GREENHOUSE
GUIDELINES

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GUIDELINES FOR GREENHOUSE GROWERS

Modern greenhouses are filled with high-tech tools and systems for monitoring and controlling the growing environment. They typically include:

- automated window operations
- computerized climate-control ventilation fans and heaters
- CO_2 level monitoring
- automated irrigation and nutrient delivery systems

The Aranet solution uses wireless sensors that can transmit data readings every minute to the centrally located base station (gateway). This provides ultimate flexibility for moving the sensors around while finding the most suitable placement – independently of any wiring!

The Aranet system helps to fine-tune your growing operations to maximize yield by monitoring:

- Air temperature and humidity
- PAR light level
- CO_2 level
- Water level in the substrate
- Salinity (EC) level in the substrate
- Temperature of the substrate
- Weight of the substrate and plants
- Micro-variation of stem diameter

> Read further for suggestions and tips for positioning Aranet sensors. There is a unique breathing environment in every greenhouse. Aranet wireless sensors allow you a complete freedom to experiment with the placement of sensors – try out until you find out what works the best for your individual greenhouse configuration.

GENERAL GUIDELINES FOR SENSOR PLACEMENT

First of all you will need to estimate the maximum height of your plants when they reach the harvest time. We suggest placing the base station as high as possible and the sensors roughly a foot or 30 centimetres above the maximum expected height of the plants.

The large water content in the plants and fruits is the main contributor to weakening of the radio signal if the sensors and base station are placed too low.

This is a good example of the placement of the temperature and RH sensor with convection shield – placed well above the plants for good signal transmission.

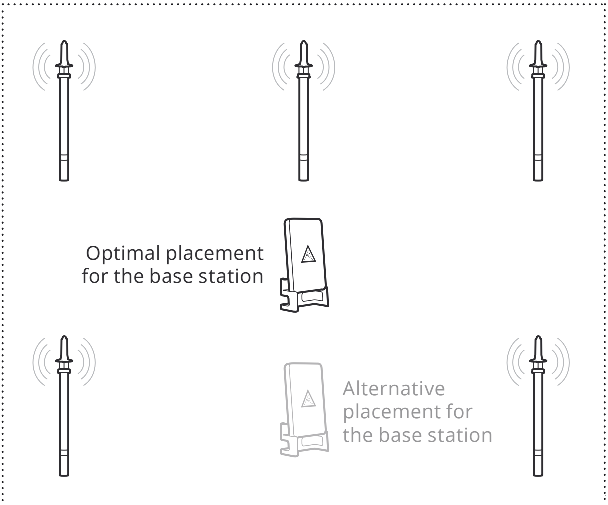
In this example the weight load device is placed correctly but the transmitter (white body) is positioned too low – below the maximum height of the plants.

This is a good example of how a weight sensor should be installed. Both the weight load cell and the transmitter (white body) are positioned above the maximum height of plants.

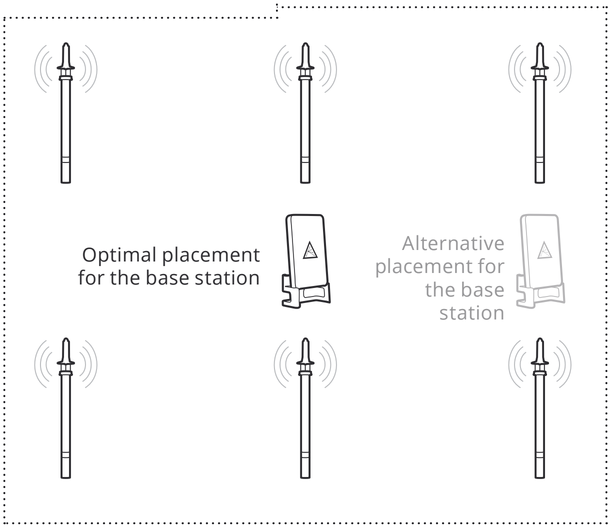
POSITION OF THE BASE STATION

Ideally you should place the base station in the middle – with all of the sensors that are sending their data to it surrounding the base station. Remember to install the base station as high as possible – well above the maximum height of the plants.

If the base station can't be placed in the middle of the greenhouse or the section, place it in another convenient location and check to make sure you are getting a good signal from all of the sensors, including the furthest ones.



