HEATSTORE WEBINAR SERIES

HOW TO DEVELOP UNDERGROUND THERMAL ENERGY STORAGE (UTES) PROJECTS?

Learnings from the European HEATSTORE project

Host: TNO, The Netherlands

heatstore
High Temperature Underground Thermal Energy Storage

GEOTHERMICA

7, 14, 21, 28 Sept. and 5, 12 Oct. 2021 | all 15-16 h (CEST)

Register on www.heatstore.eu

HEATSTORE WEBINAR SERIES 2021

All webinars are at 15 – 16 h CEST

Tuesday 7 Sept. (Holger Cremer, TNO): Challenges in Underground Thermal Energy Storage (UTES)

Tuesday 14 Sept. (Thomas Driesner, ETH Zurich): Advances in subsurface characterization and simulation

Tuesday 21 Sept. (Koen Allaerts, VITO): Integrating UTES and DSM in geothermal district heating networks

Tuesday 28 Sept. (Florian Hahn, Fraunhofer IEG): Abandoned coal mines – promising sites to store heat in the underground

Tuesday 5 Oct. (Bas Godschalk, IF Technology): The ECW Energy HT-ATES project in the Netherlands

Tuesday 12 Oct. (Joris Koornneef, TNO): The role of UTES in the future EU energy system – a moderated table discussion.

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- HEATSTORE = GEOTHERMICA ERA-NET co-fund project
- 16.3 M€ | 23 partners in 9 EU countries
- 6 demonstration sites, 8 case studies.
- Coordination: TNO Netherlands Organization for Applied Scientific Research)

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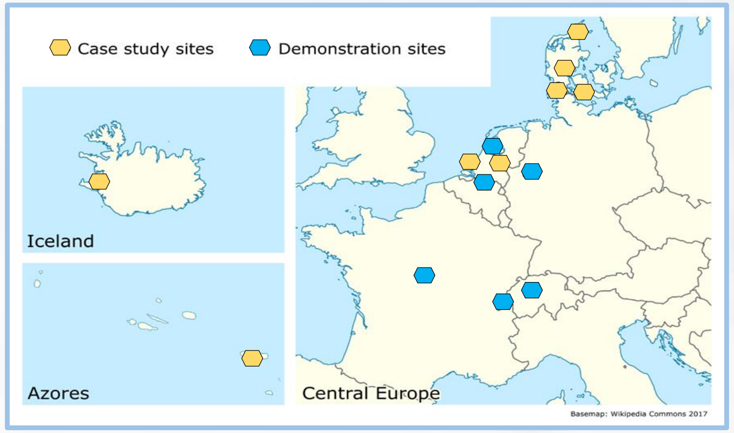
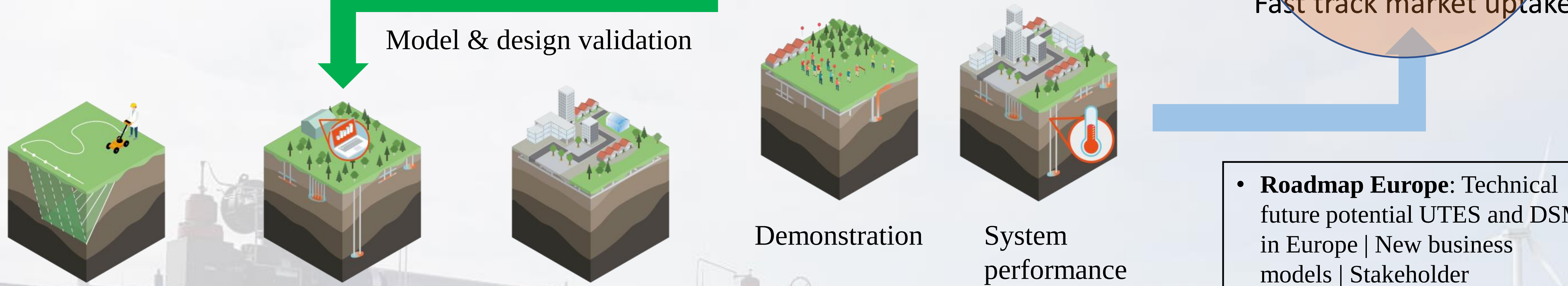


- **Best practice guidelines:** Design & System integration | Business models | Regulatory framework | Stakeholder perception & engagement | Monitoring technical, economic and environmental performance

- Proof and operation of UTES and DSM technologies

Fast track market uptake

Model & design validation



Characterization of UTES

Modelling sub-surface dynamics

Heating system integration & design optimisation

Demonstration

System performance monitoring

- **Roadmap Europe**: Technical future potential UTES and DSM in Europe | New business models | Stakeholder engagement | Roadmap for fast track uptake

Design → **Demonstration** → **Replication and scale-up**

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HEATSTORE – 12 Oct. 2021
The role of UTES in the future EU energy system – a moderated table discussion

- Joris Koornneef (TNO): Convenor & Opening
- Jacopo Tosoni (EASE): The current role of energy storage in the EU
- Gonzalo Fernández Costa (European Commission – DG Ener): Energy storage in the EU – steps forward

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ROADMAP FOR FLEXIBLE ENERGY SYSTEMS WITH UNDERGROUND THERMAL ENERGY STORAGE TOWARDS 2050

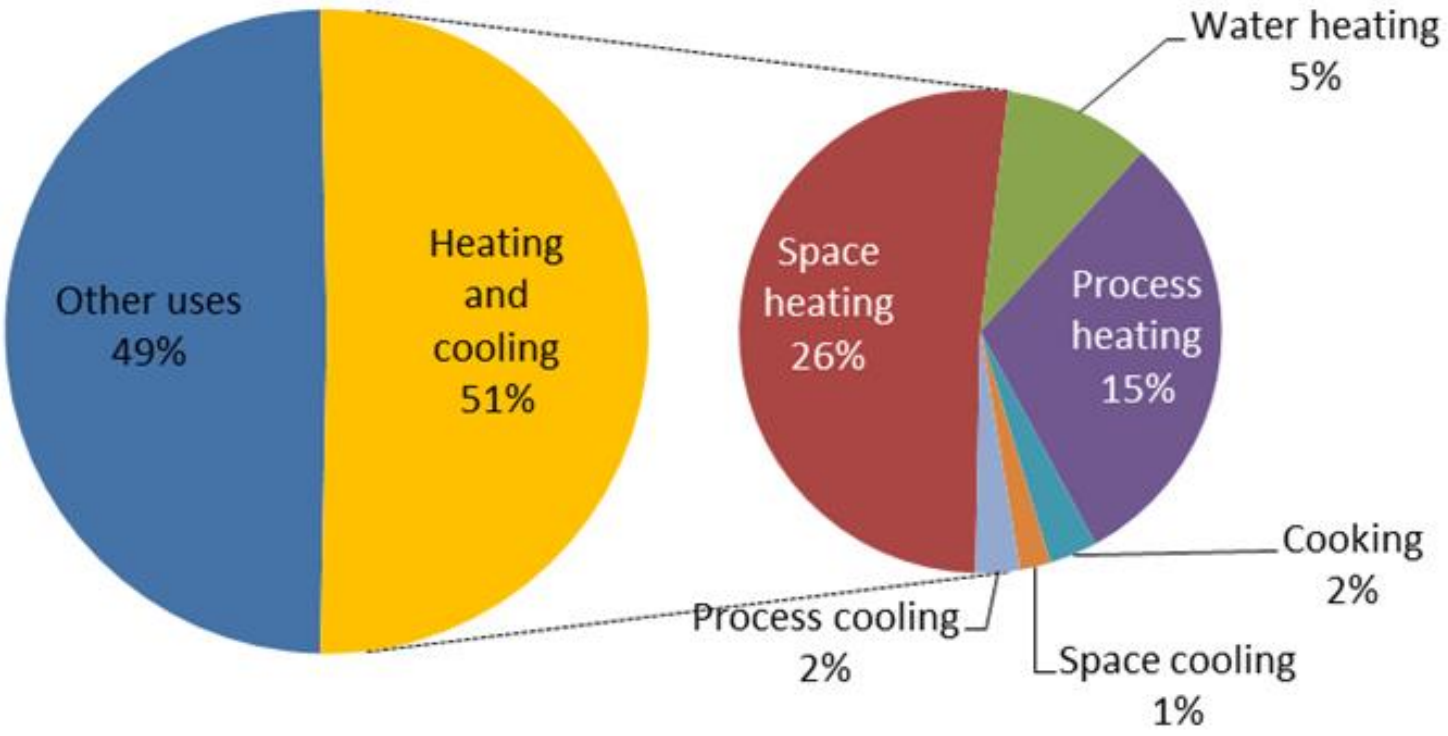
WHAT IS UTES? WHY IS IT OF RELEVANCE? WHAT DO WE NEED TO PROGRESS IT?

HEATSTORE WEBINAR, TUESDAY 12 OCTOBER,

ROADMAP FOR UTES IN EUROPE

TRANSITION IN THE HEATING AND COOLING SECTOR

- 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. 68% of all EU gas imports.
- There thousands of District Heating Networks in Europe, currently supplying more than 10% of total European heat demand.



