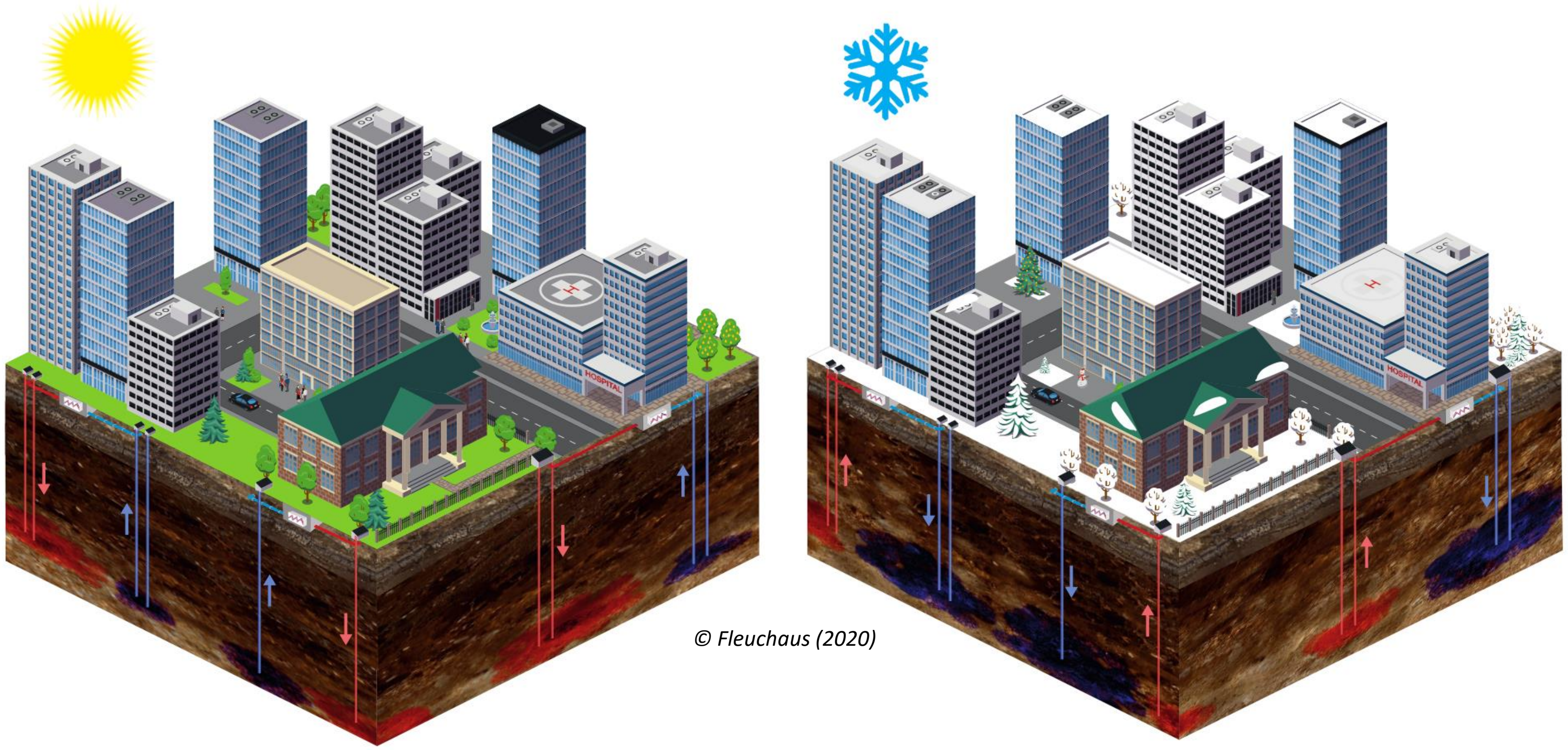
Aquifer Thermal Energy Storage (ATES) in Germany

Current trends and a glimpse into the future



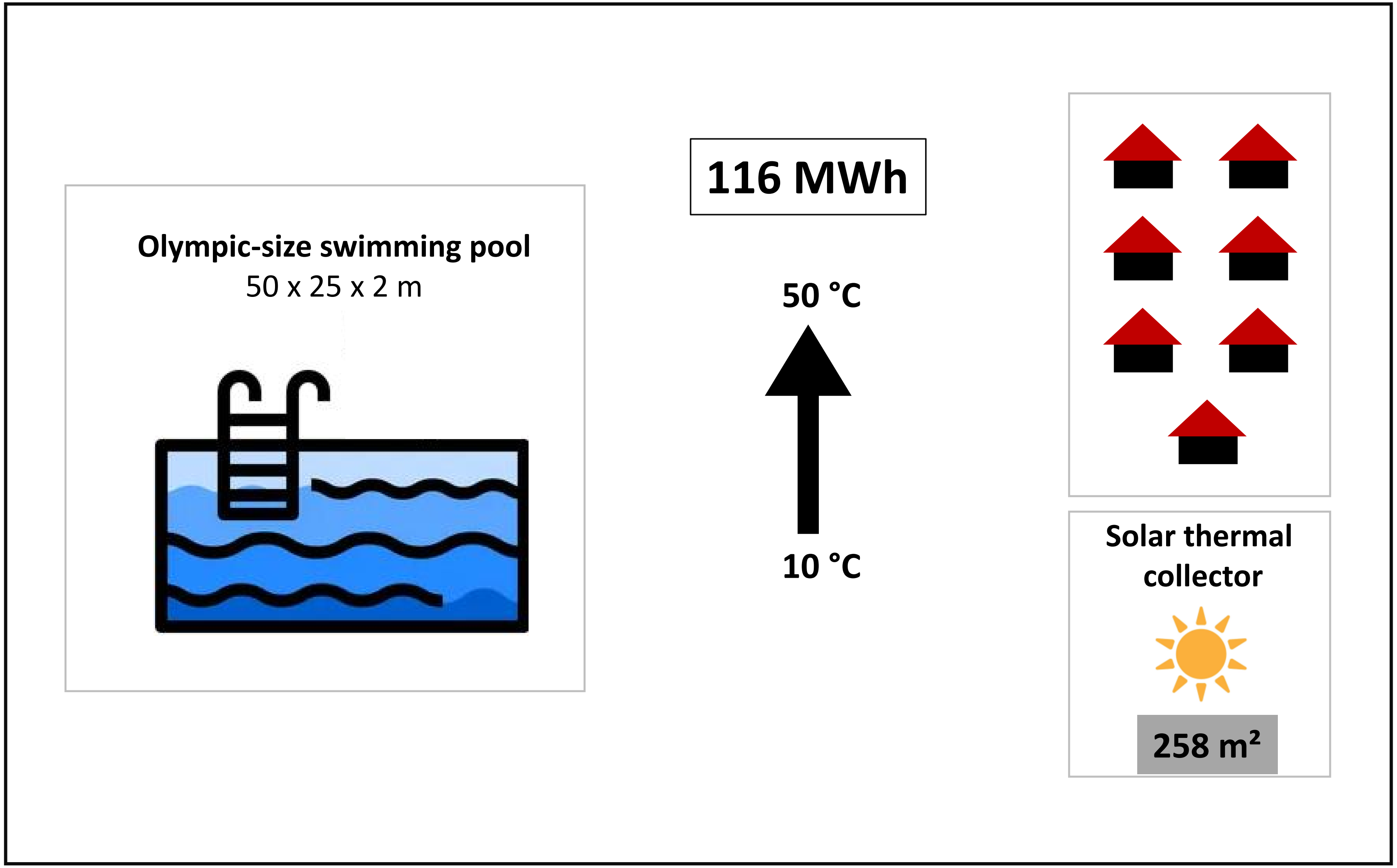
Dr. Paul Fleuchaus

tewag GmbH
Niederlassung Lohr am Main
Große Kirchgasse 1
97816 Lohr am Main
www.tewag.de
pfl@tewag.de

