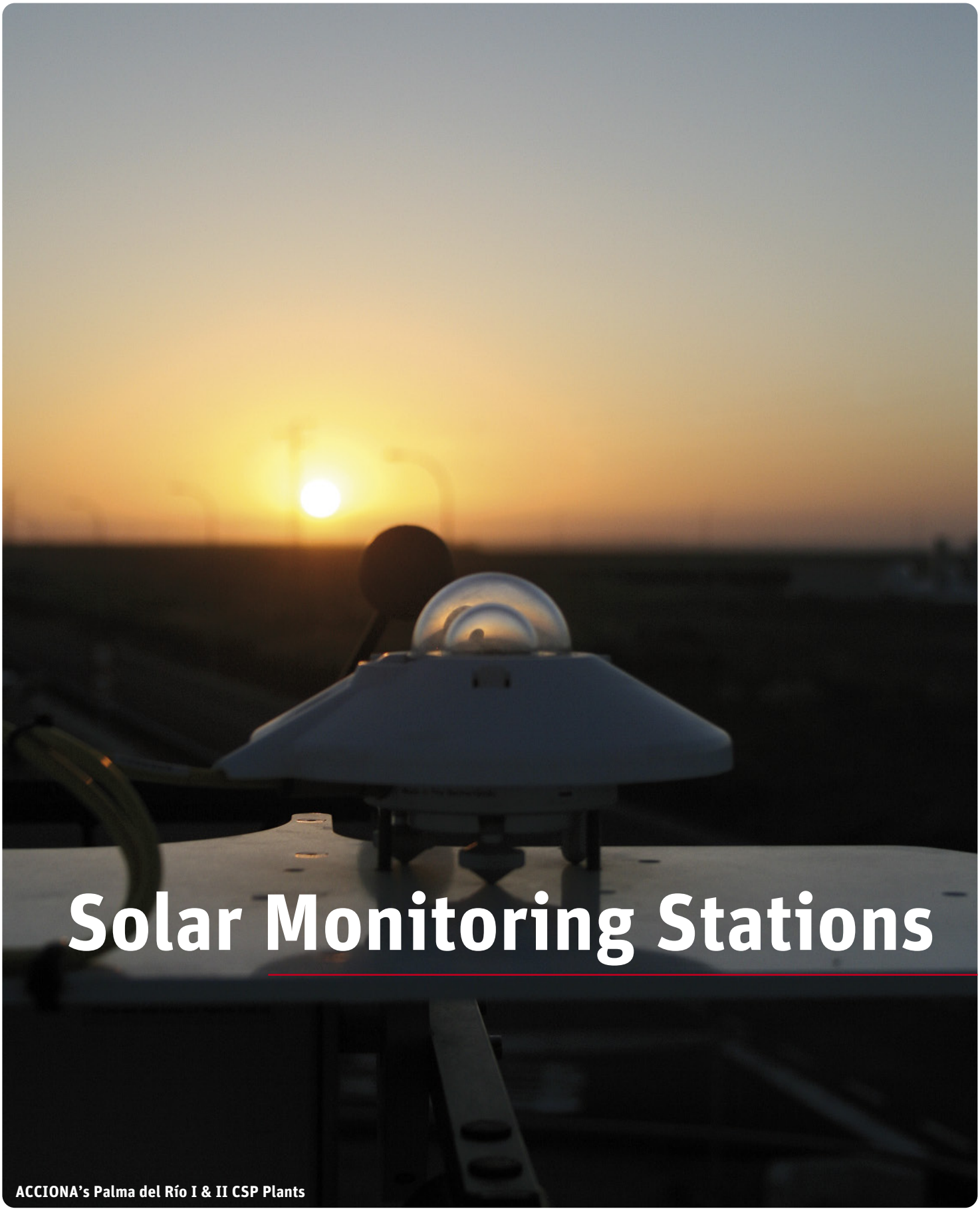


Solar Monitoring Stations

ACCIONA's Palma del Río I & II CSP Plants

KIPP & ZONEN
SINCE 1830

Content

Kipp & Zonen B.V. - 2012

Sun Trackers and their Applications

Solar radiation is normally measured using a pyranometer that sees the whole hemisphere above it, the 'global' solar radiation. However, it is often necessary to accurately measure the 'direct' radiation coming only from the sun. This is done by a pyrheliometer that has a view slightly larger than the sun and its aureole and does not see the rest of the sky.

Sun Tracker 2 AP in Spain

To make accurate measurements the pyrheliometer must point precisely at the sun and this is achieved using an automatic two-axis sun tracker. An optional shading assembly can be fitted to block the direct solar radiation from reaching a second pyranometer, mounted on the tracker so that the 'diffuse' radiation from the sky can be measured.

The sun tracker follows the solar arc using stepping motors, controlled by a micro-processor, that drive through belts or gears to provide horizontal (azimuth) and vertical (zenith) movement. An on-board programme requires accurate longitude, latitude, altitude, date, and time information for the measurement site. It then calculates the current sun position and points the tracker towards it.

A sun tracker with pyrheliometer, pyranometer and shaded pyranometer makes a high quality solar monitoring station measuring direct, global and diffuse radiation. Such stations are widely used in meteorological networks providing data to weather forecasting models and for climate studies. The highest quality is the Baseline Surface Radiation Network (BSRN). Other applications include atmospheric chemistry research, pollution forecasting and materials testing.

With increasing interest in renewable energy, good quality solar radiation data is becoming increasingly important. For electricity production (photo-voltaic systems) and thermal energy (solar collectors) the direct component is of particular interest. Activities include research and development, quality control, determination of optimal locations, monitoring installed systems and predicting the output under various sky conditions.

The new Kipp & Zonen SOLYS 2 Sun Tracker is proving to be a major success and we are increasing production to keep up with demand. It is the only fully automatic sun tracker that does not require a computer and software for installation. The integrated GPS receiver automatically configures location and time data.

SOLYS 2 is cost effective and simple to use whilst meeting the requirements of the BSRN. It is very efficient, ideal for operation at remote locations using solar power, and the belt drive system requires no maintenance.

The Kipp & Zonen 2AP Sun Tracker has been in production for many years and over 400 units are in use around the world as the basis of top quality solar monitoring stations. The high power motors and precision gear drives have the torque to break ice and to operate in high winds, enabling operation in extreme conditions, from deserts to Antarctica.

A unique feature of the 2AP is the positioning capability. When connected to a PC it can perform a sequence of pre-programmed movements to point at a series of targets.

Whatever your sun tracking need, Kipp & Zonen can provide the solution ■

How to Measure Photovoltaic Performance

Albarubens S.r.l. is a test laboratory, located near Milan in Italy, that specialises in Solar Energy systems. The company name means 'red sunrise' in ancient Latin. Albarubens performs testing and certification of PV panels for power plant projects, which are used to help decision making by the project managers. The laboratory is accredited under IEC 17025 for all the performance and endurance tests on photovoltaic (PV) solar panels, as described in the standards IEC EN 61215 (crystalline silicon), IEC EN 61646 (thin film) and IEC EN 61730-2 (safety aspects). By the end of 2009, Albarubens will also be testing to IEC 62108 (concentrators) and EN 12975 (thermal solar panels).

