statistical indicator-based methods;
- data used;
- principles for reporting.

The development of the methodology for measurement and verification of the energy savings is not in the scope of this International Standard. The methodology of construction of the scenarios for future energy-saving measures and actions is not in the scope of this International Standard.

ISO 17742:2015 provides a general approach for energy efficiency and energy savings calculations with indicator-based and measure-based methods for the geographical entities countries, regions, and cities. ISO 17742:2015 considers all end-use sectors, such as households, industry, tertiary (services, etc.), agriculture, and transport. It does not incorporate a calculation of energy efficiency and energy savings in energy supply sectors, such as power plants, refineries, and coal mines.

ISO/DIS 17747 provides approaches for the determination of energy savings from existing (implemented) or prospective energy performance improvement actions (EPIAs) in organizations. These methods may be applied to any organization, whether incorporated or not, public or private. It can be used by organizations already operating to an energy management system, such as ISO 50001, as well as by organizations with no formal energy management system. ISO/DIS 17747 addresses the following topics in the context of energy savings:

- Establishing the purpose of the determination of energy savings
- Determining boundaries
- Energy accounting, including primary and delivered energy
- Selecting an approach for the determination of energy savings
- Establishing an energy baseline
- Normalization of energy consumption
- Determination of energy savings
- Reporting and other matters.

Specific methods for measurement and verification (M&V) of energy performance which are used to calculate energy savings are not in the scope of this standard. Guidance related to M&V of organizational energy performance can be found in ISO 50015.

Originally, the standard project was managed under the standard designation ISO 17747, but the designation of the standard was adopted as part of the merger of ISO/TC 242 and ISO/TC 257 and renamed ISO 50047 (compare ISO 50047:2016).

ISO 17741:2016 specifies the general technical rules for measurement, calculation and verification of energy savings in retrofits projects or new projects.

ISO/AWI 20619 the work item for this standard is registered but the work in the technical committee has not started yet. The current status of this standard is unknown. Originally ISO/TC 257 was responsible. Meanwhile, ISO/TC 257 has been merged with ISO/TC 242.

EN 16212:2012 provides a general approach for energy efficiency and energy savings calculations with top-down and bottom-up methods. The general approach is applicable to energy savings in buildings, cars, appliances, industrial processes, etc. EN 16212:2012 covers energy consumption in all end-use sectors. The standard does not cover energy supply, e.g. in power stations, as it considers only final energy consumption. It deals with savings on energy supplied to end-users. Some forms of renewable energy "behind-the-meter" (e.g. from solar water heating panels) reduce supplied energy and therefore can be part of the calculated energy savings. Users of the standard should be aware that this renewable energy behind the meter can also be claimed as energy generated.

EN 16212:2012 is meant to be used for ex-post evaluations of realised savings as well as ex-ante evaluations of expected savings. EN 16212:2012 provides saving calculations for any period chosen. However, a short data series may limit the possible periods over which savings can be calculated.

EN 16231:2012 specifies requirements and provides recommendations for energy efficiency benchmarking methodology. The purpose of energy efficiency benchmarking is to establish the relevant data and indicators on energy consumption, both technical and behavioural, qualitative and quantitative in comparing performance between or within entities. Energy efficiency benchmarking can be either internal (within a specific organisation) or external (between organisations including competitors). EN 16231:2012 describes how to establish the boundaries of what is being benchmarked, including for example facilities, activities, processes, products, services and organisations. EN 16231:2012 provides guidance on the criteria to be used in order to choose the appropriate level of detail for the data collection, processing and reviewing which suits the objective of the benchmarking.

ISO 50047:2016 describes approaches for the determination of energy savings in organizations. It can be used by all organizations, whether or not they have an energy management system, such as ISO 50001. ISO 50047:2016 addresses the following topics in the context of energy savings:

- establishing the purpose of determining energy savings;
- determining boundaries;
- energy accounting, including primary and delivered energy and the use of common energy units;
- selecting an approach for the determination of energy savings;
- establishing an energy baseline;
- normalization of energy consumption;
- determination of energy savings;
- reporting and other matters.

Specific methods for the measurement and verification of energy performance and its improvement are outside the scope of ISO 50047:2016.

3.4.3 GreenSoul and Energy Efficiency

The Energy Efficiency Directive 2012/27/EU is a European Union directive which mandates energy efficiency improvements within the European Union. In GreenSoul we have followed the information of this regulation. It was approved on 25 October 2012 and entered into force on 4 December 2012. The directive introduces legally binding measures to encourage efforts to use energy more efficiently in all stages and sectors of the supply chain. It establishes a common framework for the promotion of energy efficiency within the EU in order to meet its energy efficiency headline target of 20 % by 2020. It also paves the way for further improvements thereafter.