Total heating and cooling demand as share of EU final energy consumption
Source: [Report WP1.pdf (europa.eu)](); https://ease-storage.eu/publication/thermal-storage-position-paper/

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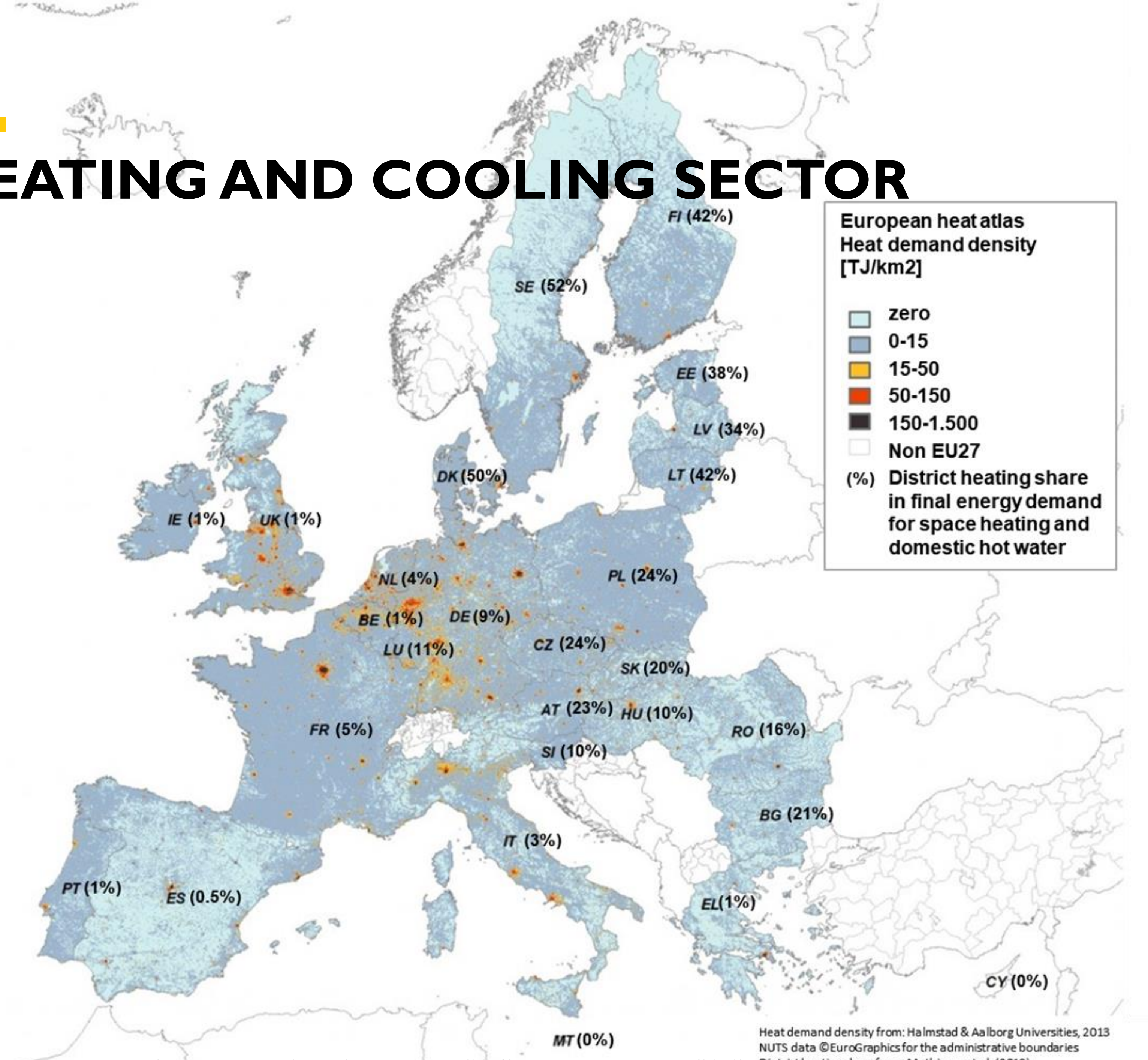
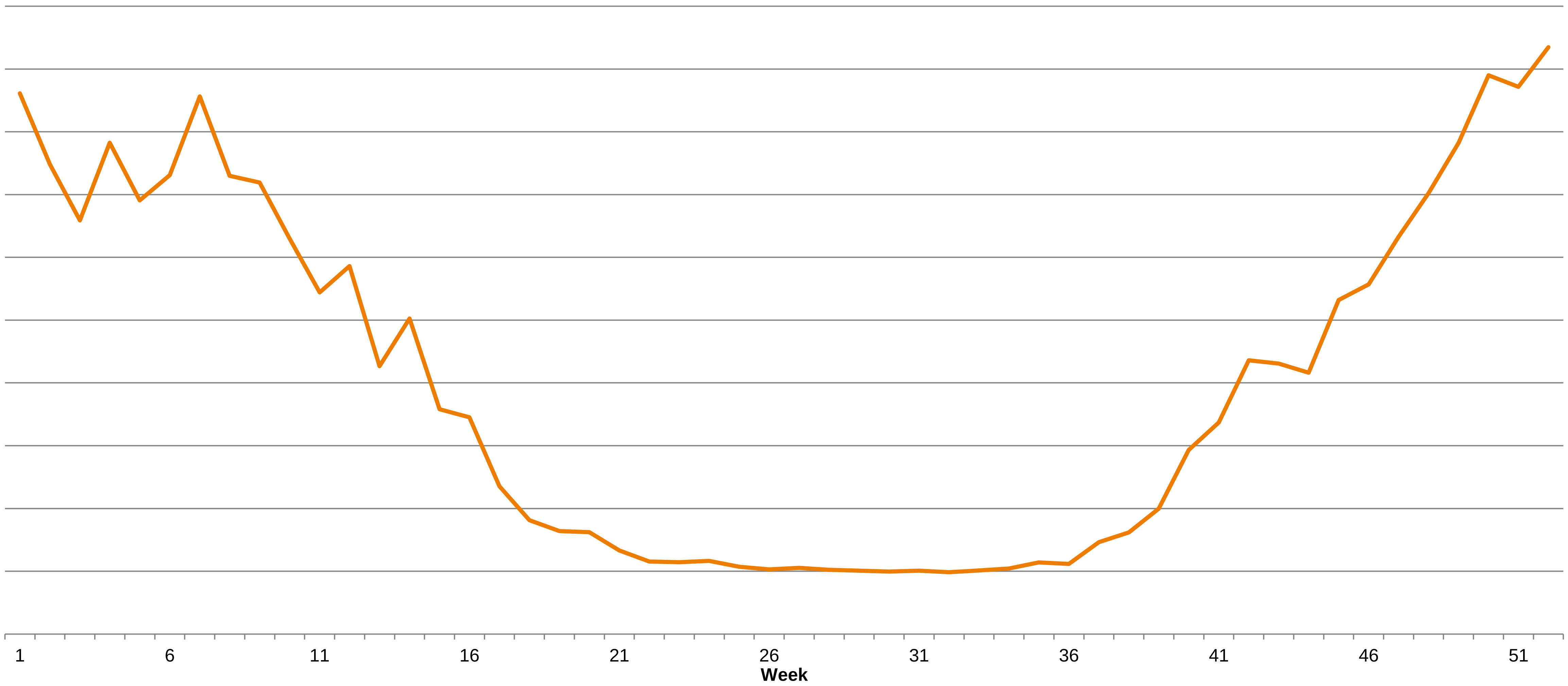
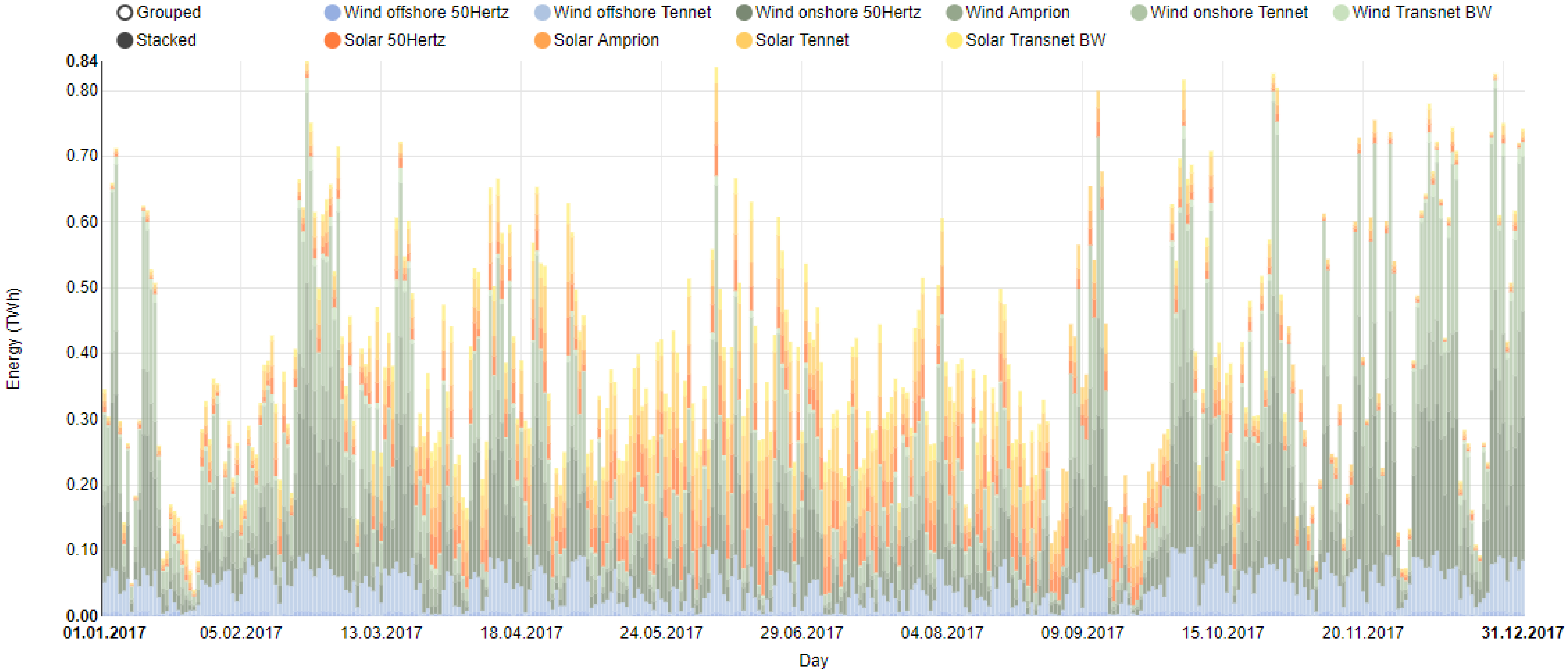