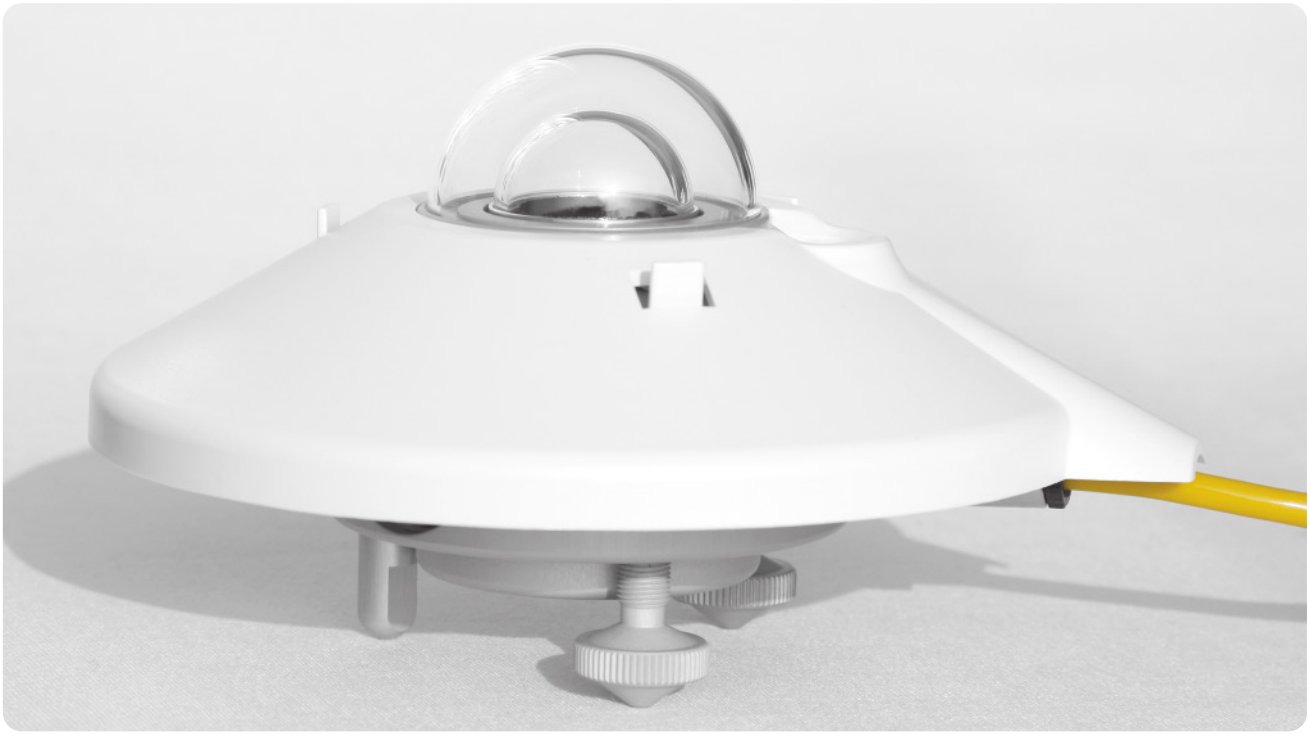
The main performance test carried out by Albarubens is the measurement of the maximum electrical power generated by a PV panel per square metre. This value depends on the module technology, which is the main factor to be considered in the choice of PV systems.

Research and development in this field results in constantly improving performance. The differences between panels from various manufacturers are quite small, so an objective power measurement has to be made with very high precision and low uncertainty to certify the performance. The quality of the measurement depends on the accuracy of the measurement of electrical power output and the solar irradiance available to the panels.

Of course, the electrical power generated by PV depends on a number of factors; the total incoming radiation, its spectrum, the angle of incidence, the module temperature and other parameters. Usually power is measured under Standard Test Conditions of 1000 W/m² solar radiation at an ambient temperature of 25 °C and with Air Mass 1.5. The Air Mass (AM) is the amount of atmosphere that light directly from the sun passes through to reach the ground, and this depends largely on the solar elevation.

The spectrum of the light is affected by the Air Mass. The Standard Test Conditions are equivalent to a clear sunny day at sea level in mid latitudes with the sun at 45 ° zenith angle.

Albarubens performs testing and certification of PV panels for power plant projects



Usually Albarubens performs measurements using a Kipp & Zonen CMP 11 pyranometer

Most manufacturers of PV modules carry out performance tests using a 'solar simulator' based on a Xenon flash lamp and an electronic load with power meter. The main advantage of testing in artificial conditions is the possibility to work at any time and independently of the weather conditions. Also, the solar simulator can be easily integrated into production line testing.

On the other hand, this also shows problems. The data requires a spectral mismatch correction, the lamp output is not homogeneous on the PV surface, and flash duration is very short (2-10 ms). This very short pulse requires a PV reference cell as the irradiance meter, but these have an uncertain spectral response. All together these problems results in a high uncertainty of the measurement; up to 6 % for commercial grade equipment and 2 % for very expensive laboratory types.

Since the beginning, Albarubens has chosen to measure the PV power under natural sunlight, which restricts the number of measurement days in a month. However, this is a negligible problem because all the other tests required by the standards take more than 2 months. Moreover, in Italy, there are many sunny days in a two month period even in winter. Under natural sunlight there are no problems with spectral simulation, source stability, duration or homogeneity. Importantly, they can use a high precision pyranometer to measure the solar irradiance.

Usually Albarubens performs measurements using a Kipp & Zonen CMP 11 pyranometer as the absolute irradiance meter, plus a reference PV module for comparison. The pyranometer calibration is traceable to the World Radiation Centre (WRC) in Davos, Switzerland and the reference modules to inter-laboratory comparisons. The parallel use of two reference sources minimises the total uncertainty. Every test is repeated ten times to calculate the mean value and repeated again in the rare case that the standard deviation is higher then 0.2 %. Albarubens regularly obtains a global radiation uncertainty of better than 1.8 % (k = 2 - 95 %).

Albarubens is confident that the best way to quantify PV module performance, for certification purposes, is in their real working condition - natural sunlight! ■

We wish to thank
Ing. Giuseppe Terzaghi of Albarubens
for contributing this article.

For more information please visit **www.albarubens.it**

Visit to China Meteorological Administration

After our International Sales Meeting in Penang, Malaysia Kipp & Zonen Business Managers Clive Lee and Ruud Ringoir visited the China Meteorological Administration (CMA) at their headquarters in Beijing and at their research centre and BSRN station in Xilinhot, Inner Mongolia. The visit was organized with considerable help from Joe Zhou, General Manager of our Chinese distributor Beijing Techno Solutions Ltd.

Kipp & Zonen instruments at Xilinhot, Inner Mongolia

CMA has a large quantity of Kipp & Zonen products and requested this visit to discuss calibration, specifications, international standards and instrument specific questions. On Sunday 14th of November in Beijing presentations were made about Kipp & Zonen and our products, and more specifically about individual instruments and their calibrations. Beijing had blue skies, a light dusting of snow and temperatures around freezing - a contrast to the +30 °C monsoon conditions in Penang!

The next day we traveled with Joe Zhou and three CMA people to their meteorological centre in Xilinhot, Inner Mongolia. There were a lot of discussions to inform them about installation, maintenance, data management and quality control.

The main measurement station is located 1 hour drive outside the city in flat tundra. The 360 degree clear view and uniform landscape makes it an ideal location for measuring radiation. The temperatures were between -20 °C and -25 °C with strong wind, making inspections of the instruments a chilly experience.

The short mast with a UVS-AB-T and a PAR Lite

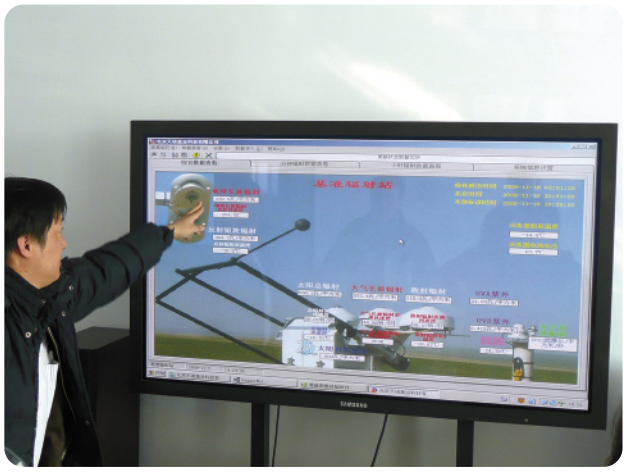
A 2AP sun tracker with shading ball assembly is fitted with a CHP 1 pyrheliometer to measure the direct radiation and ventilated CMP 21 pyranometers for global and diffuse measurement. A ventilated CGR 4 measures the downwards infrared radiation. Alongside the tracker is a short mast with a UVS-AB-T and a PAR Lite, for UVA, UVB and Photosynthetically Active Radiation.

