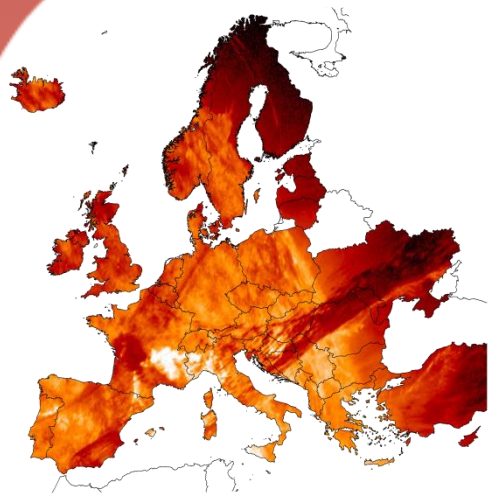


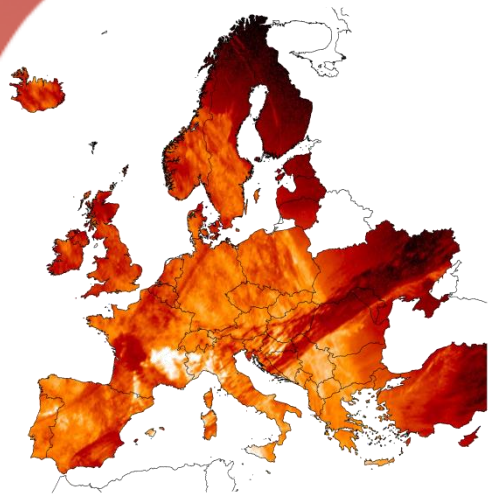
ESTMAP

Energy Storage Mapping And Planning

ESTMAP – First pan-European assessment of underground energy storage potential

Vit Hladik (Czech Geological Survey)
Serge van Gessel (TNO)

European Workshop on Underground Energy Storage
Paris, 7-8 November 2019



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Project information

- Horizon 2020 project based on tender by EC/DG Energy
- 2 years duration, completed in 2016
- leader TNO, 5 consortium partners, 24 sub-contractors

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ISPRA

I.F.M.E

University of Zagreb FACULTY OF MINING, GEOLOGY AND PETROLEUM ENGINEERING

MFGI MAGYAR FÖLDTANI ÉS GEOFIZIKAI INTÉZET

LIETUVOS GEOLOGIJOS TARNYBA LITHUANIAN GEOLOGICAL SURVEY

GZL

UNIVERSITY OF SOFIA

GeoEcoMar

ДНВП "ГЕОІНФОРМ УКРАЇНИ" geoinf.kiev.ua

UNIVERSIDADE DE ÉVORA

GTK

GEUS

ALBANIAN GEOLOGICAL SURVEY AGS 1952

Instituto Geológico y Minero de España

Univerzitet u Tuzli Bosna i Hercegovina

PAŃSTWOWY INSTYTUT GEOLOGICZNY MENTE ET MALLEO 1919 PAŃSTWOWY INSTYTUT BADAWCZY

SGU Sveriges geologiska undersökning

MIDDLE EAST TECHNICAL UNIVERSITY

asplan viak

Geological Survey of Belgium

Geologische Bundesanstalt

BGS 1835 British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL

1918 TALLINNA TEHNIKAÜLIKOOL TALLINN UNIVERSITY OF TECHNOLOGY

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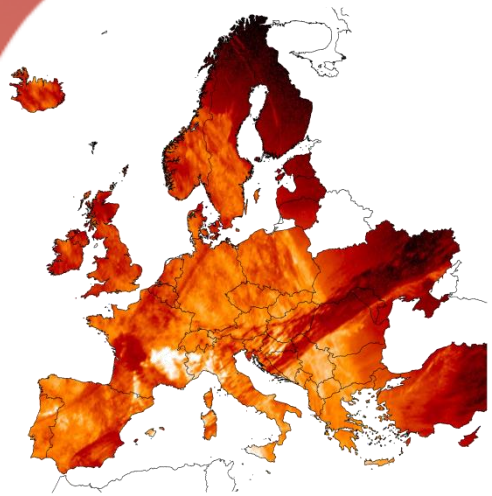


