HEATSTORE

Regulatory and policy boundary conditions for UTES

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HEATSTORE (170153-4401) is one of nine projects under the GEOTHERMICA – ERA NET Cofund aimed at accelerating the uptake of geothermal energy by 1) advancing and integrating different types of underground thermal energy storage (UTES) in the energy system, 2) providing a means to maximise geothermal heat production and optimise the business case of geothermal heat production doublets, 3) addressing technical, economic, environmental, regulatory and policy aspects that are necessary to support efficient and cost-effective deployment of UTES technologies in Europe.
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About HEATSTORE

High Temperature Underground Thermal Energy Storage

The heating and cooling sector is vitally important for the transition to a low-carbon and sustainable energy system. Heating and cooling is responsible for half of all consumed final energy in Europe. The vast majority – 85% - of the demand is fulfilled by fossil fuels, most notably natural gas. Low carbon heat sources (e.g. geothermal, biomass, solar and waste-heat) need to be deployed and heat storage plays a pivotal role in this development. Storage provides the flexibility to manage the variations in supply and demand of heat at different scales, but especially the seasonal dips and peaks in heat demand. Underground Thermal Energy Storage (UTES) technologies need to be further developed and need to become an integral component in the future energy system infrastructure to meet variations in both the availability and demand of energy.

The main objectives of the HEATSTORE project are to lower the cost, reduce risks, improve the performance of high temperature (~25°C to ~90°C) underground thermal energy storage (HT-UTES) technologies and to optimize heat network demand side management (DSM). This is primarily achieved by 6 new demonstration pilots and 8 case studies of existing systems with distinct configurations of heat sources, heat storage and heat utilization. This will advance the commercial viability of HT-UTES technologies and, through an optimized balance between supply, transport, storage and demand, enable that geothermal energy production can reach its maximum deployment potential in the European energy transition.

Furthermore, HEATSTORE also learns from existing UTES facilities and geothermal pilot sites from which the design, operating and monitoring information will be made available to the project by consortium partners.

HEATSTORE is one of nine projects under the GEOTHERMICA – ERA NET Cofund and has the objective of accelerating the uptake of geothermal energy by 1) advancing and integrating different types of underground thermal energy storage (UTES) in the energy system, 2) providing a means to maximize geothermal heat production and optimize the business case of geothermal heat production doublets, 3) addressing technical, economic, environmental, regulatory and policy aspects that are necessary to support efficient and cost-effective deployment of UTES technologies in Europe. The three-year project will stimulate a fast-track market uptake in Europe, promoting development from demonstration phase to commercial deployment within 2 to 5 years, and provide an outlook for utilization potential towards 2030 and 2050.

The 23 contributing partners from 9 countries in HEATSTORE have complementary expertise and roles. The consortium is composed of a mix of scientific research institutes and private companies. The industrial participation is considered a very strong and relevant advantage which is instrumental for success. The combination of leading European research institutes together with small, medium and large industrial enterprises, will ensure that the tested technologies can be brought to market and valorised by the relevant stakeholders.

Table of Content

1 Introduction 6
1.1 Context and objectives of WP 6.2 6
1.2 Available information 6
2 ATES 8
2.1 Denmark 8
2.1.1 Legal aspects 8
2.1.2 Enabling aspects 9
2.1.3 Drivers and barriers 9
2.2 France 9
2.2.1 Legal aspects 9
2.2.2 Enabling aspects 10
2.2.3 Drivers and barriers 11
2.3 Netherlands 11
2.3.1 Legal aspects 11
2.3.2 Enabling aspects 13
2.3.3 Drivers and barriers 14
2.4 Switzerland 15
2.4.1 Legal aspects 15
2.4.2 Enabling aspects 15
3 HT-ATES 16
3.1 Denmark 16
3.1.1 Legal aspects 16
3.1.2 Enabling aspects 16
3.1.3 Drivers and barriers 16
3.2 France 16
3.2.1 Legal aspects 16
3.2.2 Enabling aspects 17
3.2.3 Drivers and barriers 17
3.3 Netherlands 17
3.3.1 Legal aspects 17
3.3.2 Enabling aspects 17
3.3.3 Experiences 18
3.3.4 Drivers and barriers 20
3.4 Switzerland 21
3.4.1 Legal aspects 21
3.4.2 Enabling aspects 21
3.4.3 Drivers and barriers 22
4 BTES 23
4.1 Denmark 23
4.1.1 Legal aspects 23
4.1.2 Enabling aspects 23
4.1.3 Drivers and barriers 24
4.2 France 24
4.2.1 Legal aspects 24
4.2.2 Enabling aspects 24
4.2.3 Drivers and barriers 25
5 HT-BTES 26
5.1 Denmark 26
5.1.1 Legal aspects 26
5.1.2 Enabling aspects 26
5.1.3 Drivers and barriers 27

5.2 France 27
5.2.1 Drivers and barriers 27
6 PTES 28
6.1 Denmark 28
6.1.1 Legal aspects 28
6.1.2 Enabling aspects 28
6.1.3 Drivers and barriers 28
7 HT-PTES 29
7.1 Denmark 29
7.1.1 Legal aspects 29
7.1.2 Enabling aspects 29
7.1.3 Drivers and barriers 29
8 HT-MTES 30
8.1 Germany 30
8.1.1 Legal aspects 30
8.1.2 Enabling aspects 30
8.1.3 Drivers and barriers 31
9 Conclusions 32

Appendices

Appendix I: *HEATSTORE - Summary of current legal frameworks and policy incentives for UTES technologies*

1 Introduction

1.1 Context and objectives of WP 6.2

Following the demonstration of flexible energy systems with Underground Thermal Energy Storage in WP4, Task 6.2 has been assessing how this technology can be implemented within the EU by providing a detailed analysis of current regulations and standards. This report focuses on the existing regulatory frameworks associated with UTES technologies in a sample of member states (Netherlands, France, Switzerland, Denmark, Germany) participating to the HEATSTORE project, specifically observing if enabling policy frameworks are already in place and identifying potential barriers for these technologies. The report also summarises information on best practice regulatory frameworks for the above listed member states.

Depending on the country, a specific type of UTES technology has been focused on. The following list summarises the type of UTES system about which each country has been providing information:

- Germany: Risk and hazard analysis for future thermal storage projects based on the gained results during the two-year operation phase of the GZB mine thermal energy storage and the regulatory boundary conditions.

- Denmark: GEUS has been contributing in reviewing existing regulations and policies in Denmark for ATES, BTES and PTES systems.

- Netherlands: IF and TNO have provided an overview of legal frameworks for high temperature ATES in the Netherlands

- Switzerland: SIG has worked on the current Swiss legal framework for UTES systems and its potential improvements.

- France: BRGM has realised a summary of the different aspects of the French regulation to take into account for UTES implementation, from the point of view of the underground (mining and environment laws), urbanism and building thermal regulation laws.

We also invite the reader to refer to Chapter 6 of the deliverable D1.1 ***- HEATSTORE Underground Thermal Energy Storage (UTES) – state-of-the-art, example cases and lessons learned***, which has a specific section presenting an overview by country of the current regulatory frameworks in place.

1.2 Available information

The objective of task 6.2 was to analyse and summarise the various regulatory frameworks of each member state and the current limitations in implementing UTES technologies to develop a “best practice guide”.

