# Analysis of Asphalt Solar Collectors Using a Finite Element Approach

G. Guldentops[1], C. Vuye[2], S. Arimilli[2],
1. Department of Civil Engineering, Worcester Polytechnic Institute, Worcester, USA
2. Construction Department, University of Antwerp, Antwerp, Belgium

## Introduction:

- Asphalt concrete road surfaces absorb significant amounts of solar radiation which can makes it a potential heat resource.
- A pavement solar collector (PSC) is a heat exchanger system embedded in the pavement structure which can be used to harvest absorbed heat energy.

## Research Goal:

- To determine the potential output and efficiency of PSC as a function of location, weather and design parameters.

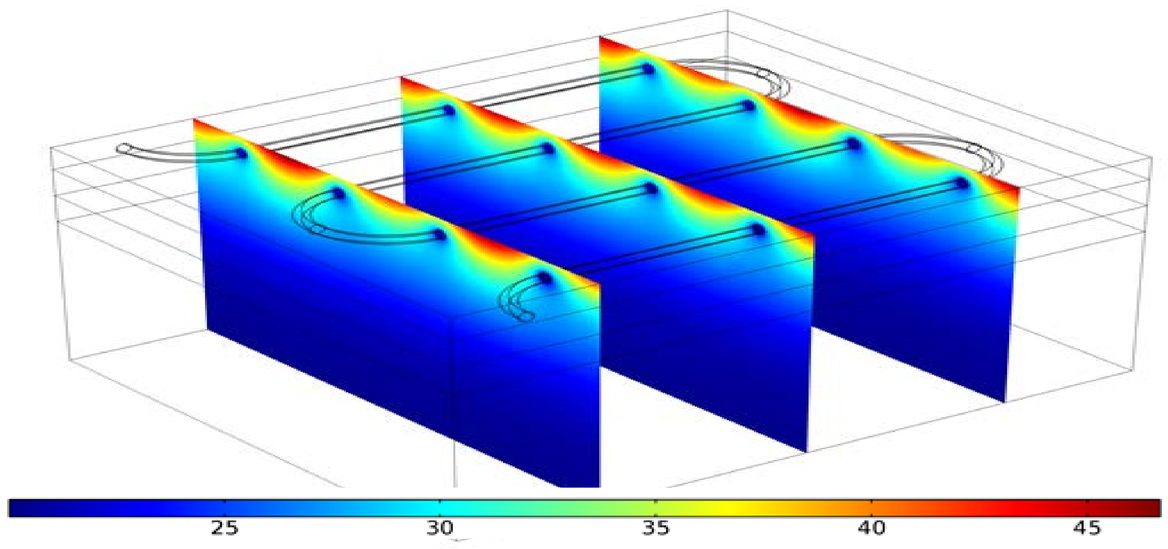


**Figure 1**: Temperature field during operation of the system.

## Computational Methods:

- A 3D PSC is simulated using Heat Transfer and CFD Module. The governing equations are time-dependent continuity, Navier Stokes and heat equations.

$$\partial\rho/\partial t+\nabla\cdot(\rho u)=0 \quad (1)$$

$$\rho\,\partial u/\partial t+\rho(u\cdot\nabla)u=\nabla\cdot[-pI+\tau]+F \quad (2)$$

$$\rho c_p\,(\partial T/\partial t+(u\cdot\nabla)T)=-(\nabla\cdot q)+\tau:S-T/\rho\;\partial\rho/\partial T\;(\partial\rho/\partial t+(u\cdot\nabla)p)+q^{\cdot} \quad (3)$$