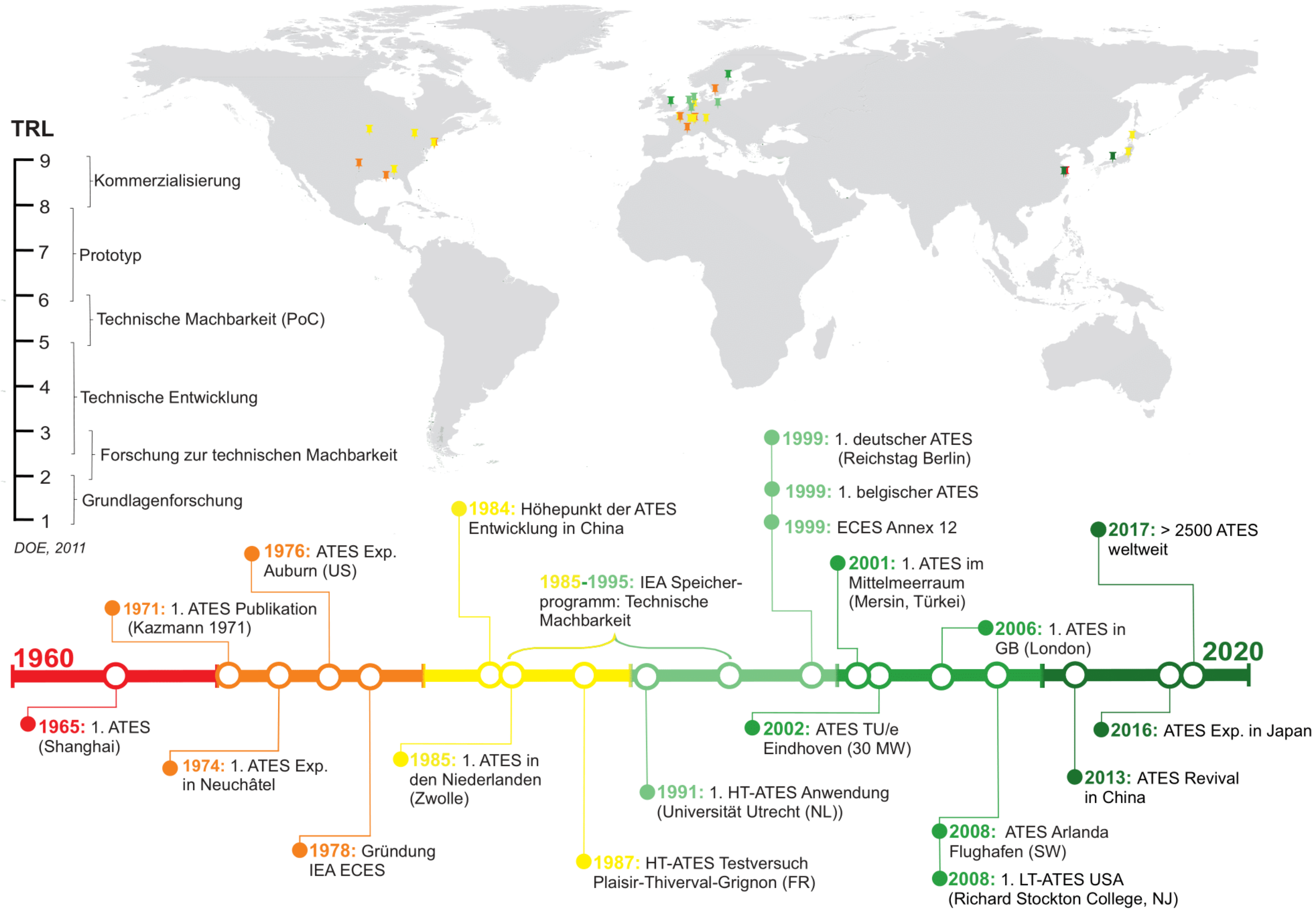
DemoSpeicher

Aquifer Thermal Energy Storage

tewag

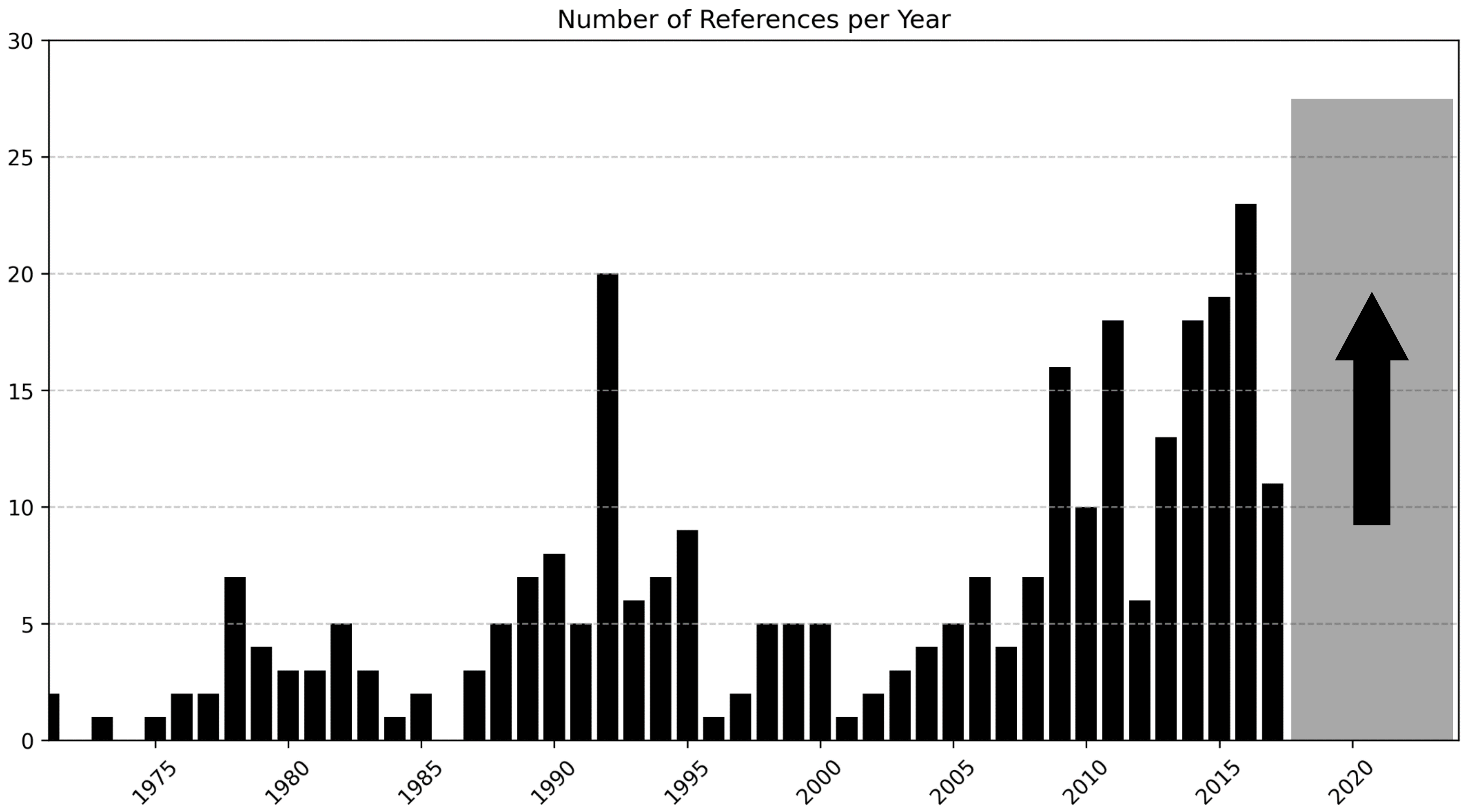


R&D activity of more than 60 years!



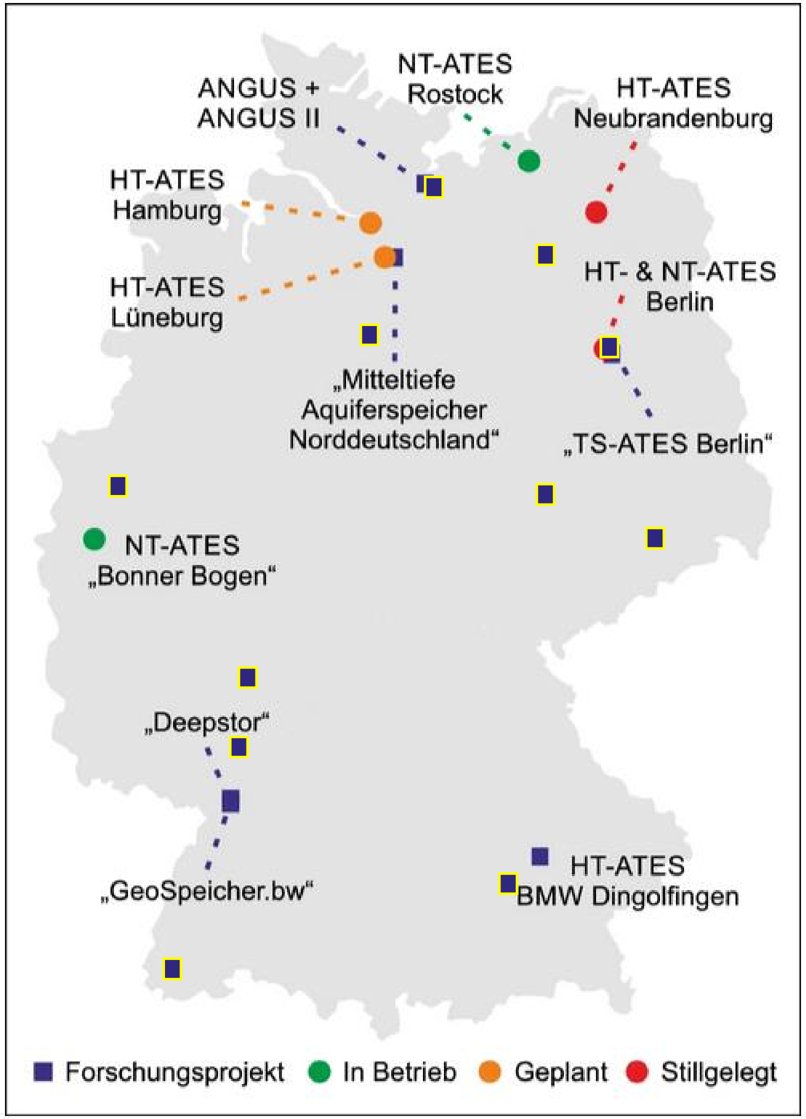
Quelle: Fleuchaus P, Godschalk B, Stober I, Blum P (2018) Worldwide application of Aquifer Thermal Energy Storage - A review. RSER, 94:861-876.

R&D activity of more than 60 years!



ATES activity in Germany

tewag



GEO:N „Möglichkeiten und Grenzen thermischer Energiespeicherung in Aquiferen“