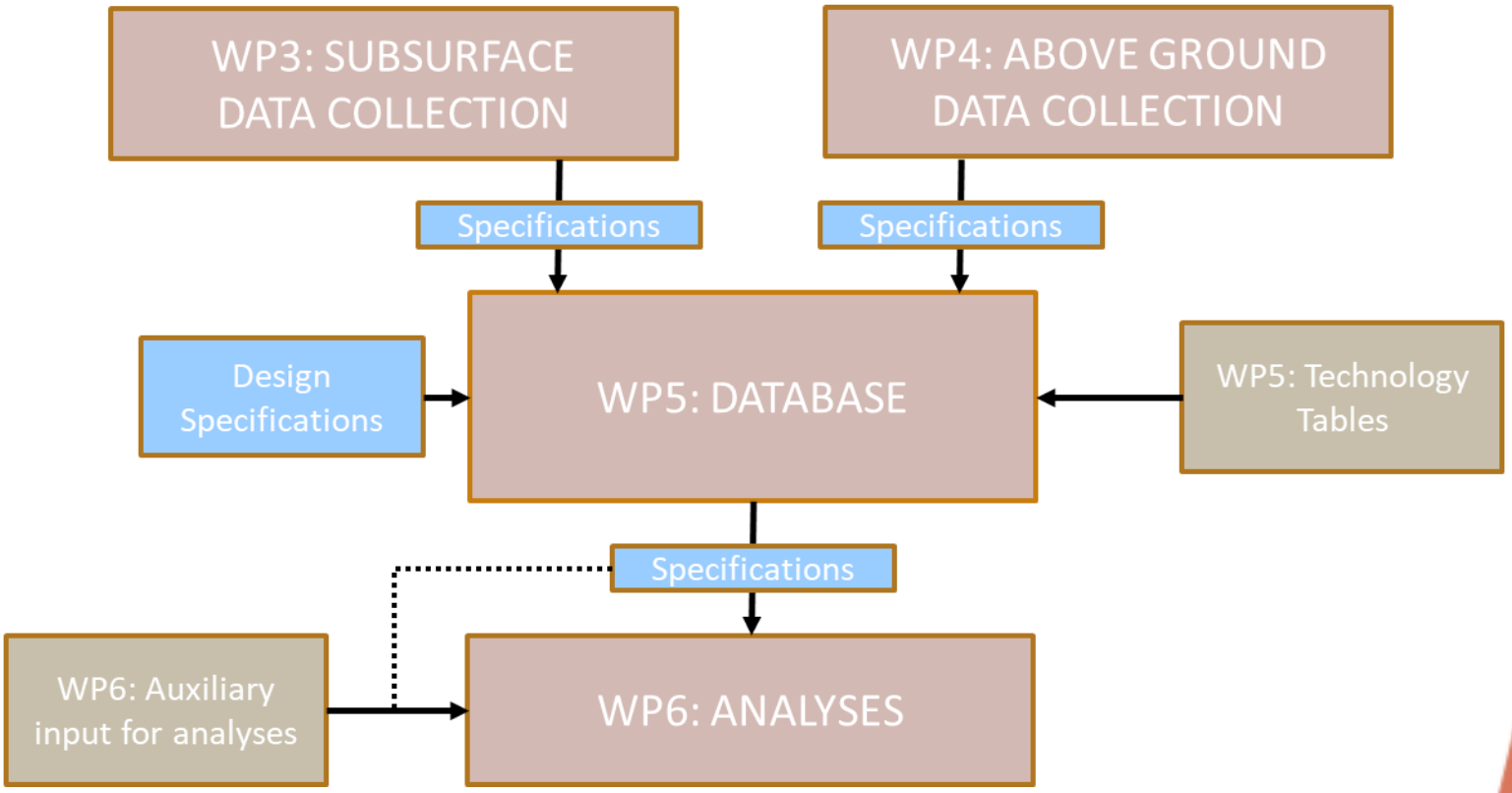
ESTMAP

Energy Storage Mapping And Planning

Project objectives

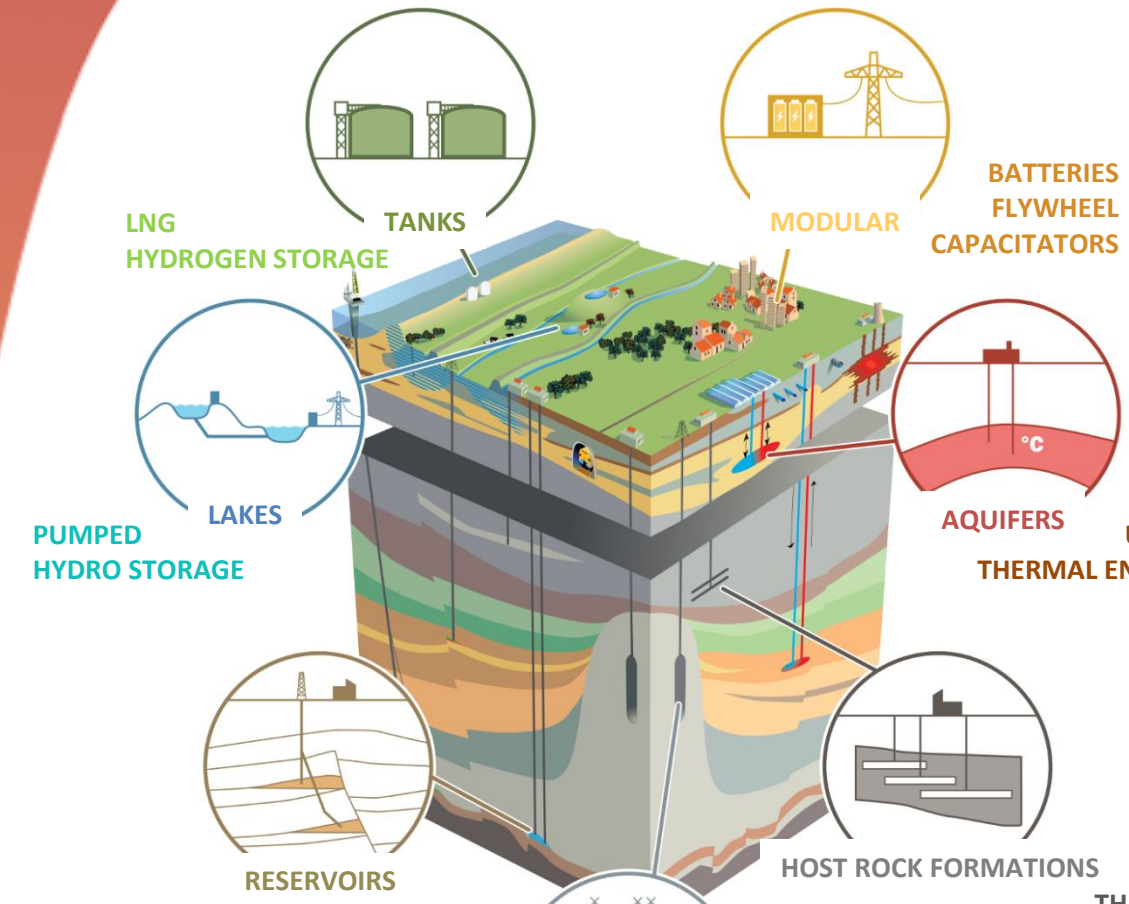
- Collect key knowledge and information on European energy storage potential
- Create a European spatial energy storage database for electricity, gas and heat technologies
- Demonstrate the utilizability and usefulness of collected data for European energy systems analysis and planning (by a case demonstration)

Project Logic & WPs



ESTMAP DATA SCOPE

Reservoirs
Technologies
Subsurface / Above ground
Existing / Potential
Electricity, Gas, Heat



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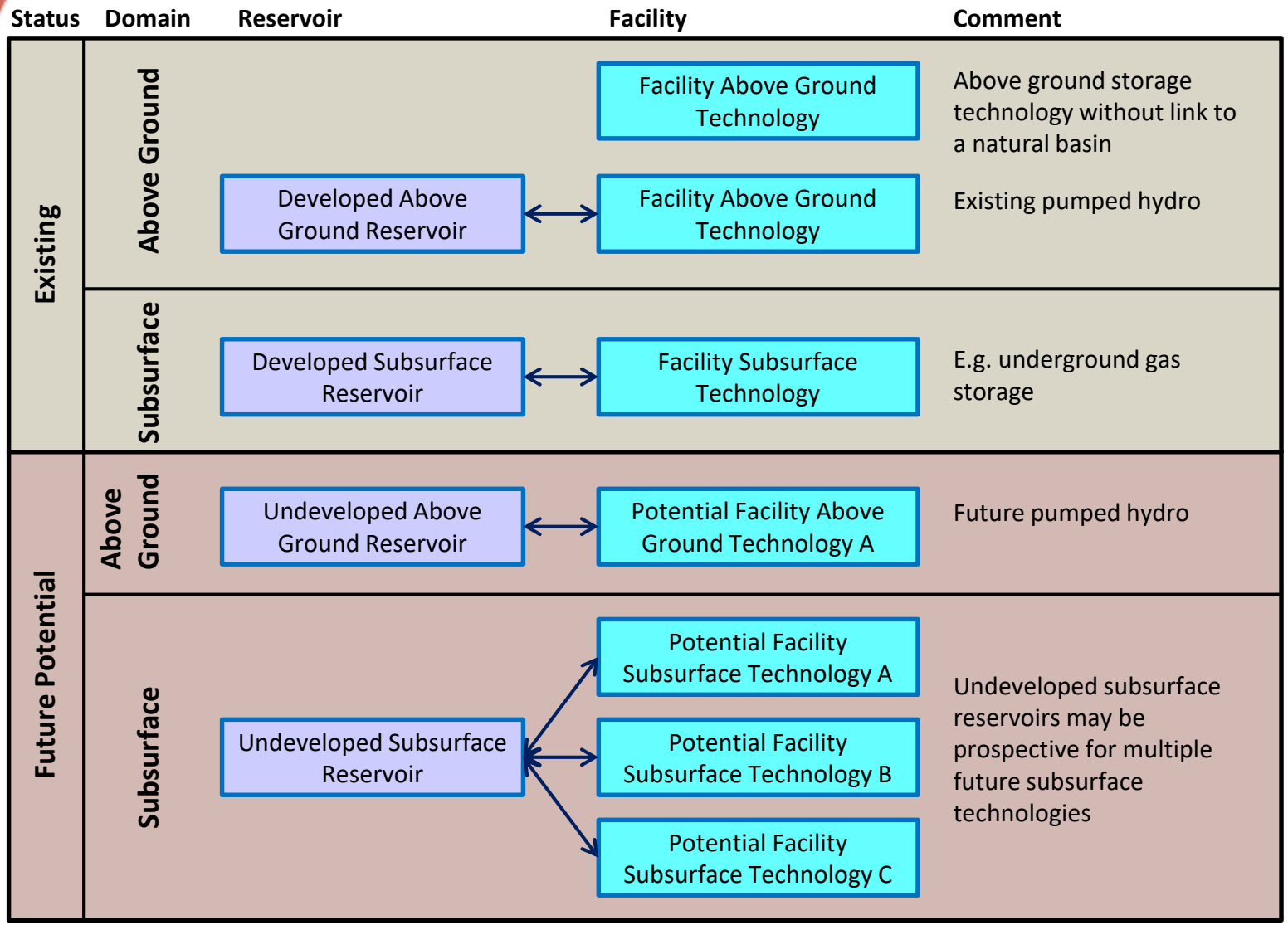
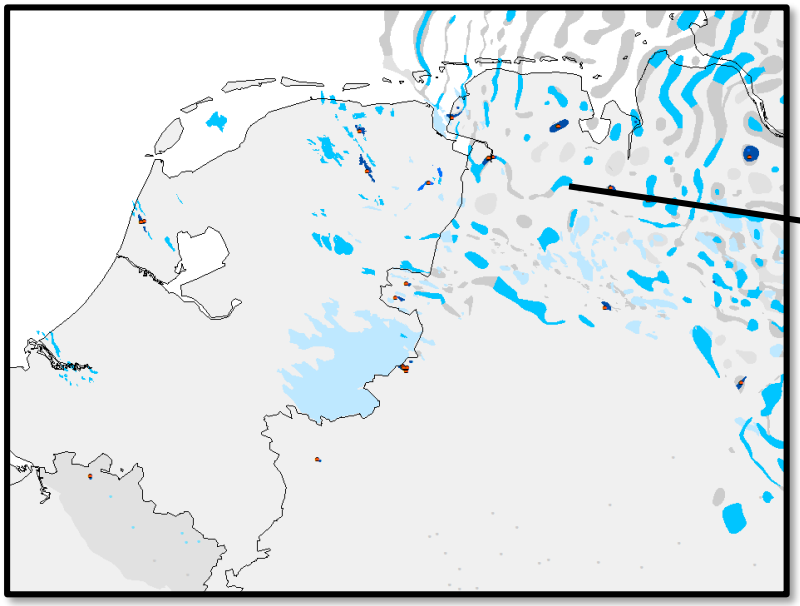

