

# **Solar Energy Insights**

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**One of the first with the new  
DustIQ soiling monitoring system, Nor-Cal**

**Ideal Class A monitoring match,  
SMP10 and CVF4 ventilation unit**

**A GreenPowered partnership**

**Jambhekar Automation Solutions  
use Lufft and Kipp & Zonen**

**Easily check Kipp & Zonen  
pyranometers on site**

**A new combination for  
entry-level PV weather monitoring**

**Bifacial PV study in Northern Chile  
using multiple pyranometers**

**Kipp & Zonen albedometers  
contribute to a new albedo model**

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If you have an application of one of our products or want to share your experiences with OTT HydroMet applications and contribute to our Insights' next issues, please email the editor: [kelly.dalu@otthydromet.com](mailto:kelly.dalu@otthydromet.com)

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May 2019 | OTT HydroMet

# Welcome to the first issue of OTT HydroMet Insights

OTT HydroMet delivers valuable insights for experts in a wide range of applications. Proudly formed from six strong brands, the OTT HydroMet Group offers the combined strength and expertise of leaders in the fields of water quality and quantity, weather and climate, solar radiation and renewable energy, agro-meteorology and telemetry, and more; with over 500 years of combined experience in environmental measurements.

The weather, climate and environment have a big impact on the planet and our lives, and it is all driven by the energy from the sun. Obviously, the solar radiation reaching the ground is the key factor in determining the output of a solar energy plant, and this is heavily influenced by environmental and weather parameters.

Two of our brands, Kipp & Zonen and Lufft, have extensive knowledge and expertise in providing measurement solutions for these parameters that is ideally matched to applications in the renewable energy market. Kipp & Zonen is known as the leader for solar irradiance measurement in meteorology, climate studies and solar energy. Lufft was the first manufacturer of all-in-one weather stations that can measure all the parameters in a single compact housing.

Combining Lufft weather stations with Kipp & Zonen's pyranometers and the new DustIQ soiling monitoring system, we have a great set-up to measure exactly what is influencing your solar power project. All the data can be sent by Modbus® directly to your SCADA system for real-time plant performance monitoring.

Whether it is for energy resource mapping and solar prospecting, aiding investment decisions, optimizing yield, managing assets, scheduling maintenance or forecasting the power output; we offer the instruments you need.

The customer and application stories in this first issue of OTT HydroMet Insights will show you some of the many possibilities and configurations that we can provide.

If you have a question or want to know more, please contact us through [www.otthydromet.com](http://www.otthydromet.com).

# DustIQ update

Our novel soiling monitoring system, DustIQ, is well on its way to become the breakthrough development that we envisioned. It is the only system to continuously measure soiling on PV panels day and night, and the optical technology doesn't need maintenance. Nothing at all. No keeping one panel clean and leaving one to become dirty. You simply add it to an array of panels and have it cleaned whenever you clean the array.

## First feedback and reports published

DustIQ has been installed by many institutes and PV projects around the world. Many customers have now finished initial tests and have added it to their plant performance systems. Nor-Cal Controls explains their laboratory and field testing experiences in California and how they integrated DustIQ into plant monitoring systems; on pages 4 and 5.

We are now getting feed-back and reports from the early adopters of DustIQ and we have gathered this information on a new webpage: [www.otthydromet.com/kippzonen/DustIQ](http://www.otthydromet.com/kippzonen/DustIQ)

On this page we will continue to publish news, whitepapers and reports. For example, you can now find the detailed test report made by Sungrow China as a download at the bottom of the page.

Don't forget to subscribe to the DustIQ updates while you visit the page to keep up to date with the latest information.



# Nor-Cal, one of the first with the new DustIQ soiling monitoring system

Nor-Cal Controls ES, Inc. of El Dorado Hills, California is a Control and Automation Systems Integrator, providing open architecture DAS and SCADA solutions to the solar PV sector, they have extensive experience in integrating weather sensors and pyranometers into PV plants around the country.

Nor-Cal was one of the first to install the new DustIQ soiling monitoring system in the USA. As part of the Midway III project 20 MW PV plant in Calipatria, California they installed 3 DustIQs at different locations across the site. Alongside each DustIQ system the incoming solar irradiance is measured using a ventilated Kipp & Zonen pyranometer and third-party reference silicon cell.

Before the installation in Calipatria, Dattatreya Poosarla, Automation Engineer at Nor-Cal Controls, tested one of the first models of DustIQ in a lab environment. We recently interviewed Datta to ask about his experiences and feedback:

**Q1: Please tell us more about Nor-Cal Controls and your involvement in working with DustIQ.**

A1: Nor-Cal provides control solutions to renewable energy power plants that include consulting, engineering and training services. We develop utility-scale SCADA (Supervisory Control and Data Acquisition) systems to meet any PPA, Utility and Owner requirements and to store data on the local historian for report generation and database queries.

Apart from this, we also offer real time DAS (Data Acquisition Systems) for plant monitoring and alarms at smaller solar plants. Additionally, Nor-Cal engineers custom design, builds and deploys Tahoe MET Stations that combine functionality, reliability and simplicity with existing technology applicable to multiple SCADA systems.

