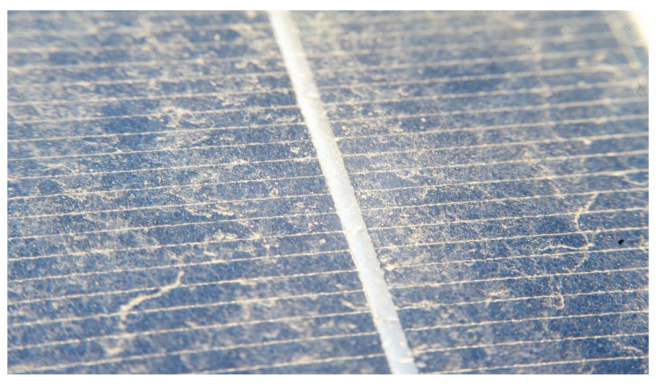
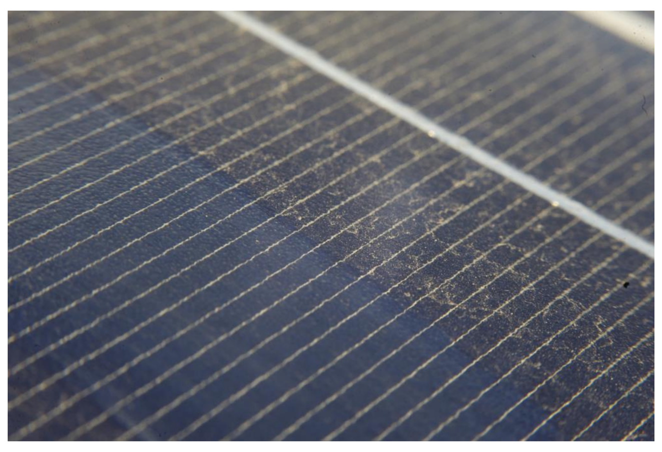
PV modules in Nordic climate: Effects of soiling and snow

A. Pettersen[a)], H. Pedersen[a)], J. K. Selj [a)], and E.S. Marstein[a)]
[a)] Solar Energy Department, Institute for Energy Technology, Norway

BACKGROUND: WHY CARE ABOUT SOILING AND SNOW?





WHAT IS SOILING: The accumulation of naturally occurring particles on solar panels is commonly referred to as soiling. This may include fine sand, soot, pollen, bird droppings, and, in colder climate, snow.

WHY CARE ABOUT SOILING: Soiling on PV modules presents a significant loss of efficiency, due to reduced transmission and also potentially due to shading effects on the system. Results related to PV in cold climate and snow are relatively scarce as PV has only recently gained market shares in such regions.

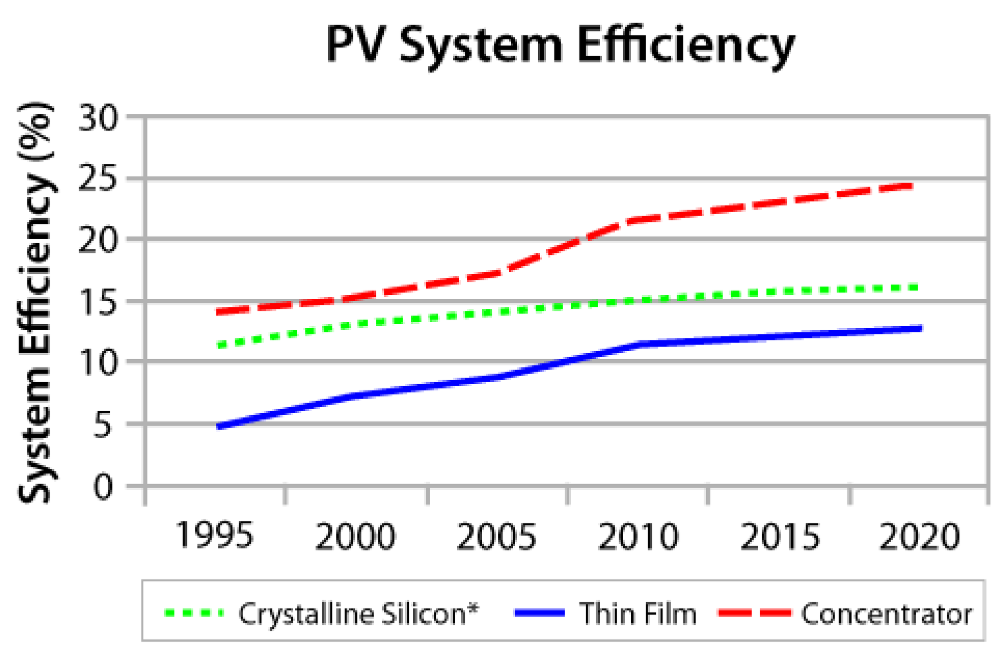


Figure 1. 5 % increase in PV system efficiency over the last 20 years.

