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Deliverable D6.1

Regulatory analysis overview guide on the implementation of renewables and GSHP in retrofit scenarios and historical buildings

WP6

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Publishable summary

Deliverable D6.1 is a public document delivered in the context of WP6, Task 6.1, subtask 6.1.1 Regulatory Implications and Outline Environmental impact of installing and managing the innovative technologies in renovation of civil and historical buildings

The report provides an overview and an update of applicable legislation and regulation on the installation of closed loop GHEs, an updated review on the transposition of the regulations with regards to the EPBD and on the permitting and regulatory requirements in place for the retrofit and refurbishment of historical buildings in all the case study jurisdictions of the project.

Abbreviations

BRO	Building Regulation Office
Cheap-GSHPs	Cheap and Efficient Application of reliable Ground Source Heat Exchangers and Pumps
CHF	Swiss Franc
DHW	Domestic Hot Water
EIA	Environmental Impact Assessment
EPBD	Energy Performance in Buildings Directive 2002/91/EC (EPBD, 2003) & subsequent amendments
EPC	Energy Performance Certificate
GHE	Ground Heat Exchanger
GEO4CIVHIC	Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings
GSHP	Ground Source Heat Pump
GWh	Gigawatt hours
HFC	Hydrofluorocarbon
IDEA	Instituto para la Diversificación y Ahorro de la Energía
Ktoe	Kilo tonne of oil equivalent
kW	kilowatt
kWh	kilowatt hours
MRA	Malta Resource Authority
NREAP	National Renewable Energy Action Plan
RES	Renewable Energy Sources
TWh	Terawatt hours

Introduction

The regulation of GSHP system in the retrofit scenarios and in the case of historical buildings is considered in the context of the regulatory frameworks that include the implementation of the EPBD in different Member States and how these are implemented though local legislation and regulations in the building sector.

This deliverable presents the outcome of an analysis of the regulatory conditions for the real and virtual case study sites of the GEO4CIVHIC project (table 1). The analysis was completed considering the results of previous EU-funded projects (Cheap-GSHPs, REGEOCITIES) and provides an updated status in regulatory context of the installation of GHEs and key EU Directives such as the EPBD.

Table 1 – Case Study site summary and locations

Case Study Type	Description	Responsible Partner
Real	Historical Building Valletta Malta	DLH
Real	Historical Building Ferrara	UNESCO
Real	Residential Building Mechelen	GEOGREEN
Real	Historical Residential Building Wicklow Ireland	GEOSERV
Virtual	Museum of Natural History of Alexandroupolis	CRES
Virtual	Administrative building "Palacete de la Cruz Roja"	UPV
Virtual	Residential building Avangarde Forest	PIETRE
Virtual	Residential building in Bucharest	RGS
Virtual	University building "Ex Ospedale Geriatrico"	UNIPD
Virtual	Historical building in Split CROATIA	UNESCO
Virtual	University Building in Erlangen	FAU
Virtual	Historical building "Castle of Attre"	GEOGREEN
Virtual	Carnegie Clondalkin Library	GEOSERV
Virtual	Administrative building "AIL (Aziende Industriali di Lugano)"	SUPSI
Virtual	Residential Building Mariënburg Soest - Netherlands	CNR-ISAC
Virtual	Residential Building Alsamora 6	CNR-ISAC

A common data acquisition template has been used to assess the applicable legislative and regulatory conditions for GSHP systems at the case study site locations.

The analysis has focussed on the design, planning, installation and operational aspects of GHSP systems at the case study site locations, as well as the updated requirements under the transposition of the EPBD for the integration of renewable energy source and ground source heat pump in retrofitting of buildings.

The results of the analysis provide an update on the conditions applicable in the case study site locations and assess the potential for implementation of the GEO4CIVHIC project technologies in deep retrofit and historical building settings.

The report provides a basic outlook of the market penetration potential in the context of the regulatory environments highlights and will form the basis for making recommendations with regard to the technologies developed in the final phases of the project.

1 Real Case Study Sites

An overview of the regulatory conditions for the installation GHSP systems and in particular closed loop ground heat exchangers at the real case study sites is covered in this chapter. This focuses on the real case study permitting and regulatory requirements that are in place with respect to installing the project technologies.

1.1 Msida Bastion Historic Garden Building, La Valletta (MALTA)

The proposed case study site is the Cafeteria building of the Msida Bastion Historic Garden in Florianan Malta. The site is adjacent to a historic protestant cemetery. This is a single storey public building with a floor area of 97m^2 where a deep retrofit is envisaged and will include the installation of a dual ground and air source heat pump. The GHEs installation is planned using the new drilling and coaxial heat exchanger technologies developed as part of the project.

1.1.1 Shallow Geothermal Legislation and Regulation

Geothermal energy is defined in Article 28 of the Malta Resources Authority Act (L.N. 510 of 2010 – CAP423) as energy stored in the form of heat beneath surface of the solid earth and subsidiary legislation 423.19 *Promotion Of Energy From Renewable Sources Regulations*. No specific definition for the shallow geothermal energy resources is given in the legislation.

A two stage permitting process administered by the Malta Resources Authority and Transport Malta is applicable in the case of the case study site. An initial application for the works of the GHE under the LN254/2008 'Borehole Drilling and Excavation Works within the Saturated Zone Regulations, 2008 (Subsidiary Legislation 423.32 - Borehole Drilling and Excavation Works within the Saturated Zone Regulations) is to be completed. This is applicable to open and closed loop heat exchangers (and any other borehole) that reaches the saturated zone (boreholes above the saturated zone are excluded). The application includes a non-refundable fee of €230 and must include a minimum of the following items:

- Details of the applicant, person drilling the borehole and qualified *perit* [1]supervising the works;
- full technical details of the location, size and depth of the borehole or excavation work;
- details of the purposes for construction of the borehole or excavation works and declarations to this effect from the applicant and the *perit*.

[1] Perit – Licensed professional under the Periti Act XIV of 1996 regulating Architecture & Civil Engineering Professionals (Periti) and certain provisions in the Civil Code defining architects' responsibilities

The application is assessed based on the environmental impact on neighbouring established users within a 500m radius of the site.

The MRA grants the permit based on the application of any relevant conditions allowing the applicant to proceed with the works provided that these are within a specific term and that adequate guidelines and standards are followed, necessary groundwater pollution measures from the drilling are put in place. The applicant must fulfil the geological and borehole data submission requirements to the authority. The Authority keeps a register of all applications and permitted boreholes

The Application of Groundwater Heating/Cooling Schemes in Malta and Gozo Consultation Paper (MRA, 2009) discusses the different types of GHEs (open and closed loop) in the context of the geological and hydrogeological setting in Malta and presents the potential impacts of these to the receiving environment. No specific requirements for monitoring for closed loop systems are set in the consultation document however recommendations with respect to the preventative measures for any discharge of GHE working fluids to the aquifer are outlined.

Based on the assessment completed interference between GHEs is not defined in the regulations or the consultation paper. Some focus is given in the consultation document with respect to the thermal impact at the operational stage on aquifers. These are considered to be outlined in the initial borehole application where the designer outlines the expected operational profile of the system.

1.1.2 Building, Heating and Cooling Plant Regulation

The regulations dealing with the transposition of the EPBD in Malta are covered under the Legal Notice 47/2018 - Energy Performance for Building Regulations under the Building Regulation Act (CAP.513). The regulations implemented through the Building Regulation Office (BRO). The Act and legal notice define the requirements in terms of building energy efficiency and inclusion of renewable energy technologies in the case of retrofit and new buildings. The following are applicable in the in the case of retrofit and new buildings:

- minimum requirements for the energy performance of new buildings and units;
- minimum requirements for the energy performance of:
    - existing buildings, building units and building elements which are subject to major renovation;
    - building elements which form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are retrofitted or replaced; and
    - technical building systems whenever they are installed, replaced or upgraded;

Exemptions from the energy performance regulations are applicable in the following cases:

- historical and protected buildings classified as scheduled property (Grade 1 or 2) by the Planning Authority under article 57 of the Development Planning Act and buildings officially protected as part of a designated environment or because of their special architectural or historical or contextual merit;
- buildings used as places of worship;

- temporary buildings with a time of use of two years or less, industrial sites, workshops and non-residential agricultural buildings with low energy demand, and non-residential agricultural buildings;
- stand-alone buildings with a total useful floor area of less than 50m^2;
- a building constructed for the Enemalta plc, the Water Services Corporation or any other similar entity, and used as a generation, transmission or distribution station.

The F Technical Guidance Conservation of Fuel, Energy and Natural Resources Part B : Minimum Requirements for Building Services in Malta (BRO, 2012) suggests that a contribution to meet the full heating and hot water demand or part of it or economically viable installations provide at least 50% of the heating and hot water demand for the building from heat pumps with a COP greater than 2.5. Energy efficiency ratios (EER) of 2.6 and 3.2 respectively for heat pumps and water loop heat pumps are defined. Recommendations for the use of minimal a control system for use with heat pumps, under floor slab, solar thermal plants and comfort cooling is also specified.

The BRO issues EPCs certificates for heating and cooling plant equipment following the submission of commissioning and inspection reports by the *perit* or independent registered system inspector. Periodic inspection to heating plant of 20kW or greater capacity and air conditioning plant of 12kW or greater capacity is carried out by BRO. The frequency of inspection is reduced where electronic monitoring and control systems are in place.

Under the Planning Act a planning application is required for any retrofit works to building (including a historical building) including the installation of indoor terminals. The permit application is processed by the planning authority and a typical fee of €1,000 for the permission is applicable.

No specific regulations aside from the Planning Act are applicable in the context of historical buildings and the inclusion of renewable technologies as part of any retrofit measures. Planning applications are required for refurbishment works of these buildings and when a change of use is envisaged.

1.1.3 Policy on Renewables

The NREAP for Malta (Energy & Water Agency, 2013) sets targets for the use of heat pumps of 1.58% of total energy consumption by 2020 (89.93 GWh – 7.73 ktoe). The fourth NREAP report for Malta (Energy & Water Agency, 2017) shows a contribution of 7.2ktoe of final energy consumption from heat pumps in 2016.

