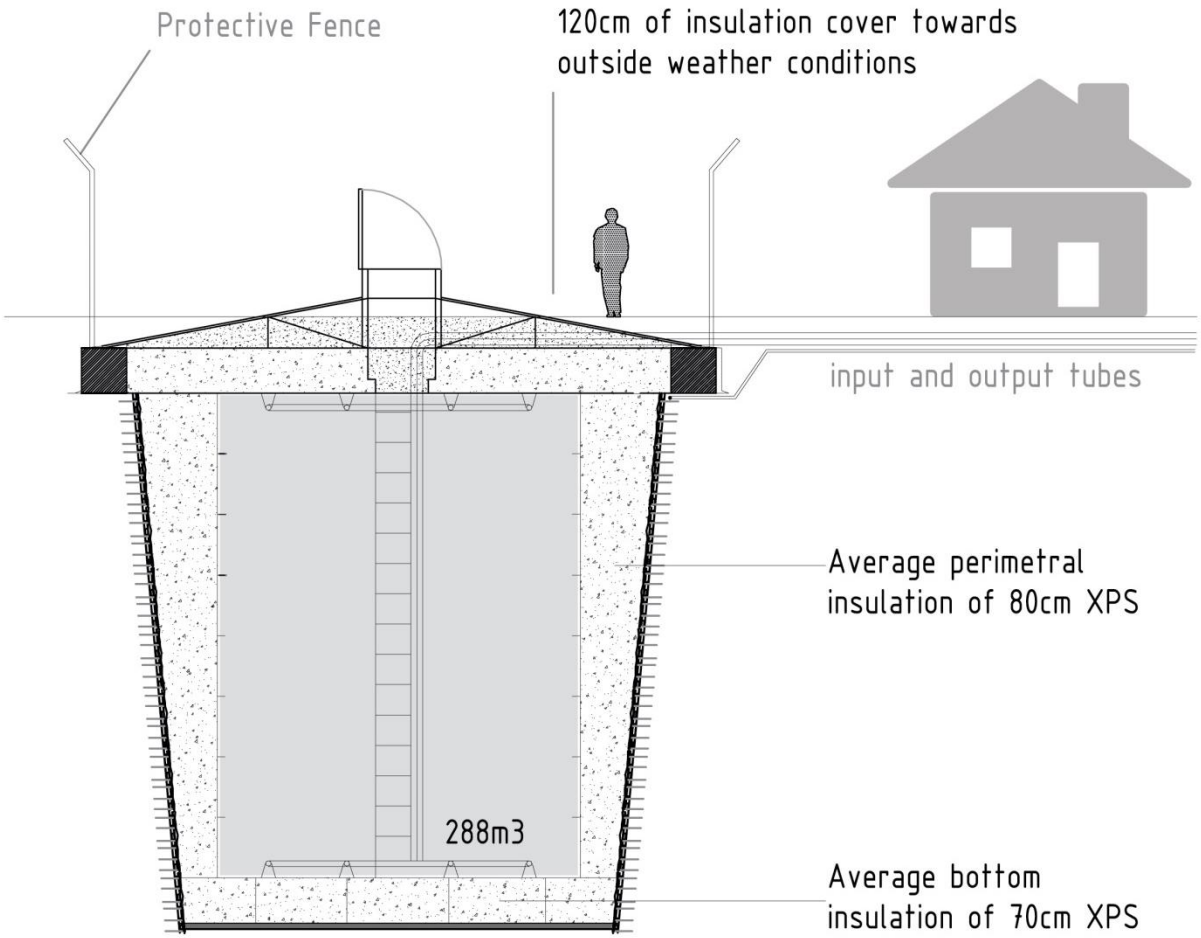
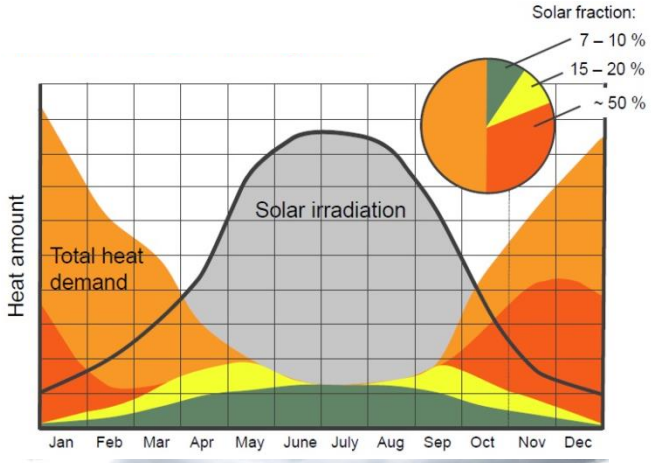
Long Term Energy Accumulation in Underground Hot Water Tanks. Fluid Convective Behaviour and its Influence on the Thermal Losses





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GOVERNING EQUATIONS AND BOUNDARY CONDITIONS

Based on the Boussinesq approximation, the nondimensional governing equations for a natural convection in the Cartesian coordinate system can be written

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}=\omega$$

Stream Function Equation

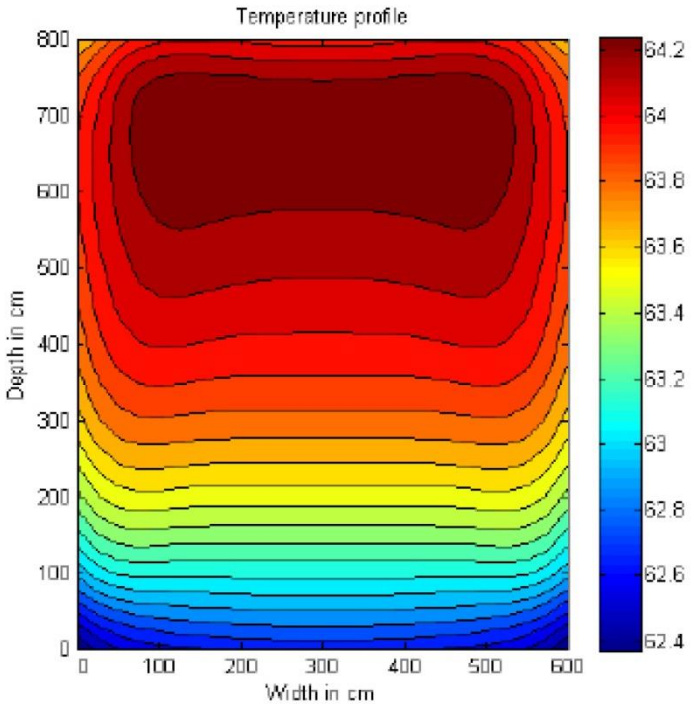
$$\frac{\partial\omega}{\partial t}+u\frac{\partial\omega}{\partial x}+v\frac{\partial\omega}{\partial y}=\mathrm{Pr}\left(\frac{\partial^2\omega}{\partial x^2}+\frac{\partial^2\omega}{\partial y^2}\right)+\mathrm{Pr\ Ra}\frac{\partial T}{\partial x}$$

Vorticity Equation

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}$$

Temperature Equation

- Resolution and non-dimensionalization for space and time
- Define internal T°C and outside air T°C in initial state
- Solving stream function equation (Successive Over Relaxation)
- Define vorticity on boundary
- Solving the vorticity equation (Finite differences approach)
  - stream function input
  - temperature input for the buoyancy term
- Solve temperature equation (Finite differences approach)
  - stream function input
- Update boundary conditions for T°C and weather update
- Return to real values and plot



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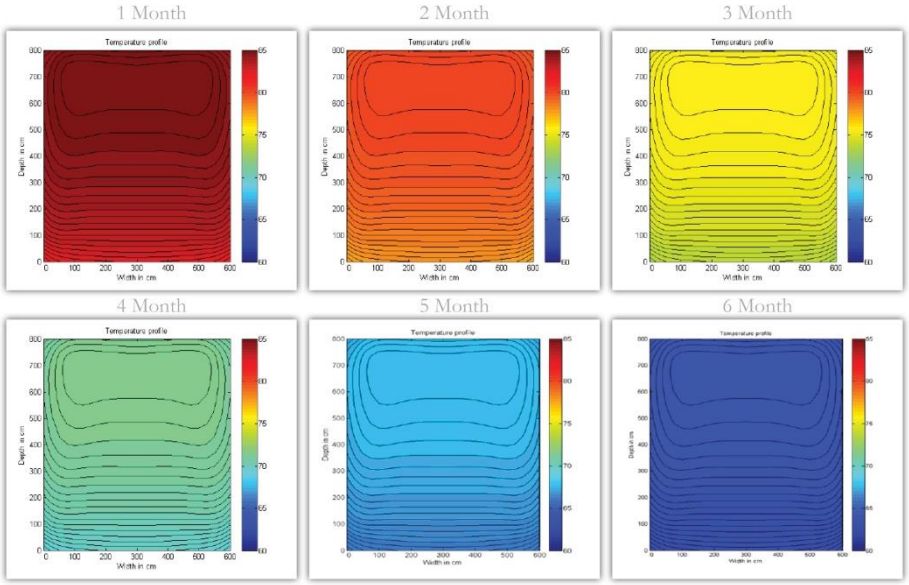
Results discussion and building application with low temperature



Calculation of disponible energy and heat losses after each month

$$Q = (T_{AV} - T_H) * Cp * \varrho * V$$

Period	Max Temp (T°C)	Aver Temp (T°C)	Min Temp (T°C)	Temp Differ (T°C)	Disponible Energy (mWh)	Energy Losses (mWh)
Initial state	90.000	90.000	90.000	0.000	16.395	0.000
1 Month	85.069	84.284	82.244	2.825	**14.521**	1.874
2 Months	80.313	79.584	77.685	2.628	12.980	1.541
3 Months	75.883	75.207	73.442	2.441	**11.544**	1.435
4 Months	71.756	71.129	69.489	2.267	10.207	1.337
5 Months	67.911	67.330	65.806	2.105	**8.962**	1.246
6 Months	64.327	63.788	62.372	1.955	**7.80 mWh**	1.161
Efficiency of the system for an year cycle:					**48%**	8.595

Thermal properties		
Heating Mean Temperature	40	°C
Specific Heat Capacity of Water	4191	J/kgK
Volume of the Water Tank	288	m3
Density of the Water	978	kg/m3

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