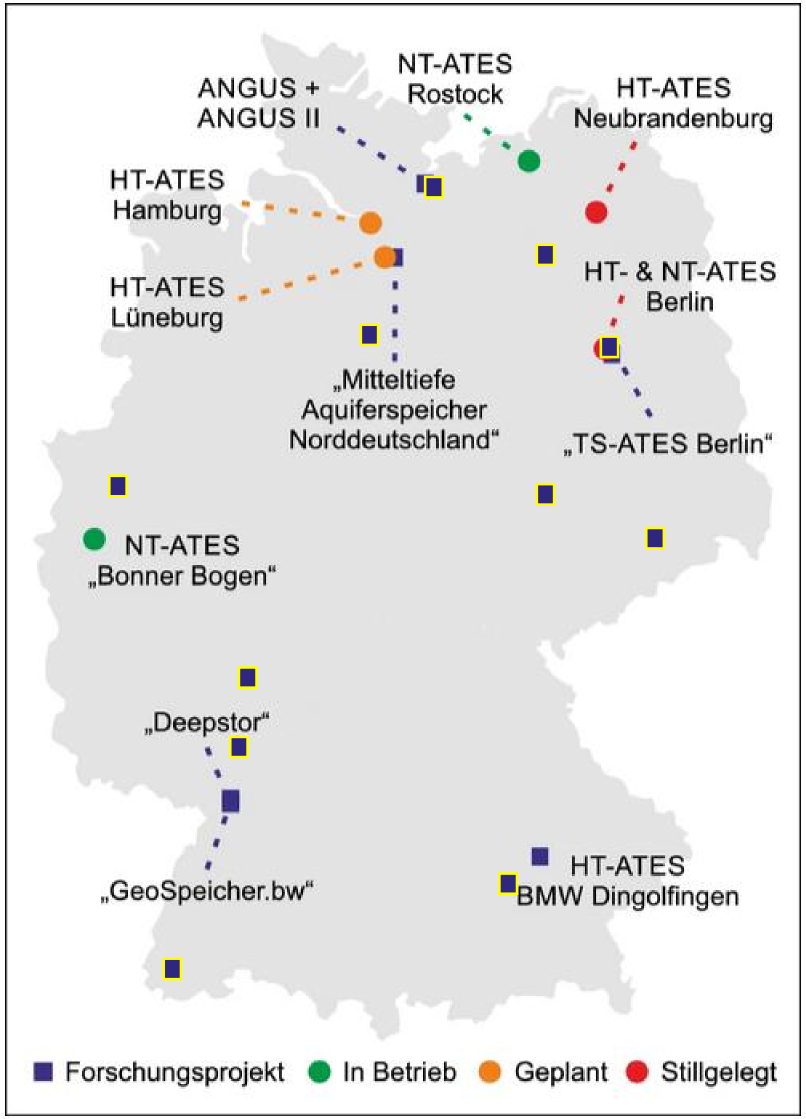
- Kiel – Bremerskamp (**SpeicherCity**)
- Wittstock Testfeld (TestUM Aquifer, TestUM II Aquifer)
- Berlin Mitte (DemoSpeicher)
- Berlin Adlershof (**SpeicherCity**, GEOFERN, GeoSpeicher Berlin, PUSH-IT)
- Berlin Spandau (**SpeicherCity**, TRANSGEO, ATES iQ)
- Burgwedel (GeoTES)
- Leipzig – Wissenschaftspark (**SpeicherCity,** KONATES)
- Mannheim & Offenbach (PotAMMO)
- München (**SpeicherCity**)
- Freiburg (**SpeicherCity**)

