



IEA Geothermal

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Christian-Albrechts-Universität zu Kiel

Kompetenzzentrum Geo-Energie

# ATES in Germany – Projects and insights

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## Prof. Dr. Sebastian Bauer



- Professor at Institute for Geosciences, Kiel University, Germany, for 17 years
- Before: 9 years at University of Tübingen
- Development and application of numerical codes for flow and transport processes in the subsurface
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## Institute of Geosciences, Kiel University & Competence-Center for Geo-Energy

**Establishment and operation of a Geo-Energy Competence Center for cooperation between industry and science in the field of applied geoscientific energy and energy transition research**

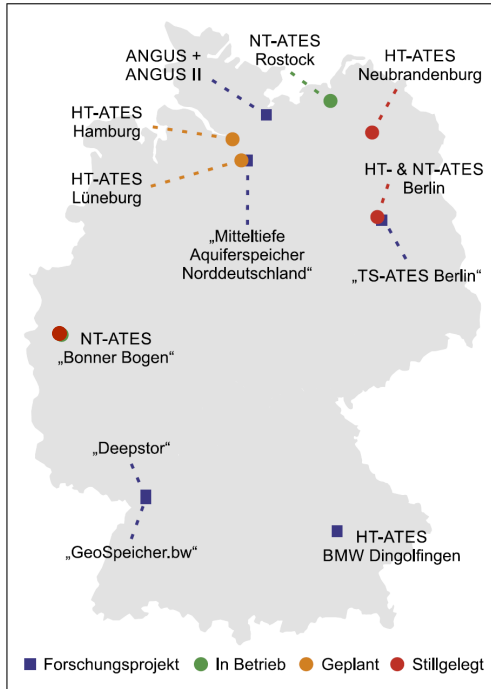
### Topics:

- Subsurface Energy and Mass Storage in the context of the energy and heat transition
- Digitalisation and sustainable use of the geological subsurface
- Climate adaptation measures in urban and coastal areas

### Research and Utilization:

- Experimental Investigations and numerical simulation of storage processes and induced effects of geological energy systems
- Potential analyses and applications for geothermal systems
- Scientific support for real-scale applications

# ATES in Germany



## Worldwide:

- 2800 ATES systems
- > 99% LT-ATES (<25°C)
- Most ATES in Netherlands

## Germany:

- Only one (!) systems operational
- Some abandoned projects and systems
- Main focus is on research projects

Abb. 2 Übersicht stillgelegter, in Betrieb und in Planung befindlicher Aquiferspeicher in Deutschland

Fig. 2 Spatial distribution of abandoned, operating and planned ATES projects in Germany

