Impact Assessment of Cool Pavement Strategies on Human Thermal Comfort

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Introduction

- Cool Pavement is one of several promising strategies to mitigate heat island and improve outdoor thermal environments.
- California Assembly Bill 296, the *Cool Pavements Research and Implementation Act*, was signed by Governor Jerry Brown in 2012.
- AB 296 would develop definitions, allocate funding for research and pilot projects and ultimately develop a standard specification for cool pavements for use on streets, freeways and highways to mitigate the local heat island effect and reduce global warming.
- Cool pavement strategies could help mitigate heat island effects and improve outdoor thermal environment in hot climates.
- Pavement plays an important role in thermal environment and thus human thermal comfort through various radiative heat loading effects such as reflective solar radiation, emitted radiation and convective heat.

Objective & Scope

- This study investigated the radiative heat loading effects from pavements and evaluated the impacts of different cool pavement technologies and management strategies on outdoor human thermal comfort.
- Based on a human body energy balance model and thermal comfort model, Physiological Equivalent Temperature (PET) was selected to evaluate and compare the effects of different pavement strategies on outdoor thermal environment for both summer and winter in three climates (Sacramento and Los Angeles in California and Phoenix in Arizona).
- The pavement strategies evaluated include high-reflectance, evaporation, high-reflectance plus evaporation, and shading along with a baseline for control.
- More pavement strategies can be evaluated using the model developed in this study to examine the effect on human thermal comfort in urban areas with different climates.

Human Thermal Comfort Modeling

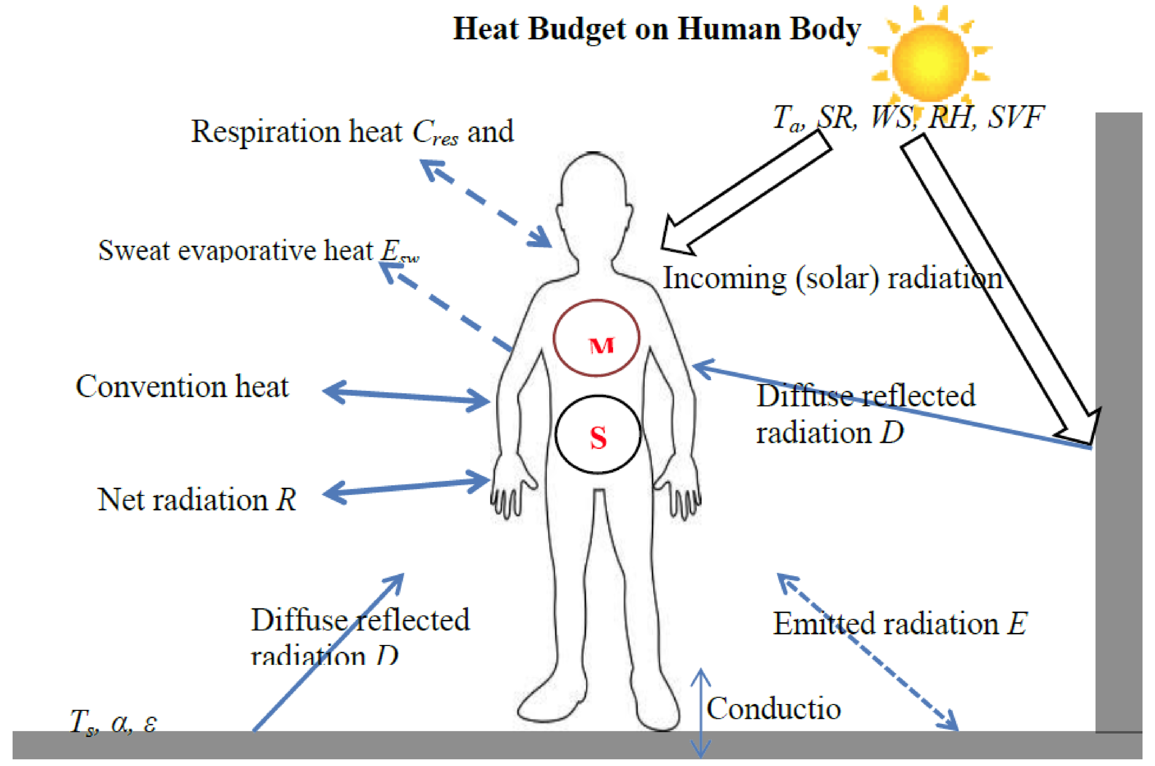
- Physiological Equivalent Temperature (PET)

