WHITEPAPER / KUBO CO2 CAPTURE STRATEGY

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KUBO Group
For A Growing World

Wouter Kuiper
Chief Executive Officer

REVOLUTIONIZING CO2 FERTILIZATION: KUBO ULTRA-CLIMA® GREENHOUSE'S INNOVATIVE "CO2 CAPTURE STRATEGY"

BLUE LAB CO2 RESEARCH 2024

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ABSTRACT

Over the past few decades, there has been a growing acknowledgment of the challenges presented by climate change and the limited availability of natural resources. This recognition has promoted worldwide efforts to address environmental protection, enhance energy efficiency, and mitigate greenhouse gas emissions. To address global energy and CO2 emission challenges, the European Union adopted the targets set out in the "Kyoto Protocol" for 2020 as its own. The Dutch government and greenhouse horticulture sector respond to climate change by advocating for climate-neutral greenhouse practices. The aim is to reduce energy consumption and transition to carbon-free energy sources like solar, wind, and geothermal energy. However, this shift presents a challenge to the traditional method of carbon dioxide (CO2) fertilization. As fossil fuel consumption decreases, the CO2 source generated from heat production diminishes and may eventually be eliminated.

The challenges of finding new CO2 sources and implementing innovative CO2 fertilization strategies to maintain the high productivity and high-quality production of Dutch greenhouses have become increasingly important and urgent.

This whitepaper investigates the challenges and innovations of greenhouse operation strategies towards sustainability. It introduces the revolutionary "CO2 capture strategy" implemented in KUBO Ultra-Clima® greenhouse. This strategy utilizes external atmospheric air for CO2 fertilization, aiming to reduce CO2 emission and enhance energy use efficiency while maintaining high productivity and high-quality production of the greenhouses. The paper outlines the innovative features of the Ultra-Clima® greenhouse and presents research findings from KUBO testing facility – Blue Lab, highlighting promising results in energy use efficiency, and CO2 fertilization.

To validate these findings, a third-party, the Climate Neutral Group (CNG) will underscore the credibility of the research. CNG's involvement reflects a broader commitment of KUBO to sustainability and aligns with global efforts towards achieving a net-zero carbon economy by 2050.

Overall, the whitepaper paints a comprehensive picture of the challenges and innovations driving the greenhouse industry towards a more sustainable future. It emphasizes the importance of technological advancements and collaborative efforts in achieving environmental goals.

KEYWORDS

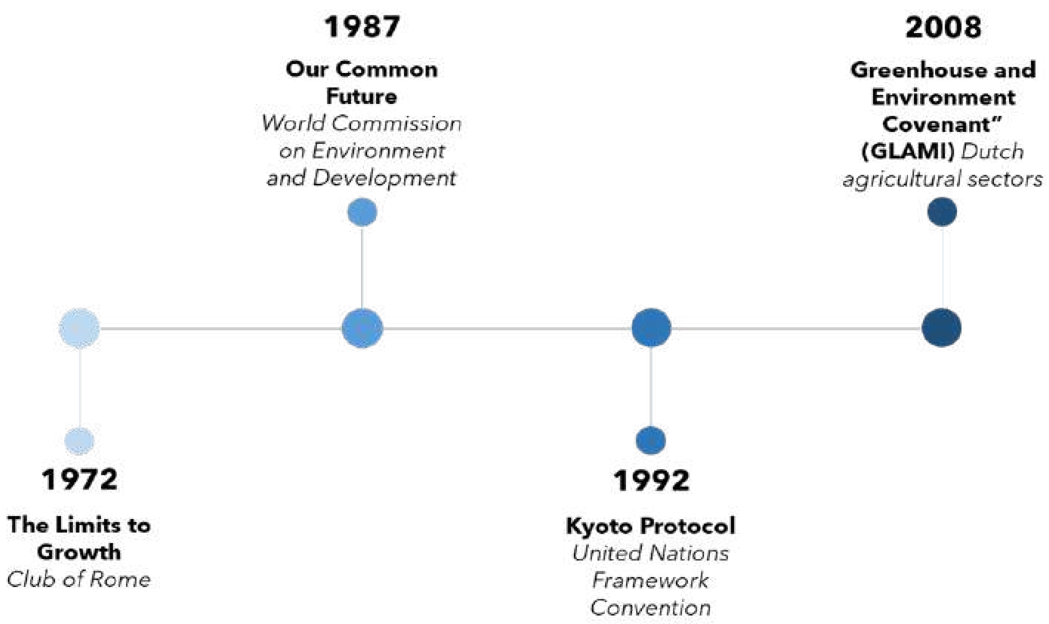
Sustainability, CO2 emission, Energy use efficiency, Climate neutral greenhouse, Venlo greenhouse, KUBO Ultra-Clima® greenhouse, CO2 fertilization, KUBO "CO2 Capture Strategy", KUBO Blue Lab research, Third-party validation, Carbon footprint.

GREENHOUSE INDUSTRY: TOWARDS A SUSTAINABLE FUTURE

SUSTAINABLE DEVELOPMENT: FROM AWARENESS TO ACTIONS

In recent decades, there has been a clear realization of the challenges caused by climate change and the limited availability of natural resources. This realization has prompted global actions in aspects of environmental protection, improve energy use efficiency, and reduce greenhouse gas emission.

