GUIDELINES, STANDARDS, CERTIFICATION AND LEGAL PERMITS FOR GROUND SOURCE HEAT PUMPS IN THE EUROPEAN UNION

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Abstract: The paper gives a review on dedicated guidelines and standards for the thermal use of ground and groundwater with heat pumps. Such documents currently exist only in countries with a mature Ground Source Heat Pump (GSHP) market, like Germany, Switzerland, and Sweden. The topics covered are, among others:
- design and sizing of the ground part
- installation of horizontal loops, borehole heat exchangers, groundwater wells, etc.
- environmental issues for protection of soil and groundwater

The first EN standard to explicitly include some GSHP technology is EN 15450. Beside technical standards issued by associations and by standards organisations, also guidelines and regulations issued by national or regional authorities have to be observed. These regulations typically concern the environmental part, and the rights of land owners to use the ground beneath their lots. The paper discusses the role of certain standards as a support, but sometimes also as a barrier to widespread application of GSHP technology. A certain harmonisation and the establishing of EU-wide standards needs to be considered.

Key Words: ***ground source heat pumps, technical standards, permits***

1 INTRODUCTION

In the geothermal and heat pump sector, standards and codes can be classified in various ways:
- Technical standards for efficiency, safety, longevity etc.; these standards apply mainly for the heat pump itself, as a system component
- Technical standards for environmental protection, as for drilling, borehole heat exchangers, etc.; these standards apply mainly for the ground side (geothermal)
- Regulations and guidelines for licensing of geothermal systems (typically concerning groundwater protection), incl. legal regulations for the access to and ownership of the geothermal resources
- Certification of skill and work quality for installers and drillers

For the heat pumps as such, a comprehensive set of technical standards with only few missing issues exist. All EU member states have adopted the basic EN standards for testing and rating, safety, etc. into national standardisation; also Switzerland, Norway and Iceland have joined into the same set of standards. In the same process, most pre-existing national standards have been withdrawn and are replaced by adapted EN standards. National standards existed in particular in the traditional heat pump countries like AT, DE, SE (and CH). In several cases, pre-existing national standards are kept valid for specific areas not yet covered by the EN standards, and in a few occasions overlapping between older national and newer EN standards does occur. Such older national standards still valid can be found in AT, DE, DK, FR, NL, IT, PL, RO, SE. Some relevant ISO standards have also been adopted into national standards, mainly in DK, GB, NL.

For geothermal energy, EN-standards are only existing for the safety of drill rigs (shallow geothermal), and for the sector of the petroleum industry (which has some relevance for deep geothermal, together with US API standards).

For GSHP systems in general, technical standards exist in the countries where the market already has developed. This includes DE (VDI 4640 is the most comprehensive of relevant standards), SE, AT, and the non-EU-member CH. This is also valid for the certification/licensing of installers and drillers (besides the countries mentioned before, FR has some activities here).

Guidelines concerning the legal regulations for shallow geothermal installations also exist in some countries (here the most elaborated ones are in some DE states and in some CH cantons; an AT state, Oberösterreich, is also just coming up with one).

2 TECHNICAL STANDARDS AND GUIDELINES FOR GSHP

For heat pumps and other components (pipes, pumps), European-wide standards are crucial, as this equipment is traded internationally. Common standards already exist for all relevant aspects of heat pumps, so no further need for action is seen here (beside the continuing updating of relevant standards). Table 1 gives some examples of standards on equipment safety and performance rating.

For the design of the whole heat pump system a common standard has been published with EN 15450; however, due to the large climatic and geological differences, this standard can hardly give more than a general minimum framework for design and installation, with many items to be filled in regionally.

European-wide standards for the geothermal side of ground source heat pump systems do not yet exist. Here a definite need is given to develop a European standard at least for the borehole heat exchangers, which represent the most popular technology. Considering the large differences in climate and geology, standards with a generic framework for Europe and appendices specific to countries (or regions) might be an option.

