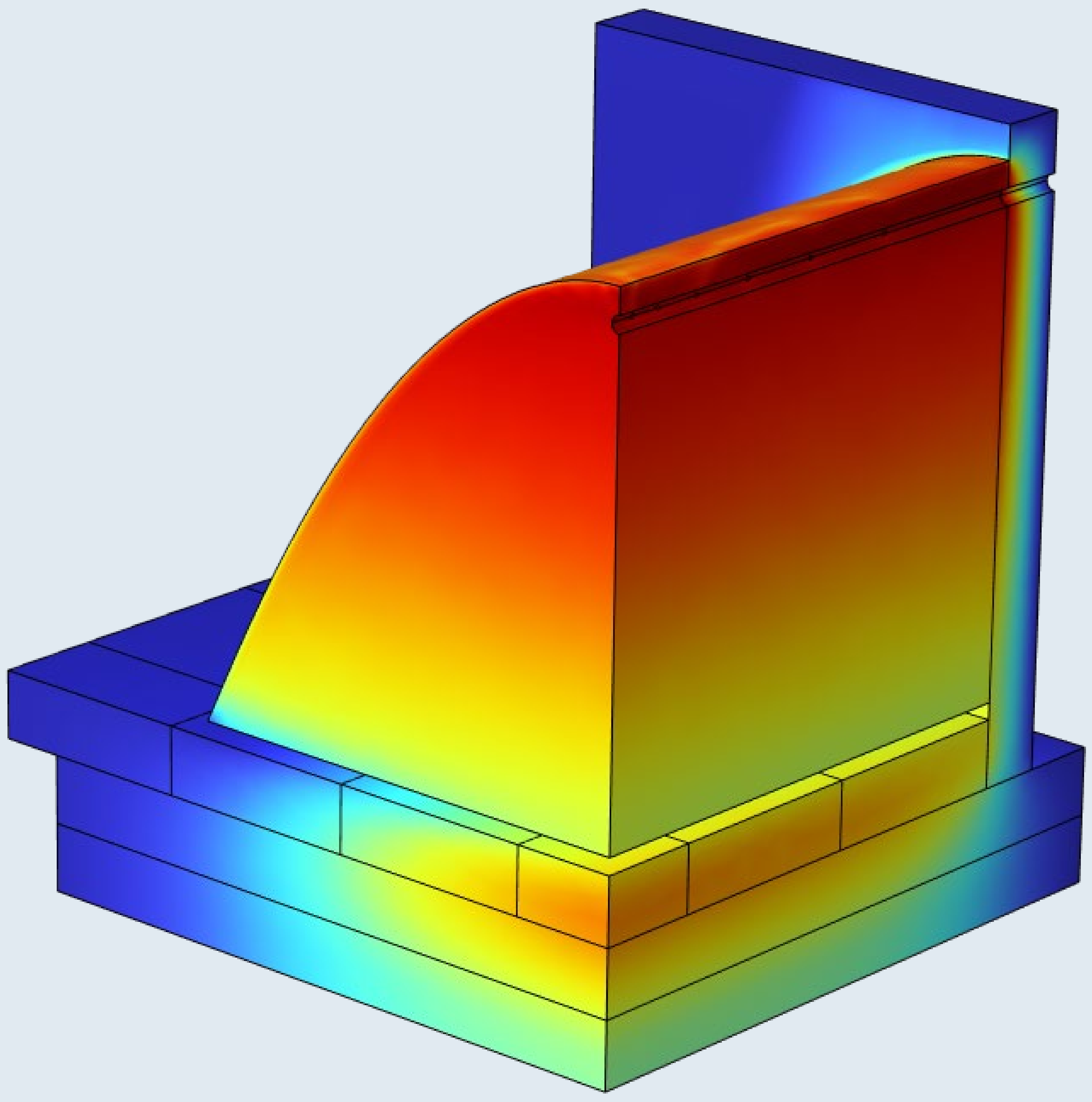

Simulation of an Under Lake Infrastructure for Capture and Storage of Solar Energy (ULISSE*)

Study by simulation of the energy storage capacity of a reduced size ULISSE mock-up representing a sub-lake water storage reservoir.

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Abstract

The transition from fossil fuels to renewable energies requires finding new sources of energy. It turns out that the hydrothermal potential of the lakes would cover a significant part of these renewable energy needs [1], [2]. The ULISSE project aims to build an underwater tank made of a semi-rigid envelope that could be filled with the warm water pumped from the surface of the lakes, heated by the sun during the hot season, and to restitute the stored thermal energy during the cold season. Before trying to build such a tank, it made sense to prove the concept over a reduced size mock-up and to use COMSOL Multiphysics® modelling to understand the behavior of the system in order to optimize its efficiency.