Under the terms of the Energy Efficiency Directive or part of its predecessors, 2004/8/EC and EDL Directive 2006/32/EC, Article 1 (1) of the Energy Efficiency Directive provides for a common framework for measures to promote energy efficiency in the Union "to ensure that the Union's overarching energy efficiency target of 20% is achieved by 2020, and to prepare further energy efficiency improvements for the period thereafter".

This will be done through rules set out in the Energy Efficiency Directive to "eliminate barriers in the energy market and market failures that hinder efficiency in energy supply and use".

The definition of 'indicative national energy efficiency targets by 2020' is an important part of implementing the requirements of the European Energy Efficiency Directive, with the requirements of the Directive being minimum requirements and not preventing the Union Member States from 'maintaining or adopting more stringent measures', provided that these measures are compatible with EU law. During the project GreenSoul we developed a system to help to fulfil the energy efficiency target of 20%.

3. 5 Life Cycle Assessment

3.5.1 Standardization bodies

The work of **ISO/TC 207/SC 5" Life cycle assessment"** covers the life cycle assessment (LCA) as one of the techniques developed to better understand and address the possible environmental impacts associated with products, processes and organizations.

The standards of this subcommittee dealing with the principles and guidelines for life cycle analysis are listed next.

3.5.2 Structure of relevant standards

Table 4 lists relevant standards for life cycle assessment.

Reference	Tittle	Standardization bodies
ISO 14040:2006	*Environmental management — Life cycle assessment — Principles and framework*	*ISO/TC 207/SC 5" Life cycle assessment"*
ISO 14044:2006	*Environmental management — Life cycle assessment — Requirements and guidelines*	*ISO/TC 207/SC 5" Life cycle assessment"*
ISO 14045:2012	*Environmental management — Eco-efficiency assessment of product systems — Principles, requirements and guidelines*	*ISO/TC 207/SC 5" Life cycle assessment"*
ISO/TS 14071:2014	*Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006*	*ISO/TC 207/SC 5" Life cycle assessment"*
ISO/TS 14072:2014	*Environmental management — Life cycle assessment — Requirements and guidelines for organizational life cycle assessment*	*ISO/TC 207/SC 5" Life cycle assessment"*

Table 4 Different standards regarding life cycle assessment

ISO 14040:2006 describes the principles and framework for LCA: including definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.

This International standard covers LCA studies and life cycle inventory (LCI) studies. It does not describe the LCA technique in detail, nor does it specify methodologies for the individual phases of the LCA.

The intended application of LCA or LCI results is considered during the definition of the goal and scope, but the application itself is outside the scope of this International Standard.

This International Standard is not intended for contractual or regulatory purposes or registration and certification.

ISO 14044:2006 specifies requirements and provides guidelines for LCA including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the LCIA phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, relationship between the LCA phases, and conditions for use of value choices and optional elements. ISO 14044:2006 covers LCA studies and LCI studies.

The intended application of LCA or LCI results is considered during the goal and scope definition, but the application itself is outside the scope of this International Standard. This International Standard is not intended for contractual or regulatory purposes or registration and certification.

ISO 14045:2012 describes the principles, requirements and guidelines for eco-efficiency assessment for product systems including:

- the goal and scope definition of the eco-efficiency assessment;
- the environmental assessment;
- the product-system-value assessment;
- the quantification of eco-efficiency;
- interpretation (including quality assurance);
- reporting;
- critical review of the eco-efficiency assessment.

Its key objectives are to:

- establish clear terminology and a common methodological framework for eco-efficiency assessment;
- enable the practical use of eco-efficiency assessment for a wide range of product (including service) systems;
- provide clear guidance on the interpretation of eco-efficiency assessment results;
- encourage the transparent, accurate and informative reporting of eco-efficiency assessment results.

Requirements, recommendations and guidelines for specific choices of categories of environmental impact and values are not included. The intended application of the eco-efficiency assessment is considered during the goal and scope definition phase, but the actual use of the results is outside the scope of ISO 14045:2012.

