# Automatic Climate Control of a Greenhouse: A Review

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**Abstract:** ***Greenhouse crop production was a very significant event in the history of agriculture since it was realized that with the help of it many plants could be protected from different biotic and abiotic stress. It emerged as a system to protect crops from critical and adverse conditions affecting the growth of plants. The greenhouse is a non-linear system and controlling becomes a difficult task. The parameters affecting the plant growth are temperature, relative humidity, carbon dioxide, nutrition, availability of water and the growing media. The quality and productivity of the crop plants is highly dependent on the management of these parameters. From all the parameters, temperature and humidity are of primary importance to most growers as it is responsible for determining the reaction rates of various metabolic processes involved in the plant growth. In addition, regulating temperature has a direct influence on the relative humidity and carbon dioxide levels of the greenhouse system.***

**Keywords:** Greenhouse, Climate Control, Control Actuators.

## 1. Introduction

The popularity of computers for the management of greenhouses is increasing in those countries where the environmental conditions are not suitable for the development of plants. In The Netherlands, computers are used for different applications like the climate control, the boiler, and the irrigation control, but the best known of them is the climate control (temperature, humidity, $CO_2$level and artificial lighting). Automatic greenhouse climate control systems are being widely installed nowadays in Southeast Spain. As a basic requirement, climate control helps to avoid extreme conditions (high temperature or humidity levels, etc.) which can cause damage to the crop and to achieve adequate temperature integrals that can accelerate the crop development and its quality while reducing pollution and energy consumption. The crop production system is characterized by both fast and slow dynamics, the first associated with the greenhouse climate and the second with crop growth. As a first approximation, seasonal optimization can treat the physical climate as immediately realizable through the control. The main improvements in the computer -based climate control are found in data logging the determination of climate set-points, monitoring and alarm functions. Nowadays, the agro-alimentary sector is incorporating new technologies due to the large production demands and the diversity, quality, and market presentation requirements. The dynamic behaviour of the micro climate is a combination of physical processes involving energy transfer (radiation and heat) and mass balance (water vapour fluxes and $CO_2$ concentration). These processes depend on the outlet environmental conditions, structure of the greenhouse, type and state of the crop and on the effect of the control actuators. The main ways of controlling the greenhouse climate are by using ventilation and heating to modify inside temperature and humidity conditions, shading and artificial light to change internal radiation, $CO_2$ injection to influence photosynthesis and fogging/ misting for humidity. The temperature in a greenhouse is affected by the ventilation and the amount of sunshine it receives Greenhouses are designed to trap the heat from the sun. If nobody changed anything, the temperature would keep rising until the sun sets. The temperature can be controlled by opening the door or opening vents in the roof. In extreme cases, air conditioning could be used to bring the temperature down to a reasonable level. The humidity inside a greenhouse is almost always close to the maximum because of the amount of greenery. Leaves naturally perform a process called transpiration, in which they release moisture into the atmosphere from pores in their surface Controls on humidity are similar to those for heat.

The idea of synchronizing graspable real models and virtual world by interfacing sensor was published for the first time by Bruns. Many ideas, applications and prototypes based on this concept have been investigated and implemented since then. In the work done by R. Caponetto *et al.* [1], the authors proposed the modelling of greenhouse from a physical point of view, which requires a large computer effort due to the intrinsic complexity of the system and of the phenomenon

involved. The synthesis of a climate control became a complicated task due to the physical dynamics involved in the greenhouse. In another work by F. Lafont *et al.* [2], the authors proposed that the greenhouse models are non-linear and are strongly disturbed often by the weather conditions that are impossible to forecast precisely. Thus, model-free control is a saviour to this problem. In the work by W. J. Roberts [3], the author proposed that controls are important part of heating and ventilating system. Capillary bulb type thermostats are the most durable for greenhouse use. Residential home type thermostats are usually more accurate but are also more subject to deterioration and malfunctioning caused by the greenhouse environment. In another work by M. Berenguel *et al.* [4], the authors proposed the development of mixed feed forward adaptive controllers for greenhouse climate control based on both simplified physical laws and online measured data and were discussed in terms of their suitability for adaptive control purposes. The schemes are tested using a highly nonlinear model of a typical Mediterranean greenhouse. The behaviour of the control scheme has been analysed during daily operation (first time scale) to compensate for changing dynamics induced by operating point changes and disturbance cycles. The authors F. Rakoczi *et al.* [5] proposed that the humidity of the atmosphere is a very important factor influencing the greenhouse intensity of the atmosphere. Greenhouse intensity is calculated as the difference between the surface temperature and the effective temperature of the atmosphere. If the water content increases by 10%, it will result in the increase of the greenhouse intensity by 1.34°C. In the case of decrease of the atmospheric water content by 10%, the greenhouse intensity will decrease by 1.6°C.

