SIMULATION OF AN UNDER LAKE INFRASTRUCTURE FOR CAPTURE AND STORAGE OF SOLAR ENERGY (ULISSE)

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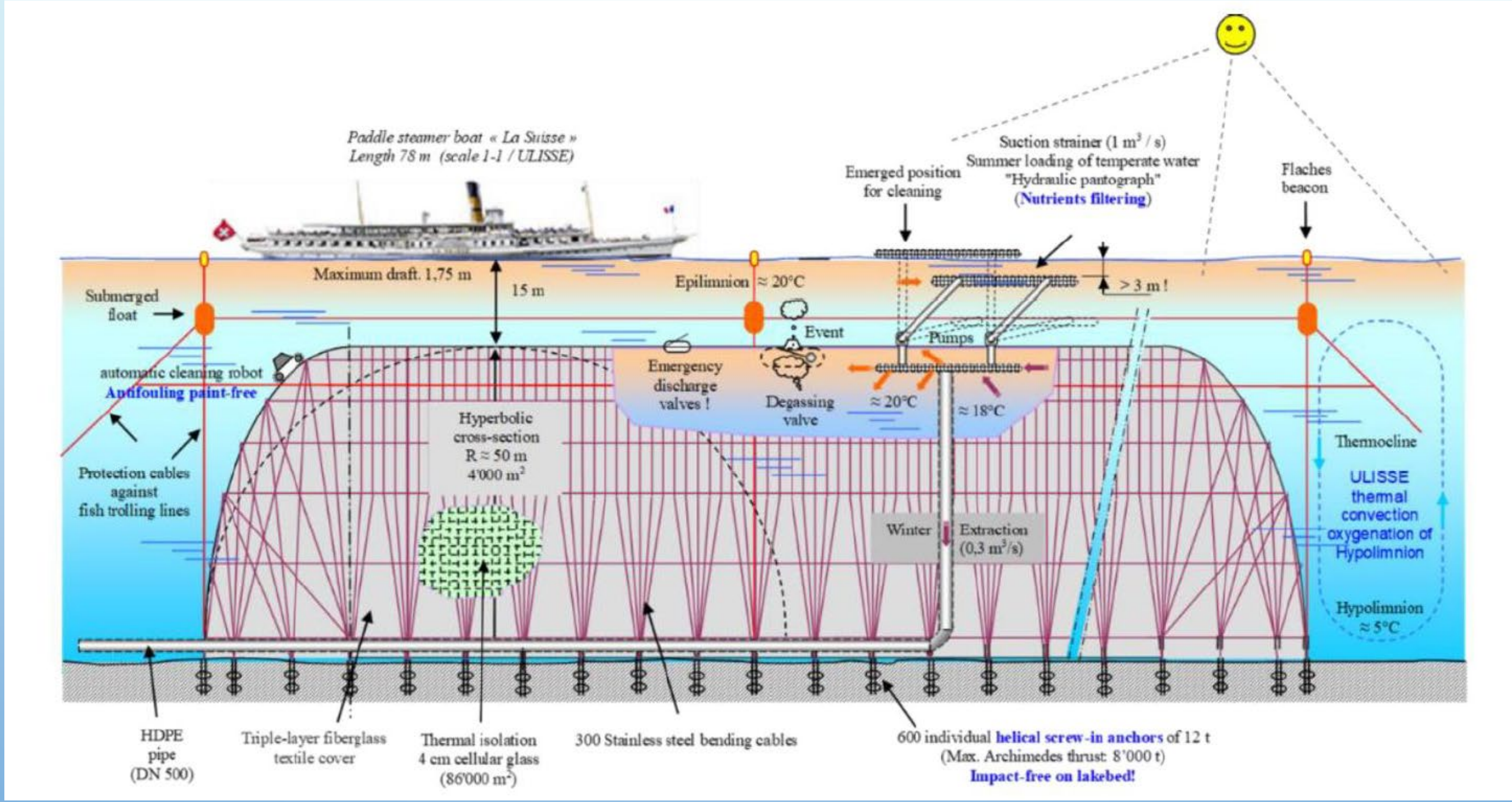
What is ULISSE ?



