Deliverable D 7.7

Report on Standards Recommendations

WP7

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Publishable summary

The Report on Standards Recommendation is a public document delivered in the context of WP7 and Task 7.5.

The main objective of this task was to build on the identification of applicable standards relating to the ground heat exchanger, drilling equipment and installation, heat pumps as well as historical buildings considered in the Cheap-GSHPs project as part of the D7.6 in M18 of the project.

The analysis of the applicable standards and the development of the Cheap-GSHPs project technologies, has highlighted terms in the text of the standards that are perceived as potentially inhibiting the route to market of the innovative technologies.

Deliverable 7.7 provides a set of recommendations to relevant CEN and IEC committees that have direct responsibility of the drafting of standards applicable to the Cheap-GSHPs technologies developed. A set of national standards where possible modifications may be necessary have also been identified and recommendations proposed.

Abbreviations

BHEs	Borehole Heat Exchangers
CEN	European Committee for Standardization
Cheap-GSHPs	**Ch**eap and **E**fficient **Ap**plication of reliable **G**round **S**ource **H**eat Exchangers and **P**ump**s**
CO_2	Carbon Dioxide
DSS	Decision Support System
DTH	Down the Hole Hammer
DHW	Domestic Hot Water
DXHEs	Direct Expansion Heat Exchangers
EN	European Standards (Européenne Norme)
GRT	Geothermal Response Test
GSHEs	Ground Source Heat Exchangers
GSHPs	Ground Source Heat Pumps
GWP	Global Warming Potential
HDPE	High-Density Polyethylene
HPs	Heat Pumps
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
PE	Polyethylene
PE-RT	Polyethylene for Raised Temperature
PE-X	Cross-linked Polyethylene
SCOP	Seasonal Coefficient of Performance
SEER	Seasonal Energy Efficiency Ratio
TRT	Thermal Response Test

Introduction

The development of new ground heat exchangers and drilling methodologies as part of the Cheap-GSHPs project has been considered in the existing European standards applicable to the technologies developed as part of the Cheap-GSHPs project.

A comprehensive review of standards undertaken as part of the WP7 and reported in Deliverable 7.6 was undertaken. This highlighted all relevant standards relating to the following key aspect:

- Heat Pumps (including materials)
- Drilling
- Ground Source Heat Exchangers (including materials)
- Historical Buildings

The standards considered as part of the early work in the project were focussed on International, European and National Standards. Figure 1 below summarises those European Standards that deal with the main topics highlighted above.

Heat Pumps	Ground Source Heat Exchangers	Drilling	Historical Buildings
• EN 1861:1999 • EN 12263:1999 • EN 12284:2003 • EN 12178:2004 • EN 15450:2007 • EN 12693:2008 • EN 13313:2010 • EN 16147:2011 • EN 12102:2013 • EN 13136:2013 • EN 16644:2014 • EN 14825:2016 • EN 1736:2008 • EN 16084:2011 • EN 14276-1:2006+A1:2011 • EN14276-2:2007+A1:2011 • EN 60335-02-40:2003 • EN 60335-02-40:2003/A1:2006 • EN 60335-02-40:2003/A2:2009 • EN 60335-02-40:2003/A12:2005 • EN 60335-02-40:2003/A13:2012 • EN 60335-02-51:2003 • EN 60335-02-51:2003/A1:2008 • EN 60335-02-51:2003/A3:2012 • EN 378-1:2008+A2:2012 • EN 378-2:2008+A2:2012 • EN 378-3:2008+A1:2012 • EN 378-4:2008+A1:2012 • EN 15316-4-2:2008 • EN 14511-1:2013 • EN 14511-2:2013 • EN 14511-3:2013 • EN 14511-4:2013 • CEN ISO/TS 16491:2012	• EN ISO 17628:2015 • EN 15879-1:2011 • NF X 10-970:2011 • NF X 10-960-1:2013 • NF X 10-960-2:2013 • NF X 10-960-3:2013 • NF X 10-960-4:2013 • NF X 10-999:2014 • UNI 11466:2012 • UNI 11467:2012 • VDI 4640-1:2010 • VDI 4640-1:2010-06 • VDI 4640-2:2015 • VDI 4640-5:2016 • UNE 100715-1:2014	• EN ISO 6807:2004 • EN 16228-1:2014 • EN 16228-2:2014 • EN 16228-4:2014 • EN 16228-6:2014 • EN 16228-7:2014	• EN 16228-2:2016

