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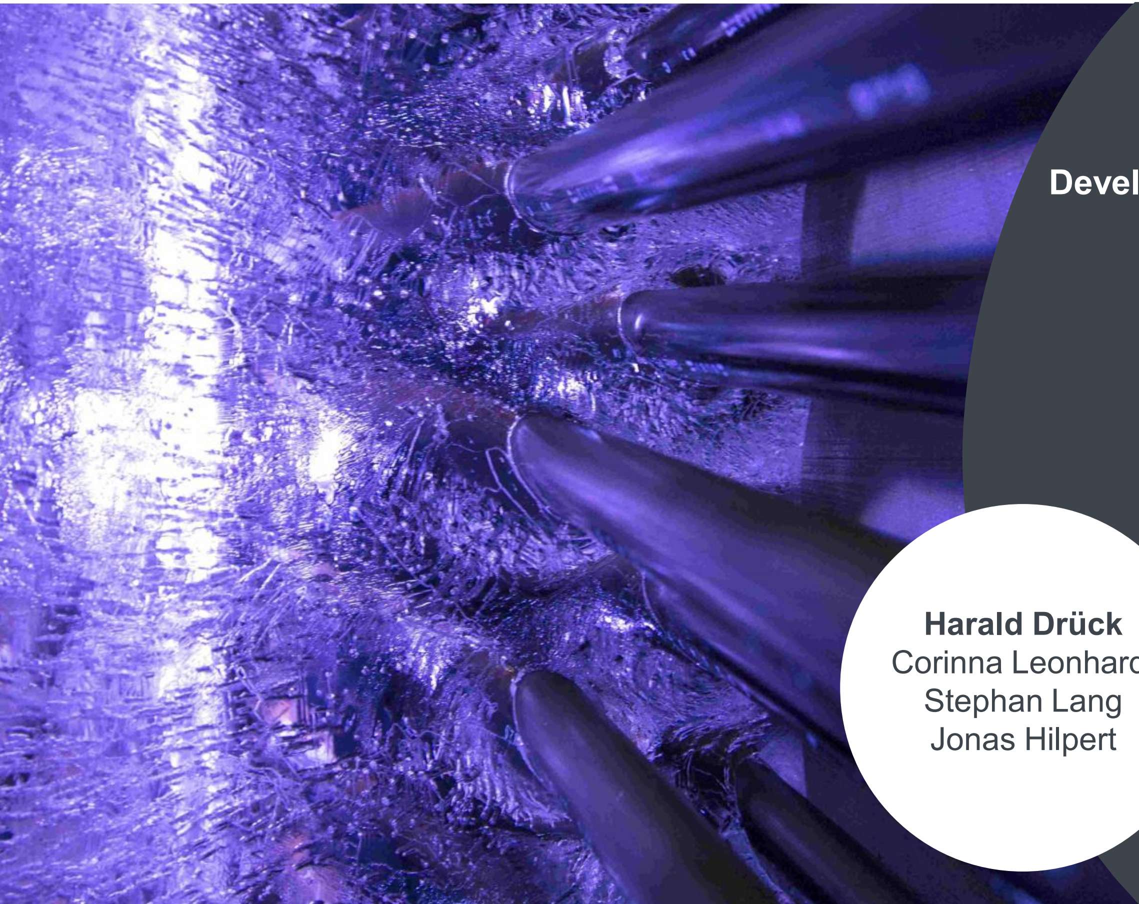

Research Project innoBeLs

Development and assessment of innovative container concepts for latent heat stores in cold solar heating networks

Introduction to the project innoBeLs

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Corinna Leonhardt
Stephan Lang
Jonas Hilpert

innoBeLs

ISEC 2026

Graz

15.04.2026

Project Objectives and Framework

Scientific and Technical Objectives of the innoBeLs Project

Innovative Latent Heat Storage

Develop and assess modular innovative container concepts for latent heat stores sized from 100 to 1,000 cubic meters for cold district heating networks.