Status
Domain
Reservoir
Facility
Comment
Existing
Above Ground
Facility Above Ground Technology
Above ground storage technology without link to a natural basin
Developed Above Ground Reservoir
Facility Above Ground Technology
Existing pumped hydro
Subsurface
Developed Subsurface Reservoir
Facility Subsurface Technology
E.g. underground gas storage
Future Potential
Above Ground
Undeveloped Above Ground Reservoir
Potential Facility Above Ground Technology A
Future pumped hydro
Subsurface
Undeveloped Subsurface Reservoir
Potential Facility Subsurface Technology A
Potential Facility Subsurface Technology B
Potential Facility Subsurface Technology C
Undeveloped subsurface reservoirs may be prospective for multiple future subsurface technologies



Reservoirs ⟷ **Facilities**

Reservoirs	Facilities
Location	Location
Geometry	Characterization
Characterization	Performance attributes
Physical properties	Cost attributes
Development	Operations and grid
Feasibility assessment	Data quality
Maturity	Source references
Reliability quality	
Spatial relations	
Source references	

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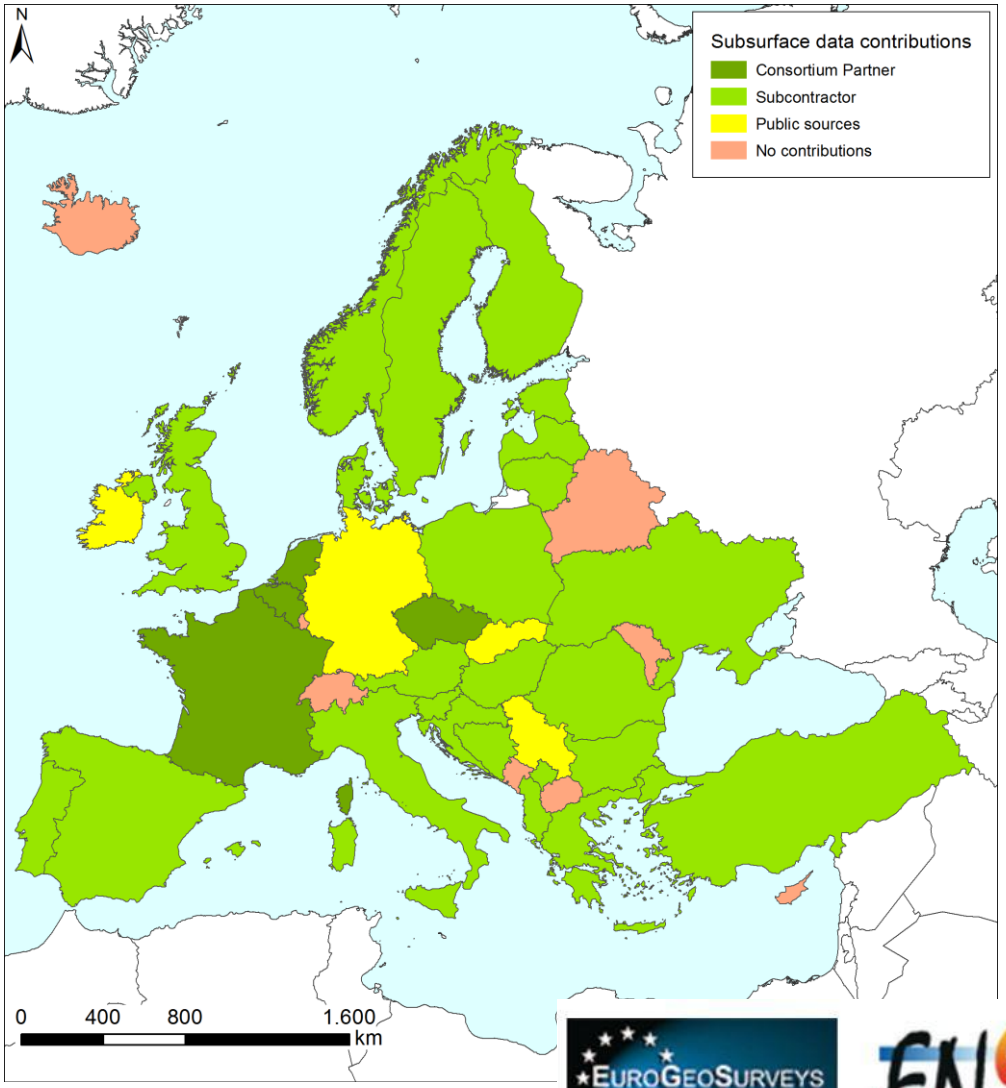
Subsurface data collection



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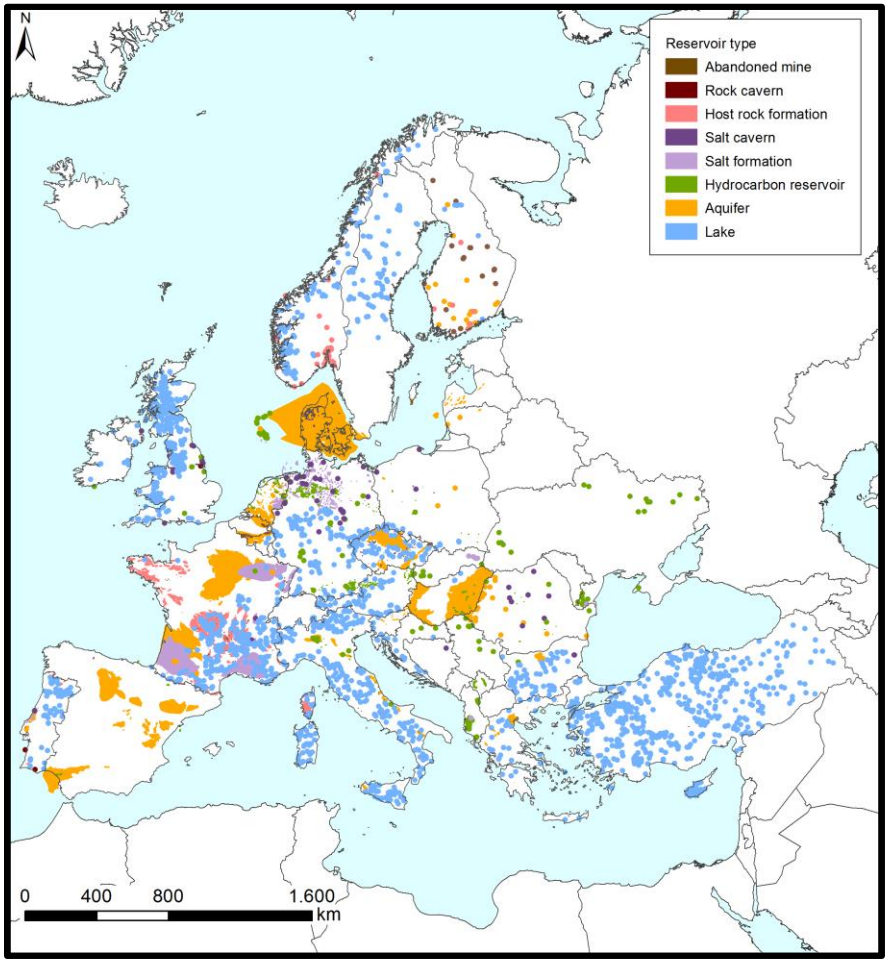
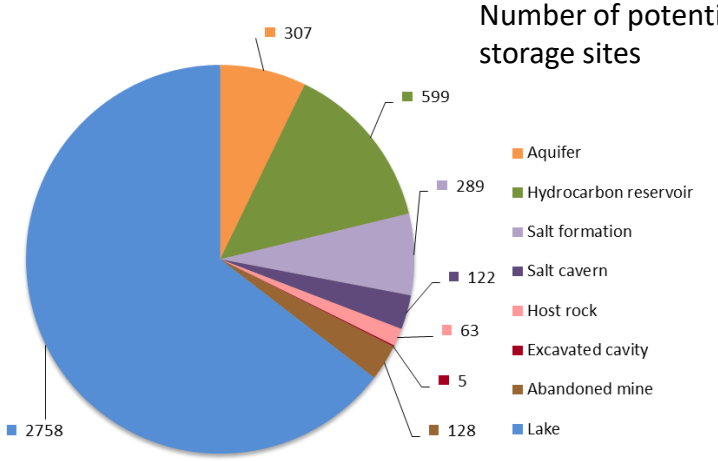
Geographical energy storage database

