Research Potential related to the Green Deal (2021)

Standardization of testing conditions to assess the performance of passive daytime radiative cooling materials

2020-12-08 Lorenzo Pattelli – INRiM I.pattelli@inrim.it



Passive cooling: a *hot* topic

using the universe as a heat sink



first pioneering works in the early '80s

renewed interest after Stanford's work in 2014

nature

Received 23 April; accepted 22 September 2014.

Passive radiative cooling below ambient air temperature under direct sunlight

Aaswath P. Raman¹, Marc Abou Anoma², Linxiao Zhu³, Eden Rephaeli¹ & Shanhui Fan¹



Passive cooling: a *hot* topic

basically a brand-new renewable energy source

relevant also for:

- passive cooling of photovoltaic panels
- water condensation/harvesting
- non-evaporative cooling
- thermo-electric generation



all these technologies have been demonstrated, many are already commercially available



Passive cooling: what's new under the Sun?



J Mandal et al. *Science* 362.6412 (2018)

Y Peng et al. Nat Sust 1.2 (2018)

L Zhou et al. Nat Sust 2.8 (2019)

D Li et al. Nat Nanotech 1,6 (2020)

a difficult comparison...



W Li et al. Solar Energy 207 (2020)

M Hu et al. *Buildings* 10.12 (2020)

D Zhao, Dongliang et al. Appl Phys Rev 6.2 (2019)

The elephant in the room: *reproducibility*

- materials: broadband/selective emitter, sub/above-ambient cooling?
- structure: reflector/diffuser, emitter/diffuser, emitter/cooled body
- setting: sun shielded, wind shielded, under vacuum?
- environment: sky access, surrounding buildings, waveguided?
- weather: humidity, wind, clouds, visibility, pollution, temperature
- assumptions: different modeling of effective atmospheric emissivity
- **figure of merit**: ΔT (between what?), cooling power
- location: latitude, longitude, instantaneous solar irradiance



(mm)

0.6

0.4

0.2

0.0

0.8

0.4

0.2

ᇤ 0.6 Precipitable Water

(b)

8

25

20

- 15 cm

-3 cm

20

Wavelength (µm)

----6 cm

- T____ = 20°C

Relative Humidity (%

0 78

· 0.86 0.93 The challenge: testing passive radiative coolers under standardized conditions

- define standard test conditions in terms of irradiance (0-1 Sun), wind, humidity, temperature
- demonstrate sub-ambient temperature reduction applying the cooling surface to a large mass (water tank?)
- a liquid nitrogen pool as an indoor heat sink?
- reproduce visibility conditions, transmittance of atmosphere
- durability/aging tests?



