Environmental impacts from constructing seasonal underground thermal energy storage systems

Jenny Weise, Christoph Bott, Kathrin Menberg, Peter Bayer

Motivation

- **Seasonal Thermal Energy Storage (sTES)**
  - Significant primary energy and emissions reduction, but often high costs and thermal losses.

C. Bott, I. Dressel, P. Bayer (2019): State-of-technology review of water-based closed seasonal thermal energy storage systems. Renewable and Sustainable Energy Reviews.

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- **Research gap**
  - Existing studies focus on ATES and operational impacts; the construction phase is underexplored.

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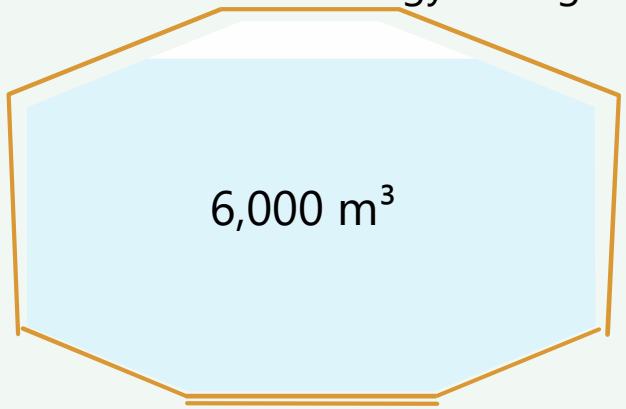
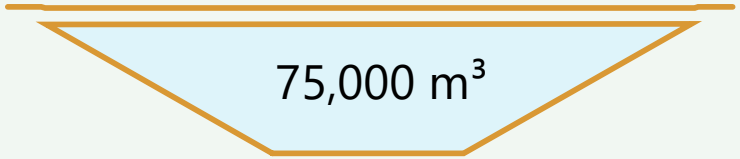
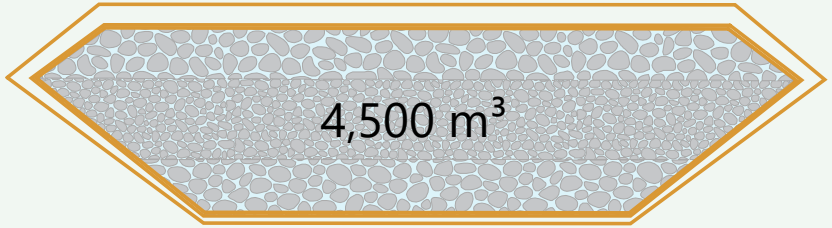
Seasonal Thermal Energy Storage (sTES)

Application Cases

	Sealing
Tank Thermal Energy Storage 	HDPE
Pit Thermal Energy Storage 	HDPE
Water-Gravel Thermal Energy Storage 	HDPE Polypropylene

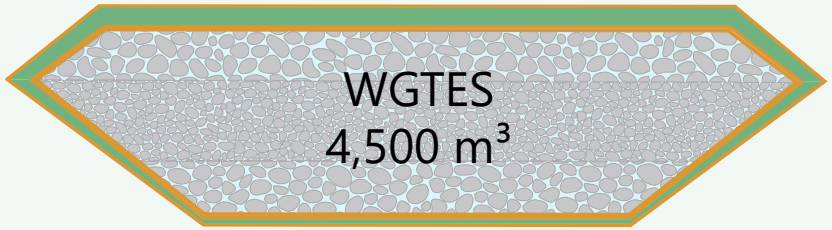
HDPE = High-density polyethylene

Seasonal Thermal Energy Storage (sTES)

Application Cases

Sealing	Insulation
HDPE	Foam glass gravel Expanded glass granulate

Sealing	Insulation
HDPE	Polymer foam



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Seasonal Thermal Energy Storage (sTES)

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Sealing	Insulation	Static elements
HDPE	Foam glass gravel Expanded glass granulate	Steel Concrete

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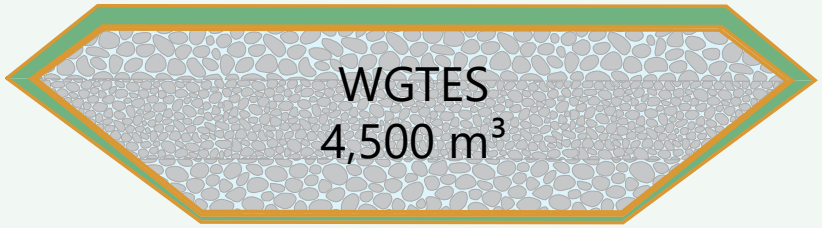