Figure 1 – Applicable Standards of GHE, Drilling, Materials and HPs to the Cheap-GSHPs technologies

Based on the assessment of the above standards, a series of recommendations following the experience of the Cheap-GSHPs project on the development and installation of the new GHE technologies, drilling equipment and heat pump have been compiled as part of this deliverable.

The sections below present the main recommendations requirements highlighted in the project in the context of the relevant standards committees and organisations at European level. A common structure to highlight the individual standards has been used and comprises the following headings:

- Standard Reference
- Technical Working Group Reference
- Title
- Description (Summary)
- Recommendations proposed

1 Helicoidal and Coaxial Collectors and Testing

Standard	CEN Technical Committee
EN ISO 17628:2015	CEN/TC 341

Title:

Geotechnical investigation and testing - Geothermal testing - Determination of thermal conductivity of soil and rock using a borehole heat exchanger

Description:

This European Standard is intended to describe the qualification procedure for type approval of the tightness of hermetically sealed and closed components, joints and parts used in refrigerating systems and heat pumps as described in EN 378. The sealed and closed components, joints and parts concerned are, in particular, fittings, bursting discs, flanged or fitted assemblies. The tightness of flexible piping made from non-metallic materials is dealt with in EN 1736. Metal flexible piping are covered by this standard.

Recommendation:

A modification or addition should be made in order to take into account the following key items with respect to the heat exchanger technologies developed as part of the Cheap-GSHPs project:

- Drilling diameters of up to 400 mm should be considered in the standard to facilitate the installation of the heat basket using the EasyDrill methodology. A revision of the standard may not be required in this case but could be considered.
- Sections 5.3.2, 5.3.4 and 5.4.1 should be modified to include the installation of stainless Steel 304L coaxial heat exchangers using the vibro-rotating drilling method. These are ideal in unstable ground conditions and provide added environmental benefits
- Section 5.4.2 on ground heat exchangers requires the inclusion of stainless steel coaxial heat exchangers collector and assembly requirements (including sealing/welding) that differ from conventional BHEs.
- Section 5.2.3 and 5.4.3 referring to the selection and method of grouting of the annular space should mention that in the case of stainless steel coaxial heat exchangers installed exclusively with the vibro-rotating method, grout and annular space filling material is not required.
- Section 5.4.4 on functional testing should be modified to reflect the different requirements between testing stainless steel coaxial and plastic heat exchangers due to differences in pipe expansion and pressure drop tolerance.

Standard	CEN Technical Committee
	CEN/TC 451
Title: Water wells and borehole heat exchangers	
Description: Standardization in the field of design, environmental aspects, drilling, construction, completion, operation, monitoring, maintenance, rehabilitation and dismantling of wells and borehole heat exchangers for uses of groundwater and geothermal energy. Oil, gas and other mining activities in these fields are excluded from the scope.	
Recommendation: A set of on going modifications have been proposed by members of the Cheap-GSHPs consortium to the above technical working group. These include: • The supply of stainless steel based coaxial heat exchangers in set length that require threading or welding on site • The use of threaded connections in the case of stainless steel coaxial heat exchangers and special sealing materials using installation and testing procedures to ensure tightness of the connections. The threading in the vertical part of the pipes to be done by trained personnel on site ensuring that applicable technical rules for the process are adhered to. All connections are to be documented. • The use of vibro-rotating drilling methods for the installation of borehole heat exchangers	

2 Heat Pumps

The following EN standards have been considered in the context of recommendations required for necessary modifications in the context of the development of the two stage CO_2 heat pump as part of the Cheap-GSHPs project.