# Conditions for ATEs in Germany

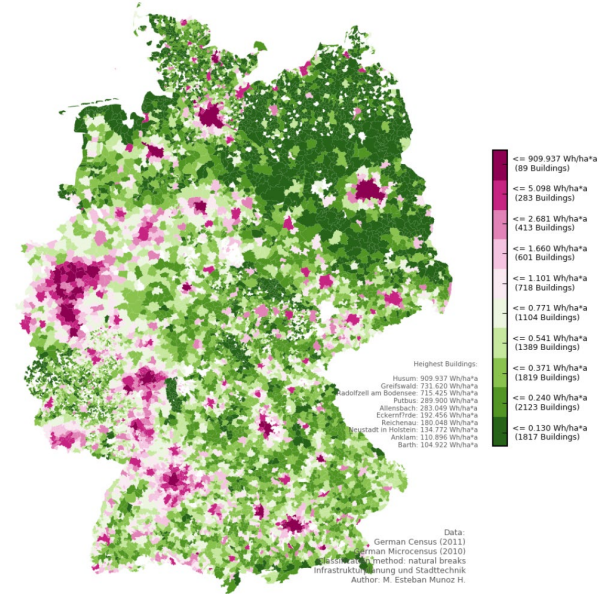
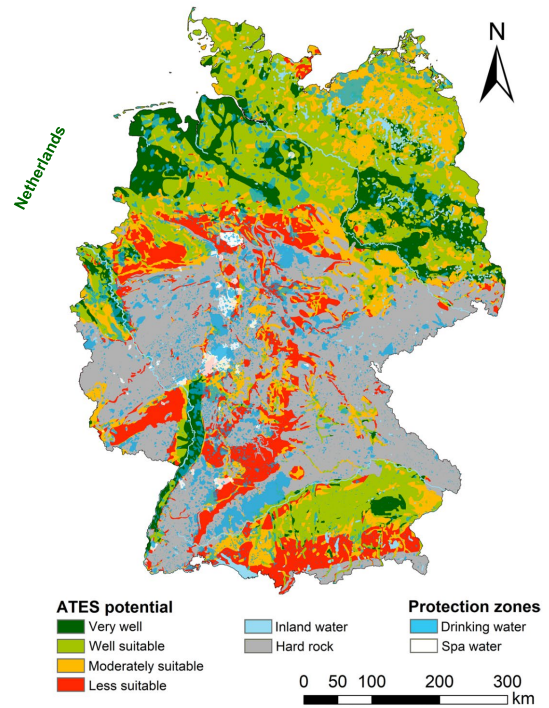
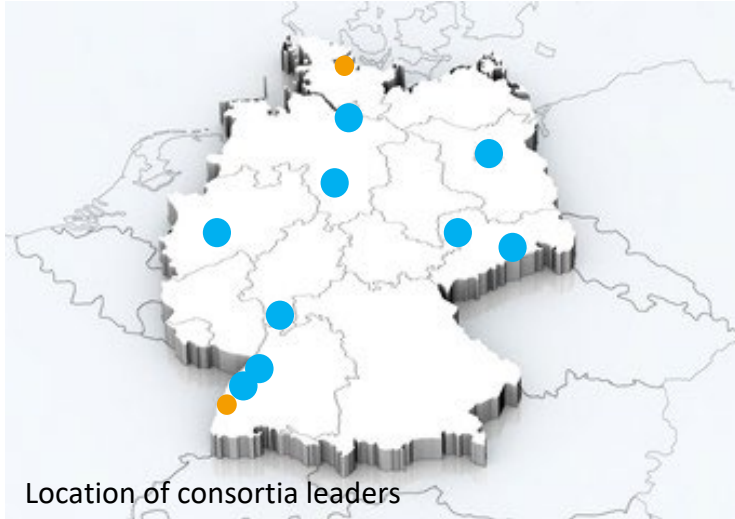


Fig. 6. Estimated heat density [Wh/ha \* a] for Germany

- Only parts of Germany show suitable geological potential
- Only some conglomeration areas coincide with areas of ATEs potential
- Less hands-on experience
- No established proceedings or regulatory procedures

Fig. 8 ATEs suitability potential in Germany for the period near future (2021–2050) based on the reference criteria weighting scheme. Drinking and spa water protection zones are included. Protection zone data from BfG (2021), LFU (2021), LUBW (2022a; b), HLNUG (2022), MULNV NRW (2022), NLWKN (2021)

## ATES Research Projects from a BMBF initiative



### „Possibilities and limitations of thermal energy storage in aquifers“

„Möglichkeiten und Grenzen thermischer Energiespeicherung in Aquiferen“

Duration: 2022 – 2025

- Total of 9 collaborative projects approved
- Online status-seminar 11/2023
- Mix of universities and research centres as well as some companies participate

GEFÖRDERT VOM



Bundesministerium  
für Bildung  
und Forschung

GEO:N – Geoforschung für Nachhaltigkeit

Fachprogramm im Rahmenprogramm „Forschung für Nachhaltige Entwicklung (FONA<sup>3</sup>)“



## OptInAquiFer

Optimized integration of thermal aquifer storage into district heating systems

## UnClog-ATES

Clogging and concrete countermeasures in ATES: experiments, modelling and forecasts

## Winzer

Heat storage in mines in the Ruhr area

## KONATES

Pilot project for the use of contaminated aquifers for heat management with ATES systems