ISO/TS 14071:2014 includes additional specifications to ISO 14040:2006 and ISO 14044:2006. It provides requirements and guidelines for conducting a critical review of any type of LCA study and the competencies required for the review. ISO/TS 14071:2014 provides:

- details of a critical review process, including clarification with regard to ISO 14044:2006;
- guidelines to deliver the required critical review process, linked to the goal of the life cycle assessment (LCA) and its intended use;
- content and deliverables of the critical review process;
- guidelines to improve the consistency, transparency, efficiency and credibility of the critical review process;
- the required competencies for the reviewer(s) (internal, external and panel member);
- the required competencies to be represented by the panel as a whole.

ISO/TS 14072:2014 provides additional requirements and guidelines for an effective application of ISO 14040 and ISO 14044 to organizations. It details:

- the application of Life Cycle Assessment (LCA) principles and methodology to organizations,

- the benefits that LCA can bring to organizations by using LCA methodology at an organizational level,
- the system boundary,
- specific considerations when dealing with LCI, LCIA, and interpretation, and
- the limitations regarding reporting, environmental declarations, and comparative assertions.

ISO/TS 14072:2014 applies to any organization that has interest in applying LCA. It is not intended for the interpretation of ISO 14001 and specifically covers the goals of ISO 14040 and ISO 14044.

3.4.4. Life Cycle Assessment and GreenSoul

During Task T6.5 an assessment of the environmental impact of the project in general, and the treatments, in particular, was carried out. The assessment loosely follows the COMMISSION RECOMMENDATION of the 9th of April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (2013/179/EU). The details of the methodology and the end results could be consulted in Deliverable D6.4 [8].

Each requirement specified in the European Commission Recommendation is based on the recommendations of similar, widely recognised environmental accounting methods and guidance documents. Specifically, the methodology guides considered were: ISO standards, in particular: ISO 14044(2006), Draft ISO/DIS 14067(2012), ISO 14025(2006), ISO 14020(2000); the ILCD (International Reference Life Cycle Data System) Handbook; the Ecological Footprint Standards; the Greenhouse Gas Protocol (WRI/ WBCSD); the general principles for an environmental communication on mass-market products BPX 30-323-0 (ADEME); and the specification for the assessment of the life cycle greenhouse gas emissions of goods and services [9].

3.6 Greenhouse gases

3.6.1 Standardization bodies

The technical body **ISO/TC 207/SC7 "Greenhouse gas management and related activities"** develops standards intended to manage and mitigate GHG emissions and to improve adaptation to the effects of climate change. This includes quantification, reporting and verification of GHG emissions applicable to the organizational level, verification bodies or emissions reduction at the project level.

3.6.2 Structure of relevant standards

Table 5 lists relevant standards for greenhouse gases.

Reference	Tittle	Standardization bodies
ISO 14064-1:2006	*Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*	*ISO/TC 207/SC 7 "Greenhouse gas management and related activities"*
ISO 14064-2_2006	*Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements*	*ISO/TC 207/SC 7 "Greenhouse gas management and related activities"*
ISO/TR 14069:2013	*Greenhouse gases — Quantification and reporting of greenhouse gas emissions for organizations — Guidance for the application of ISO 14064-1*	*ISO/TC 207/SC 7 "Greenhouse gas management and related activities"*

ISO/TS 14067:2013	*Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification and communication*	*ISO/TC 207/SC 7 "Greenhouse gas management and related activities"*
ISO 14080:2018	*Greenhouse gas management and related activities — Framework and principles for methodologies on climate actions*	*ISO/TC 207/SC 7 "Greenhouse gas management and related activities"*

Table 5 Different standards regarding greenhouse gases

ISO 14064-1:2006 (Part 1 of ISO 14064) details principles and requirements for designing, developing, managing and reporting organization- or company-level GHG inventories. It includes requirements for determining GHG emission boundaries, quantifying an organization's GHG emissions and removals, and identifying specific company actions or activities aimed at improving GHG management. It also includes requirements and guidance on inventory quality management, reporting, internal auditing and the organization's responsibilities for verification activities.

ISO 14064-2:2006 specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause greenhouse gas (GHG) emission reductions or removal enhancements. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenario, monitoring, quantifying, documenting and reporting GHG project performance and managing data quality. It provides the basis for GHG projects to be validated and verified.

This part of ISO 14064 does not specify requirements for validation/verification bodies or validators/verifiers in providing assurance against GHG assertions or claims by GHG projects. Such requirements may be specified by the authority of the applicable GHG programme or can be found in ISO 14064-3.