As Table 1 shows, for GSHP only standards and guidelines on national level can be listed (from AT, CH, DE, and SE). And most of the documents are not standards published by the relevant standardisation organisations, but technical guidelines provided by professional or scientific organisations.

Concerning drilling, only few standards exist for shallow drilling activities (as for BHE). Table 2 lists some of them, beginning with EN 791 (concerning work safety on drill rigs); EN 791 has been adopted meanwhile in all EU member states. Further standards can be found nationally e.g. in Germany and Poland, as table 2 shows.

For deep geothermal energy, the applicability of standards from hydrocarbon industry (EN ISO, but also API, the American Petroleum Institute) for geothermal applications should be checked more closely. The relative small number of large plants makes individual approaches to design and installation, and quality certification, more appropriate than general standards. This may change in future with a growing market also for deep geothermal, and thus should be observed in order to come up with EU-wide standards once the need will arise.

Table 1: List of standards and guidelines relevant to GSHP

Number	Title	Purpose	Year
Heat Pumps, general			
EN 255-3	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode	heat pumps, testing for hot water units	1997-07
EN 378	Refrigerating systems and heat pumps - Safety and environmental requirements – Part 1-4	heat pumps in general, requirements for safety and environmental protection	2003
EN 14511	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1-4	heat pumps in general, requirements and testing	2008-02
EN 15450	Heating systems in buildings - Design of heat pump heating systems	heat pumps in general, system design	2007-12
ISO 5149	Mechanical refrigerating systems used for cooling and heating -- Safety requirements	heat pumps in general, safety	1993-09
ISO 5151	Non-ducted air conditioners and heat pumps - Testing and rating for performance nationalized e.g. in GB (2005)	heat pumps in general, testing and rating	1994-12
ISO 13256	Water-source heat pumps - Testing and rating for performance nationalized e.g. in DK, NL	heat pumps in general, testing and rating	2001
VDI 2067 Blatt 6	Economy calculation of heat consuming installations; heat pumps	heat pumps, economic calculations	1989-09 (DE)
VDI 4650 Blatt 1	Calculation of heat pumps - Short-cut method for the calculation of the annual effort figure of heat pumps - Electric heat pumps for room heating	heat pumps, efficiency calculations	2003-01 (DE)
ÖNORM M 7755-1	Electrically driven heat pumps - part 1: General requirements for design and construction of heat pump heating systems	design and installation of heat pump systems	2000-09 (AT)
Ground Source Heat Pumps specifically			
DIN 8901	Refrigerating systems and heat pumps - Protection of soil, ground and surface water	heat pumps, protection of groundwater and soil against pollution	2002-12 (DE)
VDI 4640 Blatt 1-4	Thermal use of the underground - part 1-4	design and installation of geothermal heat pump systems	2000-2004 (DE)
ÖNORM M 7753	Heat pumps with electrically driven compressors for direct expansion, ground coupled - Testing and indication of the producer	geothermal, testing and rating	1995-10 (AT)
ÖNORM M 7755-2+3	Electrically driven heat pumps	design and installation of ground-source heat pump systems (groundwater, rock, soil)	2000-09 (AT)
ÖWAV RB 207	Systems for the exploitation of geothermal heat	geothermal, avoiding risks to underground and groundwater	1993 (AT)
Normbrunn-97	Energy well standard (Energibrunnsnorm)	correct installation of geothermal system	1997 (SE)
SVEP-standard	Installation standard for ground heat collectors (Tillverkningsnorm för Bergvärmekollektorer)	correct installation of geothermal system	2005-11 (SE)
SIA D 0179	Energie aus dem Untergrund - Erdreichspeicher für moderne Gebäudetech	Shallow geothermal energy	2003 (CH)
SIA D 190	Nutzung der Erdwärme mit Fundationspfählen und anderen erdberührenden Betonbauteilen - Leitfaden zu Planung, Bau und Betrieb	Energy piles	2005 (CH)
AWP T1-5	Technische Merkblätter	Heat pump heating systems with borehole heat exchangers, ground collectors, groundwater, etc.	2007 (CH)