Figure 1 The timeline of global actions on sustainable development initiatives.



First, in 1972, an influential report titled "The Limits to Growth" drew widespread attention. It was published by the Club of Rome, a global policy organization with a strong reputation. The report highlighted the necessity of addressing environmental concerns alongside economic and technological developments.

Following this, in 1987, the World Commission on Environment and Development, established by the United Nations, introduced the concept of "sustainable development" in the published report titled "Our Common Future". The report emphasized the importance of meeting present requirements without compromising the ability of future generations to meet their own needs.

Based on the foundation laid by the 1992 United Nations Framework Convention on Climate Change, the "Kyoto Protocol" marked a significant milestone in international agreements about climate change in 1997. This protocol recognized that global warming was driven by CO_2 emissions due to human activities, emphasized the necessity and urgency of collective efforts to reduce CO_2 emissions to stabilize atmospheric CO_2 levels, and required developed countries to take concrete actions to reduce their greenhouse gas emissions.

To address global energy and CO2 emission challenges, the European Union adopted the targets set out in the "Kyoto Protocol" for 2020 as its own. The Netherlands government initiated the "Clean and Efficient" program in 2007, aligning with global efforts to promote sustainability and combat climate change. This program aimed to enhance energy efficiency across various sectors.

Following this, in 2008, the Dutch agricultural sectors signed the 'Clean and Efficient Agro-sectors' agreement with the government, aiming to enhance sustainability by 2020. As part of this program, the greenhouse horticultural sub-sector signed the "Greenhouse and Environment Covenant" (known as GLAMI) with the government. GLAMI outlines specific objectives for greenhouse horticulture's performance concerning energy and environmental aspects. Regarding total CO2 emissions, a specific target value of 4.6 Megatonnes (Mt) for 2020 was agreed upon by the government and the greenhouse horticulture sector.

PRODUCTIVITY, ENERGY CONSUMPTION, AND CO2 EMISSION IN DUTCH GREENHOUSE

In 2023, exports of agricultural goods originating from the Netherlands amount to about 82.1 billion euros, while re-exported agricultural goods originating from other countries total approximately 41.7 billion euros. Agricultural exports for 2023 are projected to yield a total income of 50.4 billion euros. Within this figure, exports from the Netherlands contribute 45.7 billion euros, while 4.7 billion euros come from re-exports (Fig.2).

Figure 2 The amounts and economic contributions of Netherlands agricultural goods exportation.

From 1980 to 2010, the annual tomato production per growing area of Dutch greenhouses achieved a remarkable increase of 113%. Additionally, energy use efficiency was enhanced, with energy consumption per growing area decreasing significantly by 70%.

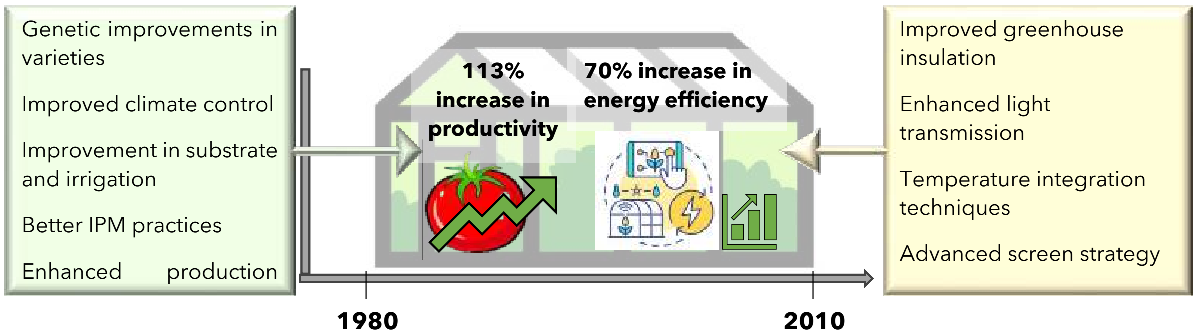
The significantly boosted commercial crop yields and improved crop quality can be attributed to several factors:

- Genetic improvements in tomato cultivars, with modern varieties exhibiting around 40% higher production compared to older varieties.
- Introduction of climate control technologies, e.g. heating, cooling, humidification, dehumidification, artificial lighting, and CO_2 fertilization.
- Better regulation of the rooting substrate, as well as improved irrigation and fertigation techniques.
- Improved crop and pest management techniques.
- Enhanced control over the production process within greenhouses.

The enhanced energy use efficiency was achieved through various measures implemented to mitigate energy consumption, including:

- Improved greenhouse insulation.
- Enhanced light transmission by anti-reflection coatings.
- Implementation of temperature integration techniques.
- Enhanced energy screen opening methods.
- Increased heat buffer capacity.

Figure 3 The improvements in greenhouse productivity and energy use efficiency.



However, despite all the improvements in crop production and energy use efficiency, operation of modern greenhouse is still facing the challenge of high energy requirements. In 2012, greenhouse horticulture accounted for approximately 82% of energy consumption in the agriculture sector. This greenhouse horticulture accounted for about 10% of the national consumption of natural gas, and the number only decreased slightly to 9% by 2022. During the period from 2014 to 2018, total CO_2 emissions from the greenhouse horticulture sector remained stable at 5.7 Mt per year, which was surpassing the specific target value for 2020 of 4.6 Mt agreed upon by the government and the greenhouse horticulture sector.

