sweet swiss energy research for the energy transition

SWEET Conference 2023 - 6 September - Bern / Switzerland

ULISSE project of the SOUR Call 1-2021

The research presented here is supported by the Swiss Federal Office of Energy SFOE as part of SOUR project ULISSE

hepia Haute école du paysage, d'ingénierie et d'architecture de Genève
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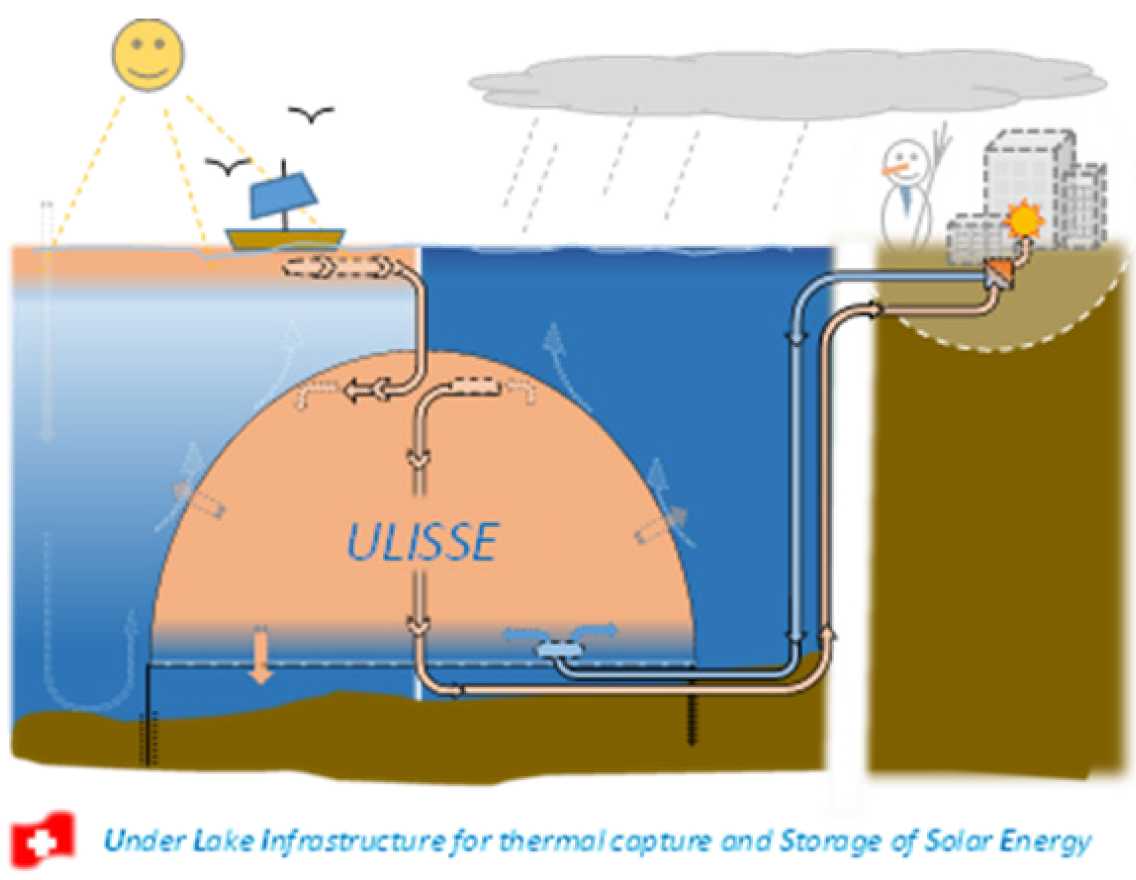
Under Lake Infrastructure for thermal capture and Storage of Solar Energy (ULISSE)

A real «SWEET Outside-the-box Rethinking» (SOUR)



Summery

Faced with climate change, **the Swiss Energy Strategy 2050 (SES-2050)** aims for a "double neutrality": Nuclear & Carbon" (2035-2050) and **foresees a structural deficit in the winter semester of 9 TWh electricity.** It results from the planned withdrawal of nuclear electricity in 2035 and the increase in electricity demand for the, Electric Mobility, Air Conditioning and Heat Pumps (HP) for building heating. **The major challenge of the SES-2050 is to have enough "doubly neutral" electricity in winter !**