I'm an automation engineer designing solutions for communication between RTUs in the field and a SCADA system, configuring the SCADA and PLC systems and implementing the automation and control solutions for utility-scale solar power plants.

My responsibilities also include custom design of the MET stations, which is where working on DustIQ came into the picture. Custom designs such as the addition of the DustIQ soiling sensor come alive in Nor-Cal's UL panel shop where each individually engineered solution is fabricated, tested and shipped to the end user.



One of 3 measurement stations at Midway III

**Q2: You were one of the first to work with DustIQ, was this mostly in a laboratory?**

A2: I've had the opportunity to work on the very first DustIQ sensors. The initial version was setup outdoors and served as a test bed for data evaluation and validation.

It was quite amazing to come across a device that accurately uses reflected light intensity to measure amount of soiling. After initial testing and configuration in lab environment I used an artificial approach to see the effects of different colours of dust. I used white, yellow, green, brown and black coloured papers. While white reflected more light from the sensor's LED back to the detector and showed higher soiling, black absorbed more light from the LED.

Color of paper	Soiling Ratio 1		Soiling Ratio 2	
	Covered/dusted	Open/clean	Covered/dusted	Open/clean
White	412	1005	480	1000
Yellow	563	1005	585	1000
Brown	929	1007	925	1000
Green	972	1007	952	1000
Black	990	1007	986	1000

The test shows that the greater the reflectivity of the dust the greater the soiling ratio

The above data proved the fact that the sensor can be recalibrated to measure the exact amount of soiling for different coloured local dust conditions.

**Q3: Did you encounter any problems with the installation of DustIQ? And, when performed, can you give us feedback on the local dust calibration?**

A3: The physical installation of the DustIQ was very straight-forward. The manual guided us throughout the quick installation steps. It is good to mention that single-side mounting (such as a horizontal installation on top of an array of panels, or on the edge of a row) is not favourable because the wind load might cause problems. It is recommended to mount with extra support if there is no possibility of mounting it in between two framed modules.

The direct relationship of the DustIQ soiling ratio to the power loss is brought close to 1:1 when the DustIQ is calibrated with a local dust profile. We wanted to get experience with the local calibration, so we artificially dusted the surface of the DustIQ. The steps were easy, but you do have to carefully keep track of the steps and the blinking LED lights that indicate the different stages of the calibration. Make sure to take the final step and save the calibration so that it appears in the software.

**Q4: How likely is it that you would recommend the DustIQ to colleagues in the industry? On a scale of 1 to 10.**

A4: I would definitely recommend it. Other soiling stations within the industry have several moving parts. It's a big advantage that DustIQ doesn't have that. A big advantage of the sensors is that you could use open Modbus® protocol to read the data. This makes it easier to use and, moreover, it has its own software interface that can be used to change the device parameter settings as required.

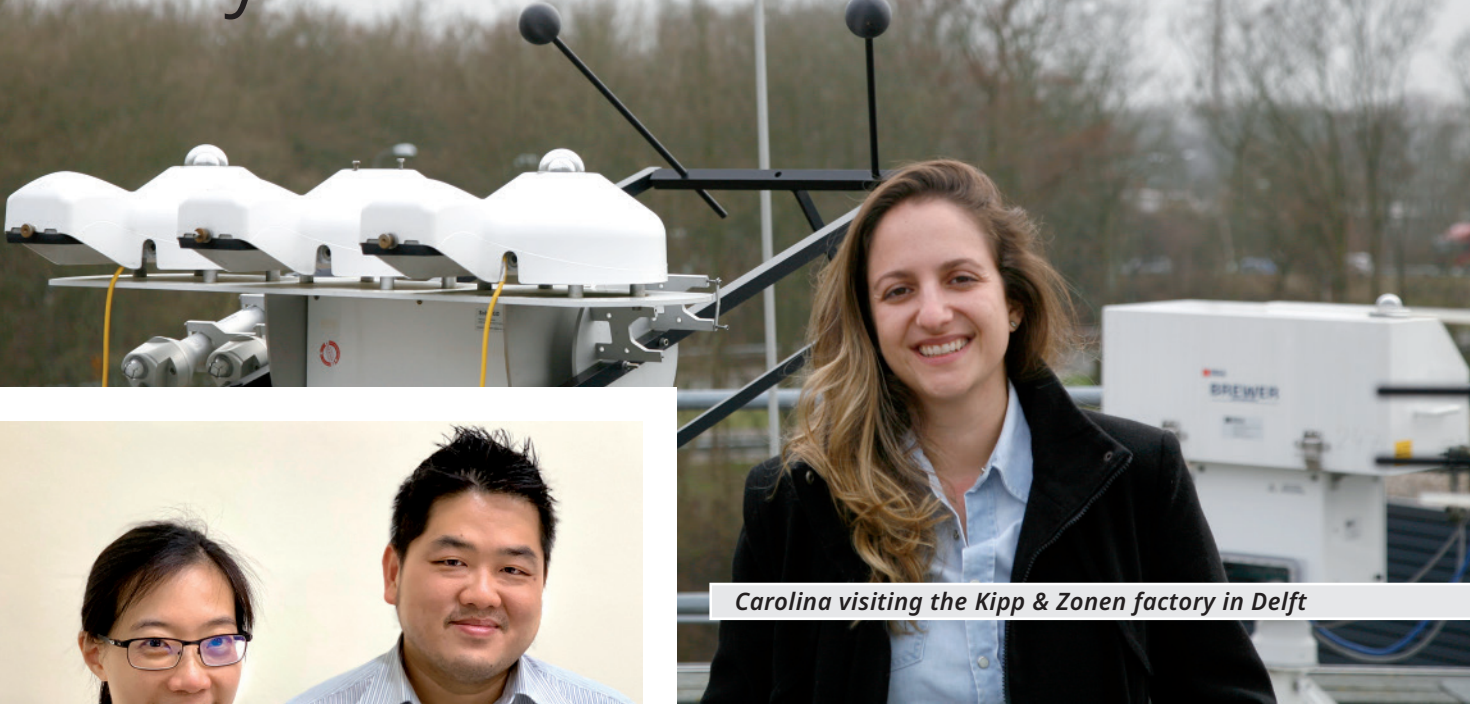
**Q5: Do you expect DustIQ to become part of your standard MET Station?**