Graphic adapted from: Connolly et al. (2013) and Mathiesen et al. (2019)

WE NEED SOLVE THIS DEMAND PROFILE….

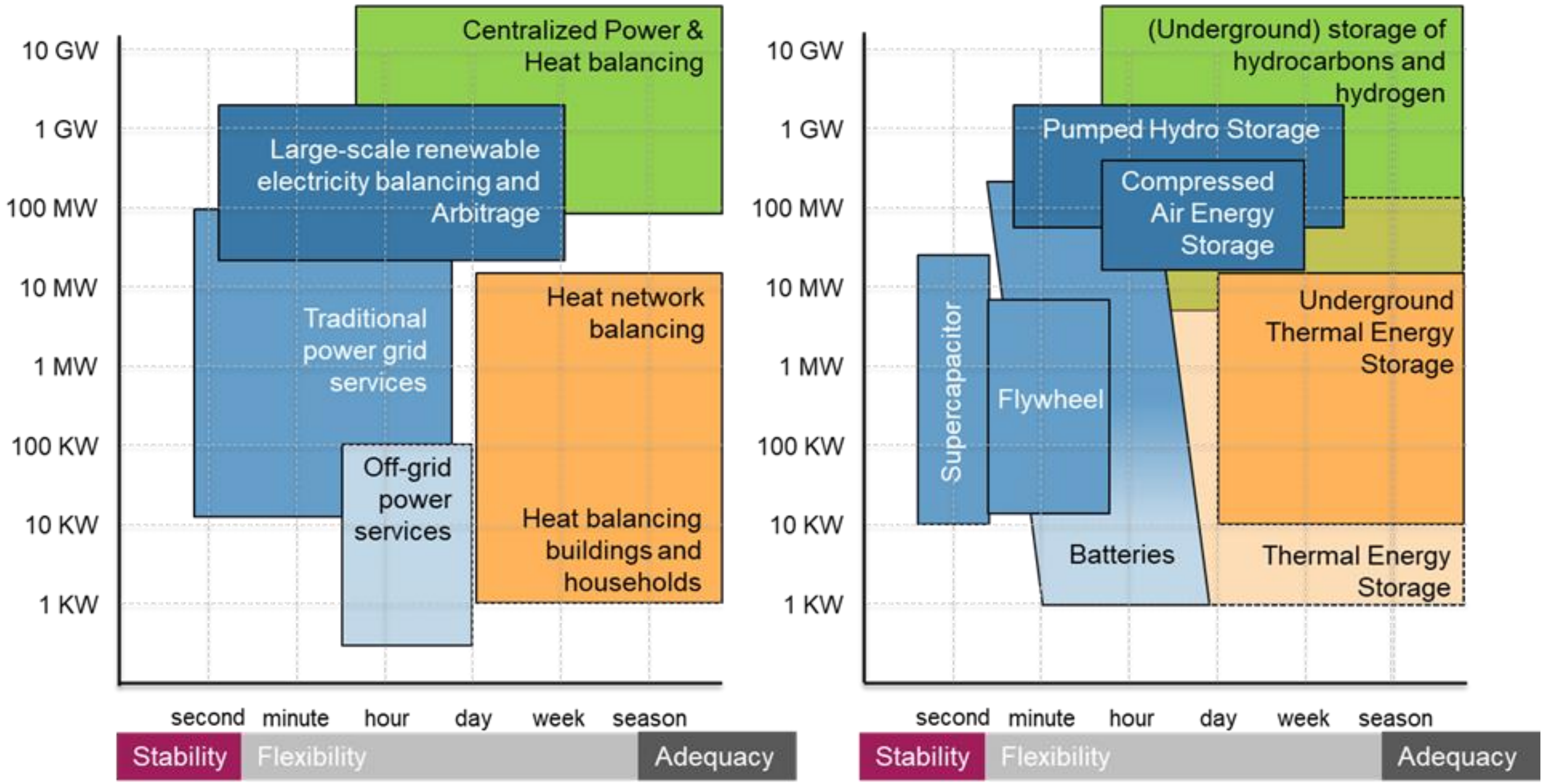


WITH THIS ONE?



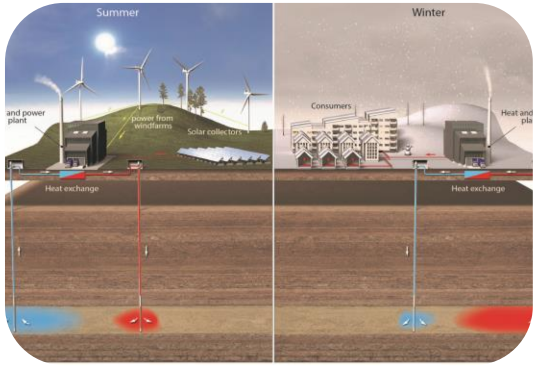
Net generation for public power supply.
Datasource: 50 Hertz, Amprion, Tennet, TransnetBW
Last update: 31 Jan 2018 02:14

UTES AS PART OF EUROPE'S ENERGY STORAGE PORTFOLIO



Source: TNO inspired by IEA

THE UTES TECHNOLOGIES IN HEATSTORE

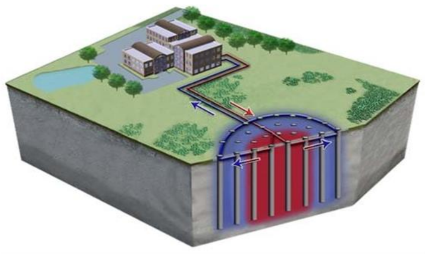


Aquifer Thermal Energy Storage

- Injection and later re-production of hot water in aquifers in both shallow and deep geological formations.T
- the aquifers can be both unconsolidated sand units, porous rocks like sandstones or limestone or e.g. fractured rock formations.
- It is an open system using geothermal or water wells and storing the heat in the groundwater and in the formation around it.

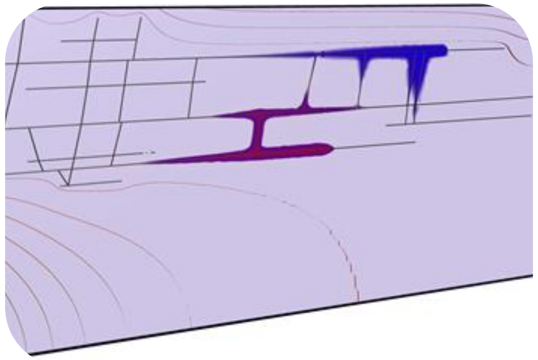
Pit Thermal Energy Storage

- Hot water is stored in very large (multiple) excavated basins with an insulated lid.
- Sides and bottom are typically covered by a polymer-liner, but can also be made of concrete.



Borehole Thermal Energy Storage

- The natural heat capacity in a large volume of underground (unconsolidated) soil or rock is used to store thermal energy with or without groundwater as the storage medium.
- It typically has several closely spaced boreholes, between 50 and 200 m deep; they act as heat exchangers to the underground, usually in U-pipe form.