Heat pumps are primarily used in cooling applications with a total of 300,000 units installed in Malta in 2017 (Energy & Water Agency, 2017). The number of heat pumps is expected to nearly double with a contribution of 280 GWh of primary energy consumption by 2030 expected as a target (Energy & Water Authority, 2018).

No specific local policies have been identified with regard to the deployment of ground source systems in buildings.

1.1.4 Other

Financial incentives are not directly available for ground source heat pump systems, with supports only provided for solar hot water generation and some generic grants for air source systems.

Training and certification is limited to that of registered installers with BRO for heating and cooling plants, with no specific training for the design, drilling and completion of ground source systems.

1.2 Historical Building in Ferrara (ITALY)

The Angel's Gate in Ferrara is located in the very core area of the UNESCO World Heritage Site of Ferrara. The building was originally a watchtower and provides special views of the fortified walls of the town and surrounding landscape.

The tower is equipped with an old and inadequate heating system and without cooling. This will be replaced using one of the innovate heat pumps developed by the project.

1.2.1 Shallow Geothermal Legislation and Regulation

Geothermal energy in Italy is defined under article 10 and 17 of the national legislation (D.Lgs 22/2010) that defines geothermal energy resources including shallow geothermal as smaller local utilizations (*piccole utilizzazioni locali*) from warm aquifers or through the use of GHEs to a maximum depth of 400m and where the installed capacity does not exceed $2MW_{th}$.

The decree also imposes responsibility on the regions as the governing authorities to develop a regional regulatory framework for the exploitation and utilisation of resources. Based on these regulations, small GHSP systems using GHEs up to a depth of 150m should not be subject to provincial regulations and permitting. The permitting of these systems is done at municipal scale and a declaration with the system specifications is required upon completion of the works.

However, the current situation in the Emilia Romagna region is that no specific normative or regulatory frameworks at provincial level are in place for GSHP systems using closed loop GHEs at the time of the assessment. Regulations R.R. 41 of 2001 and its subsequent amendments that regulate aquifers and the use of groundwater, have been deemed applicable for the use geothermal resources. In these regulations closed loop GHEs are defined as closed pipework cemented into the ground where a heat exchange fluid is used and no water abstraction occurs.

The closed GHEs are regulated under article 17 and do not require a specific permit or concession. However, a registration process through the local municipality is required where specific requirements for the completion of the GHEs may be imposed in line with groundwater protection regulations. The registration needs to be in some cases accompanied by a report from a qualified professional justifying the design and operation of the system and providing traceability details of the plant designer, person in charge of the operational phase and maintenance details.

1.2.2 Building, Heating and Cooling Plant Regulation

The transposition of the EPBD is governed by a series of legislative decrees starting with D.Lgs. 19/08/2005 n.192 (EPBD I), D.L. 63/2013 (EPBD II) and more recently amendment n. 39 of GU n. 162 and D.M. 26 June 2015. These set the set the contributions from renewable technologies in buildings, the methods for calculating energy performance and the implementation of building energy certificates, the increased minimum standards of energy efficiency in buildings (including public buildings) and incentives for private buildings. No specific targets are set for the use of GSHP in these regulations. As part of these, the following minimum requirements are observed:

- 50% for Domestic Hot Water, 50% of Total Energy Demand for new residential buildings, new non-domestic buildings and retrofit.
- 55% of Total Energy Demand for public sector buildings

Regional and provincial legislation 26/2004 defines the regional/provincial authorities and local entities as responsible for the development of renewable energy sources including geothermal (and shallow geothermal energy) as well as the implementation of local planning structures for the use of renewable energy systems.

National guidelines concerning the improvement of energy efficiency measures in cultural heritage buildings, technical specifications on climate control measures specific to heritage buildings (UNI EN 15759-1:2012) along with international standards and best practice guides (CEN/TC 346, CIBSE, ASHRAE, REHVA, AICARR) are considered in the context of the use of GSHP systems and other renewable sources in cultural heritage buildings and are implemented using a case specific assessment.

1.2.3 Policy on Renewables

A regional energy plan (Servizio Ricerca, Innovazione, Energia ed Economia Sostenibile, 2017) outlines the potential for use of renewables, energy efficiency and the reduction of emissions. The use of GSHP systems and low temperature geothermal resources is widely discussed throughout the plan, however no specific targets are set with regard to future deployment.

1.2.4 Other

National technical standards and guideline documents are published by the 'National Italian Institution for the Unification' (Ente Nazionale Italiano di Unificazione, UNI 11486:2012, 11467:2012 and 11466:2012). These consider the design, installation and construction as well as equipment and materials relating to GSHP installations for all GHE systems in Italy.

Financial incentives for the renovation of residential buildings in Italy include 65% tax credit for energy efficiency improvements in existing buildings on the investment costs (with maximum limits) in 10 years within the income declaration procedure (D.Lgs 208/28.12.2015). The programme finances measures such as: renewal or improvement of the efficiency of the heating system, and retrofitting of building envelope components and building renovations works that are able to achieve a building energy performance 20% more efficient than the values set by law.

1.3 Residential Building in Mechelen (BELGIUM)

The real case study site is a two-story detached residential building being retrofitted by means of insulation on walls and roof and substitution of windows. An 8 kW dual cycle heat pump and a radiant floor system will be installed.

1.3.1 Shallow Geothermal Legislation and Regulation

Geothermal Energy is defined in the Flemish Environmental Legislation, with shallow geothermal defined as the energy used for GSHEs up to depth of 500m.

Local regional VLAREM legislation is applicable in Belgium for GSHP systems and in the case of the site at Mechelen in the Flanders region. The utilisation of shallow geothermal energy in Flanders is regulated by the Flemish Government through Environmental Licences (VLAREM I). This legislation is divided into sections that determine when an environmental permit must be requested. This licensing in completed through the Provincial Authority and comprises 3 classes (Pasquali, 2016). A class 3 registration is applicable for the case study site at Mechelen. GSHP systems of larger capacity using either closed loop or open require more complex class 2 and 1 permits from multiple departments and provincial authorities.

The planning application process that covers GSHP installation through the Class 3 registration and permitting process are streamlined with no separate permits necessary. Drilling permits are not required in the case of closed loop collector systems.

Regulations under VLAREM II differentiate horizontal, open and closed systems. In the case of the closed loop systems, differences are identified based on the use of either geothermal brine or refrigerant in the GHE at a depth range of between 100m and 150m. Other applicable environmental regulations are focussed on the protection of aquifers and groundwater abstractions for drinking water supplies. These focus on the prevention of cross contamination through drilling and completion of heat exchangers using grout. Drilling and completion of GHEs are prohibited within the groundwater protection zones of type I and II and public drinking water supplies. These restrictions are not applicable in the case of the case study site.

Based on the above assessment no specific regulations were identified as applicable in the case of the proximity of ground heat exchangers and potential interference at the time of the assessment.

1.3.2 Building, Heating and Cooling Plant Regulation

Building and renovation works in Flanders are licensed under and *Integrated Environmental Permit* (former urban planning permission and environmental permit combined). The permits are administered by the local town and country planning services. For general refurbishment works (https://www.omgevingsloketvlaanderen.be/verbouwen) such as those proposed as part of the case study site, planning permission is not required. Detailed guidelines on exempt works

are provided. No specific regulations are provided in the case of historical buildings but the renovation of these is expected to require permission and the involvement of a specialist conservation architect.

The Flemish Energy Agency (VEA) and the Ministry of Environment, Nature and Energy are the responsible public bodies in the Flemish Region for the implementation of the EPBD. This sets out minimum requirements for energy efficiency in buildings and the potential contribution from heat pumps of 85% in domestic buildings for hot water demand or up to 10 kWh/m^2/yr from renewables in non-domestic buildings.

The current regulations also make provision for installation and commissioning to be performed by trained personnel and for yearly random inspections of operating plants (in the case of heat pumps above 12kW) by VEA appointed inspectors to take place.

1.3.3 Policy on Renewables

No specific policies on renewables or GHSP system were available at the time of the assessment.

1.3.4 Other

A regional database of GSHP systems is available through a webGIS interface where details of installed systems can be viewed. Information on this database on resources is available at www.dov.vlaanderen.be.

Financial incentives in the Flemish region are for heat pumps in the residential sector for heating only applications. Incentives including the 'Ecology Premium' are available for non-domestic installations where HFCs replace natural refrigerants.

1.4 Historical Residential Building in Greystones, Co. Wicklow (IRELAND)

The single storey historical residential building was built in the 1890's and extended c. 15 years ago and comprises a floor area of 165m^2. The building is a protected structure and therefore refurbishment works to retrofit it would require permission and would affect the character of the building. A 12kW medium/high temperature heat pump will displace a gas fired central heating system, with the existing radiator and heating terminals retained.

1.4.1 Shallow Geothermal Legislation and Regulation

Geothermal Energy in Ireland is currently not defined in any specific legislation or statutory instrument. Initial consultation for the Geothermal Development Bill in 2010 suggested that

shallow geothermal energy may be defined at depths shallower than 400m. However this is not a legal definition.

No local legislation is applicable, with local authorities in the different counties implementing necessary regulations relating. As a result of this there is currently no database or register of installed systems. The Geothermal Association of Ireland publish outline data from known large commercial system installations and any data submitted as part of national installation of the year competitions provided by its members.

Regulations are only applicable in the case of open loop systems at a national scale with no licensing and permitting procedure in place for closed loop ground source systems. Licensing is only applicable in the case of open loop systems under the implementation of Article 11(3)(e) of the Water Framework Directive (2000/60/EC) where water abstractions equal to or above 1Mm^3 per annum are applicable. Discharge licenses are required in this case of open loop system that discharges to surface or groundwaters. Typically for surface waters temperature (but also pH and conductivity) standards are included in the regulations limiting the increase in water temperature be- low a discharge point to less than 1.5^{o}C above the ambient water temperature for rivers, lakes, transitional and coastal waters. These apply to both abstractions/discharges and large scale use of heat pumps, either ground source or using surface water as the heat source.

