# Accumulation of soil on glass covers of photovoltaic modules in a Nordic climate

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The overall purpose of this study is to investigate how dusts and soil accumulate and affect optical values of glass surfaces used in photovoltaic solar modules, in a Nordic climate. Investments and utilization of electrical solar energy has increased greatly in Europe during the recent years. As from January 2015, Norwegian inhabitants can receive public subsidies for installing solar panels at home. A wide range of research has been conducted to investigate the effect of soiling on photovoltaic modules, but these are mainly focused around the Middle East or other areas with environmental characteristics that differs from a Nordic climate.

The first step in evaluating how dust and soil accumulate on glass was to establish a test-setup at a rooftop of the Institute for Energy Technology (IFE) at Kjeller. The setup consists of both normal glass samples and glass samples coated with an anti-soiling coating (TripleO), with a tilt angle of 37˚. Measurements are conducted every week, from February 17 to April 14, on glass samples exposed to one week of natural soiling.

Initial optical measurements show that the transmittance is lower for the anti-soiling coated glass samples. Results indicate that this glass has some anti-reflection function at higher angles of incidence, likely due to a change in the refractive indexes because of the additional coating.

Results show that approximately 29 % more soil accumulates on the anti-soiling coated glass samples than on the normal glass samples, but both soil densities are strongly dependent on precipitation. Rainfall helps clean the glass samples, but no recorded level of precipitation was high enough to clean the glass samples completely. Soil densities after one week of 36.9 $mg/m^2$

and 49.6 mg/m$^2$, for the normal and anti-soiling coated glass samples respectively, were recorded after periods with much rain. Weeks with no rainfall measured soil densities as high as 112.5 mg/m$^2$ and 128.0 mg/m$^2$ for the normal and anti-soiling coated glass.

Mean weekly optical measurements show that the transmittance reduced from 91.5 % to 90.3 % for the normal glass samples, and from 90.8 % to 89.9 % for the anti-soiling coated glass. The transmittance seems to be most affected at shorter wavelengths. The reduced transmittance for the normal glass samples corresponds to a decrease in efficiency for a standard c-Si solar cell about 0.2 %

An approximately linear connection between the increase in soil density and the reduced transmittance is observed. This gives an expected reduced transmittance of 0.09 % and 0.11 % per 10 mg/m$^2$ for the normal and anti-soiling coated glass samples, respectively.

Soil analyses are performed on the natural soil at Kjeller. Results show that carbon and silicon dominates, which are two common dust elements. Pictures of the glass surfaces indicate that the diameter of the dust particles are in the order of $10^0 < d < 10^1$. This provides reason to believe that Mie scattering is dominating.