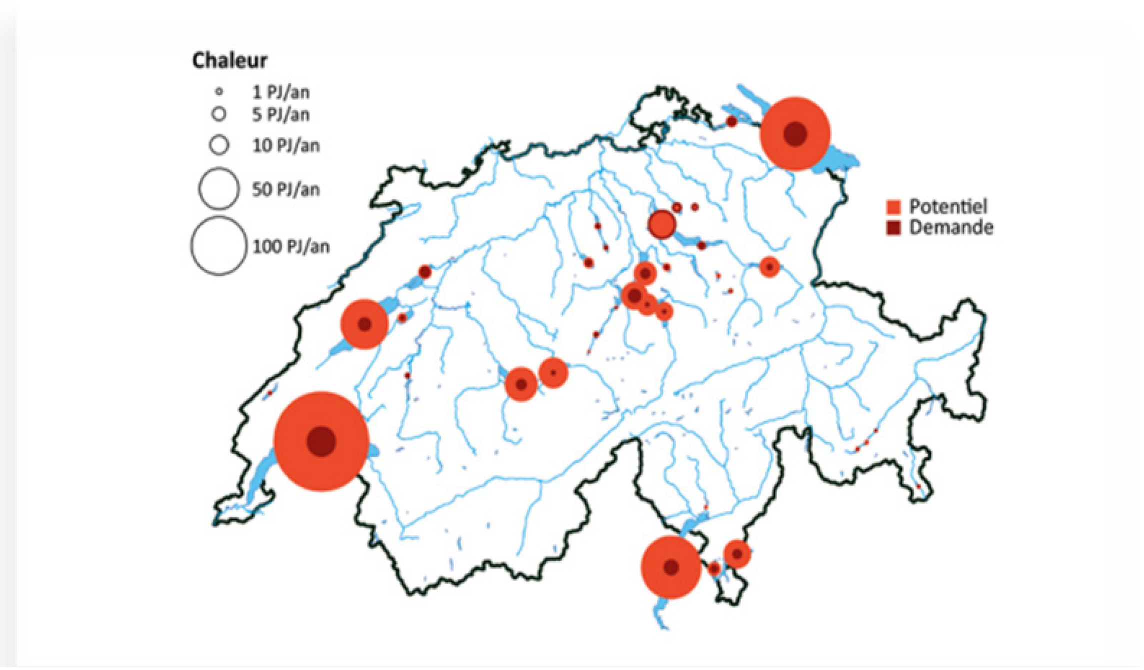
The ULISSE concept proposes an invisible **under lake anchored very large freestanding flexible almost hemi-cylindrical reservoirs for seasonal capture and storage of solar thermal energy**. A "hydraulic pantograph" captures hot water from the upper layer of the lake heated by the summer sun (2 M m^3 & 120 Tj/unite). The loading pumps are supplied with photovoltaic electricity, reducing peak-shavings (grid-overloads curtailment). **ULISSE can also complementary recover and store waste heat from cooling services.**

Good seasonal net heat storage efficiency (> 80%) with a limited thermal isolation thickness could be achieved with a large ratio between the volume sun (2 M m^3) and the surface of the reservoir envelope. Furthermore, the heat loss would induce vertical convection currents inside and outside the reservoir over the entire water column of the lake. It could enhance nutrients circulation and the oxygenation of the bottom layer of the lake.

ULISSE could boost the building heating efficiency by increasing of about 15 K the winter temperature of the lake source for the heat pumps (COP rise up + 40 to + 60%) of the Thermal Lacustrine Networks (TLNs), and supplying the CORSAIRE "free-heating" (*winter temperature correction only by heat exchangers)* of the (existing) Potable Water Networks (PWN).