## GEOTES

Possibilities and limits of thermal energy storage in deep aquifers (georeservoirs) in the context of the heat transition 2030

## PotAMMO

Potentials of aquifer heat storage in the model regions of Mannheim and Offenbach

## Demospeicher

Development and monitoring of seasonal heat and cold storage for the demonstration of an aquifer storage facility in Germany

## MineATES

Use of groundwater-filled mining cavities as thermal energy storage

## SpeicherCity

Models for system integration of aquifer storage in cities

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GEFÖRDERT VOM



Bundesministerium  
für Bildung  
und Forschung

## OptimAquifer

Optimized integration of thermal aquifer storage into district heating systems

### Brief Summary:

## Urban Clog-ATES

Clogging and concrete countermeasures in ATES: experiments, modelling and forecasts

### Investigation of

- integration of an ATES in the energy system using hypothetical sites
- Feasibility studies, looking at specific topics

## Winter

Heat storage in mine

## KONATES

Pilot project for the contaminated aquifers for heat management with ATES systems

- higher temperatures for district heating, correlated with depth of heat storage

## GEOTES

Possibilities and limits of thermal energy storage in deep aquifers (georeservoirs) in the context of the heat transition 2030

- Comparing middle-deep to deep (geothermal) settings
- Geochemical effects / scaling

## PotAMMO

Potentials of aquifer heat storage in the model regions of Mannheim and Offenbach

- using abandoned mines for heat storage

## Demospeicher

Development of demonstration sites for thermal energy storage in Germany

- Research on real sites with prospective development of an ATES only for sites in Kiel, Berlin and Leipzig

## MineAT

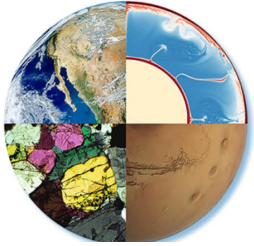
Use of groundwater-filled mining cavities as thermal energy storage

- Interest in High(er) temperature storage

## SpeicherCity

Models for system integration of aquifer storage in cities





# GeoBerlin 2023

Geosciences Beyond Boundaries - Research, Society, Future

150th PGLA (BGR) Anniversary and 175th DGGV Anniversary

Berlin | 3 – 8 September 2023

## Dedicated ATES Session

- 12 Presentations
- 7 Posters
- Contributions from research projects
- More than 80 interested scientists

-> **Community building ongoing**

### 1.5) Aquifer thermal energy storage (ATES): Potential, technologies and geoscientific challenges for a sustainable energy transition

Bauer, Sebastian (1); Bayer, Peter (2); Blum, Philipp (3); Virchow, Lioba (4); Neumann, Thomas (5); Scheytt, Traugott (6)

1: Institute of Geosciences, Christian-Albrechts-Universität zu Kiel, Germany;

2: Institute of Geosciences and Geography, Martin-Luther-Universität Halle, Germany;

3: Institute of Applied Geosciences, Karlsruhe Institute of Technology, Germany;

4: Helmholtz Centre Potsdam, Potsdam, Germany;

5: Institute of Applied Geosciences, Technical University Berlin, Germany;

6: Technical University Bergakademie Freiberg, Freiberg, Germany

Large scale and up to seasonal storage of heat in the urban subsurface allows to integrate renewable or fossil-free heat sources into the urban energy and heat supply systems. Aquifer thermal energy storage (ATES) may provide the large rates and storage capacities required. Successful application of this technology relies on an appropriate characterisation of the subsurface geosystem, the determination of spatially and temporally resolved heat supply and demand, the successful integration of the storage operation into the heat supply system and the characterization of coupled processes leading to performance reduction and impacts on the subsurface environment.

This session addresses all topics, technologies and concepts related to the successful implementation and operation of ATES systems as well as the characterization of induced impacts and aims at providing a state-of-the-art overview of current national and international activities.