MTES

- Bochum – research campus (HEATSTORE, **SpeicherCity**)
- Freiberg – Himmelfahrt Fundgrube / Reiche Zeche (MineATES)

■ New scientific projects

ATES activity in Germany



- Kiel – Bremerskamp (**SpeicherCity**)
- Wittstock Testfeld (TestUM Aquifer, TestUM II Aquifer)
- Berlin Mitte (DemoSpeicher)
- Berlin Adlershof (**SpeicherCity**, GEOFERN, GeoSpeicher Berlin, PUSH-IT)
- Berlin Spandau (**SpeicherCity**, TRANSGEO, ATES iQ)
- Burgwedel (GeoTES)
- Leipzig – Wissenschaftspark (**SpeicherCity,** KONATES)
- Mannheim & Offenbach (PotAMMO)
- München (**SpeicherCity**)
- Freiburg (**SpeicherCity**)

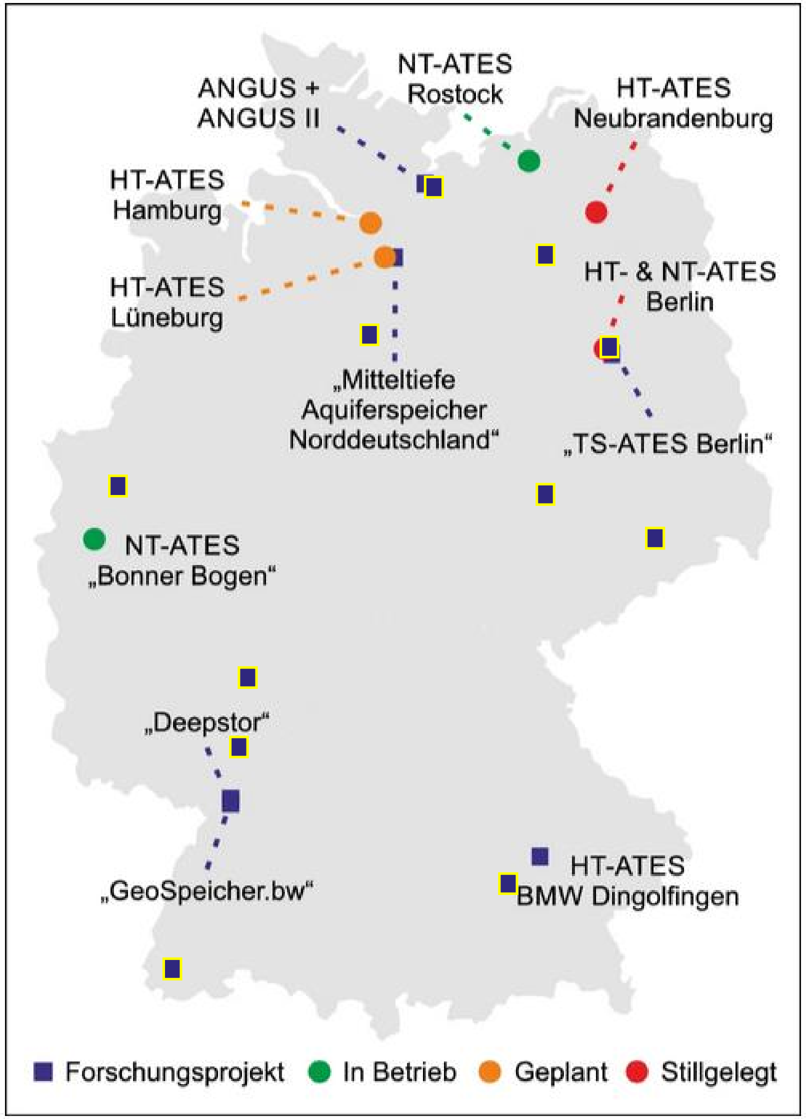
LT-ATES
- Potential analyses
- Regulatory framework
- Impact on groundwater quality
- Demonstration systems
- Monitoring

HT-ATES
- Feasibility studies
- Grid integration
- Performance evaluation
- Potential analysis
- Groundwater remediation