Sustainability and Cost Reduction

Achieve at least 50 % reduction in global warming potential and 20 % cost reduction compared to existing solutions.

Scalability and Standardization

Design scalable, modular solutions adaptable to various needs and suitable for industrial manufacturing.

Evaluation Framework

Integrate structural, thermal, ecological, and economic factors to avoid trade-offs in performance.

Project Duration, Consortium, and Funding Framework

Project Timeline

The innoBeLs project duration is from early 2025 to the end of 2028 as a multi-year research initiative.

Consortium Expertise

Academic and industrial partners collaborate, combining research expertise and practical manufacturing insights.

Funding and Policy Alignment

The project is funded by the German Federal Ministry, aligning with national energy transition and building energy policies.

Knowledge Sharing

Regular meetings and publications ensure transparency and knowledge transfer within and beyond the consortium.

Project Context and Motivation

Role of Ice Stores in Solar Cold District Heating Networks

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1. High-Density Thermal Energy Storage

2. Integration in Solar Heating Networks

3. System Flexibility and Efficiency

3. But: Sustainability Challenges

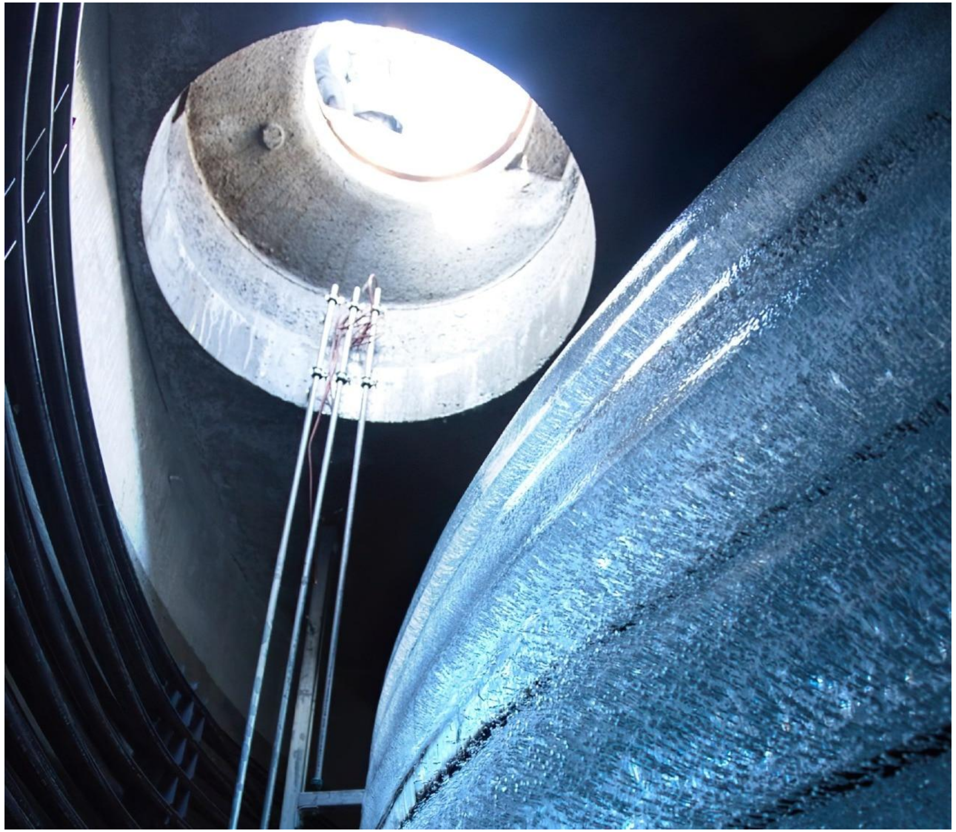
Limitations of State-of-the-Art Concrete Ice Store Containers

Environmental Impact
- Reinforced concrete production causes high greenhouse gas emissions and requires significant energy → negative ecological impacting

Economic and Scalability Challenges
- Concrete storage construction is labor-intensive, site-specific, and hard to standardize
→ limiting cost reduction and scalability.