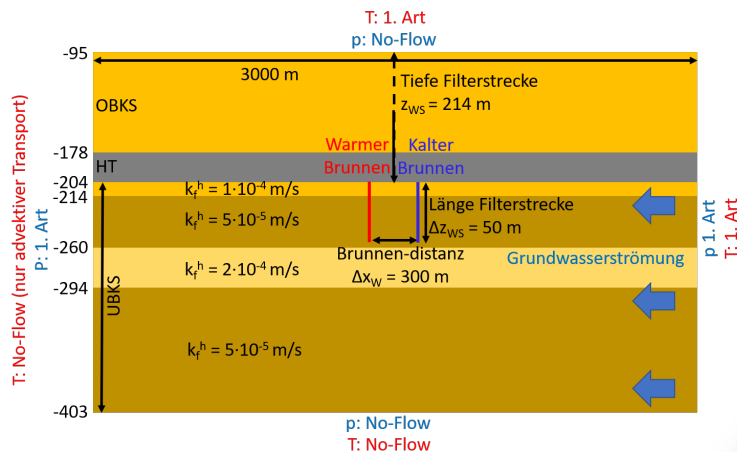
Relevant topics include but are not limited to:

- Identification and characterization of suitable storage formations
- Identification and determination of key site-specific parameters
- Development and application of suitable simulation approaches
- Concepts for integrated energy systems and their analysis
- Evaluation of data needs and data availability
- ATES scenarios contributing to reduced electricity needs and low carbon future
- Determination of induced geochemical and microbiological effects during operation
- Quantification of spatial subsurface requirements
- Site investigations for groundwater quality and environmental impacts
- Monitoring strategies and indicators for efficiency changes and adverse reactions
- Presentation of pilot and operating ATES systems

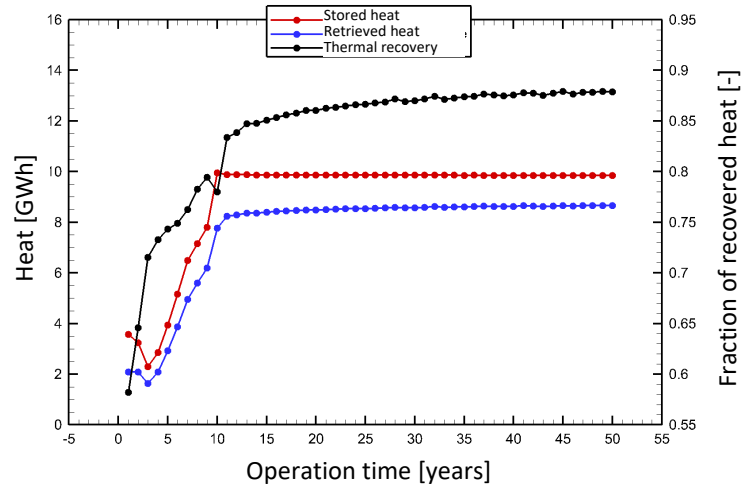
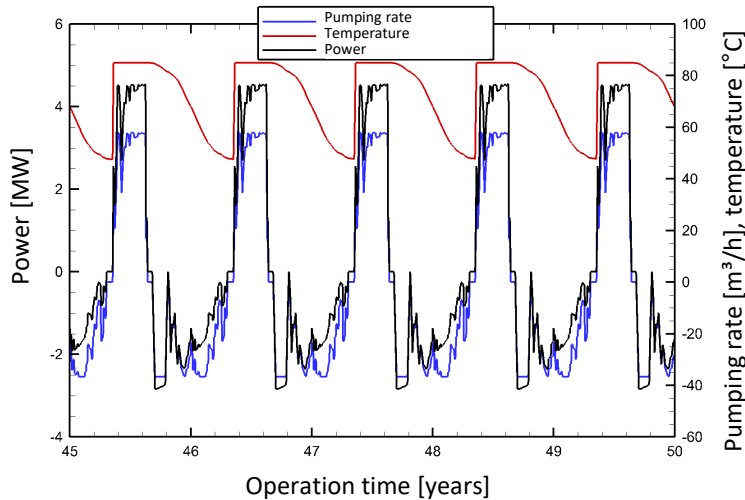
# Energetic design and thermal impacts of an HT-ATES