ISO/TR 14069:2013 describes the principles, concepts and methods relating to the quantification and reporting of direct and indirect greenhouse gas (GHG) emissions for an

organization. It provides guidance for the application of ISO 14064-1 to greenhouse gas inventories at the organization level, for the quantification and reporting of direct emissions, energy indirect emissions and other indirect emissions.

ISO/TR 14069:2013 describes for all organizations, including local authorities, the steps for:

- establishing organizational boundaries, in accordance with either a control approach (financial or operational) or an equity share approach;
- establishing operational boundaries, by identifying direct emissions and energy indirect emissions to be quantified and reported, as well as any other indirect emissions the organization chooses to quantify and report; for each category of emission, guidance is provided on specific boundaries and methodologies for the quantification of GHG emissions and removals;
- GHG reporting: the guidance is provided to promote transparency regarding the boundaries, the methodologies used for the quantification of direct and indirect GHG emissions and removals, and the uncertainty of the results.

ISO/TS 14067:2013 specifies principles, requirements and guidelines for the quantification and communication of the carbon footprint of a product (CFP), based on International Standards on life cycle assessment (ISO 14040 and ISO 14044) for quantification and on environmental labels and declarations (ISO 14020, ISO 14024 and ISO 14025) for communication.

Requirements and guidelines for the quantification and communication of a partial carbon footprint of a product (partial CFP) are also provided.

ISO/TS 14067:2013 is applicable to CFP studies and different options for CFP communication based on the results of such studies.

Where the results of a CFP study are reported according to ISO/TS 14067:2013, procedures are provided to support both transparency and credibility and also to allow for informed choices.

ISO/TS 14067:2013 also provides for the development of CFP-product category rules (CFP-PCR), or the adoption of product category rules (PCR) that have been developed in accordance with ISO 14025 and that are consistent with ISO/TS 14067:2013.

ISO/TS 14067:2013 addresses only one impact category: climate change. Offsetting is outside of the scope of ISO/TS 14067:2013.

ISO 14080:2018 gives guidelines by means of a framework and principles for establishing approaches and processes to:

- identify, assess and revise methodologies;
- develop methodologies;
- manage methodologies.

This document is applicable to climate actions to address climate change, including adaptation to its impacts and greenhouse gas (GHG) mitigation in support of sustainability. Such actions can be used by or for projects, organizations, jurisdictions, economic sectors, technologies and products, policies, programmes and non-government activities. This document does not create guidance for a specific methodology.

3.6.3. Greenhouse gases and GreenSoul

During Task T6.5 an assessment of the environmental impact of the project in general, and the treatments, in particular, was carried out. In fact, the environmental assessment was restricted to the estimation of the GHG produced or avoided by the experimental phase of the project. The methodology involved the creation of a baseline of energy consumption and procedures to estimate the impact of the intervention (both as a reduction of the energy due to the intervention and the amount of energy needed to put into practice and carry on the intervention). Then, the energy is translated to emissions using standardized emissions factors from the Covenant of Mayors for Climate and Energy: Default emission factors for local emission inventories. The details of the methodology and the end results could be consulted in Deliverable D6.4 [8].

3.7. Energy performance

One of the objectives of GreenSoul project is to evaluate the energy performance of the system to be developed in order to classify them in several categories. Specific standards for energy performance of buildings has been used.

3.7.1. Standardization bodies

TC CEN/TC 89 "Thermal performance of buildings and building components" is responsible for standardization in the field of energy performance of buildings, including particularly energy transfer through building components and thermal insulation of installed equipment in buildings, covering: - rules for expressing relevant thermal properties and requirements; - calculation and test methods; - input data, including climatic data; - effects of moisture.

TC CEN/TC 228 "Heating systems in buildings" is responsible for standardisation of functional requirements for all types of heating systems in buildings, including domestic hot water production. The work includes: - General performance requirements for heating systems, considered as a whole and taking into account work already being done in other CEN/TCs; - General requirements for design of heating systems; - Requirements for installation and commissioning, including tests on the heating system as a whole; - Requirements for preparation of instructions for operation and maintenance; - Methods for calculation of design heat loads, as basis for sizing of heat emitters and heat generators; - Methods for calculation of energy requirements of heating systems, including energy economy and environmental impact, as basis for supporting energy performance criteria and/or energy labelling of heating systems; - Co-operation with other CEN/TCs responsible for related systems and products in order to establish a common terminology and a common set of technical parameters.

3.7.2 Structure of relevant standards

Table 6 lists relevant standards for energy performance.