EFFECT OF SNOW COVERAGE

Figure 2. The topmost string has one partly snow covered module (highlighted), which results in a reduction of the effect of the whole string by 70%. Production losses due to partly snow covered modules are particularly relevant in spring time in cold climates, when snow is still present while insolation is high.

EFFECT OF PANEL ORIENTATION

Modelling in SPICE shows that the 70% reduction in production is as expected for a vertical panel where the bottom half is covered in snow. It is also clear from the modelling that horizontal orientation is preferable to a vertical orientation of the solar module. Although the same amount of snow covers a larger fraction of the panel when it is in a horizontal position, the power output is actually larger due to the series connection configuration of the cells.

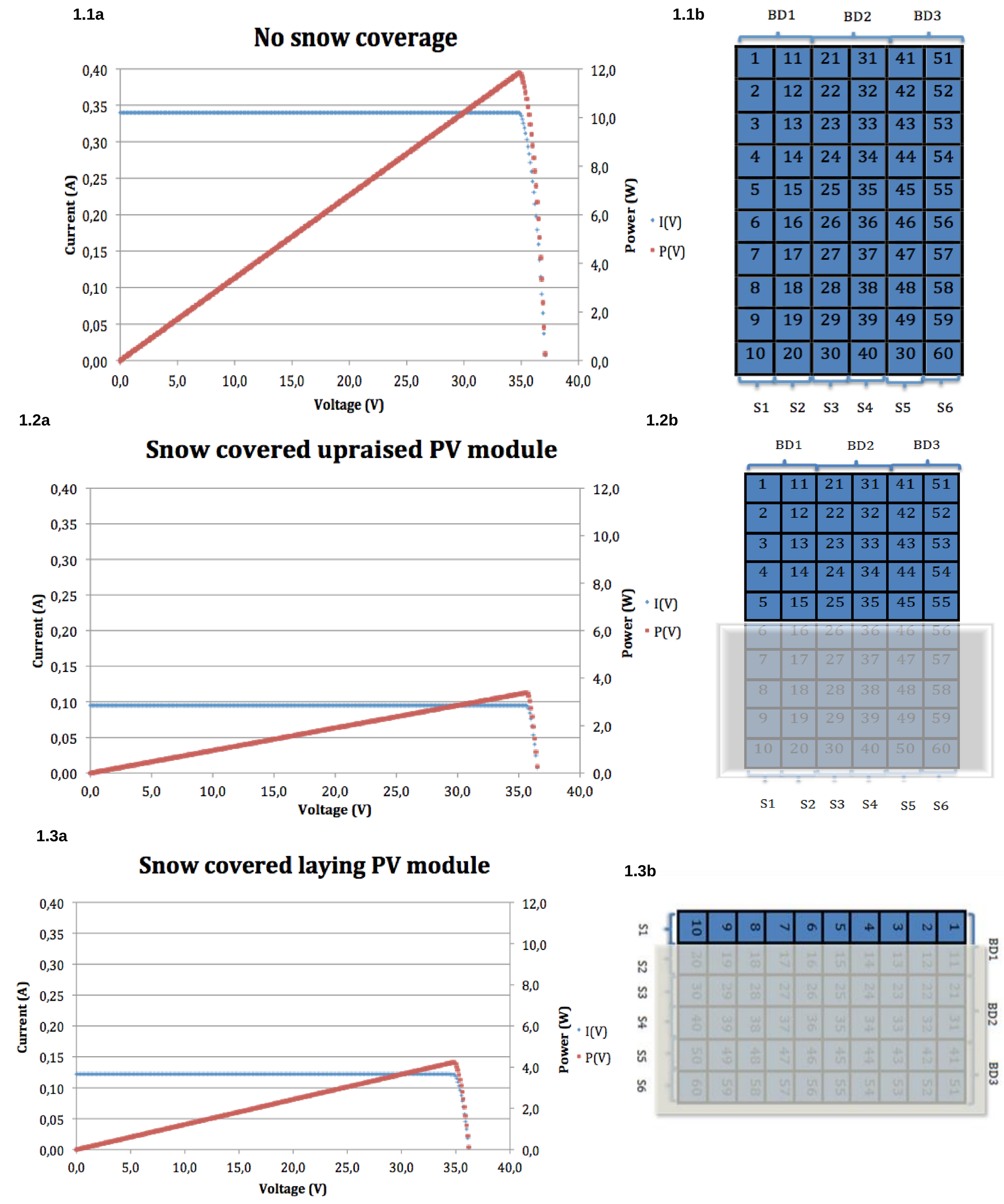


Figure 3: Comparison of simulated power for a REC255PE module with a) no snow cover, b) snow cover on an vertically oriented module, and c) snow cover on a horizontally oriented module. To the left, the simulated IV-characteristics is shown. To the right, the snow coverage of the respective modules are shown.