ENERGY SAVING AND ENERGY TRANSITION: LESS AVAILABLE BY-PRODUCT CO2

To further improve energy use efficiency and reduce CO_2 emissions, the Dutch government has vigorously advocated for the adoption of climate-neutral greenhouse practices, including two key strategies:

- Firstly, a reduction in greenhouse heating requirements.

- Secondly, a gradual transition towards carbon-free energy sources, utilizing sustainable energy sources, such as solar energy, wind energy, and geothermal heat. Despite progress, sustainable energy utilization remains relatively low, with only about 7.3% of total energy consumption derived from sustainable sources in 2018. The urgency of this transition is underscored by soaring gas prices in the past few years, emphasizing the critical need for alternative sustainable energy sources.

However, the trend of reducing fossil fuels consumption and transitioning to sustainable energy sources presents a challenge to the traditional way of CO2 fertilization, because it will reduce and eventually eliminate the CO2 source as a by-product of heat production. Currently, the greenhouse CO2 fertilization strategy is developed as a by-product of heating through fossil fuel combustion: most greenhouses combust fossil fuels for heating purposes. The heat buffer allows for the decoupling of heat and CO2 usage, CO2 by-product is distributed throughout the greenhouse during the day, while the heat is stored for later use.

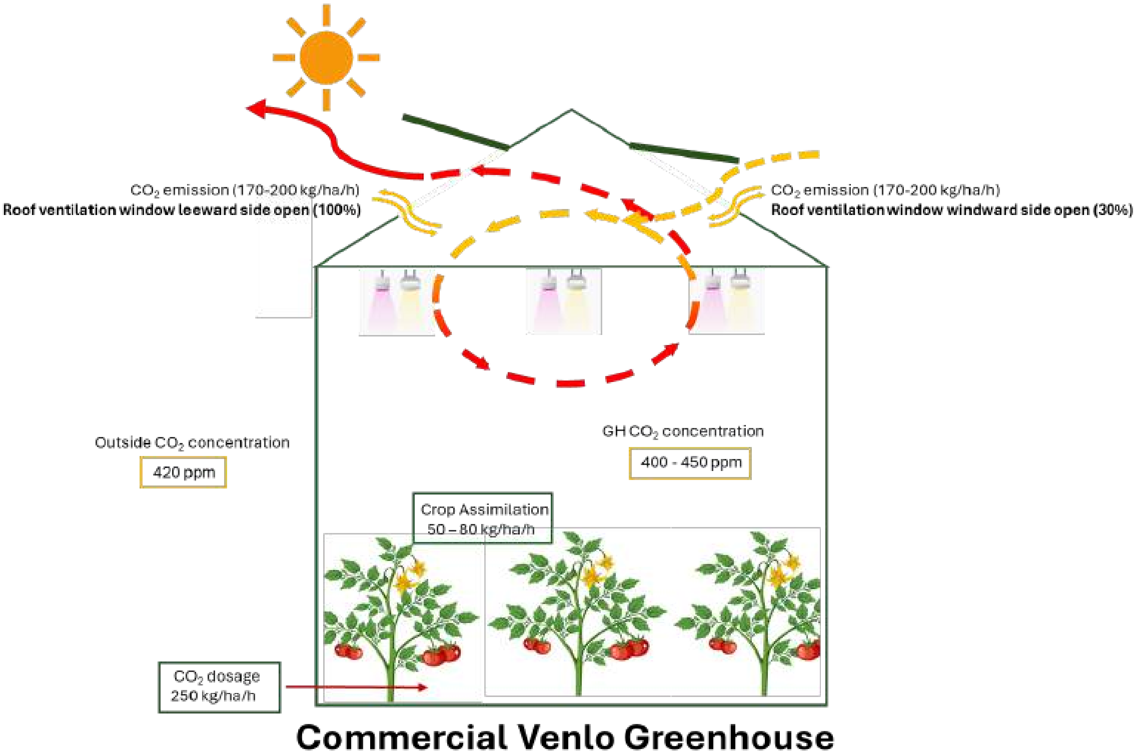
LOW CO2 FERTILIZATION EFFICIENCY AND HIGH CO2 EMISSION IN VENLO GREENHOUSE

When the external climate conditions are moderate, ventilation with outside air is the most sustainable way within a greenhouse to expel surplus energy and to regulate temperature and humidity within the optimal ranges for crop growing. However, fossil fuel usage, deforestation, industrial and agricultural practices resulted in more emission of greenhouse gases, which trap more heat in earth's lower atmosphere, and caused climate change and global warming.

When the external climate conditions become more extreme (e.g., higher radiation, temperature, and humidity), a high ventilation rate becomes necessary for effective greenhouse climate control, which leads to a reduction in the CO2 fertilization efficiency. Because to maintain same CO2 level, there is a significant increase in the demand of CO2 fertilization.