To achieve this goal, we have sent out a questionnaire to all members to collect the available information in each country for the different UTES systems (ATES, BTES, MTES, PTES) at high temperature (>50°C) and low temperature (<50°C). Not every type of UTES system has been implemented until now in each country as can be seen in Table 1 below.

Table 1. Overview of the available information for each country.

Countries	ATES	HT-ATES	BTES	HT-BTES	PTES	HT-PTES	MTES	HT-MTES
Denmark	Yes	Yes	Yes	Yes	Yes	Yes	No	No
France	Yes	Yes	Yes	Yes	No	No	No	No
Germany	No	No	No	No	No	No	No	Yes
The Netherlands	Yes	Yes	No	No	No	No	No	No
Switzerland	Yes	Yes	No	No	No	No	No	No

In the following chapters, we will present in detail the results of the questionnaire for each UTES system and each country (see also Annex 1), while emphasising the main implementation barriers and the best practice features.

2 ATES

2.1 Denmark

2.1.1 Legal aspects

Existing laws on national/regional level

ATES is regulated by The executive Order on "Heat extraction plants and groundwater cooling systems" (BEK no. 1716 of 15/12/2015) supplemented by The Water Supply Act (LBK nr 1450 of 05/10/2020), according to which extraction permits are granted. If heat is supplied to a heating network a permit according to The executive Order on Heat Supply (LBK nr 1215 of 14/08/2020) is needed as well. Finally, drilling and mandatory reporting of borehole data to GEUS is regulated by The executive Order on "Boreholes and drilling " (BEK no. 1260 of 28/10/2013).

Legal obligations regarding temperature limits and well distances

Water passing the injection valve must not exceed 25 C and in monthly average it must not exceed 20 C. Furthermore, injected cooled water must be have a monthly average temperature of at least 2 C. No distance requirements to other wells are given, but it must initially be assessed by numeric modelling that temperatures in neighbouring water supply wells will not rise more the 0.5 C.

Legal obligations regarding monitoring tools and procedures before, during and after exploitation phase

Automated temperature logging and pressure surveillance must be installed.

Objects / requirements for geological feasibility studies are given in the applicable act:

Origin, extent and hydraulic properties of the aquifer
Chemistry and microbiology of the aquifer
Pollution risk assessment
Furthermore, initial numerical modelling must show that the groundwater resource 10 year after stop of heat storage is suited for drinking water.

Legal differences between shallow and deep aquifers

For aquifers deeper that app. 300 m the Underground Act (LBK nr 1190 af 21/09/2018) also must be consulted.

Existing workflows between project developers and authorities

The developer or a consultant will produce the required material and submit it to the municipality. From this material the municipality will produce a scope for an EIA screening, will hear neighbours and organisations affected by the project and involve other authorities responsible for elements of the project. If needed a full EIA will be conducted. An EIA permission with specific requirements and permission related to other legislation will be granted.

Legal obligations regarding the abandonment/dismantling

General rules and procedures for abandonment of boreholes are given in The executive Order on Boreholes and drilling (BEK no. 1260 of 28/10/2013).

Competent authorities

The municipalities act as first authorities and are required to involve and coordinate with other authorities.

2.1.2 Enabling aspects

a) Available public databases

https://data.geus.dk/geusmap/?mapname=jupiter&lang=en

b) Subsidies or incentive programmes on national/regional level

The Danish Energy Agency has a technical development and demonstration program (EUDP) that supports innovative energy solutions.

c) Available decision-making tools

https://data.geus.dk/geusmap/?mapname=varmelagring&lang=en
Dedicated group of experts working together on national/regional level informally to some extent.

2.1.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Low maximum temperature

2.2 France

2.2.1 Legal aspects

a) Existing laws on national/regional level

At national level, geothermal Energy is regulated by the Mining Law ("Code Minier"). There is no specific framework for UTES (LT-UTES or HT-UTES).
The Mining Law gives a general framework. However, every project has to complete with the (site-specific) following regulations:

- objectives and provisions of the water management and management plans (SDAGE)
- regulations of the water management and management schemes (SAGE)
- natural hazard prevention plans (town halls)
- regulations for the protection areas of water withdrawal points intended for human consumption (town halls)
- regulations for the protection of underground storage facilities for gas, oil or chemicals instituted under Book II of the Mining Code (town halls or DREAL)
- provisions of the departmental health regulations regarding the taking of water intended for human consumption.

b) Legal obligations regarding temperature limits and well distances

Mining Law:
- Maximum temperature change 200 m away from the injection well should not exceed 4°C
- Maximum temperature injection mus be kept below 32 °C.

c) Legal obligations regarding monitoring tools and procedures before, during and after exploitation phase

Mining laws give general objectives to reach (ensure water quality, not disturb neighbouring installations, etc.), but little prescriptions to get there.

During the drilling:
- Wells must be cemented on the whole depth. The cement density must be > 1.7, with a thickness of minimum 4 cm (between the casing and the hole). The cement composition must be adapted if gypsum or salt is encountered.
- For every drilling: geological outcrop, equipment description, conditions of realisation, water intakes, and cementation description (and possible verification)

At the end of the drilling phase:
- pumping tests with constant flow rate, for at least 24 h with temperature and pH follow-up. hydraulic head must be followed up on every well. A well log must be realized.
- Further, if the flowrate is higher than 8 m^3/h, further hydraulic testing is required. Water sampling for chemical analysis in situ (pH, redox, conductivity, temperature, dissolved O2) and in lab (alkalimetries and full alkalimetries, hydrometrics, calcium, magnesium, sodium, potassium, fer, copper, zinc, manganese, aluminium, chlorides, sulphates, nitrates, nitrites, phosphates, calcite-carbonate balance, ferruginous bacterial and sulfatoreduced bacterial)

Nota 1: Here again, further requirements can be defined in the SAGE and SDAGE (regional/local levels) to ensure water quality. cf. 5.1.2

d) Legal differences between shallow and deep aquifer

One condition for the declarative regime to apply is that the borehole depth is less than 200m.

e) Legal differences between projects depending on their capacities

One condition for the declarative regime to apply is that the thermal power is less than 500kW.

f) Existing workflows between project developers and authorities

Project developers must declare the exploitation, start of work and end of exploitation online.

g) Legal obligations regarding the abandonment/dismantling

Here again, the mining law gives general prescriptions.
The quality of cementation and borehole must be checked before the borehole is filled. The borehole must be cemented, excepted on its strainer where it is filled with gravel. The upperpart of the borehole must be sealed with clay and cement and easily localisable.

h) Timeline of legal procedures

None, since it is declarative.

i) Competent authorities

The competent authority is at national level: DRIEE (direction régionale et interdépartementale de l'Environnement et de l'Énergie) in Paris Region (Ile de France) and DREAL (Directions Régionales de l'Environnement, de l'Aménagement et du Logement) elsewhere. These administrations are patronaged by the Ministry of Ecology (Nota: "Regional" = regional office of a national administration).