■ Neue Forschungsprojekte

ATES activity in Germany

tewag



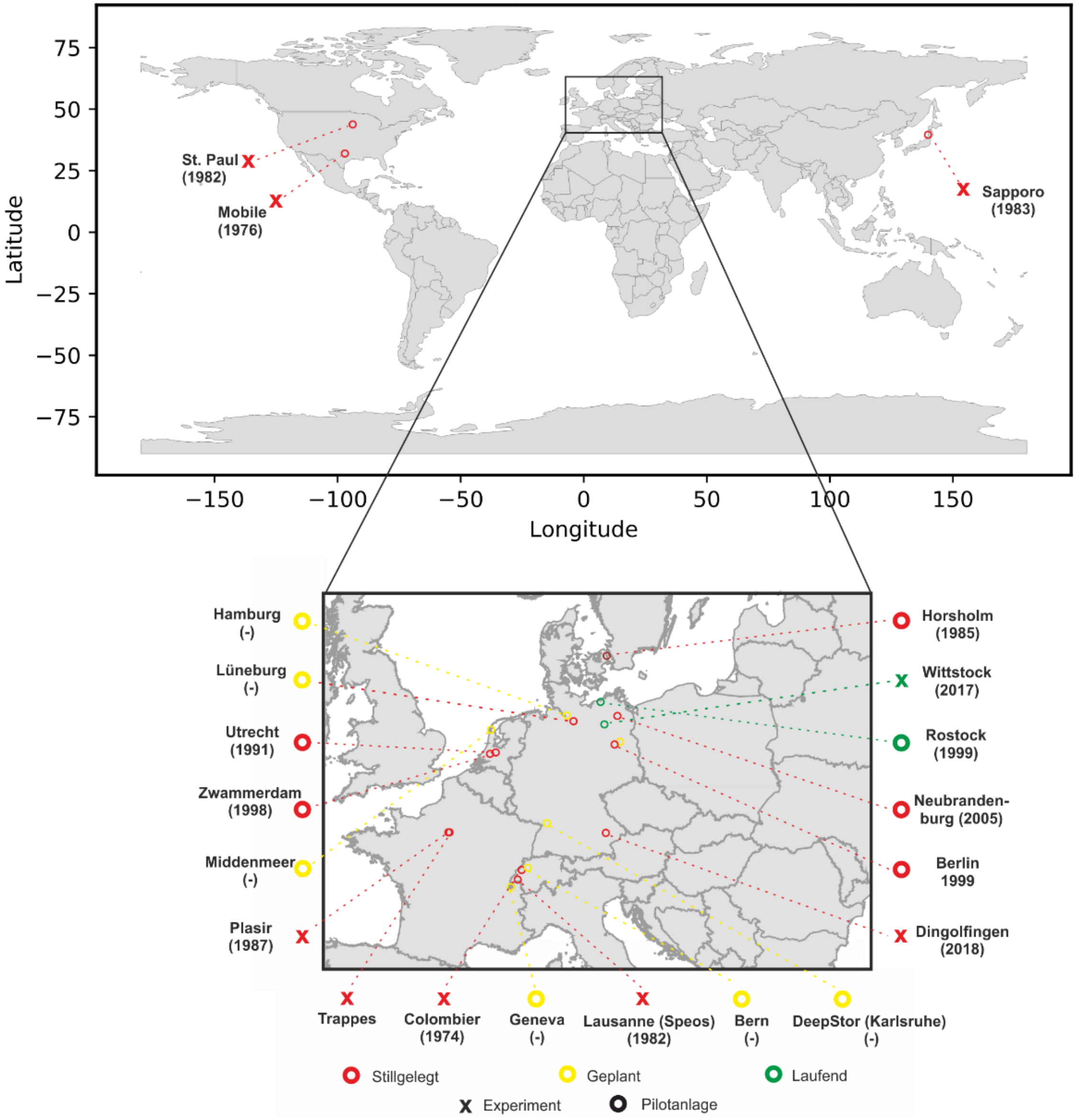
- High research activity in Germany
- Focus on High-Temperature (HT) technologies
- Research on Low-Temperature (LT) ATES focuses on overcoming barriers to market entry
- HT-ATES currently has a low Technology Readiness Level (TRL), and further research is required to assess its technical feasibility, grid integration, and other related factors
- ATES is the primary focus of current research on Underground Thermal Energy Storage (UTES) in Germany, although there are also ongoing projects related to Medium-Temperature (MTES) systems

■ Neue Forschungsprojekte

High Temperature ATES (HT-ATES)

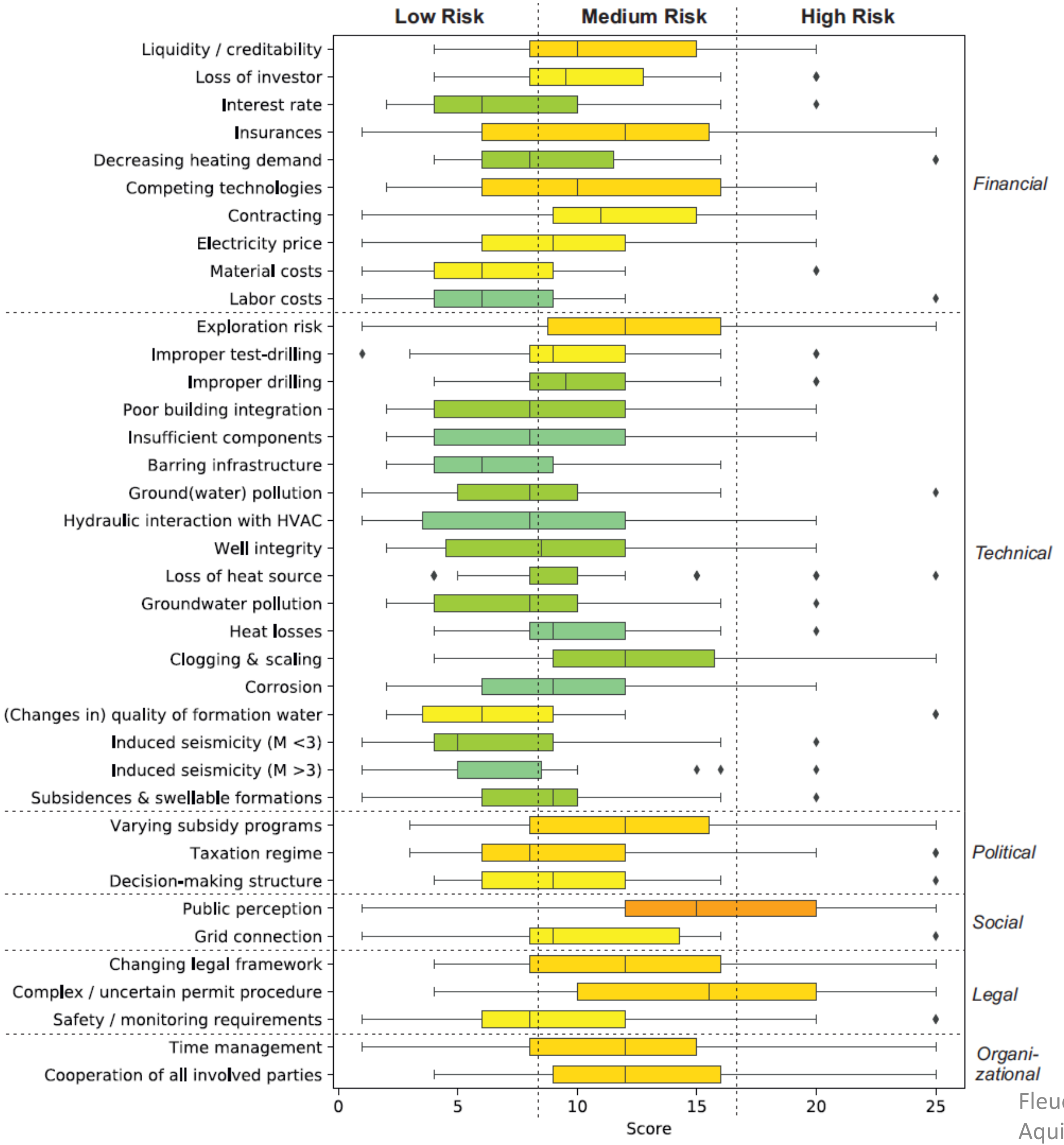
#	Location		Year	Scope	Heat source	Injection Temp. [°C]	Storage depth [m]	Geology
1	Colombier, CH		1974	E	-	70	Shallow	Sand and gravel
2	Mobile, US		1976	E	Industrial	55	39-61	Sand and clay
3	ST. Paul, US		1982	E	Industrial	117	182-244	Sandstone
4	Lausanne, CH		1982	E	Industrial	40-80	7-24	Silt and sand
5	Sapporo, JP		1883	E	Solar	40-60	95	Sand and clay
6	Hørsholm, DK		1885	A*	Industrial	100	10-25	Sand
7	Plaisir, FR		1987	A*	Industrial	180	500	Sand and clay
8	Utrecht, NL		1991	A*	Cogeneration	90	192-290	Sand
9	Zwammerdam, NL		1998	A*	Cogeneration	90	135-150	Sand
10	Berlin, DE		1999	A*	Cogeneration	70	320	Sandstone
11	Rostock, DE		1999	A*	Solar	50	13-27	Sand and gravel
12	Neubrandenburg, DE		2005	A*	Cogeneration	80	1,250	Sandstone
13	Dingolfingen, DE		2016	E	Cogeneration	120	500-700	Molasse
14	Wittstock (test-site), DE		2016	E	Artificial	-	Shallow	Sediments
15	Lüneburg, DE	X	-	A	Cogeneration	90	450	Sand
17	Hamburg, DE	X	-	A	Industrial	90	300	Sand
18	Middenmeer, NL	✓	-	A	Geothermal	90	300-400	-
19	Geneva, CH		-	A	Industrial	90	500-1,000	Limestone
20	Bern, CH	?	-	A	Power plant	120	500	Molasse
21	DeepStor, DE	X	-	A	Geothermal	110	1,000	Tertiary