A suitable distance away to avoid shadows is a 30 m mast with downwards facing CMP 21 and CGR 4 for reflected radiation and upwards infrared. This means that all four net radiation components are measured and albedo can be calculated. There is also a fully instrumented 200 m high meteorological tower that includes a CNR 1 net radiometer. With the addition of ventilation units to the downwards facing radiometers the site will comply with the requirements for an Extended Baseline Surface Radiation Network Station (BSRN).

The 30 m mast with downwards facing CMP 21 and CGR 4

A few hundred meters from the measurement site is a building used to collect and analyse the data.

Beijing Techno Solutions carried out the installation, provided the data loggers, and developed software to graphically display all the parameters on a large LCD screen.



Joe Zhou explains the radiation parameter display

We would like to thank **all the China Meteorological Administration staff** in Beijing and Xilinhot for their hospitality, and **Joe Zhou** for his assistance and enthusiasm.

Operational centre at the Xilinhot station

Solar Resource Assessments in South Africa for Concentrated Solar Power Developers

The Department of Energy of the South African Government has established a target for renewable energy production to reach 10,000 GWh by December 2013. Of this, 6,000 GWh is expected to come from mainstream on-grid electricity generation.

In order to meet the remaining 4,000 GWh of the target, the National Energy Regulator of South Africa (NERSA) published in March 2009 a Renewable Energy Feed-In Tarif (REFIT) to encourage investment in developing technologies, as follows:

- Wind: 1.25 ZAR/kWh
- Small hydroelectric: 0.94 ZAR/kWh
- Landfill gas: 0.90 ZAR/kWh
- Concentrating solar: 2.10 ZAR/kWh

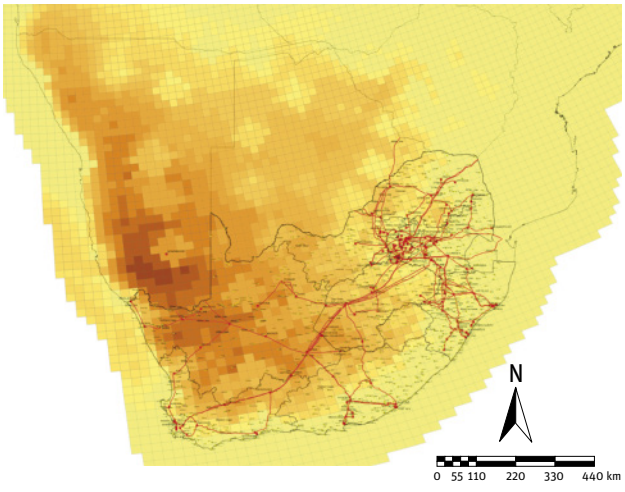
In October of 2009 the following additional tariffs were published:

- Concentrated solar power troughs without storage at ZAR 3.14/kWh
- Solid biomass at ZAR 1.18/kWh
- Biogas at ZAR 0.96/kWh
- Photovoltaic systems (large ground or roof mounted) at ZAR 3.96/kWh
- Concentrated solar power (central tower) with 6 hours storage at ZAR 2.31/kWh

1 Euro is equal to approximately 9.3 South African Rand (ZAR).

South Africa has some of the best solar energy resources in the world with locations having an annual sum of Direct Normal Irradiation (DNI) exceeding 2900 kWh/m2 (8000 Wh/m²/d). This, along with the attractive REFIT scheme, has lured many Concentrated Solar Power (CSP) developers to South Africa. A DNI map of South Africa based on satellite derived data from the National Renewable Energy Laboratory (NREL) in the USA is shown at right.

The Centre for Renewable and Sustainable Energy Studies (CRSES), situated within the Department of Mechanical and Mechatronic Engineering at Stellenbosch University, has the capability to offer solar resource assessment services to CSP developers. The service includes the specification, installation and operation of a solar measuring station for a minimum period of one year. In addition, satellite-derived data from various sources are compared to the measured ground-level data.



In February 2010 the first solar radiation measurement station was installed. This uses a Kipp & Zonen SOLYS 2 sun tracker, a CHP 1 pyrheliometer, two CMP 6 pyranometers and a Campbell Scientific CR800 data logger to measure direct, diffuse and global solar radiation.

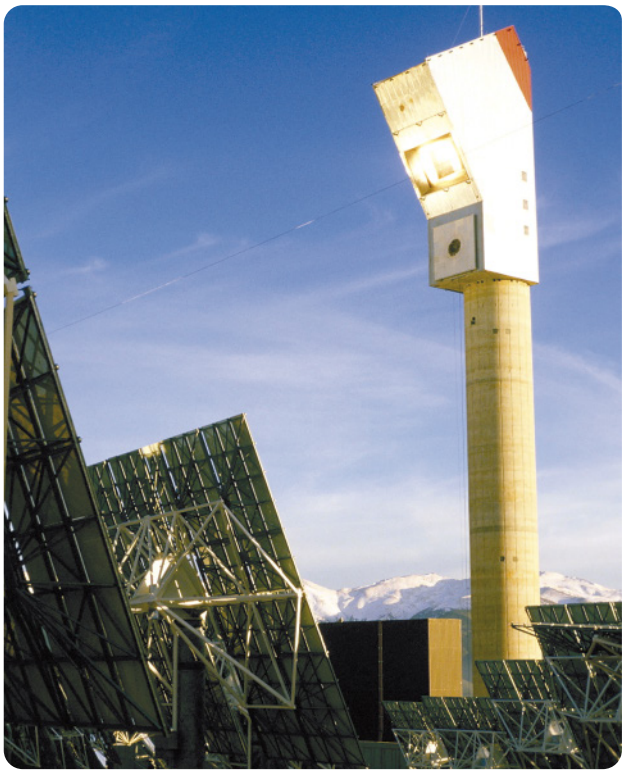
A second station was installed in May, comprising two CMP 6 pyranometers and a CM 121 shadow ring. The installation will be expanded in July by adding a CHP 1 pyrheliometer, a SOLYS 2 sun tracker, a Campbell Scientific CR1000 data logger and a 10 m meteorology mast with anemometer, wind vane, temperature, humidity and barometric pressure sensors.

Both stations are located in Upington; a town in the Northern Cape Province that is known for having high annual DNI sums, due to low rainfall and minimal cloud cover. When it does rain in Upington, it is mainly during the night or in the early morning hours. It was found that, in general, for the Upington area the satellite-derived data under-estimates the measured data. This is good news for CSP developers and the future of solar energy in South Africa ■

We wish to thank **Riaan Meyer** of the **Centre for Renewable and Sustainable Energy Studies**, (CRSES) Stellenbosch University, South Africa for contributing this article. The Kipp & Zonen distributor in South Africa that provides the equipment to CRSES is Campbell Scientific Africa (Pty) Ltd. of Stellenbosch, www.csafrica.co.za

SOLYS 2 Sun Tracker in the Pyrenees

Since 2006, CNRS-PROMES, a leading centre for concentrating solar systems, has been working on a project called PEGASE (Production of Electricity from Gas and Solar Energy) which aims to design and evaluate an innovative hybrid system that combines solar energy and gas-turbines for electricity generation. The project is taking place at the Themis solar test site near Targasonne in the Eastern Pyrenees.