- The PET is developed by a German research group headed by Peter Hoppe and is recommended as a thermal index by the German Association of Engineers VDI guidelines (German guidelines for urban and regional planners) .
- PET is defined as the equivalent air temperature at which, in a typical indoor setting the heat balance of the human body is maintained with core and skin temperatures equal to those under the actual complex conditions being assessed.

- Mean radiant temperature (MRT)

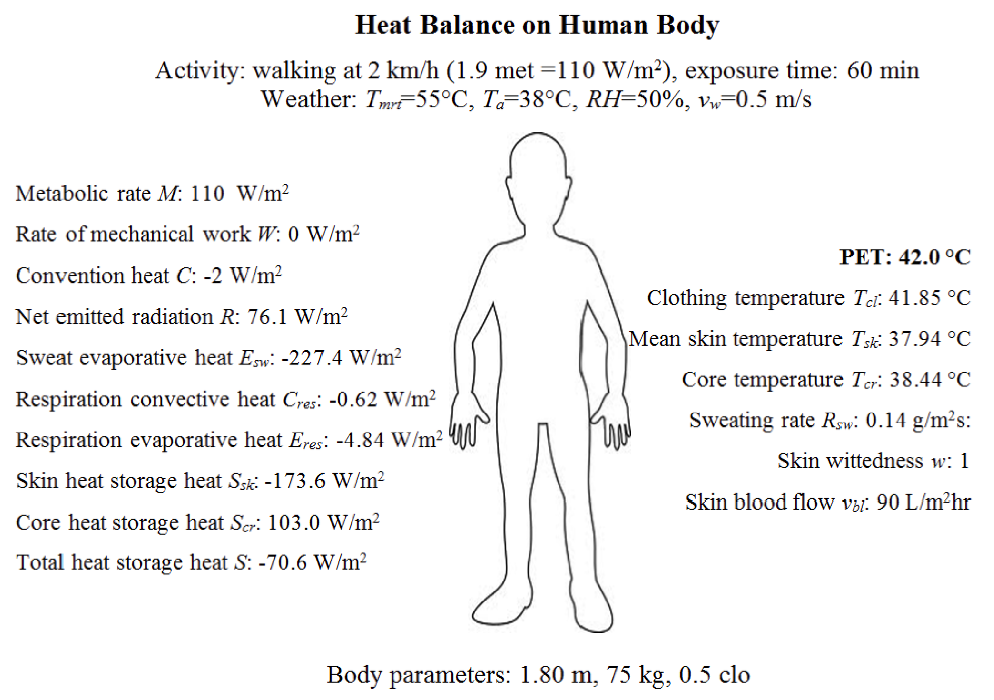
- The MRT is defined as the uniform temperature of an imaginary enclosure (or environment) in which radiant heat transfer from the human body is equal to the radiant heat transfer in the actual non-uniform enclosure (or environment).
- MRT is the most important parameter governing human energy balance, especially on hot sunny days. MRT also has a major influence on thermophysiological comfort indexes such as physiological equivalent temperature (PET) .
- MRT measures the combined net radiant heat loss and gain of human body from the environment.