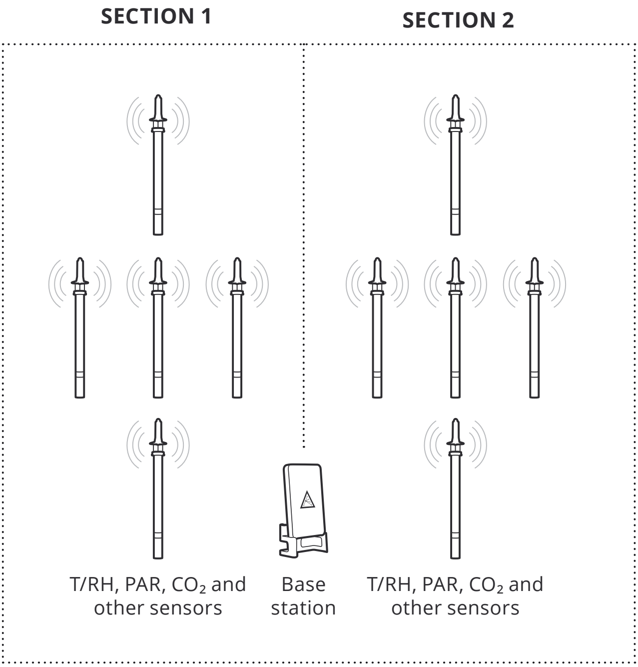
According to our observations the distance between base station and sensors can be up to 100 – 150 meters (350 – 500 feet) in a typical greenhouse (steel construction, glass walls with few gates/doors).

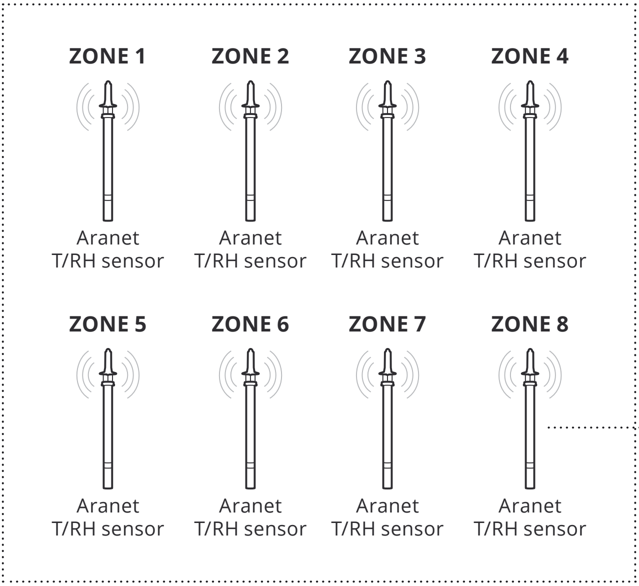


HOW MANY SENSORS DO I NEED PER SECTION?

We often get the question of the amount of sensors needed per section. The answer to this is that it depends.

If your greenhouse is divided into several sections with each section containing windows that can be opened and closed, working ventilation outlets, possibility to regulate temperature, adjust the CO_2 gas level, adjust the content and amount of the irrigation solution, then typically one type of each of our horticulture solution sensors per section should be sufficient (T/RH, CO_2, Soil moisture level, Weight, PAR sensor).



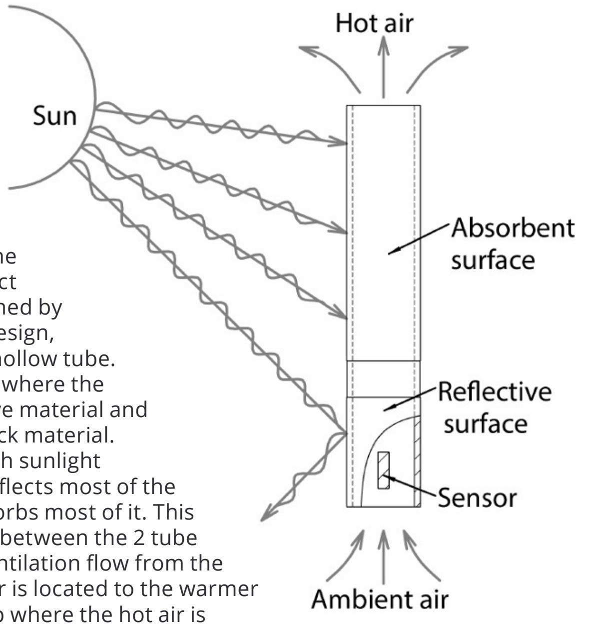


Aranet T/RH sensor with Convection Radiation Shield

Regardless of the number of sections, sometimes you need temperature and relative humidity control down to individual zones. You can add up to 100 sensors per base station – add as many as you need for micro-control of your greenhouse.