- In a traditional Venlo greenhouse with high ventilation rate, the greenhouse CO2 concentration often remains relatively lower than the setpoint (typically around 400-450 parts per million (ppm), while the target setpoint is 700-800 ppm), even with massive CO2 supply (maximum dosing rate of 250 kg/ha/h). Since only a small fraction of the supplied CO2 is absorbed by the crop, a significant portion of the supplied CO2 is released into the outside atmosphere through the roof ventilation windows whenever the greenhouse CO2 concentration is higher than the external concentration (Fig. 4).

Figure 4 Schematic representation of the air flow and CO2 balance in a Venlo greenhouse with a high ventilation capacity.



- In general, when a greenhouse requires a high ventilation rate for climate control purposes, the greenhouse heating requirement is typically low, and resulting in insufficient by-product CO2 from heat production. More fossil fuels need to be burned for additional CO2 requirements and the extra heat energy needs to be consumed at the same time, or an alternative CO2 source is required (e.g., liquid CO2, OCAP CO2 – greenhouses in the Westland area of the Netherlands is connected to a piping system carrying waste CO2 from industrial plants, mainly around the port of Rotterdam). Otherwise, without CO2 fertilization, the CO2 concentration in the Venlo greenhouse can drop to 250 ppm due to the crop actively uptakes CO2 for photosynthesis, this decrease in CO2 levels can become a limiting factor for crop growth, and eventually resulting in reduced production.

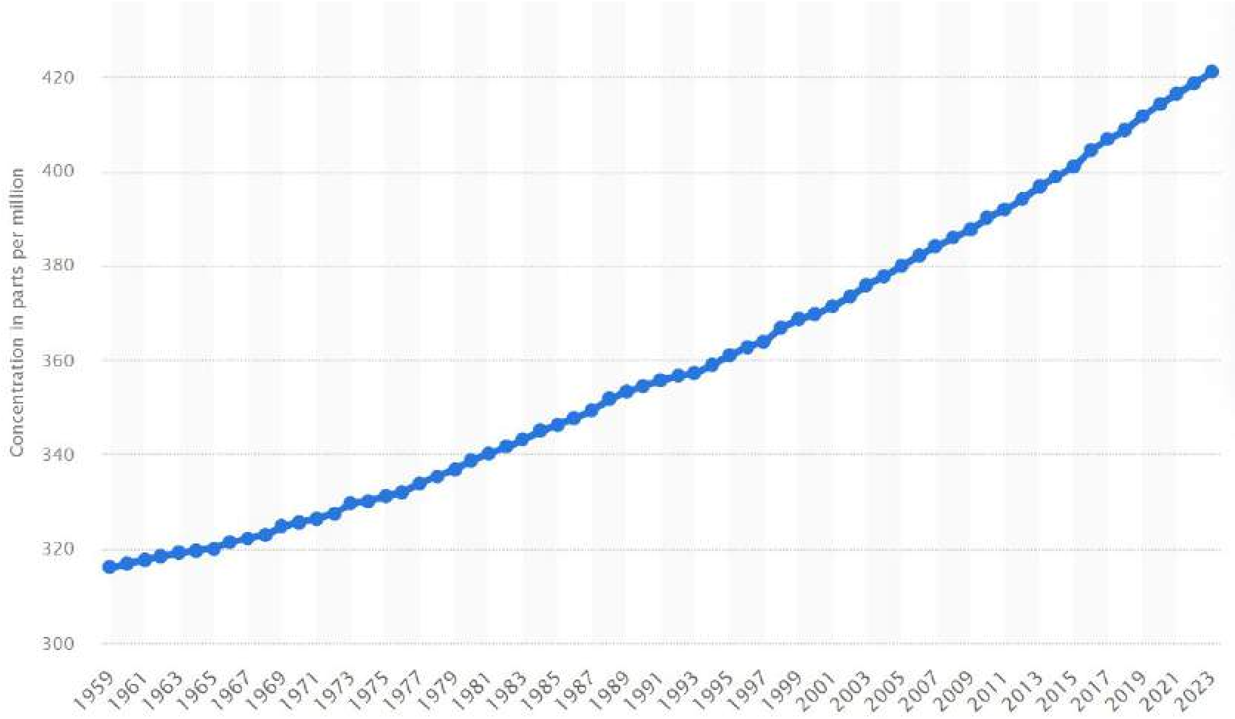
CHALLENGES TO CO2 FERTILIZATION IN VENLO GREENHOUSE

To combat climate change and support environmental sustainability, the Dutch greenhouse horticulture sector remains dedicated to sustainable strategies, reducing fossil fuel consumption and transitioning to sustainable energy, even these actions will bring conflicts over the shortage of CO2 sources and the high demand of CO2 fertilization in Venlo greenhouses. The challenges of finding new CO2 sources and implementing innovative CO2 fertilization strategies, to keep the high productivity and high-quality production of Dutch greenhouse become more important and urgent.

REVOLUTION: KUBO ULTRA-CLIMA® "CO2 CAPTURE STRATEGY"

CROP CULTIVATION WITH EXTERNAL ATMOSPHERE CO2 CONCENTRATION

Figure 5 Average CO_2 levels in the atmosphere worldwide from 1959 to 2023 (in ppm).