- Human Body Energy Balance Modeling in Complex Conditions



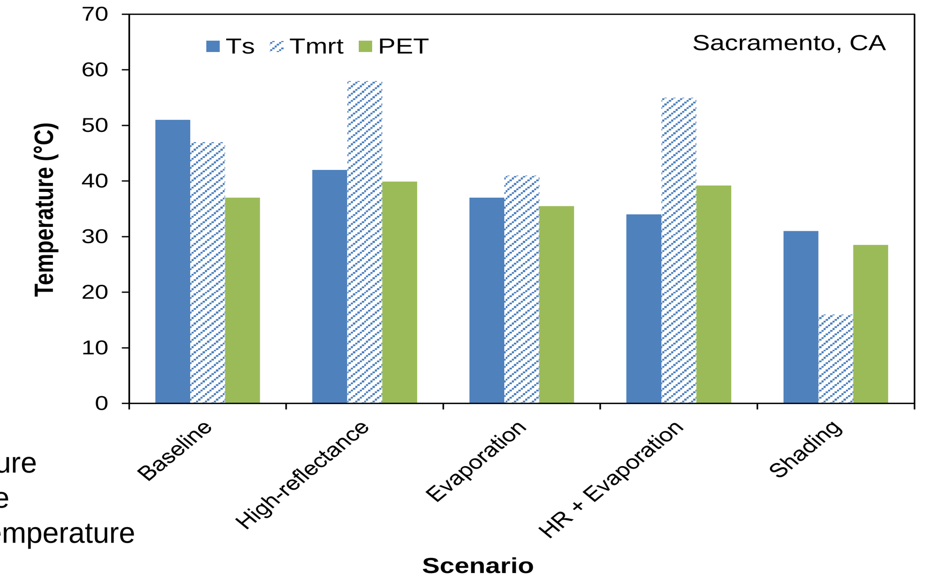
Results

- Demonstration Simulation of PET



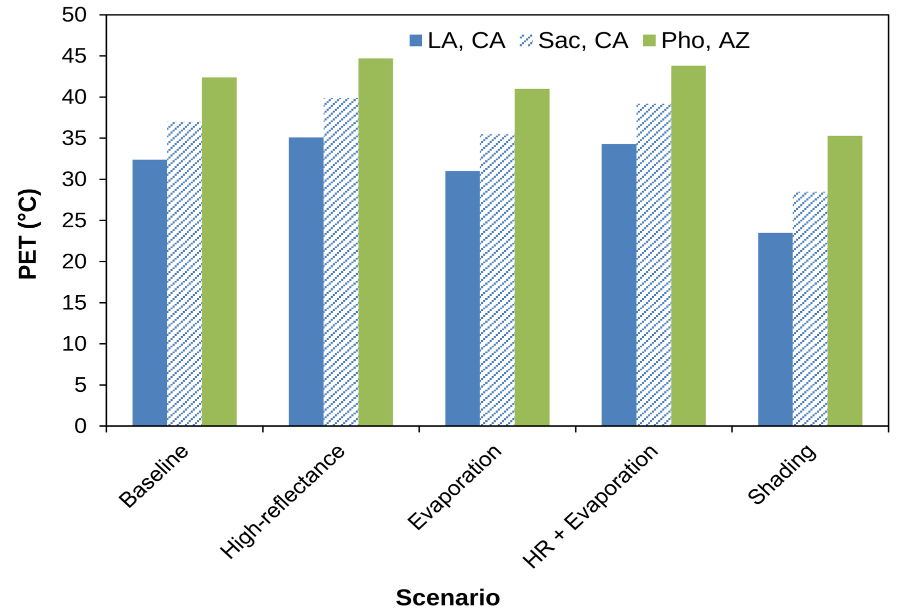
- Impacts on Human Thermal Comfort (summer)

