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Modeling the soiling of glazing materials in arid regions with geographic information systems (GIS)

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Abstract

The deposition of dust and other airborne particles on the glazing of solar collectors (soiling) reduces its transmittance and therefore its efficiency significantly. This effect is particularly relevant in arid regions with high amounts of mineral dust. This study uses Geographic Information Systems (GIS) to model the soiling potentials in Middle East and North Africa (MENA). Various environmental parameters like wind conditions, precipitation and earth's surface conditions are involved in this model. The first result, a dust risk map of the MENA region, implies a significant differentiation of soiling potentials. This study makes a contribution to the development of appropriate indoor durability testing procedures and the identification of the most favorable solar locations.

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1. What is soiling and why is it a problem?

The actual efficiency of solar systems is influenced by various factors. Beside global irradiance and technical characteristics, the local environmental conditions are crucial for the reliability and resulting power output. In this respect, the deposition of airborne particles on the glazing of solar thermal collectors and photovoltaic modules has to be considered as an important aspect [1]. Soiling, as the accumulation of dust and other inorganic and organic particles on surfaces is commonly named, causes a reversible optical loss and reduced transmittance of the glazing. Several empirical studies investigated this phenomenon by correlating the time of exposure or the amount of dust on glazing materials with the measured performance of solar collectors [2,3]. All studies report a reduction in efficiency

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with increasing soiling rates. In some cases efficiency losses of 30 % and more are found [4]. However, extreme events like a nearby construction site can increase this value significantly [5]. Fig. 1 illustrates soiling on a thermal collector over a long period of time without cleaning on Gran Canaria (Spain). Our own initial indoor soiling experiment with one short simulated dust event and different solar glass produced an average transmittance loss of about 10 %.
Thus, soiling is a potential key factor for the economic feasibility of larger solar energy plants in particular [6]. In addition to the accumulation of particles on glazing, longer periods of exposure in critical conditions can also cause an irreversible degradation of components by abrasion.

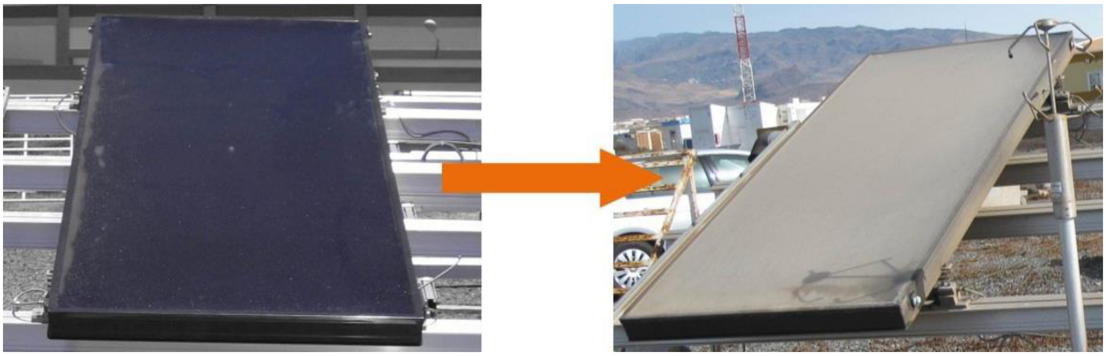

Fig. 1. Example of soiling on a thermal collector on Gran Canaria (Spain).

2. Soiling in arid regions

Arid and semi-arid areas cover a big part of the earth's surface. They are mostly located around the tropics about 23° north and south of the equator (Fig. 2). According to the commonly used Köppen-Geiger climate classification these areas are defined by limited precipitation and high potential evaporation rates. The climatic conditions especially of the hot deserts seem to supply the best requirements for the effective use of solar power. High rates of solar irradiation throughout the year promise huge energy outputs (Fig. 3). But high amounts of available mineral dust and frequent dust events induce heavy soiling and therefore the advantages of this area could be reduced considerably. Special coatings, designed to reduce the accumulation of dust on the glazing, have to be adapted to these particular conditions. Beyond the economic view, the necessary cleaning process consumes serious amounts of water. Considering the deficit of this resource in arid regions, soiling potentially reduces the sustainability of solar power usage. Therefore, a better understanding of the complex soiling process in deserts and, as a result, a dust risk map is needed.

This base study investigates the soiling potentials of glazing materials in the greater region of Middle East and North Africa (MENA) covering the Sahara and the deserts on the Arabian Peninsula and, in the case of Africa, extending the economic definition of this region to the south. It forms the largest coherent arid area in the world and is of considerable interest for future solar power installations on a large scale. In general, the different deserts are characterized by manifold natures. In a first geomorphologic approach we can distinct three basic desert landscapes shaping large parts of the MENA region: sandy deserts with or without dune fields, stony deserts dominated by gravel covering and strongly shaped rocky deserts. They form a diverse mosaic of landscapes with different soiling potentials and mechanisms.