Part of IW<sup>3</sup> project in Heat Transition in the City of Hamburg, North Germany

- Load curve generated from heating demand and heat supply by geothermal and conventional energy
- Integrated into the district heating network using heat pumps
- Site specific hydro-geological model of groundwater flow and ATES operations



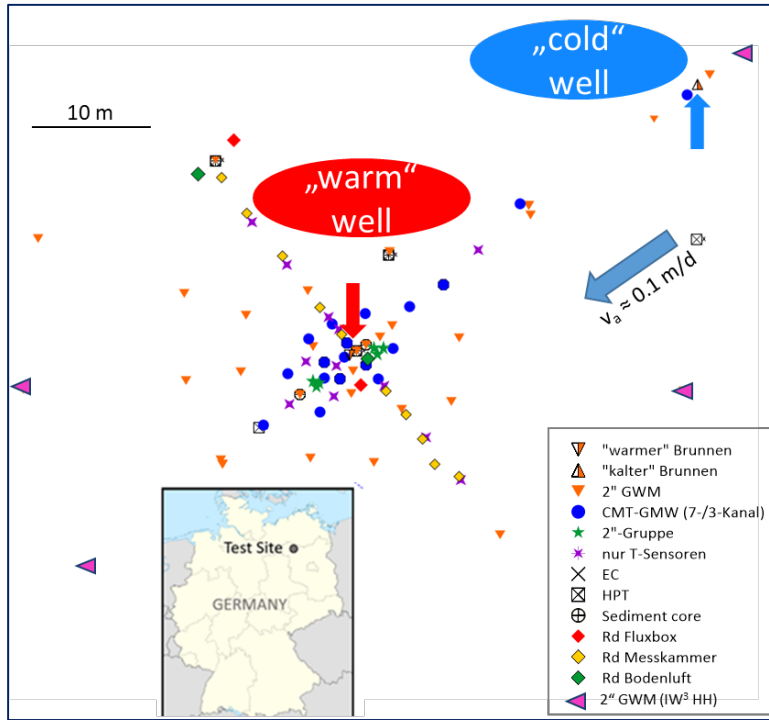
# Energetic design and thermal impacts of an HT-ATES



Heldt et al., submitted

- Load curve can be fulfilled using a HT-ATES with 85°C injection temperatures
- Long-term stability and heat recovery > 85% after ramp-up phase of first 10 a