Standard	**CEN Technical Committee**
EN 378-2:2008 (2016)	CEN/TC 182 (WG 6)
Title: Refrigerating systems and heat pumps - Safety and environmental requirements – Part 2: Design, construction, testing, marking and documentation	
Description: This European standard refers to the design, construction and installing of refrigerant systems –including heat pumps, taking into account piping, components and materials, as well as ancillary equipment that is directly associated with these systems. In addition, the requirements concerning testing, commissioning, marking and documentation are defined.	
Recommendation: The development of the two stage heat pump using CO_2 refrigerant in the first stage and R1234$_{ze}$(E) in the second stage will result in high operating pressures required for efficient operation when using CO_2. The resulting higher pressures will require some modifications to section 6.2.2 of the standard on the determination of the maximum allowable pressure. Additional changes may be considered to further support the application of alternative refrigerants with lower GWP as is the case in the context of the Cheap-GSHPs HP.	

Standard	**Technical Committee**
IEC 60335-2-40 (2005)	IEC technical committee 61 – Subcommittee 61D CEN/TC 182 (WG 12) - Mirror Group Flammable Refrigerants
Title: Household and similar electrical appliances – Safety – Part 2-40: Particular requirements for electrical heat pumps, air conditioners and dehumidifiers	
Description: This European standard refers to the design, construction and installing of refrigerant systems –including heat pumps, taking into account piping, components and materials, as well as ancillary equipment that is directly associated with these systems. In addition, the requirements concerning testing, commissioning, marking and documentation are defined.	
Recommendation: The new two stage heat pump, developed during the Cheap-GSHPs project, using CO_2 refrigerant in the first stage and a mildly flammable refrigerant R1234$_{ze}$(E) in the second stage should be considered. Changes to the standard should also be considered to further support the application of alternative next generation mildly flammable refrigerants with lower GWP in the context of those listed in Annex BB of the standard.	

Standard	CEN Technical Committee
EN 14511-1:2013	CEN/TC 113
Title: Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1: Terms, definitions and classification	
Description: This European Standard specifies the terms and definitions for the rating and performance of air conditioners, liquid chilling packages and heat pumps using either, air, water or brine as heat transfer media, with electrically driven compressors when used for space heating and/or cooling.	
Recommendation: A modification or addition should be made in order to take into account the dual cycle CO_2 heat pump developed as part of the Cheap-GSHPs project. A reference with respect to high temperature heat pumps that differs to that of single stage 'conventional' heat pumps should be included in the standard with respect to required renewable energy contributions	

Standard	CEN Technical Committee
EN 1736:2008	CEN/TC 182
Title: Refrigerating systems and heat pumps - Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes - Requirements, design and installation	
Description: EN 1736 describes requirements, design and installation of flexible pipe elements (e.g. metallic flexible pipe, metallic flexible tube, vibration isolator, expansion joint) and non-metallic tube used in the refrigerant circuits of refrigerating systems and heat pumps. This standard also describes the requirements to qualify the tightness of non-metallic tubes (e.g. plastic) used in evaporating and/or condensing sides of refrigerating systems and heat pumps.	
Recommendation: Paragraph 7 describes the procedure in order to test permeability of non-metallic flexible tubes. Some modifications/additions should be made in order to take into account the use of CO_2 (leading to higher pressure and temperature) as a refrigerant in the Cheap-GSHPs dual cycle heat pump.	

Standard	CEN Technical Committee
EN 16084:2011	CEN/TC 182
Title: Refrigerating systems and heat pumps - Qualification of tightness of components and joints	
Description: This European Standard is intended to describe the qualification procedure for type approval of the tightness of hermetically sealed and closed components, joints and parts used in refrigerating systems and heat pumps as described in EN 378. The sealed and closed components, joints and parts concerned are, in particular, fittings, bursting discs, flanged or fitted assemblies. The tightness of flexible piping made from non-metallic materials is dealt with in EN 1736. Metal flexible piping is covered by this standard.	
Recommendation: A modification or addition should be made in order to take into account the use of CO_2 as a refrigerant in the calculation formulas of Annex A of the standard	

3 Drilling

The EN standards listed below have been identified as part being directly related to the innovative drilling technologies developed in the Cheap-GSHPs project.