Recently, a SOLYS 2 sun tracker and a set of solar sensors (for global, direct and diffuse radiation measurement) have been installed on the top of the 100 meter high tower, facing the field of 201 concentration mirrors. Together with other meteorological sensors, Kipp & Zonen instruments will help the researchers and energy companies to precisely characterise the site, to control parts of the installation (such as the heliostats and the solar receiver) and to analyse the efficiency of the complete system.

Improving solar energy efficiency

With this experimental project, CNRS-PROMES is looking in the near future to improve the efficiency and reduce the costs of generating clean solar energy ■

Monitoring Solar Radiation to improve Photovoltaic Efficiency

The limited supply and rising prices of traditional energy sources, together with the increasing awareness of climate change and 'Carbon Footprint' costs, have resulted in rapid development of alternative energy sources, in particular solar and wind energy.

Photovoltaic (PV) is the field of technology and research related to the application of Photovoltaic Cells to convert sunlight directly into electricity. The cost of solar cells, panels and arrays is still rather high, so research into new materials and improvement of efficiency continues. Monitoring the solar radiation plays an important role in analysing both the efficiency of the cells and evaluating optimal locations for 'solar farms'.

Existing meteorological stations are often too far away, so measurement in-situ of the available radiation allows a better understanding of the local (micro) climate. Based on these figures decisions on funding and investment are made for projected renewable power plants.

PV panels are specified under Standard Test Conditions (STC). These conditions are 1000 W/m² of solar radiation, 25 °C, Air Mass 1.5 and no wind. Because these conditions are far from the real world, additional measurements are required to show the PV panel's typical performance. Both pyranometers and reference PV cells are used to measure the radiation. Because pyranometers have standard characteristics they can be used to independently compare all types of PV cells.

When the pyranometer is mounted at the same angle as the PV panel it can be used to calculate the panel's efficiency. Furthermore it can indicate failing panels or cells by a sudden drop of efficiency, whilst a gradual decline of efficiency will indicate the need for cleaning the panels. Kipp & Zonen CMP pyranometers provide accurate and reliable measurements for PV monitoring.

Pyranometers are also used for checking PV panels and cells under laboratory conditions. Because CMP pyranometers are specified up to 80 °C (or 150 °C for the CM 4) they can monitor the output of the high energy lamps used in solar simulators.

For thermal energy solar concentrators, and sun tracking PV systems, the direct component of the solar radiation is also required. The CHP 1 Pyrheliometer together with a Sun Tracker measures the direct radiation. Sun tracker systems measuring global, direct and diffuse radiation are often used in PV monitoring and research.

Testing of Photovoltaic devices and reference cells using pyranometers is described in IEC 60904, IEC 61215 and IEC 61646 standards. Characterization and calibration of pyranometers is based on ISO 9060 and ISO 9847

SOLAR ENERGY APPLICATIONS

- Solar prospecting for optimum locations
- Radiation check for PV materials research
- Radiation check for thermal systems research
- PV and thermal power plant efficiency check
- Specification and quality testing of PV panels
- Determination of losses in PV and Reference cells
- Tests according to IEC 60904 standards
- Independent comparison of PV panels
- Solar simulator radiation verification

SOLYS 2 Sun Tracker at CNIM's Solar Concentrator Module

Originally named Constructions Industrielles de la Méditerranée, CNIM has an active environmental division that specialises in energy production from the treatment of household and industrial waste and biomass. Now the company is expanding into Concentrated Solar Power (CSP) systems. CNIM designs, develops and produces turn-key solutions. In July 2010 their prototype CSP module was installed at La Seyne sur Mer in the South of France.

The concentrator module uses Fresnel mirror technology that takes a large area of sunlight, concentrates it, and directs it towards a specific target in order to produce steam, and thus energy. The energy produced is renewable, storable, and easily integrated into the existing electrical networks. The CNIM technology is eco-friendly thanks to its low carbon footprint and the use of recyclable and non-polluting fluids and materials. The large and powerful stand-alone module has a 50 m x 20 m footprint and 720 m² of mirrors that can produce steam at up to 100 bar pressure.

On July 26th 2010 CNIM inaugurated its solar concentrator installation in the presence of Mr Christian Estrosi, the French Government Minister of Industry.

Kipp & Zonen SARL is working closely with a number of power companies in France to provide instruments for solar energy applications.

Find out more about CNIM at www.cnim.com

The SOLYS 2 sun tracker and CHP 1 pyrheliometer from Kipp & Zonen are used to accurately measure the Direct Normal Irradiance (DNI) in order to determine the solar concentrator module performance. Thanks to the continuous measurement with Kipp & Zonen instruments, CNIM is able to calculate the energy output of its module and enhance its productivity and efficiency.

Kogan Creek Solar Boost Project

Australian electricity generator CS Energy has installed a Kipp & Zonen sun tracker and instruments at their Kogan Creek Power Station, to develop a detailed understanding of the local solar resource.

Kogan Creek Power Station in Queensland is a 750 MW supercritical dry-cooled coal-fired power station, and is Australia's largest single unit. CS Energy is developing 'Solar Boost', a 44 MW solar thermal augmentation of the existing coal-fired power station, which would be the largest coal-solar hybrid power station in the world. The project will use Areva's Compact Linear Fresnel Reflector (CLFR) technology to turn feedwater into superheated steam, supplementing the steam generation from the coal-fired boiler. This solar addition will enable the Kogan Creek Power Station to produce more electricity with the same amount of coal and reduce the station's greenhouse intensity.

CS Energy is also developing two large (150-250 MW) standalone solar thermal power stations in the Kogan Creek area, having been shortlisted within two consortia for funding under the Federal Government's Solar Flagship Program.

Dr. Ben McGarry, renewable energy engineer at CS Energy, said the design and deployment of high quality monitoring hardware for the solar resource assessment was pivotal to establishing the business cases for all three solar thermal projects. The solar resource assessment campaign is contributing to the design and sizing of the solar thermal technology as well as the revenue side of the business model. Dr McGarry said "Raw renewable energy may be free, but the technology required to convert sunlight to useful electricity requires a relatively large capital expenditure upfront. The electricity and revenue produced from that investment depends heavily on the local solar resource, so we needed to use the best available instruments to minimise uncertainty. Where there are hundreds of millions of potential investment dollars riding on the data, you want to be able to sleep at night."

The system comprises a Kipp & Zonen SOLYS 2 sun tracker with CHP 1 Pyrheliometer, 2 x CMP 21 Pyranometers and a third party legacy pyranometer carried over from a previous installation. Dr McGarry said the Kipp & Zonen equipment was an easy choice - "When I started researching the instruments that were out there, it quickly became clear that we couldn't go past Kipp & Zonen in terms of accuracy and reliability. As a mechanical engineer, I was impressed by the mechanical design of the tracker and instruments, and I'm comfortable that it will withstand the tough site conditions." ■

Russian Solar Radiation Monitoring Network

In 2008 Kipp & Zonen provided the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) with solar radiation monitoring equipment to set up the first WMO Baseline Surface Radiation Network (BSRN) station in Russia. The station was installed in Orgurtsovo, Western Siberia.

This first station was just a small part of a major project to update and modernise the Roshydromet network from manual observations to automated measurements and centralised data collection.

Now Kipp & Zonen is proud to announce that we have won the international tender to supply 18 solar monitoring stations to Roshydromet for installation at key locations across Russia. The stations are based on the 2AP sun tracker with active tracking sun sensors, cold weather covers, heaters, tripod stands, height extension tubes and shading ball assemblies.

The trackers are fitted with CHP 1 pyrheliometers, CMP pyranometers and CGR 4 pyrgeometers; to measure direct, diffuse and global short-wave radiation and downwards long-wave radiation. An additional pyranometer and pyrgeometers measure reflected short-wave radiation and upwards long-wave radiation. All the pyranometers and pyrgeometers are fitted with CVF 3 ventilation units.

