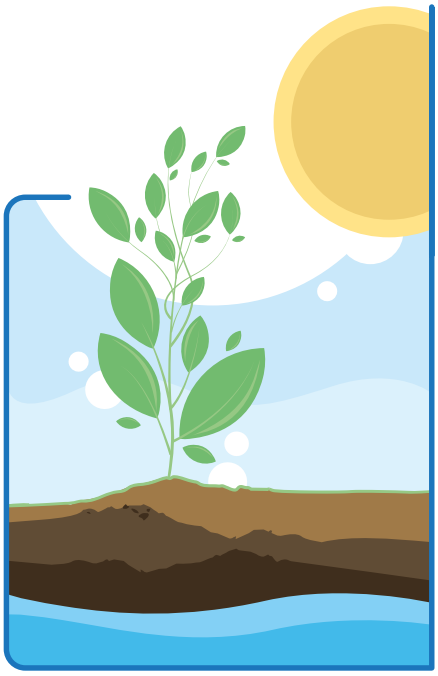
Fuji Electric

Innovating Energy Technology

Increase the yield and the quality of greenhouse crops with an accurate CO_2 control

Food Farming



Photosynthesis is life

Photosynthesis is clearly the source of the oxygen we breathe, but also the food we eat. Without the photosynthesis process, the light energy would not convert carbon dioxide into oxygen.

This unique process is more or less efficient depending on severals parameters, including the carbon dioxide concentration in the surrounding air.

Photosynthesis makes our life sweeter

Did you know that in addition with oxygen, our plants also generate sugar?

As well as carbon dioxide, the plant needs sugar to grow. And the key point is that it indeed creates sugar by itself. Minerals, water and light are the other components required.

Photosynthesis reaction is then as follows:

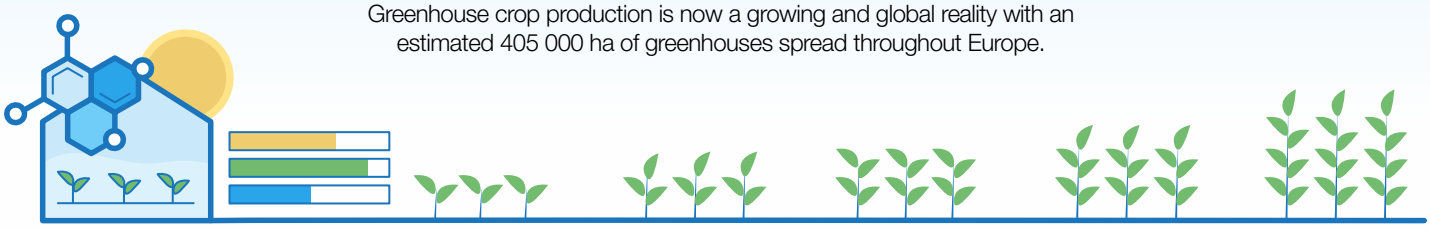
$CO_2 + H_2O + Light \longrightarrow Sugar + O_2$

The plant more precisely uses this sugar as a fuel. It allows it to generate new cells and, in a way, to breathe.

Why monitoring CO_2 in greenhouses?

The answer is now straight forward: in order to optimise the photosynthesis process thus stimulating and controlling growth of plants.

Greenhouse crop production is now a growing and global reality with an estimated 405 000 ha of greenhouses spread throughout Europe.



The last 20 years have seen a revolution in greenhouse cultivation and technologies.
Just a few years ago, a tomato yield of 100 tonnes/ha in a greenhouse was considered a good performance.
Today, a harvest of 600 tonnes/ha is not unusual in high-tech greenhouses."

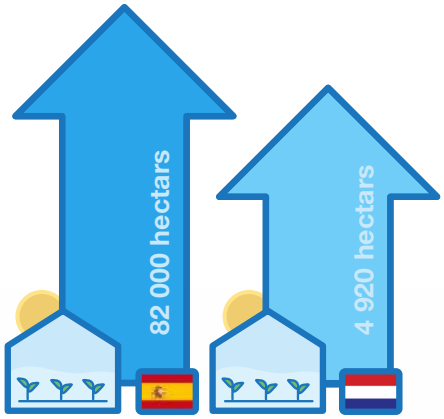
Hans Dreyer, Director of Plant Production and Protection Division
at Food and Agriculture Organization of the United Nations

Greenhouses are required everywhere to optimise crops growth

One may think that world areas where the sunshine is abundant do not require greenhouses.
But this is not true.