Reference	Tittle	Standardization bodies
EN 15217:2007	*Energy performance of buildings. Methods for expressing energy performance and for energy certification of buildings*	*TC CEN/TC 89 "Thermal performance of buildings and building components"*
EN 15459:2007	*Energy performance of buildings. Economic evaluation procedure for energy systems in buildings*	*TC CEN/TC 228 "Heating systems in buildings"*
EN 15603:2008 (withdrawn)	*Energy performance of buildings - Overall energy use and definition of energy ratings*	

Table 6 Different standards regarding energy performance

EN 15217:2007 specifies:

- overall indicators to express the energy performance of whole buildings, including heating, ventilation, air conditioning, domestic hot water and lighting systems. This includes different possible indicators;
- ways to express energy requirements for the design of new buildings or renovation of existing buildings;
- procedures to define reference values;
- ways to design a procedure for building energy certification.

The standard can be applied to a group of buildings, if they are on the same lot, if they are serviced by the same technical building systems and if no more than one of them has a conditioned area of more than 1.000 m². This European Standard provides different options at different levels. When this European Standard is used to set up national or regional methods for expressing energy performance and/or for energy certification of buildings, the choices between the options is not made by the individual user, but by authorized national or regional bodies.

EN 15459:2007 provides a calculation method for the economical issues of heating systems and other systems that are involved in the energy demand and energy consumption of the building. This standard applies to all types of buildings. The fundamental principles and terminology are explained in this standard. The main items of the standard are:

- definitions and structure of the types of costs, which shall be taken into account for calculation of the economical efficiency of saving options in buildings;
- data needed for definition of costs related to systems under consideration;
- calculation method(s);
- expression of the result of the economic calculation;
- informative annexes indicating default values of e.g. lifetime, costs for repair, costs for maintenance, in order to introduce default values for calculations.

This standard is applicable to calculation of economic performance of energy saving options in buildings (e.g. insulation, better performing generators and distribution systems, efficient lighting, renewable sources, combined heat and power). The scope of this standard is to standardise required inputs, calculation methods and required outputs for economic calculations of energy systems related to the energy performance of buildings.

The standard **EN 15603:2008** was withdrawn in 2018. For completeness, this will be explained below anyway. The purpose of the standard **EN 15603:2008** was to:

- collate results from other standards that calculate energy use for specific services within a building;
- account for energy generated in the building, some of which may be exported for use elsewhere;
- present a summary of the overall energy use of the building in tabular form;
- provide energy ratings based on primary energy, carbon dioxide emission or other parameters defined by national energy policy;
- establish general principles for the calculation of primary energy factors and carbon emission coefficients.

This standard defined the energy services to be taken into account for setting energy performance ratings for planned and existing buildings, and provides for this:

- method to compute the standard calculated energy rating, a standard energy use that does not depend on occupant behaviour, actual weather and other actual (environment or indoor) conditions;
- method to assess the measured energy rating, based on the delivered and exported energy;
- methodology to improve confidence in the building calculation model by comparison with actual energy use;
- method to assess the energy effectiveness of possible improvements.

This European standard was applicable to a part of a building (e.g. flat), a whole building, or several buildings. It is up to national bodies to define under which conditions, for which purposes and for which types of buildings the various ratings apply. This standard handled the energy performance of a building as a whole. The assessment of the energy performance of specific technical building systems is handled in the appropriate part of EN 15241, prEN 15243 and EN 15316 series.

3.7.3. Energy performance and GreenSoul

EN 15603:2008 was used for determining the primary energy factors by the compilation of the energy audits. This standard provides the calculation procedure to determine the annual overall energy use for heating, cooling, hot water, ventilation, and lighting.

A building generally uses more than one energy carrier, such as gas, coal, oil, wood, district heating or cooling, electricity and so on. Therefore, a common expression of all energy carriers is essential in order to aggregate the amounts used, which are otherwise sometimes expressed in different units and always leading to a variety of impacts. Clause 8 of EN 15603 offers the following aggregation methods:

- Primary energy rating
- CO2 emissions rating
- National policy energy rating

The first one is compulsory according to the EPBD (Energy Performance of buildings directive). In Green Soul, a determination was made only by primary energy rating. Meanwhile, the standard EN 15603:2008 standard has been withdrawn.

3.8 Internet of Things

The term "Internet of Things" refers to the increasing interconnectedness between "intelligent" objects both internally and externally with the Internet. Various objects, everyday objects or machines are equipped with processors and embedded sensors so that they are

able to communicate with each other via the IP network. As GreenSoul also uses such systems, these standards must be taken into account.