Figure 1: The reduced size ULISSE mock-up immersed in a container

Methodology

The mock-up is immersed in a container (Fig. 1), playing the role of the lake. Both are filled with water at the room temperature. Then starts a cycle imitating the change of seasons. Hot water at 33.5 ^{0}C is injected by a pump in the ULISSE mock-up chasing the initial water. After a period of rest, the water is pumped back. The recovered energy is calculated. Real-time measurements are made by temperature sensors and water flow sensors allowing comparisons with the simulation results.

Results

The qualitative behavior of the system is well reproduced by the simulation helping to understand how the convection currents move away the thermal energy evacuating heat along its exterior boundaries to the container open boundary above the top of the mock-up (Fig. 2). An amount of the thermal energy is also absorbed by diffusion in the ground of the system (header image representing the temperature distribution). The recovered energy is about 82% of the amount of energy stored (Table 1), in agreement with the physical tests results on the mock-up and its theoretical model calculation [1].

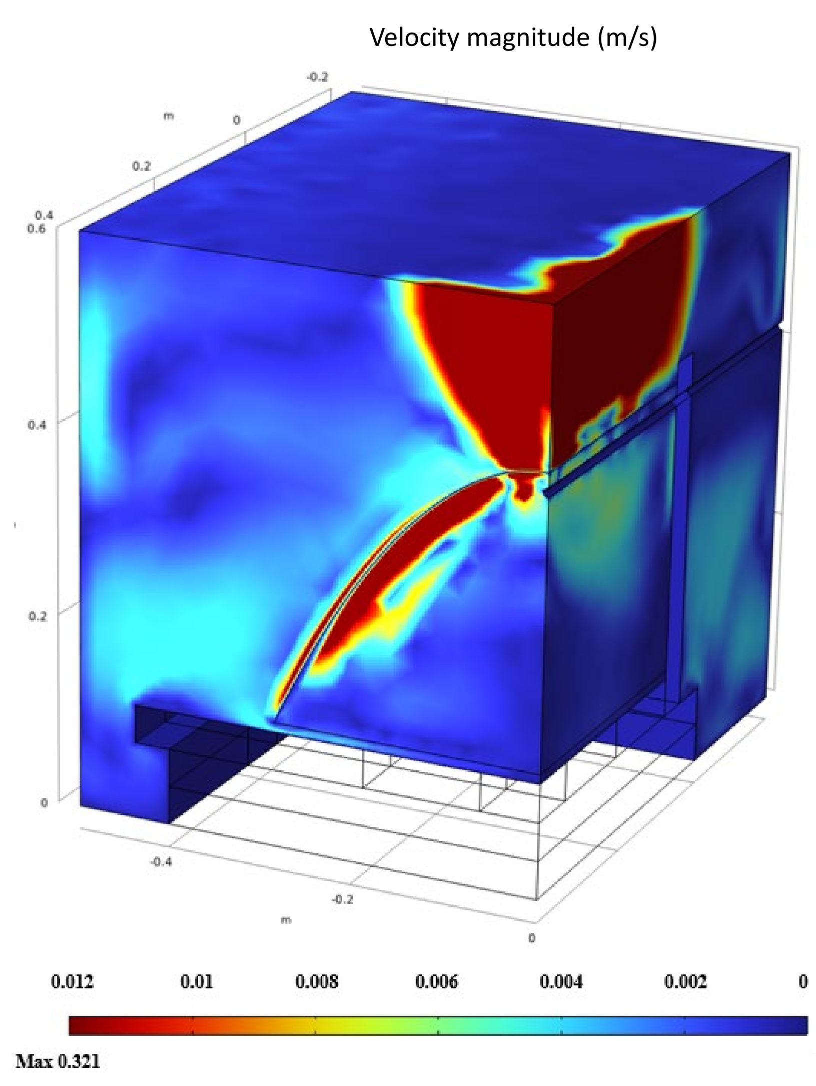

Figure 2: Velocity magnitude at the end of filling

Initial Internal Energy	Injected Internal Energy	Internal Energy after Filling	Internal Energy after Rest
0.3861 MJ	7.8920 MJ	2.7891 MJ	2.4608 MJ
Energy Stored After Filling	**Energy Available After Rest**	**Energy Lost by Rest**	**Energy Extracted**
2.403 MJ	2.0747 MJ	0.3283 MJ	1.9757 MJ

Table 1: Energy balance results

REFERENCES

[1] W. van Sprolant, ULISSE, Under Lake Infrastructure for thermal capture and Storage of Solar Energy, OFEN Final Report (May 2023)

[2] A. Gaudard, M. Schmid, A. Wüest, Utilisation thermique des eaux superficielles, potentiel des lacs et rivières suisses, Eawag et EPFL, AQUA & GAS No 6. , 2018