2.2.2 Enabling aspects

a) Existing guidelines on national/regional levels

French norm NF X 10-999 "Water and geothermal drilling - Construction, monitoring and abandonment of collection or monitoring works for groundwater carried out by drilling".

b) Best practice guidelines on national/regional levels

See above.

c) Available public databases

- Underground DB (Banque de données du sous-sol - infoterre.brgm.fr)
- geothermies.fr
- databases related to groundwater: SIGES and BD-LISA

d) Subsidies or incentive programmes on national/regional level

The "Fonds Chaleur" is a financial support system for the development of renewable heat production managed by ADEME (French Energy Management Agency), giving subsidies to almost economically viable projects. The subsidy may be completed by the Regions (site-specific). Minimum project size corresponding to 50 MWhRE/y extracted from the ground.

e) Dedicated group of experts working together on national/regional level

Mainly ADEME (French Energy Management Agency), AFPG (French Association of Geothermal Energy Professionals) and BRGM.

f) Other enabling aspects

Several documents published by ADEME, BRGM and AFPG demonstrating the variety of use of GSHP.

2.2.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

The thermal regulation of building (RT2012) has not been favourable to GSHP so far (e.g. computation of excessive peak powers, etc.). This may change in next approach (RE2020).

2.3 Netherlands

2.3.1 Legal aspects

a) Existing laws on national/regional level

The legal framework applicable to ATES systems is dependent of the depth at which it is installed: up to 500 m below ground surface (mbgs), the Water Law applies. At greater depth, the Mining Act is applicable with more stringent safety prescriptions. In the Netherlands, all low temperature (<25 ºC) ATES systems are located shallower than 500 mbgs. HT-ATES categorizes as an ATES system hence the same legal framework applies to ATES and HT-ATES on a national level. In this report, it is focussed on the legal framework for ATES and HT-ATES systems for depths < 500 mbgs, i.e. the Water Law. Regulations for (HT)ATES systems deeper than 500 mbgs (permitted through the Mining Law) are not discussed.

The Water Law assigns the Provinces as the licensing authority for ATES systems. The expectation is that the Water Law will be incorporated in the ‘Environmental Law’ as from July 2022, but the regulations do not significantly change.

b) Legal obligations regarding temperature limits and well distances

Generally, the Water Law states that ATES systems may be realized when infiltration temperatures are below 25 ºC and when no net heat is added/extracted from the subsurface. Exceptions to these rules are possible, but only conditionally when the interest of the protection of the subsurface is not violated. This means that HT-ATES (>25 ºC, net addition of heat to the subsurface) can be permitted if the conditions are met, according to the licensing authority.

The general criterium is that ATES wells are not allowed to negatively impact other interests, and that the system itself is effective. No specific well distance regulations apply.

c) Legal obligations regarding monitoring tools and procedures before, during and after exploitation phase

No specific monitoring activities are prescribed in the Water Law. However, the provinces have committed to following the 'BUM' guidelines for permitting low temperature ATES systems, and these guidelines include an 'example permit' for ATES-systems in which (monitoring) prescriptions are formulated. For low temperature ATES, most provinces strictly follow these example permit prescriptions, but customization is possible. Following the BUM, more elaborate monitoring activities are prescribed for ATES in fresh groundwater aquifers (compared to saline water).
HT-ATES systems cannot comply with the standard BUM prescriptions, because of 1) the higher maximum infiltration temperature (>25 ºC) and 2) the net heat addition to the subsurface. The BUM states that custom prescriptions can be applied regarding these two aspects, provided that HT-ATES systems are assigned as 'research projects'. No further regulations apply to this status however, which leaves the province with the responsibility to assess the risks and formulate prescriptions.

d) Legal differences between shallow and deep aquifers

For ATES systems up to 500 mbgs (permitted under the Water Law), no further depth-related criteria are applied. ATES deeper than 500 mbgs need a permit issued through the legal framework of the Mining Law, but regulations for these deep ATES systems are not covered here.

e) Legal differences between projects depending on their capacities

No specific rules are applied to systems with larger flow rates (capacities). However, systems with higher capacities will have larger effects, while negative impacts on other interests still need to be avoided.

f) Existing workflows between project developers and authorities

For all ATES systems, the hydrological, thermal and geochemical effects have to be described in the permit application, so that the Province can assess whether these effects are acceptable for other subsurface stakeholders. The standard permitting procedure for ATES and HT-ATES systems under the water law is as follows:
1) the ATES license applicant starts up a permitting procedure by providing three documents:

- a permit application form, specifying the requested storage volumes, temperatures and other specifications of the ATES system;
- a report in which the effects of the ATES system are described;
- an application to follow a brief procedure, in which no large-scale 'MER'-study of the effects is required (this application is referred to as the 'MER'-assessment).

2) The province, being the permitting authority, has to decide within 6 weeks whether it is acceptable to follow the permitting procedure without the large-scale 'MER'-study, which is almost always the case for (HT)ATES systems. Simultaneously, they have to issue the permit within 8 weeks after permit application (following the regular terms), or after 6 months if the extensive procedure is followed (choice for the extensive procedure needs to be substantiates by province).
3) Once the permit is granted, it is published so that other parties can object within 6 weeks. If no objection is raised during this period, the permit will automatically be irrevocable.

The 'BUM' is an assessment workflow used by the permitting party during the permitting procedure of low temperature ATES systems. Although most of the prescriptions in the BUM apply to HT-ATES too, the higher temperatures and net addition of heat to the subsurface still require specific attention.

g) Legal obligations regarding the abandonment/dismantling

The BUM also provides standard prescriptions for the abandonment and dismantling of ATES wells. These will also be applied to HT-ATES wells, potentially with additional requirements for the heat left in the subsurface.

h) Timeline of legal procedures

Following the formal procedure terms, it usually takes 14 weeks from the day of application to obtain an irrevocable ATES permit, assuming that the regular procedure applies (8 weeks permit + 6 weeks objection) , see section f) above. For HT-ATES, the 14 weeks apply to the formal procedure. However, before the formal procedures start, the permit applicant typically organized multiple meetings with the province to introduce the plans, to discuss what local policies apply and to learn about the permitting procedure term that the province pursues. This may take several months.

i) Competent authorities

The Water law states that the mandate of issuing ATES and HT-ATES permits is with the Provinces, but these may submit its authority to a (governmental) environmental executive party.

j) Other legal aspects

Regional policies which are defined at a provincial or municipal level may further work out the regulatory framework for ATES systems. For example, ATES is forbidden in areas where drinking water is produced. Also, municipalities may assign specific locations for the positioning of hot/cold ATES wells in an ATES Masterplan.

2.3.2 Enabling aspects

a) Existing guidelines on national/regional levels

The legal framework facilitates both ATES and HT-ATES systems up to 500 mbgs (Water Law). The BUM (discussed above) provides the workflow for a consistent assessment of ATES permit applications. This combination has proven to be essential for large-scale implementation of low temperature ATES since 2013. The BUM is also applicable to HT-ATES systems, but for the higher temperatures and net heat addition to the subsurface, an assessment framework is desirable which is currently being worked out within the national WarmingUP program.

b) **Obligatory technical guidelines for the design, realization and exploitation are defined in ‘BRL’ certifications.** These guard the successful application of ATES through regular auditing of the certified parties and through updating the guidelines based on new insights. Best practice guidelines on national/regional levels

c) Technical best practice guidelines have been translated to protocols and certifications (see a)), which are also applicable to HT-ATES. Also, parties with knowledge and experience in ATES and HT-ATES know how to find each other.

d) Mid to long term development schemes/masterplans for sustainable use.