> 4200 potential and proven natural energy storage capacities

> 700 planned and developed energy storage facilities



Number of potential storage sites



Web-GIS version available at www.estmap.eu

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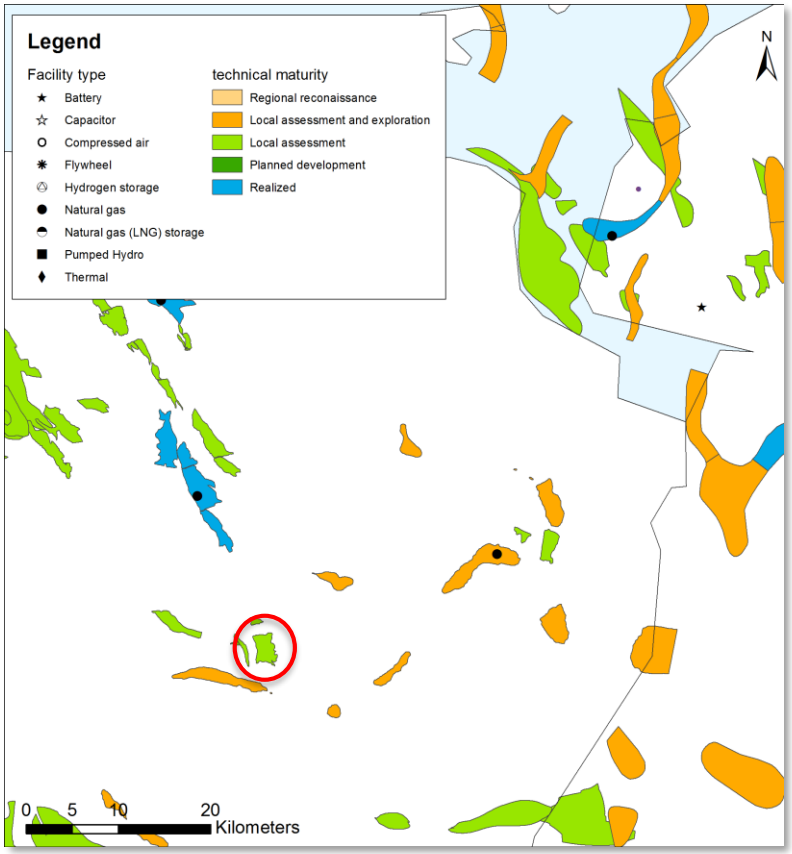
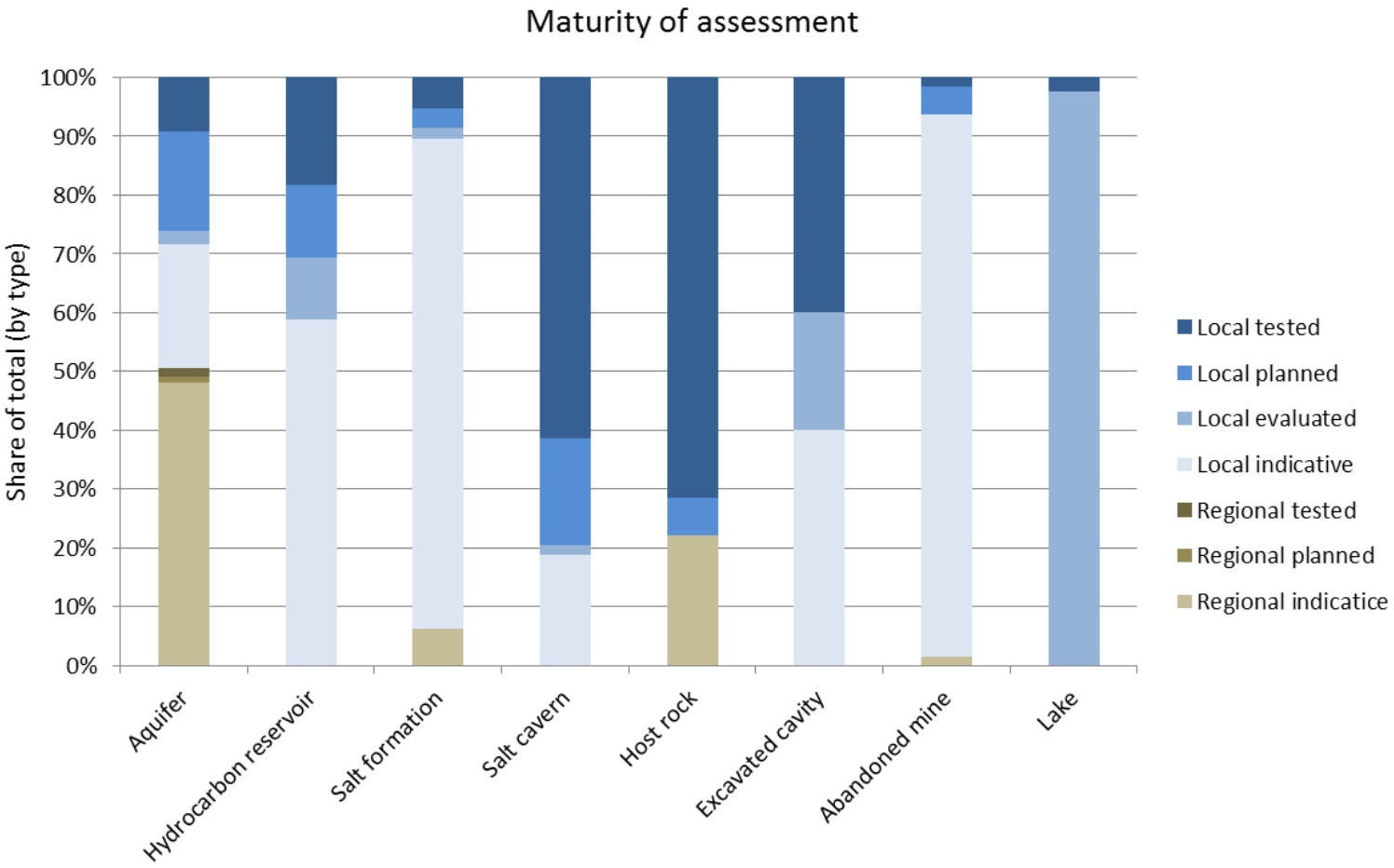
Example Site Characterization