Standard	**CEN Technical Committee**
EN 16228-1:2014	CEN/TC 151
Title: Drilling and foundation equipment - Safety - Part 1: Common requirements”	
Description: This is the common standard outlining the main safety requirements for all drilling and foundation equipment with this part (Part 1) dealing with the significant hazards common to drilling and foundation equipment (associated with the whole life time of the machine including transport, assembly, dismantling, equipment in service and out of service, maintenance, moving on site, storage, disabling and scrapping) and is intended to be used in conjunction with one of parts 2 to 7. The requirements specified are common to two or more families of drilling and foundation equipment. For multipurpose machinery, the parts of the standard that cover the specific functions and applications are used, e.g. a drilling machine also used as a piling machine will use the relevant requirements of EN 16228 parts 1, 2, and 4. Drilling and foundation equipment within the scope of EN 16228 parts 1 to 6 may include interchangeable auxiliary equipment within the scope of EN 16228 part 7, either as an integral part of its construction or as interchangeably fitted equipment.	
Recommendation: A modification should be made in order to take into account the Cheap-GHSPs technologies, the innovative “vibrasond + easy drill” drilling machine and the innovative drilling head that combines vibration and rotation for coaxial heat exchangers in specific.	

Standard	CEN Technical Committee
EN 16228-2:2014	CEN/TC 151

Title:

Drilling and foundation equipment - Safety - Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining

Description:

The standard discusses all significant hazards of mobile drill rigs for civil and geotechnical engineering, quarrying and mining when they are used as intended and under the conditions of misuse, which are reasonably foreseeable by the manufacturer associated with the whole life time of the machine.

The standard includes several different types of machines used in civil engineering, water well drilling, geothermal installations, landfill, underpinning, tunnelling, mining and quarrying applications both above ground as well as underground.

The process of drilling processes covered are considered in the context of the addition of drill rods, tubes, casings or augers using threaded connections as the borehole extends to depth.

Recommendation:

Inclusions to this standard are required to ensure that the Cheap-GHSPs drilling and coaxial heat exchanger technologies are considered.

The following aspects of the coaxial heat exchanger should be included:

- Vibrating and rotating head for the installation of coaxial stainless steel heat exchangers;
- The use of a combined vibrating and water jetting technology to complete the installation of coaxial heat exchangers;
- The use of welded connections in vibrating drilling to install stainless steel coaxial heat exchanger;
- The use of water injection heads.

In the case of the EasyDrill drilling technology the following may need to be included:

- The use of auger like casing as opposed to conventional augers
- The use of interlocking casing section (non-threaded connections)
- The use of a unlocking drill bit lost in the borehole during casing retrieval

Standard	CEN Technical Committee
EN 16228-4:2014	CEN/TC 151
Title: Drilling and foundation equipment - Safety - Part 4: Foundation equipment	
Description: The standard deals with additional aspect of drilling with types of machines used for installation and/or extracting by drilling (machines with a rotary torque greater than 35 kNm), driving, vibrating, pushing, pulling or a combination of techniques, or any other way, of: — longitudinal foundation elements; — soil improvement by vibrating and soil mixing techniques; — vertical drainage.	
Recommendation: A modification of this standard may be required to ensure that the EasyDrill system is considered, given the rotary head torque requirement of 78 kNm.	