Operational data and any potential interference related issues from operating system in close proximity to each other and other sub surface users are not available.

1.4.2 Building, Heating and Cooling Plant Regulation

Planning and Building regulations in Ireland are governed under the Planning and Development Act 2000 and its subsequent amendments. With respect the historical buildings, the Act gives the responsibility to the planning authorities create a record of protected and listed structures (RPS) and sets out the obligation of the authorities to provide clear objectives and strategies in local development plans to protect and preserve such structures. Where a structure is listed as protected, restrictions are applicable to elements including the structure itself, its interior and the land within its curtilage and other structures within that curtilage (including their interiors) and all fixtures and features which form part of the interior or exterior of all these structures. All works which would materially affect the character of a protected structure, or a proposed protected structure, will require planning permission.

A revision to the Building Regulations in 2017 for Dwellings (DHPLG, 2017) and for Buildings Other Than Dwellings (DHPLG, 2017) makes provisions for the inclusion of Nearly Zero Energy Buildings.

The building regulations for dwellings define geothermal as a renewable energy source. A minimum contribution of 10 kWh/m^2 /annum contributing to energy use for domestic hot water heating, space heating or cooling with an energy output in excess of 2.5 times the electrical energy directly consumed (DHPLG, 2017) for domestic applications. An amendment to the current building regulations introduces a requirement that where a dwelling is undergoing a major renovation, defined as a renovation involving a floor area equal to or greater than 25% of the surface envelope of the building, the entire building should achieve a cost optimal energy performance; The regulations apply in respect of dwellings which are commenced on or after 31 March 2019.

The regulation for all other buildings (Buildings Other Than Dwellings) set out *minimum energy performance requirements* based on the EPBD recast including:

- requirements for new buildings to achieve Nearly Zero Energy Buildings;
- Buildings undergoing major renovations (more than 25% of the floor area) meet thermal performance requirements as much as reasonably possible.

The building performance is assessed in line with the NEAP modelling guide. Maximum Permitted Energy Performance Coefficient (MPEPC) of 1.0 and Maximum Permitted Carbon Performance Coefficient (MPCPC) of 1.15 thresholds used to assess the performance along with a Renewable Energy Ratio (RER) target of 20% on the final constructed building to assess the performance. These thresholds represent an improvement of 60% from the previous 2008 regulations.

A Whole Building Cost Optimal Level performance is calculated in the context of new buildings and Major Renovation Cost Optimal Performance kWh/m^2/yr of primary energy consumed is set for specific building types.

The Part L Regulations clearly states that the requirements imposed under the regulation are not applicable to buildings of architectural or historical interest as the application of measures to improve energy efficiency could affect the character of the structure. The implementation of works to improve energy building efficiency should be given careful consideration and adequate consultation with a conservation architect sought. Guidelines for planning Authorities (DAHG, 2011) and energy efficiency measures for traditional buildings (SEAI, 2011) discuss possible strategies, the use of certain material for the improvement of energy efficiency and demonstrate the process of consultation required in advance of the implementation renovations to historical buildings. No specific references to changing heating infrastructure are made other than highlighting the potential protected of building elements including windows, historical wall components (eg plaster) and heating system elements such as ventilation grids that form the building structure.

Under the Planning and Development Act, 2000, the owner or occupier of a protected structure may seek a declaration from the relevant planning authority to determine the works to the structure that would materially affect its character and therefore require planning permission, and those works which may be carried out as exempted development

1.4.3 Policy on Renewables

The National Renewable Energy Action Plan (NREAP) for Ireland fourth progress report (DCCAE, 2017) show the energy produced from heat pumps (including geothermal, aerothermal and hydrothermal) of 45 ktoe in 2015 increasing to 55 ktoe in 2016. This demonstrates a deficit of 6 ktoe in 2015 and 9 ktoe respectively to the targets set in the NREAP (DCENR, 2010).

The Energy White Paper 2015-2020 (DCCAE, 2015) identified geothermal energy, heat pumps and district heating as technologies for addressing the heat energy demand in Ireland and meeting renewable energy targets.

The Initial Public Consultation National Energy & Climate Plan (NECP) which aims to set targets for renewable energy source deployment between 2021-2030 to comply with the EU Renewable Energy Directive, will set targets for renewable technologies. The current proposal makes reference to the use of geothermal energy and ground source heat pumps for heating & cooling

applications in 4 different scenarios. These scenarios suggest an increase in the use of heat pumps between 8 to 10 times the contributions of energy generated by source from the 2017 levels could be possible.

Wicklow County Council, the local authority responsible for planning at the case study site references the promotion of renewable energy technologies as part of the Wicklow Economic and Community Plan 2016-2022. No specific reference to shallow geothermal are made.

1.4.4 Other

Financial incentives for the installation of The Heat Pump System grant provides home owners with €3,500 towards the cost of a heat pump system (irrespective of the type) subject to adequate energy efficiency upgrades being implemented that reduce heat loss in the building fabric below 2W/K/m^2.

The Support Scheme for Renewable Heat supports the adoption of renewable heating systems by commercial, industrial, agricultural, district heating, public sector and other non-domestic heat users not covered by the emissions trading system. The grant based scheme provides funding of up to 30% of eligible costs to air source, ground source and water source heat pumps based on the buildings and heat using processes adhering to verified energy efficiency criteria, Building Regulations, Construction Products Regulations, EN Standards, efficiency, technology standards and air quality standards in relation to emissions.

Certification of heat pump installers under the QII scheme is applicable and a register of these in help by SEAI. Whilst there is no official certification for designers, drillers and installers of GHEs, the recent development of technical best practice guidelines for the installation of shallow geothermal energy collectors in Ireland by the Geothermal Association and the implementation of the EN Standard 17628:2015 are referenced in the contractor code practice implemented by SEAI for the installation of ground source heat pumps.

Data on ground source heat pump systems is not directly available. The number of heat pumps installed in Ireland is known through market data from heat pump manufacturers and installers. Locations of drilled GHEs are also not knows as the lack of regulations does not oblige drillers and installers to submit these data. The Geological Survey has developed a series of collector suitability maps used as a screening tool for determining initial feasibility of GHEs (https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228)

2 Virtual Case Study Sites

An analysis of the regulatory conditions has been performed in the virtual case study sites considered in the GEO4CIVHIC project. However, as no effective installation is planned at these locations, the applicability of regulatory requirements in the context of retrofitting has been considered and where historical buildings are concerned, an outline assessment of any applicable regulations has been completed.

2.1 Museum of Natural History, Alexandroupolis (Greece)

The Museum in Alexandroupolis plans a retrofit of the building consisting of upgrading the interior design and bringing the energy performance to an nZEB standard. A hybrid two-source heat pump with a GSHE field will be simulated as part of the project.

2.1.1 Shallow Geothermal Legislation and Regulation

Law 3175/2003 defines geothermal potential as the total of geothermal natural vapors, hot waters (surface waters or groundwaters) and the heat of geological formations with temperature higher than 25 °C. Shallow Geothermal Energy is defined as the heat of geological formations and waters (surface waters or groundwaters) that are, not characterized as geothermal potential.

Ministerial Decision Δ9Β,Δ/Φ166/οικ13068/ΓΔΦΠ2488 (1249/2009) distinguishes between open and closed loop systems and sets out the required license for a GSHP system installation and outlines the potential conditions and terms to be followed in the case of both. The same document also highlights the responsible authority for the permitting process. In case of the case study site it is the Regional Authority of Alexandroupoli.

As part of the permitting process a study to be completed by competent engineers must be submitted as part of the license. The study must outline the maximum cooling and heating capacity (power) of the system. The permitting process typically takes approximately 1 to 3 months. A drilling and works permit is required to complete the drilling and GHE installation works. The cost of this permit is included as part of the main licensing cost. Requirements for the completion of the borehole and trenches associated with the system include:

- Casing with steel tubing and cementing for at least of the upper 5 meters must be done;
- a distance of 2 meters from the boundaries of the ownerships;
- a distance of 5 meters from the existing neighbouring building of different ownership;
- a distance of 5 meters from the boundary of the expropriated railway zone, ten (10) meters from the main natural gas pipeline,
- a distance of 5 meters from main underground pipelines (water supply, irrigation, drainage, etc.),

- a distance of 5 to 10 meters from electrical distribution lines (distance based on the type of cable).

The legislative and regulatory framework for GSHP systems has no suitable indicator to describe or quantify interference for GSHPs defined.

2.1.2 Building, Heating and Cooling Plant Regulation

A planning application is required for the proposed refurbishment works at the Museum. The permission must be submitted to the regional Authority of Alexandroupoli and a planning study is required. The following characteristics must be included as part of the study:

- applicant data, property data,
- project manager engineer’s data,
- coordinates of the installation,
- topographic diagram,
- description of the space in radius of 100 meters,
- definition and description of required drilling (location, number, depth, drawings, etc.),
- detailed description of ground heat exchangers,
- description of conditioning spaces,
- description of the electrical and mechanical equipment.

The implementation of the EPBD is transposed by Ministerial Decision Δ6/Β/οικ. 5825 which is titled "Rules of Building Energy Efficiency" as well as Law 4122/2013. However no specific targets are set with regard to heat pumps and GSHPs in the above documents. The definition of major renovation is set in Law 4122/2013, after being amended in Law 4409/2016, Article 49 (Α’ 136). A renovation is considered as major when the total cost relating to the building envelope is higher than 25% of the value of the building, excluding the value of the land upon which the building is situated.

Law 4342/2015 (Α’ 143), which is the transposition of the EED into national legislation, sets the obligation that, from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by the central government must be renovated each year so as to meet at least the minimum energy performance requirements. The requirements for existing buildings have not been altered since the end of 2014 and when the building undergoes major renovation, it should achieve an energy class of B or better, unless it can be proven, through a technical report, that this is technically, functionally and economically not feasible (Androutsopoulos, 2016).

