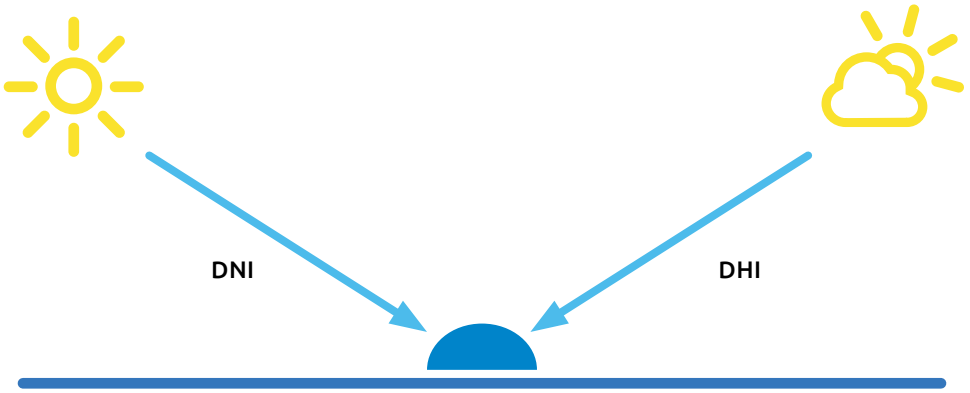
SOLAR RESOURCE ASSESSMENT

HOW AND WHAT TO MEASURE

KINTECH ENGINEERING



Global Horizontal Irradiation (GHI) = DHI + DNI x cos (Θ)
Θ is the solar zenith angle

DHI is the Diffuse Horizontal Irradiation
DNI is the Direct Normal Irradiation

BRIEF INTRODUCTION

Gathering data on radiation and meteorological data is key for estimating and simulating the prospective energy yields and the operation and maintenance costs incurred by environmental conditions that might impair the operation of a large scale solar power plant.

Depending on your target technology - CSP or photovoltaic - our technical department will support you in choosing the best instruments and technologies like precision sun trackers, pyranometers, pyrheliometers, shadow rings, etc.

In order to perfectly characterize the solar radiation conditions several components has to be measured and quantified.

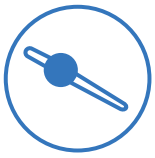
Depending on your target technology some components of the radiation are more important to measure than others.

Apart from the solar irradiation components, there are several other factors that influence on the power output of a solar power plant.

Our solar resource assessment product portfolio offers a complete set of instruments for the utility-scale photovoltaic project developer. From the data logger to the sensors all the way down to installation and maintenance.

Here are some of the other components to consider measuring:

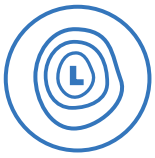
Wind speed (important when calculation loads on the support structures for the solar panels).



Wind direction (important when calculation loads on the support structures for the solar panels).