In the past six decades, the global average CO2 concentration increased about 100 ppm (Fig. 5). Nowadays, the average CO2 concentration in the external atmosphere stands at approximately 420 ppm, and it presents opportunities for effective and innovative CO2 fertilization strategies:

- When the external climate conditions become extreme, and a high ventilation rate is required for climate control purposes, the outside air can be used as a source of CO2 fertilization (Fig. 6).
- When the ventilation rate is insufficient to supply outside air CO2 to the greenhouse, additional CO2 can be supplied only when the roof vents are closed, with a maximum setpoint same as outside CO2 concentration. This ensures that the greenhouse CO2 concentration is at the same level as the external atmosphere when the roof vents are open. With this approach, there would be no CO2 emissions to the atmosphere through the roof vents, ensuring that all CO2 supplied into the greenhouse is absorbed by the crop (Fig.7).

Figure 6 Schematic representation of the air flow and CO2 balance in a KUBO Ultra-Clima® greenhouse with a high ventilation capacity.

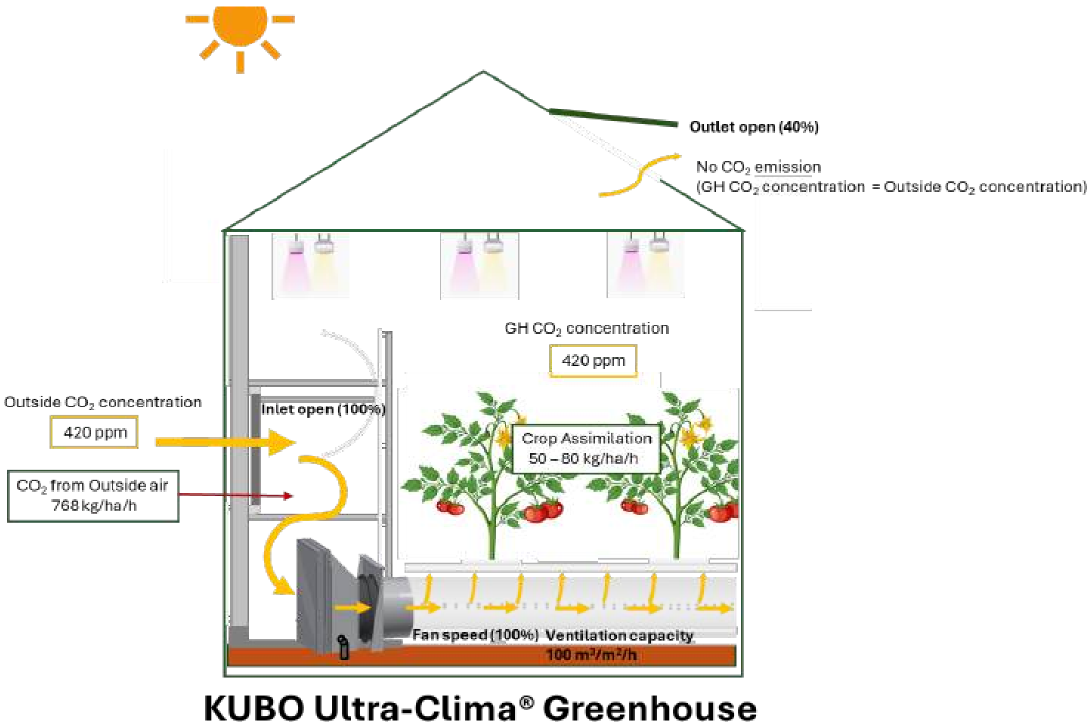
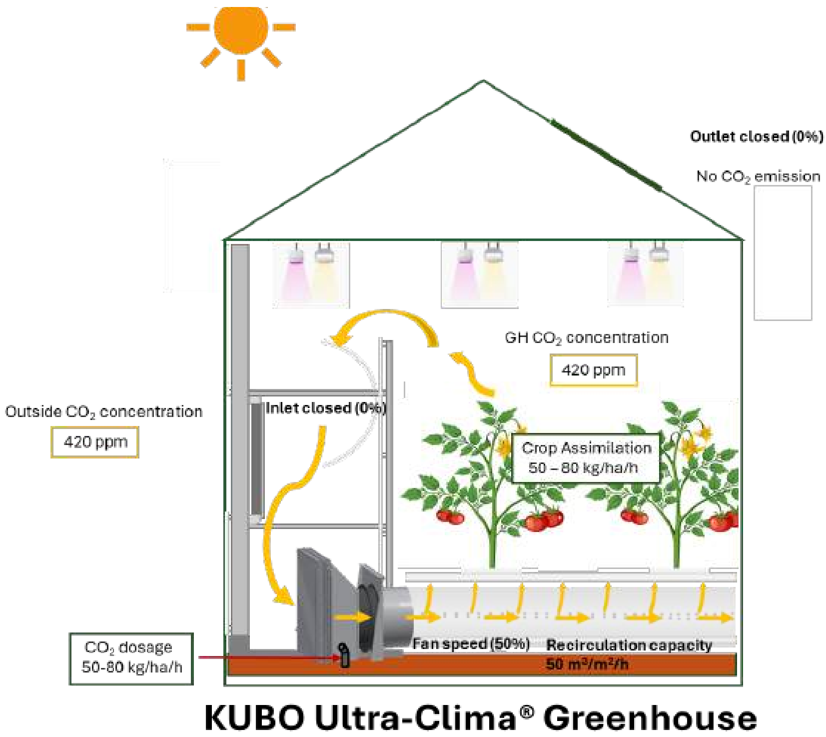
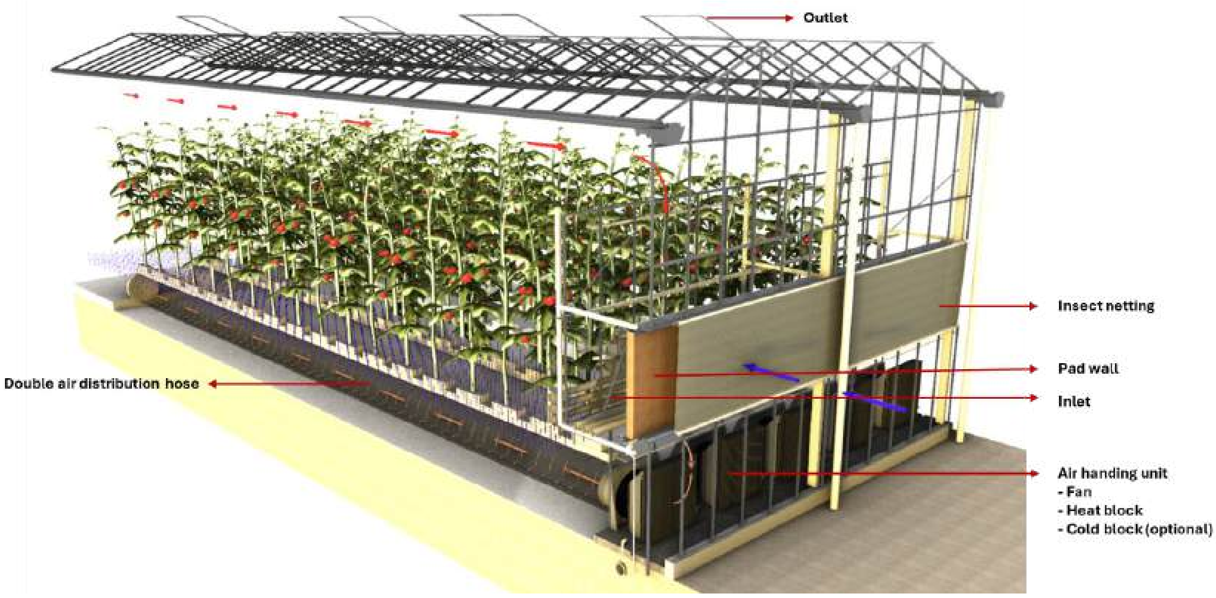