THE SOILING-PRECIPITATION CORRELATION

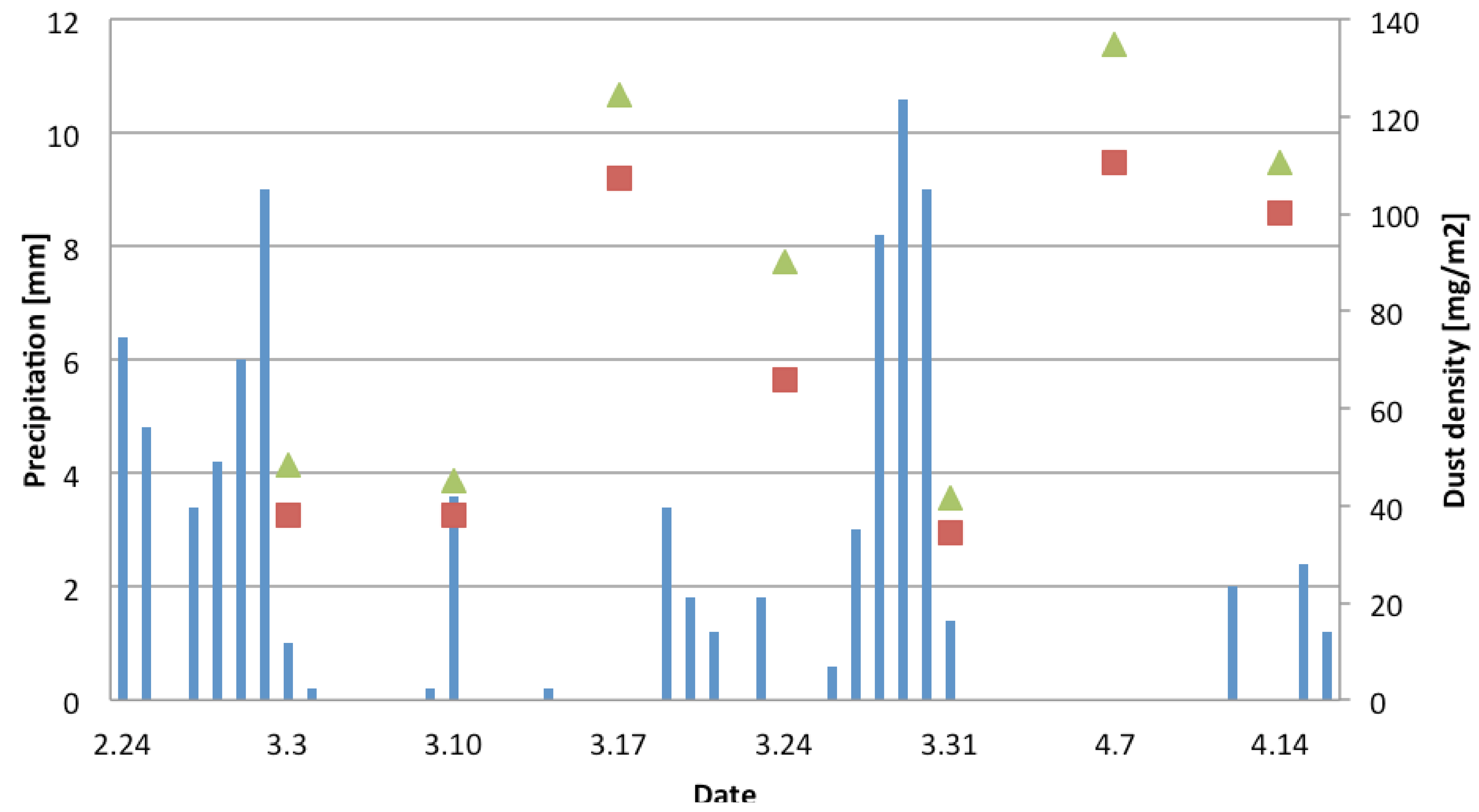


Figure 4. Daily precipitation data from eKlima and measured dust densities accumulated at the normal and anti-soiling coated glass samples. The values for the dust densities are scaled to [mg/m^2]. Note that the rainfalls do not wash the modules perfectly clean.

