Mastering the Sand in the Arabian Desert with DustIQ and NOMADD's Cleaning Robots

Challenge

Soiling significantly impacts the efficiency of PV plants. Energy output losses can amount to even 60% on windy days. Manual cleaning of PV panels in desert regions is inappropriate due to harsh conditions and the lack of desalinated water.

Solution

Automated, robust cleaning robots take the sand from the panels regularly. Human engagement is not needed. Our maintenance-free soiling monitoring system DustIQ assures proper cleaning operation by reliably measuring the soiling ratio in real-time.

Benefits

Only clean PV panels can tap the full potential of solar energy. With automated cleaning, PV plants can operate by efficiently handling costs and water. Integrated soiling monitoring systems help reduce human interaction to a minimum.

"NOMADD is very impressed with the potential applications of the DustIQ. The build quality and rugged ergonomic design are top notch. We are already suggesting the use of DustIQ to our clients and see a big future for this device."

Georg Eitelhuber | CEO | NOMADD Desert Solar Solutions

Meteorology Division of OTT HydroMet

Case Study

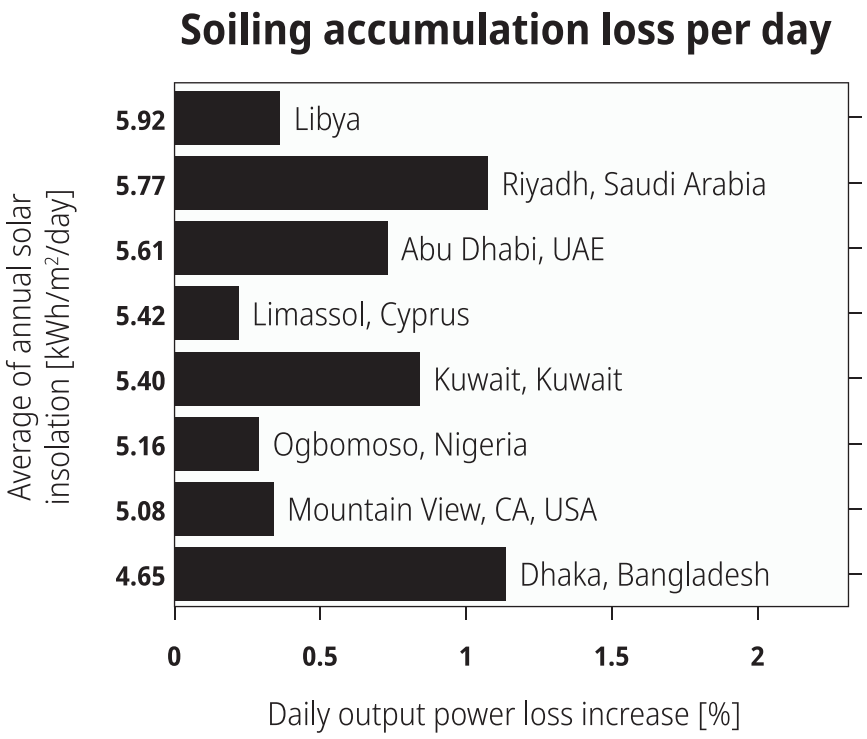
NOMADD Desert Solar Solutions was founded in 2012 at the King Abdullah University of Science & Technology, (KAUST) near Jeddah, Saudi Arabia. NOMADD has developed a range of unique cleaning robots for PV panels in desert locations.

These robots have been developed and tested for over four years in harsh Saudi Arabian West Coastal conditions. This gives the NOMADD robots an unparalleled track record of longevity and effectiveness in high temperature, high humidity, salty dusty conditions. Over the last three years, NOMADD robots have been deployed commercially across the region. Sites include remote wellheads, rooftops, fixed tilt, east-west and tracker array projects. The name NOMADD is an acronym relating to the nomadic tribes and their ability to survive even under harshest desert conditions. It stands for **NO** Water **M**echanical **A**utomated **D**usting **D**evice.