Mine Thermal Energy Storage

- Mine water of abandoned and flooded mines is used as a storage medium for high temperature storage.
- The mine water can also be used as an ambient energy source in combination with heat pumps.

COMMERCIAL SCALE DEPLOYMENT OF UTES

DRONINGLUND PTES, BUILT IN 2013

- DH heat demand: 40,000 MWh/a
- 37,600 m^2 solar collectors
- 60,000 m^3 pit heat storage
- 10 MW bio-oil boiler
- 5 MW gas boiler
- 3.6 MW_{el} CHP gas engine
- 3 MW_{th} absorption heat pump

- Storage capacity: 5,400 MWh (T_{max} 89°C, T_{min} 12°C)
- Efficiency: 90% (2014-2016)
- Investment/capacity: 0.43 €/kWh
- Max charge/discharge capacity: 27 MW
- Investment/max charge capacity: 85 €/kW

MARSTAL PTES, BUILT IN 2011-2012

- DH heat demand: 32,000 MWh/a
- 33,300 m^2 solar collectors
- 75,000 m^3 pit heat storage
- 2,100 m^3 buffer tank
- 18 MW bio-oil boiler
- 4 MW biomass boiler
- 750 kW_{el} biomass CHP Organic Rankine Cycle
- 1.5 MW_{th} CO_2 heat pump

- Storage capacity: 6,960 MWh (T_{max} 90°C, T_{min} 10°C)
- Efficiency: 67% (2016)
- Investment/capacity: 0.374 €/kWh (without transmission pipe)
- Max charge/discharge capacity: 10.5 MW
- Investment/max charge capacity: 252 €/kW

BRÆDSTRUP BTES, BUILT IN 2011-2012

- DH heat demand: 45,000 MWh/a
- 18,600 m^2 solar collectors
- 19,000 m^3 borehole heat storage
- 5,500 m^3 + 2,000 m^3 steel buffer tanks
- 10 MW electric boiler
- 13 MW gas boiler
- 8 MW_{el} CHP gas engine
- 1.2 MW_{th} ammonium heat pump

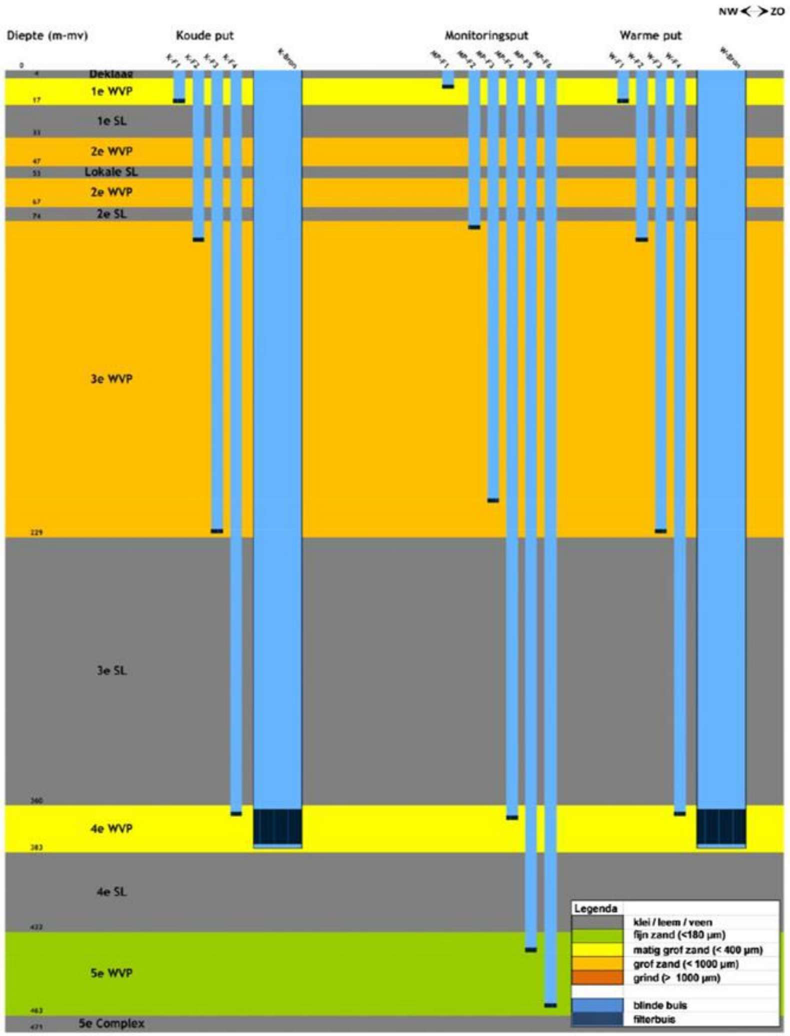
- Storage capacity: 400 MWh (T_{max} 50°C, T_{min} 11°C)
- Efficiency: 63% (2014-2016)
- Investment/capacity: 0.65 €/kWh (without buffer tank)
- Max charge/discharge capacity: 600 kW
- Investment/max charge capacity: 433 €/kW

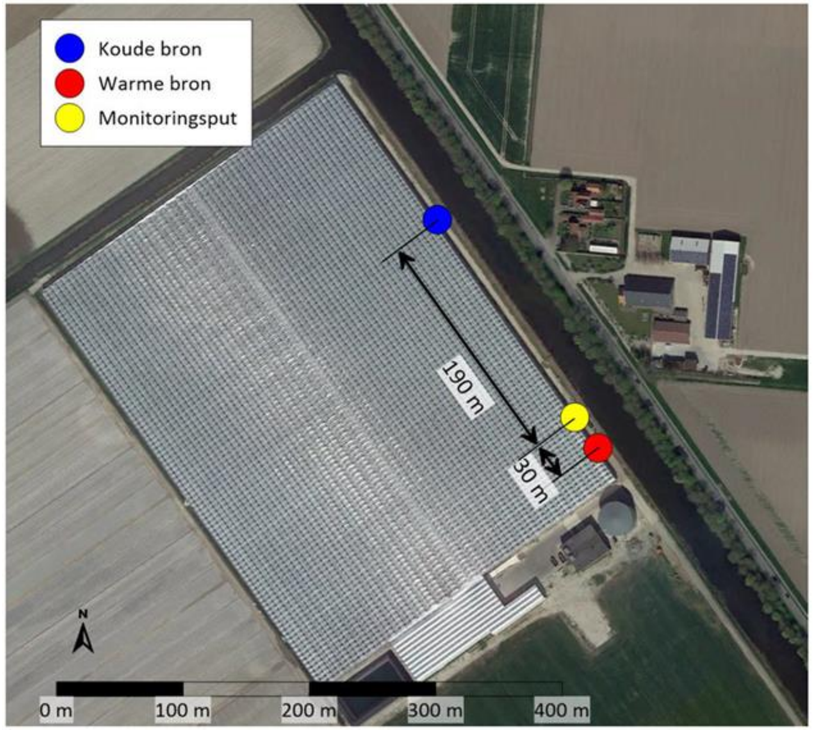
ECW ATES, BUILT IN 2020-2021

- 70 MW peak demand
- 43 MW geothermal (3 doublets)
- Biomass and gas fired CHP plants
- Network operating temperature of 85 °C