3.8.1 Standardization bodies

The scope of **ISO/IEC JTC 1 "Information Technology"** is the standardization in the field of information technology. ISO/IEC JTC 1 serves as the focus and proponent for JTC 1's standardization programme on the Internet of Things and related technologies, including Sensor Networks and Wearables technologies. This committee provides guidance to JTC 1, IEC, ISO and other entities developing Internet of Things related applications.

The scope of **ISO/IEC JTC 1/SC 31 "Automatic identification and data capture techniques"** are standardization of data formats, data syntax, data structures, data encoding, and technologies for the process of automatic identification and data capture and of associated devices utilized in inter-industry applications and international business interchanges and for mobile applications.

3.8.2 Structure of relevant standards

Table 7 lists relevant standards for Internet of Things.

Reference	Tittle	Standardization bodies
ISO/IEC 30141:2018	*Internet of Things (IoT) — Reference Architecture*	*ISO/IEC JTC 1/SC 41 "Internet of Things and related technologies"*
ISO/IEC 21823-1:2019	*Internet of things (IoT) — Interoperability for internet of things systems — Part 1: Framework*	*ISO/IEC JTC 1/SC 41 "Internet of Things and related technologies"*
ISO/IEC 20924:2018	*Information technology — Internet of Things (IoT) — Vocabulary*	*ISO/IEC JTC 1/SC 41 "Internet of Things and related technologies"*

ISO/IEC TR 22417:2017	*Information technology — Internet of things (IoT) use cases*	*ISO/IEC JTC 1/SC 41 "Internet of Things and related technologies"*
ISO/IEC 29161:2016	*Information technology — Data structure — Unique identification for the Internet of Things*	*ISO/IEC JTC 1/SC 31 "Automatic identification and data capture techniques*

Table 7 Different standards regarding Internet of Things

ISO/IEC 30141:2018 provides a standardized IoT Reference Architecture using a common vocabulary, reusable designs and industry best practices. It uses a top down approach, beginning with collecting the most important characteristics of IoT, abstracting those into a generic IoT Conceptual Model, deriving a high level system based reference with subsequent dissection of that model into five architecture views from different perspectives.

ISO/IEC 21823-1:2019 provides an overview of interoperability as it applies to IoT systems and a framework for interoperability for IoT systems. This document enables IoT systems to be built in such a way that the entities of the IoT system are able to exchange information and mutually use the information in an efficient way. This document enables peer-to-peer interoperability between separate IoT systems. This document provides a common understanding of interoperability as it applies to IoT systems and the various entities within them.

ISO/IEC 20924:2018 provides a definition of Internet of Things along with a set of terms and definitions forming a terminology foundation for the Internet of Things

ISO/IEC TR 22417:2017 identifies IoT scenarios and use cases based on real-world applications and requirements. The use cases provide a practical context for considerations on interoperability and standards based on user experience. They also clarify where existing standards can be applied and highlight where standardization work is needed.

ISO/IEC 29161:2016 establishes a unique identification scheme for the Internet of Things (IoT), based on existing and evolving data structures. This International Standard specifies the common rules applicable for unique identification that are required to ensure full compatibility across different identities. The unique identification is a universal construct for

any physical object, virtual object, or person. It is used in IoT information systems that need to track or otherwise refer to entities. It is intended for use with any IoT media.

3.8.3. Internet of Things and GreenSoul

The different devices either enhanced (Universal Monitoring Device) or created from scratch during this project (Interactive Coaster, Dimmer or Smart Plug Stripes) have followed the IoT standards described above (See Deliverable D3.9 [6]). Doing that, we can ensure a quick launch to potential markets if we would like to continue enhancing the new designed IoT products. Furthermore, the Interactive Coaster and the Smart Plug Stripe have been designed with modularity and recyclability (electronic disassembling) in mind. Thus, instead of soldering all the components we decided to use special pinboards for the connection. Doing that, at the end of the project we can reuse the microcontrollers and other sensing equipment to future projects or teaching activities carried out in the university.

Besides the manufacturing phase, IoT devices created have explored the SAREF ontology for communicating with other systems through TCP/IP and MQTT. Specifically, all three components connect to the Edge through Wi-Fi and use these two underlying protocols to communicate the status of the sensors or receive actions such as change lights/switch SP off. Nevertheless, the microcontroller used for the Interactive Coaster and Smart Plug Stripe supports to change the communication channel from Wi-Fi to BLE.