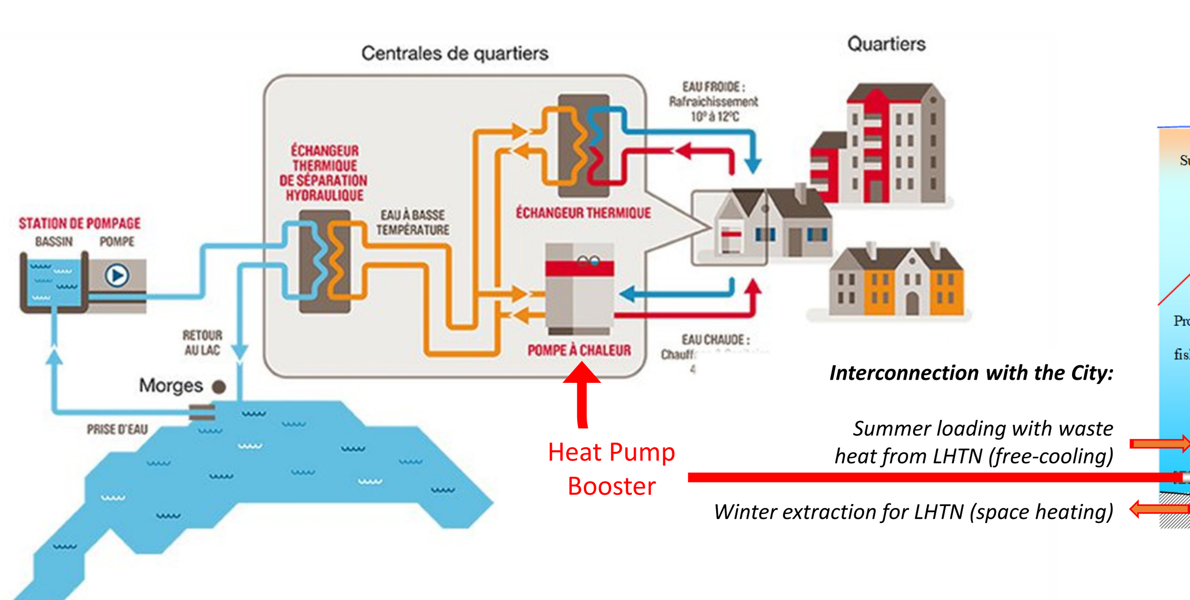
In 2050, about 300 ULISSE Reservoirs distributed invisibly in the 15 large Swiss lakes and connected on the TLNs, in association with the CORSAIRE free heating (including outside the lake regions), could provide nearly 60 PJ or 30 % of the 200 PJ of the national needs of heat energy for room heating and domestic hot water. For an investment around 3 to 4 billion CHF, this **would save 3 TWh of gross electricity production in the winter semester, i.e., 1/3 of the 9 TWh structural winter electricity deficit** (= twice the winter production of the largest Swiss hydroelectric complex of Grande-Dixence: 2 x 1.5 TWh).

Heat requirements versus Swiss lakes potential : 1/3 or 135/400 PJ



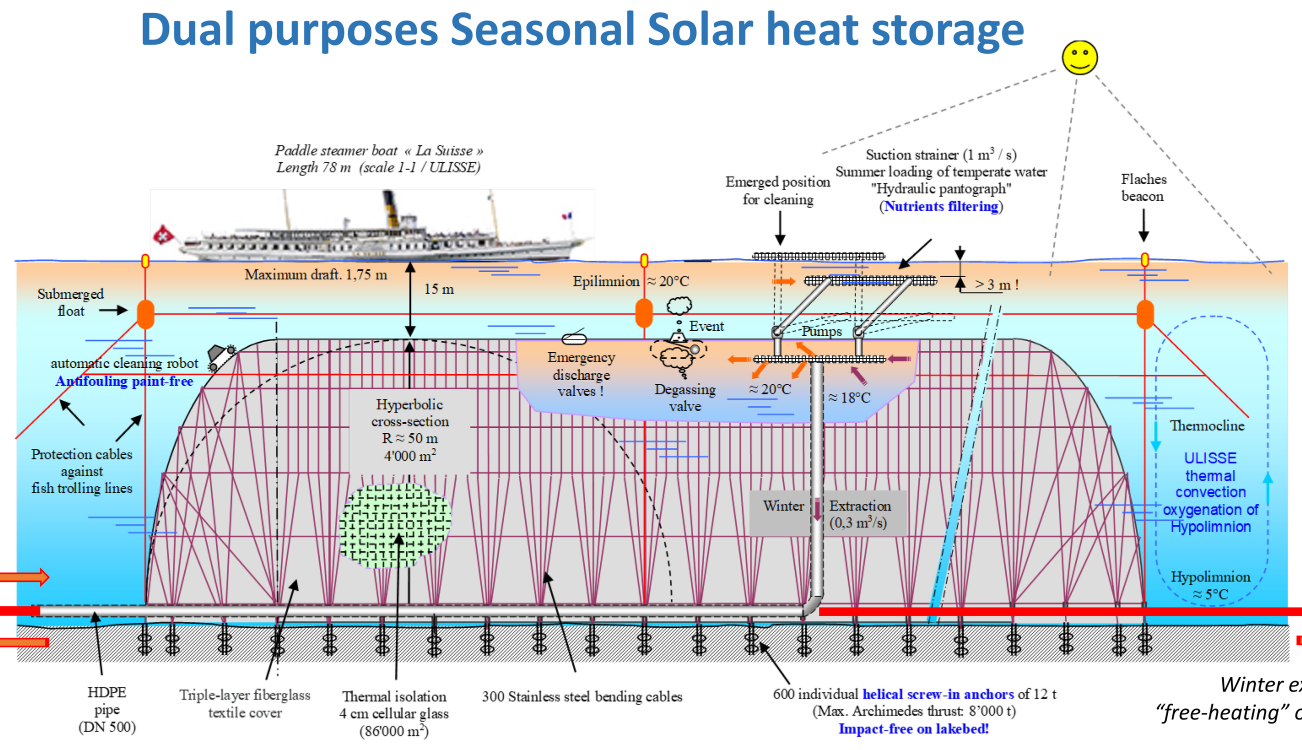
Source: Utilisation thermique des eaux superficielles…
A. Gaudard; M. Schmid, Eawag; A. Wüest, Eawag et EPFL, AQUA & GAS no 6 | 2018