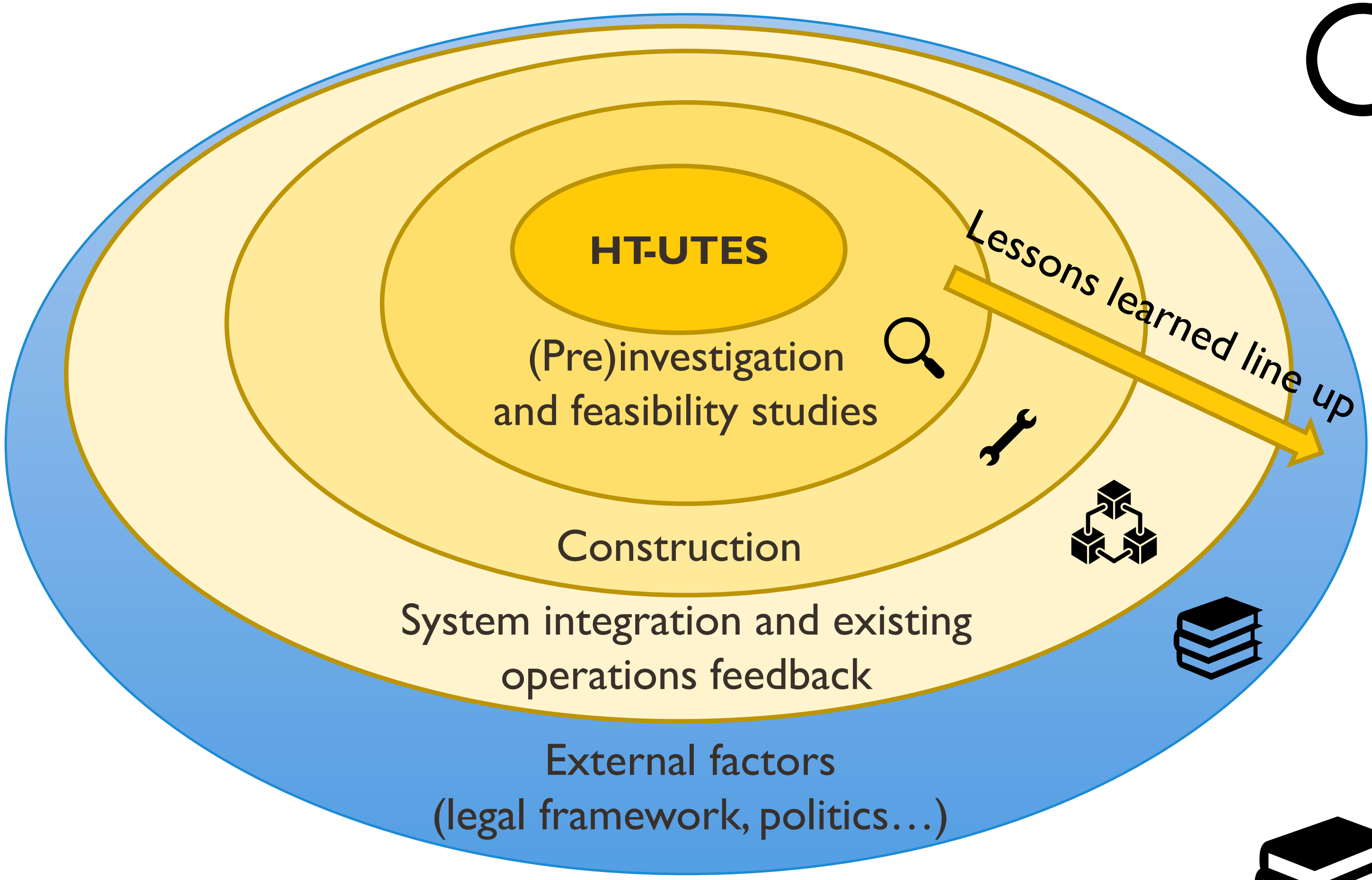
- Storage capacity: 20-28 GWh
- Efficiency: ~70-75% (estimate)
- T injection (summer/winter): 85-90 °C / 30°C
- Max charge/discharge capacity: 16 MW/ 12 MW
- Flow rate: max 150m³/ hour
- Water displacement: 600.000 – 700.000 m^3 per season
- Investment/capacity: 0.2 €/kWh
- Investment/max charge capacity: 200-300 €/kW

HTO ECW - Filterstelling bronnen en peilbuizen



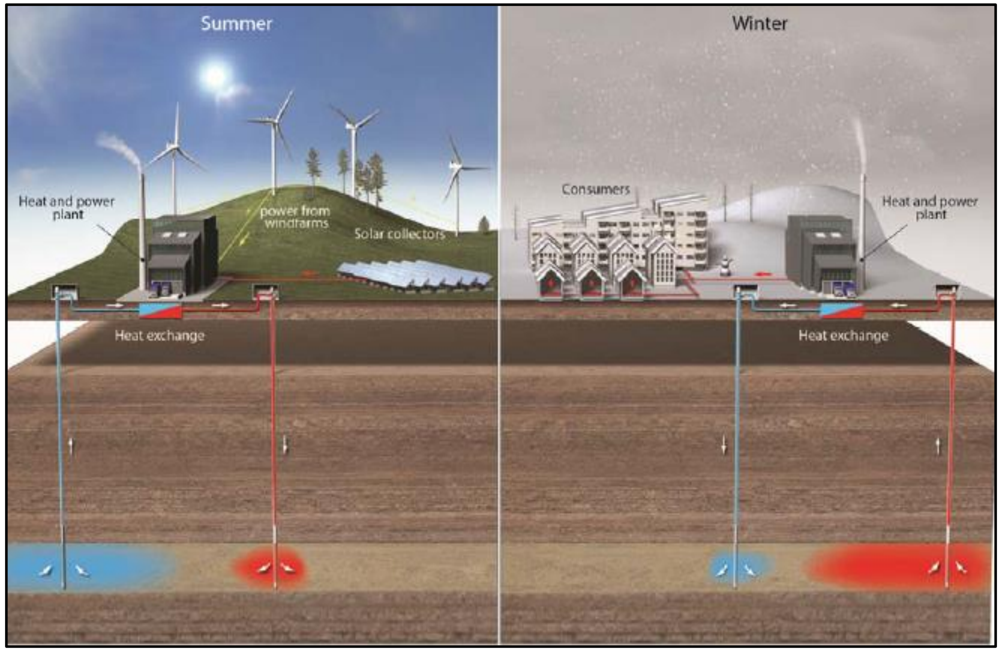


HT-UTES – LESSONS LEARNED FROM DIFFERENT PHASES



- Screening for geographical parameters is essential (subsurface and surface)
- Modelling of the entire energy system
- Experiences from drilling, borehole completion, design and selection of materials
- Experiences from system operations and integration
- Socio-economic factors
  Legal/regulatory barriers

Characterization of UTES	Modeling subsurface dynamics	System integration & UTES design optimisation	Demonstration	System performance monitoring	Fast track market uptake



- UTES State-of-the-art
- Tools for simulating subsurface dynamics of HEATSTORE UTES sites
- Improved models of subsurface heat storage dynamics
- Technical characteristics of heat demand and supply at demo sites
- Design of business case models for the demo sites

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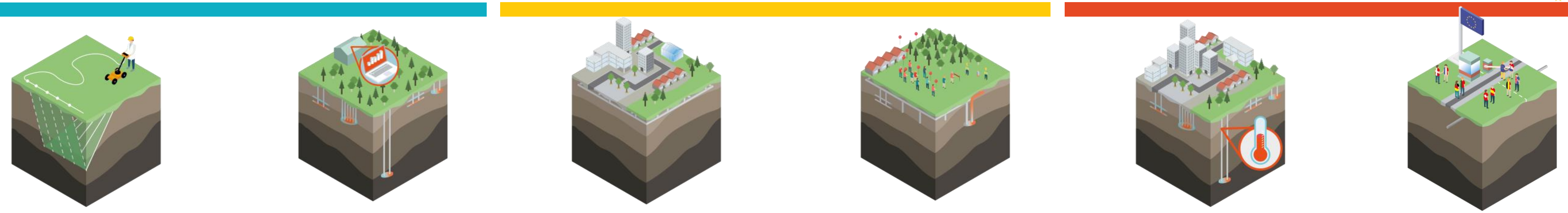

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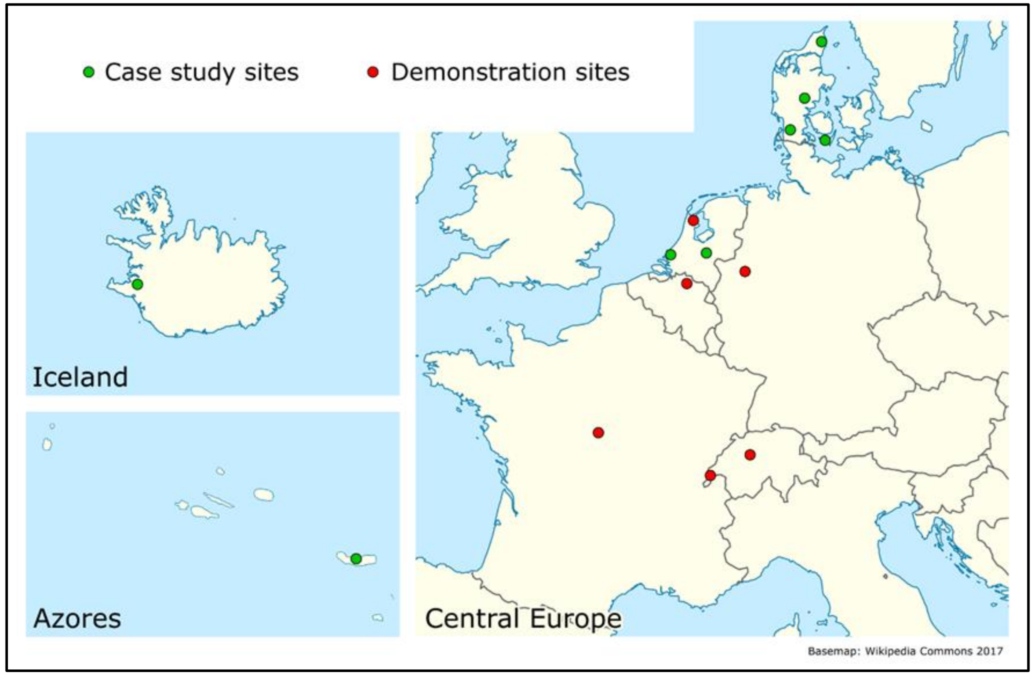