## 2. Greenhouse Control

A lot of simulations, referring to different control techniques, can be done like standard bang-bang control technique, fuzzy controller designed on the basis of expert description, fuzzy controller optimized via GAs; and, finally distributed proportional integrative derivative (PID) controller. Soft computing methodologies are complementary and synergistic than competitive. The guiding principle of soft computing is to exploit the tolerance for imprecision, uncertainty and partial truth, and the approximation to achieve the tractability, the robustness, the low solution cost, and the better rapport with reality. When there is difference between the temperature and humidity of the measured data and the data stored in the database of natural temperature and humidity, adjust by data detector, transfer the signal information to the temperature and humidity adjusting device which control the test point temperature and humidity. The physical point of view for designing a Greenhouse requires a large computer effort. It is due to the internal complexity of the system and operation involved. The effectiveness of a Greenhouse, which is a distributed parameter system, depends on several non-linear phenomena. Radiation and convectional effects are the factors on which the heat transferred in a Greenhouse depends. Moreover, on account of many uncontrollable signals like the solar radiation, the crop transpiration, and so on, makes validation of the model even difficult.

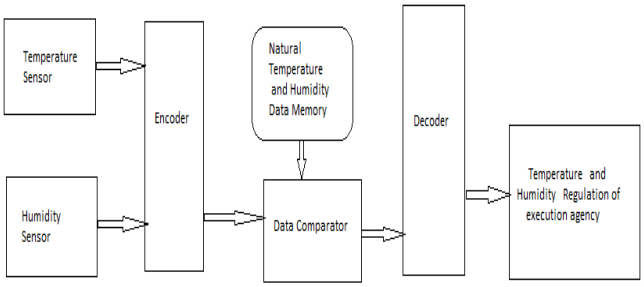


**Figure 1**: Schematic Diagram of simulation control system of temperature and humidity

Factors affecting the climate of the green house are temperature, humidity, $CO_2$, soil composition, light and soil ph. It is difficult to control the parameters of the green house using conventional techniques, the advanced technologies like fuzzy logic, genetic algorithm, PID distributed control and system modelling are widely accepted nowadays The use of fuzzy logic controllers in a greenhouse for controlling parameters like temperature humidity reduces the energy cost for heating. Climate control of greenhouse involves control and modification of day and night temperature, $CO_2$ and relative humidity for maximum plant growth. Extreme values of temperature as well as humidity need to be controlled for both summer and winter season. In order to make the feasible condition for the optimum plant growth, the cooling and the heating system need to be installed. The heating system is installed to exchange the energy lost from the greenhouse when the temperature outside the greenhouse remains lower than the desired temperature in the greenhouse growing area. As we know the nutrition of the crops depends upon the light, temperature, moisture and $CO_2$ concentration but the level of these climate parameters particularly during rainfall will vary between location and years due to the difference in its climate.

## 3. Summary

Automatic greenhouse climate control systems are being widely installed worldwide, using computers

for different applications like the climate control and the irrigation control, climate control being one of the major concerns. As a basic requirement, climate control helps to avoid extreme conditions (high temperature or humidity levels, etc.) which can cause damage to the crop. Simulation, referring to different control techniques, can be done like standard bang-bang control technique, fuzzy controller designed on the basis of expert description.Climate control of greenhouse involves control and modification of day and night temperature, $CO_2$ and relative humidity for maximum plant growth.

## 4. Conclusion

Due to the physical dynamics involved in a greenhouse, the synthesis of a climate controller becomes a complicated task using traditional techniques of control. The temperature was controlled by regulating the water temperature within an appropriate set of pipes uniformly distributed in the greenhouse, while the humidity was controlled indirectly by the ventilation rate regulation (which affects both temperature and humidity). Thus, using these systems were quite expensive and not an efficient way of controlling. Thus, automatic control of the greenhouse became the mainstream technique which created the most desirable environment for crop growth according to the growth habits of the greenhouse crops and the needs of the market, some even get rid of the natural environment constraints. It is also suitable for large scale production.

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