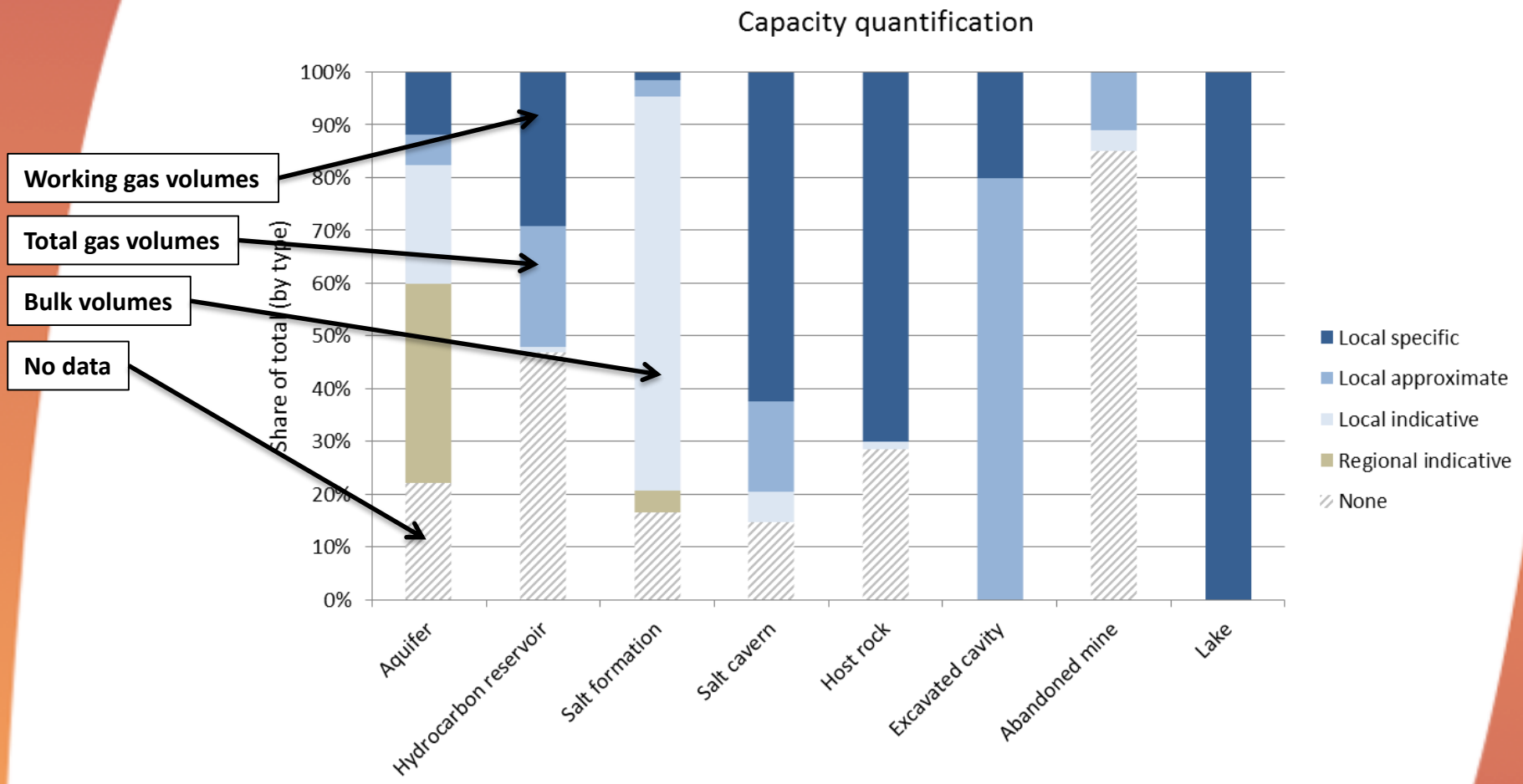
Parameter	Value
ID:	NL-F-RES-060
NAME:	Eleveld gas field
GEOLOGY:	Slochteren Formation
LITOLOGY:	Sandstone
SEAL:	Salt
FILL:	Gas
DEVELOP:	Producing
OPERATOR:	NAM B.V.
LICENCE:	Drenthe IIIb
NATURA2000:	Overlap
ALT USE:	CO2 storage
INFRA:	Gas Grid and Production

Parameter	Value
DEPTH:	3170 m
AREA:	7 km2
THICKNESS:	100m
GIIP:	12 bcm
P_MIN:	20 bar
P_MAX:	377 bar
ESTOR ASSESS:	Local evaluation
UGS:	Possible
UGS WV:	1 bcm
H2:	Theoretically
CAES:	Unlikely
THERM:	Unlikely
UPHS:	Unsuitable

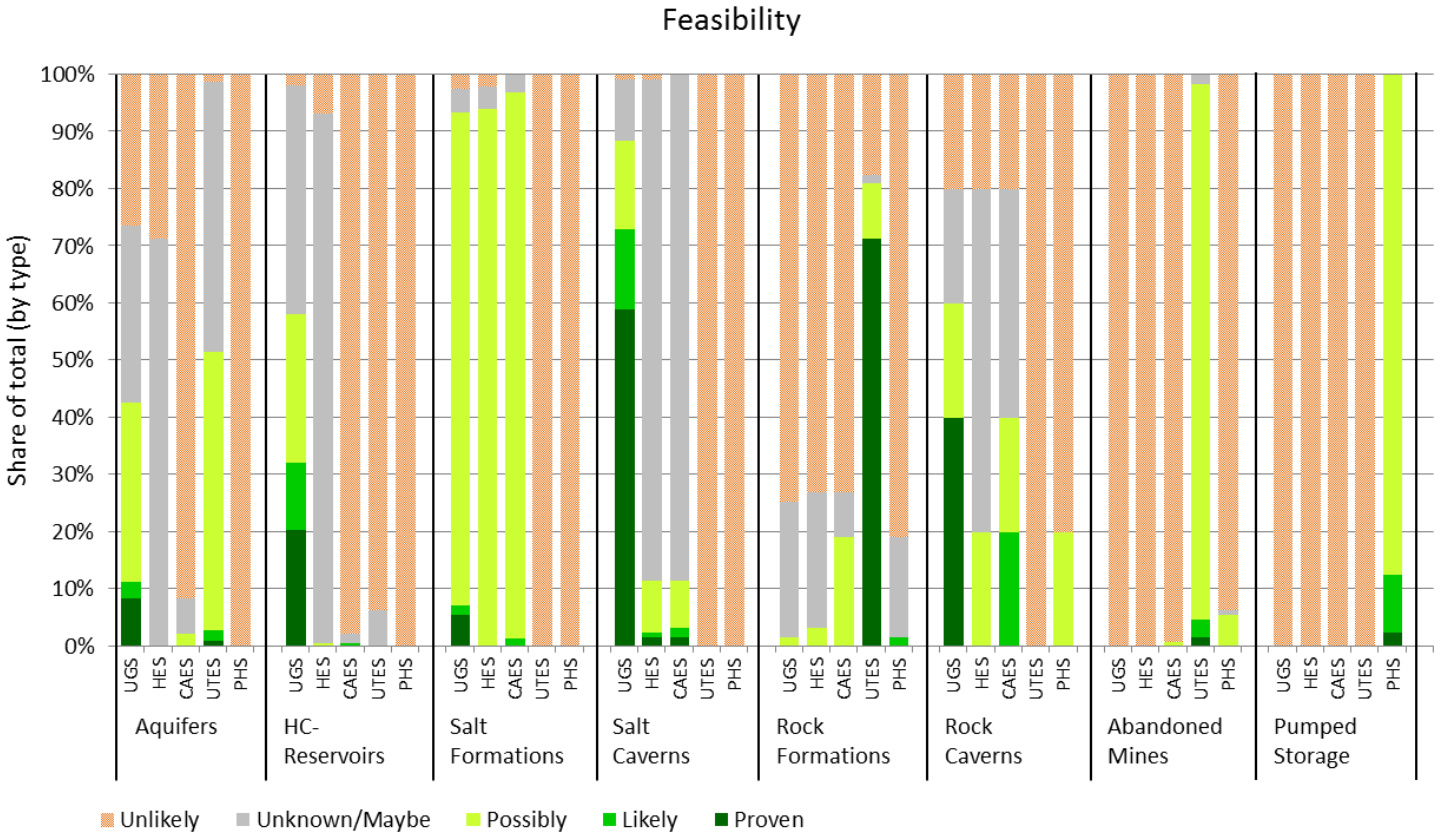
EU summary of collected sites: Maturity of Assessment