A5: We design our MET stations based on clients needs and specializations. DustIQ became a sensors highly recommended by our team. Since initial development and implementation, Nor-Cal has provided numerous sensors to various clients. We will continue to recommend and supply the instrument for our clients.

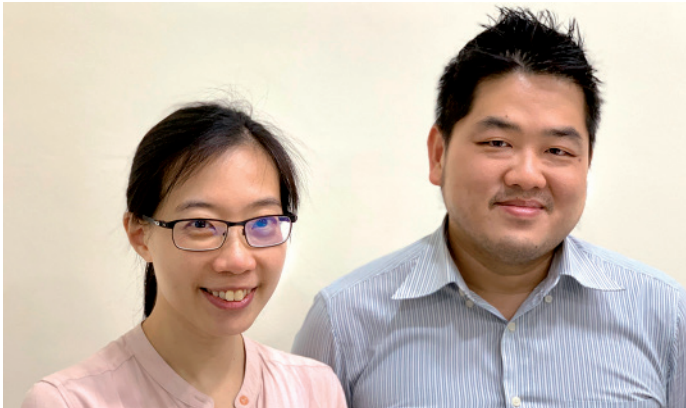
<https://norcalcontrols.net/solutions/met-stations/>



# New members of the global OTT HydroMet sales team



*Carolina visiting the Kipp & Zonen factory in Delft*



*Hsiao Chi Chua and Tang Hwee Min*

Solar energy is a growing industry globally, in some regions such as Europe it's stabilizing but in other areas it is growing at increasing speed where they have started to accelerate solar project developments. In these strategic areas we are expanding our sales, technical and support staff for both solar energy and meteorological customers.

Meet some new members of the OTT HydroMet sales team!

## ***Carolina Minozzi, Business Development Manager Brazil***

"I'm Carolina, the new Kipp & Zonen and Lufft BDM in Brazil. My main goal is to develop the local market, bringing new clients and also finding new distributors for areas that we are not supporting now.

I'm new in the group and really excited with this work, especially with the big growth of the solar energy industry in Brazil. With good numbers in recent years and big plans for 2019, to grow solar farms by more than 20%.

We have a big challenge with national companies, but we have strong brands that are known for quality to support us here. That's why I'm really happy with this opportunity and excited to grow with the solar market in Brazil!"

## ***Hsiao Chi Chua, Sales Support Administrator at OTT HydroMet Pte. Ltd. in Singapore***

"It is exciting joining the big family of OTT HydroMet. As a member of the OTT Met APAC team based in Singapore, my job focus is mainly to ensure that quotations are generated on time for the customers, orders from customers are

processed promptly and also to support the sales and marketing activities and general operations in achieving the organisation's objective.

As the APAC region enjoys high volumes of sunshine through the year, there is a growing demand for the use of solar energy for power generation. Many governments are now showing their support and have focused more attention on the use of renewable energy and in climate research. This region is thus a fast-growing market for OTT Met's meteorological sensors.