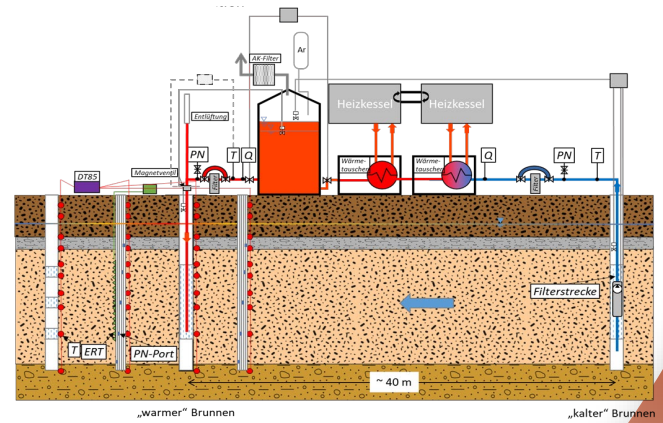
# HT-ATES Test at the Testum Field site



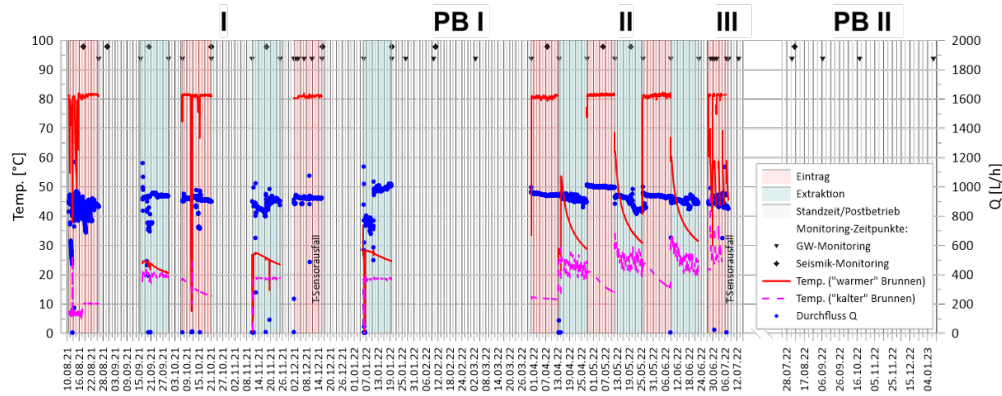
„heating“ system



„warm“ well

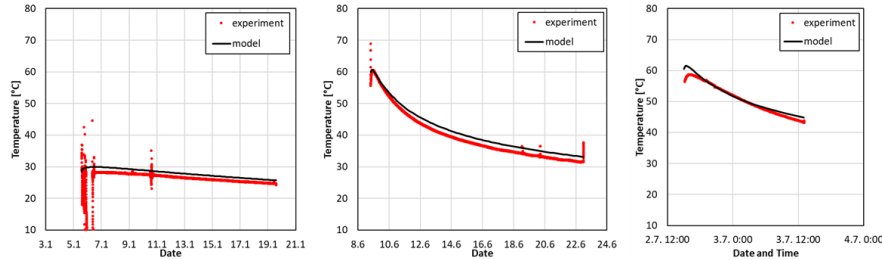


# HT-ATES Test at the Testum Field site



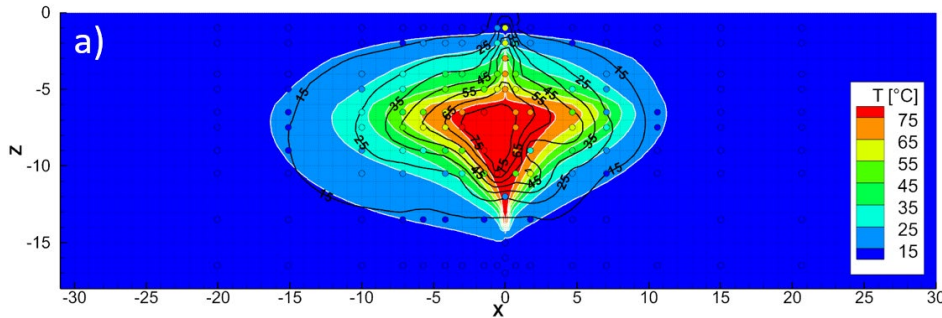
- Hot Water injection at 80°C
- Cycle times of 2 weeks down to 1 day, intermittent resting times
- Monitoring of temperatures at ~ 600 sensors continuously
- Groundwater chemistry samples at 80 locations and 30 sampling times
- Microbiology at 8 locations and 15 times

# HT-ATES Test at the Testum Field site



## Heat transport simulation

- Good approximation of return flow temperatures  
=> closed energy balance and reliable prediction of thermal recovery
- Good approximation of spatial temperature distribution  
=> temperature impacts characterized



## Summary and Conclusions

### Summary

- Missing practical expertise / knowledge and know-how, but applied research ongoing
- Theoretical know-how from research principally available, but missing interface to or interest of implementers
- Missing local geological knowledge to determine site-specific ATES or BTES potential
- Changing cost environment and missing / unclear / uncertain regulations

### Conclusions

- Demonstration systems required
  - > dissemination of know-how and practical applicability
  - > regulatory approval and state of the art
- Research required on effects of elevated temperatures and operating conditions
- Screening of ATES potential and suitable geological settings
- Clear regulatory environment with respect to climate goals
- Climate change will make ATES more attractive due to rising cooling demands



**Thank you for your attention !**

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