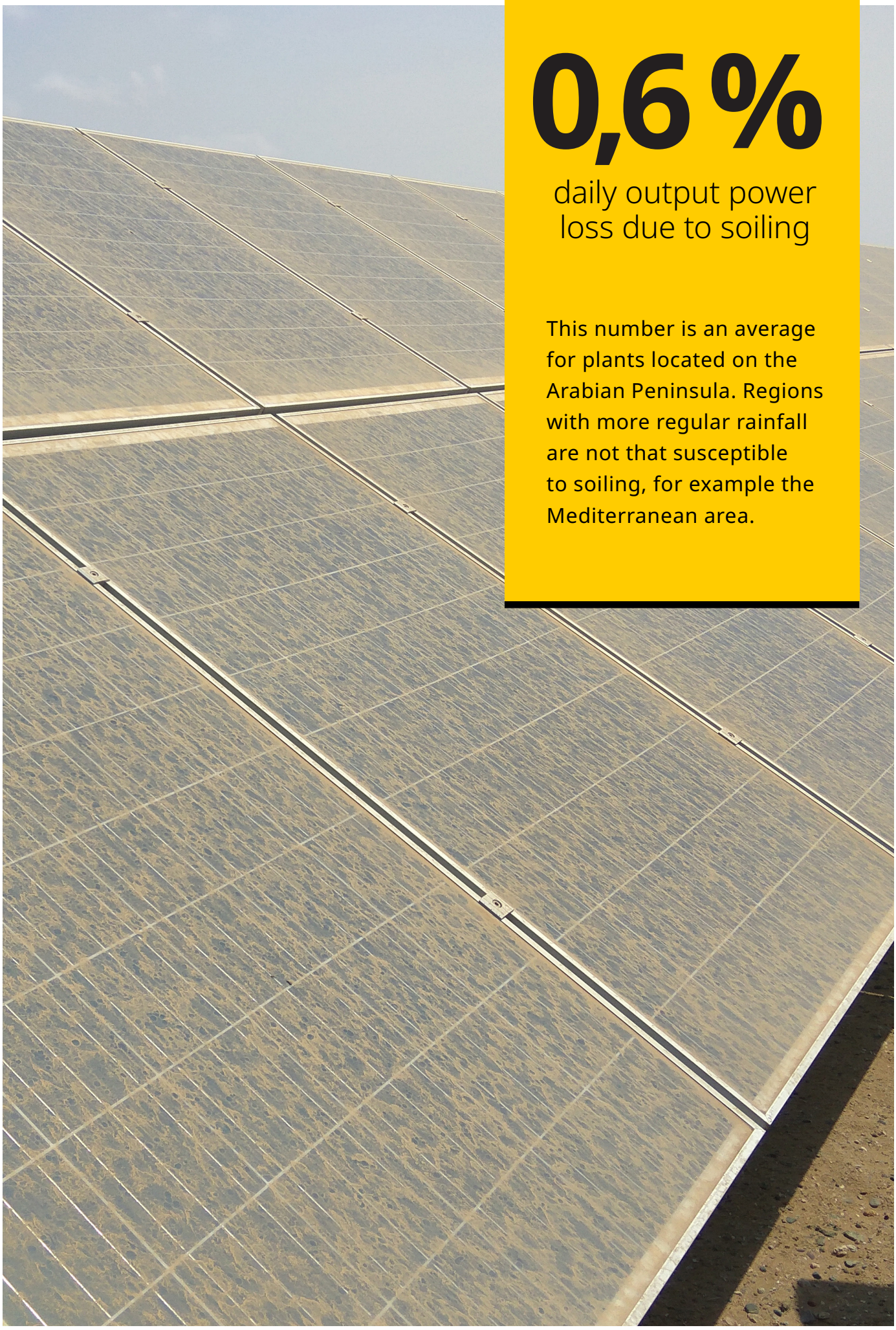
Deserts hold great promise for solar energy plants – but also present unique challenges.