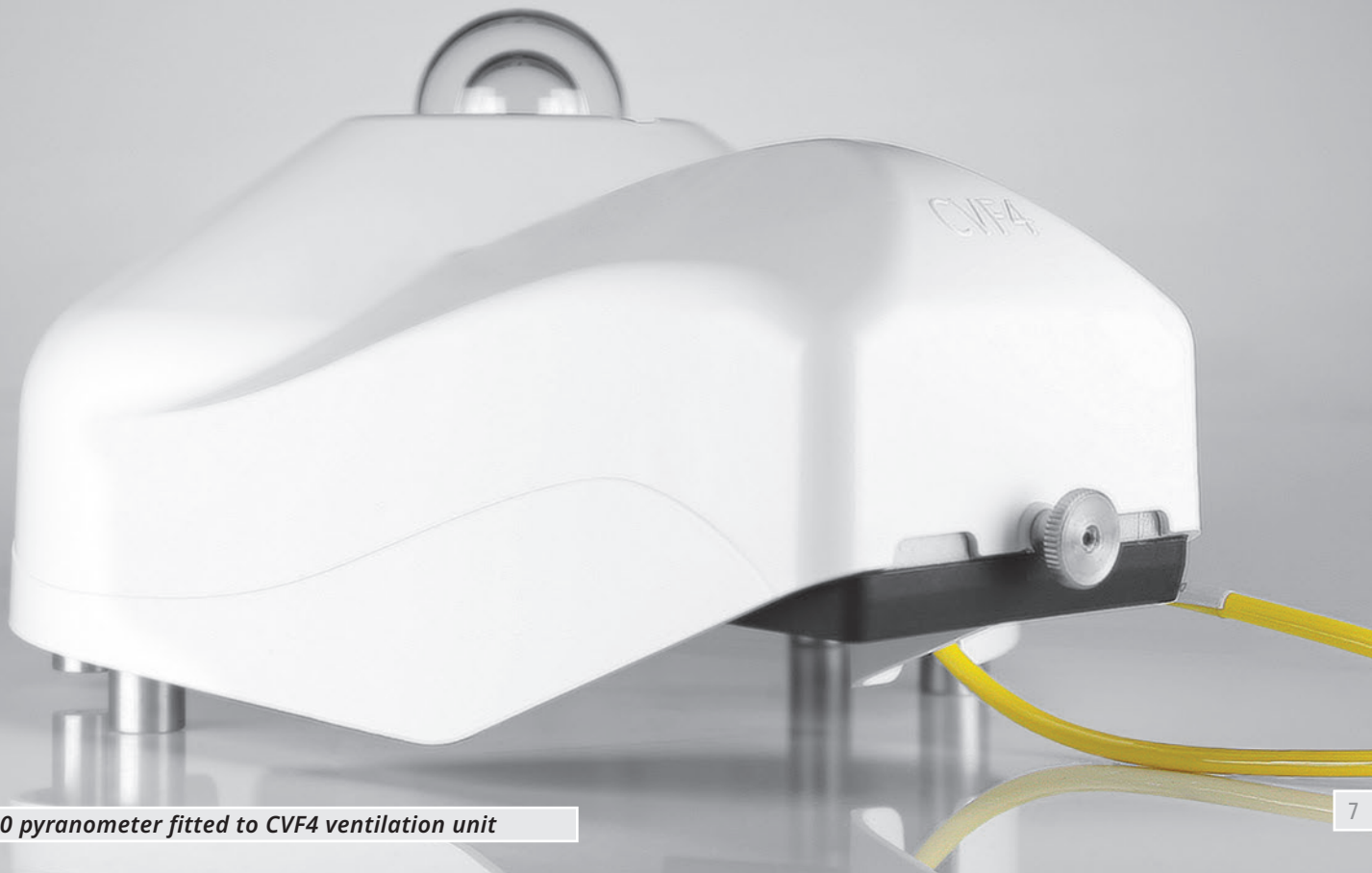
Together with my colleagues in Singapore, we are working very closely with the local distributors and channel partners in the APAC region to reach out to new potential customers and grow our business. OTT HydroMet's continuous determination to improve its quality and innovate will light up the industry."

## ***Tang Hwee Min, Sales Manager for Meteorology and Solar Energy at OTT HydroMet Pte. Ltd. in Singapore***

"It's indeed my warmest pleasure to be part of OTT HydroMet. My role is to grow this ever-shining business in the Asia Pacific Region and I am looking forward to it. In my previous sales role, I have specialised in precision weighing balances and platform scales based on land, never did I imagine that one day I would be dealing with precision measuring instruments for the atmosphere.

Over the last decade, projects delivering energy from renewable sources have become credible alternatives to carbon-intensive fossil fuel-based projects, due to this, many countries in APAC, are increasing their investments in PV plants. I see this as a great opportunity to grow our market share in APAC. It's definitely not a sunset industry but a shining one indeed in years to come."

# Ideal Class A monitoring match, SMP10 and CVF4 ventilation unit



*SMP10 pyranometer fitted to CVF4 ventilation unit*

Since March 2017 IEC 61724-1 has become the reference standard for monitoring photovoltaic system performance. It applies to all types of PV systems; fixed, single-axis and dual-axis tracking and concentrating. The standard covers how to monitor every parameter that affects plant performance in three monitoring classes: Class C – Basic Accuracy, Class B – Moderate Accuracy, Class A – High Accuracy. Class A represents the best that is realistically achievable without excessive costs.

Complying with the highest accuracy means using pyranometers with a low measurement uncertainty meeting the requirements of ISO 9060:1990 Secondary Standard or ISO 9060:2018 Spectrally Flat Class A, and accurate alignment of them.