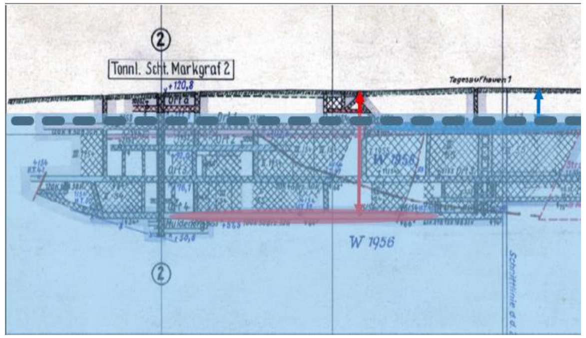

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Characterization of UTES	Modeling subsurface dynamics	System integration & UTES design optimisation	Demonstration	System performance monitoring	Fast track market uptake

Vision 2050

Technology & innovation

Market & Economics

Society & Environment

Policy & regulation

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TOWARDS UTES AS LARGEST (HEAT) STORAGE OPTION IN EUROPE

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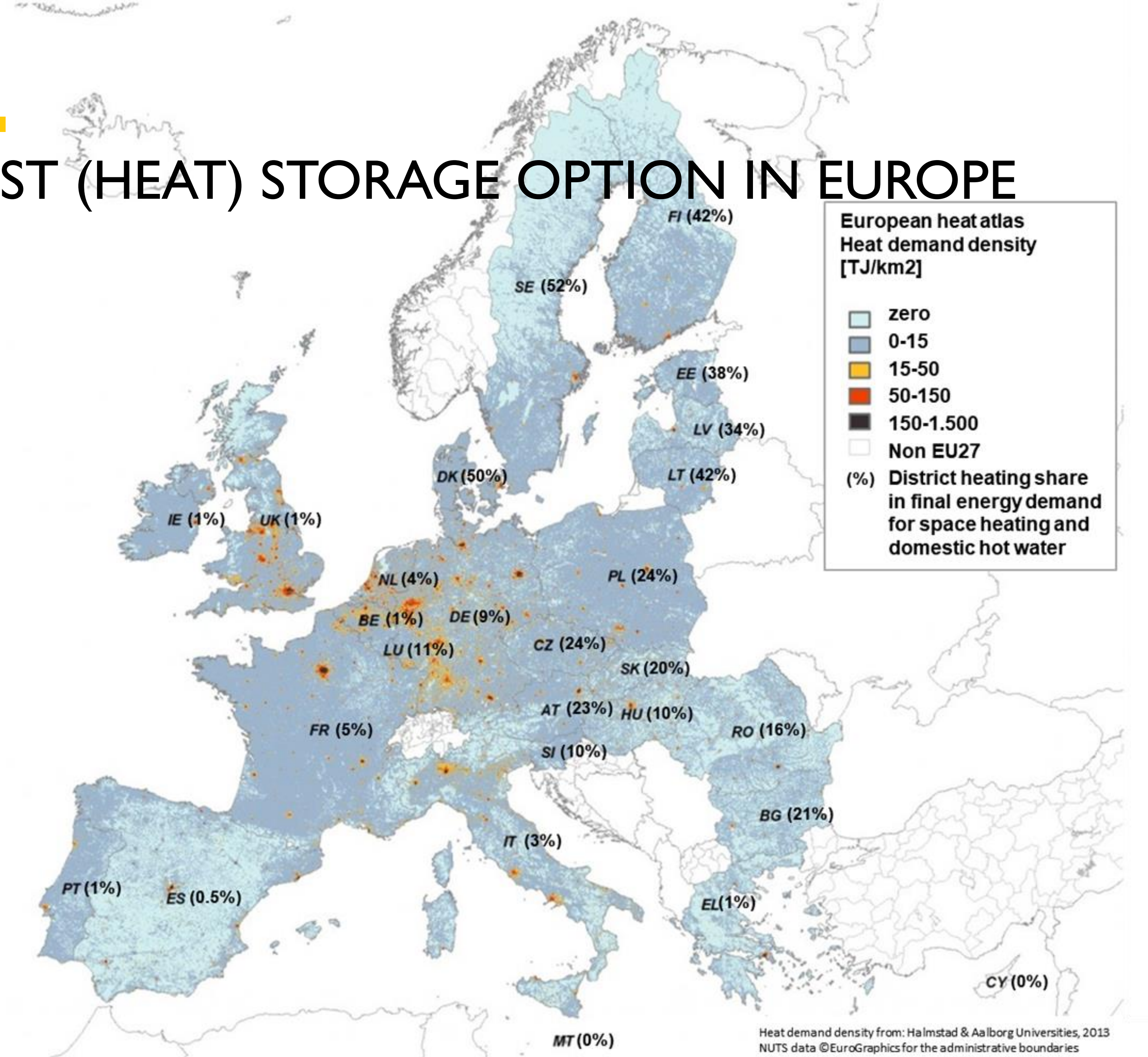
Technology & innovation

Market & Economics

Society & Environment

Policy & regulation



Graphic adapted from: Connolly et al. (2013) and Mathiesen et al. (2019)

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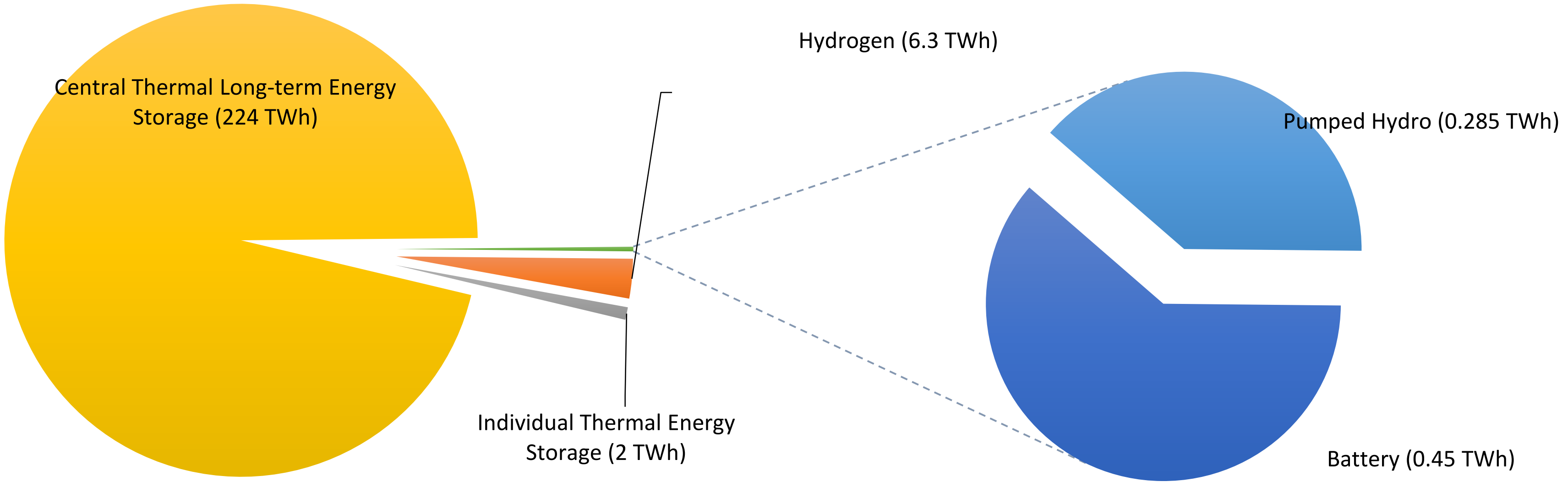

Source: Victoria et al. 2019

- District heating could be a cornerstone of the decarbonation strategy of the EU, and in order for the district heat networks to be as sustainable, flexible and economically viable as possible, large scale UTES is part of that promise.
- Overall, the integration of low carbon heat sources in the energy system implies that ***hundreds to even thousands of large scale UTES systems need to become operational in Europe in the next thirty years*** in order for the European heating and cooling sector to contribute to the sustainability goals of the Paris agreement and EUs Green Deal.