* E = Experimental, A= Applied, A*= Applied (realized)



Fleuchaus P, Schüppler S, Bloemendal M, Guglielmetti L, Opel O, Blum P (2020): Risk analysis of High Temperature Aquifer Thermal Energy Storage (HT-ATES). RSER, 133

Risk analysis of HT-ATES



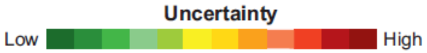
1. Permit procedure
2. Public perception
3. Exploration risk

Uncertainty U_C (1-5)

Severity S_V (1-5)

Occurrence probability O_P (1-5)

Risk = $O_P \times S_V$

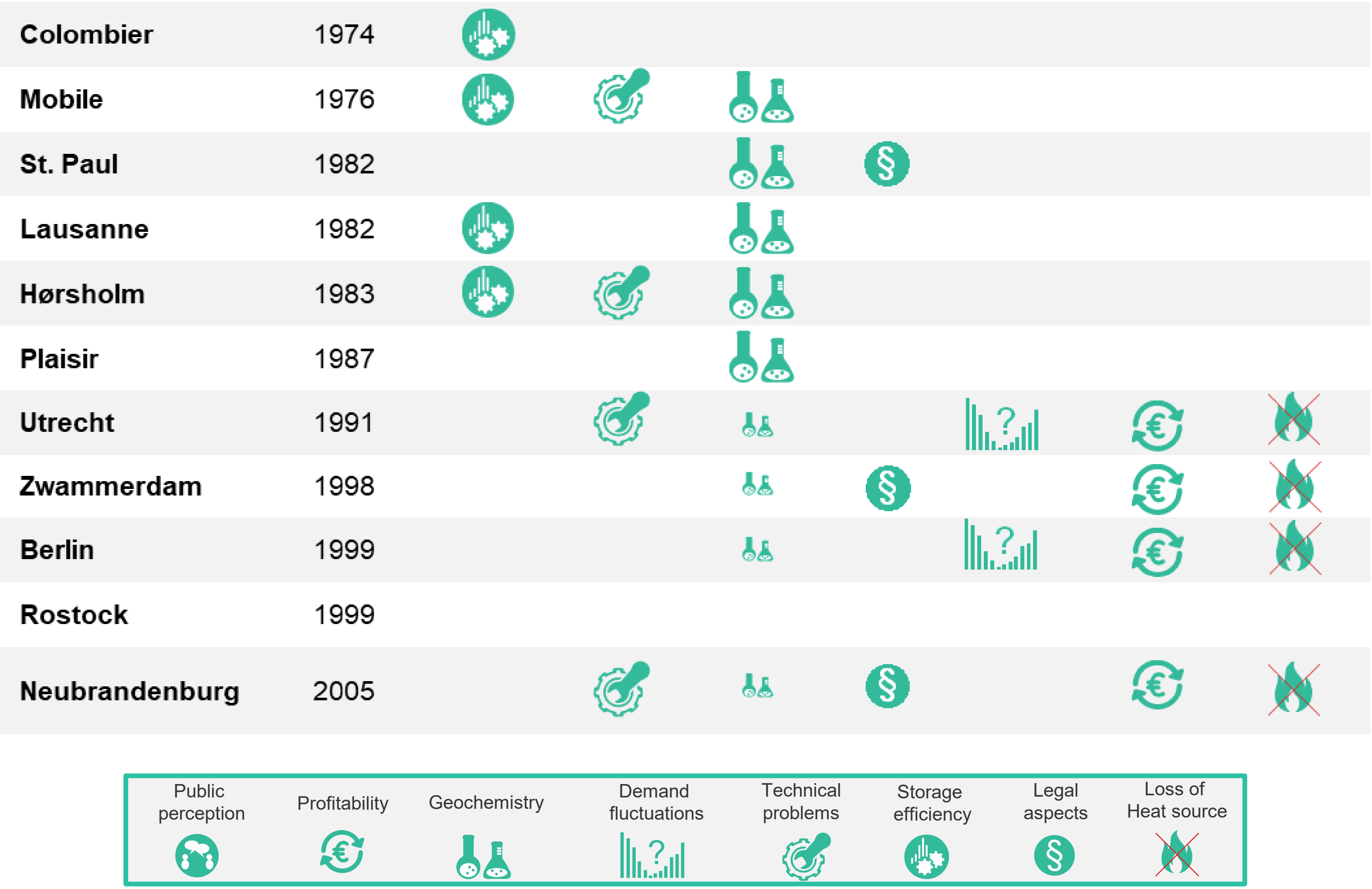


Fleuchaus P, Schüppler S, Bloemendal M, Guglielmetti L, Opel O, Blum P (2020): Risk analysis of High Temperature Aquifer Thermal Energy Storage (HT-ATES). RSER, 133