Figure 7 Schematic representation of the air flow and CO2 balance in a KUBO Ultra-Clima® greenhouse with recirculation air.



INNOVATIVE CO_2 FERTILIZATION STRATEGY: KUBO ULTRA-CLIMA® "CO_2 CAPTURE STRATEGY"

Figure 8 KUBO Ultra-Clima® greenhouse.



The KUBO Ultra-Clima® greenhouse shows a significant potential as a foundational solution for addressing the challenges posed by limitations on energy consumptions and CO_2 emissions through various ways:

- The primary heating system in the KUBO Ultra-Clima® greenhouse, known as the Air Handling Unit Heat Block (AHU HB), is designed as highly energy-efficient heating equipment that utilizes low-grade heat. Low-grade heat, defined as heat with a relatively low temperature in the range of 35°C to 55°C, is employed to warm up the greenhouse air. This utilization of low-grade heat offers significant advantages in terms of energy efficiency, as it requires less energy to heat up the air compared to a conventional tube rail system, which typically requires higher-grade heat with water temperatures of 60°C to 75°C; and the AHU HB has higher heat exchanging surface and better heat exchanging properties. Drawing from KUBO's extensive worldwide greenhouse building experience, the AHU HB has demonstrated its compatibility with various renewable energy sources technologies in numerous projects, including waste heat, geothermal, and solar energy systems.

- The Air Handling Unit Fan (AHU Fan) in the KUBO Ultra-Clima® greenhouse is the driving force of ventilation. The Ultra-Clima® greenhouse can maintain CO_2 concentration levels equivalent to those present in the external environment (420 ppm) under high ventilation capacities.

  In addition, the air is treated (heating, cooling, humidifying, dehumidifying, CO_2 fertilization) in the Ultra-Clima® corridor according to the target blow-in air conditions. Afterwards, the air is supplied to the greenhouse growing area through the double air distribution hose (DADH) which is below the growth gutter, which ensures the fresh CO2 can passing through the whole crop canopy and been absorbed and utilized by the crop.