Functional and Structural Limitations
- Ensuring trafficability and stability often leads to conservative designs with excessive material use and complexity → high costs

Innovation Opportunities
- Exploring alternative structural concepts can reduce environmental impact, costs, and material use while improving performance.



Methodology and Work Structure

Integrated Methodological Approach: Simulations, Experiments, and Assessment

Requirement Analysis and Technology Screening

- Detailed requirement analysis guides identifying promising technologies through structured screening for future container concepts.

Numerical Simulations for Performance

- Thermal, structural, and system simulations evaluate charging behavior, load capacity, and integration into heating networks.

Experimental Validation

- Laboratory experiments validate simulation models and examine material behavior under real temperature and load conditions.

Environmental and Economic Assessment

- Life cycle assessment and costing link ecological benefits with economic feasibility for transparent concept comparison.

Core parameters of the state of art ice store as benchmark.

Parameter	Value and Unit
Inner diameter	9.5 m
Inner internal volume	284 m³
Latent storage capacity	16 143 kWh
Sensible storage capacity[1)]	5 413 kWh
Total storage capacity	21 557 kWh
Discharge power	90 kW

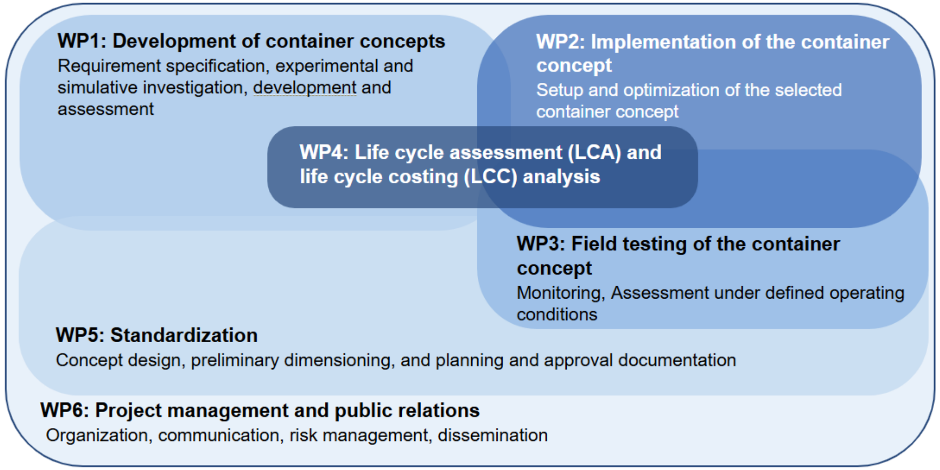
Work Package Structure and Project Progression

Structured Work Packages
- The project is organized into six linked work packages guiding research from concept to dissemination.

Technical Development and Testing
- Packages 1 to 3 focus on container concept development, optimization, and real-world field testing.

Evaluation and Standardization
- Work Packages 4 and 5 cover environmental assessment, life cycle costing and preparation for market approval.

Management and Dissemination
- Work Package 6 manages project risks, communication, and public dissemination for successful project delivery.



Innovative Container Concepts

Harald Drück

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Overview of the Seven Container Concepts Under Investigation