Law N.3028 / 2002 (Government Gazette 153 / A / 28.06.2002) protects antiquities and cultural heritage establishing new criteria for recovery interventions in cultural heritage buildings. According to Law 4122/2013 (“Regulation on the Energy Performance of Buildings” - KENAK) and Ministerial Decision Δ6/Β/οικ. 5825 (407/2010) the minimum energy performance requirements are not applicable to historical buildings. The historic / preserved buildings are recorded by the Ministry of Culture and Tourism as well as by the Ministry of Environment, Energy and Climate Change. A permit is required for all activities in registered buildings from the Ministry

of Culture and Tourism, the Ministry of Environment, Energy and Climate Change as well as the Architectural Committee.

Ministry of Environment and Energy approved a long term strategy the renovation of the national stock of residential and commercial buildings that sets goals for 2050 to achieve high performance in 80% of existing buildings through renovation by 2050. These scenarios consist of different mixtures of renovation types and renovation rates. More specifically, four different renovation types have been introduced:

- low renovation that achieves 20% savings;
- medium renovation with 40% savings;
- total renovation with 60% savings;
- NZEB renovation with 80% savings.

2.1.3 Policy on Renewables

The actual contribution from heat pumps energy in Greece to meet the binding 2020 targets in the NREAP reported in the 4th progress report for heating and cooling shows 206.7 and 238.6 ktoe of energy produced in 2015 and 2016 respectively (Ministry of Energy and Environment, 2018). This is considerably higher than the targets of 127 and 126 ktoe for the same years set out in the NREAP for Greece.

The Municipality of Alexandroupolis has a SEAP but no specific targets for renewable energy, retrofit or GSHPs are given.

2.1.4 Other

Two main forms of grants are applicable to GSHP systems under the ESPA 2014-2020 national programs. The first for residential building under the "Energy Savings in Households" ("Eksikonomisi kat' Oikon") programme provided incentives for household owners to implement energy efficiency measures and replacement of heating, cooling and DHW systems. This grant closed in 2016 but a future grants scheme is expected to be published during the course of the project.

The national programme "SAVE I" ("Eksikonomo I"), addressed to municipalities with over 10,000 inhabitants, provides subsidies for the implementation of energy efficient technologies in buildings owned/used by municipal services. The subsidy provided was up to 70% of the cost of the energy efficiency measures (Androutsopoulos, 2016).

There are no databases relating to operating GHSP data and information promotion is carried out by CRES through organization of workshops and conferences, distribution of brochures and other dissemination activities.

2.2 Palacete de la Cruz Roja, Valencia (Spain)

This historical building (constructed in the early 1900's) under protection of the Regional Council (Diputación) of Valencia and has a floor are of 1,258 m^2. The on-going renovation process includes structural and architectural aspects as well as energy efficiency. The case study site considers an optimised HVAC system based on shallow geothermal energy using the heat pump and heat exchanger technology developed by the project.

2.2.1 Shallow Geothermal Legislation and Regulation

Geothermal energy is defined in the principal mining legislation in Spain (Ley de Minas and ITC Recursos geotérmicos) but is specific for high-enthalpy resources. No specific definition of shallow geothermal energy is available in the legislation with some non-legal definitions as part of municipal regulations and licensing systems. These vary from one autonomous community to another. Vertical closed loop collectors are covered by non-mandatory UNE 100715-1 regulations.

Under the Valencian Community, there is no specific licensing for ground source heat pump systems. A registration process is applicable and upon completion of the work, the installation must be registered with the Regional Ministry of Industry as set out in the *RITE* law. A threshold of 70kW installed capacity is applied to all thermal installation including GHSPs with large systems considered above this value. Where the installed capacity is between 5 and 70kW, a technical notification is required (Pasquali, 2016).

No specific permits are required for drilling and earth works in the Valencia Community. An EIA/EIS is typically not required in the case of closed loop GHEs where borehole do not exceed 100m depth and the total system capacity if not greater than 70kW. In the case of this case study site if a HP capacity of greater than 70kW was considered, an EIA/EIS submitted to the Ministry of Environment and Regional Environment Ministry would be applicable. A typical processing time of 3 to 6 months would apply. Monitoring on plants in excess of 70kW would be required with energy consumption and power consumption of equipment being the main parameters recorded.

No specific register of installed systems is available and the distance between GHEs installed is typically not known. There are regulations with respect to siting GHEs on a site with the exception of rules of thumb with spacing of 6 and 10m between heat exchangers being used. Restrictions are applicable for GHEs installations in areas where main utility infrastructure is present (water, electricity, gas etc). No suitable indicators to quantify interference are used.

2.2.2 Building, Heating and Cooling Plant Regulation

The law governing all building works and refurbishment projects introduced in the Comunidad Valenciana in 2014 is Ley de Ordenación del Territorio, Urbanismo y Paisaje (LOTUP). Under this law any proposed refurbishment works to the case study site (including the completion of the GSHP system) would be subject to planning permission lodged with the City Council of Valencia. A typical processing time of 3 to 6 months is applicable in this case and the costs (excluding professional fees) are proportional to the level of refurbishment being undertaken.

No specific permitting requirements and regulations in addition to those outlined in the main building regulations have been identified for the refurbishment of historical buildings, provided

that the facade or the building structure are not changed or affected. This would be the case in the event of any works to the proposed case study site.

The Codigo Técnico de la Edficicación (CTE) is the main regulation with respect to the transposition of the EPBD. The document sets targets for contribution of renewable technologies in public sector building, retrofit scenarios and historical buildings of at least 50% of hot domestic water demand depending on the location of the building with this target applicable also to historical building with a floor area greater then 1,000m^2. The applicability of these thresholds to historical buildings is subject to exceptions in specific cases where this cannot be achieved.

2.2.3 Policy on Renewables

The main policy documents setting targets on the deployment of renewables for the heating and cooling sector in Spain is the NREAP. The fourth progress report (IDEA, 2018) suggests that 352.9 and 375.2 ktoe of final energy consumption for heating and cooling from heat pumps has been achieved. This is considerably higher than the original targets of 30.8 and 33.6 ktoe set out in the NREAP.

An SEAP for the city of Valencia is available however no specific targets on the uptake of renewables of any specific targets for GSHPs are set in this or other local policy documents.

2.2.4 Other

Standards on the completion of ground source collectors are applicable and these include the UNE100715-1 in conjunction with best practice technical guidelines (Guía Técnica de Diseño de sistemas de intercambio geotérmico de circuito cerrado). National Standards on the refurbishment of historical buildings (Plan Especial De Protección Del Entorno Del Bic) but these do not cover specifics with regard to GSHP or renewable systems.

Financial incentives in the form of grants (PAREER, GEOTCASA) are available from IDEA and regional energy agencies for the installation of systems. Tax incentives and low interest loans for the works are also applicable.

2.3 Residential building Avangarde Forest (Romania)

This residential building completed in 2013 is part of a complex of 28 similar houses. The building has a floor area of 180m^2 and is equipped with radiant floor and a gas fired boiler. The house is going to be enlarged and the current opaque envelope is going to be insulated. In this case the solution will be a small size reversible low temperature HP with co-axial GSHEs.

2.3.1 Shallow Geothermal Legislation and Regulation

The definition of Geothermal Energy provided by the RES Directive was transposed into national legislation through art. 2 of the Law 220/2008 and No.1535/2003 'National strategy for RES (Renewable Energy Sources) Use' and the Mining Law (85/2003) where Geothermal Energy is defined as "the energy stored in the form of

heat beneath the surface of the solid earth". However, no legal or practical definition of shallow geothermal energy exists in the legislation.

The Environment Protection Law (No. 137/1995 old version, modified by Law No. 265/2006) stipulates that the activity of drilling wells for underground fluid production is subject to the environmental authorization procedure. Only water wells for domestic use (residential areas, family houses) with depths of less than 100 m are exempted from this procedure.

When the drilling are > 100 meters deep the approval must be issued by the National Authority for Mineral Resources (ANRM). Because ANRM does not issue a drilling procedure for GSHP applications purposes, all closed systems in Romania are <100m.

Where GHE depths are > 100 meters an "Environment Authorization" authorisation is required. A similar requirement for open loop systems is in place. The National Agency for Environmental Protection is the responsible authority and a processing time of 30 days is applicable.

A limited amount of regulations are in place with respect to the design and installation of GSHP systems. Local offices in the National Water Authority apply some restrictions on open loop systems forbidding re-injection of extracted water to the same aquifer. Restrictions on requirements in source protection areas are applicable and in specific cases a specific impact assessment on the flora and fauna of the receiving environment is required.

Typically, no permits are required in the residential or local/site specific use of geothermal energy and GSHPs however permits, EIA and annual monitoring requirements from licensed facilities where energy is produced and sold are applicable.

2.3.2 Building, Heating and Cooling Plant Regulation

Construction works fall under Law no.50/1991 on the authorisation of construction works and Law no.350/2001 on land planning and urbanism. Building and renovation works are subject to obtaining and *Urbanism Certificate* and a *Construction Permit* from ANRE and the local municipal authority are applicable. A typical processing time of 1 to 2 months and cost of € 1,000 is applicable.

Law No. 372/2005 on the Energy Performance of Buildings (new version of this Law is No. 159/2013) that transposed the EPBD into the national legislation entered is applicable since January 1, 2007. It contains a mandatory request regarding the presence of heat pumps as an alternative in the feasibility study for new buildings larger than 1,000 m^2 and major renovations (Bendea, 2015).

The integration of renewable technologies in historical monuments can be carried out in compliance with the following special regulations and guidelines:

- Law 50/1991 – The Construction Law
- Law nr. 422/2001 – Regarding The Historical Monuments Protection
- Art. 5 from Rule of the Cultural Ministry no. 5878 from 3 nov 2004
- HG 1430/2003 – Regarding Retroffit Works For Historical Buiding
- Law 147/2017 – Concearning Building Construction Authorisation

Therefore any intervention on historical monuments must be performed only on the basis of and in conformity with the above regulations and permits issued by the City Hall and Ministry of Culture must be obtained. The above-mentioned authorisation is needed for the retrofit of H&C systems if the works are meant to modify in some way the façade or the external aspect of

the historical building or, in some cases, also the internal aspect should the latter have historical value (according to the urban planning certificate and the consequent historic study of the building performed by an authorized specialist).