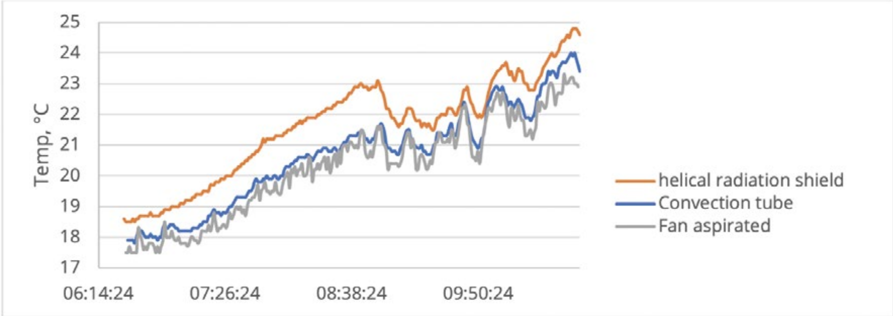
MEASURING TEMPERATURE AND RELATIVE HUMIDITY INSIDE A GREENHOUSE

The **Aranet T/RH sensor with Convection Radiation Shield** <u>**should always be used**</u> to measure **temperature** and **relative humidity** accurately inside the greenhouse where there is possibility of direct sunlight hitting the sensor. This is the only sensor capable of eliminating the effects of sensor heating due to direct sunlight exposure. This is accomplished by an innovative, elegant, and simple design, where the sensor is placed inside a hollow tube. The tube is divided into 2 segments, where the bottom one is coated with a reflective material and the top segment is coated with a black material. These two coatings each interact with sunlight differently – the reflective coating reflects most of the sunlight, whereas the black one absorbs most of it. This results in a temperature differential between the 2 tube segments, which drives a passive ventilation flow from the cooler bottom part where the sensor is located to the warmer black part and eventually out the top where the hot air is exhausted.



In experiments comparing regular T/RH sensors to the Radiation Shield sensor, a difference of **up to 7 °C (~15 °F)** can be observed. This highlights the importance of using this particular sensor as opposed to any other T/RH sensor – if you are making decisions based on temperature measurements that are off by 7 °C degrees, you might as well be better off

If we compare the Aranet T/RH sensor with Convection Radiation Shield with other products on the market, that aim to achieve a similar goal of eliminating direct sunlight effects, we can see that it performs better than other passive solutions (helical radiation shield) and nearly **equivalent to actively cooled fan based solutions at a fraction of the cost**.

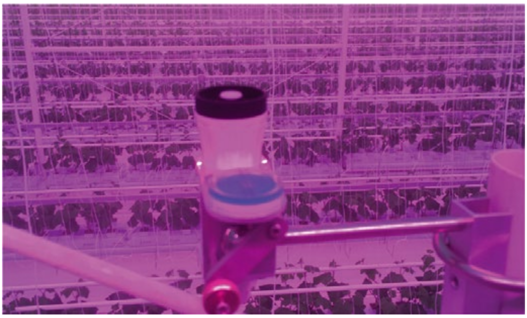


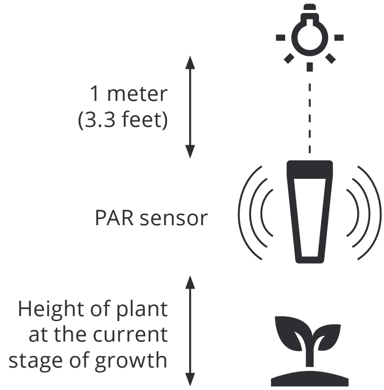
SOIL MOISTURE, EC AND TEMPERATURE SENSOR

The placement of the Aranet Soil moisture, EC and T sensor depends on the type of substrate you are using in your greenhouse. For some users and greenhouses, the best results will be achieved by inserting the probe in the substrate – the needles of the sensor – from the top, for others it works the best to insert them from one of the sides. For optimal results, experiment with the position of the probe until you achieve accurate readings. Once you find the best placement for you the adjustment of the calibration curve should be performed (see the Aranet SensorHUB software for details).