All four components of the radiance balance are measured and Albedo can be calculated. Six of the stations also have UVS-AB-T radiometers to monitor UVA and UVB. The order includes spare instruments and an additional 2AP station for training purposes, which will be located in Moscow.

Our instruments were extensively tested by the Main Geophysical Observatory (MGO) in St. Petersburg to ensure that they comply with Russian requirements.

The Kipp & Zonen partner in Russia for this project is the Lanit systems integration company of Moscow ■

Improving Solar Radiation Data in Brazil

The Instituto Nacional de Pesquisas Espaciais (INPE) is part of the Ministério da Ciência e Tecnologia of Brazil and one of their key projects is SONDA (Sistema de Organização Nacional de Dados Ambientais). Among the goals of SONDA is the collection of meteorological and radiation data at several selected sites across Brazil. This network of stations provides a basis for the publicly available data necessary for the validation of climate models and for the assessment of renewable energy resources, mainly solar and wind power.

The Laboratory for Meteorological Instrumentation (LIM) develops robust and cost effective technologies relevant to the Brazilian National Institute for Space Science (INPE) missions. LIM supports the logistics for several research projects, including SONDA. High precision instruments from Kipp & Zonen provide the solar radiation data. The measurement sites include instruments such as the CMP 11 pyranometer, CHP 1 pyrheliometer, CGR 4 pyrgeometer and the 2AP sun tracker.

SONDA follows international standards, which makes some of these stations suitable to join the Baseline Surface Radiation Network (BSRN), part of the World Climate Research Program (WCRP) of the World Meteorological Organization (WMO). The goals of BSRN are; to provide high accuracy data for calibrating satellite-based estimates of the surface radiation budget and radiation transfer through the atmosphere; and to monitor long-term regional trends at the Earth's surface for climate change research.

Previously, new investment in the wide-scale intensive application of renewable energy technologies in Brazil has been inhibited by the lack of adequate solar and wind resource data and by the lack of tools to evaluate these data for energy planning. The necessary database is now available and will make an important contribution, not only to slowing down the growth in greenhouse gas emissions associated with the increasing Brazilian energy demand, but also to the guarantee of national energy security.

You can find out more about SONDA at:
http://sonda.ccst.inpe.br ■

Chile, High Potential but Little Solar Data

Chile is a country that heavily depends on imports to provide its energy needs. Fossil fuels provide a large percentage of the primary energy consumption, whilst renewable energy sources are still very limited. Therefore, the Chilean government has adopted renewable energy quotas for electricity production, creating interest in wind, geothermal and biomass power plants.

SOLYS 2 sun stracker at the PUC station, installed in 2010 at San Pedro de Atacama, in the Chilean desert

Strangely enough, solar energy is not yet part of the discussion. You would assume that there is a lot of solar radiation available, especially in the Northern part of the country. The climatic conditions are perceived to be better than in many other locations around the world where solar energy conversion systems are in use today.

Mr. Alberto Ortega, assistant researcher and advisor in Scientific and Technical Management, and Rodrigo Escobar, Mechanical Engineering professor, both of the Pontificia Universidad Católica de Chile, are the project leaders in the Solar Resource Assessment for Chile.

Ortega says that “A proper atlas of solar energy, with actual data of low uncertainty is not available to the public or to planning authorities. This is part of the reason why solar energy has not been considered in Chile as a major energy source. There is no bankable data that could help gather the required financing that large-scale projects need.”

They have reviewed and analyzed the available solar energy data of ground stations from several sources and compared them to satellite derived measurements obtained by the Brazilian National Institute of space research, INPE, and weather simulations from Universidad de Chile.

The available ground-station information comes from three different sources:

- A database of measurements from 89 stations throughout Chilean territory from 1961-1983
- Data from the Chilean Meteorological Service from 1989
- A network of stations at Pozo Almonte, San Pedro de Atacama and Crucero that collect data for the Chilean Comisión Nacional de Energía (CNE).

Each CNE station utilises three Kipp & Zonen CMP 11 pyranometers, a data logger, wind speed and temperature probes. One pyranometer measures global horizontal irradiance and the remaining two are mounted on a simple solar tracker.

The first measures the tilted global irradiance and the second measures the tilted diffuse irradiance by being covered with a shadow ring. Although this set-up is non-standard, and the data requires extensive post-processing, it nevertheless allows an estimate of the direct normal irradiance (DNI) with a reasonable degree of uncertainty, which is useful to assess solar energy potential.

There are locations in Chile for which data is available, but of varying quality and with interrupted periods of time. However, large regions of the Atacama Desert (in the Northern part of Chile) have no ground-station coverage and no solar radiation measurements. This is right where it is supposed, and widely discussed, that the best solar energy potential is located.

The team led by Ortega and Escobar is focusing on the development of a remote measurement technique based on satellite image processing. “The methodology works with a radiative energy transfer model in the atmosphere, utilizing climatic parameters (temperature, relative humidity, visibility, ground albedo and topography) to determine the aerosol profiles in the atmosphere.

Satellite images in the visible and infrared channels are processed as an indication of how much radiative energy is leaving the atmosphere. A special treatment allows us to detect and classify the optical properties of clouds, and the final product is an estimation of global horizontal, diffuse horizontal, and direct normal irradiance at the earth´s surface”, explains Escobar. This work, developed in collaboration with INPE, Abengoa Solar NT, the Chilean Meteorological Service and the Military Geographical Institute, aims to produce solar radiation maps for the whole country which will be published in an atlas by 2012.

The satellite-derived data needs to be validated by accurate ground station measurements. The team is deploying several Kipp & Zonen stations around the country, all of which are composed of SOLYS 2 sun trackers, CMP 11 Pyranometers, CHP 1 pyrheliometers, CGR 4 pyrgeometers and CUV 5 Ultraviolet radiometers. “The ground measurements are used to validate the satellite estimation model, and also provide valuable data in proper temporal resolution. We have chosen Kipp & Zonen as it offers accuracy and reliability”, explains Ortega, while mentioning that several of the ground stations are deployed in hostile environments such as the Atacama Desert - the driest in the world.

Mr. Ortega believes that the adoption of a proper solar atlas will result in an enhanced ability for the analysis and design of solar energy systems, thus allowing accurate project estimations. This is perceived as the first step towards the large-scale utilisation of solar energy in Chile for power generation, industrial, commercial and residential heat supply, and solar-assisted cooling ■

A CHP 1 on Every Soitec CPV Plant

Soitec's concentrated photovoltaic (CPV) power plants use lenses to focus direct sunlight onto small, extremely efficient solar cells. To check that the output is optimal a CHP 1 pyrheliometer is mounted directly onto the frame of the tracking panel.

Soitec is a leading supplier of concentrated photovoltaic (CPV) equipment for the installation of power plants in high irradiation regions. The company was founded in February 2005 as a spin-off of the world-renowned Fraunhofer Institute for Solar Energy Systems ISE, which developed the basic principles of the technology over more than ten years. At present about 80 people are employed at Soitec, which became a division of the Soitec Group (listed on Euronext Paris) in December 2009. As the world's leading innovator and provider of engineered substrate solutions, Soitec's products serve as the foundation for today's most advanced microelectronics.

CPV is a very innovative technology which is revolutionizing the solar power industry. It uses a completely different concept from conventional photovoltaic (PV) technology. CPV systems use a concentrating optic - for example, mirrors or lenses - to bundle the sunlight and focus it onto very small solar cells which convert the light into electrical energy. By concentrating the sunlight, the required active area of the solar cell is reduced to only a small fraction of the area normally required by conventional solar cells. As a result, it is economically viable to use high quality solar cells with very high efficiencies.