2.3.3 Policy on Renewables

The NREAP for Romania sets targets for 2 and 3.5 ktoe of final energy consumption produced form heat pumps for 2015 and 2016. However, the 4th progress report does not include any figures for geothermal heat pumps or heat pumps in general. No other specific local policy documents were identified as part of the analysis as setting targets for GHSP systems.

2.3.4 Other

A database of the main GSHP systems in Romania is compiled by the Romanian Geoexchange Society (RGS) with data contributed by the larger companies installing systems. The database contains some limited data on the systems (https://geoexchange.ro/baza-de-date/).

2.4 Residential building Bucharest (Romania)

EFdeN House is a single-family prototype house that represented Romania's entry to the Solar Decathlon Europe 2014 contest. The building is now a research centre for indoor quality and energy efficiency. This virtual case study site considers the use of a GSHP proposed in the project against air source technology currently in use.

2.4.1 Shallow Geothermal Legislation and Regulation

Section 2.3.1 above describes the conditions in Romania

2.4.2 Building, Heating and Cooling Plant Regulation

Section 2.3.2 above describes the conditions in Romania

2.4.3 Policy on Renewables

Refer to sections 2.3.3 for national policy.

The SEAP - MARATHON 2020 for Bucharest Sector has sets out the goals to 2020 to increase use of renewable energy sources and names geothermal as one of the technologies for achieving these goals.

2.4.4 Other

Included in section 2.3.4 above

2.5 University building "Ex Ospedale Geriatrico" (Italy)

This is an on-going deep renovation of a historic building pertaining to the University of Padua (15,000 m^2). The overall plant capacity is approximately 900 kW for both heating and cooling. A GSHP of 300 kW will operate in heating and cooling with using 60 No GHE's of 120 m depth. The system is coupled with 620 kW reversible air to water heat pump. The deep retrofit and the performance of the hybrid solution using co-axial probes against the conventional ones being installed is being carried out as part of this study site.

2.5.1 Shallow Geothermal Legislation and Regulation

The national legislative and regulatory framework for the geothermal and SGE systems is discussed in section 1.3.1. Legislation and Regulation are in place for the Padua Municipality but specific to thermal groundwater exploitation.

A certified notification of the commencement of works (SCIA - Segnalazione Certificata di Inizio Attività) is required for geothermal systems where no fluids are pumped out from the reservoirs or aquifers. The cost of the notification is less than €100 and the processing time is generally 90 days. A notification to ISPRA (Institute for the Environmental Protection and Research - Law D.Legs. 464/1984) is required for every borehole deeper than 30m. Notification must be completed within 30 days of the end of the drilling activities. No further permits are required when no groundwater exploitation is being undertaken like in the case of GHEs (Pasquali, 2916).

A typical system threshold of 100kW is applicable for undertaking the analysis of underground impacts through an EIA/EIS in the case of closed loop systems. A monitoring requirement is also imposed requiring the operator to submit daily data reported on an annual basis to the *Comune di Padova*. The parameters considered include BHE temperatures (in and out), groundwater temperature, carrier fluid yield and power consumption of the heat pump and auxiliary systems. The size of the GHSP system being considered as part of the Padua virtual case study site would fall under these requirements

2.5.2 Building, Heating and Cooling Plant Regulation

Building Regulations and the regulations regarding the Transposition of the EPBD are implemented at national level. Guidelines on the refurbishment of historical buildings are also considered at national level and described in section 1.3.2 for the Ferrara case study site.

2.5.3 Policy on Renewables

National policy on renewable energy and the deployment of heat pumps is discussed in section 1.3.3.

The Municipality of Padova has developed An Initiative For The Energy Refurbishment Of Multi-Property Residential Buildings Of The City Of Padova - PadovaFIT (http://www.padovafit.it/wp-content/uploads/2016/05/PadovaFIT_flyer_EN.pdf) as part of the ratification of Decision n. 2011/48 of 6.6.2015 the Sustainable Energy Action Plan SEAP that envisages actions to reduce and improve energy use in households. This initiative highlights renewable technologies for the total or partial renovation of heating systems.

2.5.4 Other

A database of operating systems is available with the Padua Municipality but is not publicly available. Interference between systems is considered on case by case basis.

Details of applicable national standards and financial incentives are provided as part of the Ferrara case study site in section 1.3.4

2.6 Historical Building, the Palace of Diocletian, Split (Croatia)

The palace is a historic building and a UNESCO World Heritage Site where renovations are planned. The case study site is considering HP solutions developed by the project with co-axial heat exchangers. The regulatory assessment is based on recent previous from the Cheap-GSHPs project (Pasquali, 2016).

2.6.1 Shallow Geothermal Legislation and Regulation

Geothermal Energy is defined by technical definition only in the Energy strategy for the Republic of Croatia (2009) and in the national Energy Act. No specific definition of shallow geothermal energy exists; a technical definition as the heat stored in ground up to a depth of 400 m (Official Gazette 56/15) is used.

No licensing or permitting process is in place for closed loop GHEs system and no drilling permits are required. Open loop systems do have a licensing requirement under the Water Act. These are administered by the Hrvastske Vode who is the authority responsible for these.

Restriction to the development of ground source heat exchangers are in place in certain water protection zones defined in the Pravilnik O Uvjetima Za Utvrđivanje Zona Sanitarne Zaštite Izvorišta (Official Gazette 153/09 - http://www.propisi.hr/print.php?id=3947). These are typically confined to Zone 1 area. The exact zoning of the Palace of Diocletian in Split could not be assessed at the time of the analysis.

A database and register of systems is in place for those using groundwater below depths of 10m registered heat pump systems coupled to ground heat exchangers exists. Access to the database information is not public. Monitoring requirements for those systems pumping groundwater is a requirement but not for GHEs.

2.6.2 Building, Heating and Cooling Plant Regulation

The Building Act (Official Gazette 153/2013) has set the legislative basis for applying minimum technical requirements for the energy performance of buildings and their components, as well as for setting requirements for existing buildings and their components that are undergoing renovation. It also requires the drafting of studies containing technical, environmental and economic analyses of alternative energy supply systems, to be developed prior to building permit issuance for all buildings with a total useful surface area exceeding 50 m^2. The technical regulation (OG 97/2014 and 130/2014) prescribes the requirements of the energy performance of new buildings and, in case of major refurbishment, of existing buildings. These include *Maximum allowed annual thermal energy needs for heating of residential and non-residential buildings heated to a temperature of 18°C or more* based on a shape factor (area/volume) shown in table 2 below.

Table 2 – Maximum allowed annual thermal energy needs for heating of residential and on residential buildings heated to a temperature of 18°C or more

Building Type	Location	Shape Factor (f_0) ≤ 0.20	Shape Factor 0.20 < f_0 <1.05	Shape Factor f0 ≥ 1.05
Building ≤ 80m²	Continental & Littoral	51.31	41.03 + 51.41 x f_0	95.01
Single Family House	Continental	40.50	33.62 + 34.4 x f_0	69.74
	Littoral	21.60	17.73 + 19.33 x f_0	38.03
Other residential and non-residential buildings	Continental	40.50	33.39 + 40.58 x f_0	75.00
	Littoral	21.60	17.27 + 21.65 x f_0	40.00

It is important to note that under the transposition of the EPBD in Croatia the renovation of public sector buildings promotes the refurbishment of the building, which therefore includes measures for the building envelope and for technical systems. As part of this a private capital investment scheme is used, with no extra cost to the state budget. The profitability of the measures to be implemented are therefore considered and buildings classified as protected structures or of important cultural heritage are generally not included in this programme as the payback period is considered too long (>14 years).

Heating and cooling system with an installed capacity greater than 30kW requires planning permission and a building permit (Ordinance on simple and other construction works - (Official Gazette No. 79/14, 41/15, 75/15).

2.6.3 Policy on Renewables

The fourth progress report on the NREAP for Croatia reported figures of 14.9 and 15.8 ktoe produced from air source heat pumps with no contribution specified from ground source. No detailed market data is available. Updated local energy policies and national strategy documents were not available at the time of the assessment.

2.6.4 Other

GHSP collector equipment standards relating to the use of PE100-RC or PE100 specification pipe materials are applicable in line with drinking water pipes standards. Standards: HRN EN 12201-1, HRN EN 12201-2, PAS 1075 are applicable.

National certification standards for drillers and installers of GSHPs are also applicable and are regulated under the 2016 Energy Efficiency Act (Official Gazette 127/14) for installers and the Ordinance regulating drilling and hydrogeology works (Official Gazette 83/10, 126/12 i 112/14).

Some financial incentives have been previously reported in 2016 as being available to support the installation of GSHP systems. However, the applicability of these at the time of the assessment could not be verified.

2.7 University building Erlangen (Germany)

The University of Erlangen is renovating the historic Palaeontology Department building built in 1893. Different possible solutions for making the building more efficient are being considered and the use of GSHP systems with co-axial heat GSHE’s is considered as part of the virtual case study site.

2.7.1 Shallow Geothermal Legislation and Regulation

Geothermal Energy is considered a licensable mineral in the federal mineral legislation *(§3 Para., 3 No.2 Letter b BBergG*). A non-legal definition of shallow geothermal energy is given in VDI 4640 ("Thermal use of the underground - Part1") applies to the thermal use of the underground up to approximately 400 meters depth.

Where the exploration and extraction of geothermal energy from depths 0 to 100 m, the conditions of the BBergG are not applicable. The terms of the Water Management Act (WHG) in connection with the applicable Water Acts of the different Federal States is regulates shallow geothermal energy use. The Local Water Authority of Bavarian is the licensing body and the Regional Administrative Authority at Erlangen is responsible for processing the permit.