Our experience with 10 centimeters (4 inches) thick rockwool slabs shows that the most accurate results are achieved when placing the sensor probe horizontally on one of the sides of the slab and 4cm from the bottom and in the middle of the length of the slab (as pictured in the image above).

PAR SENSOR





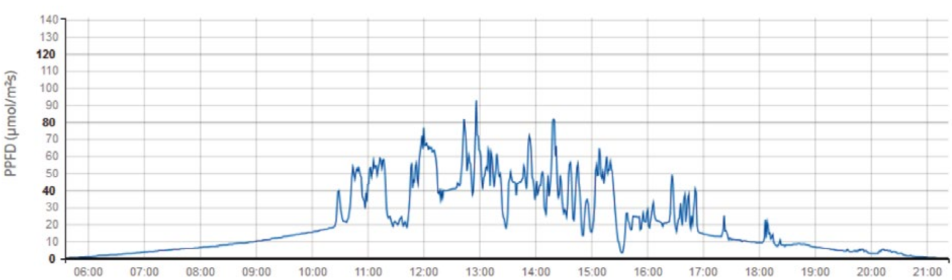
The PAR (photosynthetically active radiation) sensor measures the amount of light radiation (within 400 – 700 nm) that your plants are exposed to. The total amount of light radiation consists of sun radiation plus any artificial source of light from specialized light bulbs or LED lamps.

It's important to place the PAR sensor in a position with equal amounts of light shining on it from different LED lamps.

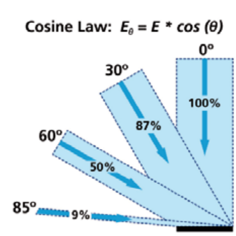
If possible try to position the PAR sensor about 1 meter below the LED lamps and close to the height of your plant at the current stage of growth.

ARANET PAR SENSOR FAQ

THE CURVE FROM MY PAR SENSOR IS JAGGED. SHOULDN'T IT BE SMOOTH? WHAT IS HAPPENING?

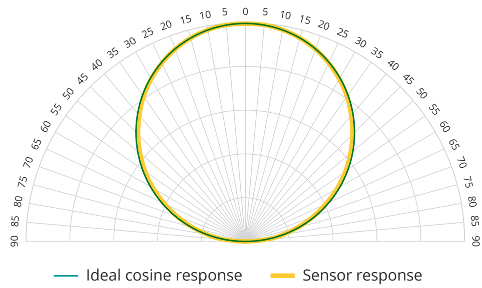


First of all, here are some basics about measuring light. The PAR sensor measures light in micro-moles per square meter second. What does that mean? To put it simply it counts the number of photons – particles of light – that hit the surface area of the detector every second. The surface of the detector is flat, so the angle of the light also matters. If the sun is directly above the sensor, it receives its light entirely. If the sun comes in at an angle, the sensor gets less light. How much light exactly? That is described by the cosine law:



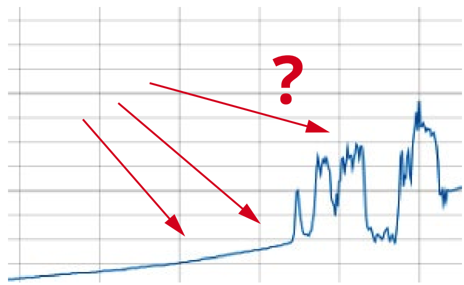
That' s why we also show the typical cosine response of the sensor – the relative measurement of light depending on the angle from which the light is coming – in our datasheets. It matches almost perfectly the cosine law illustrated above.

TYPICAL COSINE RESPONSE



So essentially there are two effects that can make PAR curve jagged. The first one is straightforward – as the sun moves across the sky, the construction of the greenhouse casts a shadow on the detector. When there is a shadow on the detector, it detects less light. Therefore, it can cause drops in the curve.

The second effect is more subtle. At certain times during morning and evening there are jumps in the measurement. It looks like the detector suddenly receives more light. How can that be?



The answer lies in the clouds which might seem counter-intuitive at first. When the morning sun shines at an angle on a cloudless day, the light received by the detector follows the cosine law.

However, if there are clouds right above the detector that don't block the sun itself, the sunlight can be reflected from the cloud. In that case, the detector receives the same amount of light from the sun as in the first case – plus additionally the reflected light from the cloud. Therefore, the PAR reading in this case is higher.

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For more detailed information about Aranet products, please visit www.aranet.com, contact your Aranet representative or write to info@aranet.com. Product specifications are subject to change without prior notice.