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Seasonal Thermal Energy Storage (sTES)

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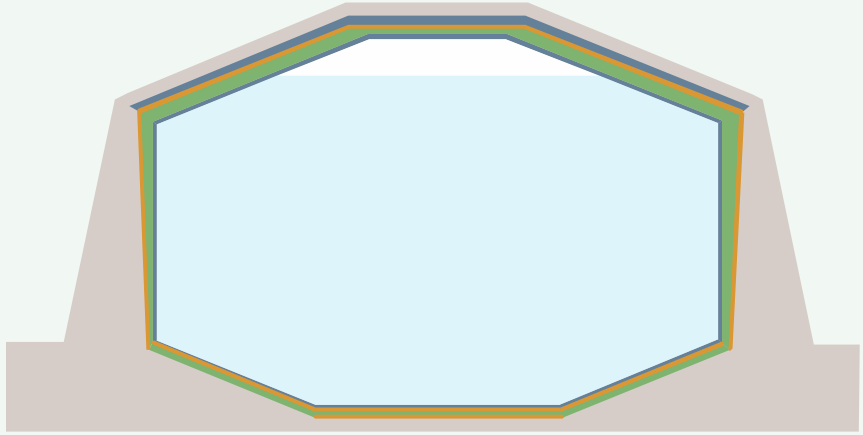	HDPE	Foam glass gravel Expanded glass granulate	Steel Concrete
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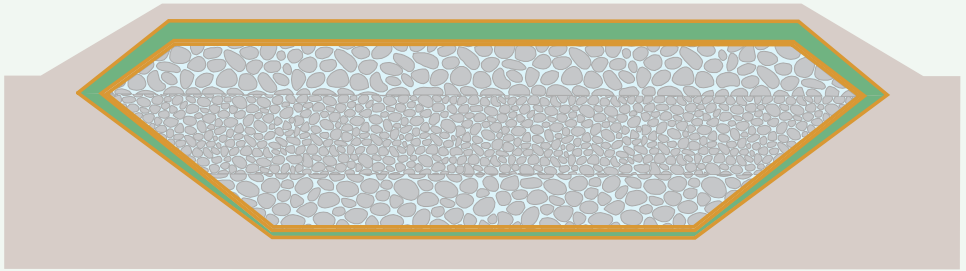	HDPE Polypropylene	Foam glass gravel Expanded glass granulate	–

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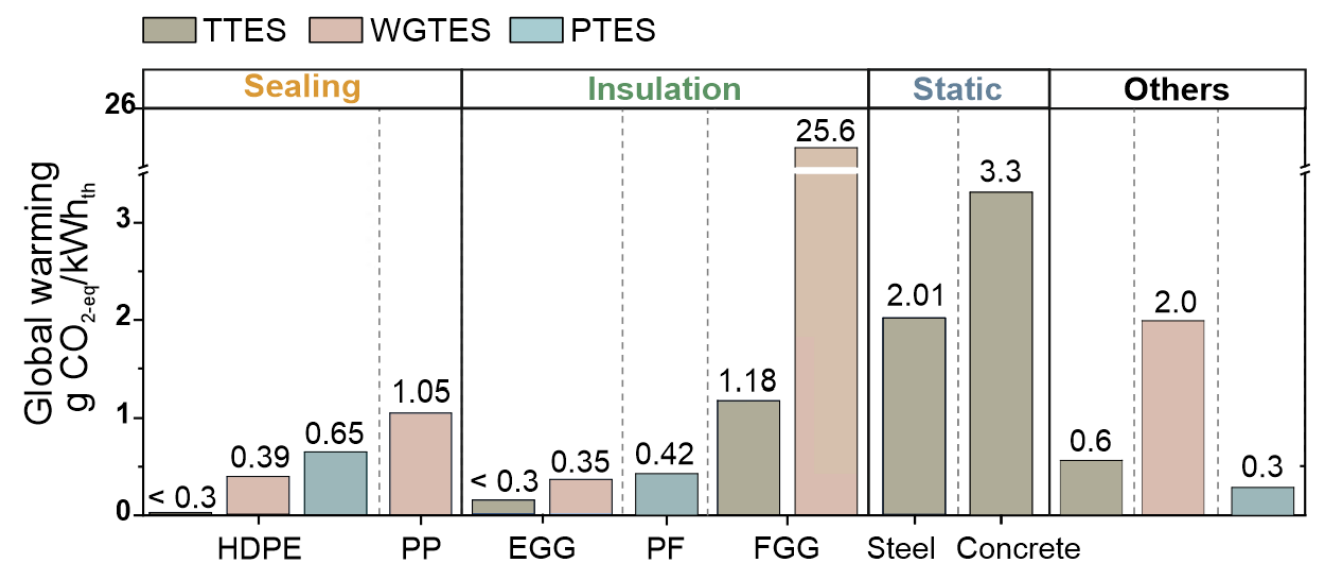
Results