Provinces acknowledge the need for low temperature ATES to achieve climate goals, as this technology has been proven successful over the past 2-3 decades. Hence, the promotion of ATES is included in regional policies. Increasingly more provinces also stimulate the application of HT-ATES, but generally special attention is given to its potential negative effects. On a municipal level, increasingly more Master plans are set up, in which large-scale low temperature ATES systems are planned in an optimal way. Also, more district heating networks are planned and constructed, which opens up opportunities for (HT)ATES.

e) Available public databases

Various public databases are available (www.dinoloket.nl, www.grondwatertools.nl), holding subsurface information, which are used to research the subsurface effects (during permitting procedure) and to work out an ATES design. Also, information from all Dutch oil and gas drillings over 5 years old are publicly available through www.nlog.nl. Borehole logs of nearby wells may be available at the province, upon request.

f) Supporting policies on national level

The Dutch government has formulated a national Climate Accord in 2019 (Klimaatakkoord 2019), together with over 100 parties, aiming for at least 55% reduction in CO2-emissions in 2030 and a net zero emission in 2050, in line with the EU goals. The accord aims for sustainable heating and cooling of the built environment, which will require even greater ATES application.

Regarding HT-ATES, the Climate Accord specifically mentions that the heating sector strives to develop high temperature heat storage, ‘in addition to the HEATSTORE project’.

g) Subsidies or incentive programmes on national/regional level

Generally, for all technically potential systems that provide sustainable heat, the unprofitable difference may be subsidized (DEI+). Subsidies may be available for realization and for optimization research. Also, subsidies for sustainable heat production (SDE+ for geothermal, solar heat) provides a stimulus for HT-ATES realization, as HT-ATES increases the net yearly production of these heat sources.

h) Available decision-making tools

The BUM provides the assessment framework for LT-ATES. An additional assessment framework is being set up for HT-ATES to handle the high-temperature related aspects.

i) Dedicated group of experts working together on national/regional level

On many levels of society (governmental, research, engineering companies, market), experts are working together to develop, implement and optimize both ATES and HT-ATES. Many of these various stakeholders of society and the value chain are brought together in the Dutch ATES sector network (BodemenergieNL), which coordinates and/or tracks these developments.

2.3.3 Drivers and barriers

For low temperature ATES, the drivers and barriers are:

- Driver: the technique has been proven successful over the last decades, and the procedures for permitting, designing, realizing and exploiting these systems are well-established, meaning that further implementation is possible.
- Driver: Knowledge sharing occurs between industry/experts and authorities
- Barrier: ATES is not as prominently discussed as wind/solar power, even though it is a successful technique.

Barrier: the large-scale application of many ATES system in urbanized areas requires planning, but a proactive attitude is needed of municipalities as authority on the subsurface on a municipal scale.

2.4 Switzerland

2.4.1 Legal aspects

a) Existing laws on national/regional level

- Law on Water (OEaux)
- Competent authorities on regional level (cantons).
- Important differences in legislation on regional level

b) Legal obligations regarding temperature limits and well distances

- Temperature difference in the aquifer of max. 3°C (except within a radius of 100 m)
- Max. injection temperature: 30°C
- No distance limitations for production wells
- No depths limitations

2.4.2 Enabling aspects

a) Existing guidelines on national/regional levels

Existing technical standards (norm SIA 384/7).

b) Best practice guidelines on national/regional levels

Each case needs a specific and elaborate analysis for the approval procedure

c) Mid to long term development schemes/masterplans for sustainable use

No mid to long term development schemes

d) Available public databases

Available public databases (maps and GIS tools)

e) Supporting policies on national level

Funding possibility ('CO2 law')

3 HT-ATES

3.1 Denmark

3.1.1 Legal aspects

a) Existing laws on national/regional level

- 'Environmental Protection Act' (LBK nr 1218 of 25/11/2019)
- The Danish Subsoil Act ' (LBK nr 1533 of 16/12/2019) for wells > 250 m
- Drilling and mandatory reporting of borehole data to GEUS is regulated by The executive Order on Boreholes and drilling (BEK no. 1260 of 28/10/2013).
- If heat is supplied to a heating network a permit according to The executive Order on Heat Supply (LBK nr 1215 of 14/08/2020) is needed as well.

b) Existing workflows between project developers and authorities

P.T. not developed

c) Legal obligations regarding the abandonment/dismantling

General rules and procedures for abandonment of boreholes are given in The executive Order on Boreholes and drilling (BEK no. 1260 of 28/10/2013).

d) Competent authorities

The municipalities act as first authorities and are required to involve and coordinate with other authorities.

3.1.2 Enabling aspects

a) Subsidies or incentive programmes on national/regional level

The Danish Energy Agency has a technical development and demonstration program (EUDP) that supports innovative energy solutions.

b) Subsidies or incentive programmes on national/regional level

Tax on unused surplus heat

3.1.3 Drivers and barriers

More knowledge about deeper reservoirs needed

3.2 France

3.2.1 Legal aspects

a) Existing laws on national/regional level

'Mining Law' (no specific framework for UTES) for wells > 200 m

b) Legal obligations regarding temperature limits and well distances

No temperature limits for reinjection except for drinking water resources

c) Legal obligations regarding monitoring tools and procedures before, during and after exploitation phase

Demonstration of no impact on neighbouring installations

d) Legal differences between projects depending on their capacities

- Two types of exploration procedures
- Two types of mining permits (< or > 200 MW)

e) Timeline of legal procedures

Timeline of legal procedure about 3 years

f) Competent authorities

Competent authority at national level (same as for section ATES).

3.2.2 Enabling aspects

a) Best practice guidelines on national/regional levels

Existing best practice guide

b) Available public databases

Available public databases

c) Supporting policies on national level

Financial support system 'Fonds Chaleur'

d) Dedicated group of experts working together on national/regional level

Group of experts (ADEME, AFPG, BRGM)

3.2.3 Drivers and barriers

No implementation barriers

3.3 Netherlands

3.3.1 Legal aspects

Following the Dutch legal definitions for ATES up to 500 m depth, High Temperature ATES (HT-ATES) is juridically equal to ATES. Therefore, the legal framework of ATES and HT-ATES are discussed under the ATES section (see 2.3.1). The main issue is that regulations apply up to 25°C and that above those operating temperatures a project can only be permitted as ‘research’ or ‘pilot’ project. Therefore, divergence in permit provisions may occur depending on which province is the licensing authority.

3.3.2 Enabling aspects

The enabling aspects for both low temperature ATES and HT-ATES are discussed in 2.3.2.

3.3.3 Experiences

The regulatory framework most relevant for HT-ATES is summarized in the table below[1]. Important aspects to consider for HT-ATES that have influence on the applicable framework and specific guidelines are the temperature and the depth of injection/production. The depth determines whether the Mining act and related regulations are applicable or the Water act and related regulations. It also determines the competent authority for the permitting procedure.

When a project is proposed to be shallower than 500 m depth. This results in some important restrictions for ATES projects. The most important restrictions are the maximum allowed injection temperature of 25°C, limitations on the effect of heating the subsurface and the requirement to achieve net energy equilibrium every 5 years.