Saudi Arabia is investing strongly in renewable energy sources, especially in solar power plants. With around 350 days of clear skies a year, the deserts of the Arabian Peninsula could become a Mecca for solar power generation.

Dust poses one of the greatest challenges that must be overcome. The wind raises dust and sand on a daily basis, covering the PV modules with a lightproof blanket. This reduces the energy output of the whole plant. In average, locations on the Arabian Peninsula are experiencing daily output losses of 0.6 % caused by soiling. In cases of violent sandstorms, losses can grow to a reported 60 % at a time.



Soiling loss accumulation per day for various locations with average annual solar insolation given (recreated from A. Sayyah, M. Horenstein, and M. Mazumder, 'Yield loss of photovoltaic panels caused by depositions', Solar Energy 107, 2014)



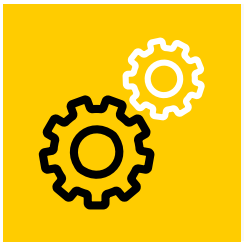
0,6 %

daily output power loss due to soiling

This number is an average for plants located on the Arabian Peninsula. Regions with more regular rainfall are not that susceptible to soiling, for example the Mediterranean area.

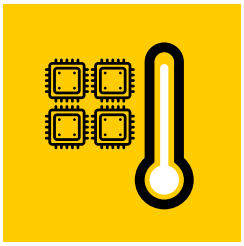
NOMADD Cleaning Systems

Thanks to several patented mechanisms and processes, NOMADD robots are unbeatable at providing dust control solutions at any scale. Several key advantages and features can be noted:



SIMPLE, RUGGED MECHANICAL CONSTRUCTION

All anodized aluminium and marine-grade stainless steel components, with no exposed gears, pulleys, or cables.



RUGGED, HI-TEMPERATURE ELECTRONICS

IP-65 enclosures and cables, LiPo hi-temp battery.

LIGHTWEIGHT

Under 35kg total weight at 4 m span.

CLEANING BENEFITS THROUGH ANGLE

Rooftop and low angle arrays need less passes.

AUTOMATED OPERATION

Sophisticated, easy-to-use control and monitoring, cloud-based.

WATER-FREE PRINCIPLE

Accurate cleaning without wasting valuable water.

Proven Performance

NOMADD has partnered with OTT Hydromet to evaluate product cleaning performance in real desert conditions.

The test design comprised three setups consisting of a PV panel and a DustIQ sensor

The experiments took place at a test field at the King Abdullah University of Science and Technology (KAUST) in Thuwal, Saudi Arabia.

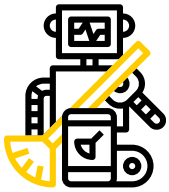
The university's test field has a peak power capacity of 100 kW. Thuwal and the KAUST campus are near the Red Sea, about 90 kilometers north of Jeddah. The ground is covered with sand and dust, swept by regular strong winds from the coast. Ideal conditions for testing a device intended to operate in humid, dusty regions like the Arabian desert.

Three setups have been installed. Each consists of a photovoltaic module of which the short circuit current is monitored combined with a DustIQ mounted on the side. The three setups were chosen to monitor three cases:

- manual cleaning
- unattended robot cleaning
- no cleaning

Since the setups have been installed close to each other the three different scenarios were tested with a minimal spatial distribution. The soiling ratio was calculated according to IEC 61724-1.