Meteorological institutes, climate networks, and leading PV companies have been using external ventilation units with pyranometers for many years, to reduce soiling deposits (dirt and dust) and with heating to evaporate dew and rain drops and to melt frost. This leads to a greater uptime of good quality irradiance measurements and reduces the dome cleaning frequency.

IEC 61724-1 Class A monitoring requires that pyranometers must have ventilation and if there is condensation and/or frozen precipitation on more than 7 days a year (which is almost everywhere) there must be heating. It also specifies cleaning at least once per week and calibration every year.

Kipp & Zonen offers the CVF4 ventilation unit as an accessory that can be fitted with all our pyranometers, but we usually see it combined with the CMP10 or SMP10 models for solar projects. It is good to know that CVF4 can be placed horizontally, tilted or even upside down, for reflected radiation in bifacial PV and albedo applications.

The CVF ventilation unit has a strong track record with over 4000 pieces installed globally from polar stations to high mountains and desert environments, thanks to its robustness and impressive operating temperature range.

Because of the importance of ventilation and based on customer feedback, Kipp & Zonen has recently improved the CVF4 with a new fan, for better air flow, that is fully protected to IP68 against dust and water ingress, and new electronics. The improved CVF4 will be released soon and shipping in July 2019.

Since the release of the DustIQ, Kipp & Zonen has gained a lot of knowledge on the subject of soiling and this contributed towards the update of the CVF4.

Furthermore, Kipp & Zonen has recently set up a scientific study to determine the exact performance and deposit benefits of ventilators, in a test field with arid conditions, initiated by the raised customer interest due to the IEC61724-1 standard that requires ventilation for Class A monitoring.



*Kipp & Zonen SMP10 measuring plane of array irradiance*

# A GreenPowered partnership

With monitoring photovoltaic solar power plants as its expertise, GreenPowerMonitor is undeniably aware of the importance of using the best instruments with their systems. One of the key inputs to their vision 'Your data is always secure and your plants monitored' is the insights that are provided by a high quality weather monitoring setup. The insights for experts that forms the vision of OTT HydroMet is a great match that was made official in February 2019 with a global partnership.

## **Background to GreenPowerMonitor**

GreenPowerMonitor is a leading provider of renewable energy monitoring, control and asset management systems. It is known for experience with solar and wind power plants ranging from 2 kW to 585 MW capacity across the globe, with more than 3500 facilities totalling 21.5 GW. Its monitoring systems help developers, owners and asset managers of solar power plants to optimize performance.

GreenPowerMonitor, was established in 2008 in Barcelona, Spain and has been part of DNV GL, the largest resource of independent energy experts, since 2016.

[www.greenpowermonitor.com](http://www.greenpowermonitor.com)

## **Importance of on-site measurements**

Many different techniques are utilized to capture accurate plant meteorological information. It is always considered best to have local equipment capturing the real values.

When talking specifically about a solar power facility, the most important single data point is the electrical energy generated followed very closely by the insolation (solar energy) received.

Knowing the amount of energy produced directly translates to the return on the plant investment. Also knowing the amount of solar resource, with the insolation value, allows a huge amount of performance analytics to be performed so that you can now definitively state if the plant is producing as much energy as it should. Obviously, many other data parameters and information are critical for successful operation of any energy facility but these two are widely considered as the most important.

## **Best practices using Kipp & Zonen and Lufft products**

When discussing project best practices for meteorological equipment the first item is always budget, unfortunately. Understanding the size, scope and budget of a project will quickly help identify the appropriate equipment to be deployed.

As a general rule, it is best to have at least three sensors for any critical parameter, for example irradiance with the SMP10 Spectrally Flat Class A pyranometer. A remote operator can validate data and definitively know the plant operating state with two confirmed good data points, even if a single sensor experiences issues.



Additionally, for large utility-scale projects deploying more cost-effective sensors, such as the RT1 pyranometer with back of module temperature probe at each of the distributed inverter pads provides much more granular information for the operations of the different blocks within a larger solar plant.

