As photovoltaic arrays have increasingly generated more electrical energy in the past decade, they have established themselves as viable sources of renewable energy. At present, the efficiency of solar panels is at best 15-23%, meaning only 15-23% of incident energy in the form of light get converted into electrical energy. There are further performance losses in the life time of a solar array. Loss due to dust accumulation on power generation is becoming increasingly important as the total installed size increases. System owners have to find a way to assess losses in energy production due to various factors. Incidentally, there are large PV installations in dry desert regions where natural rain events are scarce and loss in energy production is encountered due to dust accumulations on the solar panels resulting in soiling losses. Several studies have been made in the past to quantify these losses. Ryan et al. estimated the loss in energy production from the plant performance data. This paper describes a field deployable soiling loss monitoring system that is based on the method adopted by Ryan et al., and is easy to install. It provides a daily averaged soiling loss index (SLI) that can be used to make cleaning decisions. The SLI is calculated from effective irradiance reaching the cells calculated from the short circuit current of the panels. This method is simple and avoids the complication and cost of a full I-V curve tracer. We also present the decision in a cost effective manner.

Several studies have been made in the past to quantify these losses. Ryan et al. \( ^1 \) compared output of a clean panel versus an identical test panel accumulating dust naturally. Several other researchers, \( ^2, ^3 \) estimated the loss in energy production from the performance data. In our study we define Soiling Loss Index (SLI) as loss in the irradiance reaching the solar cells. If all other factors are same then this loss is primarily due to the loss in transmission properties of the glass as a result of the soil accumulation. This loss index is calculated from short circuit current as

\[
\text{SLI} = \frac{1 - \frac{G_{\text{eff,Ref}}}{G_{\text{eff,Test}}}}{1} \times 100\%.
\]

Where, \( G_{\text{eff,Ref}} \) and \( G_{\text{eff,Test}} \) are the effective irradiances of a clean reference panel and a dirty test panel, and is defined as:

\[
G_{\text{eff}} = \frac{1 - \frac{I_{SC}}{I_{SC,STC}}}{1} \times 100\%.
\]

Where, \( I_{SC} \) is the short circuit current at STC

\( T \) : temperature of the modules and it takes some time to recover from this temperature. The soiling loss index (SLI) uses the effective irradiances of a clean reference panel and a dirty test panel, and is defined as:

\[
\text{SLI} = \frac{1 - \frac{G_{\text{eff,Ref}}}{G_{\text{eff,Test}}}}{1} \times 100\%.
\]

Where, \( G_{\text{eff,Ref}} \) is the effective irradiance calculated from the clean reference panel and \( G_{\text{eff,Test}} \) is the same quantity calculated from the test panel.

### EXPERIMENTAL PROCEDURE

Two identical full size PV panels are mounted side by side. The short circuit current is measured on both panels with a precision current sensing shunt. Back of-module temperatures are also measured using a thermistor. Measurements are performed during sunset and sunrise. The two modules are short-circuited using a solid state relay for about 5 seconds every 30 seconds. The short-circuit current is measured using a current shunt. Back of-module temperatures on both modules are also monitored.

An effective irradiance reaching the cells is calculated in accordance with the IEC 60904, according to the equation above. An initial offset between the two panels is estimated in the beginning and periodically afterwards each time both panels are cleaned. This offset is applied to the subsequent measurements.

In accordance with IEC 60904, we limit the SLI calculation within one hour of local solar noon and for effective irradiance > 800 W/m². This avoids any differences in soiling loss due to zenith angle of sun, module current dependence on irradiance level or spectral differences. We also use a filtering scheme to filter out any unstable data due to clouds etc. The stability criteria adopted is based on the recommendations made in IEC-60904.

### RESULTS

For more information on the CRSI2 Soiling Index Datalogger, please visit: https://www.campbellsci.com/crsi2