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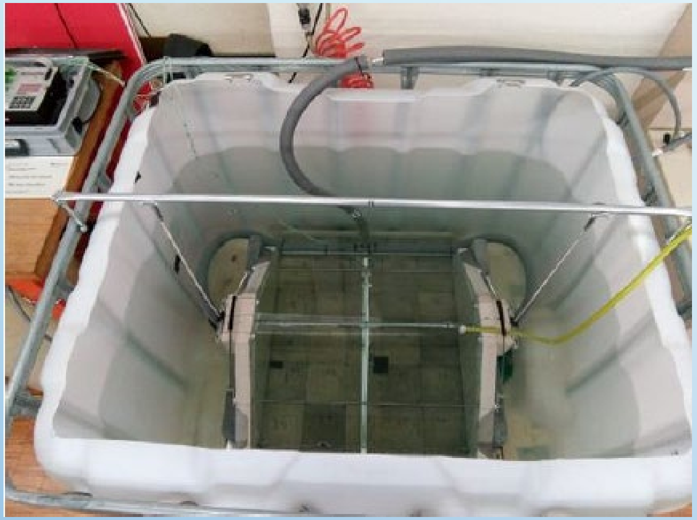
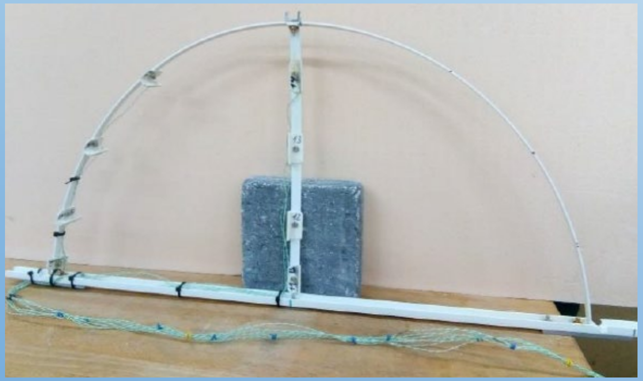
The Experimental Mock Up





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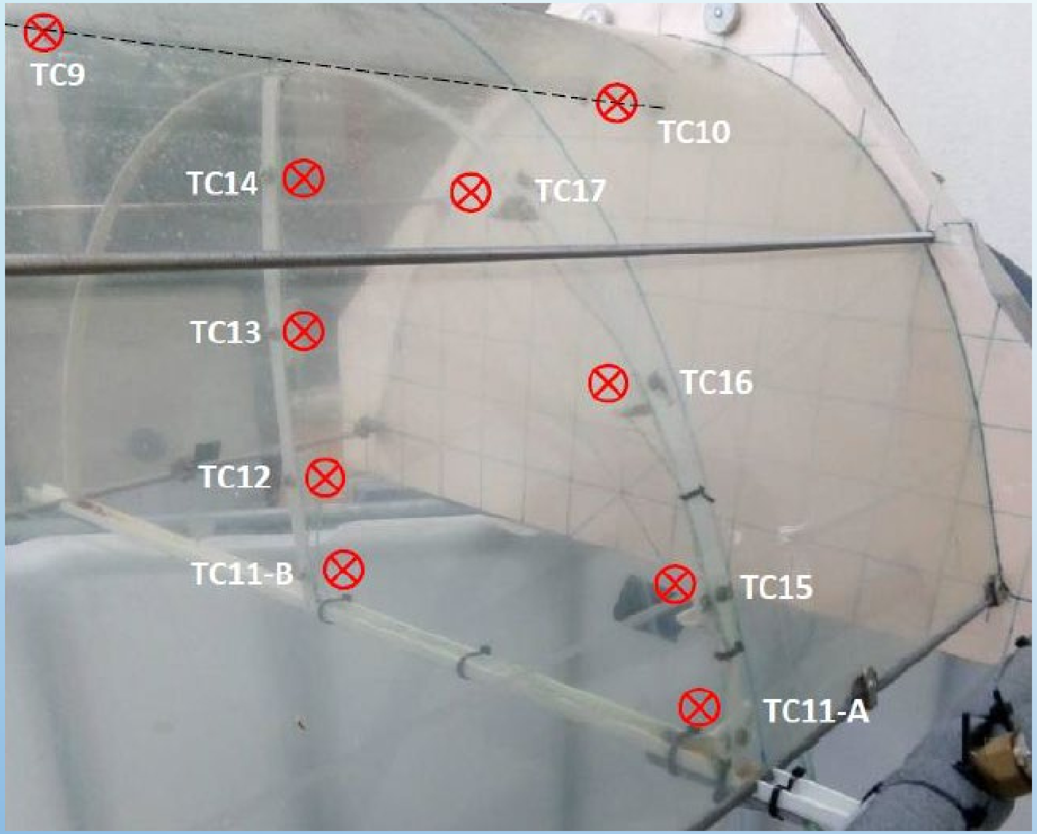
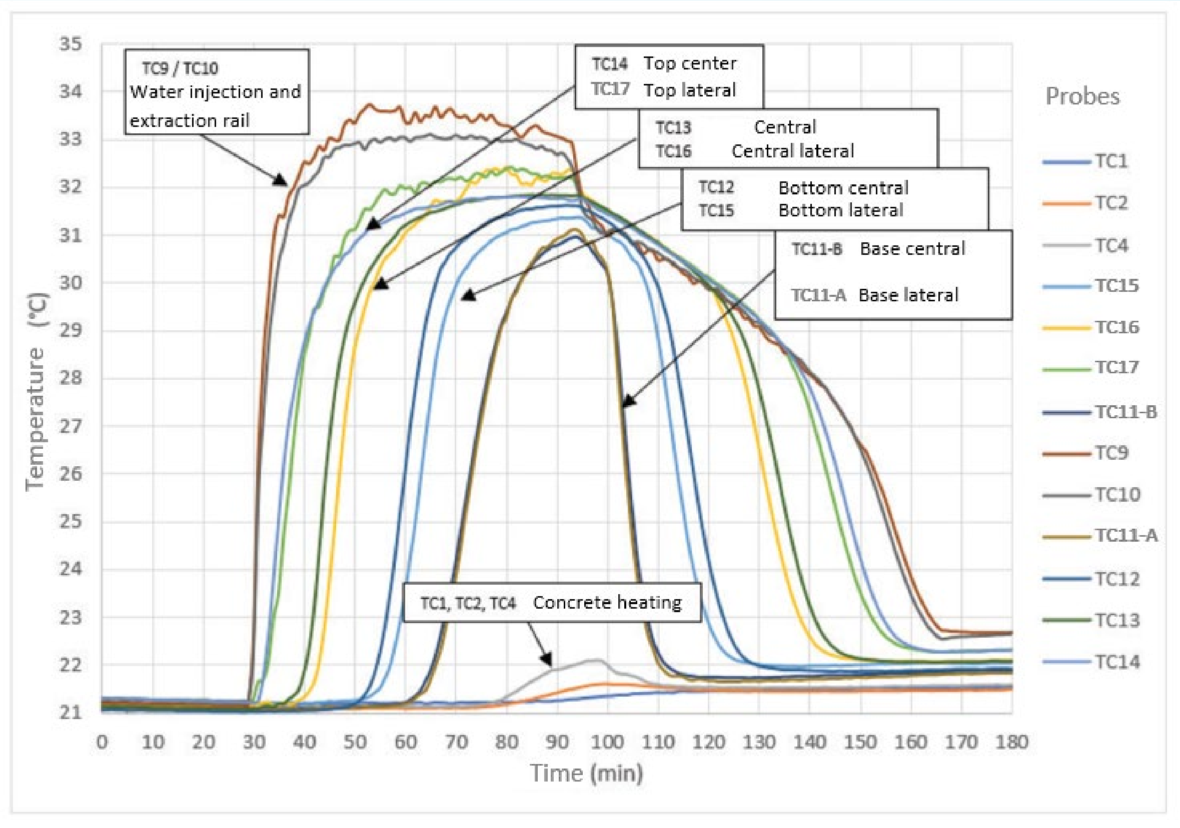
Measurements Over a Cycle





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Physical Modelling : Governing Equations

Fluid Mechanics : Laminar Flow with the Boussinesq Approximation

$$\rho_w \frac{\partial \boldsymbol{u}}{\partial t} + \rho_w (\boldsymbol{u} \cdot \nabla)\boldsymbol{u} = -\nabla p + \rho_w \boldsymbol{g} \qquad (1)$$

$$\rho_w = \rho_{ref}\left(1 - \alpha_p\right)\left(T - T_{ref}\right) \qquad (2)$$

$$\alpha_p = -\frac{1}{\rho_w}\left(\frac{\partial \rho_w}{\partial T}\right)_p \qquad (3)$$

$$\nabla \cdot \boldsymbol{u} = 0 \qquad (4)$$

$$p = p_{ref} + \rho_w \boldsymbol{g} \cdot (\boldsymbol{r} - \boldsymbol{r_{ref}}) \qquad (5)$$

+ Initial Conditions + Boundary Conditions

Heat Transfer : in Fluids

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \boldsymbol{u} \cdot \nabla T - \nabla \cdot (-k\nabla T) = 0, \qquad (6)$$

+ Initial Conditions + Boundary Conditions

Heat Transfer : in Solids

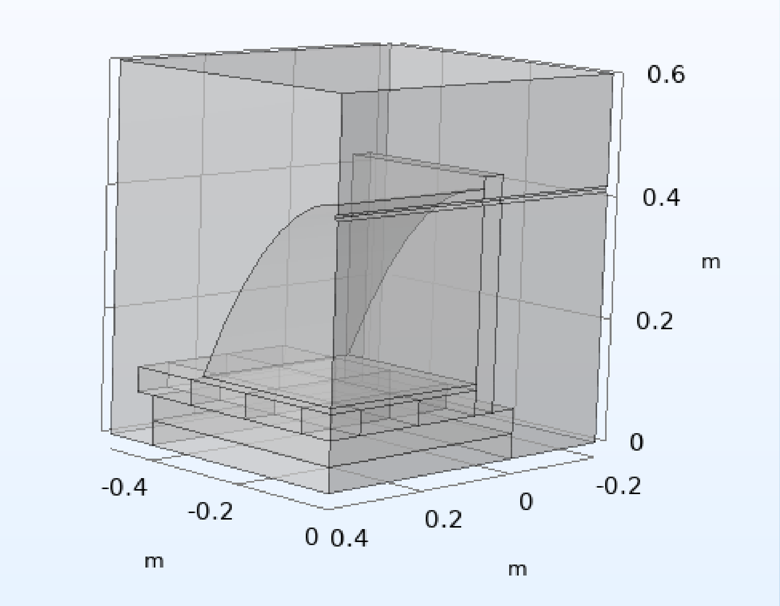
$$\rho C_p \frac{\partial T}{\partial t} - \nabla \cdot (-k\nabla T) = 0, \qquad (7)$$

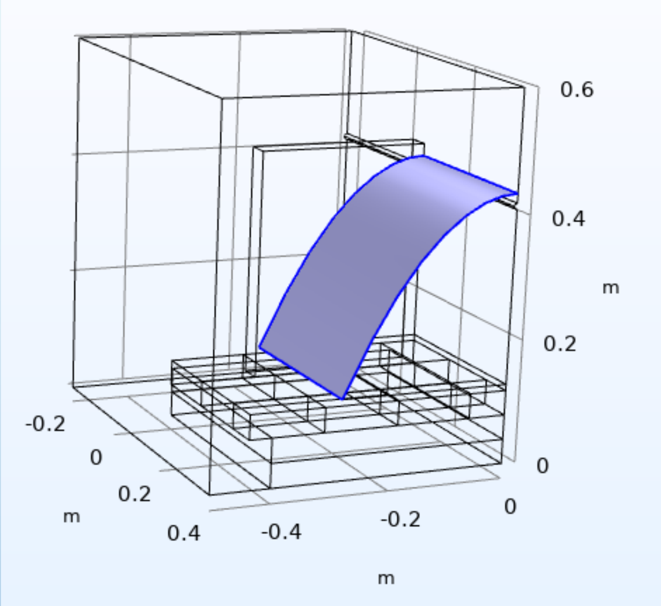
+ Initial Conditions + Boundary Conditions

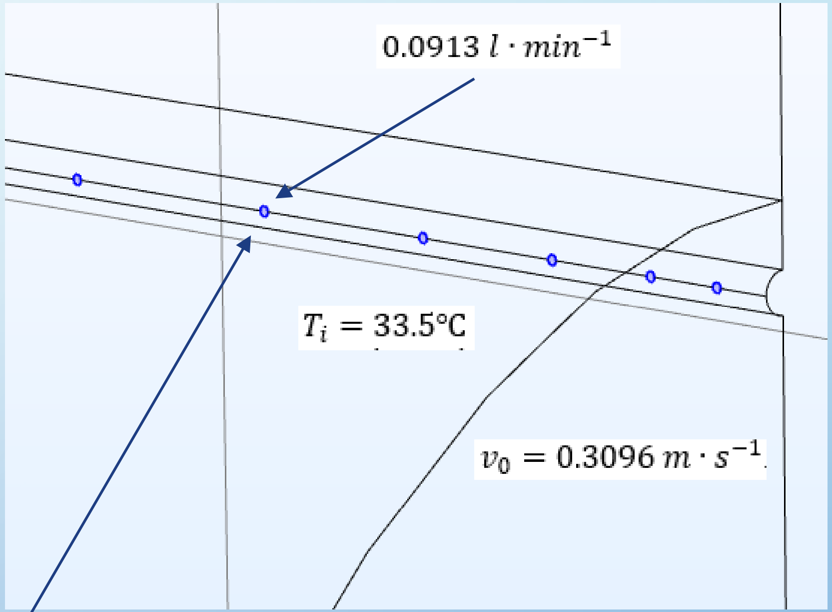
Comsol Modelling : Implementation

$T_0 = T_{ext} = 21.3°C.$

$h = 11\, W \cdot m^{-1} \cdot K^{-1}$







Phase	Description	Time Range (min)
1	Water injection	[0;64]
2	Relaxation	[64;70]
3	Water extraction	[70;134]

Phase	Laminar Flow	Heat Transfer
1	v_0 (ramped)	T_i
2	No Slip	Thermal Insulation
3	$-v_0$ (ramped)	Thermal Insulation

Total Debt

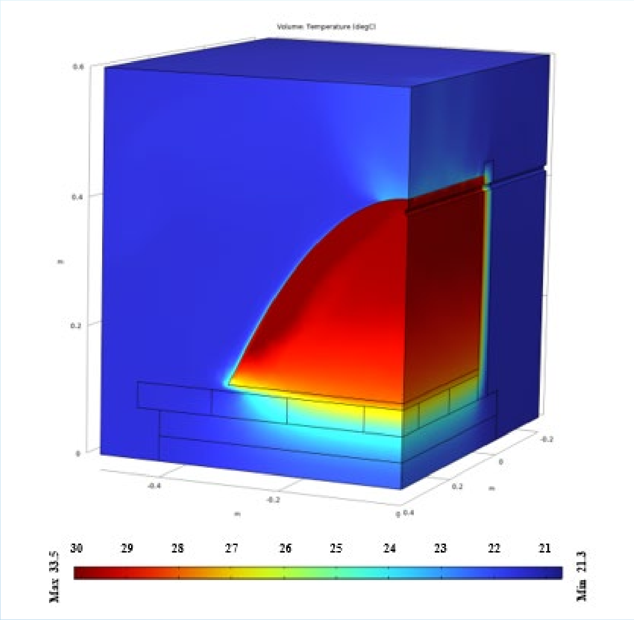
$2.19\, l \cdot min^{-1}$

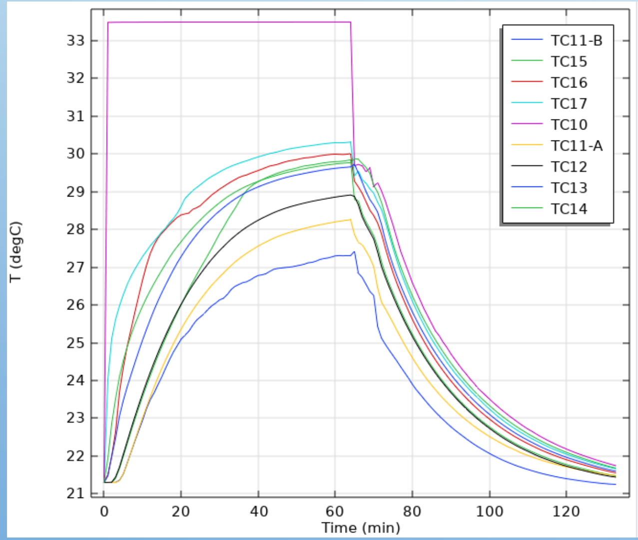
Simulation Results

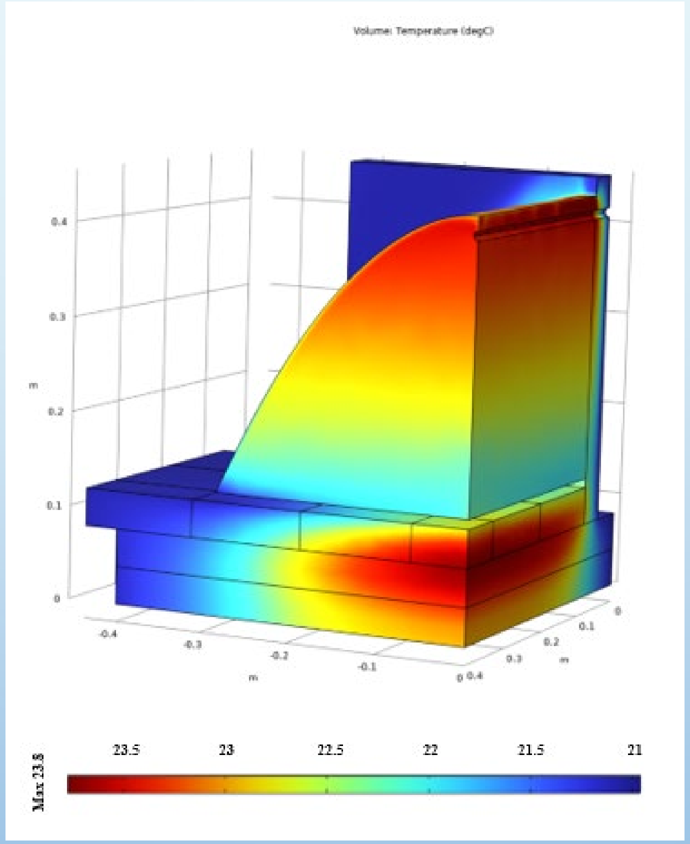
Temperature Distribution

Velocity Magnitude

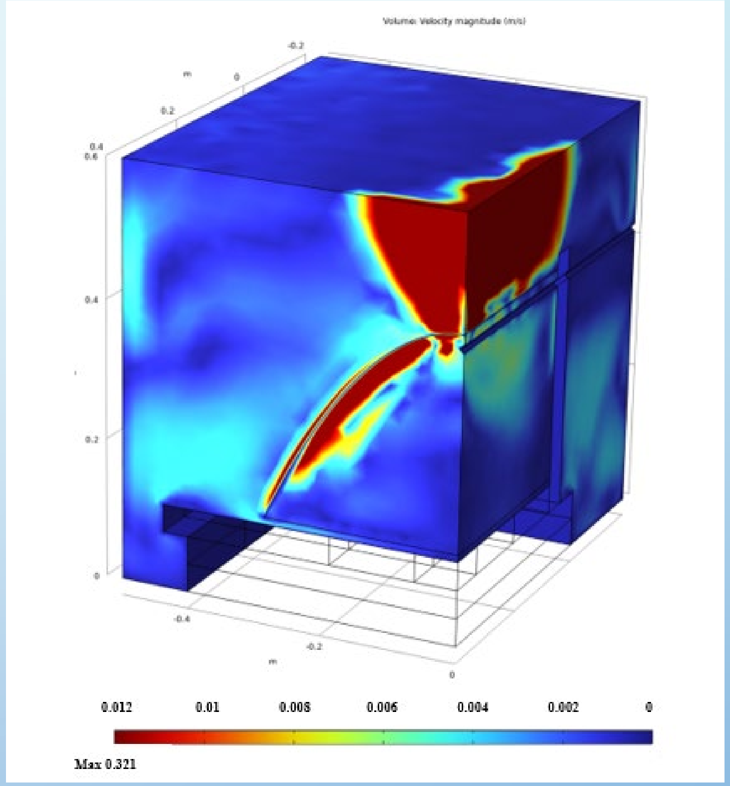
t = 64 min







t = 89 min



t = 64 min

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Energy Balance

U is the internal energy of the tank

U_0	U_i	U_{64}	U_{70}
0.3861	7.8920	2.7891	2.4608
E_S	E_a	E_L	U_x
2.403	2.0747	0.3283	2.3618

Energy balance results (MJ)

$E_a = U_{70} - U_0$ Available energy for extraction

$E_L = U_{64} - U_{70}$ Lost energy during relaxation

$E_s = U_{64} - U_0$ Stored energy

$S = 4.9159 \cdot 10^{-6}\ m^2$

$T_{ref} = 20\ °C$

$$U_x = 4 v_0 S \sum_{k=1}^{6} U_k \qquad (8)$$

$$U_k = \int_{t_{70}}^{t_{134}} \rho_w(\bar{T}_k) C_p(\bar{T}_k)(\bar{T}_k - T_{ref})\,dt \qquad (9)$$

Energy Recovered by Extraction

$$E = U_x - U_0 = 1.9757\ MJ$$

E is 82% of the stored energy E_s

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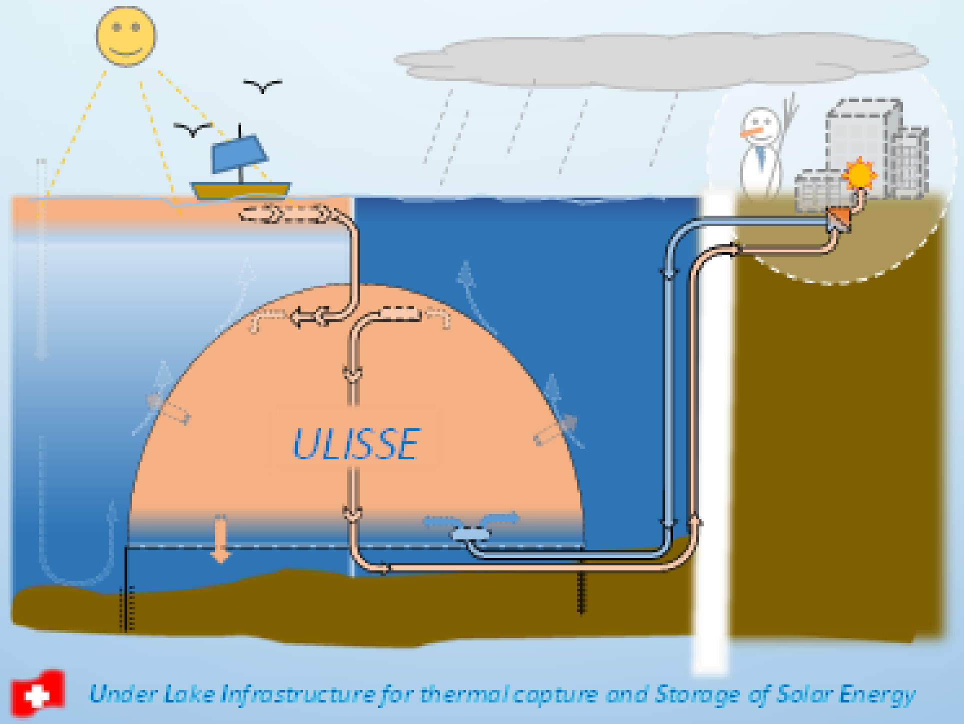
Concluding Remarks



Thank You Very Much For Your Attention

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