Restrictions are applicable in the context of the installation of GHEs in Bavaria where these are limited to installation above the first aquifer only. GHEs in groundwater source and spa water protection areas require special permission from the water authority. Any other thermal use of the underground is precluded. Similar restrictions in areas of confined or deep groundwater aquifers and areas with sulphate rich sedimentary rocks are applicable. Thermal usage of the underground should be limited to groundwater close to the surface with a free water table; in the case of deeper groundwater levels being used special protective measures are required. Restrictions are also applicable in the context of the installation of GHEs in urban areas for environmental reasons.

In the case of GHEs in Bavaria where the case study site is located two scenarios are applicable:

- If the geothermal system extracts ≤ 50 kJ/s of energy (outside of water protection areas (1), inherited pollution burden (2), artesian groundwater (3)) you need an allowance by the water authorities. This allowance requires a report from an authorized expert. (Article 15, Para. 1+3 & Article 70, Para. 1 & 2, BayWG).

- If the system extracts > 50 kJ/s of energy within an area of water protection (2.1), inherited pollution burden (2.2) or artesian or more deep aquifers (3) then Article 15 BayWG applies. In this case the local water authorities take over the role of the authorized expert and they give the final permission if an installation is allowed.

In Bavaria small plants require water management expert's ("PSW") permission, whilst larger plants (> 50kW) requiring TRT testing (for local water authorities), EED Simulation, building service planner ("TGA-Planer"), an official plant expert for dealing with water-endangering substances ("VAwS") in industrial plants. Design of GHE systems typically requires that the ground temperature does not drop below -3°C over the operational life of the plant and the GHE spacing is not lower than 5m for short probes to 50m depth and 6m for longer probes to 100m depth.

EIAs are not excluded for closed loop GHEs. More specific requirements with regard to the assessment of the impacts is stated in the case study regulatory analysis sheet and in previous public regulatory brochures produced as part of the Cheap-GHSPs project. Monitoring by the Bavarian Environment Agency and the local Water Authorities on systems greater than 50kW is applicable.

Specific permission for drilling works to be performed by certified drillers is required. The drilling operations must be carefully documented with parameters including borehole construction, materials used for the probe, grouting process (refer to R.2.8 in the case study analysis sheet) and procedures, probe testing results being included. The documentation must be submitted prior to the building inspection in accordance with Article 65 BayWG and the regional authority requires notification no later than 4 weeks from the inspection date. Authorised experts are used by the authorities to verify the installation of the GHEs and the heat pump installation.

2.7.2 Building, Heating and Cooling Plant Regulation

Building regulations applicable to the use of GSHP systems are covered under §5a, EEWärmeG and specify the requirement of 15 % of H&C or environmental energy demand by geothermal energy or other renewable energy sources in the case of retrofit buildings and 50% in the case of public sector buildings. In the case of electrically driven heat pumps, these require a COP of 3.5 (air/water; air/air) or 4.0 (other heat pumps). Producing DHW the COP has to be 3.3 (air/water; air/air) or 3.8 (other heat pumps). The heat pump has to have a heat meter and an electricity meter to calculate the corresponding COP values. This regulation applies if the flow temperature of brine/water, water/water heat pumps exceeds 35 °C. Heat pumps have to be marked with the "Euroblume", "Blauer Engel" or "European Quality Label for Heat Pumps" eco-label.

No specific regulations are applicable to historical buildings; however individual rules set out on a case by case basis are applicable. In the case of protected buildings, these require initial consultation with the State Office for Historical Monuments to set out the individual rules and a specific permit from the same authority is required.

2.7.3 Policy on Renewables

Geothermal heat pumps have contributed 344 and 364 ktoe in 2015 and 2016 of the total share of renewables for heating and cooling (NREAP 4th progress report) respectively. No specific local targets or energy plans were reported as part of the assessment.

2.7.4 Other

On a national scale the "Bundesverband Wärmepumpe" (Heat Pump Agency of Germany) monitors the annual installation of GSHPs. The position and spacing of existing GHEs can be assessed using a GHE can by using a web based viewer and measurement tool by the Bavarian Ministry of environment.

(http://www.umweltatlas.bayern.de/mapapps/resources/apps/lfu_angewandte_geologie_ftz/index.html?lang=de&layers=service_ageo_18&stateId=69506db8-ea56-4d08-906d-b8ea56dd08bc)

2.8 Attre Castle (Belgium)

The Attre Castle is listed in the national list of exceptional buildings in Belgium. The castle was built in 1752 and comprises a total of 1,200m^2 of living space. The virtual case will consider the deployment of hybrid two source heat pump with stainless steel co-axial heat exchanger probes.

2.8.1 Shallow Geothermal Legislation and Regulation

Geothermal energy is not defined in legislation in the Wallonia region where the case study site is located. A technical working definition of shallow geothermal energy defined as vertical heat exchanger exploited with a heat pump is generally adopted. The Wallonia regional Authority through the Water Division has the overall responsibility of managing shallow geothermal energy systems and exploitation.

A licensing system is applicable for GHSP systems using all types of GHEs. In the case of closed loop systems a class 2 environmental permit is required and this is lodged with the municipal authority but processed by the regional authorities. The typical permitting time is 4 months and an administrative cost of €250 is applicable.

The regulation in Wallonia requires that all GHEs where the heat pump capacity is up to 32kW, a TRT is performed and an operational system simulation for a 20 year period be completed. The regulations also impose a requirement for grouting of GHEs with gout of permeability of 10^{-10} m/s or less. Restrictions are also applicable with regard to the distances of GHEs where a distance of at least 5m from neighbouring boundaries and 10m from adjacent GHEs is applicable.

The same regulations apply restrictions in the use of closed loop GHEs in karstic geological settings and where sites are located in groundwater protection areas or zones of contribution of public water supplies where the GHEs are not allowed.

2.8.2 Building, Heating and Cooling Plant Regulation

Mandatory building permit to be filed with the local municipality are applicable in Wallonia for renovation and refurbishment works. It was not clear however at the time of the assessment if works regarding the installation of GHSP and GHE at the case study site would require a permit.

The implementation of the EPBD rests with the Public Service of the Walloon Region, Department of Energy and Sustainable Buildings. This is implemented in line with the Code for Spatial Planning (territorial development).

The Département du Patrimoine de la *Direction Générale de l'Aménagement du Territoire, du Logement, du Patrimoine et de l'Énergie* is responsible for the management of the cultural, historical and natural heritage of the region. Restoration, conservation and maintenance works to public or private properties listed under the regional heritage register is likely to require a heritage certificate *(certificat de patrimoine)* and an urban and planning permit (*permis d'urbanisme*).

2.8.3 Policy on Renewables

Aside from national policy measures reported in section 1.4.3, the *Plan De Développement Durable, 2016-2019* demonstrates objectives for the reduction of energy consumption in buildings and the increased use of renewable energy sources. No specific targets for GSHP systems are outlined.

2.8.4 Other

A register and database of installed and operating systems is available with the regional authority but is not publicly available. There are no guidelines or parameters for the assessment of interference between GHEs in the regulations. The regional authority can inspect installed systems however these checks are rarely implemented.

A certification scheme for drillers in Wallonia is applicable and specific courses are provided. Certified drillers are the only operators allowed to drill and complete GHE systems. There are no specific certifications for installers.

Financial incentives are not available specifically for the installation of GHSP systems but a premium for retrofitting measures of 0.10 € per kWh of saved energy compared to the replaced/original installation is applicable. Some financial incentives are possible from local municipalities and regions in the case refurbishment and preservation works of historical buildings, however the application of these to GSHP installations is not clear and would require specific consultation.

2.9 Clondalkin Library (South Dublin), Ireland

The building is a historic detached six-bay two-storey public library built in 1912. The Clondalkin library will be used as virtual case study site to test the viability of deployment of the GEO4CHIVIC technologies including a high temperature HP.

2.9.1 Shallow Geothermal Legislation and Regulation

Shallow geothermal regulations in Ireland are applicable nationally and presented in section 1.4.1 above.

2.9.2 Building, Heating and Cooling Plant Regulation

Building regulations in Ireland are applicable nationally and presented in section 1.4.2 above.

2.9.3 Policy on Renewables

The national policies and targets with respect to the use of heat pumps are discussed in section 1.4.3 above.

The South Dublin Sustainable energy Action Plan (SDCC, 2013) identifies geothermal as one of the energy sources with potential to achieving the objectives of 20% CO_2 emission reductions by 2020.

A Spatial Energy Demand Analysis (SDCC, 2015) has identified geothermal and heat pumps as potential contributing energy source for the deployment of district heating network in areas of

high energy demand allowing high levels of efficiency to be achieved. Where the heat density is identified as low and waste heat is unavailable, the Council seeks to support individual building-based sustainable solutions including the use of ground source and shallow geothermal.

2.9.4 Other

Other measures are discussed in section 1.4.4.

2.10 Administrative building “AIL (Aziende Industriali di Lugano)” – (Switzerland)

The AIL (Aziende Industriali di Lugano) is an administrative building from the 1960s located in Muzzano, Switzerland (cold climate). The building with a total useful floor area of 6,000m^2 has been completely refurbished with an attached new building in 2017. The H&C demand will be met using a GSHP system with solar panels. The use of smart meters allows for the comparison of the heat consumption before and after the refurbishment.

2.10.1 Shallow Geothermal Legislation and Regulation

Shallow geothermal energy is not defined in primary legislation in Switzerland but referenced as the "*Use of heat from soil and subsoil*" by the Federal Office for the Environment (FOEN). The aim of this definition is to ensure harmonisation of the approval practice for geothermal heat probes, groundwater heat pumps, soil records and geothermal energy cages and piles in Switzerland. It also defines the necessary conservation measures on the basis of ambient water protection legislation. The exploitation of heat from underground (open and closed loop) is governed by the Water Protection Act (WPA) and Water Protection Ordinance (WPO) at federal state level.

The technical aspects of shallow geothermal energy and the criteria quality assurance for geothermal probes are dealt with in the standard SIA 384/6 geothermal probe to a depth of 400 m. Annexe E and F of SIA 384/6 establish the applicable regulations in the context of the borehole construction, drilling equipment and methodologies to be used. Grouting materials and methodologies needed to comply with enforcement aids (UFAM, 2009) are outlined in SIA 384/6 (5.3.1, 5.4 and the annex F.3).