- Example temperatures results for Sacramento



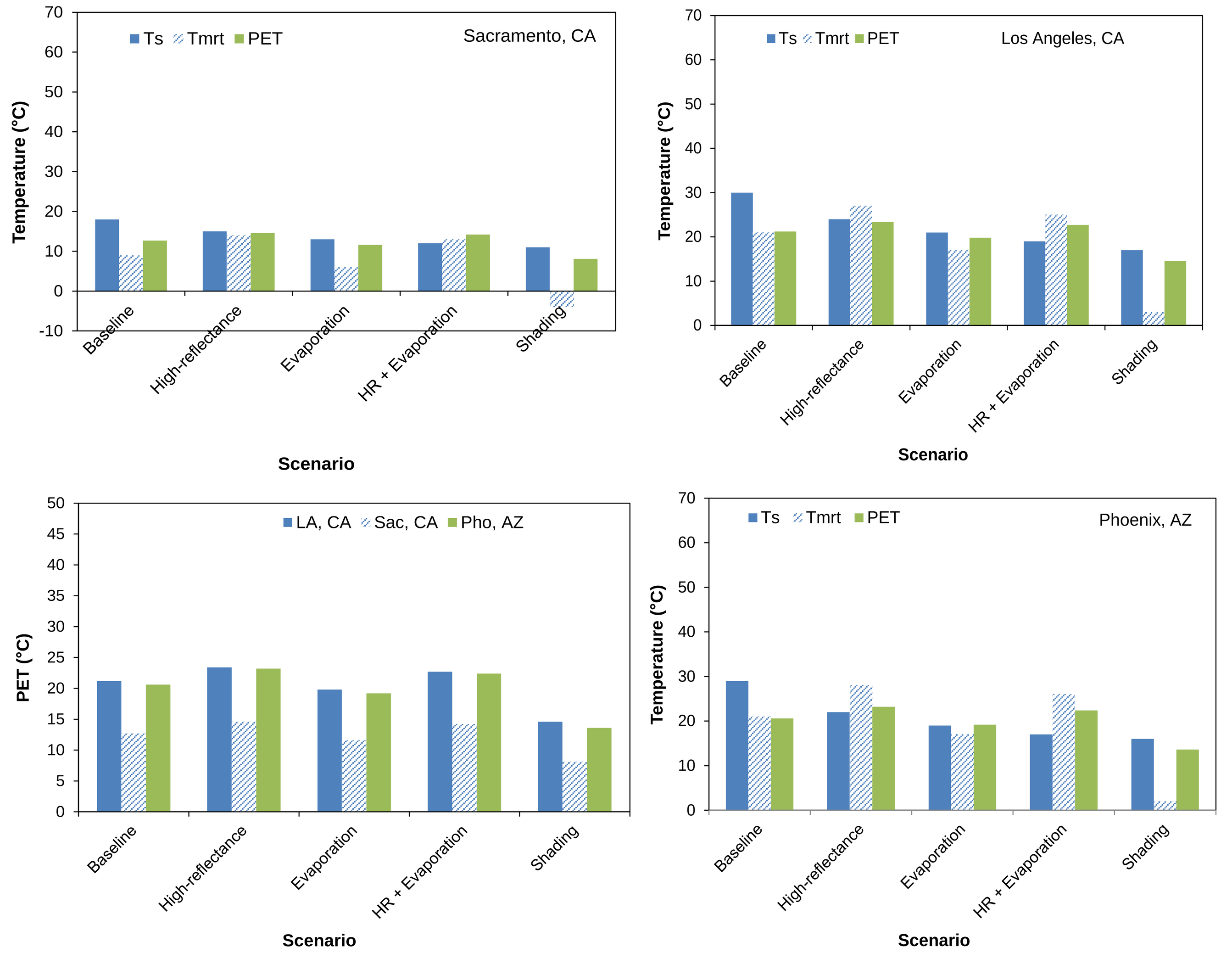
Ts: Pavement Surface Temperature
Tmrt: Mean Radiant Temperature
PET: Physiological Equivalent Temperature

- Comparison of PET for different pavement scenarios



- Impacts on Human Thermal Comfort (winter)

- Temperatures results at three regions and different scenarios



Summary & Conclusions

- Using reflective pavement will reduce pavement surface temperature; however, increasing pavement reflectance will increase Mean Radiant Temperature due to the increased reflected radiation and consequently increase the risk of reducing human thermal comfort during hot periods.
- Enhancing pavement evaporation and/or shading pavement with trees or other canopies are effective strategies to reduce both pavement surface temperature and PET, helping improving human thermal comfort in hot periods.
- For some areas such as Sacramento, California, where it is hot in summer and cold in winter, some cool pavement strategies (e.g. pavement evaporation or shading) used to improve the summer thermal environment might make the cold winter slightly colder.