Table 2: List of standards and guidelines relevant for drilling

Number	Title	Purpose	Year
EN 791	Drill rigs. Safety	work safety	1996-01
DVGW W 110	Investigations in bore holes and wells sunk to tap ground water; compilation of methods	investigations for geological reconnaissance inside a borehole	2005-06
DVGW W 115	Boreholes for exploration, capture and observation of groundwater	well drilling	2001-03
DVGW W 116	Use of mud additives in drilling fluids for drilling in groundwater	selection of drilling fluids in order to protect the groundwater	1998-04
PN-G-01201	Drilling - Terminology	drilling terminology	1992-12
PN-G-01215	Drilling engineering -- Designation of drilling tools	drilling tools	1998-01
PN-G-02305	Structure and water well drillings -- Drilling rigs -- Requirements	drilling rigs	1994-11
PN-G-08611	Drilling -- Drilling machinery -- Requirements of safety and ergonomy	work safety	1999-07

3 GUIDELINES FOR PERMITS / LICENSES

The biggest administrative barrier for geothermal energy is in the legal treatment of the resource; this is true in particular for deep geothermal plants. A clear title must be available for investors allowing them to explore and later to exploit a geothermal resource. A common EU-wide minimum standard for regulation of geothermal energy should be developed, requesting the member states to set out rules for a suitable legislation:

- administrative permit to explore and exploit a geothermal resource
- no or low royalties for the heat, in order to help geothermal technology to become economic (there are also no royalties on solar radiation or wind)
- provisions to regulate the co-existence of small, shallow systems (ground source heat pumps) and deep geothermal plants
- Suitable environmental regulations

A basic requirement for a consistent legal coverage is the clear and unequivocal definition of geothermal energy. However, this cannot be regulated by standards, but must be dealt with by the legislative bodies. The ALTENER-project GTR-H is working on a proposal for such regulations (cf. http://www.gtrh.eu).

In some countries geothermal energy is governed by the mining law, in other just the thermal water is considered. Sometimes the delineation between different laws is weak, or overlapping; a particular difficult system can be seen in Germany. Here it is not easy to understand which authority will have to grant the license eventually. Fig. 1 tries to sort out the path through the delineation process. This works well for deep geothermal systems and large shallow geothermal projects, but as a “geothermal field” under German law (BBergG) extends from ground surface to infinite depth, a definite solution for coexistence of small, shallow installations with larger, deep ones still has to be found.

Hence in geothermal energy use with GSHP, regulation should allow heat extraction (and injection) down to a certain depth (e.g. 200 m) free for the land owner, as long as no other conflicting rights are existing, and environmental issues are not touched (see below).

In the field of permits for geothermal drilling and exploitation, a European harmonisation could provide a framework only, to be filled in by national or even regional provisions. As an example for shallow geothermal installations, the various guidelines of German states for borehole heat exchangers might serve.

Legal basis:			
	Mining	**Water**	Footnote
Federal level	Bundesberggesetz BBergG	Wasserhaushaltsgesetz WHG	
State level ("Länder")	-	Landeswassergesetz in each state	
Consideration of Geothermal Energy:			
BBergG §3	***"bergfrei"*** (owned by state)	-	
BBergG §4	exception to §3, for own lot →	→ water regulation	1
WHG §3	-	thermal use of groundwater	
Final license	Mining authorities, BBergG §7, §8	Water authorities, WHG §7	
	Rights of use of resource is secured to investor, area/field is protected	**no right for amount or temperature of water; no protection of use of resource**	
	Two-phase process for exploration and exploitation (one-phase possible for shallow geothermal)	process with lower water authority, often governed by state guidelines (can also be simplified to notification only)	
BBergG §127	All drilling >100 m has to be licensed by mining authorities	Geothermal energy use of holes >100 m can be under exception §4 nevertheless	
Practical consequence	deep geothermal always, shallow geothermal sometimes governed by mining law	shallow geothermal mostly governed by water law (by exception BBergG §4)	2
New discussion:	If geothermal heat can only used through heat pumps, it is not considered "bergfrei" in the sense of §3		
Consequence:	heat pump systems go to water authorities →	→ distinction mining / water law simplified, but no possibility to protect right of use	