The GESPOS database, which is controlled at Cantonal level, acts as the main repository of information with regard to GHEs installed. The information in the database includes basic underground conditions (geological stratigraphy, boreholes, piezometric level, water protection areas) and preliminary GHE data submitted as part of the licensing and authorisation process. The database is also used to show the depth limitations applicable in different areas where probes can be installed and a minimum distance from the others properties, which must be not below 5% of the length of the proposed probes. No operational data from GSHP systems is included.

A licensing system in the Ticino Canton is applicable for GHES and the *Sezione Protezione Aria Acqua Suolo – Ufficio Protezione delle Acque e dell’Approvigionamento Idrico, SPAAS – UPAAI* is the licensing authority that issues the permit relating to the Waters Protection Ordinance

(WPO). The licensing process is combined with a mandatory building permit. This is further discussed in section 2.10.2 below.

The permit assessment is performed by the Ticino Canton based on mapped groundwater protection zones and areas where GHEs are allowed. The permitting time is approximately 2 months at a cost of 600 CHF for the administrative procedures and taxes as well as a cost of 100 CHF per GHE every 10 years. No follow up inspections are undertaken once the permits are granted.

EIA and EIS are not applicable as part of the permitting process and individual assessments are made by the Canton administration. Monitoring is also not applicable in the case of GHEs.

Restriction on the performance of geothermal probes (see SIA 384/6, 3.1) are applicable with average minimum temperature of the heat transfer fluid must be of -1.5°C calculated for 50 years during the extraction (following 3.2.4.2, SIA 384/6). For the injection a maximum temperature of the fluid dependent on the material of probes and grouting (following 3.2.4. and 4.1 of SIA 384/6 and UFAM, 2009) is also applicable. Additional restrictions including the prohibition of installation of GHEs in water protection zones, karst area, contaminated sites and area of unstable ground are also applicable.

2.10.2 Building, Heating and Cooling Plant Regulation

Building permission in the Canton is governed by the *Legge Dell'Edilizia* and *Regolamento Della Legge Edilizia* concerning all aspects of building licenses not only GSHP and is therefore required as part of the installation of a GSHP system. Consultation with neighbouring property owners forms part of the permit submission and objections can be received during the 2 month submission period.

The EPBD is transposed by the RUEn (*Regolamento sull'utilizzazione dell'energia, 2008)* regulations and building certification is achieved through the MINERGIE® standard. RUEn, 2008 - art. 11 and art.15 define requirements for new buildings; retrofit and transformation of public property, government buildings or buildings subsidised by a public body and set the requirements for heating and hot water (40% of renewable energy for heating - compared to needs before the replacement of the system - and 50% of the renewable energy for water heating). Article 12 of the same regulations identified heat pumps with geothermal probes as a standard solution for retrofit scenarios.

Building regulations and permissions for historical buildings are similar to those mentioned above, however specific permission and requests from cantonal, federal or municipal authorities (depending on the building) may be required and a consultation with the relevant authority is advised.

2.10.3 Policy on Renewables

National energy policy and targets for renewable energies are set in the Energy Strategy 2050 for Switzerland. Local policy on renewable energy sources for the Ticino Canton is covered under the current *Energy Plan* (DT, 2013). The plan identifies the need for identifying zones of possible use of GHEs, favours these in the case of uses with district heating networks and the use of communal GHEs for multiple buildings in retrofit scenarios. The plan is however currently under review by an energy working group (DT, DFE, AET, SUPSI, Ticinoenergia) in advance of

the approval of the State Council of Canton Ticino. The previous policy document did not provide tangible contributions from GSHPs, however this may different in the upcoming revision.

2.10.4 Other

Whilst databases of existing systems are in place in all Cantons and a requirement under 84/6, 2.3.3.2 and 2.3.3.5 necessitating the consideration of GHE design and sizing based on the planned use of the system to avoid interferences (seasonal storage, or seasonal recharge), increasing number of probes in cities are becoming a problem. The interference issues are considered in the context of the rules of thumb with regard to distances between GHEs and property boundaries and in some cases the lack of follow up data and recording of multiple GHE collectors as a single location.

2.11Residential Building Mariënburg Soest – (Netherlands)

This building is one of the two real demo cases present in 4RinEU project (H2020 call EE-10-2016). The case study site located in the Netherlands comprises a three storey building with 65 dwellings with an average surface area of 50 m^2 used as service and support structures for elderly people. A preliminary design of a GSHP system with the technologies proposed in GEO4CIVHIC is considered as part of this virtual case.

2.11.1 Shallow Geothermal Legislation and Regulation

Shallow geothermal energy systems in the Netherlands are defined in the Decree Shallow Geothermal Energy Systems (Besluit Bodemenergiesystemen), article I and V where aquifer thermal energy storage (ATES) and borehole thermal energy storage (BTES) to a depth of 500m below the surface and are defined as follow:

- ATES: "installation that uses the subsurface for the supply of heat and cold for the purpose of heating and cooling of spaces in buildings, by means of the extraction of groundwater that is re-infiltrated into the subsurface after use, including the above ground part of the installation"

- BTES: "installation that uses the subsurface for the supply of heat and cold for the purpose of heating and cooling of spaces in buildings, by means of a closed circuit of piping in the subsurface, including the above ground part of the installation"

The above are governed under the Water Law (van Beek, 2013). A revision of the Decree on SGE in 2013 included the use of BTES systems and established the local municipality as the authority for registration of BTES system. Where these are of below 70kW installed capacity a declaration is required. This declaration must include the following items:

- name of the owner
- drilling company

- plan of the site with the location of the boreholes
- thermal effects
- date of installation
- system type
- depth of the boreholes

If a system has a capacity that is higher than 70 kW, a permit is needed. This permit is issued by the municipality which decides to grant permission based on nearby existing users and the long term impact of the proposed operation.

There are no conditions or requirements attached to the permit, like for ATES systems. As part of the application, a description of the expected effects of the intended system has to be included.

The decree makes provision for the evaluation of interference that can exist between two ATES systems, two BTES systems and an ATES and BTES system. The following general rules and regulations in the case of BTES systems are applicable:

- the system has to be registered;
- the design and construction of a system has to be done by licensed persons and/or company;
- the minimum return temperature is -3 °C, the maximum retour temperature is 30 °C;
- a surplus of heat is forbidden, a surplus of cold is allowed;
- negative interference with existing open and closed systems (if registered) is not permitted;
- to prevent leaking, the pressure in the system has to be monitored continuously;
- when decommissioning a system, the glycol has to be removed and the borehole has to be filled with swelling clay (bentonite);
- monitoring/registration of certain parameters when system is in operation.

Furthermore, the decree foresees the implementation of geothermal energy systems in spatial planning. This is done by the municipality designating the so called ‘areas of interference’. Through using these areas, the interference between different systems can be prevented.. These are zones where the amount of SGE systems is or is expected to be high in a way that the application of SGE systems is or will be problematic due to a lack of space. Spatial planning of the subsurface in these zones is necessary. In these ‘zones of interference’, all BTES systems require a permit.

2.11.2 Building, Heating and Cooling Plant Regulation

The key technical document referenced in the act is the Bouwbesluit (Building Decree). The Dutch Ministry for Infrastructure and the Environment (Ministerie van Infrastructuur en Milieu, IenM) is responsible for setting planning and building regulations. The Building Decree sets out technical requirements for existing and new construction.

All building and construction in Holland must comply with the Housing Act, and thus with the Building Decree. However, some minor construction work is exempt from assessment and does

not require a permit. These can include interior refurbishment works that do not alter the structure or character of the building.

Under the Housing Act, municipalities issue building permits, supervise construction work and check permit applications for new developments against the Building Decree. Municipalities are also required to check permit applications against zoning regulations. Permit applications may also be assessed for aesthetic issues. The permitting process allows for a pre-application consultation that allows for any proposed plans to be assessed in line with the permitting requirements. In the case of the case study site the Gemeente Soest Municipality administers the *Environmental Permit for (re) building and demolition*. Depending on the nature of the proposed refurbishment works, a permit may be required. An online permit checking system can be used to ascertain the necessity based on the works and a pre-consultation with the municipality may be required at a cost of €155. In the event of historical building listed in the archaeological monuments permission and specific regulation are applicable and permission can be rejected if the works are deemed to extensive.

The implementation of the EPBD in the Netherlands has given rise to a number of legislative changes for commercial office buildings. New energy performance certificate (EPC) regulations in the Netherlands aim to reduce the country's carbon footprint. As of 2023 office buildings will be required to have an energy label of C or better, meaning that the use of office buildings with a D energy rating or lower will be illegal as of 2023. It is intended that by 2030 office buildings will have to achieve an A label. The retail, industrial and hotel sectors are likely to be selected for regulatory changes as well. Some exceptions to the above are applicable where:

- Buildings with an office function < 50%.
- Offices buildings with a total size of <100 m².
- The building is considered a national monument.

2.11.3 Policy on Renewables

The NREAP fourth report for the Netherlands suggests the contribution from heat pumps energy in the 4th progress report for heating and cooling accounted 87 and 92 ktoe of energy produced in 2015 and 2016 respectively (Ministry for Economic Affairs and Climate, 2018). This is lower than the targets of 193 and 209 ktoe for the same years set out in the NREAP.

The Municipality of Soest has set a goal of achieving CO_2 neutrality by 2050. To achieve this a Energy Transition Task force is being set up and an Energy Transition Plan is being developed. This will include the development of a *Transition Vision for Heat* to be published by 2021 where Dutch municipalities state the alternatives to natural gas as the primary source of space heating. GSHP system could play a significant role in achieving any goals set under this vision.

2.11.4 Other

Certified professionals under the implementation of the BRL 11000 and protocol 11001 (www.sikb.nl) are required for the design, construction, management and maintenance of GHEs. The regulation and protocol set out requirements for training and work experience of personnel.