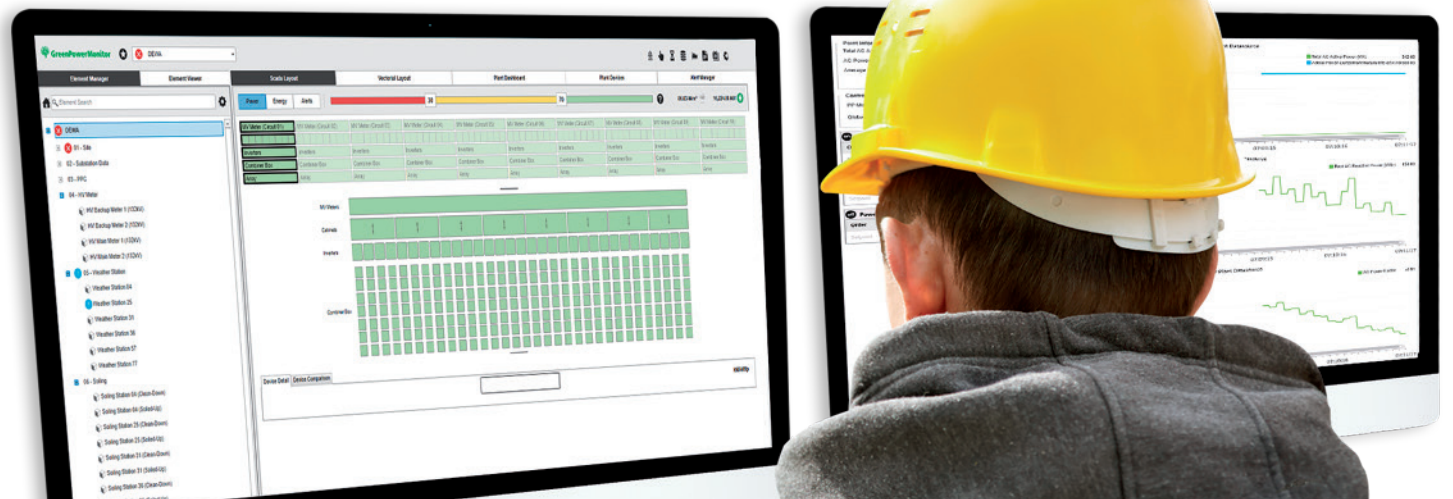
This approach was successful for a project that has 6 main weather stations with top-tier sensors spread out at strategic locations to capture highly accurate plant average values; combined with more than 50 RT1 sensors, one at each solar inverter pad, to get the necessary inverter level operations data to more accurately dive into smaller performance variances.

**Future outlook**

With this partnership, both OTT HydroMet and GreenPowerMonitor will be able to provide a strong solar monitoring solution to the solar energy industry. Juan Carlos Arévalo, CEO of GreenPowerMonitor says: "We are thrilled to announce the enhanced relationship between GreenPowerMonitor and OTT HydroMet. This will be the perfect advantage of global synergies between our organizations and will allow both teams to better serve the global market place with faster deliveries, more competitive pricing, and support at all levels in the chain value."

GreenPowerMonitor will be able to fully support customers on specific Kipp & Zonen and Lufft products around the globe. Even when it comes to warranty and logistics you can contact them directly for quick handling of any queries you might have.

Guillermo Esquivel, Direct Sales Manager at OTT HydroMet Corp. says "We've collaborated with GreenPowerMonitor on many projects worldwide. As experts in the renewable energy market, they add significant value to our product and service offerings. We are excited and proud to strengthen our relationship with GreenPowerMonitor. This partnership reinforces our shared global strategy to provide our customers with the highest quality products, service and support".



GreenPowerMonitor power plant monitoring



*GHI and POA CMP10 pyranometers and WS600-UMB*

# Jambhekar Automation Solutions use Lufft and Kipp & Zonen

*By Hemant Agarwal, Sales Director at Jambhekar Automation Solutions, Pune, India and Huzefa Motiwala, Business Development Manager, OTT HydroMet*

Solar energy is one of the important sources of energy all over the world, and especially in India. In several parts of the country, clear sunny weather is experienced 250 to 300 days a year, hence several initiatives have been launched by the Indian government and lots of solar power plants are coming up.

For a solar power plant it is very important to investigate the potential and actual performance. Climatic conditions play an important role in the electrical power generated, such as solar radiation, temperature, etc. Accurate pyranometer and weather sensor data are very important for the design phase and particularly for calculating the theoretical performance ratio, which is a paramount parameter for the design and is even more important when the plant is operational. Therefore, keeping in mind the long term commercialization of a utility-scale solar power plant, weather sensors which are accurate, efficient, reliable, as well as affordable, are a necessity today.

Jambhekar Automation Solutions manufactures data loggers and provides complete weather monitoring systems for solar power plants. We have earned a reputable name in the solar energy industry by providing precise and accurate weather monitoring stations to more than 150 large-scale plants in India. The pyranometers we use are Kipp & Zonen, as we prefer to work with the most reliable and accurate instruments available on the market. These are often combined with weather sensors of our own make or of other reputed manufacturers, such as Lufft, as per the client requirement.

We would like to share two of our installed weather monitoring systems:

## **5MW project at Vizag Steel for Ujaas Energy Ltd.**

At this plant for EPC Ujaas Energy we have provided two Kipp and Zonen CMP10 pyranometers, for GHI and POA irradiance, a Lufft WS600-UMB all-in-one weather sensor with radar rain sensor, a PV module temperature sensor and a Jambhekar data logger.

The data logger collects measurements from the sensors and sends data to the SCADA system over Modbus® TCP/IP. The system was installed in 2016 and is running smoothly till date.

## **5MW solar power plant for Enrich Energy Pvt. Ltd.**

For EPC Enrich Energy we installed on a mast a Jambhekar module temperature sensor and data logger with two Kipp & Zonen CMP10 pyranometers, a WS500-UMB weather sensor from Lufft and a tipping bucket rain gauge.



*A different installation for 2 x CMP10 and WS500-UMB*

As before, the Jambhekar data logger feeds information into the SCADA system over Modbus® TCP/IP. This system was also installed in 2016 and is still working well.