1 Exception is governed by state interpretation, examples comprise:
well or BHE inside lot / distance from lot boundary 5 m / dist. 6 m / max. heating capacity <200 kW
If a commercial use is given (selling heat on the lot or to the outside), it is always under mining law

2 In case a mining field for geothermal energy exists on a site, the exception of BBergG §4 is not allowed in the opinion of some state authorities (Hessen), and is allowed in other states (NRW)

NB: Depth limit is not used for distinction mining/water - 100 m is valid only for the drilling, 400 m is used in incentive schemes

Figure 1: Schematic showing distinction of the realms of mining and water law for shallow geothermal applications (GSHP) in Germany

For small, shallow geothermal installations the licensing in respect to groundwater protection is of highest importance; here an EU-wide regulation could help for the states or regions to set up easy and effective procedures, as e.g. shown in the guidelines of some German states (Table 3, Figure 2).

Table 3: List of guidelines for permit applications for BHE in German states

Name	German Title	English Title	year
Leitfaden BE	Erdwärmenutzug in Berlin - Leitfaden für Erdwärmesonden und Erdwärmekollektoren mit einer Heizleistung bis 30 kW	Geothermal heat use in Berlin - Guideline for ground heat collectors and borehole heat exchangers up to a heating capacity of 30 kW	2005
Leitfaden BW	Leitfaden zur Nutzung von Erdwärme mit Erdwärmesonden (Baden-Württemberg)	Guideline for use of geothermal heat with borehole heat exchangers (Baden-nWürttemberg)	2005
Leitfaden BY	Leitfaden Erdwärmesonden in Bayern	Guideline for borehole heat exchangers in Bayern	2003
Leitfaden HE	Erdwärmenutzung in Hessen - Leitfaden für Erdwärmepumpen (Erdwärmesonden) mit einer Heizleistung bis 30 kW	Geothermal heat use in Hessen - Guideline for use of geothermal heat with borehole heat exchangers up to a heating capacity of 30 kW	2005
Merkblatt 48 NRW	Wasserwirtschaftliche Anforderungen an die Nutzung von oberflächennaher Erdwärme (Nordrhein-Westfalen)	Water economic requirements for the use of shallow geothermal energy (Nordrhein-Westfalen)	2004
Leitfaden NS	Leitfaden Erdwärmenutzung in Niedersachsen	Guideline for geothermal heat use in Niedersachsen	2006
Leitfaden RP	Leitfaden zur Nutzung von Erdwärme mit Erdwärmesonden Rheinland-Pfalz	Guideline for use of geothermal heat with borehole heat exchangers Rheinland-Pfalz	2006