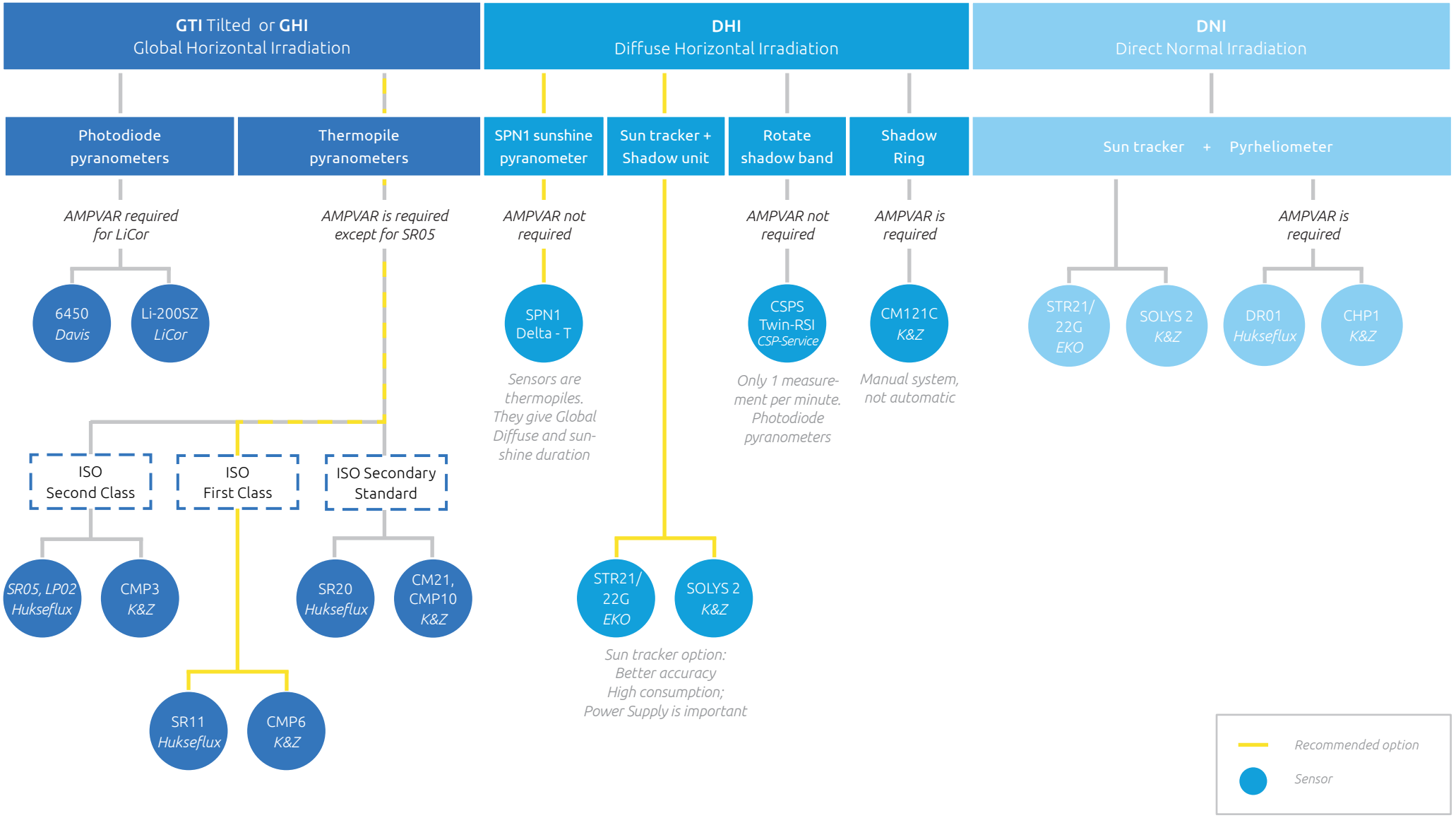
Ambient temperature (the higher the ambient temperature, the lower the efficiency of a photovoltaic solar panel).

Relative humidity (this is important to calculate the dew point and to know when the mirrors in a thermosolar plant are wet or when the photovoltaic solar panels are covered with dew).



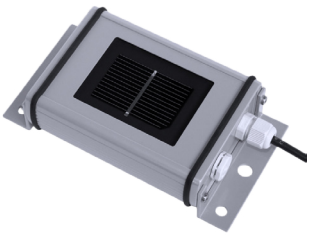
Atmospheric pressure (pressure variations affect the solar farm production)

Rainfall (this affects the amount of dirt on the solar panels as well as the mirrors (CSP))


GTI Tilted or GHI
Global Horizontal Irradiation
DHI
Diffuse Horizontal Irradiation
DNI
Direct Normal Irradiation
Photodiode pyranometers
Thermopile pyranometers
SPN1 sunshine pyranometer
Sun tracker + Shadow unit
Rotate shadow band
Shadow Ring
Sun tracker + Pyrheliometer
AMPVAR required for LiCor
AMPVAR is required except for SR05
AMPVAR not required
AMPVAR not required
AMPVAR is required
AMPVAR is required
6450 Davis
Li-200SZ LiCor
SPN1 Delta - T
CSPS Twin-RSI CSP-Service
CM121C K&Z
STR21/ 22G EKO
SOLYS 2 K&Z
DR01 Hukseflux
CHP1 K&Z
Sensors are thermopiles. They give Global Diffuse and sun-shine duration
Only 1 measure-ment per minute. Photodiode pyranometers
Manual system, not automatic
ISO Second Class
ISO First Class
ISO Secondary Standard
SR05, LP02 Hukseflux
CMP3 K&Z
SR20 Hukseflux
CM21, CMP10 K&Z
SR11 Hukseflux
CMP6 K&Z
STR21/ 22G EKO
SOLYS 2 K&Z
Sun tracker option: Better accuracy High consumption; Power Supply is important
Recommended option
Sensor

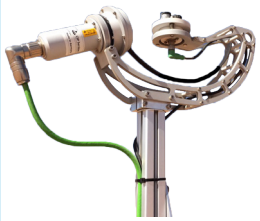
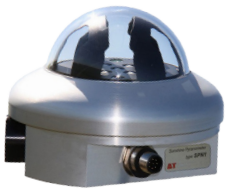
Here are some examples of solar radiation measurement stations depending on the variable you want to measure:

GLOBAL IRRADIATION

	WHAT YOU NEED TO MEASURE GHI (GLOBAL HORIZONTAL IRRADIATION) AND GTI (GLOBAL TILTED IRRADIATION)		
	Thermopile Pyranometers	**Calibrated solar cell**	**Photodiode Pyranometers**
			