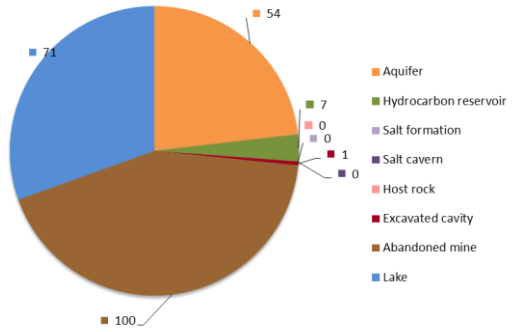
EU summary of collected sites: Quality of Capacity Determination

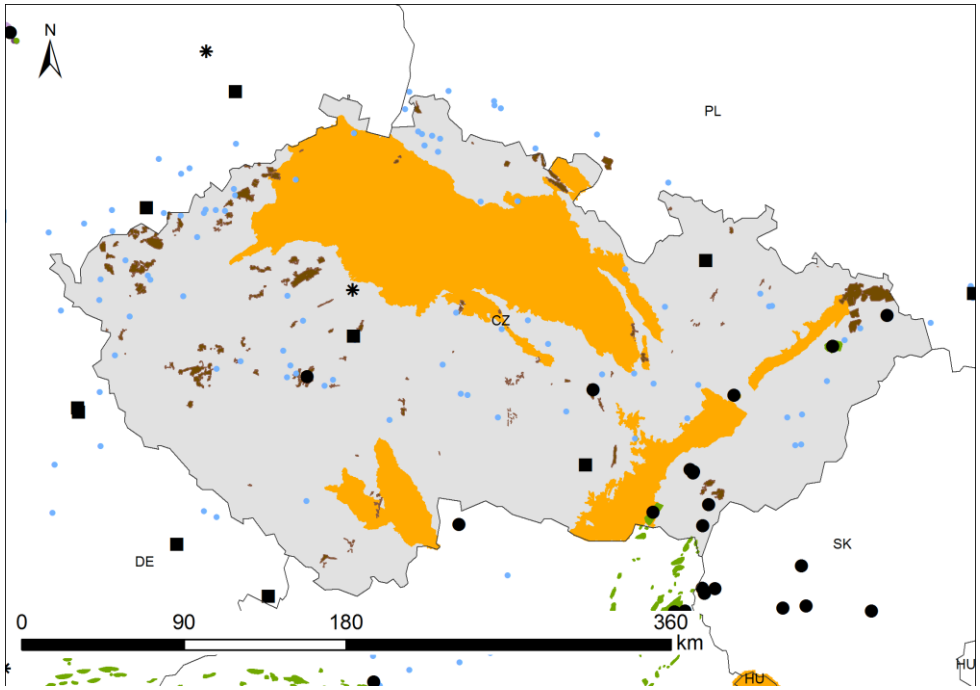


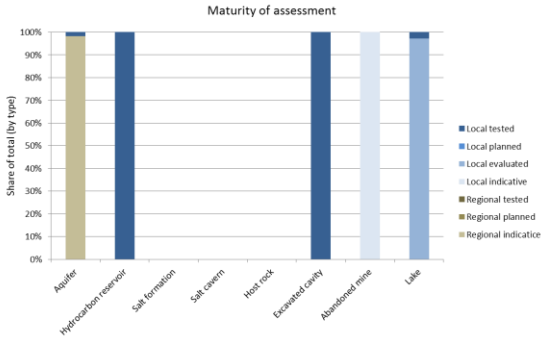
EU summary of collected sites: Feasibility

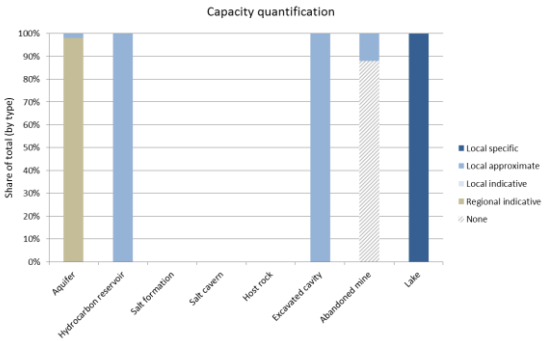


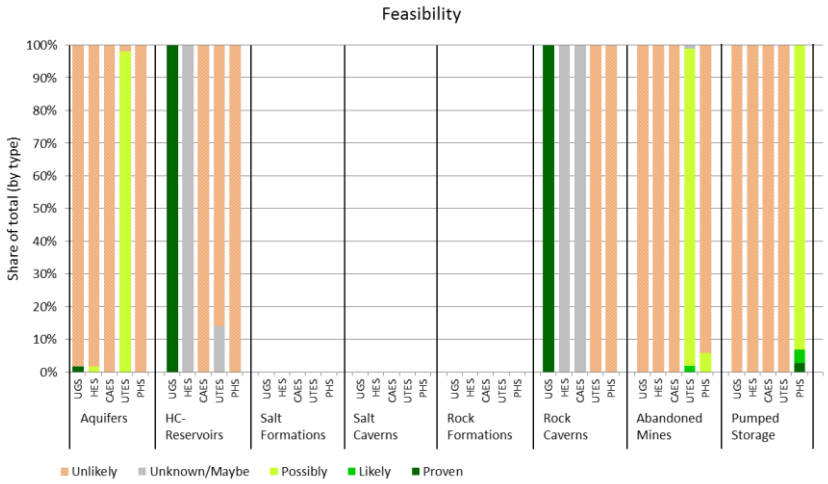
Per country data reviews (example Czech Republic)











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Per country data reviews (example Czech Republic)

3.7. Czech Republic

3.7.1. Provider administration

Main providing organisations subsurface storage information:
CGS – Czech Geological Survey
ESTMAP Consortium Partner
Contact Person: Jan Holecek

Main providing organisations above ground storage information:
ECOFYS Netherlands
ESTMAP Consortium Partner
Contact Person: Eline Begemann

Last Version Delivery Dates:
2015.11.27 (subsurface data)
2015.11.26 (above ground data)

3.7.2. Main data sources

Table 3.7-1: List of common sources used

Source name / URL	Description	Version / Date
Geological Survey Data Archives	No further source details available	
GIE, 2015: Gas Storage Map Europe	Overview of planned and operated underground gas storage	April 2015
DOE, 2015: Global Energy Storage Database: https://www.energystorageexchange.org	Overview of planned and operational energy storage projects across the globe	April 2015
JRC, 2013. Assessment of the European potential for pumped hydropower energy storage	A GIS-based assessment of pumped hydropower storage potential	2013

3.7.3. Storage Data Review Czech Republic

Subsurface storage potential in the Czech Republic is mainly defined in abandoned mines and regional aquifers. Feasibilities and capacity determinations are still unconfirmed and technically immature. Some developed UGS sites in hydrocarbon reservoirs and one rock cavern are included as well. There is good and local defined potential for above ground pumped hydro storage across the entire country.

Table 3.7-2: Evaluation and summary of data and energy storage potential

Reservoir Type	Status description, remarks	Recommended actions maturing and extending future potential
Aquifers	Potential for UTES in aquifers is regional defined and extends over a large part of the country. Feasibilities are still theoretical (regional indicative) and largely unconfirmed. Very limited information regarding storage capacities is available. One local defined site has been developed as UGS.	Target aquifers are regionally in view, but substantial efforts are needed to define and confirm local-specific potential and estimate capacities.
Hydrocarbon reservoirs	Seven hydrocarbon fields are tested and developed as UGS. Reservoir capacities are approximated from total gas volumes. The reservoirs are in theory also suitable for HES, but this has not been confirmed.	No or very limited scope for future investigation
Salt formations and caverns	No entries available in ESTMAP. As far as known the Czech Republic does not have salt formations that allow for development of suitable caverns.	No or very limited scope for future investigation
Host rock, caverns, mines	An extensive dataset on local defined abandoned mines is available to ESTMAP. These mines are considered a main target for UTES. Feasibilities are still theoretical (local indicative) and unconfirmed. Very limited information regarding storage capacities is available. There is one rock cavern that has been developed for UGS (operational capacities provided) and which could in theory also host HES and CAES. Further potential in host rock formations has not been assessed.	substantial efforts are needed to define and confirm local-specific potential in the abandoned mines and to estimate capacities. Check whether there is future scope to investigate potential in host rock formations
Lakes	The Czech Republic has abundant realisable potential for pumped hydro storage, including options based on two existing nearby lakes. Two out of 71 sites included in ESTMAP are developed as PHS. All identified sites include specific determinations of energy storage capacities and lake volumes. Further theoretical sites are identified but not publicly available to ESTMAP.	Confirm suitability and capacity from location-specific assessments. Consider future inclusion of theoretical potential.