For more information go to [www.jambhekar.co.in](http://www.jambhekar.co.in)



# Easily check Kipp & Zonen pyranometers on site

For help during pyranometer installation, or a confidence check of performance on site, Kipp & Zonen offers our new hand-held data logger METEON 2.0. The original METEON remains available, but the new model has greatly increased functionality in response to customer requests. Like the original, METEON 2.0 has one analogue input for the Classic CMP series pyranometers, but you can now also connect up to 5 of our Smart SMP series by RS-485. Simple, quick, convenient and accurate.

However, METEON 2.0 is not just for pyranometers. You can connect and power any Smart Kipp & Zonen radiometers and easily set up the Modbus® address and communication parameters in the field, without using a computer and software.

## Perfect for PV projects

METEON 2.0 can be of great help when you are responsible for the maintenance of a solar energy plant. To verify that the pyranometers are installed and operating correctly, to perform a confidence check of the measurements, and to validate the data being received at the plant management system. It stores the average, maximum and minimum values over the selected logging interval.

METEON 2.0 can also provide you with the basic parameters you need to calculate the performance ratio (PR). For this you need to know the incoming plane of array solar irradiance measured by a tilted pyranometer and the PV module temperature; you can hook up a Mencke & Tegtmeier Modbus® panel temperature sensor. Of course, a key parameter is the electrical energy generated and METEON 2.0 can read the pulses from a kWh meter (S0 output). All of these measurements can be displayed and recorded by a

METEON 2.0 and you have a very easy way to check the efficiency of your PV plant in real time and on the spot.

As mentioned, METEON 2.0 can connect with multiple Kipp & Zonen Smart instruments, which means that it can be used with two SMP pyranometers to measure the incoming and reflected solar radiation in bi-facial PV applications, to enable the albedo to be calculated.

You can view and compare live data on the display and, depending on the number of instruments connected and the logging interval selected, it can store weeks of data. You can export the logged data files to a Windows™ computer using the USB interface. Once downloaded, the free METEON 2.0 software visualizes the data nicely in a graph and it can be exported to Microsoft® Excel for further processing.



Visit [www.kippzonen.com/meteon2](http://www.kippzonen.com/meteon2) to read more, find the specifications and download the manual.

# A new combination for entry-level PV weather monitoring

By David Smock, Systems Specialist at Traffic Products Inc, Pennsylvania, USA



Lufft WS10 and Kipp & Zonen RT1

Back in 2012, Burlington County Engineering of New Jersey purchased a solar panel system to help generate their own electrical energy. Part of the system was a weather station and irradiance sensor, all this data going into Deck monitoring software from AlsoEnergy that compiles all the data and displays the power generation, weather parameters, etc.

The old weather system had become inoperative and obsolete; due to lack of attention and no-one stepping up and caring for the system since 2012. In mid-2018, this customer contacted us to replace the weather system and be on call for repairs and monitoring.

## A new combination for basic but high quality weather data

Well, I have been in the weather business since 1987 but have never done work in relation to a solar power system. I reached out to my partner at Lufft, Laura Goodfellow, and she pointed out various Smart weather sensors and the irradiance sensor. I had spoken with her about the new WS10 sensor, that it would be great for this project since they just want basic weather readings but high quality; a combination of the Lufft WS10 and the Kipp & Zonen RT1 for irradiance and PV panel temperature was the answer.

I had to coordinate the sensor specifics with an engineering firm so that their engineer could write the appropriate code for their software to 'see' and interpret the data from the WS10 and RT1. Personally, I now had to teach myself about Modbus® communications; I had never had to use this before in my career. I did so, and the job was accomplished.

## Modbus® communication all set

I programmed the sensors for Modbus® and assigned each their own specific ID within the customer's communication system. I used the Lufft config tool and the SmartExplorer software for the RT1 to program and test in my home office.

The day of commissioning: the sensors were installed, powered up and the customer's system was again complete. It is a great combination for the customer, quality sensors at a value price. Not realizing it at the time, these products of Lufft and Kipp & Zonen symbolize the Meteorology Division of OTT HydroMet.

The customer now plans, upon my suggestion, upgrading his other solar site to a similar setup.

Traffic Products Inc started in business in 1978 as a supplier of premium traffic signal control equipment. Our success results from quality products, expert service and honest application of the solutions we supply. As technology changed and our customers' needs developed TPI followed, adding central control systems, networking solutions, wireless and cellular communications, connected vehicle technology and weather solutions and now mobile weather to our offerings.

<https://trafficproducts.net/>



David Smock is the Systems Specialist at Traffic Products and has extensive field device experience in project planning, deployment and installations for airports, DOT and municipal agencies, state-wide project management, communications and broadcasting.

# Bifacial PV study in Northern Chile using multiple pyranometers

At Kipp & Zonen we see a growth in applications for pyranometers to study and monitor the additional power that can be generated by bifacial PV modules. The research featured in this newsletter by the PhotoVoltaic Materials and Devices group of TU Delft uses an albedometer for validating their model.