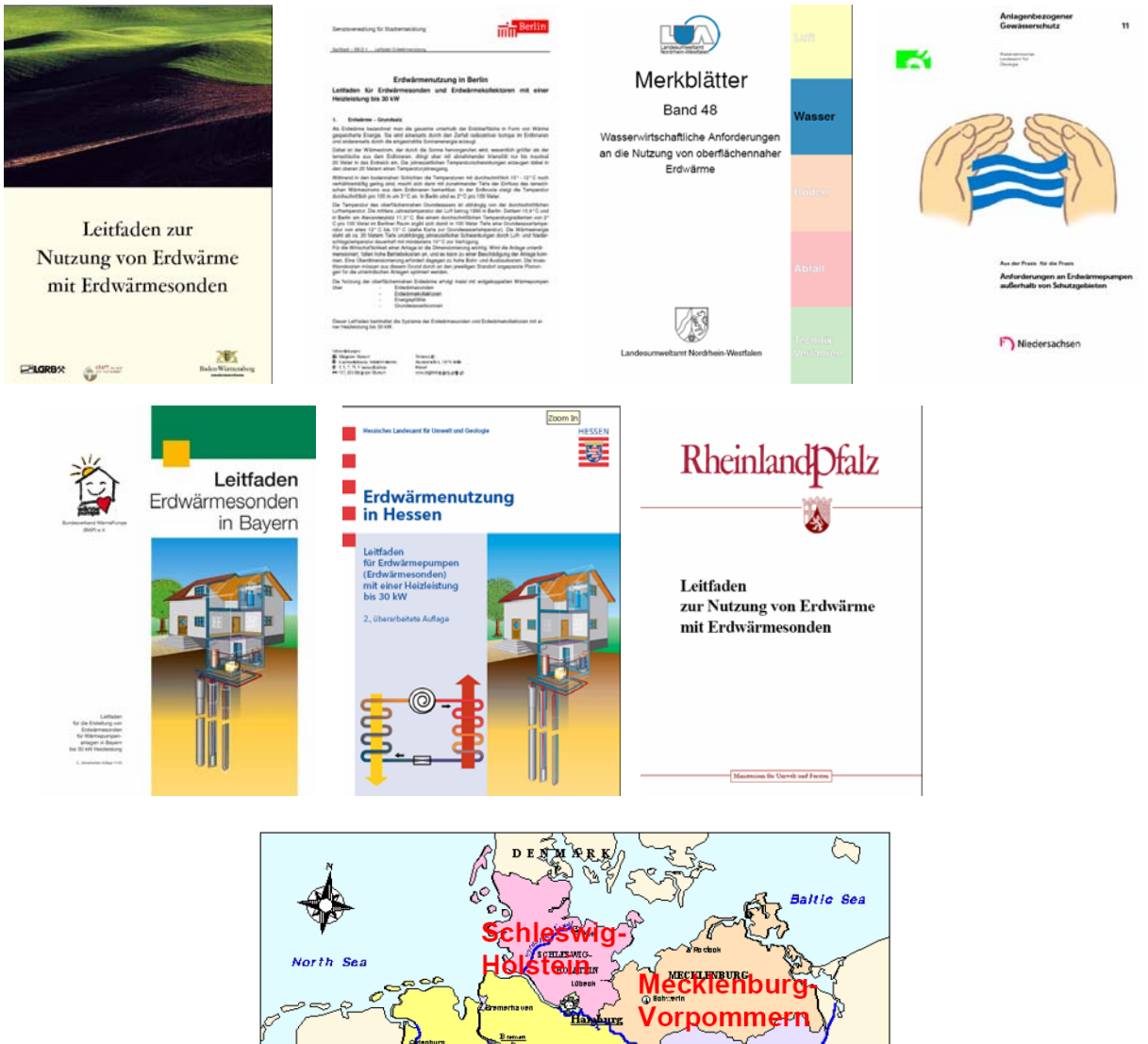

Figure 2: Covers of various German licensing guidelines, and map with German states providing a guideline named bold red (guideline under preparation in red Italics)

These publications actually guide the applicant to understand the procedure and points out the requirements for water protection. Good guidelines provide also an easy path for GSHP projects below a certain capacity, and in hydrogeologically unproblematic conditions.

4 Certification

Certified planners, manufacturers and installers (incl. drillers) are necessary to ensure high efficiency and longevity of a GSHP system. Also for the certification of drilling companies, joint basic rules should be developed in order to facilitate cross-border service. Such certificates for drillers currently exist only in Germany, Sweden, and non-EU-country Switzerland, with Austria to follow soon. Table 4 lists the most important programs.