Depending on the plant cultivated, here again CO_2, as well as temperature and air speed, is a key parameter, and its optimal level varies. The CO_2 concentration in ambient air, is famous for increasing dramatically since the industrial revolution, and faster and faster nowadays.

However, its average level is currently around 400 ppm (parts per million) which means 0,04% of the air we breathe, whereas, for instance, under adequate light and temperature conditions, tomatoes grow best with 900 ppm and cucumbers with 700 ppm.



Carbon dioxide optimal concentration for growth

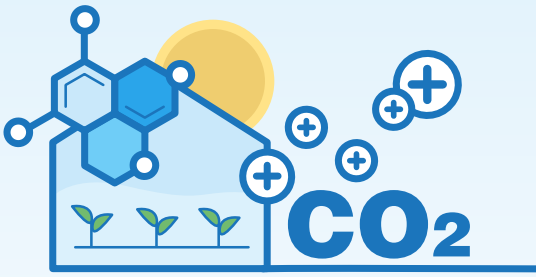
It appears then obvious that CO_2 controlled the atmosphere, thus greenhouses are to be developed at any place in order to meet the challenge of human nutrition in the coming years.

The Netherlands are well known as the pioneer country for crop growth in climate-controlled houses. With the huge and still growing number of 9000 large greenhouses, which occupy 0.25% of the total land area, this market represents a significant part of the country's GDP. 150 000 workers are employed and 80% of the products are exported.

Spain is also famous famous for having one of the largest greenhouses in the world. This is in Almeria, where greenhouses cover almost a 200km2 area.

Almeria, Spain, greenhouses

How to control CO_2 enrichment in a greenhouse ?



Supplementary CO_2 should be used during periods of sunny weather, but not in cloudy weather or at night.

It can be extracted from burners using oils or natural gas. In such cases, care must be paid to avoid the presence in the greenhouse of toxic gases – whether for plants (SO_2, ethylene etc.) or humans (carbon monoxide).

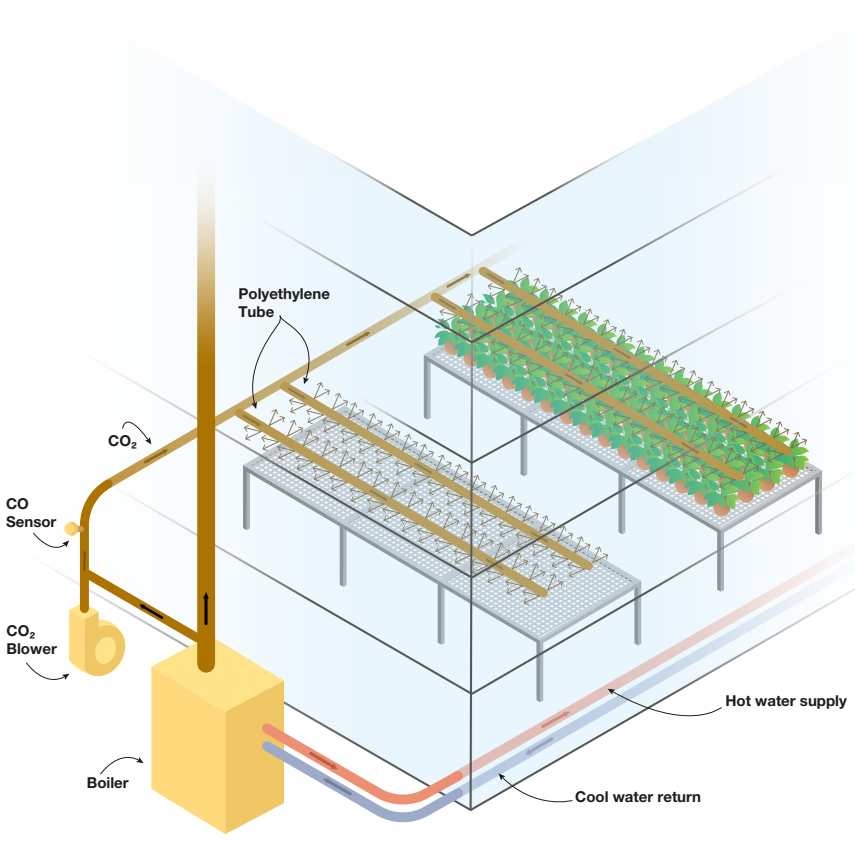
Alternatively, pure liquid CO_2 purchased from commercial suppliers may be used. The most common method of CO_2 enrichment for greenhouse applications is the combustion of fossil fuel. And the most used fuel for CO_2 enrichment is natural gas. With the combustion of 1 m^3 of natural gas, approximately 1.8 kg CO_2 is generated.

