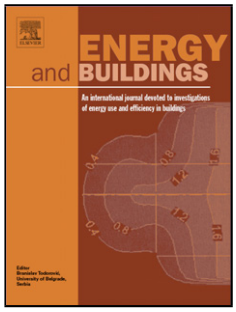

Title: The Thermoheliodome - Air conditioning without conditioning the air using radiant cooling and indirect evaporation

Author: Forrest Meggers Hongshan Guo Eric Teitelbaum Gideon Aschwanden Jake Read Nicholas Houchois Jovan Pantelic Emanuele Calabro

PII: S0378-7788(17)32021-2
DOI: http://dx.doi.org/doi:10.1016/j.enbuild.2017.06.033
Reference: ENB 7696

To appear in: *ENB*

Received date: 1-10-2016
Revised date: 9-5-2017
Accepted date: 12-6-2017

Please cite this article as: Forrest Meggers, Hongshan Guo, Eric Teitelbaum, Gideon Aschwanden, Jake Read, Nicholas Houchois, Jovan Pantelic, Emanuele Calabro, The Thermoheliodome - Air conditioning without conditioning the air using radiant cooling and indirect evaporation, <*![CDATA[Energy & Buildings]]*> (2017), http://dx.doi.org/10.1016/j.enbuild.2017.06.033

The Thermoheliodome - Air conditioning without conditioning the air using radiant cooling and indirect evaporation

Forrest Meggers[a,b,*], Hongshan Guo[a], Eric Teitelbaum[a], Gideon Aschwanden[c], Jake Read[d], Nicholas Houchois[e], Jovan Pantelic[f], Emanuele Calabro[g]

[a] *Princeton University School of Architecture, Princeton, New Jersey, USA*
[b] *Princeton University Andlinger Center for Energy and the Environment, Princeton, New Jersey, USA*
[c] *University of Melbourne, Melbourne School of Design, Australia*
[d] *University of Waterloo, Waterloo Architecture, Canada*
[e] *Columbia University, New York, USA*
[f] *Center for the Built Environment, University of California Berkeley, USA*
[g] *Reddington Group, London, UK*

Abstract

The Thermoheliodome is an experimental pavilion that explores cooling without air conditioning. The two research aims were to explore the use of indirect evaporative cooling and the geometric reflection of radiant cooling. For evaporative cooling we utilize a cooling tower outside of the pavilion to indirectly supply water chilled near the wet-bulb temperature. The radiant cooling system is made up of 55 coaxial chilled pipes each located in the central axis of cones with reflective surfaces that spectrally reflect the surface of the pipes and expand their radiant view factor to the occupants inside the pavilion. The specific geometry was digitally fabricated using an industrial robot and hot-wire foam cutter. The mean radiant temperature (MRT) was shown to be significantly decreased using thermal imaging cameras and with a novel scanning MRT sensor. The radiant cooling delivered from the fluid is maximized by reflection and concentration of heat emitted by occupants on the pipes, while the convective cooling of the air is minimized because only the small pipes are cooled and the reflecting surfaces are not, so the convective heat transfer surface area is small. Under typical indoor conditions the ratio of radiant to convective cooling is slightly greater than one, and for warm daytime conditions it was greater than 10 inside the pavilion. Occupant surveys found that although the air temperature was not modified, they felt that inside the space there is a cooling sensation ($p \leq 0.01$). The day of the survey they felt on average 3 °C cooler.

Keywords: Thermoheliodome, radiant cooling, evaporative cooling, low exergy, digital fabrication

*Corresponding Author fmeggers@princeton.edu