Manually cleaned PV panel

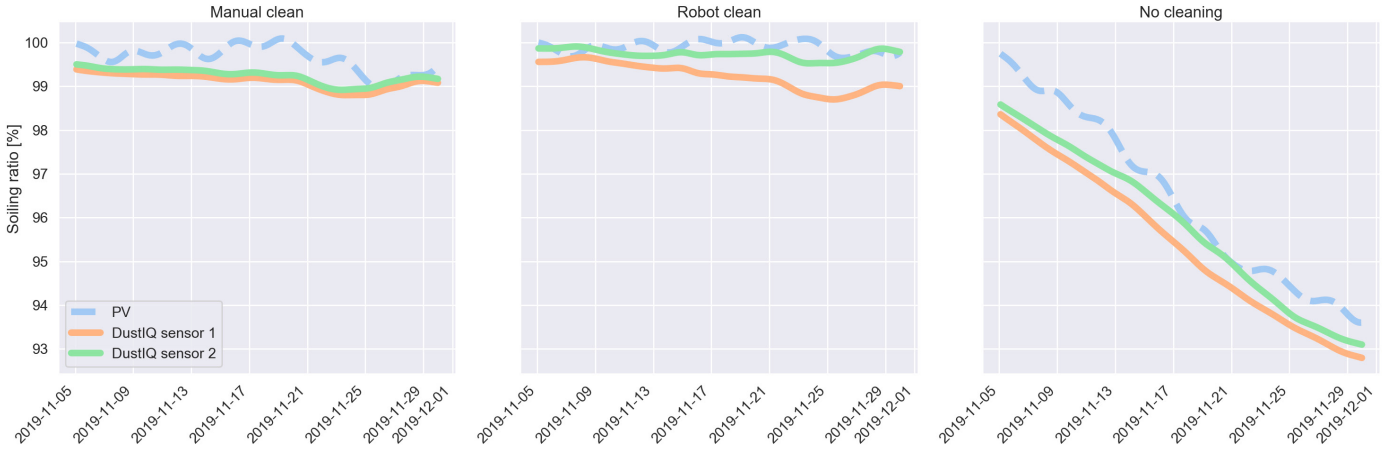


Robot cleaned PV panel

Soiled panel

The results

Measurements have been taken over one month from November to December 2019. The data month was acquired and processed to calculate the soiling ratio of the PV modules and is shown with the DustIQ reading below.



There is no distinction to be made between the manual and the robot cleaning. A clear distinction is made when these cases are compared to the not cleaned setup. This not cleaned setup has a soiling loss of ~6% in a one-month period.

Conclusion

The difference between the soiling ratios measured by the DustIQ and the PV modules is shown to be less than 1%, confirming the expected DustIQ accuracy.

Comparing the DustIQ and PV module cleaned by the robot with the DustIQ and PV module cleaned manually a difference <1% in soiling ratio is observed. This shows that the robot cleaning is efficient and that the DustIQ can be installed in an array without the need for special cleaning. This confirms the easy soiling ratio monitoring that is expected for a stand-alone, maintenance-free, and easy to integrate dust sensor.

	DustIQ sensor 1	DustIQ sensor 2	PV
No cleaning	1.7 %	1.7 %	1.8 %

Table 1: Average weekly soiling increase for the different no cleaning setup

The weekly increase in soiling loss shown in table 1 shows that the DustIQ is measuring a soiling loss increase comparable to the adjacent PV module.

For the setups that are cleaned the soiling fluctuates between nearly zero and 1%. Right on the edge of the DustIQ and PV panel accuracy. The average soiling over the whole month is calculated.

	DustIQ sensor 1	DustIQ sensor 2	PV
Robot cleaning	0.8 %	0.6 %	0.2 %
Manual cleaning	0.6 %	0.6 %	0.3 %

Table 2: Average monthly soiling loss of the cleaned test setups

The difference between manual cleaning and robot cleaning is small and mainly present on the bottom sensor of the robot cleaned test setup. Once the COVID-19 restrictions have been lifted, local research will be done on the potential reasons for this small difference.

Note: Due to the relatively low soiling rate the numbers for the cleaned test setups are susceptible to rounding and inherent uncertainty influences.

Technologies used

DustIQ Soiling Monitoring System

Know when and where to clean

Optical soiling sensor to optimize the yield of your PV plant. Maintenance-free operation after simple integration into the plant management software.

NOMADD Robotic Cleaning Solution

Waterless and laborless

Waterless, laborless and fully automated desert ready solution. Remotely controlled and monitored. No power transmissions, cables, gears and pulleys.

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Meteorology Division of OTT HydroMet