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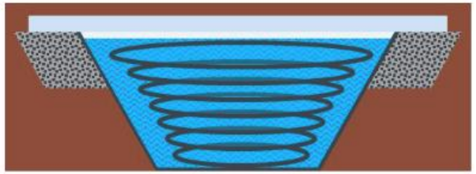
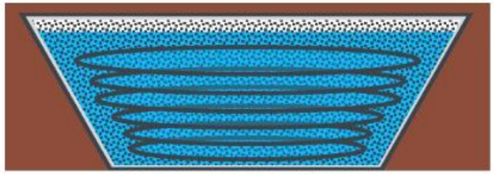
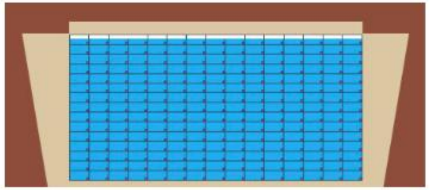
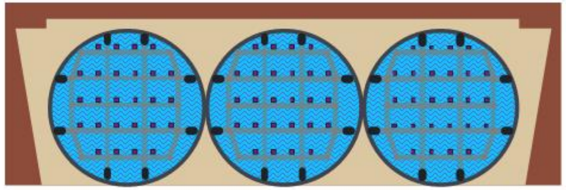

Pit thermal energy store (PTES) with load-bearing cover

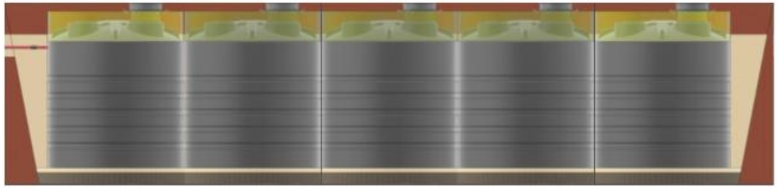

Gravel-water pit thermal energy store (GW-PTES)


Soil-water pit thermal energy store (SW-PTES)


Infiltration crate store


Extruded polymer profile store


Pipe store


Cascaded small-tank store

Key Technical Challenges and Selection Criteria

Structural Stability and Trafficability
- Ensuring structural stability and trafficability under soil and vehicle loads is a key aspect

Material Behavior in Cold Temperatures
- Material brittleness and strength reduction below 0 °C affect the performance.

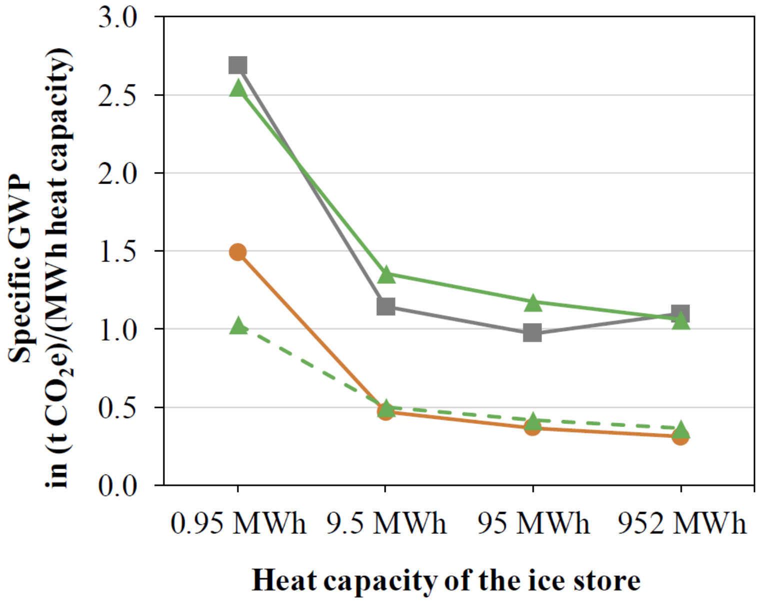
Manufacturing and Transport Feasibility
- Tooling costs and transport constraints for large modules impact manufacturing feasibility.