Table 2. Summary of regulatory framework for ATES.

Depth of storage	**<500 m**	**>500 m**
Applicable regulatory framework	• Waterwet • Waterbesluit (AMvB Wijzigingsbesluit bodemenergiesystemen) • Waterregeling • Besluitvormingsuitvoeringsmethode (BUM) provinciale taken en Hand-havingsuitvoeringsmethode (HUM) provinciale taken,	• Mijnbouwwet • Mijnbouwbesluit • Mijnbouwregeling
Most important restrictions	• Infiltration temperature <25°C • No heating of the subsurface • Net energy equilibrium every 5 years	*No specific limitations set for HT-ATES*
Competent authority	Province	Ministry of Economic affairs
Procedure duration	~5 months (minimally)	6-9 months
Permit	Watervergunning (artikel 6.4 Waterwet)	Opslagvergunning (art. 25 Mijnbouwwet)

According to Dutch law[2] injecting water with a temperature above 25°Celsius is only allowed if the project is considered to be a pilot R&D project. Pilot projects for injection of water with temperatures above 25°Celsius have been permitted and realised in the Netherlands[3]. Important lessons have been learned with the vast amount of ATES projects and with the pilot HT-ATES projects, but the regulatory framework has not yet fully materialised. Experiences gained during the legal procedures of four different HT-ATES systems are described.

[1] This information is originally assessed and printed in the following TNO reports: TNO, Technische en Juridische belemmeringen Hoge Temperatuuropslag (HTO), 2015 and TNO, Feasibility study of a High Temperature Aquifer Thermal Energy Storage at AVR Duiven,

[2] Besluit van 25 maart 2013 tot wijziging van een aantal algemene maatregelen van bestuur in verband met regels inzake bodemenergiesystemen en enkele technische verbeteringen, https://zoek.officielebekendmakingen.nl/stb-2013-112.html

[3] Thermisch rendement hoge & middelhoge, temperatuur warmteopslag in de bodem, IF Technology 2014. https://www.kasalsenergiebron.nl/content/user_upload/MTO_en_HTO.pdf

HT-ATES Geomec

In the province of South-Holland a HT-ATES project has been permitted, but the project execution has never started. The project has yielded some interesting experiences regarding regulatory framework.

The project was designed to store heat from geothermal sources in target reservoirs at 85–200-meter depth. It would have a volumetric injection/production capacity of 600 m^3 per hour and a thermal capacity of 20-25 MWth. Injection temperature in summer was designed at 84 °C.

In TNO (2015, 2016)[4],[5] the lessons learned have been reported. Further details are there included on the provincial guidelines that indicate the set of boundary conditions for (HT-)ATES design and operation and set guidelines for monitoring.

The process for this project followed a now outdated permitting procedure and regulatory framework but did show that the whole process took about 11 months from submitting the permit request to issuing of the permit for a pilot period of 6 years. The delay compared to minimal duration for this procedure was due to the relative new nature of HT-ATES technology and its potential impacts, complexity in the procedure and unclarity/unfamiliarity with setting permitting requirements. At several occasion new information was requested by the competent authority and added to the permit request.

The experience with the permitting procedure yielded that important aspects to take into account are:

- The effects of the injection of high temperature reservoir water, including hydrothermal effects, geo-chemical effects and effects on microbiological populations in the subsurface.
- The amount of heat stored, the surplus of heat stored and the possible effect of surplus heat in the subsurface.
- The expected energy efficiency and its related environmental benefits (e.g. emission reduction).

To assess, minimize and monitor these effects careful procedures have been developed in earlier (pilot) projects and implemented to assess and monitor these effects over the full life cycle of the projects. These procedures have been laid down in permitting procedures. To minimise the environmental effects due to the proposed project these procedures can be followed and be improved/adapted as necessary. Careful discussion with the competent authority (and other stakeholders) are thus important to set the boundary conditions for design and operation of the ATES.

HT-ATES at NIOO (HEATSTORE case study)

At NIOO in Wageningen, solar heat is produced and stored in a HT-ATES system at maximum 45 ºC. The target aquifer was a fine sand layer with salt groundwater at 220 – 300 mbgs, located approximately 50 m below a high-quality freshwater aquifer (120 – 170 mbgs). The heat storage was permitted under the Water Law, providing that the quality of the fresh water aquifer was not negatively affected. To track the effects of the HT-ATES on the freshwater aquifer, multiple monitoring wells were to be installed between the top of the heat storage and the bottom of the freshwater aquifer. In the original permit (2010), monitoring activities were prescribed, resulting in high yearly monitoring expenditures at NIOO, while the effects remained limited. In January 2021, the permit was adjusted after months of preparatory communication, which is related to the fact that fresh water is an important natural resource in the Netherlands. The lesson learned from this project is that changing only the set of monitoring parameters (based on new insights) was a long-term and time-consuming process, advocating for more flexible ways to change monitoring plans in

[4] TNO, Technische en Juridische belemmeringen Hoge Temperatuuropslag (HTO), 2015
[5] TNO, Feasibility study of a High Temperature Aquifer Thermal Energy Storage at AVR Duiven, 2016

other HT-ATES systems, without having to follow extensive Water law procedures. In the Dutch HT-ATES demonstration project in Middenmeer, a better approach was used for the monitoring of groundwater effects.

HT-ATES at ECW in Middenmeer (HEATSTORE demonstration project)
One must note that for a HT-ATES initiator, a permit is regarded as a legal 'green light' for HT-ATES, allowing the investor to open up financial resources to further develop the project: the initiator may not order for a costly test drilling when the permission is uncertain.
The positive experience with this project was that the permit procedure was relatively streamlined, resulting in a permit in 2018. On the one hand, this was due to limited effects on the surroundings, because of the local subsurface conditions and limited number of stakeholders around. But, importantly, in the permitting process there was no need for detailed discussions about what parameters needed to be monitored: The permit simply stated that a monitoring plan was to be put up by the initiator, and to be agreed upon by the authorities, before the HT-ATES was to be taken into operation. This meant that the monitoring plan could be constructed after the test drilling, i.e. after the lithology and groundwater composition were known. This allowed for an accurate assessment of environmental risks and an effective monitoring plan. The monitoring plan was proposed to and approved by the authorities in 2021, before operation started in May 2021. As an additional advantage, the monitoring activities are not taken up in the permit itself but in the monitoring plan, meaning that it is easier to adapt the plan based on new insights.