Then supplying CO_2 may lead to local variations in CO_2 concentration throughout the greenhouse. Horizontal, and vertical gradients in environmental conditions are disadvantageous, but inevitable. Most importantly is to prevent a decrease in the homogeneity of plant growth and crop production.

For instance, with a distribution network, a high CO_2 concentration is found near the distribution tubes and a low level close to the ridge, or near the opened ventilation windows. It is then recommended to place the CO_2 distribution lines on a low level near the crops. This way, the natural diffusion of the carbon dioxide to the top of the greenhouse will ensure CO_2 enrichment homogeneity on the vertical axis.

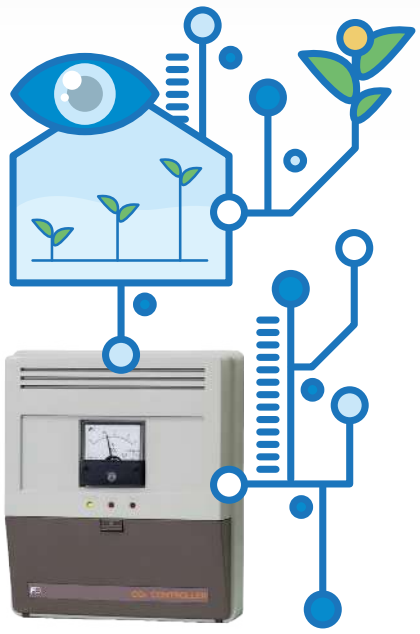
The horizontal distribution is also a challenge since the whole surface of the greenhouse should also contain the same amount of CO_2, so that all plants grow at the same speed and the maturity and quality are homogeneous throughout the whole culture.

Principle of CO_2 distribution in a greenhouse

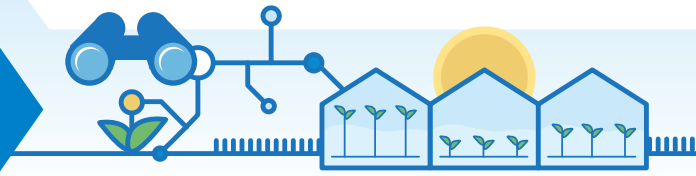


Mots clés

- Photosynthesis
- CO_2 enrichment
- Greenhouse
- Crops yield
- Human nutrition
- Gas analyser



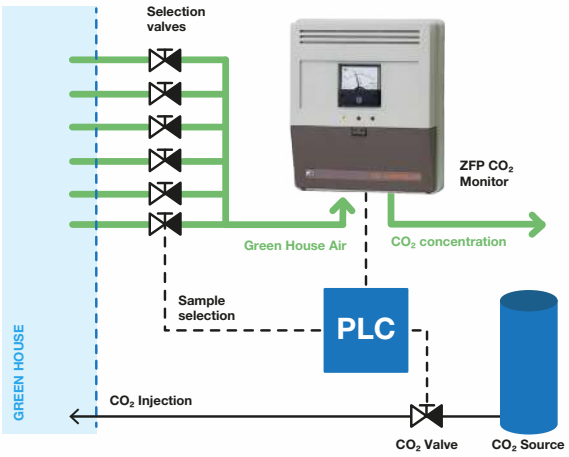
Setting up a Fuji Electric ZFP CO_2 monitoring network in a greenhouse



To ensure a volumetric (both horizontal and vertical) homogeneity of CO_2 concentration in the greenhouse, the best strategy is to measure it at several places in the greenhouse.

This can be done with several analysers and/or making a multipoint sampling with one single analyser, depending on the greenhouse size, and the available budget.

CO_2 green house monitoring system example



In the case of a large greenhouse, several CO_2 monitors will be used to cover the whole volume. And to ensure the best representativity of all plants' atmosphere, each monitor will measure simultaneously several (usually 4 or 6) smaller areas. This optimised strategy allows controlling that the CO_2 is equally spread to all crops.

The Fuji Electric ZFP greenhouses CO_2 monitor is a dedicated NDIR (Non-Dispersive Infra-Red) gas analyser. It was designed years ago for this purpose and has been improved with experience. More than 10 000 ZFP CO_2 monitors are in use currently throughout Europe to optimise our food production improving photosynthesis with CO_2 fertilisation.