The CPV technology of Concentrix uses special highly efficient solar cells which were designed to power satellites and which are now being used for the first time on Earth. These III-V based triple-junction solar cells consist of three different types of cells stacked on top of each other. Each cell type is sensitized to convert a certain spectral region of the solar radiation; short wave, medium wave and the infrared range. The Fresnel lens on top of each cell concentrates the solar radiation by up to 500 times. This technology is very well suited for use in areas with high direct radiation and high temperatures.

The best efficiency is achieved when the concentrators are exactly facing the sun. The two-axis tracking system ensures that the focal point of the concentrated sunlight is right on the cells at every moment during the day, following the sun with a very high accuracy of 0.1°. The Concentrix tracking system is outstandingly robust. Even in high wind speeds, the trackers follow the sun without incurring losses.

With this technology, Soitec achieves AC system efficiencies of 25 percent, which are almost twice as high as those achieved by conventional silicon technologies. The Kipp & Zonen CHP 1 pyrheliometer is a vital component for checking and proving the efficiency of the system. For research and on installed solar power plants the accurate measurement of DNI (Direct Normal Irradiance) is crucial.

For more information visit **www.soitec.com** ■

Moldova's Solar Monitoring Station

Collecting accurate, long-term solar radiation measurements can help increase scientific understanding of the Earth's climate, and researchers in the Republic of Moldova are doing just that through their country's solar radiation monitoring station.

"All radiometric and ozone data acquired at the monitoring station are freely accessible to research centers and universities worldwide." says Dr. Alexander A. Aculinin, a senior scientist with the Atmospheric Research Group (ARG) at the Institute of Applied Physics of the Academy of Sciences of Moldova.

The ARG team is carrying out monitoring of solar radiation, aerosol optical properties and total ozone content (TOC) at the ground-based station located at the IAP in Kishinev, Moldova. The station was completed in 2003 and is situated in an urban part of Kishinev City. It was equipped using financial grants from the Civilian Research and Development Foundation (CRDF Global, USA) and the Moldovan Research and Development Association (MRDA) and under support from the AERONET project, NASA/GSFC.

The station has state-of-the-art instrumentation that consists of three principal automatically operated units; radiometric complex, Skye Instruments MiniMet automatic weather station, and a Cimel-318 sun photometer.

The radiometric complex is a key element of the whole station and it consists of the set of nine broadband radiometric sensors from Kipp & Zonen. The sensors are connected to the "brain" of the station - to the datalogger CR10X SM 4M running under remote control from PCs. Continuous measurements of direct, diffuse and total solar radiation are fulfilled within the wavelength range from UV to IR with broadband sensors such as CM 11 pyranometers, CH 1 pyrheliometer, and SP Lite, PAR Lite, UV-B and UV-A sensors. These sensors are mounted at the stationary (for total radiation) and rotating (for direct and diffuse radiation) platforms.

The monitoring station has been in operation since 2003 and is registered as a regional fixed station by the World Meteorological Organization (WMO). It is installed on the roof of the Institute of Applied Physics and is equipped with state-of-the-art radiometric instrumentation, an automatic weather station and an ozonometer.

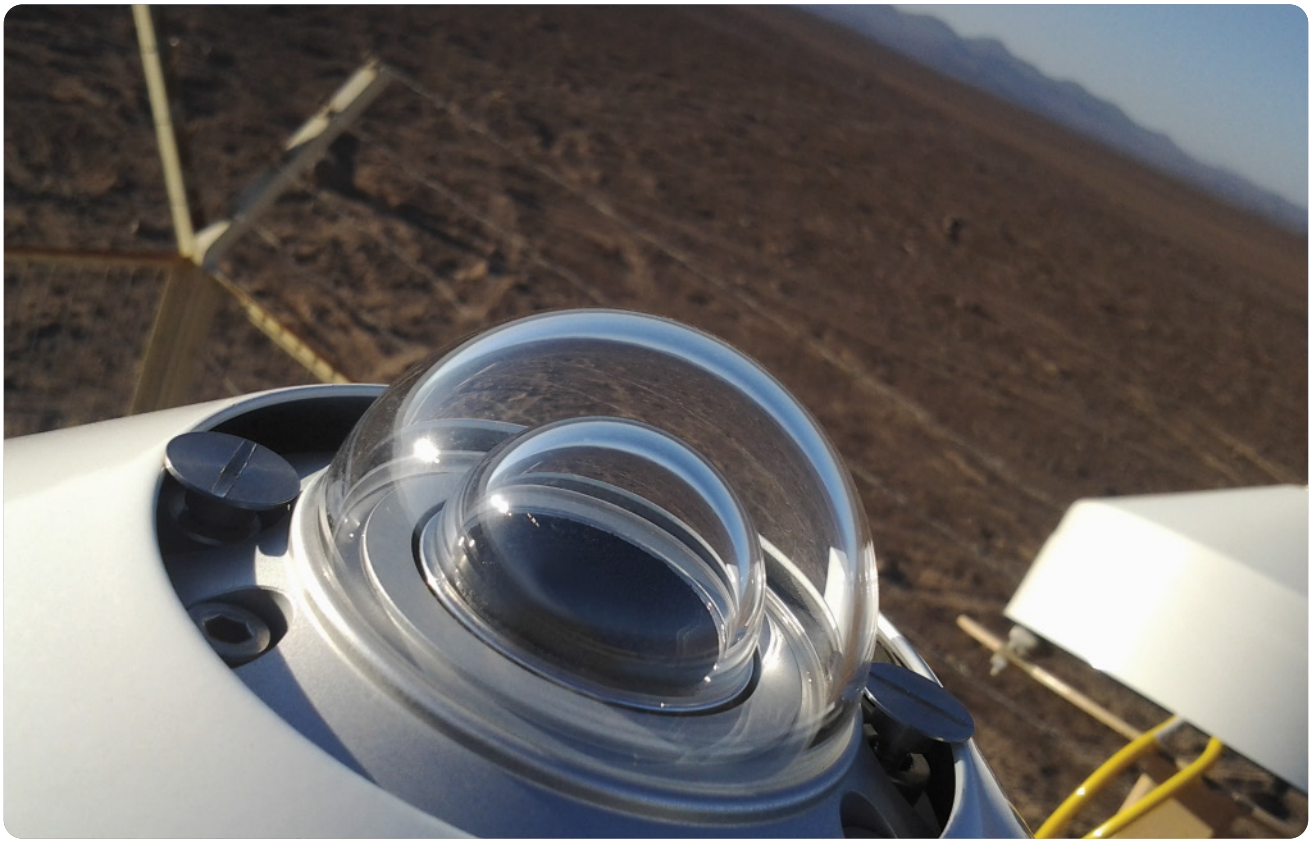
"Since the measurement program started we have the opportunity to carry out complex researches, such as interconnection between solar radiation and optical properties of atmospheric aerosols, long-term variability of these parameters and total column ozone content, to use these measurements to validate satellite observations. We've chosen Kipp & Zonen simply because it's very reliable, of course, if it is used reasonably and efficiently."

Data centers with which the team is cooperating include the World Ozone and Ultraviolet Radiation Data Center (WOUDC) and the World Radiation Data Center (WRDC) ■

UV and Solar radiation monitoring at the ground-based station in Kishinev, Moldova

Measuring Irradiation is Critical to PV Projects in Chile

By Patricia Pérez CEng, MEng, Senior Energy Analyst at Mainstream Renewable Power



Chile is located in South America, between high mountain ranges and the coast. The geography of the country covers at least seven major climatic subtypes ranging from the driest desert in the world, the Atacama, to alpine tundra and glaciers in the south. In addition, the extreme topography of the country leads to the development of microclimates.

The Andes and the Atacama desert

The Andes reach over 6,900 m above sea level and the Chilean coastal range beyond 3,000 m. Though not an isolated case, a clear example of the effects produced by microclimates is the 'Camanchaca', a thick coastal fog that occurs in the morning at low altitudes near the coast in the northern part of Chile. This fog helps to create places like the Fray Jorge Forest where, in a dry Mediterranean climate area, one can see the northernmost Valdivian temperate rainforest.