3.3.4 Drivers and barriers

a) Current implementation barriers regarding existing regulatory and policy framework

- Only a limited number of provinces (the competent authority for HT-ATES) has formulated policies for HT-ATES, leaving HT-ATES initiators in some provinces uncertain about the Province's standpoint on this technique.
- Although the legal framework offers room for HT-ATES application, there is no workflow available to the permitting party for the assessment of the risks related to high temperature and net heat addition to the subsurface. Historically, this has resulted in long and complex permitting procedures with uncertainty about the prescriptions.
- Before costly investments are done in the realization of a HT-ATES system (e.g. test drilling, well design), the HT-ATES initiator needs a permit, as this is seen as the legal 'green light' for HT-ATES application. This also means that delay in the permit procedure delays the development of the system as a whole. The complex procedure with uncertain outcome is a barrier to large-scale implementation of HT-ATES.
- The BUM prescribes that HT-ATES should be assigned a 'research project'-status.
- In permitting procedures the duration of the permit is in cases restricted to certain amount of years (e.g. 5 or 6) which results in a uncertain project lifetime for the project initiator, yielding a project financial risk.
- Funding schemes are complicated and a specific funding scheme for HT-ATES is absent.
- CO2 tax and subsidies are sometimes perceived as unfair (higher CO2 tax and subsidies for HT-ATES needed)
- HT-ATES is not yet ranked high enough on the political agenda (awareness and strategy needed; a joint vision on the importance of HT-ATES on a national level).

b) Current implementation drivers regarding existing regulatory and policy framework

- Vast experience with ATES systems and recent experience for some competent authorities with pilot HT-ATES systems provide a steppingstone for future HT-ATES projects. Some procedural learnings with these projects have helped to start discussions of common national guidelines for HT-ATES projects.

- A major driver for the short-term implementation of more sustainable heating systems, is the rapid phasing out of natural gas production and consumption in the Netherlands, because production is causing earthquakes. As natural gas forms the backbone of the Dutch heating system, there is a huge drive to develop alternatives now that gas production planned to be phased out in a short time frame.
- National and international climate ambitions have been translated to laws and policies, which act as concrete drivers for sustainable heating including HT-ATES.
- EU Emissions Trading System (ETS) starts paying of, as CO2-emissions become more expensive. This drives sustainable applications for heating. As sustainable heat sources (geothermal, solar heat) typically mismatch the demand pattern, heat storage becomes of vital importance for the heating system.
- Grid congestion on the electricity transmission and distribution grid warrants alternatives for supplying heat for heating commercial buildings and dwellings via heat pumps. This opens up opportunities for local and regional heating grids to expand or emerge. This in turn opens up opportunities for heat storage systems supporting the transition of fuelling these heat grids.
- Subsidy schemes for low carbon heating sources such as geothermal, solar thermal and biomass provide a starting point for building minimal viable business cases. But this is not yet enough to support commercial project development without specific support mechanisms for heat storage.

3.4 Switzerland

3.4.1 Legal aspects

a) Existing laws on national/regional level

- Water Law (OEaux) but no specific legislation for aquifer temperatures > 25 °C
- Competent authorities on regional level (cantons)
- Important differences in legislation on regional level

b) Legal obligations regarding temperature limits and well distances

- Temperature difference in the aquifer of max. 3°C (except within a radius of 100 m)
- No distance limitations for production wells

c) Legal differences between shallow and deep aquifers

No depth limitations.

3.4.2 Enabling aspects

a) Existing guidelines on national/regional levels

No technical standards/guidelines existing.

b) Best practice guidelines on national/regional levels

Each case needs a specific and elaborate analysis for the approval procedure.

c) Mid to long term development schemes/masterplans for sustainable use

No mid to long term development schemes.

d) Available public databases

Available public databases (maps and GIS tools).

e) Supporting policies on national level

Funding possibility ('CO2 law').

f) Dedicated group of experts working together on national/regional level

Experts working together through research projects.

3.4.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Implementation barriers: max. temperature difference of 3°C, no guidelines for T> 25 °C, need for more flexibility.

4 BTES

4.1 Denmark

4.1.1 Legal aspects

a) Existing laws on national/regional level

- 'Environmental Protection Act' (LBK nr 1218 of 25/11/2019)
- The Danish Subsoil Act ' (LBK nr 1533 of 16/12/2019) for wells > 250 m
- If heat is supplied to a heating network a permit according to The executive Order on Heat Supply (LBK nr 1215 of 14/08/2020) is needed as well.

Finally, drilling and mandatory reporting of borehole data to GEUS is regulated by The executive Order on Boreholes and drilling (BEK no. 1260 of 28/10/2013).

b) Existing workflows between project developers and authorities

The developer or a consultant will produce the required material and submit it to the municipality. From this material the municipality will produce a scope for an EIA screening, will hear neighbours and organisations affected by the project and involve other authorities responsible for elements of the project. If needed a full EIA will be conducted. An EIA permission with specific requirements and permission related to other legislation will be granted.

c) Legal obligations regarding the abandonment/dismantling

General rules and procedures for abandonment of boreholes are given in The executive Order on Boreholes and drilling (BEK no. 1260 of 28/10/2013).

d) Competent authorities

The municipalities act as first authorities and are required to involve and coordinate with other authorities

4.1.2 Enabling aspects

a) Existing guidelines on national/regional levelsz

No existing guidelines

b) Best practice guidelines on national/regional levels

No official best practise guidelines, but as a result of monitoring of the performance of BTES and PTES in Denmark PlanEnergi produced "Best Practise for implementation and operation of large scale borehole and pit thermal energy storages" https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Best-practice-Br%C3%A6dstrup-Marstal-Dronninglund-and-Gram-003.pdf

c) Subsidies or incentive programmes on national/regional level

No subsidies or incentives for BTES, but the Danish Energy Agency has a technical development and demonstration program (EUDP) that supports innovative energy solutions.

d) Available decision-making tools

https://data.geus.dk/geusmap/?mapname=varmelagring&lang=en
Dedicated group of experts working together on national/regional level informally to some extent.

4.1.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Specific areal planning needed. Tax on heat from waste incineration

4.2 France

4.2.1 Legal aspects

a) Existing laws on national/regional level

'Mining Law' (no specific framework for UTES). Mining Law regulations are general prescriptions.

b) Legal obligations regarding temperature limits and well distances

- Injection temperature into the borehole heat exchangers (BHE) must be between -3 °C and 40 °C.
- At least 5 m from the plot boundary and from buried pipes of wasted water.

Legal differences between shallow and deep aquifers

Legal procedure is only declarative (for wells < 200 m and capacities < 500 kW and injection temperature < 40°C).

c) Legal differences between projects depending on their capacities

Site-specific regulations.

d) Competent authorities

Competent authority at national level.

4.2.2 Enabling aspects

a) Existing guidelines on national/regional levels

Existing technical standards

b) Available public databases

Available public databases

c) Supporting policies on national level

Financial support system 'Fonds Chaleur'

d) Dedicated group of experts working together on national/regional level

Group of experts (ADEME, AFPG, BRGM)

4.2.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

- stacking of regulations
- data must be retrieved from different platforms
- no long-term development plans
- no supporting policies
- thermal regulation of buildings not in favour of GSHP

5 HT-BTES

5.1 Denmark

5.1.1 Legal aspects

a) Existing laws on national/regional level

- Environmental Protection Act (LBK nr 1218 of 25/11/2019)
- The Danish Subsoil Act ' (LBK nr 1533 of 16/12/2019) for wells > 250 m
- Drilling and mandatory reporting of borehole data to GEUS is regulated by The executive Order on "Boreholes and drilling" (BEK no. 1260 of 28/10/2013).
- If heat is supplied to a heating network a permit according to The executive Order on Heat Supply (LBK nr 1215 of 14/08/2020) is needed as well.