Risk analysis of HT-ATES

	Experiences from abandoned and running projects											Expected risk	
Source of risk	Colombier	Mobile	St. Paul	Lausanne	Hørsholm	Plaisir	Utrecht	Zwammerdam	Berlin	Rostock	Neubrandenburg	Hamburg - shallow	Hamburg - deep
Liquidity/creditability	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Loss of investor	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Interest rate	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Insurances	○	○	○	○	○	○	-	-	○	○	○	🟡	🔴
Decreasing heating demand	○	○	○	○	○	○	🔴	-	🔴	🟢	🟢	🟢	🟢
Competing technologies	○	○	○	○	○	○	🔴	🔴	🟡	🟢	🔴	🔴	🔴
Contracting	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Electricity price	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🔴	🟢
Material costs	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟡	🟡
Labor costs	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Exploration risk	🟡	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢	🟢	🔴
Improper test-drilling	○	○	○	○	○	○	○	○	🟢	🟢	○	🟢	🔴
Improper drilling	○	🔴	🟢	○	○	○	🟢	🟢	🟢	🟢	○	🟢	🟢
Poor building integration	○	○	○	○	○	○	🟡	-	🟡	🟢	○	🟢	🟢
Insufficient components	○	○	○	○	🔴	○	🟡	🟢	🟢	🟢	🟡	🟢	🟡
Barring infrastructure	○	○	○	○	○	○	○	○	🟡	🟢	🟢	🟡	🟡
Hydraulic interaction	○	○	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢
Well integrity	-	-	-	-	-	-	🔴	🟢	🟢	🟢	🟡	🟢	🟢
Loss of heat source	○	○	○	○	🟢	○	🔴	🔴	🔴	🟢	🔴	🟡	🟢
Groundwater pollution	-	-	-	-	-	-	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Heat losses	🔴	🔴	🟢	🟡	🟡	-	🟡	🟡	🟢	🟢	🟢	🟢	🟢
Clogging & scaling	-	🔴	🔴	🔴	🔴	🔴	🟡	🟢	🟡	🟢	🟡	🔴	🔴
Corrosion	-	-	🟡	🔴	🔴	-	🟢	🟡	🟡	🟢	🟡	🟢	🟡
(Changing) quality of form. water	-	-	-	🟡	-	🔴	-	-	🟢	🟢	🟡	🟡	🟢
Induced seismicity	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡
Induced seismicity (M >3)	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Subsidences & swellable formations	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Varying subsidy programs	○	○	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢
Taxation regime	○	○	○	○	○	○	○	○	🟢	🟢	🟢	🟢	🟢
Decision-making structure	○	○	○	○	○	○	○	○	🟢	🟢	🟢	🔴	🔴
Public perception	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Grid connection	○	○	○	○	○	○	🟢	🟢	○	○	🟢	🟢	🟢
Changing legal framework	○	○	○	○	○	○	-	-	🟢	🟢	🟡	🟢	🟢
Complex permit procedure	○	○	🟡	-	-	-	-	🟡	🟢	🟢	🟢	🔴	🟢
Safety/monitoring requirements	-	-	🟡	-	-	-	-	🟡	🟢	🟢	🟡	🔴	🟢
Time management	-	○	○	○	○	○	-	-	🟢	🟢	🟢	🟢	🟢
Cooperation of all involved parties	○	○	○	○	○	○	-	-	🟢	🟢	🟢	🟡	🟡

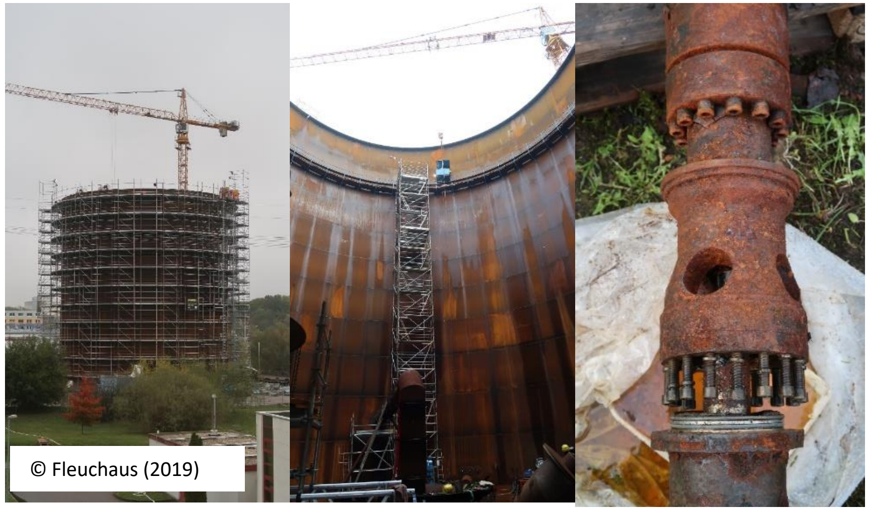
* - = No information, ○ = Not relevant, 🟢 = Not encountered (low), 🟡 encountered (medium), 🔴 = Crucial (high)



Fleuchaus P, Schüppler S, Bloemendal M, Guglielmetti L, Opel O, Blum P (2020): Risk analysis of High Temperature Aquifer Thermal Energy Storage (HT-ATES). RSER, 133

HT-ATES project examples

Neubrandenburg


© Fleuchaus (2019)

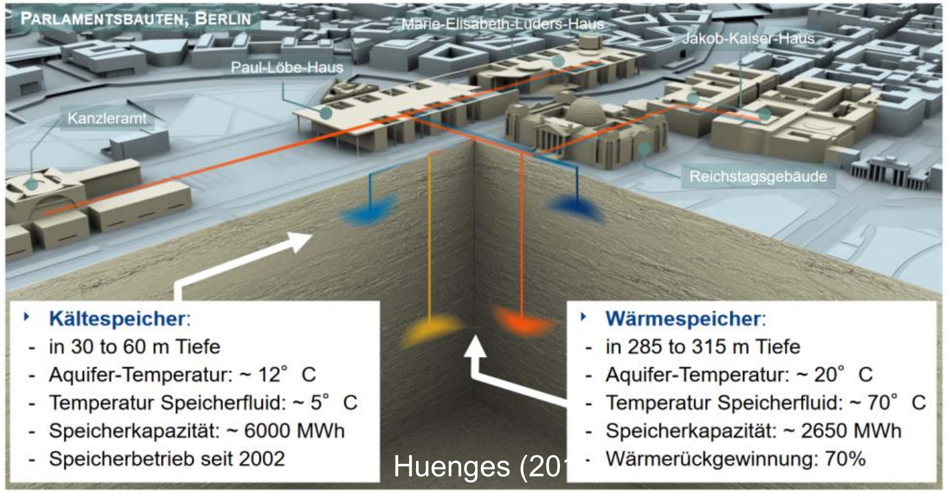
Replaced by flexible tank storage

IW³ – Hamburg Wilhelmsburg


© Mopo (2018)

Unproductive sand layer

Berlin parliament buildings



Overestimated heating and underestimated cooling demand

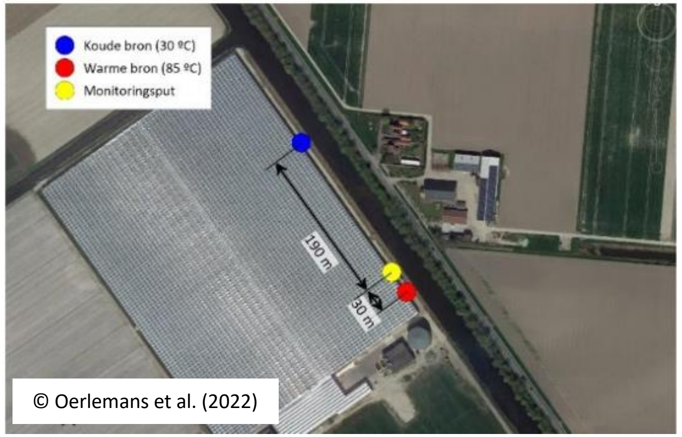
→ Inefficient operation of the heat storage

HT-ATES project examples

Rostock

Similar system running at NIOO in Wageningen (NL)