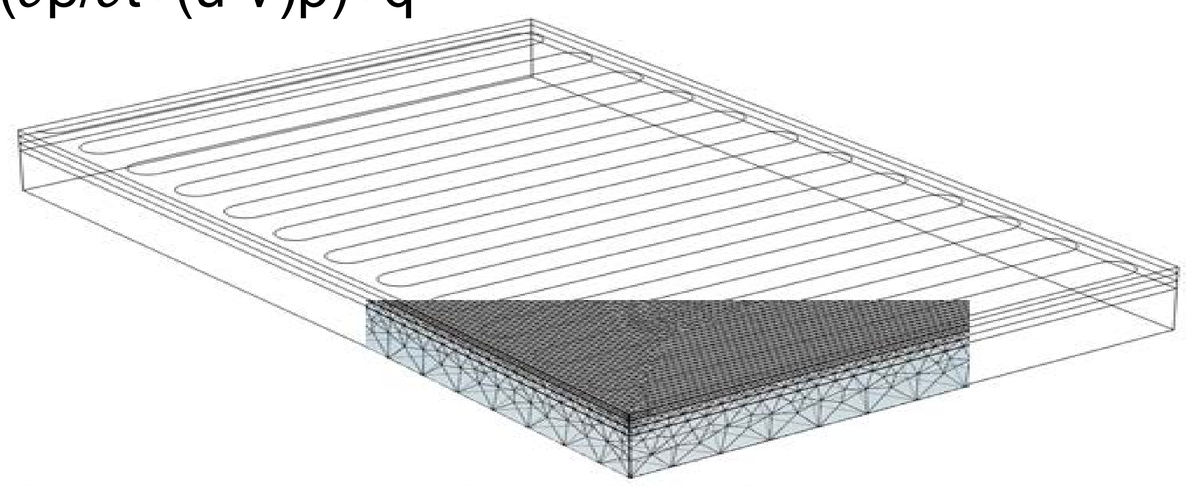

**Figure 2**: Geometry and mesh of the finite element model.

## Conclusions:

- Weather parameters and their statistical distribution have the biggest impact on the performance of the PSC.
- Even during summer at a latitude of 43° N, The exceeding chance of the weather parameters needs to be higher than 60%, in order to have a meaningful amount of energy harvesting. This is summarized in Figure 4.

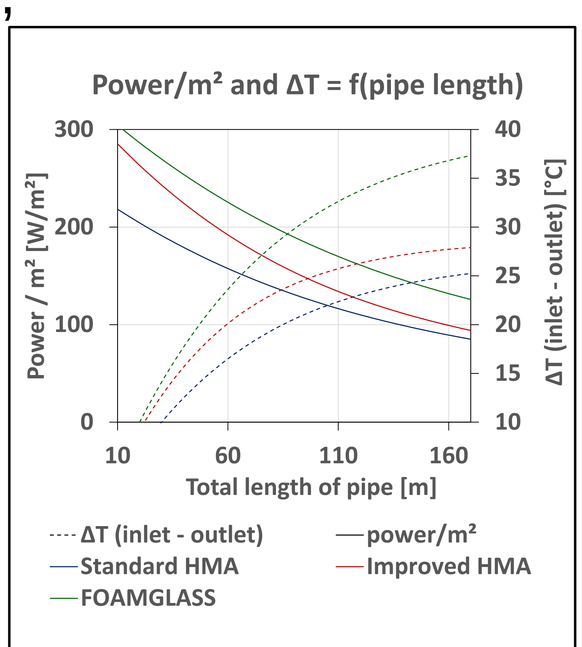


**Figure 3**: Power and temperature gains as a function of pipe length.

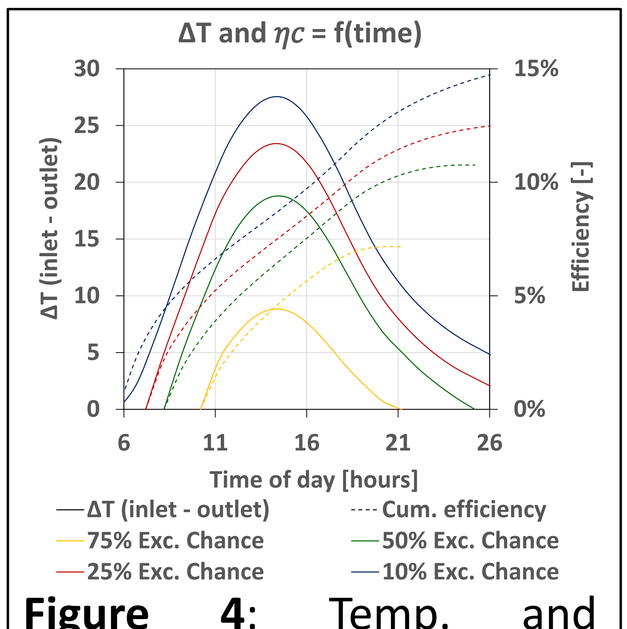


**Figure 4**: Temp. and cumulative efficiency for different exceeding chances of key weather parameters as a function of time.

- Pavement structures containing Improved HMA (Hot Mix Asphalt) materials with higher thermal conductivities give rise to larger performance of the PSC compared to pavement structures with standard HMA especially in the case of short pipe loops.
- An increase in this temperature can be obtained by placing an insulation material underneath the heat exchanger, for example FOAMGLASS. This significantly increases the performance of the PSC.

## References:

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2. F. P. Incropera, D. P. DeWitt, T. L. Bergman, and A. S. Lavine, Fundamentals of Heat and Mass Transfer, Seventh ed., vol. 6th. John Wiley & Sons, 2007, p. 997.
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