Finally, drilling and mandatory reporting of borehole data to GEUS is regulated by "The executive Order on "Boreholes and drilling" (BEK no. 1260 of 28/10/2013).

b) Existing workflows between project developers and authorities

The developer or a consultant will produce the required material and submit it to the municipality. From this material the municipality will produce a scope for an EIA screening, will hear neighbours and organisations affected by the project and involve other authorities responsible for elements of the project. If needed a full EIA will be conducted. An EIA permission with specific requirements and permission related to other legislation will be granted.

c) Legal obligations regarding the abandonment/dismantling

- General rules and procedures for abandonment of boreholes are given in The executive Order on Boreholes and drilling (BEK no. 1260 of 28/10/2013).

d) Competent authorities

The municipalities act as first authorities and are required to involve and coordinate with other authorities

5.1.2 Enabling aspects

a) Existing guidelines on national/regional levels

No existing guidelines

b) Best practice guidelines on national/regional levels

No official best practise guidelines, but as a result of monitoring of the performance of BTES and PTES in Denmark PlanEnergi produced "Best Practise for implementation and operation of large scale borehole and pit thermal energy storages" https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Best-practice-Br%C3%A6dstrup-Marstal-Dronninglund-and-Gram-003.pdf

c) Subsidies or incentive programmes on national/regional level

No subsidies or incentives for BTES, but the Danish Energy Agency has a technical development and demonstration program (EUDP) that supports innovative energy solutions.

d) Available decision-making tools

https://data.geus.dk/geusmap/?mapname=varmelagring&lang=en
Dedicated group of experts working together on national/regional level informally to some extent.

5.1.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Specific areal planning needed. Tax on heat from waste incineration.

5.2 France

5.2.1 Drivers and barriers

a) Current implementation barriers regarding existing policies

The non-access to the simplified declarative procedure if injection temp. > 40°C

6 PTES

6.1 Denmark

6.1.1 Legal aspects

a) Existing laws on national/regional level

- 'Environmental Protection Act' (LBK nr 1218 of 25/11/2019)
- If heat is supplied to a heating network a permit according to The executive Order on Heat Supply (LBK nr 1215 of 14/08/2020) is needed as well.

b) Existing workflows between project developers and authorities

The developer or a consultant will produce the required material and submit it to the municipality. From this material the municipality will produce a scope for an EIA screening, will hear neighbours and organisations affected by the project and involve other authorities responsible for elements of the project. If needed a full EIA will be conducted. An EIA permission with specific requirements and permission related to other legislation will be granted.

c) Competent authorities

The municipalities act as first authorities and are required to involve and coordinate with other authorities

6.1.2 Enabling aspects

a) Existing guidelines on national/regional levels

No existing guidelines

b) Best practice guidelines on national/regional levels

No official best practise guidelines, but as a result of monitoring of the performance of BTES and PTES in Denmark PlanEnergi produced "Best Practise for implementation and operation of large scale borehole and pit thermal energy storages" https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Best-practice-Br%C3%A6dstrup-Marstal-Dronninglund-and-Gram-003.pdf

c) Subsidies or incentive programmes on national/regional level

No subsidies or incentives for BTES, but the Danish Energy Agency has a technical development and demonstration program (EUDP) that supports innovative energy solutions.

d) Available decision-making tools

https://data.geus.dk/geusmap/?mapname=varmelagring&lang=en
Dedicated group of experts working together on national/regional level informally to some extent.

6.1.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Specific areal planning needed. Tax on heat from waste incineration.

7 HT-PTES

7.1 Denmark

7.1.1 Legal aspects

a) Existing laws on national/regional level

- Environmental Protection Act' (LBK nr 1218 of 25/11/2019)
- If heat is supplied to a heating network a permit according to The executive Order on Heat Supply (LBK nr 1215 of 14/08/2020) is needed as well.

b) Existing workflows between project developers and authorities

The developer or a consultant will produce the required material and submit it to the municipality. From this material the municipality will produce a scope for an EIA screening, will hear neighbours and organisations affected by the project and involve other authorities responsible for elements of the project. If needed a full EIA will be conducted. An EIA permission with specific requirements and permission related to other legislation will be granted.

c) Competent authorities

The municipalities act as first authorities and are required to involve and coordinate with other authorities

7.1.2 Enabling aspects

a) Existing guidelines on national/regional levels

No existing guidelines

b) Best practice guidelines on national/regional levels

No official best practise guidelines, but as a result of monitoring of the performance of BTES and PTES in Denmark PlanEnergi produced "Best Practise for implementation and operation of large scale borehole and pit thermal energy storages" https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Best-practice-Br%C3%A6dstrup-Marstal-Dronninglund-and-Gram-003.pdf

c) Subsidies or incentive programmes on national/regional level

No subsidies or incentives for BTES, but the Danish Energy Agency has a technical development and demonstration program (EUDP) that supports innovative energy solutions.

d) Available decision-making tools

https://data.geus.dk/geusmap/?mapname=varmelagring&lang=en
Dedicated group of experts working together on national/regional level informally to some extent.

7.1.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Specific areal planning needed. Tax on heat from waste incineration.

8 HT-MTES

8.1 Germany

8.1.1 Legal aspects

a) Existing laws on national/regional level

Water Law is the main legal framework

b) Legal obligations regarding temperature limits and well distances

- Mining Law for wells > 100 m
- No temperature or well distances restrictions yet (pilot testing phase), but in any case, any harmful alteration of the water body properties should be avoided

c) Legal obligations regarding monitoring tools and procedures before, during and after exploitation phase

Monitoring of water chemistry and other physical properties during test storage

d) Existing workflows between project developers and authorities

No existing workflows between project developers and authorities

e) Competent authorities

Currently decided on the municipal level, but overall guidance is provided on the regional level (state).

8.1.2 Enabling aspects

a) Existing guidelines on national/regional levels

No guidelines nor technical standards existing

b) Best practice guidelines on national/regional levels

No guidelines nor technical standards existing

c) Mid to long term development schemes/masterplans for sustainable use

No development plans

d) Supporting policies on national level

Supporting policy (Kohleausstiegsgesetz)

e) Subsidies or incentive programmes on national/regional level

Subsidies granted to research projects only

f) Available decision-making tools

No decision-making tools

8.1.3 Drivers and barriers

a) Current implementation barriers regarding existing policies

Liability agreement with former mine owner

9 Conclusions

This report focused on the existing regulatory frameworks associated with UTES technologies in a sample of member states (Netherlands, France, Switzerland, Denmark, Germany) participating to the HEATSTORE project, and specifically observed if enabling policy frameworks are already in place and identified potential barriers for these technologies.

It appears among the answers from almost all the above-mentioned countries that the low maximum temperature allowed was the most restricting and recurrent form of barrier found.

Then we identified forms of barriers that are less recurrent and less penalizing, occasionally mentioned by certain countries, like stacking of regulations, data scattering on multiple platforms, lack of long-term development plan, no supporting policies, thermal regulation of buildings not appropriate to help sector development, lack of optimized declarative procedure and liability agreement with former mine owner. These problems may have to be solved through legal and structural adaptations.

Then, other concerns are more focused on little experience by authorities which complicates the permit procedure, and a sharper framework may be created through regional policies, restriction areas, drinking water resources. These barriers are more the responsibility of a better communication, feedback from previous projects and education.