Heat pump efficiency boosting



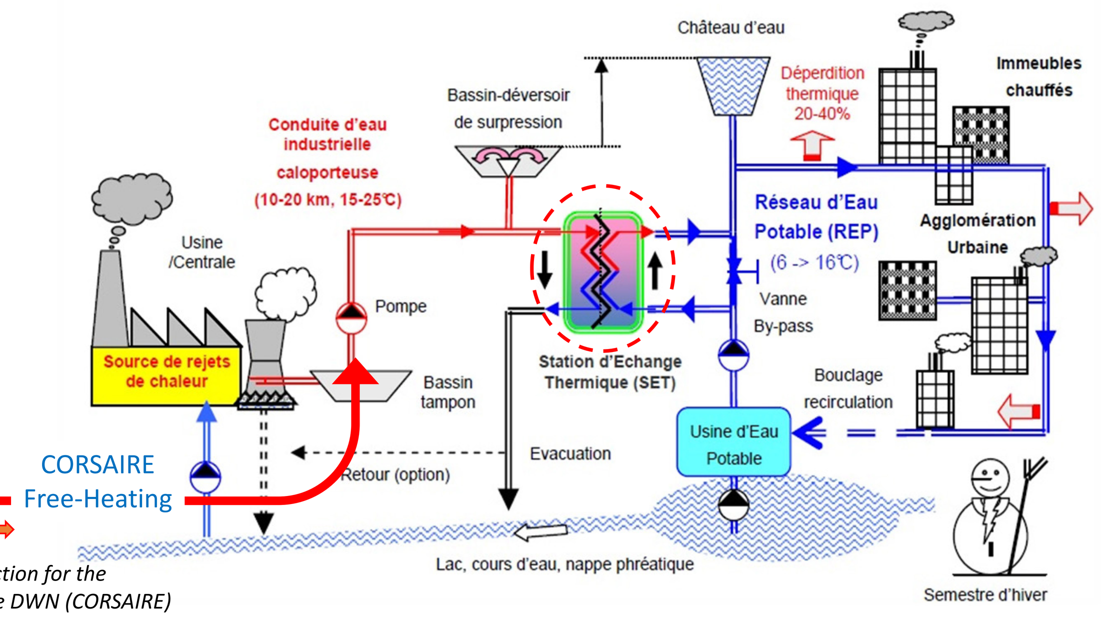
Example of a TLN: Thermal Lacustrine project MorgesLac, Enerlac (commissioning 2021)

Dual purposes Seasonal Solar heat storage



Typical ULISSE reservoir: hemi-cylindrical dimensions: 550 x 100 x 50 m, volume 2'000'000 m^3
Energy content: 125 TJ @ ΔT 15 K ≈ 2'900 toe, avoid 9'600 t CO_2