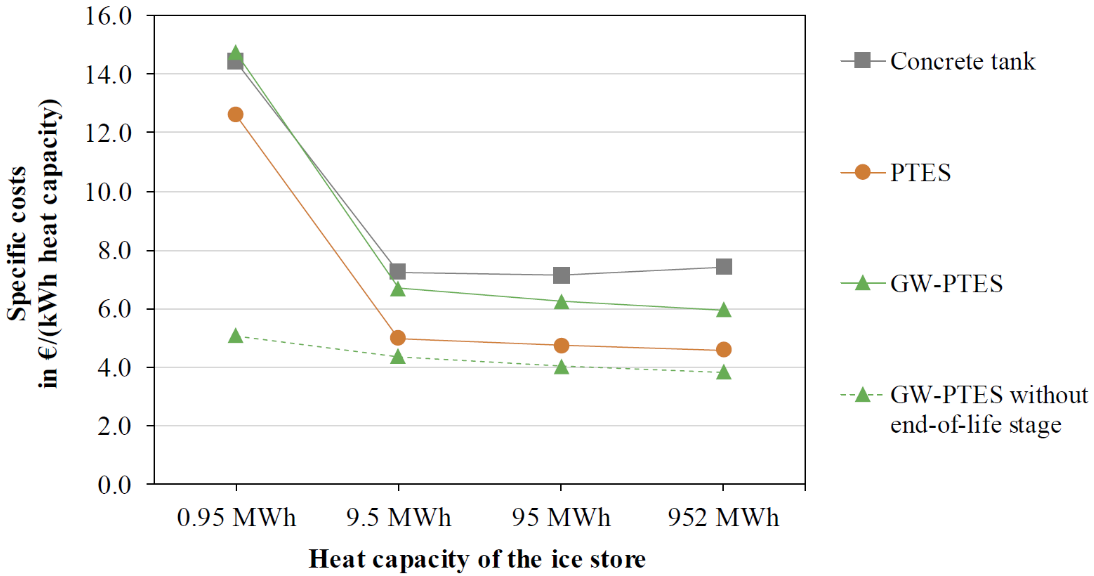
System Integration
- The integration of heat exchangers in the store is a central challenge.

Source: AI-generated illustration (Microsoft 365 Copilot, GPT-5-based), adapted by the authors.

Current Status and Outlook

Intermediate Results from Environmental and Economic Assessments





Source:
Lang, S. et al. “Life cycle assessment (LCA) and life cycle costing (LCC) analysis for existing and new container concepts of ice stores for cold solar district heating networks,” contribution to the ISES Solar World Congress, 3.–7. November 2025 in Fortaleza, Brazil

Next Steps: Demonstration, Monitoring, and Market Readiness

Field Demonstration Phase

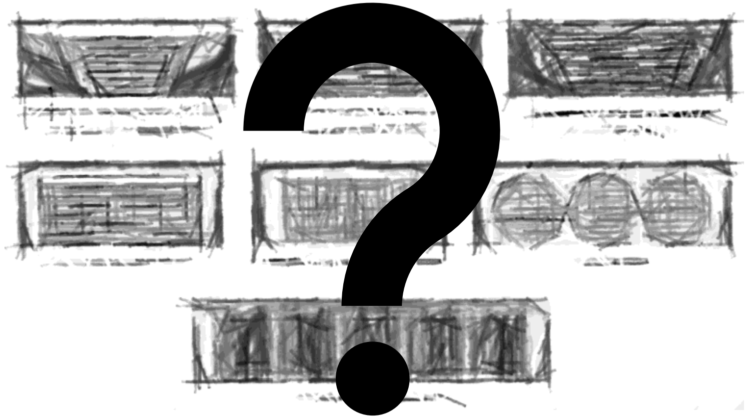
- The resulting most promising container concept will be implemented in a field test facility and tested over a period of at least one year.

Advanced Monitoring Development

- Developing sensors and measurement techniques to improve state-of-charge detection in ice store.

Design Optimization and Standardization

- Field test insights will guide design improvements and standardization for market-ready container solutions.



→ the innoBeLs project makes a significant contribution to the sustainable heat supply of the future.

Introduction to the project innoBeLs – Development and assessment of innovative container concepts for latent heat stores in cold solar heating networks

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