Vision 2050

Technology & innovation

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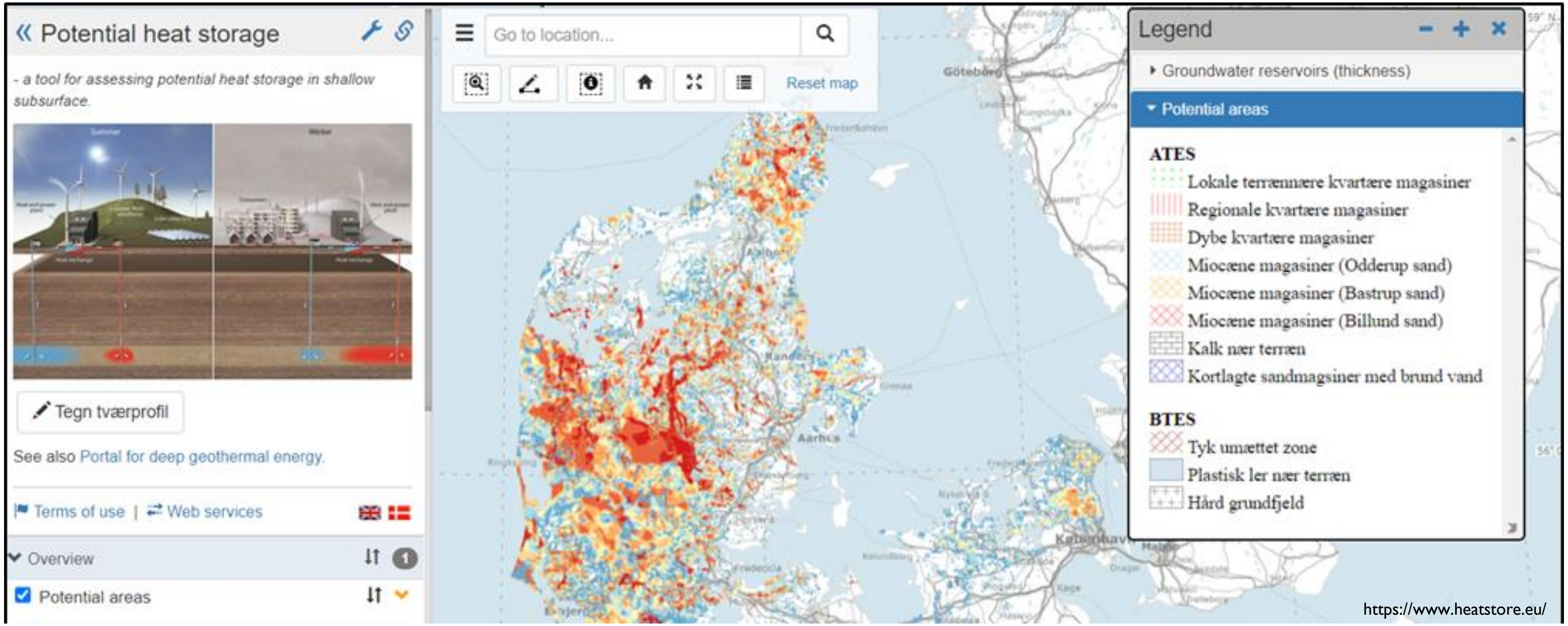

- **Reduce subsurface uncertainty by data acquisition and mapping**
- Gain skills and experience
- Integration of UTES in heat grids
- Improve (initial) efficiency of UTES
- Reduce operational risks

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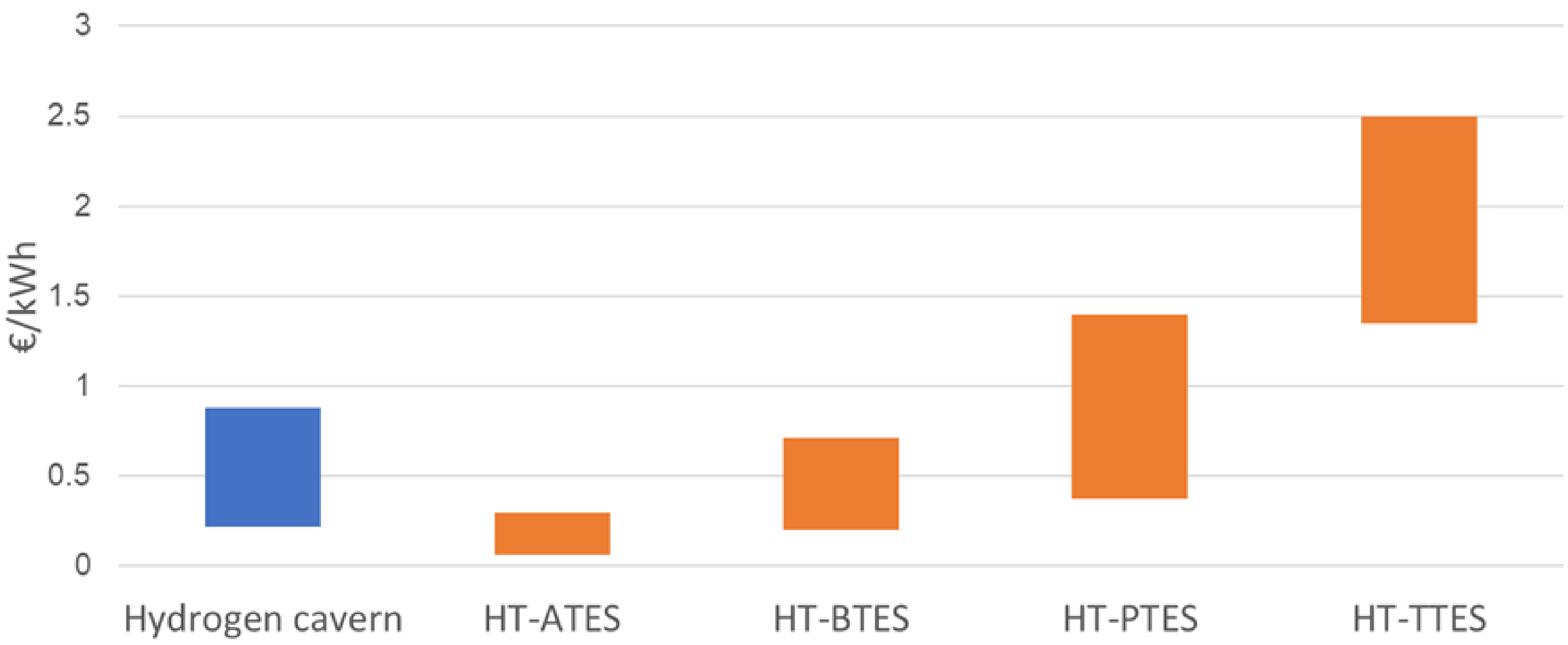
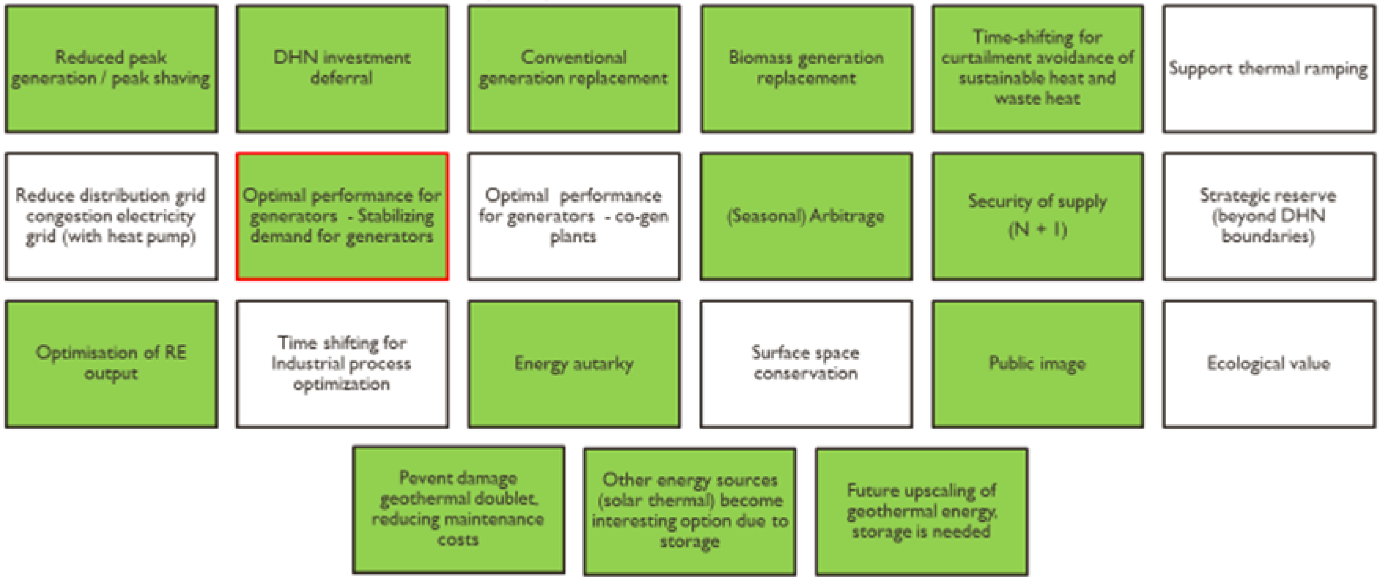


Source: HEATSTORE

- Follow a structural approach to establish a robust business case model Source: HEATSTORE
- **Improve storage economic project fundamentals – further CAPEX and OPEX reduction**
- Create and stack business model revenue opportunities
- Transparent ownership and market player relationships

HEAT STORAGE SERVICES/ACTIVITIES/VALUE PROPOSITION
Example Netherlands demo
Value proposition for HT-ATES ECW



Source: Evaluation of new business models for flexible energy systems with UTES in Europe

- Follow a structural approach to establish a robust business case model
- Improve storage economic project fundamentals – CAPEX and OPEX reduction
- **Create and stack business model revenue opportunities**
- Transparent ownership and market player relationships

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Effect \ Risk	HT-ATES							MTES		BTES	PTES
	Koppert_Cress	NIOO	GEo-01		GEo-02		Bern	Bochum		Brædstrup	Marstal
	Operations	Operations	Drilling	Operations	Drilling	Operations	Operations	Drilling	Operations	Operations	Operations
Air quality	L	L	M	L	M	L		L	L	L	L
Noise and vibration	L	L	M	L	M	L		M	L	L	L
Formation water quality	M	M	L	H	L	H	M	M	M	L	M
Formation water temperature	M	M		M		M				L	
Surface clear water	L	L	M	L	M	L		M	M	L	L
Soil occupation	L	M	M	M	M	M		L	L	L	L
Wastes and dangerous substances	L	L	M	L	M	L		L	L	L	L
Environment	L	L	L	L	L	L				L	L
Nature	L	L	L	L	L	L				L	L
Soil mechanics	L	L		L		M		L	L	L	L
Seismicity	L	L	M	M	M	M		L	L	L	L
CO2 intensity redyction	H			H		H			H	H	H

Guglielmetti et al 2021: Environmental effects of UTES technologies in Europe

- **<u>Evaluate, mitigate</u> and monitor environmental impacts**
- Solid spatial planning for subsurface
- Create social awareness and support

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Guglielmetti et al 2021: Environmental effects of UTES technologies in Europe

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WHAT LESSONS ARE LEARNED AND ACTIONS REMAIN?