Table 4: List of certification activities

Number	Title	Purpose	Year
Heat Pumps			
EU-CERT.HP	Certified Heat Pump Installer	Certificate of persons for installation of heat pumps, following certification framework EN 17024	2004
DACH-Güte-siegel WP	Wärmepumpen-Gütesiegel	Certification of products (heat pumps)	1998 (AT/CH/DE)
SPCR 130	Certifieringsregler för P-märkning av Värmepumpar	Certification of products (heat pumps)	2005-03 (SE)
Drilling			
DVGW W 120	Qualifikationsanforderungen für die Bereiche Bohrtechnik, Brunnenbau und Brunnenregenerierung	certification of professional drilling companies	2005-12 (DE)
DACH-Güte-siegel EWS	Gütesiegel für Erdwärmesonden-Bohrfirmen	certification of professional drilling companies	2001/2006 (CH/DE)
RAL/ZDB	RAL-Gütezeichen „Erdwärme“, Güte-gemeinschaft Geothermische Anlagen	certification of professional drilling companies	2007 (DE)
C-Borrare	Certifiering av brunnsborrningsföretag	Certification of well drilling companies	2006 (SE)

5 EUROPEAN HARMONZATION NEED

The first EN standard for the heat pump system in general is EN 15450 (Heating systems in buildings - Design of heat pump heating systems), currently in the form of a draft. This standard also elucidates the basic problem for a geothermal standard on a European level:

- Climatic conditions throughout Europe vary widely, resulting in large differences in heating/cooling demand and, in consequence, system design
- Geological conditions also vary widely, with predominant underground situations in most countries (e.g. sand, loam, clay in the Netherlands, or in Finland hard, crystalline rock with a frequent cover of softer overburden); the geothermal system must be adapted to the local situation
- Traditions in heating and cooling vary (e.g. hydronic versus air-based systems)

As a result, EN 15450 is only able to give a general minimum framework for design and installation, with many items to be filled in regionally.

For the heat pumps, the introduction of EN and ISO standards was crucial, as these products are manufactured and traded throughout Europe. The current market situation could not be imagined without the existence of the relevant EU-wide standards. Because the drilling and installation for geothermal systems in the shallow geothermal realm typically is a service rendered by contractors more locally, the need for harmonised standards is not so urgent as

the need for suitable standards at all, as in many countries no guidelines and standards exist and thus consumer protection is not guaranteed. Here a negative impact on the market can be expected if demand increases and poor workmanship is delivered in countries without specific standards.

Items to be covered in new, European standards for shallow geothermal applications are in particular (cf. VDI 4640, parts 1-4, as an example):

- Layout (sizing) of the geothermal system (groundwater wells, borehole heat exchangers, horizontal loops, etc.), in accordance to the different climatic and geological conditions within Europe
- Materials for wells, borehole heat exchangers, other pipe loops, manifolds, etc.
- Geothermal groundwater wells: Drilling, well construction and well completion
- Borehole heat exchangers: Drilling, installation and completion (grouting, or open completion)
- Pipe laying for horizontal loops
- Other types of ground heat exchangers
- Connection to heat pump or other systems, system integration, interfaces

Considering the large differences in climate and geology, standards with a generic framework for Europe and appendices specific to countries (or regions) might be an option.

6 CONCLUSIONS

A study of existing standards and codes gives the following picture:

- For the heat pumps, EN standards are well adapted and allow for a free circulation of machines and components within the common market. For the ground side of shallow geothermal installations, relevant standards and codes exist only in a few countries with developed GSHP market (AT, DE, SE and CH). In FR, IE and NL the matter is somewhat covered, and work is ongoing on developing standards and codes. A common EU-wide harmonisation is not in sight, and will be difficult as the geological and climatic differences will have to be considered. An approach for common standards can be seen between AT, DE and CH, where geology and work practice is similar.
- In deep geothermal, specific standards do not exist yet. The relevant EN standards for the petroleum industry can be applied for deep drilling. However, not all safety regulations for hydrocarbon drilling and exploitation are required for geothermal drilling, so specific geothermal standards will be desirable with increased application of deep geothermal energy. On the heat delivery side, deep geothermal system typically feed into district heating systems. For district heating, own standards and regulations exist, that are not covered in this study.
- Concerning licenses and certifications, only few countries have existing schemes. It must be made sure that existing and upcoming national regulations will not prevent the exchange of work and services in the common market. For the heat pump installation, the EU-CERT.HP program may prove very helpful. No common activity exists yet for the ground side. For setting up such schemes, the co-operation of the relevant professional bodies and industrial associations would be necessary, in order to ensure acceptance of the resulting programs in the geothermal sector.

Some new national standards relevant for shallow geothermal are known to be under development, for all GSHP types or for specific technologies like borehole heat exchangers (BHE) only:

- ÖWAV on shallow geothermal (harmonisation with VDI 4640 is under way)
- DIN xxx “Geothermiesonden” (DE, for BHE; work may be abandoned due to lack of finance)

- NF X 10/999 ”Réalisation, suivi et abandon d´ouvrage de captage ou de surveillance des eaux souterraines” (FR, for drilling)
- HVCA TR330 (GB, for GSHP)
- SN 565 384/6 “Erdwärmesonden zum Heizen und Kühlen” (CH, for BHE)

7 REFERENCES

Instead of references in the conventional sense, the relevant national standard organisations and the websites where they catalogues can be found are listed in the following table:

Country	Country	Name of institution	Website
(Europe)	(Europe)	CEN	www.cen.eu
AT	Austria	Austrian Standards Institute	www.norm-online.info/
BE	Belgium	NBN	www.nbn.be/
BG	Bulgaria	Bulgarian Inst. f. Standardization	www.bds-bg.org
CY	Cyprus	Cyprus Org. f. Standardization	www.cys.org.cy
CZ	Czech Rep.	Czech Standards Institute	www.cni.cz
DE	Germany	Deutsches Institut für Normung e.V. DIN	www.beuth.de
DK	Danmark	Dansk Standard	www.ds.dk/
EE	Estonia	Estonian Centre f. Standardisation	www.evs.ee
ES	Spain	AENOR	www.aenor.es
FI	Finland	Finnish Standards Association	www.sfs.fi
FR	France	AFNOR	www.afnor.org
GB	United Kingdom	BSI British Standards	www.bsi-global.com/
GR	Greece	Hellenic Org. f. Standardisation	www.elot.gr
HU	Hungary	Hungarian Standards Institution	www.mszt.hu/
IE	Ireland	National Standards Authority of Ireland	www.nsai.ie/
IT	Italy	Italian Org. for Standardisation	www.uni.com
LT	Lithuania	Lithuanian Standards Board	alpha.lsd.lt/
LU	Luxembourg	Org. Luxembourgeois de Normalisation	jsappl.etat.lu/see/
LV	Latvia	Latvian Standard	www.lvs.lv/
MT	Malta	Malta Standards Authority	www.msa.org.mt/
NL	Netherlands	NEN	www.nen.nl/
PL	Poland	Polish Committee for Standardisation	www.pkn.com.pl
PT	Portugal	Instituto Português da Qualidade	www.ipq.pt
RO	Romania	Asociația de Standardizare din România	www.asro.ro/
SE	Sweden	Swedish Standards Institute	www.sis.se/
SI	Slovenia	Slovenian Inst. f. Standardisation	www.sist.si/
SK	Slovak Rep.	Slovak Standards Institute	www.sutn.gov.sk
Non-EU			
CH	Switzerland	Schweizerische Normen-Vereinigung	www.snv.ch
IS	Iceland	Icelandic Standards	www.stadlar.is/
NO	Norway	Standard Norges	www.standard.no/