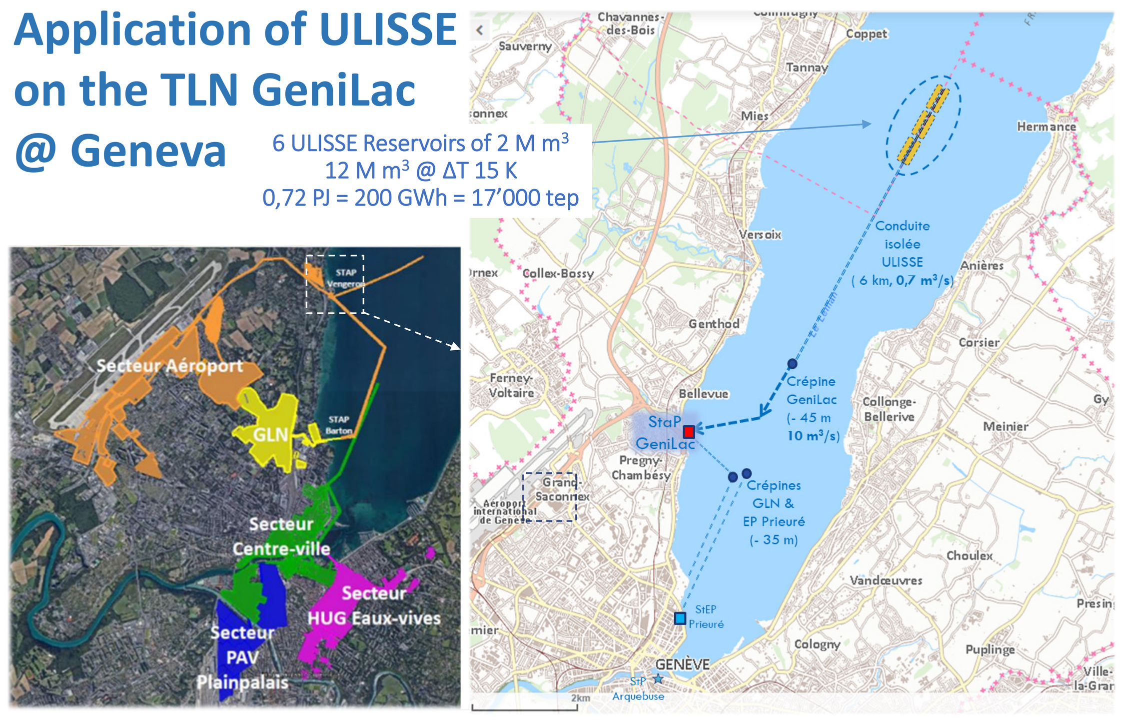
Free Heating (CORSAIRE process)



The CORSAIRE process: Seasonal (winter) temperature CORrection of the District Potable Water Network (master thesis W. van Sprolant EPFL 1995)

Application of ULISSE on the TLN GeniLac @ Geneva

6 ULISSE Reservoirs of 2 M m^3
12 M m^3 @ ΔT 15 K
0,72 PJ = 200 GWh = 17'000 tep



Multidisciplinary Study of the ULISSE-SOUR project

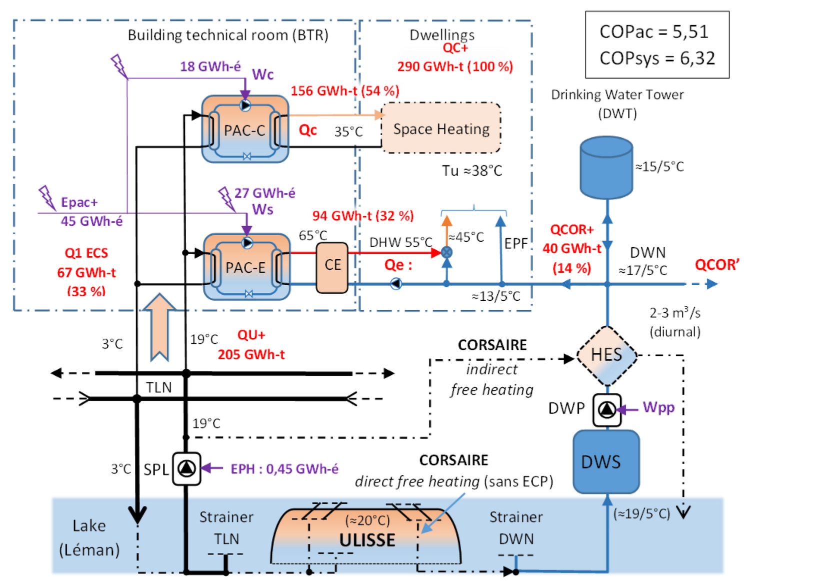
The present study explores the dual purpose of the original ULISSE's Thermal Lacustrine Network (TLN) booster associated with the CORSAIRE "free heating" process (without Heat Pumps).

