Development of innovative high-vacuum based solutions for the industrial clean energy transition

Daniela De Luca[a,b], Paolo Strazzullo[b,c], Antonio Caldarelli[b,c], Eliana Gaudino[b,c], Marilena Musto[b,c], Emiliano Di Gennaro[a,b], Roberto Russo[b,*]

[a] *Physics Department, University of Napoli "Federico II", Complesso Universitario di Monte Sant'Angelo, Via Cinthia, 21, 80126 Napoli, Italy*
[b] *Institute of Applied Sciences and Intelligent Systems, National Research Council of Italy, via Pietro Castellino 111 80131 Napoli, Italy*
[c] *Industrial Engineering Department, University of Napoli "Federico II", Piazzale Vincenzo Tecchio, 80, 80125 Napoli, Italy*
**roberto.russo@na.isasi.cnr.it*

In Europe about 50% of energy is used for heat and cooling applications [1]. A large fraction of that required for industrial applications (about the 30%) is used to produce heat at low temperatures (below 150 °C) [2], and is mainly produced by the combustion of natural gases. The road to an industrial transition to clean energy requires producing such heat from renewable sources. Evacuated flat panels (EFP) have an extremely high solar energy conversion efficiency and can play a fundamental role in this transition [3]: the high vacuum insulation allows to reduce convective and conductive losses and to increase the overall conversion efficiency achieving unparalleled working temperatures and solar conversion efficiencies [4-6].

We present concepts to lay the foundations for the development of a next-generation of non-concentrated solar collectors such as pure thermal collectors and hybrid photovoltaic-thermal (PVT) solar collector. Such new EFPs will be capable of generating heat throughout the year at medium temperature grades (where the main technological challenges lie) and ensure efficient production of electricity. Thus, these devices are capable of serving industrial-scale applications of multi-energy systems, including heating and cooling systems as well as the generation of hydrogen for efficient energy storage.

The prospect of solar thermal energy is the dominant engine of the new proposed PV-T designs which aim at the full exploitation of the solar spectrum. They are in fact designed to serve energy systems in which thermal energy is or can constitute an important part of the overall energy load on the application side (consumption). In parallel, by smartly and efficiently integrating photovoltaics, the proposed hybrid solar systems will be able to meet local electricity loads and/or to produce hydrogen for energy storage.

References:

[1] IEA Electricity/Heat in World in 2009.

[2] Solar Payback Project, 2017.

[3] A. Mellor *et al.*, «Roadmap for the next-generation of hybrid photovoltaic-thermal solar energy collectors», *Solar Energy*, vol. 174, pagg. 386–398, nov. 2018, doi: 10.1016/j.solener.2018.09.004.

[4] D. De Maio *et al.*, «A Selective Solar Absorber for Unconcentrated Solar Thermal Panels», *Energies*, vol. 14, n. 4, pag. 900, feb. 2021, doi: 10.3390/en14040900.

[5] D. De Maio et al., «Multilayers for efficient thermal energy conversion in high vacuum flat solar thermal panels», Thin Solid Films, vol. 735, pag. 138869, ott. 2021, doi: 10.1016/j.tsf.2021.138869.

[6] D. De Maio et al., « *Solar Selective Coatings for Evacuated Flat Plate Collectors: Optimisation and Efficiency Robustness Analysis" Accepted for publication on Solar Energy Materials and Solar Cells (12 April 2022 article number* SOLMAT_111749)