QUANTIATIVE ASSESSMENT OF DUST IN THE FIELD

A quantitative measurement of dust is performed by drying module glass with a cloth. The glass sample and the cloth were both weighted before and after drying to validate the method. Both dry cleaning and wet cleaning was tested, both giving clean surfaces as determined by visual inspection and transmission measurements. The dry cleaning gave the most consistent and reproducible results. The method is highly relevant for quantitative assessment of dust om modules in the field.

SMALL DUST DENSITIES: LINEAR CORRELATION WITH TRANSMISSION

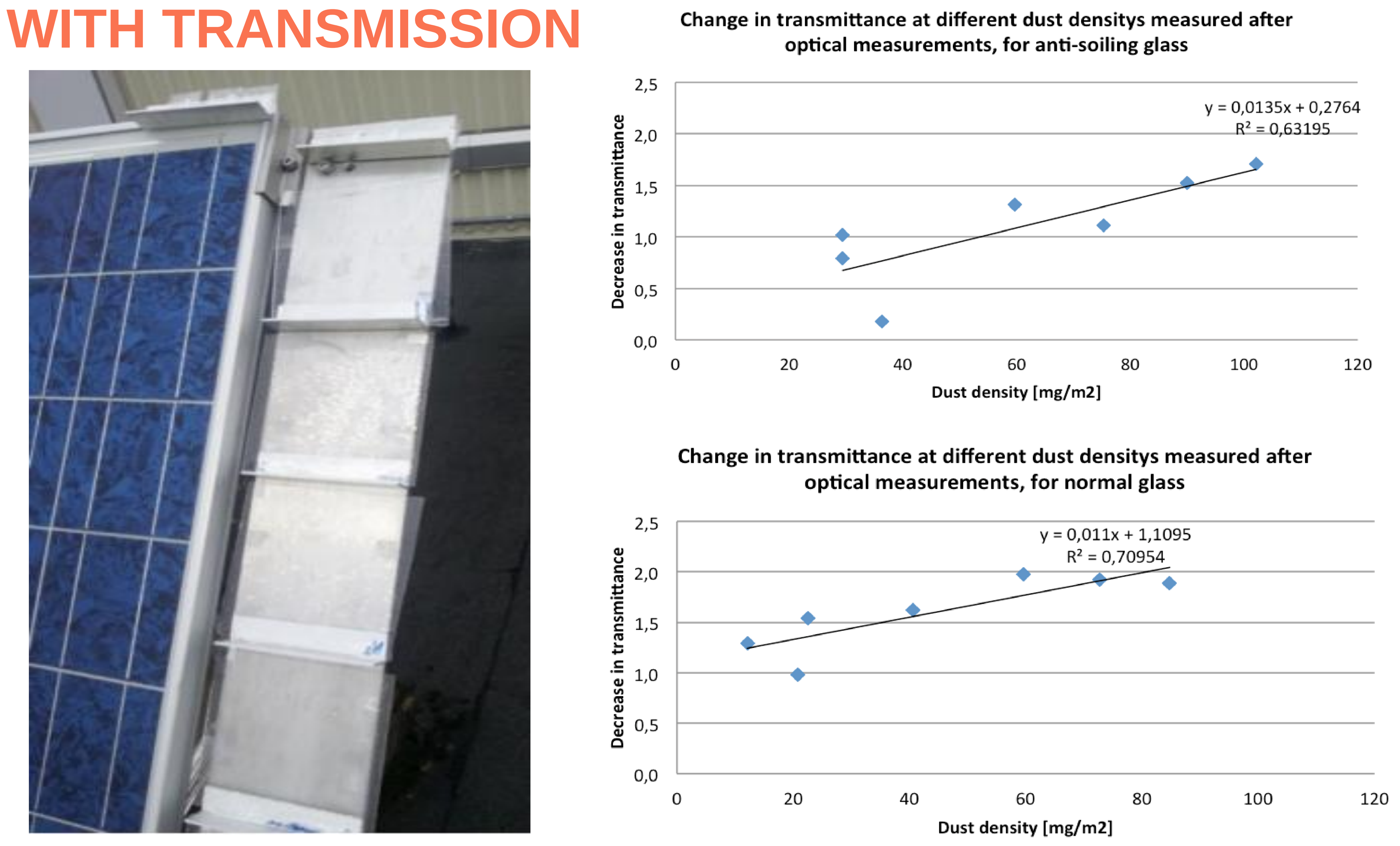


Figure 5. Soiling experiment on small module glass samples with and without antisoiling coating. Soiling levels at Kjeller, Norway were found to give transmission reductions of 1-2%, which are considered to be low. A linear correlation is found between transmission and dust density.