A national database LGR (Landelijk Grondwater Register; National Groundwater Register) of all groundwater extractions that are present including both ATES and BTES systems. This database

is implemented under the Basic Registration Subsurface Act of 2015. Data from the database do not appear to be publicly available. Data held by municipalities on ATES and BTES systems (refer to 2.11.1) is typically not publicly available and design certified personnel can access these data on an individual case basis.

2.12Residential Building Alsamora 6 (Spain)

This is the second demo case of the 4RinEU (H2020 call EE-10-2016) project. The study site is located in Lleida in Catalonia and comprises a four storey, multi-family building of 24 dwellings with an average surface area of 45 m^2. A preliminary design of a GSHP system with the technologies proposed in GEO4CIVHIC is considered as part of this case study site.

2.12.1 Shallow Geothermal Legislation and Regulation

The definition of geothermal legislation is outlined in the section 2.2.1 for Spain. Additional regulation and legislation in Catalonia including Legislative Decree 3/2003 and Decree 328/1988, of October 11 that establish protection and additional rules regarding procedure in relation to several aquifers in Catalonia are applicable to GHE installations.

A licensing system administered by the Department of the Territory and Sustainability (and the Agència Catalana de l'Aigua in case of open loop systems) and an authorization needs to be requested for the installation of a geothermal system, open (with water collection) or closed (without water collection). The application must be completed in person through the *Territorial Demarcation Office* of the Catalan Water Agency (ACA). The application process takes 18 months and the ACA is responsible for taking care of any objections or resolutions necessary.

Closed loop GHEs are defined in the legislations and *regulations as heat exchangers where fluid from the heat pump circulates through a horizontal or vertical underground circuit of pipes. The closed loop systems do not capture groundwater, but take advantage of the driving mechanism. The circuit can reach kilometres of total length, depending on the thermal load to be dissipated*. Depending on how they are built, they can also have an impact on the subsoil.

As part of the permission the following documents are required:

- Owner ID and authorization (by owner or third party) that your data may be consulted in other administrations or agencies;
- Land Registry details site;
- Legal documents in the case of property co-ownership of representation of a company
- A technical report with the type of systems, specification documentation and the model details of the proposed system.

No specific index for quantifying interference is noted and no data on the subject appears to be publicly available.

2.12.2 Building, Heating and Cooling Plant Regulation

Catalonia's planning laws are basically those laid down by the *Generalitat*, the autonomous government of Catalonia. Other regulations can be imposed by the *Urbanisme* (planning) departments of each province, and in particular, by the *Ajuntaments* or local councils.

Building in Catalan villages, towns and residential estates brings different rules and regulations and rural lands with specific regulations and guidelines

Catalonia does have a listed building system and internal renovations to a building can be undertaken broadly without a permit provided you meet structural and habitation standards. Specific guidelines for the renovation of facades are applicable and permission is required.

Two types of permission can be sought *Obras Mayores* and *Obras Minores* depending on the works and the advice of *aparejador* or architect may be required to advise on the best process once a consultation with the municipal technical architect in completed.

2.12.3 Policy on Renewables

National policy with respect to the deployment of renewable energy sources in Spain is discussed in section 2.2.3 and includes Catalonia. An SEAP for Lleida is published but no details with regard to the use of shallow geothermal or heat pumps are specified.

2.12.4 Other

Dedicated guidelines for the use of GHSP systems in heating and cooling applications in buildings are used as a reference point (ACA, 2010). A web-GIS map viewer from the Cartographic and Geological Institute of Catalonia (http://www.icgc.cat/Administracio-i-empresa/Eines/Visualitzadors-Geoindex/Geoindex-Geotermia-superficial) publishes maps of the underground soils properties, hydrogeological characteristics, locations of large scale GSHP plants and energy produced per annum from closed loop collectors. Two of these systems are shown in Lleida. Other standards and regulations applicable are noted in section 2.24 and are applicable at national level.

Conclusion

The results of the analysis of the regulatory conditions that specifically deal with the GEO4CIVHIC technologies and their potential for deployment is summarised in table 3 below. These can be summarised as follows:

- Licensing and permitting systems for GHEs and GSHP systems are in place in 9 out of the 15 case study jurisdictions examined. These broadly range from simple authorisation and notifications to more complex permitting procedures in the case of larger systems. The assessment also demonstrates that several restrictions are in place and that these are associated with the protection of drinking water supplies and aquifers. The primary concern of the restrictions relates on the one hand to drilling through aquifers and causing potential cross contamination and on the other hand the impact on groundwater temperatures that GHEs can have during the operational phase. Other restrictions in urban areas are also in place with basic rules with regard to proximity of GHEs to other systems and neighbouring boundaries.

- Databases and registers are available generally at regional or municipal level where licensing and permitting of systems is in place. The information included in the databases is often limited to details of the location, owner, system size, type and depth of heat exchangers and in some cases of the drilling and construction of the GHEs themselves. In very few jurisdictions are monitoring data from operating systems available and these are typically confined to larger scale systems.

- The interference between operating GHEs in close proximity is generally not specifically defined and specific rules or regulations relating to this are generally not applied with the exception of basic rules of thumb applied to small scale installations and more prevalently on larger systems when at the permitting phase, detailed modelling studies are required to demonstrate the long term operation of the system on the ground.

- The transposition of the EPBD into local regulations has been reviewed for all the jurisdictions of the case study sites. In line with Article 4 of the Directive increased targets for heating, cooling and hot water demand to be met by renewable energy sources or increased Renewable Energy Requirements (RER) for the total energy demand of buildings are implemented. The implementation of the EPBD more widely refers to the use of heat pumps (not necessarily geothermal) than previously reported. The implementation of thresholds on system efficiency with respect to heat pumps for heating, cooling and domestic hot water is also applied. This is expected to further change during the implementation of the GEO4CIVHIC project.

- The implementation of the requirements under the EPBD to the refurbishment of buildings extend to retrofit of residential and public sector buildings whilst requirements are not imposed on historical buildings which are considered as mostly exempt.

- Requirements with regard to the refurbishment of historical buildings are mostly in line with existing planning and construction laws and regulations but in some cases additional laws and permits, including the use of expert advice, are required from government departments responsible for the preservation of cultural heritage. This is especially true when buildings are listed as protected. Overall there are guidelines in many of

the case study jurisdiction that present the main aspects of refurbishment of historical buildings but none that specifically deal with the implementation of renewable energy sources.

The overall applicability of these regulations demonstrates that the GEO4CIVHIC technologies may have the potential to address two broad areas of applicable regulations analysed as part of this assessment.

The first deals with restrictions applied to the use of ground heat exchangers. Where groundwater protection zones are applicable or where specific drilling methodologies forbid the installation of probes, the GEO4CIVHIC innovative drilling method combined with the coaxial heat exchanger may have the potential for additional areas to be considered for GHEs. This would be also true where areas in urban environments that may be restricted due to the impact associated with the construction operations associated with larger GHE systems. The project drilling methodology focuses on noise reduction, minimising waste disposal and reducing construction operation time.

The second area of regulations where the project technologies have potential to address the regulatory conditions analysed is the transposition of the EPBD and the potential contribution that high temperature and dual cycle heat pumps can make in the retrofitting of historical and protected buildings. These typically are exempt from the regulations, however the project technologies could significantly reduce building operational costs without altering building structure or character and promoting preservation of cultural heritage. This could potentially position the GEO4CIVHIC technologies to deliver on low impact retrofit solutions for heating and cooling which could benefit from reduced permitting requirements.

Table 3 – Regulatory Analysis Summary for the GEO4CIVHIC Case Study Site

CASE STUDY SITE		GHEs				BUILDINGS				
							Retrofit	Historical Building		
Type	Description	Licensing / Permit	Official Database	Standards / Norms	Interference (Rules)	Permit for GSHP or Retrofit	H/C & HW target	H/C & HW target	HB Permit	HB Regulation (Rg) / Guidelines (G)
Real	Historical Building Valletta Malta	Y	Y		N	Y	50% H & HW	Exempt	Y	N
Real	Historical Building Ferrara	N	Y	Y	N		50% H & HW Resid. 55% H & HW PSB			G
Real	Residential Building Mechelen	Y	Y	Y	N	Y	85% Resid. HW 10kWh/m2/yr PSB			
Real	Residential Building Wicklow Ireland	N	N	N	N	Partial	10kWh/m2/yr Resid. RER >20% of entire PSB demand	Exempt	Y	G
Virtual	Museum of Natural History of Alexandroupolis	Y	N		N	Y	achieve energy class B or better - PSB 20% to 80% saving for low to nZEB renovation	Exempt	Y	G
Virtual	Palacete de la Cruz Roja	N	N	Y	N	N	50% of hot domestic water demand	Y if >1,000m^2 ex-ceptions possible	N	
Virtual	Residential building Avangarde Forest	Y if >100m	N	N	N	Y	considered as total consumption	Exempt	Y	G
Virtual	Residential building in Bucha-rest	Y if >100m	N	N	N	Y	as above	Exempt	Y	G
Virtual	University "Ex Ospedale Geri-atrico"	Notification	Y	Y	Individual case		50% H & HW Resid. 55% H & HW PSB			G
Virtual	Historical building - Split CROA-TIA	N	Y	Y	N		Specific to building type and location	Exempt		
Virtual	University Building in Erlangen	Y	Y	Y	Individual case	Y	15 % of H HW Resid. 50% of H HW PSB		Y	
Virtual	Historical building "Castle of Attre"	Y	Y		N	Y			Y	G
Virtual	Carnegie Clondalkin Library	N	N	N	N	Partial	as above for IRL	Exempt	Y	G
Virtual	AIL - Aziende Industriali di Lu-gano	Y	Y	Y	Y	Y	40% of H & 50% of HW		Y	
Virtual	Mariënburg Soest - Netherlands	Y	Y	Y		N*	A rating by 2023			
Virtual	Alsamora 6, Catalonia	Y	Y	Y		N*			N	G

H - Heating
HW - Hot Water
RER - Renewable Energy Requirement
Resid. - Residential Building
N/A - Not Applicable
HB - Historical Building
* - in the case of minor works
PSB - Public Sector Building

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