Equipped with its internal filter and internal pump, this Infrared analyser is able to suck the ambient air around its own position, but also from remote areas through a network of sample pipes. A usual strategy like illustrated below consists in sucking the air from several areas to ensure the homogeneity of CO_2 in the targeted area.

The installation is extremely simple, and its unique stability requires a calibration frequency not more than once a year.

How does the CO_2 NDIR analyser work?

Fuji Electric Non-Dispersive Infrared technology is famous since the 1960's for its robustness and signal stability under the hardest climatic conditions.

The sensor works by an infrared (IR) lamp directing waves of light through a tube filled with a sample of air. This air moves toward an optical filter in front of an IR light detector. The IR light detector measures the amount of IR light that passes through the optical filter.

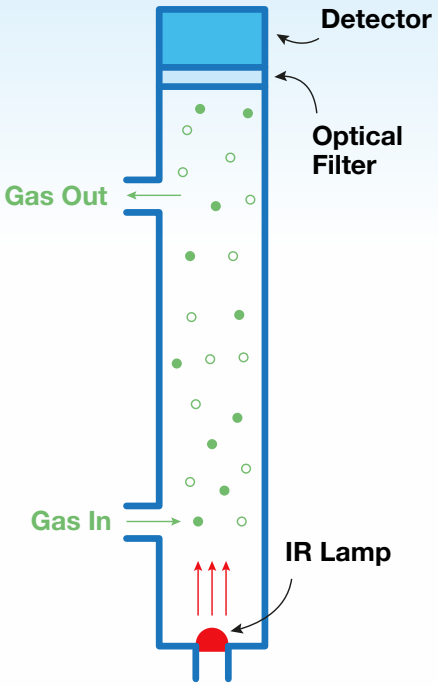
The band of IR radiation also produced by the lamp is very close to the 4.26-micron absorption band of CO_2. Because the IR spectrum of CO_2 is unique, matching the light source wavelength serves as a signature or "fingerprint" to identify the CO_2 molecule.

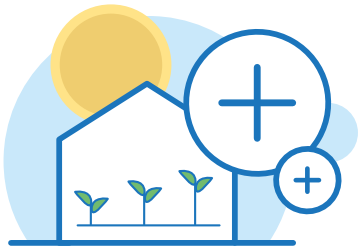
As the IR light passes through the length of the tube, the CO_2 gas molecules absorb the specific band of IR light while letting other wavelengths of light pass through. At the detector end, the remaining light hits an optical filter that absorbs every wavelength of light except the wavelength absorbed by CO_2 molecules in the air sample tube.

Finally, an IR detector reads the remaining amount of light that was not absorbed by the CO_2 molecules or the optical filter.

The difference between the amount of light radiated by the IR lamp and the amount of IR light received by the detector is measured. Since the difference is the result of the light being absorbed by the CO_2 molecules in the air inside the tube, it is directly proportional to the number of CO_2 molecules in the air sample tube.

This data is then treated by the internal DSP board and then output, most usually as a 4-20 mA signal to be used for the process control: the CO_2 enrichment system here in our case.





Your advantages

- **Ensure a perfect CO_2 enrichment of the greenhouse cultivation**
- **Keep your customers satisfied,**
  allowing them to benefit fully from the greenhouse
- **Increase profit using all the potential and easy-to-install ZFP analyser**

Fuji Electric ZFP greenhouse CO_2 monitor

Easy installation and operation
The ZFP CO_2 monitor is a turnkey wall-mounted instrument

A gas analyser designed for greenhouses monitoring
Its integrated pump and filter allow to pumping
the atmosphere from any place in the greenhouse

Large flexibility and choice of measurement ranges
The CO_2 measurement ranges can be chosen to adapt to any type of crops cultivation

Data you can trust
High precision NDIR gas analyser with guaranteed specifications

Easy maintenance
The gas analyser itself requires no maintenance, and the integrated dust filters
and sample pump are cheap, available and extremely easy to maintain.

Long calibration intervals
The ZFP NDIR technology is unique for its signal stability
and requires a calibration no more than once a year.

Relax, your CO_2 fertilisation is controlled by a Fuji analyser

Take advantage of 57 years of experience with NDIR industrial gas analysers

Fuji Electric

FUJI ELECTRIC FRANCE S.A.S.

46, rue Georges Besse - ZI du Brézet - 63 039 Clermont-Ferrand Cedex 2 - France
Tél. France : 04 73 98 26 98 - Fax. 04 73 98 26 99
Tél. International : +33 4 73 98 26 98 - Fax. +33 4 73 98 26 99
Email : sales.dpt@fujielectric.fr - Web : www.fujielectric.fr