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GIS, TIMES and PowerFys have been combined to demonstrate potential analysis on ESTMAP database

	Database	GIS mapping	TIMES model	PowerFys model
Description	• Compile a database with existing and future potential energy storage • Integrate contributions from geological and technical institutes and open source information • EU	• Calculate connection costs for future storage facilities • Develop storage maps depicting analysis results, after TIMES and PowerFys model runs	**TIMES PanEU:** • Optimize configuration of storage sites & power plants • Time resolution of day, night and peak time slices • EU-28, NO, CH • 2010 – 2050 **TIMES regional:** • Time resolution of 2- and 3-hourly time slices • DE, BE & NL	• Optimize operation of energy storage and power generation assets • Optimize storage use • Assess cross-border electricity flow & congestion • Calculate marginal energy costs • Hourly resolution • DE, BE and NL • 2050
Outcomes	• Storage locations • Storage specifications	• Storage connection costs	• Optimal config. of storage sites and power plants	• Hourly storage use • Generation mix • Marginal costs

Combining the TIMES and PowerFys model allows for both optimizing the configuration of storage sites and power plants and optimizing the operation of these facilities

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Main results of ESTMAP energy system modelling

1. **Energy system models were successfully coupled with ESTMAP database** on large-scale storage potential in EU28 to assess its role in the energy system.
2. **Model results allowed the selection of specific technologies and locations** from the geographic large-scale storage potential database.
3. **Some interesting observations** can be made on the role of large-scale energy storage based on the example modelling analysis.
4. **Capturing time-dynamics** effectively is essential for quantifying the demand for flexibility options, such as energy storage.
5. **ESTMAP project delivers an excellent toolbox** to further quantify the role of large-scale energy storage and to assess key drivers and risks.

Conclusions and recommendations regarding subsurface storage potential assessment

- **Necessity for large scale energy storage development is expected** (in mid- and long-term)

- **Now is the time to invest in developing the key knowledge:**
  - Long lead times on development
  - Technological breakthrough needed for certain technologies
  - Benefit from synergies with other research areas (geothermal, CCS)
  - Make use of key E&P technical knowledge while they are still active (Joint Industry Projects)

- **Subsurface is key to developing flexible, large-scale storage solutions for Electricity, Gas and Heat related energy sources**

Recommendations regarding subsurface assessment

- **Harmonize and extend geological mapping and characterization of subsurface reservoirs** that are considered suitable for energy storage. Complete parameter definitions;
- Establish **harmonized methodology** to assess energy storage capacities and performance indicators for different subsurface technologies. Include stochastic approaches to assess uncertainties and confidence levels;
- Further **explore and confirm site-specific potential** for multiple storage options and uniformly rank these options on the basis of technical, economic and environmental criteria;
- Select and **develop sites** that are primary targets **for** potential energy storage **demonstration projects;**
- Set up the appropriate procedures and means to **maintain and regularly update the udergorund storage potential database** with new contributions from third parties (industry) and national research!

Position papers

ESTMAP
Energy Storage Mapping and Planning

Doc.nr: ESTMAP-position-paper
Version: 2016.11.02
Classification: Public
Page: 1 of 2

Position paper for large-scale energy storage development

The ESTMAP project brings together information and knowledge on energy storage capacities from leading geological and technical institutes and makes this information accessible for European energy systems analyses and planning. The scope of ESTMAP covers all subsurface and above ground energy storage technologies, including for power, gas and heat.
This position paper discusses the essential R&D actions that are needed to enable large-scale energy storage deployment in a timely and economically efficient way.

Flexibility is required in our future low-carbon energy system

A low carbon energy system requires adaptations to accommodate the changing patterns of energy production and consumption. Future energy systems will be characterised by a larger share of (intermittent) renewables, complemented by flexible forms of fossil-fuel and renewable power/heat production, improved grid interconnectivity, demand-response functionalities and the deployment of energy storage technologies.

Energy storage will play a pivotal role in providing the needed flexibility and offering balancing options to the integrated energy system. Greater deployment of energy storage is required at different scales, i.e. from low power and fast response solutions (< 1kW; <1s) to longer-term balancing needs for the grid (>1GW; hours to days and beyond). Large-scale and centralized energy storage can provide flexible bulk power management services for electricity, gas and heat commodities. In addition to flexibility, large-scale energy storage offers essential services to society in the form of strategic energy reserves and balancing solutions for unavoidable seasonal variations. The growth of these services to sufficient scale is key to ensuring a reliable and secure energy supply. Among the limited number of alternative sources of flexibility, large scale energy storage is a cost effective option.

Large -scale energy storage has substantial potential to deliver flexibility to the energy system

ESTMAP has investigated the EU-potential for energy storage based on existing information from European technical and geological institutes as well as JRC-IE. The assessment includes, among others: pumped hydro storage, compressed air energy storage, underground thermal energy storage, (synthetic) natural gas storage and hydrogen storage. Results from future energy systems analyses demonstrate a substantial potential and expected future role of large-scale energy storage in Europe. Some of these technologies (e.g. pumped hydro storage) have been applied at scale for decades, while others have thus far been applied in pilot projects or at modest scale only (e.g. compressed air energy storage).

Uncertainties should be reduced to stimulate new large-scale storage investments

The current energy market does not provide incentives for extensive investments in large-scale energy storage. There is uncertainty in the specifics and timeline of future policies and regulations to drive decarbonisation of the energy system. In addition, the outlook is uncertain on further cost reduction potential of both renewable energy and competing flexibility options. Thirdly, the development and deployment of new large-scale energy storage projects across Europe inherently requires longer lead times than many other

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ENeRG Position Paper June 2017

ENeRG

Energy storage in the subsurface: an important component of transition to low carbon energy

Role of energy storage in future energy systems

The transition towards a clean and low carbon energy system will be accompanied by far-reaching changes in energy production and consumption patterns due to a strong foreseen growth of intermittent renewables in the energy system. These changes require solutions in order to ensure reliable, clean and affordable energy for all citizens and industries of Europe. Besides the development of flexible forms of power/heat production, improved grid interconnectivity, smart grids and demand-response functionalities, energy storage (Fig. 1) will play a pivotal role in providing the needed flexibility and offering balancing options to the integrated energy system.