Another study on the benefits of bifacial modules is taking place in Chile and Thore Mueller, Solar Energy Engineer at ENGIE Laborelec explains how they use multiple pyranometers in the reverse plane of array to monitor the reflected irradiance at different heights.

“At Laborelec’s outdoor laboratory ‘El Águila’ in Chile’s Atacama Desert we are testing the latest generation bifacial panels in order to characterize and maximize their energy gain. For that we are relying on low uncertainty, ISO 9060 Secondary Standard pyranometers from Kipp & Zonen for front and rear face irradiance measurements.

This data, complemented by panel temperature and climate measurements, allows us to validate and improve simulation models specifically designed for bifacial panels. Consequently we are able to transfer the insights gained in northern Chile to every potential power plant construction site around the world.”



*Pyranometers for plane of array incoming and reflected irradiance*

# Kipp & Zonen albedometers contribute to a new albedo model

By Dr. Hesam Ziar, researcher at the PVMD group of TU Delft, the Netherlands

As the market of photovoltaics (PV) is shifting towards bifacial PV technology, in which both sides of a solar cell can absorb sunlight and contribute to energy production, researchers get more interested in the albedo component of sunlight.

## Albedo feeds the back of bifacial PV modules

The albedo component is the part of the light that is reflected from the surface back to the sky and it plays an important role in the Earth-Atmosphere energy balance. This light can be captured by photovoltaic cells to produce electrical energy. Bifacial PV cells benefit more from this reflected energy because while the front side of the cell looks up to the sky and radiation from the Sun, the rear side has no hope for energy production except from reflected radiation. It is predicted that by 2022, bifacial PV modules will constitute one fifth of the newly installed PV market.

## The difficulties of predicting albedo

Albedo depends on many factors as any material with any shape and size has an albedo. Sun position and weather conditions also affect albedo. Basically, whatever is present in an environment influences the albedo. For the front side of a bifacial cell, predicting the irradiation falling on the active area is simpler as there is only one Sun in the sky, but there are many tiny light sources on the Earth surface which form the albedo component.

That is what makes it difficult to predict. Consequently, available albedo prediction models are empirical and site-dependent, developed by long-term albedo measurement at specific locations. In other words, to know and predict the local albedo globally, a huge number of albedometers are needed to be installed all over the world for a long time which is practically impossible. However, researchers at Delft University of Technology have formulated an alternative approach.

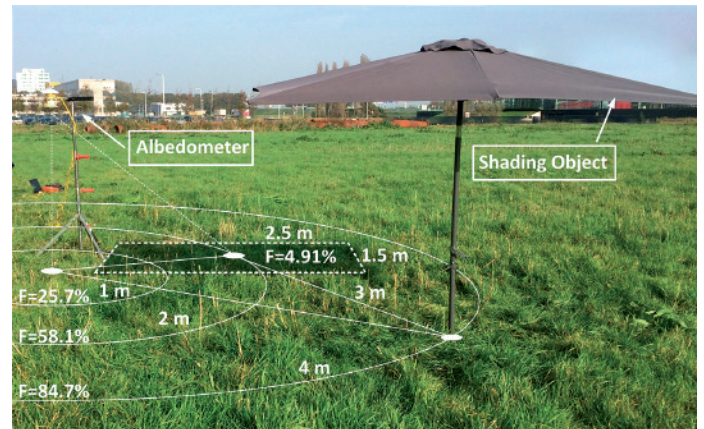




An array of frameless bifacial PV modules

### A theoretical model for albedo

Researchers have developed a theoretical model to predict albedo by mathematically pointing out the difference between *reflectance and albedo*, incorporated shadowing effects within the equations to make the math simpler. They managed to categorize all influential parameters on albedo into: material, geometry and solar irradiance, all in one equation.



Modelling shadow effects on reflectance

Dr. Hesam Ziar, researcher at the PhotoVoltaic Materials and Devices (PVMD) group of TU Delft and the developer of the new albedo model: “This model finds the spectral geometry of the shadows in an environment and predicts the albedo on a probabilistic platform. So, if one knows about the shadows, you would know about the albedo as well.”

To validate the model full day measurements were conducted in Delft, the Netherlands using a Kipp & Zonen albedometer consisting of two SPM10 pyranometers.



SPM10 albedometer

The model can be used in many applications in the fields of research related to climate and solar energy. “Working on the applications of the new albedo model, for example integrating it into our PVMD modelling toolbox, is the next step for our team which broadens our research scope and applications”, stated Dr. Olindo Isabella, head of the PVMD group, TU Delft.

Initial results were presented at the 35<sup>th</sup> European Photovoltaic Solar Energy Conference and Exhibition (EUPVSEC 2018) and will be published in the coming months.

OTT HydroMet provides valuable insights for experts in water, weather and energy applications to help protect lives, the environment, and infrastructure



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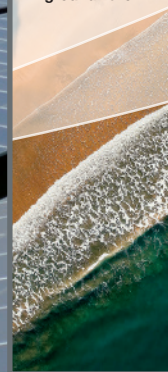
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