Standard	CEN Technical Committee
EN 16228-7:2014	CEN/TC 151
Title: Drilling and foundation equipment - Safety - Part 7: Interchangeable auxiliary equipment	
Description: This document specifies the specific safety requirements for interchangeable auxiliary equipment to be This European standard, refers to all significant hazards for interchangeable auxiliary equipment. This document adds or replaces the requirements of EN 16228-1:2014 for interchangeable auxiliary equipment. Interchangeable auxiliary equipment includes pile installation and extraction equipment, impact hammers, extractors, vibrators, deep vibrators, static pile pushing/pulling devices, rotary percussion hammers, rotary drilling drives, drill mast equipment such as leaders equipped with a drill stem and gears attached to the boom of an excavator and casing oscillators/rotators.	
Recommendation: Additions to the standard should be considered in the context of the Cheap-GSHPs drilling equipment which allows the installation of interchangeable heads on the same mast type including the high torque head for the EasyDrill system and the vibro-rotating head for the coaxial stainless steel heat exchanger.	

4 National Standards

Additional National standards identified as part of the project as requiring potential modifications with respect to the development of the drilling technologies developed as part of the project are included below.

Standard	**Country of Origin**
UNI 11466:2012	Italy
Title: Heat pump geothermal systems – Design and sizing requirements	
Description: UNI 11466 standard defines the procedure of calculations for the definition of GSHP system efficiency. In addition, it specifies the monthly temperature of the fluid in the heat exchanger in order to specify the energy efficiency of the GSHP, so that the energy certification of the building is defined. This standard applies to GSHPs with a secondary circuit for heating, cooling and domestic hot water production.	
Recommendation: Geometrical characteristics of coaxial type could be added in Table A.2 (p.33)	

Standard	**Country of Origin**
UNI 11467:2012	Italy
Title: Heat pump geothermal systems – Installation requirements	
Description: UNI 11467 standard defines the following: drilling methodology, procedure of boreholes construction, TRTs, technical specifications and requirements for the installation and operation of GSHPs and auxiliary equipment, characteristics of fluids for the heat exchanging and drilling, as well as of grouting material, equipment for the boreholes construction, TRTs and technical report for the project completion. The UNI 11467 standard is applied to GSHP systems with secondary circuit or direct expansion for heating, cooling, air-conditioning and domestic hot water production.	
Recommendation: “Vibrasond + easy drill” could be added as a prototype drilling technique in the description of boreholes drilling [4.3 Sonde verticali (boreholes) p.5].	

Standard	Country of Origin
VDI 4640-1:2010	Germany
Title: Thermal use of the underground – Fundamentals, approvals, environmental aspects	
Description: VDI 4640 guidelines concern the thermal utilization of the underground, down to a depth of approximately 400 m. The VDI 4640 series consist of four parts; Part 1 deals with fundamentals, approvals and environmental aspects. In relation specifically to the innovations developed by the Cheap-GSHP project, the following points of the standard should be mentioned: In Paragraph 2 "Terms and definitions", in the definition given for "borehole heat exchangers", concentrically arranged and helical tubing are also mentioned. In Paragraph 9.1 "Materials used in wells, ground source heat collectors, borehole heat exchangers and pipes" it is mentioned that "materials installed underground shall be non-toxic and non-corroding". In addition, it is mentioned that "when using steel pipes in borehole heat exchangers in exceptional cases, attention must be paid to sufficient wall thickness, steel quality and corrosion proofing, and the chemical composition of the Groundwater taken into consideration".	
Recommendation: An additional modification to ensure that the use of the threaded (or welded) stainless steel (304L) coaxial heat exchangers should be included in the standard. Details of the pipe connections and their sealing should also be included. A specific addition with regard to the sealing of the threads should be made in the case of the construction and design of metal ground heat exchangers.	