From the point of view of a solar and wind energy developer, this is challenging. Currently, the biggest source of uncertainty for large scale PV development comes from the input data. Chile has very few ground stations with high quality irradiation measurements. This forces many developers to use satellite data and solar models with very little validation. The satellite data and modelled data are typically validated via high quality ground stations. However, these are scarce in Chile and leads to high uncertainties in quantifying the long-term solar resource.

This means that planning and executing a high quality measurement campaign is essential for minimising uncertainties and giving investors comfort in the accuracy of the yield of the solar plant.

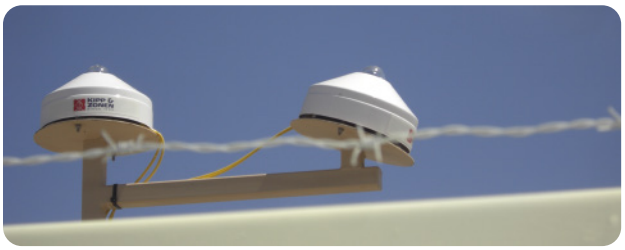
A typical Mainstream solar radiation measurement station

Mainstream is developing several PV projects in Chile, in total around 350 MW. It was clear from the start that the best way of addressing project risks was to carry out our own high quality solar radiation and meteorological measurements. This ensures that all our projects have high quality measured data that can be used with confidence in financial models.

Our measurement stations typically use two Kipp & Zonen CMP 11 pyranometers to measure irradiation, both with CVF 3 ventilation units. We use one pyranometer in the horizontal plane and another inclined in the same plane as the panels will be once they are installed. This adds some redundancy to the measurements and also allows us to reduce the uncertainties in the transposition models used. The CVF 3's ensure that we minimise suspect data due to condensation and also reduce somewhat the need for pyranometer cleaning due to accumulated dust. We also measure other atmospheric parameters such as wind speed, wind direction, humidity and temperature.

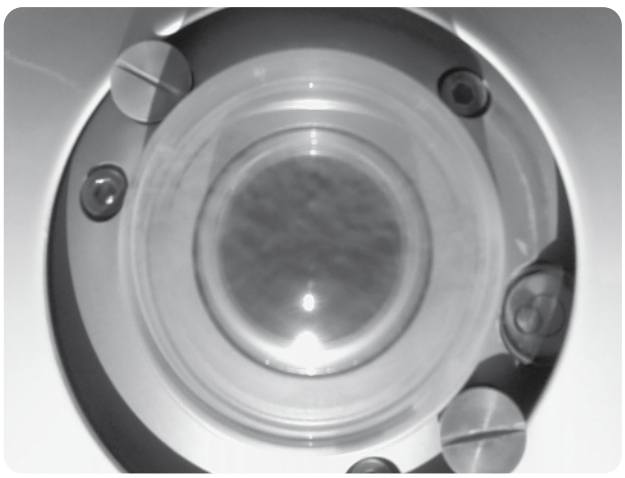
We ensure that the equipment is regularly maintained and have local contractors servicing each station several times a week. They clean the domes of the pyranometers and the solar panel that powers the data logger and the ventilation units. They also check the silica gel desiccant in the pyranometers and the CVF 3 inlet filters once a month, to monitor if they need replacements and in very remote areas they can download data to ensure we are able to carry out regular checks of the measurements.

We are aware that most of the ground stations operated locally do not follow such strict standards regarding data quality and often do not have any form of a maintenance record log. As a result the consistency and accuracy of these datasets is often questionable and in addition there is higher uncertainty in the measurements. The pictures show the effect of not cleaning pyranometer domes regularly.

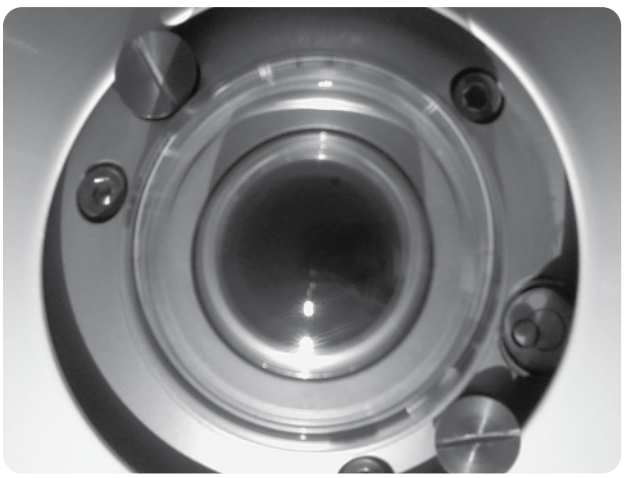


By using equipment of the highest accuracy and regularly maintaining it, we are obtaining quality datasets with the very low uncertainty that is critical to successful solar project development.

Find out more about Mainstream Renewable Power at **www.mainstreamrp.com** and their projects in Chile at **www.mainstreamrp.com/our-markets/onshore/chile** ■



Pyranometer dome before cleaning



Pyranometer dome after cleaning

Turkey's Growing Research in Solar Energy

Solar energy is becoming increasingly important in Turkey, along with other renewable sources such as hydro and wind power. There is no grid connected system yet, but an infrastructure is planned to be realised very soon.

Basic solar monitoring station with two CMP 11's in Konya City

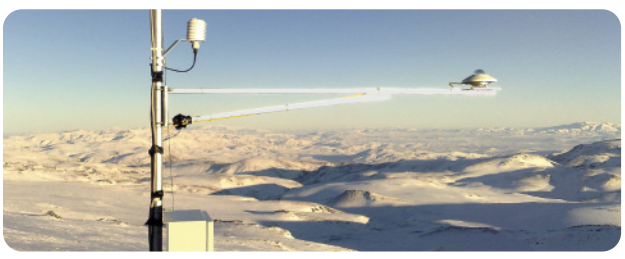
Turkey is located in an advantageous geographical position for solar power. Therefore, the energy market regulatory authority has prepared targets for solar energy investment. The goal is for 600 MW of solar electricity production plant investment by the end of 2013. Once the 600 megawatt capacity facilities are completed and producing electricity, the government plans to authorise further investments according to a structured plan.

This Authority is also working on determining standards for solar measurements. Pro-actively, some investors have already started setting up measurement stations for research and site prospecting. One of the applications is shown in the picture. This basic solar monitoring station has been installed in Konya City, Central Anatolia by a consulting company for PV panel applications. This station includes two CMP 11 pyranometers to measure horizontal global radiation and tilted global radiation.

For the measurement of solar energy resources Elite AS have been installing solar energy measurement stations for investors and consulting companies in Turkey. The most commonly used instrument is the CMP 11 pyranometer, for the measurement of global radiation for fixed PV panel applications. When the measurement of direct solar radiation is needed, for CSP applications, we have installed complete solar monitoring stations with a SOLYS 2 sun tracker, CMP 11 pyranometer and CHP 1 pyrheliometer.

Elite AS has been working on measurements for meteorology and environment in Turkey for 25 years and has installed hundreds of measurement stations and systems at various sites across the country. Applications include; research, general meteorology, renewable energy and agriculture. Elite supplies and supports the best quality sensors and systems for such applications including, of course, Kipp & Zonen.

Find out more at **www.elite.com.tr**



Installation on Erzurum Palandöken Mountain

Four SOLYS 2 Sun Trackers at ACCIONA's Palma del Río I & II CSP Plants

Thanks to our Spanish distributor Dilus Instrumentación y Sistemas S.A. we had the unique opportunity to shoot part of our new corporate video at two Concentrating Solar Power Plants of ACCIONA Energy; Palma del Río I and II. The two are identical plants right next to each other. Together they have four of our SOLYS 2 sun trackers in operation to provide the control rooms with input of the real-time direct, global and diffuse solar radiation.