Middemeer



TU Delft

	Rostock	Middemeer	TU Delft
Storage depth	< 100 m	300 – 400 m	120 – 180 m
Geology	Sand	Sand	Sand
Storage temperature	50 °C	85 °C	75-80°C
Heat source	Solar collectors	Geothermal	Geothermal & heat pump
Consumer	Residential building complex	Greenhouses	University Campus

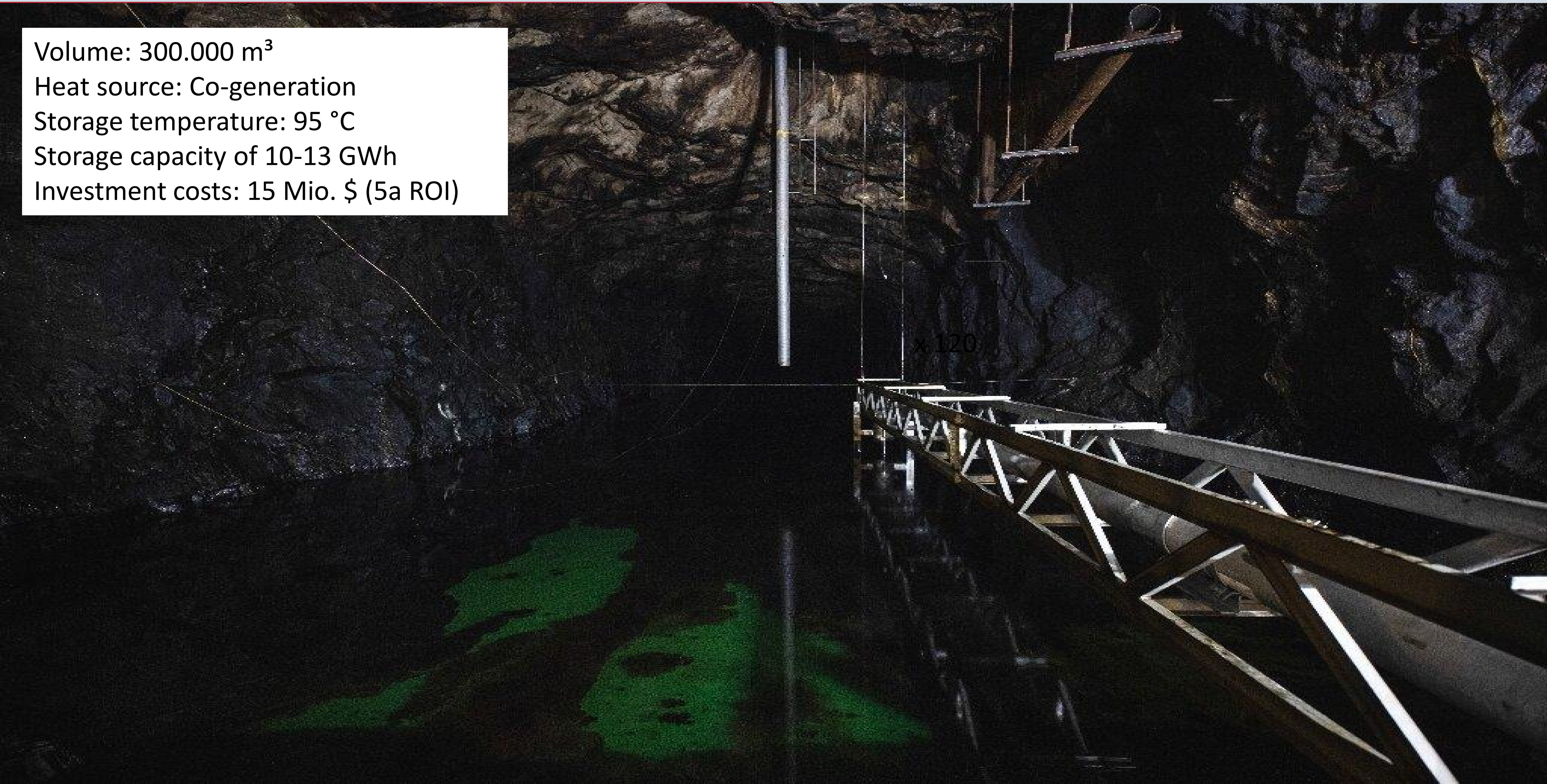
Fleuchaus P, Schüppler S, Bloemendal M, Guglielmetti L, Opel O, Blum P (2020): Risk analysis of High Temperature Aquifer Thermal Energy Storage (HT-ATES). RSER, 133

Local heat planning („Kommunale Wärmeplanung“)

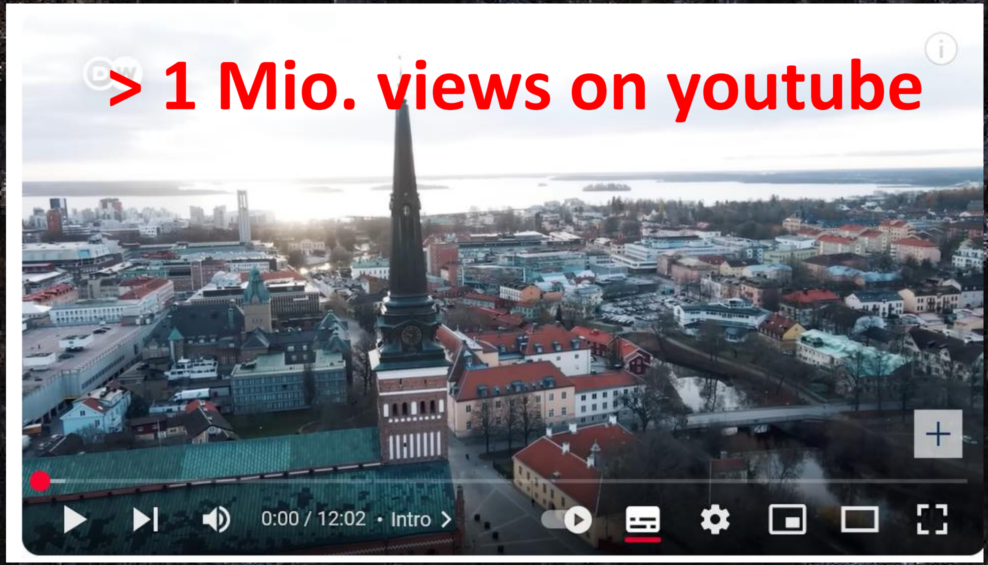
tewag

Abandoned cavern in Västerås (Sw) to stockpile oil

Volume: 300.000 m³
Heat source: Co-generation
Storage temperature: 95 °C
Storage capacity of 10-13 GWh
Investment costs: 15 Mio. $ (5a ROI)



> 1 Mio. views on youtube



„People try to aviod risk. If somebody has taken the risk and it has been successfull, then you will have followers.“ (Prof. Sven Werner)

tewag GmbH

Technologie – Erdwärmeanlagen – Umweltschutz
Niederlassung Lohr am Main
Große Kirchgasse 1
97816 Lohr am Main
Ansprechpartner: Dr. Paul Fleuchaus
E-Mail: pfl@tewag.de
Tel.: +49 7483 26908-20
Mobil: +49 171 5635470

Demo Speicher

Bundesministerium für Bildung und Forschung