ISO Clasification	Yes	No	No
Uncertainty	≈2%	10%	5%
Spectral response	High	Low	Low
Cost	$$$	$	$
Response speed time	Low	Fast	Fast
Heat and ventilation option*	Yes	No	No
Secondary Standard Pyranometers	Hukseflux SR25, SR22, SR20 Kipp & Zonen CMP10, CMP11, CMP21 EKO Instruments MS-802	Not available	Not available
First Class Pyranometers	Hukseflux SR12, SR11 Kipp & Zonen CMP 6 EKO Instruments MS-402	Not available	Not available
Second Class Pyranometers *(not to be confused with Secondary Standard)*	Hukseflux SR03, SR05, LP02 Kipp & Zonen CMP3 EKO Instruments MS-602	Not available	Not available
Without classification	-	Ingenieurburo: Si-13TC	Davis Instruments: #6450 Li-Cor: Li200-SZ
Amplifier required for Zenith	Yes	No	No
Typical applications	PV resource, Fixed PV plants, Meteorology	Fixed PV plants, Meteorology	Green Houses, Meteorology, Agriculture

**To keep the outer dome on the pyranometer at the same temperature as the surrounding air temperature. This will keep the zero (a) offset as low as possible. But also to keep the dome as dry and clean as possible (from rain snow, ice and dirt).*

DIFFUSE HORIZONTAL IRRADIATION

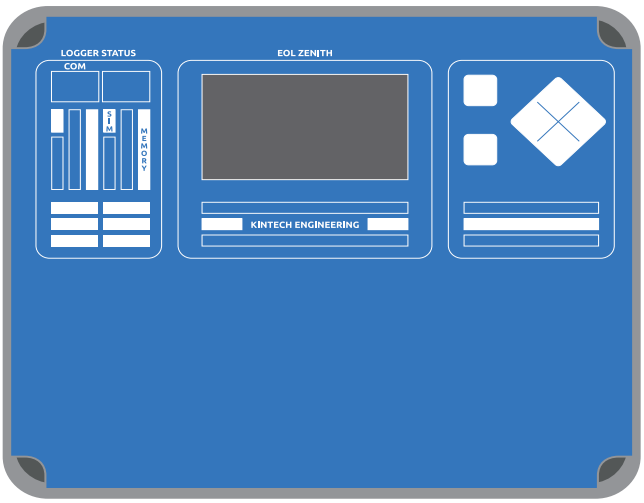
	WHAT YOU NEED TO MEASURE DHI (DIFFUSE HORIZONTAL IRRADIATION)			
	Shadow ring	**Rotating shadow band**	**Sunshine Pyranometer SPN1**	**Sun tracker with Shadow unit**
				
ISO Clasification	Yes	No	No	Yes
Uncertainty	≈2%	5%	5%	≈2%
Spectral Response	High	Low	Low	High
Estimated costs	$	$$$$	$$$	$$$$
Response speed time	Low	High	High	Low
Model	CM121B/C	CSPS Twin-RSI	SPN1	STR22G, SOLYS2
Other specs	Not automatic method. Required adjust each 3-4 days.	Photodiode pyrano-meter. Only 1 diffuse measure each minute.	Give GHI, DHI and Suns-hine duration. No moving parts. Sensor are 7 miniature thermopiles.	The most accurate method
Amplifier requiered for Zenith	Yes	No	No	Yes
Typical Applications	Fixed PV installations, Concentrated Solar Power and redundancy calculations of GHI			

In case you use the option “Pyranometer with Shadow unit installed on sun tracker” the Sun tracker can also be used for measuring DNI.

DIRECT NORMAL IRRADIATION

	WHAT YOU NEED TO MEASURE DIRECT NORMAL IRRADIATION (INSTALLED ON SUN TRACKER)	
	Hukseflux DR02	Kipp&Zonen CHP1
		
ISO Clasification	First class	First class
Uncertainty	≈2%	≈2%
Spectral Range	200 to 4000 nm	200 to 4000 nm
Cost	$$	$$$
Response time	2 sec	< 5 sec
Temperature response	<±0.4%	<0.5%
Field of view	5°	5 ±0.2°
Amplifier required	Yes	Yes
Typical app	Concentrated solar power and concentrated PV power	

EOL ZENITH DATA LOGGER FOR SOLAR RESOURCE ASSESSMENT



Gathering data on radiation and meteorological data is crucial for estimating and simulating prospective energy yields. The EOL Zenith data logger is designed for solar resource assessment as well as monitoring of solar plants.