Standard	Country of Origin
NF X 10-999:2014	France
Title: Water wells and geothermal drilling – Construction, monitoring and dismantling of catchwords and wells to tap into underground water	
Description: The NF X10-999 standard describes the technical recommendations and methods for the design, implementation, operation, monitoring, maintenance, rehabilitation structures, operation and monitoring (quality and quantity) of groundwater, made by drilling. It applies to all types of works, monitoring and operation (capture or re-injection) of the ground or geothermal water, and covers all types of uses: public or domestic water supply, agricultural, industrial, and bottling of mineral and thermal waters. This document is intended for constructors, developers, hydrogeologists, drillers, suppliers of material and drilling equipment, consumer associations and public authorities.	
Recommendation: "Vibrasond + easy drill" could be added as a prototype drilling technique in the description of boreholes drilling development.	

Standard	Country of Origin
NF X 10-960:2013	France
Title: Water and geothermal drilling	
Description: This standard comprises several parts and has two main objectives: to ensure environmental protection, mainly the protection of underground waters, and sustainability of GSHPs installations with boreholes. This standard specifies design criteria and characteristics of GSHEs. It applies to GSHEs installed into boreholes and it does not apply to horizontal GSHEs, geothermal baskets or compact heat exchangers, DXHEs, energy piles (geostructures), and any mechanical assembly. This standard applies to multi-U, coaxial and multi-tube borehole heat exchangers. It can also be applied to innovative structures. It applies to heat exchangers made of polyethylene PE 100, PE-X or PE-RT. Other materials for this application exist but are not addressed in this document.	
Recommendation: Modifications to this standards could be considered to include: • The Vibrasond and EasyDrill technologies could be added as a prototype drilling technique in the description of boreholes drilling development. • The use of 304L stainless steel coaxial heat exchangers	

5 Historical Buildings

The principal national standard on the improvement of energy efficiency measures in historical buildings was published in late 2016. This postdates the publication of D7.6 in the Cheap-GSHPs project. The section below briefly describes this standard and proposes potential recommendations based on the current text.

Standard	**CEN Technical Committee**
EN 16228-2:2016	CEN/TC 346
Title: Conservation of cultural heritage - Guidelines for improving the energy performance of historic buildings	
Description: This European Standard provides guidelines for sustainably improving the energy performance of historic buildings, e.g. historically, architecturally or culturally valuable buildings, while respecting their heritage significance. The use of this standard is not limited to buildings with statutory heritage designation, it applies to historic buildings of all types and ages. This European Standard presents a normative working procedure for selecting measures to improve energy performance, based on an investigation, analysis and documentation of the building including its heritage significance. The procedure assesses the impact of those measures in relation to preserving the character-defining elements of the building.	
Recommendation: The following recommendations in the context of historical buildings and the selection of measures for improving energy performance in section 10 of the standard could be considered: • Use of Cheap-GSHPs ground heat exchangers and drilling methods where limited space is available and low construction outdoor impact is required • Use of dual cycle heat pumps in the context of space heating & cooling as well as for hot water loads of different temperatures that would allow limited indoor impact with appropriate delivery terminals.	

6 Conclusions

A total of 45 No. applicable standards were reviewed as part of the Cheap-GSHPs project undertaken in WP7. The standards considered cover the main aspects of design and development of the ground heat exchanger, drilling and heat pump technologies.

The implementation of the project and the analysis of the route to market have highlighted a number of key technical aspects covered by these standards that lack clarity in the context of the use and applicability of the Cheap-GSHP technologies.

The text of two standards on Ground Heat Exchangers, one of which is still currently being drafted, has been highlighted for potential modification to allow for the use of helicoidal and stainless steel ground source heat exchangers. The recommendations proposed have been made in the context of the heat exchanger materials, their installation and testing procedures.

The proposed innovative drilling technologies developed in the Cheap-GSHPs project are subject to compliance to 6 No. current EN standards. Recommendations for potential modification to the text of 5 of these standards has been proposed based on drilling rig and plant equipment safety, description of the drilling methodologies developed by the project and their usage.

Numerous standards relating to compliance of Heat Pumps and their associated materials were reviewed as part of the work in WP7. The standards directly related to heat pump manufacture and compliance of the use of specific refrigerants and their requirements were highlighted for potential recommended change, in order to consider the dual cycle heat pump developed in the project.