The ULISSE Reservoirs are a winter heat source of around 20°C, higher than ordinary at 5-6°C of the TLNs. This doubles the efficiency of heat pumps (HP) and reduces the volume of water by a factor of 5 and by 95% the electrical energy for pumping and circulating water from the TLN.

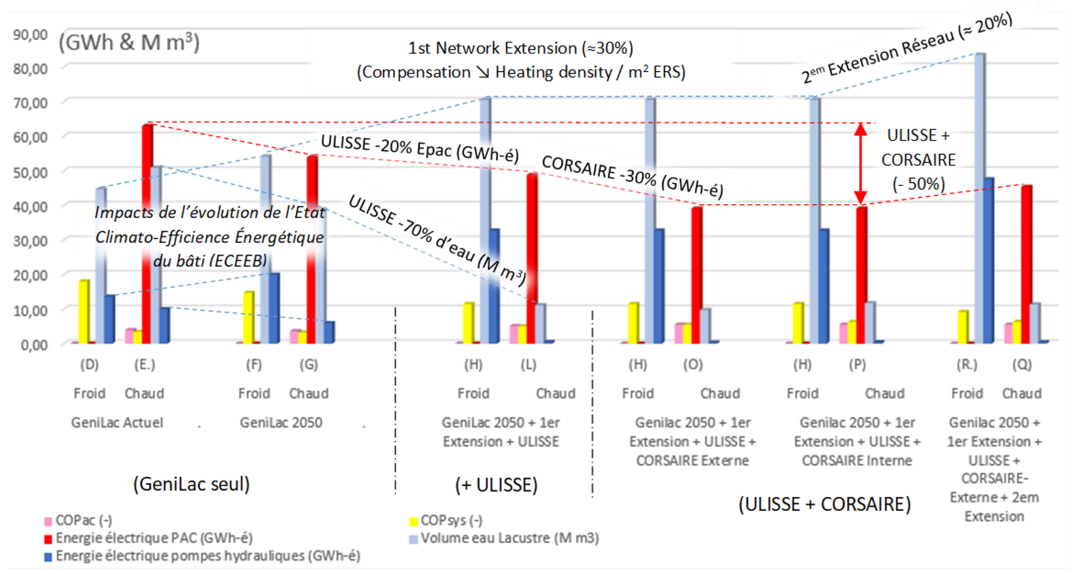
The study analyzes:

A. **the ULISSE - CORSAIRE system applied to the TLN GeniLac and the DWN in Geneva**
B. **Comparison with alternative seasonal solar heat storage systems (solar collector, storage basin)**
C. **Potential of ULISSE-CORSAIRE at a national scale**
D. **The storage efficiency of the ULISSE reservoirs is also analyzed by 3 different methods** :
   1. Reduced size mock-up for a physical reproduction of a annual charging/discharging cycle,
   2. theoretical model calculation for the mock-up and the full size reservoir,
   3. Numerical simulation by COMSOL Multiphysics software.
E. **ULISSE reservoir Envelope material & structural investigation, anchoring, etc.**
F. **Potential environmental lake impacts of the ULISSE reservoir**
G. **Next step in-dept study (pilots)**