GPS

The EOL Zenith includes a GPS module, providing perfect timing, accurate positioning of the met mast for micrositing as well as simplifying site management and supervision. The GPS module also allows the user to view their mast position(s) directly in Google Earth.

GSM / GPRS COMMUNICATION

The EOL Zenith includes a GSM/GPRS modem for communicating remotely with the data logger. Download data, collect real-time values and refine the logger settings remotely.

THE EOL ZENITH DATA LOGGER

The EOL Zenith collects data in compliance with IEC 61400-12 for high quality wind assessment campaigns, where maximum performance and reliability is a must. The perfect combination of data logger technology together with the most advanced software for modern wind assessment.

The EOL Zenith is suitable to work in all climates (from the north of Norway to the desert in Saudi Arabia). This is thanks to the carefully designed electronics, the robustness and reliability as well as the low power consumption (something very important when you are operating equipment in remote areas and unique to the EOL Zenith data logger).

The EOL Zenith is the 3rd generation data logger from Kintech Engineering. The EOL Zenith features 1 Hz sampling rate (complying with IEC 61400-12), extended turbulence calculation (TI30), st. dev., max. and min. for all input channels and advanced sensor error diagnosis (e.g. wind vane st. dev.). Real time data together with the Tower Management Tool (TMT) helping you to keep track of all your wind assessment sites.

ABOUT AMPVAR

The signal from radiation sensors with Thermopile technology such as pyrheliometers and pyranometers is very low (measured in mV).

To accurately measure the signal with the data logger (analog input range 0 to 5V), we amplify the signal and adapt it to values ranging from 1 to 5 Volts.

The AMPVAR is a current amplifier and includes a precision resistor which means that the result is an output in voltage.

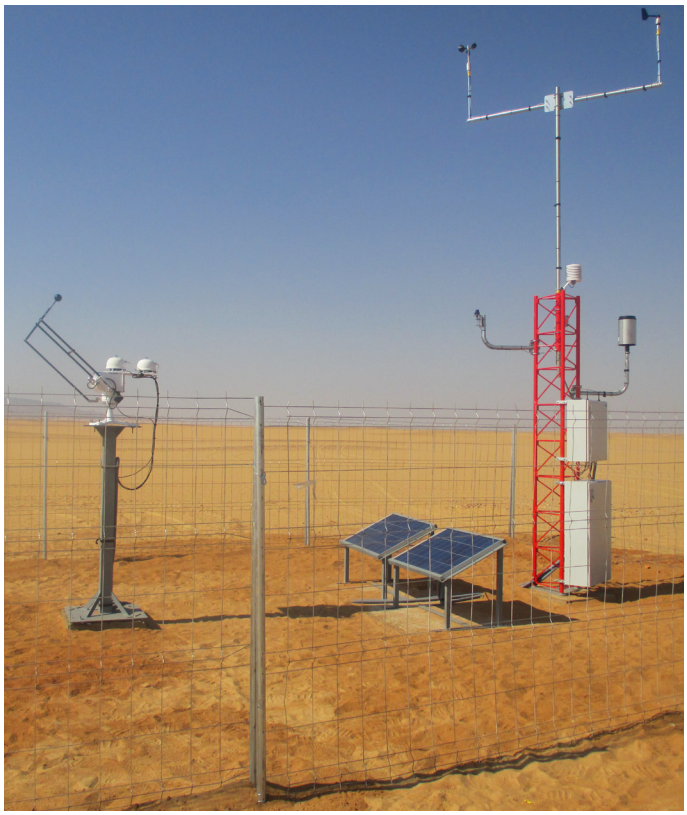
REFERENCE PROJECTS

The assessment of solar resources is one of the most important phases in the development of a solar energy project. The data obtained determines project viability. We have supported the development of solar farms in many different countries with our products and services since 1999 including, at the time, the biggest double axes solar farm in Spain.

Photovoltaic solar farm

Spain 2008

In the year 2008 Kintech Engineering was contracted to install what was to become our first meteorological met towers for controlling 6 separate photovoltaic solar farms for Iberdrola (a total of 18 meteorological masts). Some of them with fixed structures and others mounted on dual axe sun trackers. The biggest of the solar farms (located in Abertura, Caceres) with 20 MW was at that time the world's biggest solar farm with double axe sun trackers.



Solar Resource Assessment

Egypt 2015

As part of the Benban project in Egypt, Kintech Engineering supplied instrumentation for the solar resource assessment campaign. The measurement station was designed for a complete solar resource campaign including autonomous power supply, intelligent on/off system, Sun tracker and Pyranometers from Hukseflux. The EOL Zenith data logger, equipped with GPRS communication and GPS synchronization, was used to collect all the data with 24 hour remote access for our customer.

Last modified: 19.05.2017

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