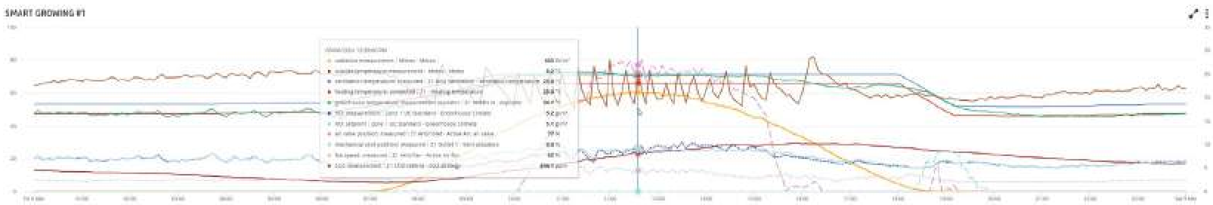
The below climate graph shows an example of climate control in Ultra-Clima® greenhouse. During the day period, the ventilation capacity was high to ensure the temperature and humidity were controlled within optimal ranges for tomato crop cultivation, without additional CO2 fertilization, the greenhouse CO2 concentration was maintained at around 425 ppm, same as the external atmosphere CO2 level. During the night period, the greenhouse CO2 concentration was built up because of the crop respiration, these CO2 can be utilized by the crop photosynthesis at the second morning, when the greenhouse is kept relatively closed and the climate is controlled within the optimal ranges. (Fig.9).

Figure 9 KUBO Ultra-Clima® testing facility Blue Lab climate performance graph.

- Different from the traditional Venlo greenhouse roof ventilation windows, the roof windows in the KUBO Ultra-Clima® greenhouse, known as "outlets," fulfill a completely different function: regulating greenhouse pressure based on ventilation capacity and climate control purposes. This feature allows for a significant reduction in the number of outlets, and the outlets can be fully closed under certain conditions, allowing necessary CO2 fertilization, the CO2 supplied into the greenhouse will be kept inside and eventually absorbed by the crops.

Below, the climate graph shows another example of climate control in an Ultra-Clima® greenhouse. The temperature and humidity were controlled within optimal ranges for tomato crop cultivation, the outlets were fully closed during the day period, which enabled the CO2 supplied from OCAP system once the greenhouse CO2 concentration dropped below the minimum setpoint of 375 ppm. The CO2 supplied from the OCAP was kept inside the greenhouse and actively absorbed by the crop (Fig. 10).

Figure 10 KUBO Ultra-Clima® testing facility Blue Lab climate performance graph.



KUBO BLUE LAB RESEARCH: ULTRA-CLIMA® "CO2 CAPTURE STRATEGY"

DIMINISHING MARGINAL RETURNS: CO2 FERTILIZATION AND CROP EXTRA GROWTH

Increasing the greenhouse CO2 concentration enhances crop photosynthesis, thereby improving crop growth and productivity. However, the photosynthesis rate, growth and production show a saturation type of response to CO2 concentration, as the CO2 concentration increase beyond a certain point, the extra growth or yield benefit gained by further increasing CO2 concentrations becomes smaller.

The relative increase in crop growth rate and yield production caused by every 100-ppm increase in CO2 concentration can be roughly estimated by following rule of thumb:

- Increase in crop growth per 100 ppm = $1.5 \times 10^6 / [CO2]^2$

CO2 concentration increases from 250 to 350 ppm contributes 24% growth, from 350 to 450 ppm gives 12% growth, from 450 to 550 ppm shows 7% more growth, and lowered to only 5% when increases from 550 to 650 ppm (Table 1).

Table 1. The crop extra growth gained by every 100-ppm increase in CO2 concentrations.

CO2 concentration (ppm)		Extra growth (%)
Increase from	to	
250	350	24
350	450	12
450	550	7
550	650	5
650	750	4
750	850	3
850	950	2
950	1050	2
1050	1150	1
1150	1250	1

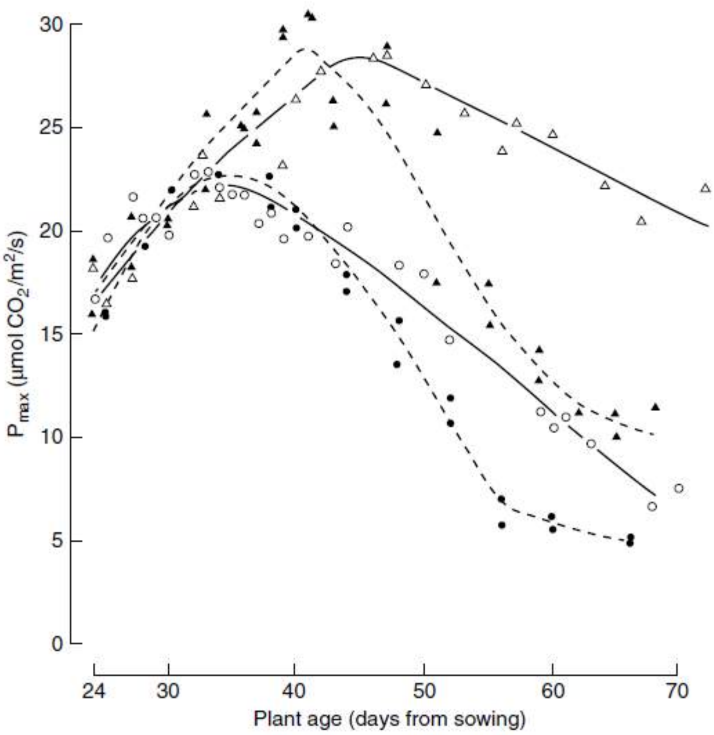
CROP ACCLIMATION TO HIGH CO2 CONCENTRATION

Once the CO2 concentration rises past a specific threshold, the additional crop growth or yield production achieved by further elevating CO2 levels diminishes. The reason behind this is that the crop becomes 'lazy' when grown long-term under high CO2 concentrations.