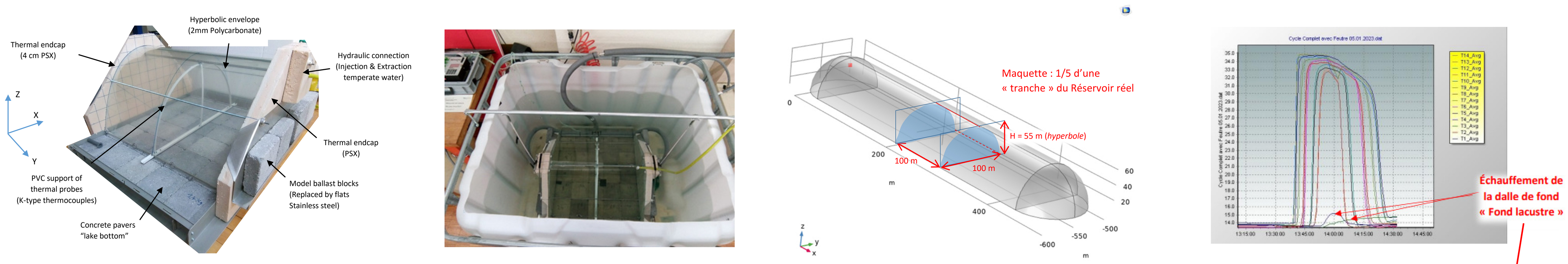
TLN GeniLac network in the Winter Semester with ULISSE & CORSAIRE-DWN (2050)



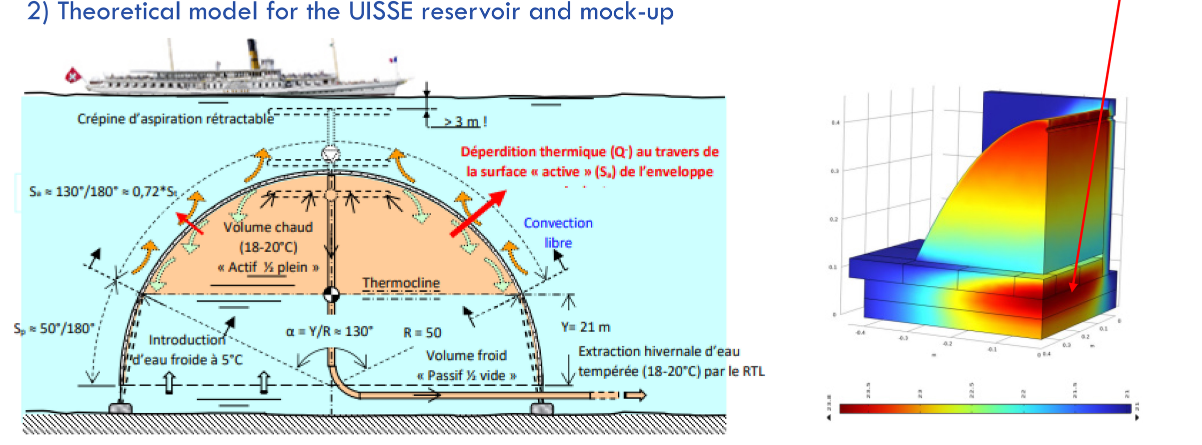
Energy comparison of cold (free-cooling) and heating (hot), associated with the volume of lake water (M m^3) as well as the electricity (GWh) of the pumps - hydraulic and heat (HP) applied at GeniLac alone and with ULISSE and CORSAIRE



1) Reduced size ULISSE Mock-up physical annual charging/discharging cycle reproduction