Data Models

Just like the Dimmer, the GreenSoul Information Model (GIM), as already explained in detail in D2.5 [10], has explored multiple ontologies and standards to support the basic functionalities of the GreenSoul system. Some of the core standards/ontologies explored in depth and integrated at some degree are the following:

gbXML

Starting from the pilot topologies, which was used within the Decision Making processes, GIM has engulfed the gbXML [11] representation for Building Information Modelling (BIM). By doing so, is supports the capability to link sensors, users, measurements, etc. with a 3D building representation for better estimating the building behaviour under different

operational and environmental conditions. Even though not explored in depth, certain services were delivered within the GreenSoul project. Having the foundation layed, this feature could easily expanded to fully integrate the standard.

Within the latest version of gbXML equipment and measurements have also been added. Nevertheless, for complexity reasons, a simpler data model was adopted for information exchange.

obXML

As described in D4.1 [12], to model energy-related occupant behaviour, GreenSoul has investigated the obXML schema [13, 14]. For complexity reasons, once more very specific components of this framework have been integrated within the GreenSoul system. The DSS developed takes into account quite a few of the DNAS framework for the decision making, with the information being available (for these aspects) in the obXML format.

Communication Protocols

The lowest level of the GreenSoul multi-sensorial network includes a variety of communication protocols especially due to the high heterogeneity of the pilots. These include:

- KNX (EN 50090, ISO/IEC 14543)
- EnOcean (ISO/IEC 14543-3-10)
- ZigBee (IEEE 802.15.4), and
- WiFi (IEEE 802.11)

3.9 Lighting

3.9.1 Standardization bodies

ISO/TC 274 "Light and lighting" is responsible for standardization in the field of application of lighting in specific cases complementary to the work items of the International Commission on Illumination (CIE) and the coordination of drafts from the CIE, in accordance with the Council Resolution 19/1984 and Council Resolution 10/1989 concerning vision, photometry

and colorimetry, involving natural and man-made radiation over the UV, the visible and the IR regions of the spectrum, and application subjects covering all usage of light, indoors and outdoors, energy performance, including environmental, non-visual biological and health effects.

CEN/TC 169 "Light and lighting" is responsible for standardization in the field of vision, photometry and colorimetry, involving natural and man-made radiation over the UV, the visible and the IR regions of the spectrum, and application subjects covering all usages of light, indoors and outdoors, including environmental and aesthetic effects.

3.9.2 Structure of relevant standards

Table 8 lists relevant standards for lighting.

Table 8: Different standards regarding lighting

Reference	Tittle	Standardization bodies
ISO 8995-1:2002	*Lighting of work places -- Part 1: Indoor*	*ISO/TC 274 "Light and lighting"*
ISO 8995-1:2002/ Cor 1:2005	*Lighting of work places -- Part 1: Indoor -- Technical Corrigendum 1*	*ISO/TC 274 "Light and lighting"*
EN 12464-1:2011	*Light and lighting - Lighting of work places - Part 1: Indoor work places*	*CEN/TC 169 "Light and lighting"*
EN 12464-2:2014	*Light and lighting - Lighting of work places - Part 2: Outdoor work places*	*CEN/TC 169 "Light and lighting"*

3.9.3. Lighting and GreenSoul

To facilitate integration with existing systems while also increasing performance of existing systems without requiring additional studies on the lighting topology or efficiency, the GreenSoul Dimmer focused on the control of existing lighting fixtures, either by simply turning them on/off or for maximising efficiency, dimming up or down. Evaluating a variety of

dimming protocols [15] the simplest solutions were adopted, which have been identified as the most easily applicable to commercially dimmable lighting fixtures/ballasts:

- 1-10V : Quite a few dimming ballasts support external control through a voltage regulation between 1-10V. To provide this, the GS-ed Dimmer follows the ANSI C137.1-2019 (Lighting Systems - 0-10V Dimming Interface for LED Drivers, Fluorescent Ballasts, and Controls)[16] protocol
- Phase Cut: Another dimming control protocol is the phase cut dimming control protocol. It operates by limiting the power delivered to the load, only conducting a certain percentage of the AC mains each half-cycle. Varying the dimmer position varies the conduction period and hence the power delivered to the load, resulting in a change in light output. The GS-ed Dimmer adopted a forward phase cut dimming approach based on the NEMA SSL 7A-2013 (Phase Cut Dimming for Solid State Lighting: Basic Compatibility) [17] and the DS/IEC TR 63036:2016 (Electrical interface specification for phase-cut dimmer in phase-cut dimmed lighting systems) [18].