ACCIONA Energy is a leading company in the development of renewable energy sources. The company has installed 9,766 MW for clean energy generation of which it owns and operates 8,211 MW in 13 countries. The company works in a wide range of clean technologies; wind, hydro, CSP, photovoltaic, biomass, biodiesel and bioethanol.

ACCIONA Energy is one of the world's top firms in concentrating solar power, owning a total of 264 MW of capacity in four operational plants in Spain and one in Nevada (USA). With the opening of Orellana (Badajoz, Spain) this summer, a total capacity of 314 MW will be reached in 2012. That means more than one million mirrors and enough power to supply around 170,000 homes.

Located in the municipality of the same name in Cordoba province, Palma del Río I went into service in 2011, seven months after its 'twin' plant Palma del Río II, situated alongside it. The two Palma del Río plants generate renewable energy equivalent to the consumption of around 70,000 homes a year, avoiding the emission of approximately 220,000 metric tons of CO_2 into the atmosphere from conventional coal-fired power stations. Together, the plants have a solar field of 270 hectares with a potential of 100 MW.

Palma del Río I and II are based on parabolic trough technology. This consists of mirrors installed in rows that concentrate the sun's rays into pipes where a fluid is heated to around 400 degrees Celsius. This energy is then used to produce steam and drive a conventional turbine that, connected to a generator, produces electricity.

Like the plants, there are also 'twin' platforms, both with two of our SOLYS 2 sun trackers. In 2011 Dilus installed the platforms for weather and solar radiation monitoring at the power plants. On each platform there is one SOLYS 2 sun tracker with pyrheliometer for direct radiation, a pyranometer for global radiation and a shaded pyranometer for diffuse radiation. The second SOLYS 2 sun tracker functions as a back-up and only measures direct radiation with a pyrheliometer. The measurement data is stored and transferred to provide the control room with real-time inputs to monitor the yield of the CSP plant.

The result of filming two days at ACCIONA's CSP plants can be found on **www.youtube.com/kippzonen** and shows the greatness and beauty of it. Thank you ACCIONA Energy for your hospitality and thank you Dilus for all the assistance in preparation and during our stay at Palma del Río.

For more information about Acciona Energy go to **www.acciona.com** and for Acciona Concentrating Solar Power (CSP) plants in Spain, **http://www.acciona-energia.com/activity_areas/csp/installations/plantsinspain.aspx**

Setting Up a SOLYS 2 in Braşov, Romania

On 24th October 2012 experts from Echipot S.R.L., our distributor for Romania, together with researchers from the Transylvania University of Braşov, installed and set up a solar radiation measurement system supplied by Kipp & Zonen.

The solar station is based on a SOLYS 2 sun tracker and monitors global, diffuse and direct solar radiation in the short wavelength range, as well as atmospheric radiation in the far infrared. To optimise performance the pyranometers and the pyrgeometer are ventilated.

With this system, complex monitoring of solar radiation will be performed for the first time in Romania at world-class level, using the best instruments available.

The SOLYS 2 system operats within the Centre for Renewable Energy and Recycling Systems of Transylvania University Braşov. It will provide precise solar radiation data for research concerning development, simulation and comparison between solar energy conversion systems (photovoltaic and thermal) in real weather conditions.

Precise solar radiation data play an important role in designing solar arrays and farms; as well as in developing the software to control the orientation of the panels, which means programming the control system of the stepper motors. Solar radiation is the main input parameter both in designing systems that convert solar energy into thermal and electrical energy, and in building management systems.

The data recorded by the solar station can be used to precisely calculate the solar energy available at a given location for thermal and photovoltaic panels. The solar database obtained in this way becomes the best starting point for predicting the output of thermal and PV solar systems in the area of Braşov city.

The same data will be of great use in calculating the true price/performance ratio of solar energy conversion systems.

We wish the Centre success in their research work performed with these high-end instruments!

The Echipot website is at **www.echipot.ro** and you can find out more about the Transylvania University of Braşov at **www.unitbv.ro/en/home.aspx** ■

Solar Monitoring in Qatar

Launched in 2011, QEERI is the Qatar Environment & Energy Research Institute and a member of the Qatar Foundation for Education, Science and Community Development. QEERI is conducting research in the areas of Concentrated Solar Power (CSP), Efficient PV Systems and the effect of dust on Solar Collectors. A Reference Solar Monitoring Station was installed in Doha, Qatar to obtain accurate solar radiation data for research and investigation.

The CMP 11 pyranometers and CGR 4 pyrgeometer being fitted on CVF 3 ventilation units before the covers are mounted

Concentrated Solar Power is used for generating electricity and for water desalination. Other points of interest are the Qatar Energy footprint and a Qatar solar atlas. Even though oil and gas are still important export products of Qatar, QEERI is looking to the future for alternatives and clean long term solutions.

In November 2012 Ruud Ringoir from Kipp & Zonen visited Doha to install and commission a Solar Monitoring Station for the Alternative Energy Group of QEERI, on the roof of a building of the Qatar Foundation. Together with Dr. Mokhtar Chmeissani, an affiliate scientist in the Alternative Energy group, Dunia A. Bachour and Dr. Daniel Perez Astudillo, both researchers at QEERI, the station was installed and operating in three days.

Dr. Daniel Perez Astudillo, Dr. Mokhtar Chmeissani and Ruud Ringoir

The basis of the station is a SOLYS 2 sun tracker with sun sensor kit and shading ball assembly. The system measures Global and Diffuse radiation with CMP 11 pyranometers. Direct radiation is measured with a CHP 1 pyrheliometer and the long-wave (FIR) radiation with a CGR 4 pyrgeometer. The three top-mounted radiometers are fitted with CVF 3 ventilation units.

Dunia A. Bachour mounting a CMP 11 pyranometer

The instruments are connected to a COMBILOG data logger with 230 VAC power supply and a 12 V battery with solar panel as backup. Communication between the data logger and a computer is via RS-232 cable. However, when the station is moved to its final location communication will be via GSM/GPRS modem. The selection of the site will be based on availability and an optimal free field of view ■

Passion for Precision

Kipp & Zonen is the leading company in measuring solar radiation and atmospheric properties. Our passion for precision has led to the development of a large range of high quality instruments, from all weather radiometers to complete measurement systems.

We promise our customers guaranteed performance and quality in; Meteorology, Climatology, Hydrology, Industry, Renewable Energy, Agriculture and Public Health.

We hope you will join our passion for precision.

HEAD OFFICE

Kipp & Zonen B.V.
Delftechpark 36, 2628 XH Delft
P.O. Box 507, 2600 AM Delft
The Netherlands

T: +31 (0) 15 2755 210
F: +31 (0) 15 2620 351
info@kippzonen.com

SALES OFFICES

Kipp & Zonen France S.A.R.L.
7 Avenue Clément Ader
ZA Ponroy - Bâtiment M
94420 Le Plessis Trévise
France

T: +33 (0) 1 49 62 41 04
F: +33 (0) 1 49 62 41 02
kipp.france@kippzonen.com

Kipp & Zonen Asia Pacific Pte. Ltd.
10 Ubi Crescent Lobby E
#02-93 Ubi Techpark
Singapore 408564

T: +65 (0) 6748 4700
F: +65 (0) 6748 6098
kipp.singapore@kippzonen.com

Kipp & Zonen USA Inc.
125 Wilbur Place
Bohemia
NY 11716
United States of America

T: +1 (0) 631 589 2065
F: +1 (0) 631 589 2068
kipp.usa@kippzonen.com

Go to www.kippzonen.com for your local distributor or contact your local sales office

KIPP & ZONEN
SINCE 1830