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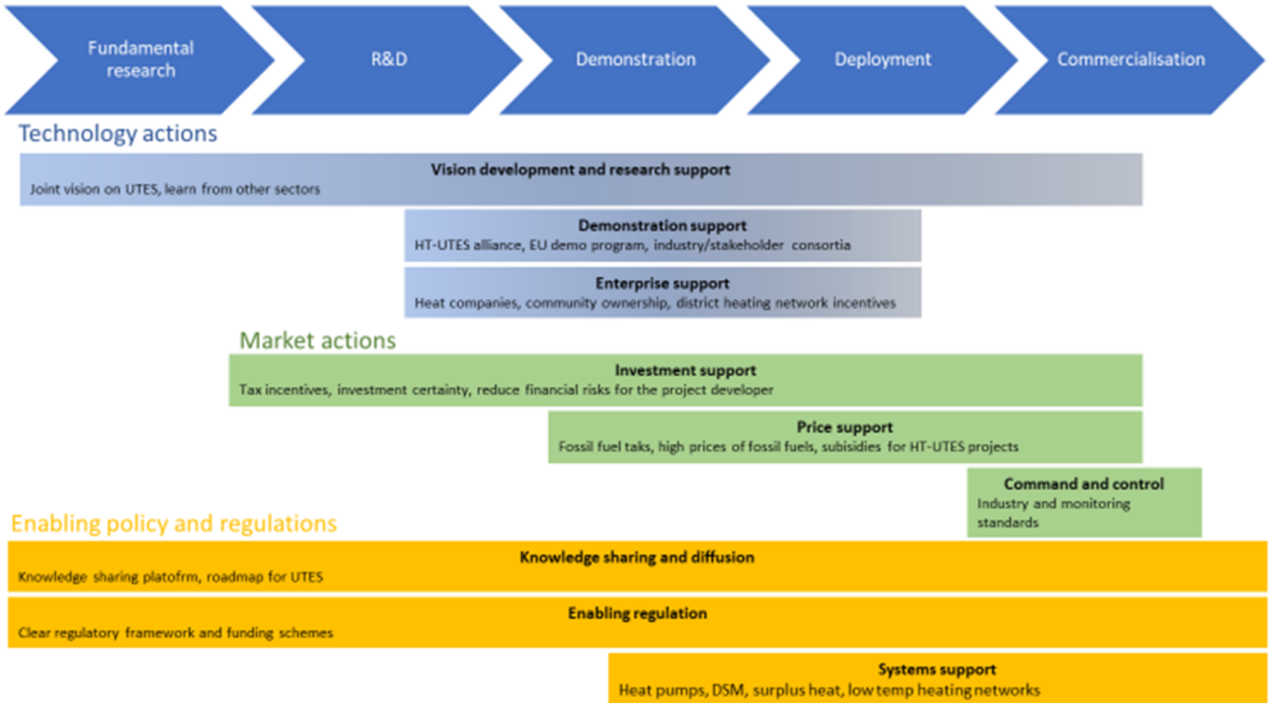


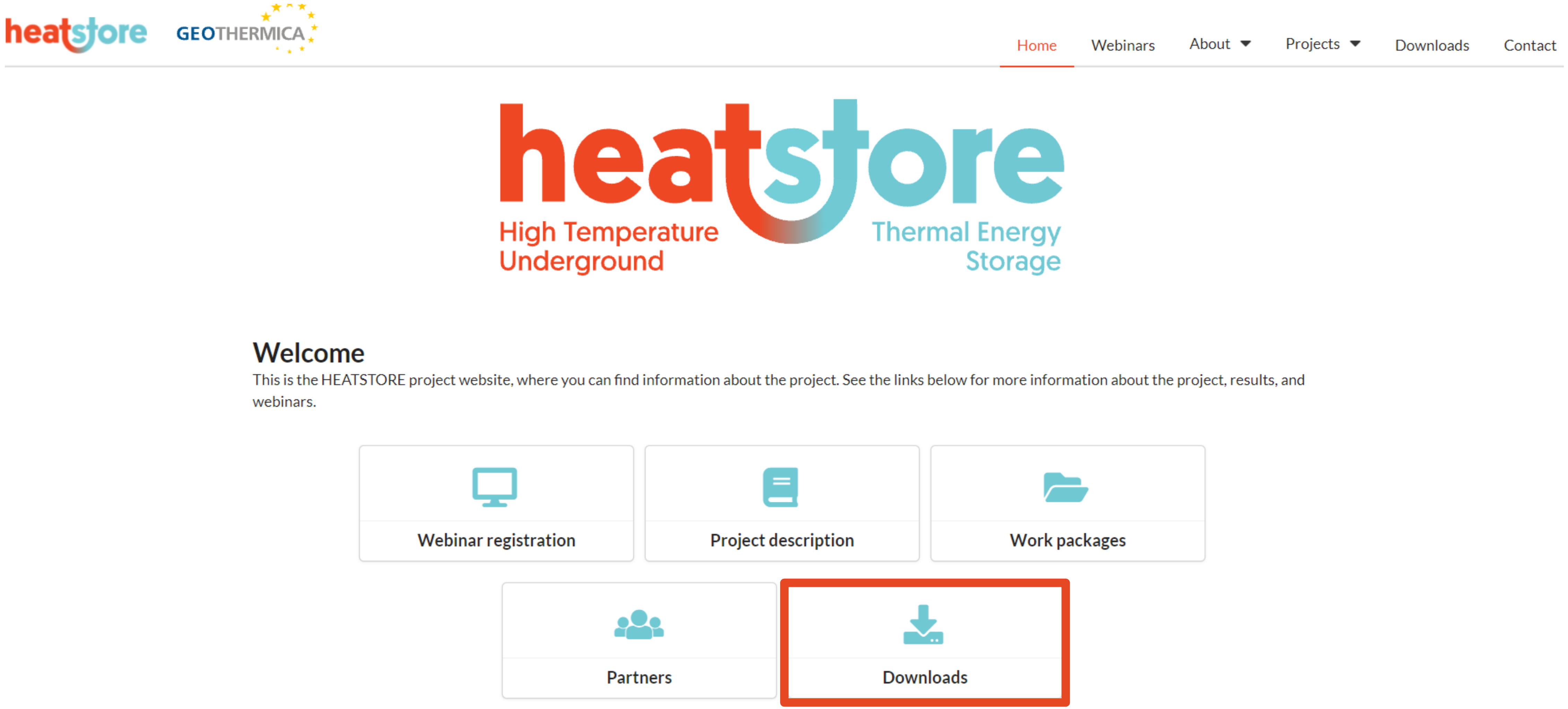
Adapted from IRENA Innovation outlook: Thermal energy storage, 2020

- Create a joint vision on UTES
- Provide clear regulatory framework
- **Adapt policy to UTES: support programme to lower financial risks**

KEY RECOMMENDATIONS FOR THE SHORT TERM

- **Strong need for awareness and strategy on local, national and European level**
- **Help early movers with financial de-risking and support scheme for early commercialisation**
- **Launch the European Underground Thermal Energy Storage Alliance**

WWW.HEATSTORE.EU/



THANK YOU FOR YOUR ATTENTION

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. The three-year project will stimulate a fast-track market uptake in Europe, promoting development from demonstration phase to commercial deployment within two to five years, and provide an outlook for utilisation potential towards 2030 and 2050.

This project has been subsidized through the ERANET cofund GEOTHERMICA (Project n. 731117), from the European Commission, RVO (the Netherlands), DETEC (Switzerland), FZJ-PtJ (Germany), ADEME (France), EUDP (Denmark), Rannis (Iceland), VEA (Belgium), FRCT (Portugal), and MINECO (Spain).

THANK YOU!

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