Finally, besides the control protocols, the GS-ed Dimmer has explored the SAREF ontology for communicating with other systems through TCP/IP and MQTT.

4. Standardization initiatives from GreenSoul

During the project implementation, GreenSoul partners have made use of this Standardisation landscape analysis to follow current standards during the implementation of the different hardware and software components of the GreenSoul system.

GreenSoul partners have tried also to contribute to new standards. Specifically, WSC has contributed actively with the developments done with the Universal Monitoring Device and software with the CNT178 *Grupo de trabajo Semántica de Smart Building* (Working Group Semantic in Smart Buildings) organized by AENOR. During the meetings a document with recommendations for new standards have been done.

Spain is a referent recognized at the international level in the field of Smart City. The Spanish model of standardization developed in the UNE technical committee, CTN 178 chaired by the

Secretary of State for the Information Society and Digital Agenda (SESIAD), counts on 23 national technical standards that it is serving. to draw up international standards on the sine of the ITU.

The standards UNE 178104:2017 Comprehensive Intelligent City Management Systems. Interoperability Requirements for a Smart City Platform and UNE 178108: 2017 Smart Cities. Intelligent building requirements for consideration as the IoT node in accordance with UNE 178104 has been the latest in publication. Specifically, Standard UNE 178104, which first edition dates from 2015, has given rise to recommendations ITU-T Y.4200: Interoperability Requirements for Intelligent City Platforms, and ITU-T Y.4201: High Level Requirements and benchmark of Intelligent City Platforms, which has gained international relevance.

Based on the leadership of the Ministry of Industry, the Technical Committee for Standardization 178 (CTN 178) has been created at the UNE (Spanish Association for Standardization), how has work materialized in the generation of various relevant norms around the smart city, among highlighting them:

• UNE 178104, which defines the concept of the Intelligent City Platform, its architecture and underpins the interoperability of the different verticals. This standard has been moved to the international level, and is the basis for a recommendation of the ITU in the scope of the Studio Commission 20.

• UNE 178108 which introduces the concept of building as an inner object of the city and as the basic cell of the same through the incorporation of an IoT node into the same. This standard defines the basic parameters of interest for the city, as well as the minimum characteristics of node design.

• UNE 178201: Intelligent Cities: Definition, attributes and requirements, it has as its objective to propose a formal definition of the concept of “Smart City”, to identify the attributes that characterize, the necessary requirements for a city to be considered Intelligent City and to describe an City semantics that allows a definition of normalized, coherent and comparable indicators across time and between cities.

• UNE 178301, Open Data (Open Data), establishes how to evaluate the publication of open data for a city.

According to the previous general model, buildings integrate into the smart city as an IoT (Internet of Things) node, which provides all building information with a smart city platform compatible with the UNE 178104 standard.

The integration of the IoT node of the building with the city platform is recognized in the PNE 178108 standard project "Requirements for the application of the UNE 178104 standard in smart buildings". This integration will allow the internal objects of the city to bring to the platform data related to, for example, levels of atmospheric contamination at different heights, water acoustics; meteorological information like speed of the wind, temperature, humidity or rainfall; information on consumption of services such as electricity, water, gas or gas; information on the energy produced and storage capacities; between others.

WSC has contributed in the recommendations documents that deal with the definition of a semantic common among all the internal objects of the city that guide the cities in the development of new services based on the Intelligent Territories Model mentioned above. Specifically, the contribution has been based on the use case of Smart Buildings taking into consideration what has been developed for the Universal Monitoring Device for measuring energy consumption and the platform WeSave to monitor the energy performance [D3.9]. During the meetings, WSC, as represented by the project consortium has contributed with the knowledge gained during the project implementation, in the contribution on how energy management systems in the buildings can contribute to the new standards for Smart Buildings and their connections with the Smart Cities.

Conclusions

This deliverable has reviewed the state of the arts of the main standards related to the GreenSoul system deployed in the pilot buildings. Starting from a set of keywords (i.e. Energy Audits, Energy Management Systems, Energy Savings and Energy Efficiency, Energy performance, Life cycle assessment, Greenhouse gases, Internet of Things) we have addressed and given information about all the relevants standardization bodies, published standards and the relationship between the standards and GreenSoul. Finallay, we provide information about how the knowledge acquired during the project has been included into recommendations for new standards in the fields of Smart Cities and Smart Buildings.

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