Appendix I

HEATSTORE - Summary of current legal frameworks and policy incentives for UTES technologies

Heatstore - WP 6.2

Annex 1 - Assessment of currently existing regulatory frameworks for UTES technologies in Europe - Overview

Countries	ATES	HT-ATES	BTES	HT-BTES	PTES	HT-PTES	MTES	HT-MTES
Denmark	- Act on "Heat extraction plants and groundwater cooling systems" - Injection temperature < 25 C and monthly average < 20 C. - Automated temperature logging and pressure surveillance - 'Underground Act' for wells > 300 m - Existing workflows between project developpers and authorities - The municipalities act as first authorities and are required to involve and coordinate with other authorities - The 'Drilling Act' for abandonment of wells - Technical development and demonstration programm from the Danish Energy Agency - Available decision making tools - Implementation barriers: Low maximum temperature	- No existing plants - 'Environmental Protection Act' - 'Underground Act' for wells > 300 m - Existing workflows between project developpers and authorities - The municipalities act as first authorities and are required to involve and coordinate with other authorities - The 'Drilling Act' for abandonment of wells - Technical development and demonstration programm from the Danish Energy Agency - Tax on unused surplus heat - Implementation barriers: C7	- 'Environmental Protection Act' - 'Underground Act' for wells > 300 m - Existing workflows between project developpers and authorities - The municipalities act as first authorities and are required to involve and coordinate with other authorities - 'Drilling Act' for abandonment of wells - Technical development and demonstration programm from the Danish Energy Agency - Best practices - Available decision making tools - Tax on heat from waste incineration - Implementation barriers: D7	- 'Environmental Protection Act' - 'Underground Act' for wells > 300 m - Existing workflows between project developpers and authorities - The municipalities act as first authorities and are required to involve and coordinate with other authorities - 'Drilling Act' for abandonment of wells - Technical development and demonstration programm from the Danish Energy Agency - Best practices - Available decision making tools - Tax on heat from waste incineration - Implementation barriers: Specific areal planning needed	- Environmental Protection Act - Existing workflows between project developpers and authorities - Best practices - Technical development and demonstration programm from the Danish Energy Agency -The municipalities act as first authorities and are required to involve and coordinate with other authorities	- Environmental Protection Act - Existing workflows between project developpers and authorities - Best practices - Technical development and demonstration programm from the Danish Energy Agency - The municipalities act as first authorities and are required to involve and coordinate with other authorities	Not relevant	Not relevant
France	- 'Mining Law' (no specific framework for UTES) - Site-specific regulations - Max. injection temperature < 32° C - Max. temp. change 200 m away from the injection well < 4°C - Mining Law regulations are general prescriptions - Legal procedure is only declarative (for wells < 200 m and capacities < 500 kW) - Competent authority at national level - Existing technical standards - Available public databases - Financial support system 'Fonds Chaleur' - Group of experts (ADEME, AFPG, BRGM) - Implementation barriers: stacking of regulations, data has to be retrieved from different platforms, no long term development plan, no supporting policies, thermal regulation of buildings not in favor of GSHP	- 'Mining Law' (no specific framework for UTES) for wells > 200 m - Two types of exploration procedures - Two types of mining permits (< or > 200 MW) - No temperature limits for reinjection except for drinking water ressources - Demonstration of no impact on neighbouring installations - Timeline of legal procedure about 3 years - Competent authority at national level - Best practice guide - Available public databases - Financial support system 'Fonds Chaleur' - Group of experts (ADEME, AFPG, BRGM) - No implementation barriers	- 'Mining Law' (no specific framework for UTES) - Site-specific regulations - Injection temperature into the borehole heat exchangers (BHE) must be between -3 °C and 40 °C - At least 5 m from the plot boundary and from buried pipes of wasted water - Mining Law regulations are general prescriptions - Legal procedure is only declarative (for wells < 200 m and capacities < 500 kW) - Competent authority at national level - Existing technical standards - Available public databases - Financial support system 'Fonds Chaleur' - Group of experts (ADEME, AFPG, BRGM) - Implementation barriers: stacking of regulations, data has to be retrieved from different platforms, no long term development plan, no supporting policies, thermal regulation of buildings not in favor of GSHP	- Implementation barrier: The non-acces to the simplified declarative procedure if injection temp. > 40°C	- No existing plants - Not applicable	- No existing plants - Not applicable	Not relevant	Not relevant
Germany	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	- Water Law is the main legal framework - Mining Law for wells > 100 m - No temperature or well distances restrictions yet (pilot testing phase), but in any case any harmful alteration of the water body properties should be avoided - Monitoring of water chemistry and other physical properties during test storage - No existing workflows between project developers and authorities - Currently decided on the municipal level, but overall guidance is provided on the regional level (state). - No guidelines nor technical standards existing - No development plans - No decision making tools - Lack of data - Supporting policy (Kohleausstiegsgesetz) - Subsidies granted to research projects only - Current implementation barriers: liability agreement with former mine owner
Netherlands	- 'Water Law' for storage capacities < 500 m - 'Mining Law' for storage capacities > 500 m - Max. injection temperature < 25°C - No net addition of heat or cold over 5 years - Competent authorities are the Provinces - Monitoring of T, chemical parameters and heat/cold extracted - Existing legal procedures to apply for a permit - Drilling and monitoring only by certified parties - Existence of regional ATES plans - Available public databases and guidelines for permit procedures - Experts working together through sector's network - Subsidies are granted to research projects - Current implementation barriers: little experience by authorities (Provinces) which complicates the permit procedure, a sharper framework could be created through regional policies, restriction areas, drinking water ressources	- 'Water Law' for storage capacities < 500 m - 'Mining Law' for storage capacities > 500 m - Min. injection temperature > 25°C - Specific and elaborate research required to apply for a permit - Competent authorities are the Provinces - Compulsory monitoring - Same legal procedures to apply for a permit as for ATES, but timeline can last over a year - No specific technical standards - No regional HT-ATES plans - Available public databases and guidelines for permit procedures - Supporting policy: 'Climate Accord' - Experts working together on research projects - Existing funding programms - Current implementation barriers: little experience by authorities (Provinces) which complicates the permit procedure, a sharper framework could be created through regional policies, HT-ATES projects have the assignment of 'pilot project', in case of abandonment the net heat has to be taken out (in some provinces)	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Switzerland	- Water Law (OEaux) C10 - Competent authorities on regional level (Cantons) - Temperature difference in the aquifer of max. 3°C (except within a radius of 100 m) - Max. injection temperature: 30°C - No distance limitations for production wells - No depths limitations - Existing technical standards (norm SIA 384/7) - Important differences in legislation on regional level - Each case needs a specific and elaborate analysis for the approval procedure - No mid to long term development schemes - Available public databases (maps) - C10	- Water Law (OEaux) but no specific legislation for aquifer temperatures > 25 °C - Competent authorities on regional level (Cantons) - Temperature difference in the aquifer of max. 3°C (except within a radius of 100 m) - No distance limitations for production wells - No depth limitations - No technical standards/guidelines existing - Important differences in legislation on regional level - Each case needs a specific and elaborate analysis for the approval procedure - No mid to long term development schemes - Available public databases (maps) - Funding possibility ('CO2 law') - Experts working together through research projects - Implementation barriers: max. temperature difference of 3°C, no guidelines for T> 25 °C, need for more flexibility	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant