

# Modeling of Horizontal GSHP System for Greenhouse

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**Introduction:** In this study, a greenhouse has been considered. The air temperature inside of greenhouse has to be kept at same temperature along the year. Vertical slinky heat exchanger give best performance in given area as compared other.

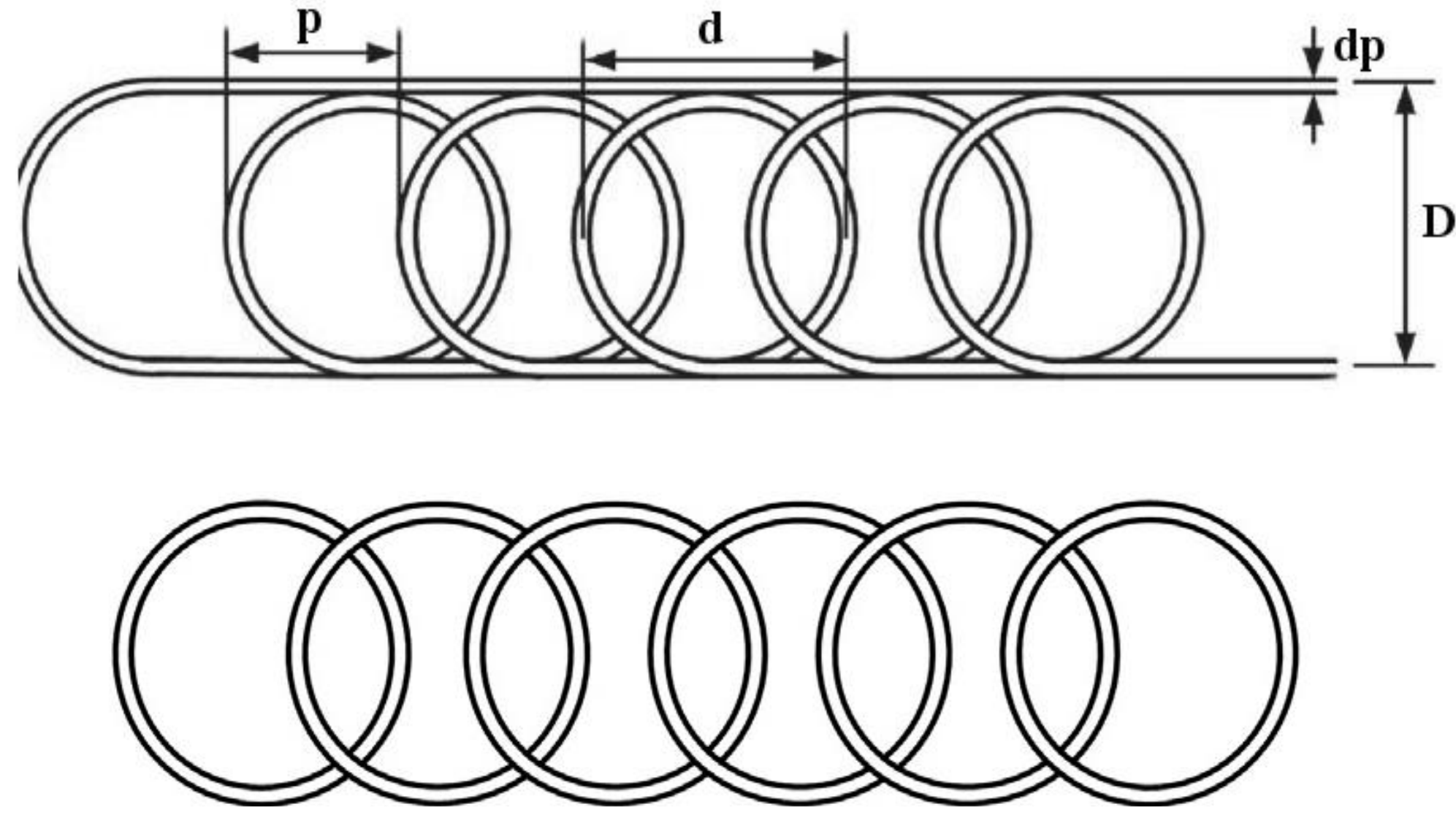


Figure 1. Slinky ground heat exchanger.

**Experimental Results:** An experimental test is done based on similar conditions. To simulate non-stop working condition of GHE in heating mode, cooler constant temperature test method is applied. During the entire test, same flow temperature (5°C) is sent to the GHE.

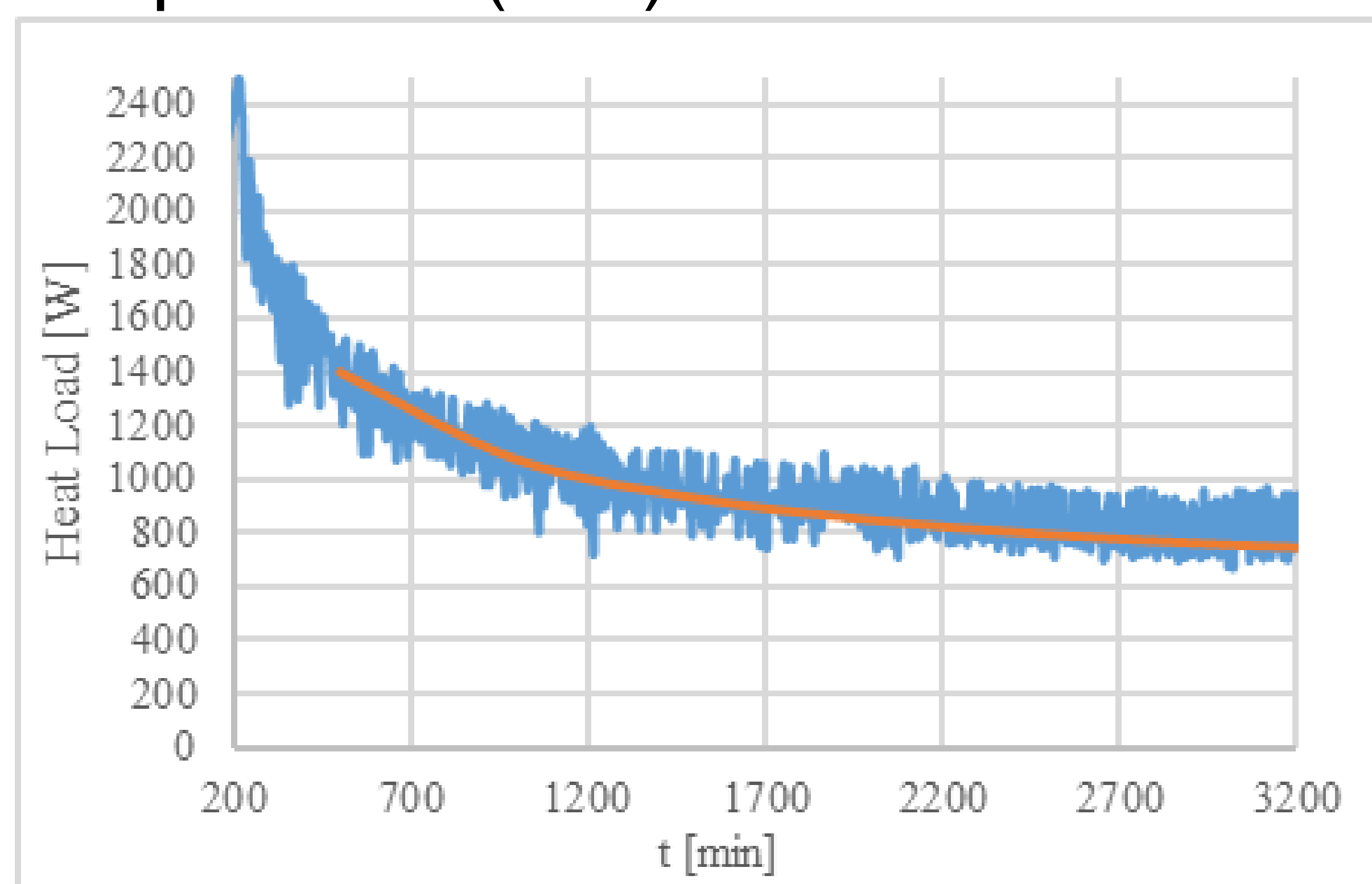
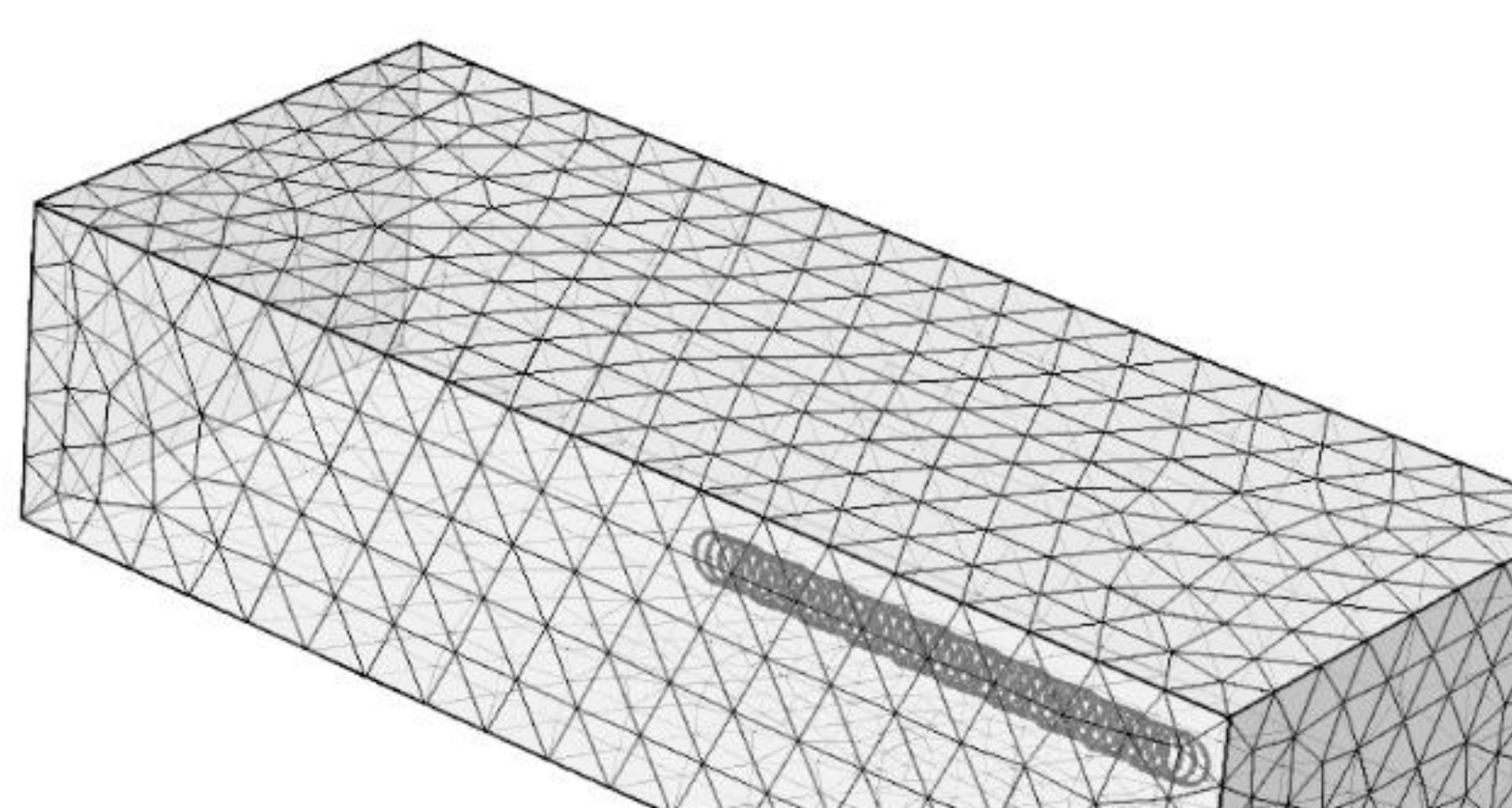


Figure 2. Experimental heat loads and fitting curve of the model.

**Computational Methods:** The same conditions are built in COMSOL Multiphysics®. The surrounding ground is added to the model as a box. The temperature data from the experiment is entered in COMSOL Multiphysics®



Governing equations in the ground:

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \mathbf{u} \nabla T + \nabla q = Q$$

Upper Boundary Condition

$$q_0 = h(T_{amb} - T)$$

GHE Boundary Condition

$$T = T_{avg-exp}$$

Figure 2. Slinky GHE and ground model in COMSOL Multiphysics® and equations.

**Results:**

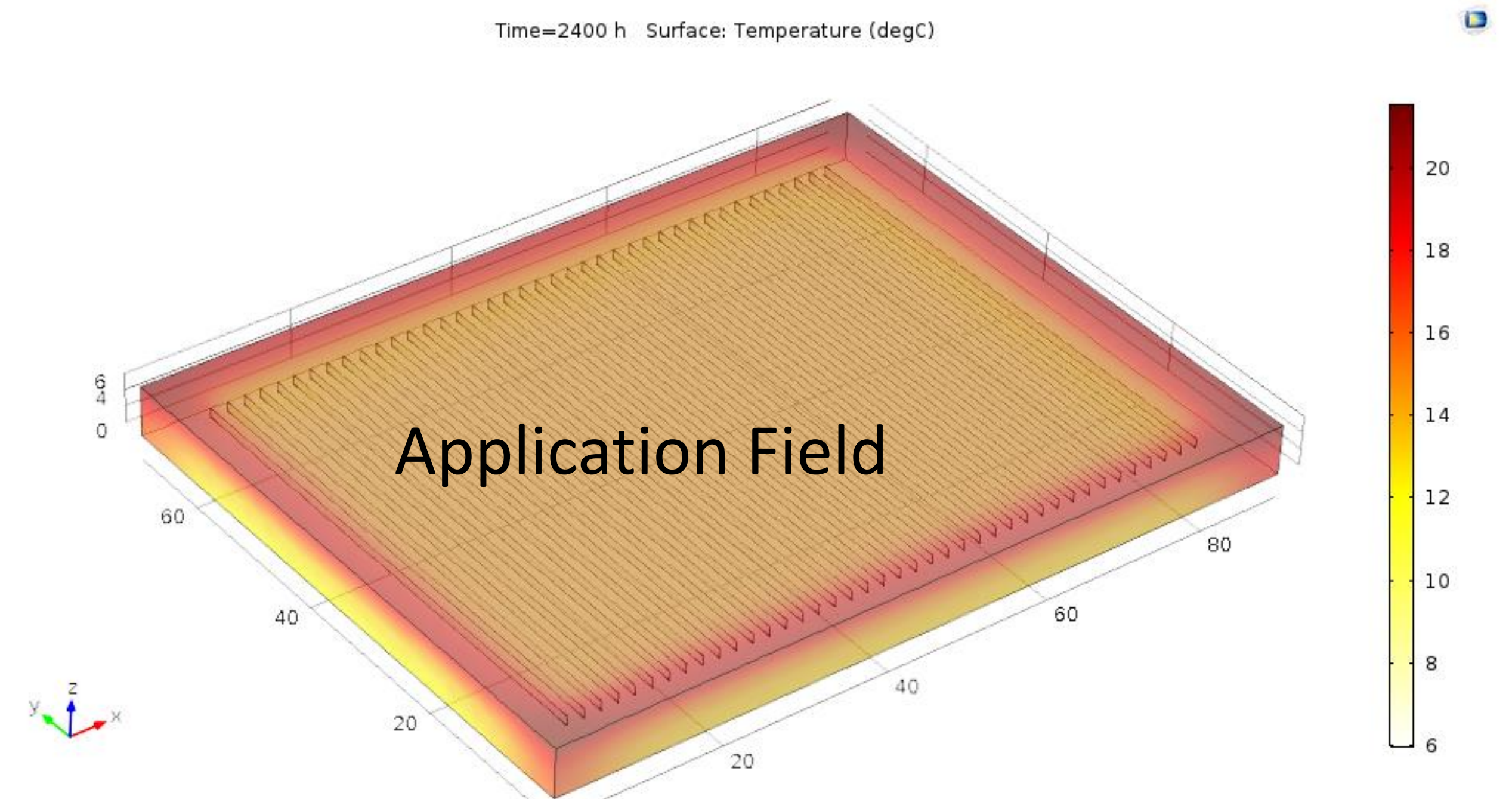


Figure 3. Field Application of Slinky GHE.

After fitting is achieved, the model is extended to field scale. In this process the best economical solution is tried to achieved for giving area by using COMSOL Multiphysics®.

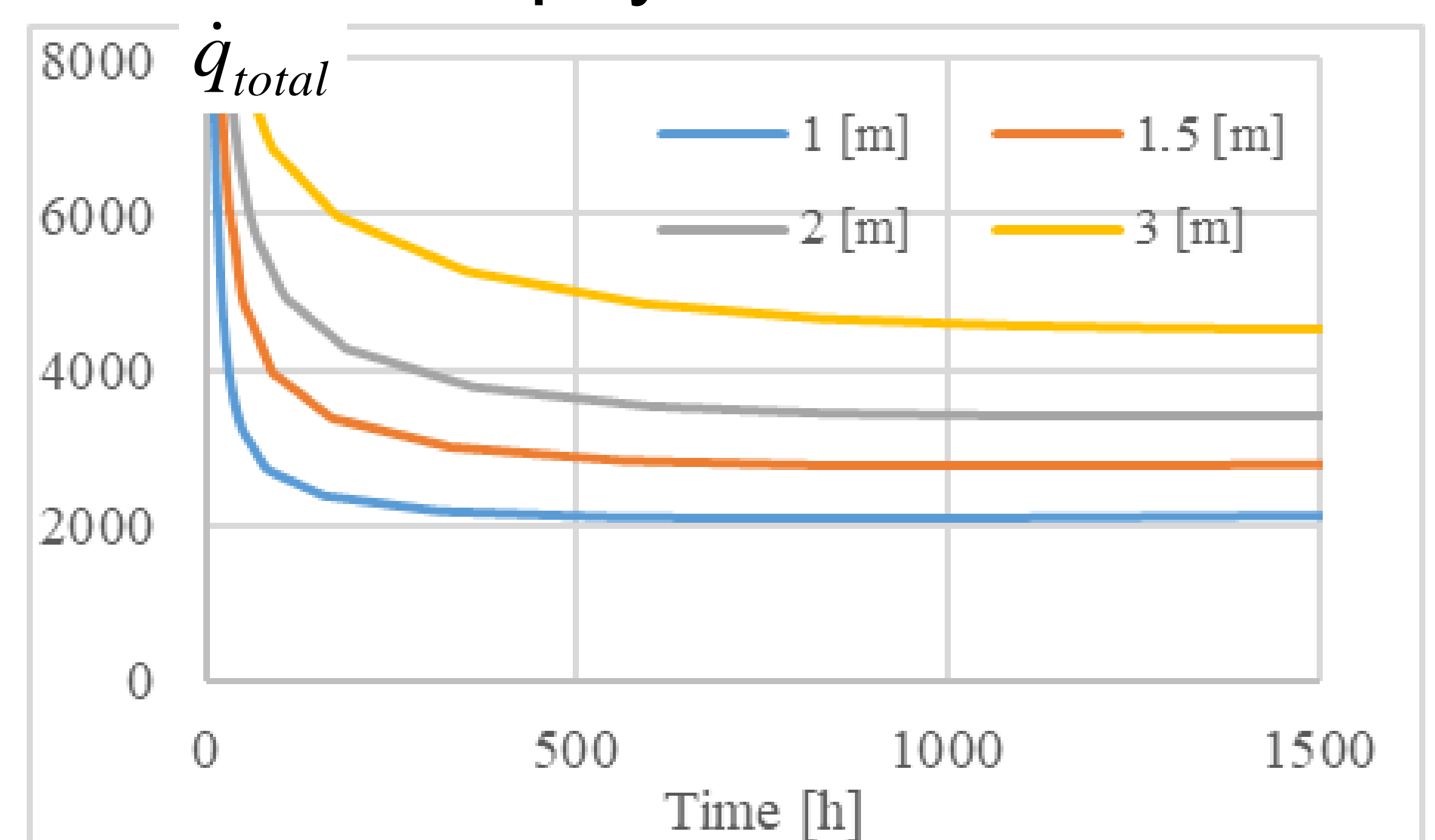


Figure 5. Heat load obtained from 100m slinky GHE.

Table 1. Total heat value obtained from 60mx80m field end of the 2400h non-stop working running.

Distance between trenches [m]	Obtainable heat load from ground [kW]		Given Heat to the Greenhouse [kW] Total Heat (COP:4)
	One Layer	Two Layers	
1	172	309	412
1.5	149	275	366
2	136	258	344
3	117	228	304

**Conclusions:** Experimental results of a sample vertical slinky is imported in COMSOL Multiphysics® and the model is validated. Then, underground of the greenhouse is used as the application field and it is shown that double layer with 1.5m distance between each loop is given best performance. However, required heat energy and the best allocation for a greenhouse may be different depending on the location.