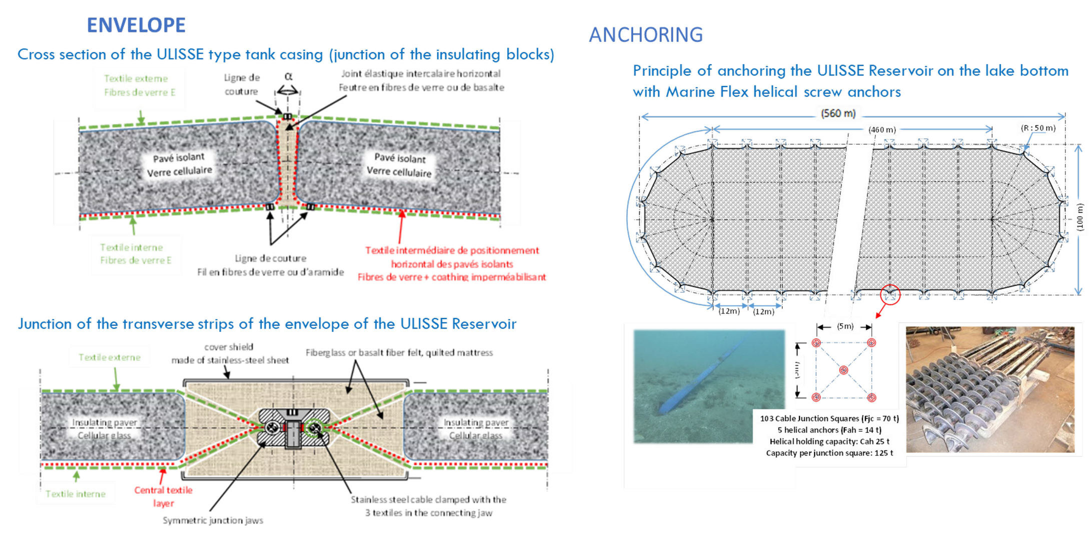


2) Theoretical model for the ULISSE reservoir and mock-up



Temperature distribution at end discharging (COMSOL)

Constructive details of the ULISSE reservoir



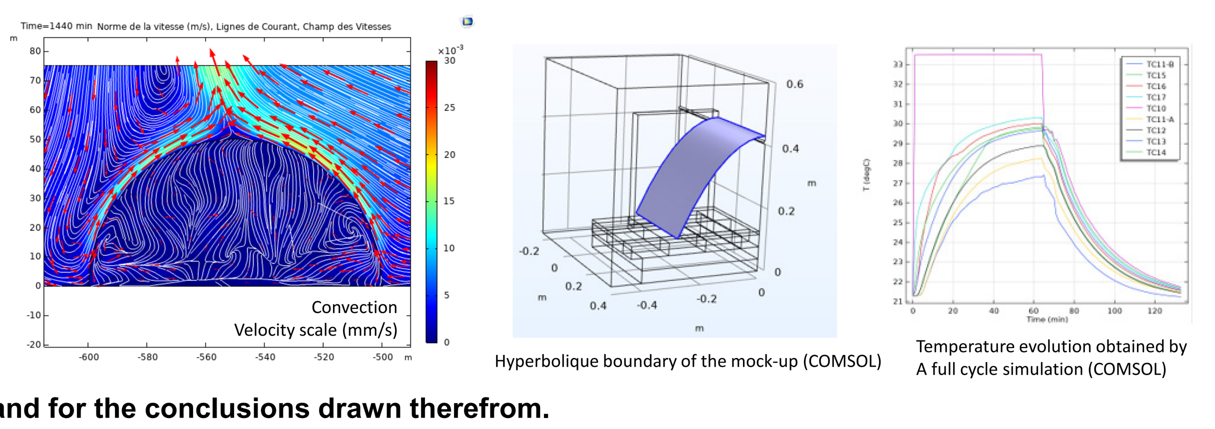
Potential environmental lake impacts

- **External convection currents**, induced by heat loss through the **biocompatible envelope** (textile and cellular glass) of ULISSE reservoirs, can **improve the circulation of nutrients and the oxygenation of the lake bottom**, protecting the aquatic ecosystem against eutrophication and global warming.
- The presence of the ULISSE reservoirs can create, around (vicinity), **ecological niches** protected from fishing and thus promote the development of aquatic fauna.
- Selective capture (**filtration of phytoplankton**) would make it possible to regulate "blooms" (toxic algal blooms), if necessary, to **recover GHGs and CH_4** (for energy use).
- The confinement of the heat captured in the reservoirs would **lowering the surface temperature of the lake**, the loss of water by **evaporation** and would further **increase the dissolved oxygen** in the water.

Next step in-dept study (pilots)

The study concludes by proposing a "roadmap" for creating a **pilot ULISSE Reservoir (connected to the TLNs of the EPFL-UNIL campuses with observations by the LéXPLORE floating laboratory)** and a **CORSAIRE pilot on the Cité du Lignon** (6,500 inhabitants and shops) and supplied with waste heat from the waste Water Treatment Plant, WTP Aïre in Geneva.

3) Numerical simulation of the Mock-up (COMSOL Multiphysics)



Hyperbolique boundary of the mock-up (COMSOL) — Temperature evolution obtained by A full cycle simulation (COMSOL)

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