Environmental impacts

Material contributions to environmental impacts of global warming



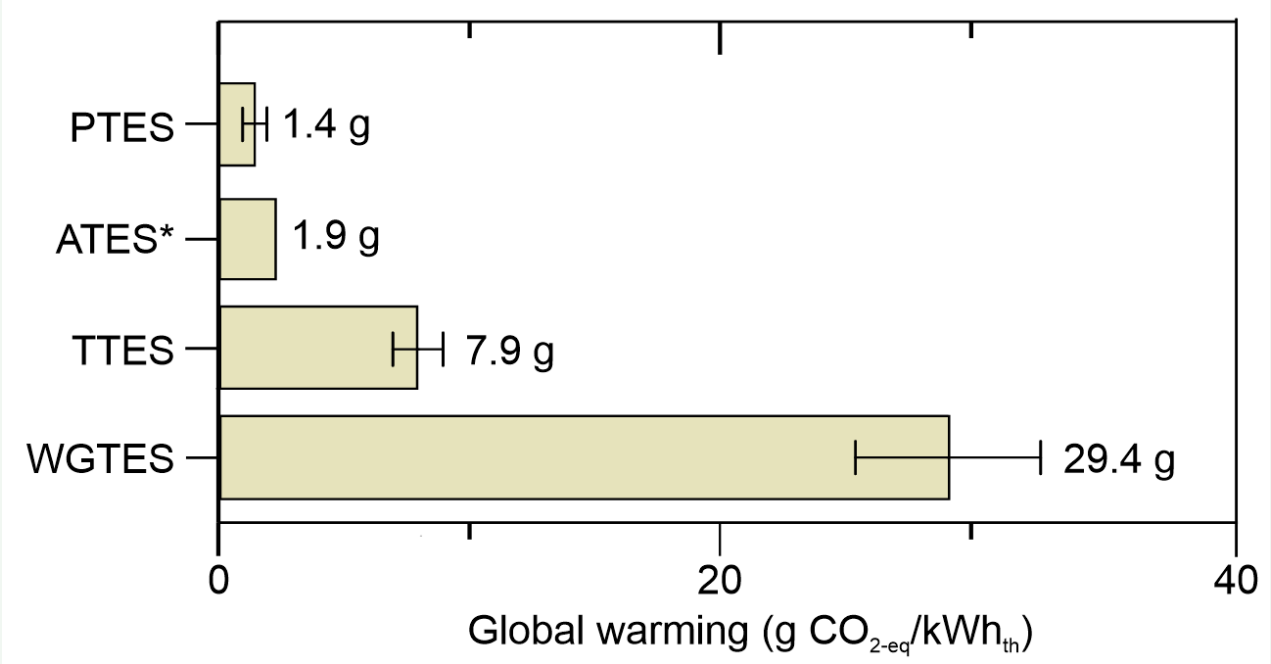
Life cycle inventory of the three sTES

Components	TTES in t	WGTES in t	PTES in t
HDPE	0.9	3.6	113
Polypropylene	-	2.3	-
Expanded glass granulate	149	102	-
Polymer foam	-	-	72.7
Foam glass gravel	16.7	101	-
Steel	27	-	-
Concrete	898	-	-

Results

Environmental impacts

Evaluation of global warming



** R. Stemmle, P. Blum, S. Schüppler, P. Fleuchaus, M. Limoges, P. Bayer, K. Menberg (2021) Environmental impacts of aquifer thermal energy storage (ATES), Renewable and Sustainable Energy Reviews 151.*

Conclusions

- **Environmental impact of sTES**
  - Construction-phase emissions range from 1.4 to 29.4 g $CO_{2\text{-eq}}$ /kWh_{th}, with WGTES having the highest and PTES the lowest impact.

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  - Minimising concrete, steel, and foam glass gravel improves environmental performance.

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- **Optimisation potential**
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- **Further research**
  - A full life cycle perspective, including operation and end-of-life, is essential to avoid burden shifting.

Thank You

For Your Attention

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