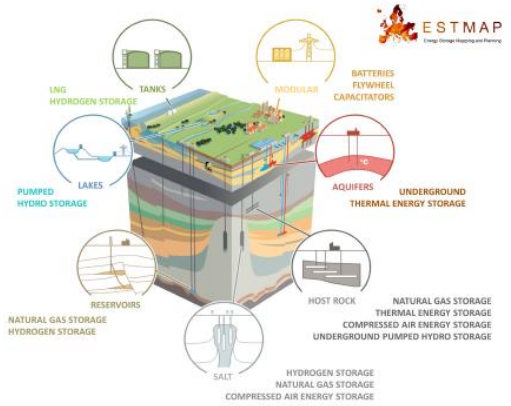

Fig. 1 Main types of above ground and subsurface energy storage

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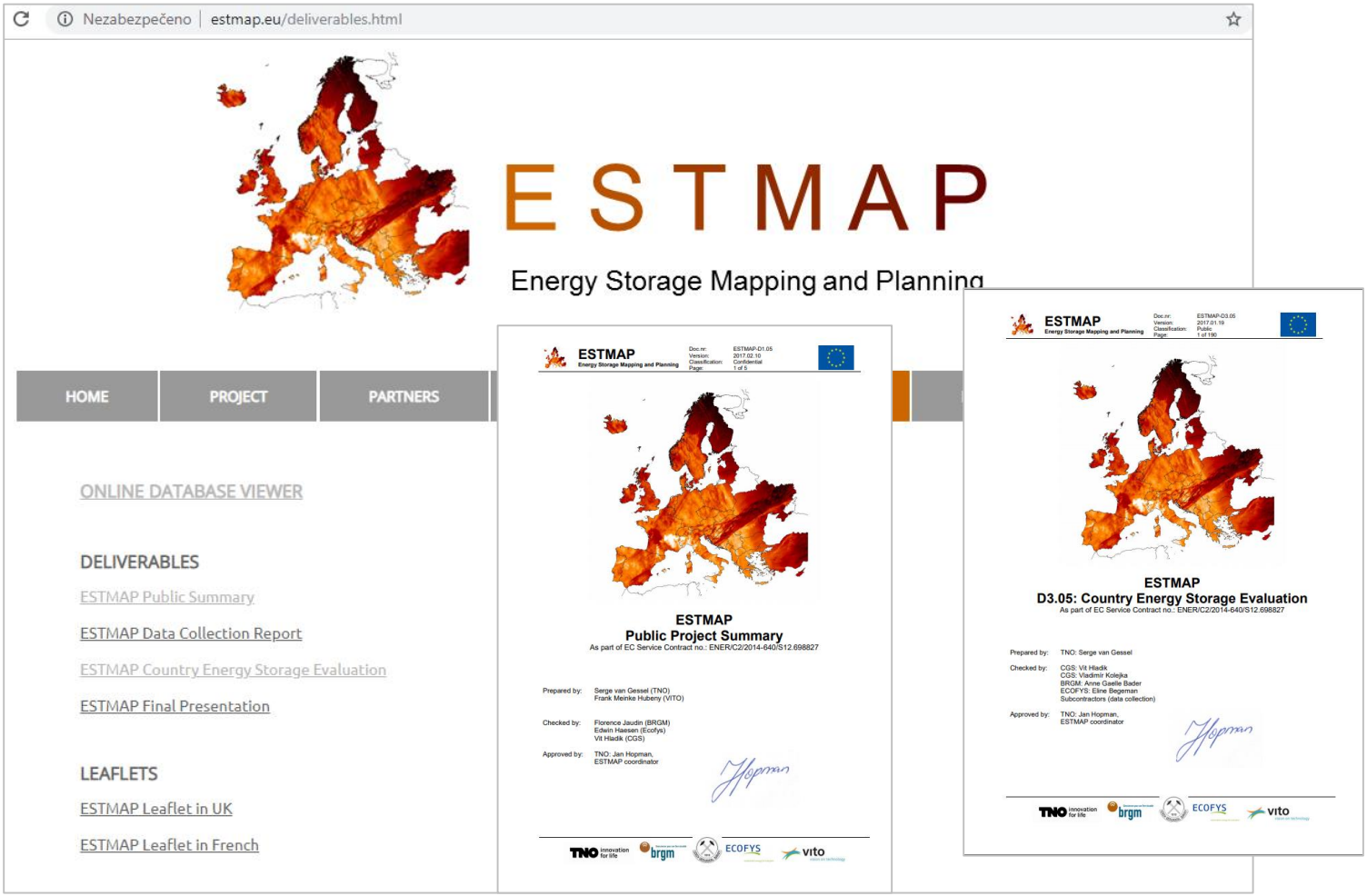
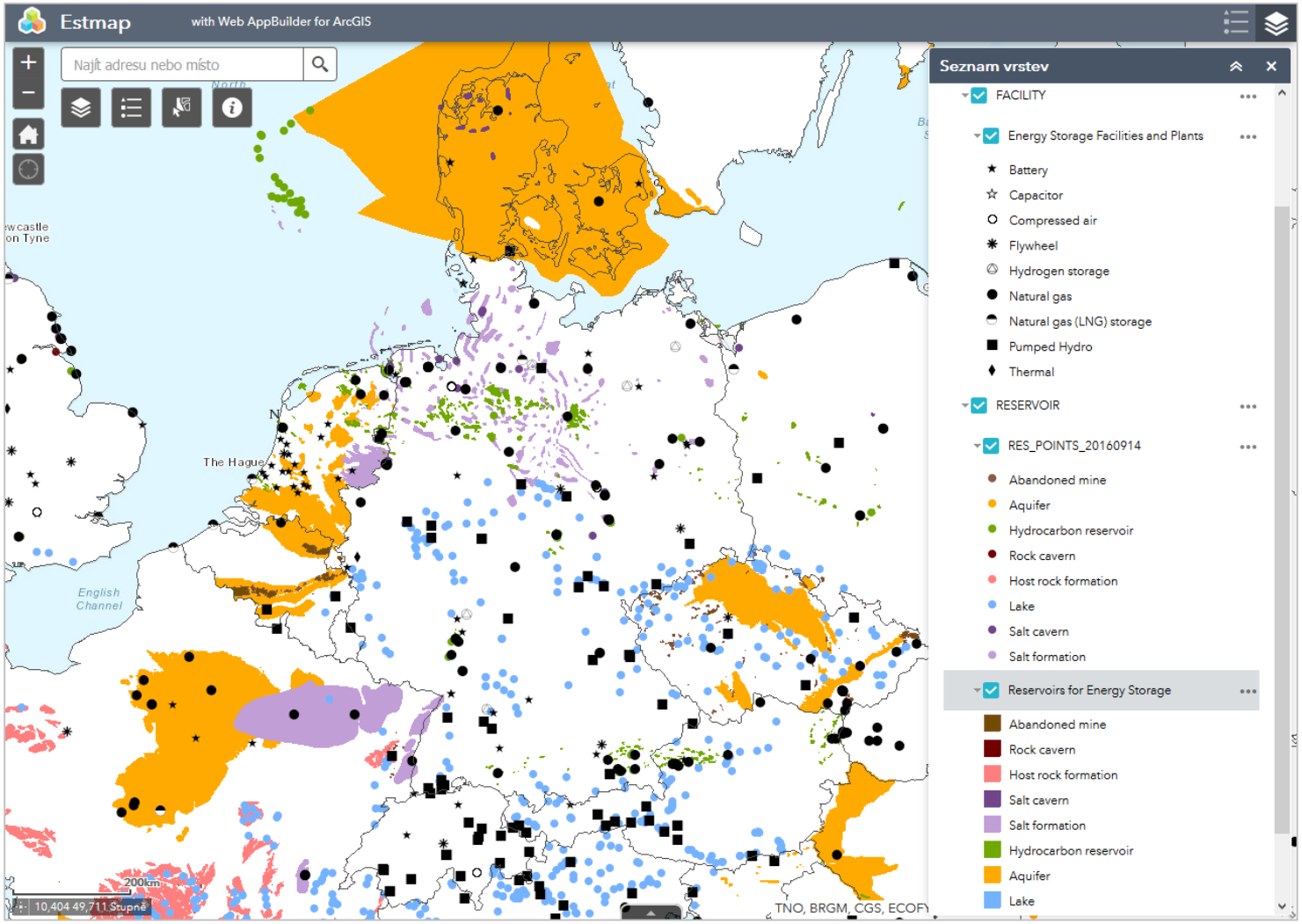
Project website – www.estmap.eu



Project website – www.estmap.eu



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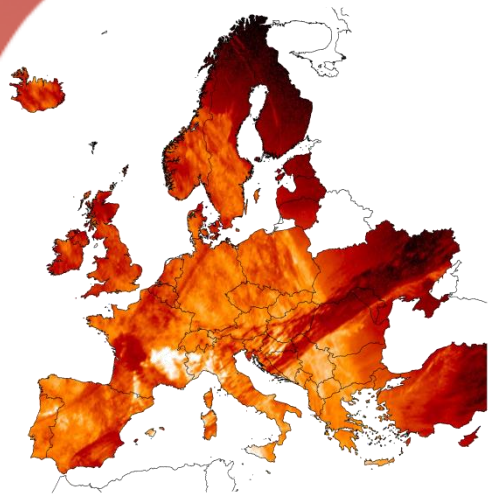

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The ESTMAP project results preseted here have been produced within a contract with the European Union, Service Contract Number ENER/C2/2014-640/S12.698827.

The opinions expressed are those of the contractor only and do not represent the contracting authority's official position.