When plants are exposed to elevated CO2 concentrations, there is initially an immediate increase in the photosynthesis rate due to the inhibition of photorespiration as the atmospheric CO2/O_2 ratio increases. However, the plant's photosynthesis capacity can decrease when plants are grown for extended periods of time at high CO2 concentrations. This phenomenon is known as 'acclimation', the benefits of CO2 fertilization often decline significantly, which are shown in the graph below, the photosynthesis rate of tomato plants with different CO2 conditions (Fig.11).

Taking the goals of sustainable development into consideration, the CO2 fertilization strategy could be optimized by comparing the extra costs of CO2 and the increased value of the extra yield, rather than the current strategy of maintaining a high CO2 concentration constantly.

Figure 11 Light saturated rate of photosynthesis of the tomato plant at various stages of development.

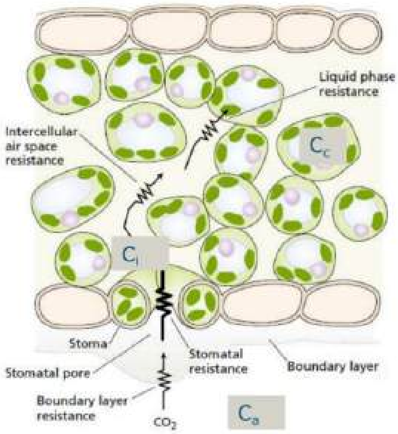


- Plants grown in 340 ppm CO2 and measured in 1000 ppm CO2 (△)
- Plants grown in 340 ppm CO2 and measured in 300 ppm CO2 (○)
- Plants grown in 1000 ppm CO2 and measured in 1000 ppm CO2 (▲)
- Plants grown in 1000 ppm CO2 and measured in 300 ppm CO2 (●)

KUBO ULTRA-CLIMA® GREENHOUSE: LESS RESISTANCE ALONG THE CO2 UPTAKE PATH

Photosynthesis takes place inside the chloroplast; therefore, CO2 must move from the greenhouse air into the leaf cells. The plant's capability to utilize CO2 not only depends on the CO2 concentration gradients along the CO2 uptake path but also on the resistances in this pathway.

Figure 12 The pathway of CO2 taken by the lea from the environment to the chloroplast.



- CO2 concentration gradients: (1) between environment and leaf, (2) between intercellular air space and chloroplast interior.
- Resistances along the pathway: (1) Boundary layer resistance: the boundary layer is a thin layer of non-moving air around the leaf. (2) Stomatal resistance: stomata are small openings in the leaf epidermis for gas exchanges (CO2, O_2, H_2O), and the plant controls their opening and closing by shrinking or swelling the guard cells, in response to environmental conditions, e.g. light and humidity. (3) Mesophyll resistance: the mesophyll resistance is the resistance between the air spaces in the leaf and the chloroplast, and it can greatly contribute to the total resistance. CO2 must move from the air and dissolve into the water phase of a plant cell.

The relationship between photosynthesis (A), CO2 concentration (C_a, C_i, C_c), and resistances (r_b, r_s, r_m) could be quantified by below formula:

- $A = (C_a - C_i) / (r_b + r_s) = (C_i - C_c) / r_m$

The boundary layer resistance and stomatal resistance are expected to be lower in an Ultra-Clima® greenhouse compared to a traditional Venlo greenhouse, due to active air ventilation and increased air movement and thinner the boundary layer; and the humidity levels within the Ultra-Clima® greenhouse are well controlled by active air ventilation, adiabatic cooling, and/or active cooling, which reducing the likelihood of unexpected stomatal closure.

PROMISING RESULTS FROM KUBO BLUE LAB RESEARCH 2023

There is a considerable amount of research on climate control, energy consumption (heat, electricity, and water), CO2 fertilization strategy, and production potential of tomato crops in greenhouses. However, information about the energy inputs and productivity of tomato crop cultivation in Ultra-Clima® greenhouses operating with a "CO2 capture strategy" is limited.

During the 2023 crop cycle, the "CO2 capture strategy" was implemented at the KUBO Ultra-Clima® testing facility – Blue Lab. Promising results were consistently observed throughout the entire cycle. To produce 1 kg of fresh tomatoes, it was found that:

- 0.34 m^3 of natural gas was required for heating demands in the KUBO Ultra-Clima® greenhouse, compared to 0.48 m^3 needed in a traditional Venlo greenhouse, representing a roughly 1.4 times higher gas use efficiency.
- only 0.03 kg of additional CO2 was required for CO2 fertilization in the KUBO Ultra-Clima® greenhouse, whereas in a traditional Venlo greenhouse, 0.64 kg of CO2 was needed, indicating a roughly 19.0 times higher CO2 use efficiency.

KUBO BLUE LAB RESEARCH 2024: EVALUATING ENERGY INPUTS, YIELD AND QUALITY

To further investigate the performance and robustness of this "CO2 capture strategy," a full crop cycle test was set up in 2024 to compare the energy inputs and production outputs of tomato crops in an Ultra-Clima® greenhouse operating with the "CO2 capture strategy", and a Venlo greenhouse operating with traditional CO2 fertilization strategy. Below parameters are precisely monitored and measured throughout the crop cycle in both greenhouses:

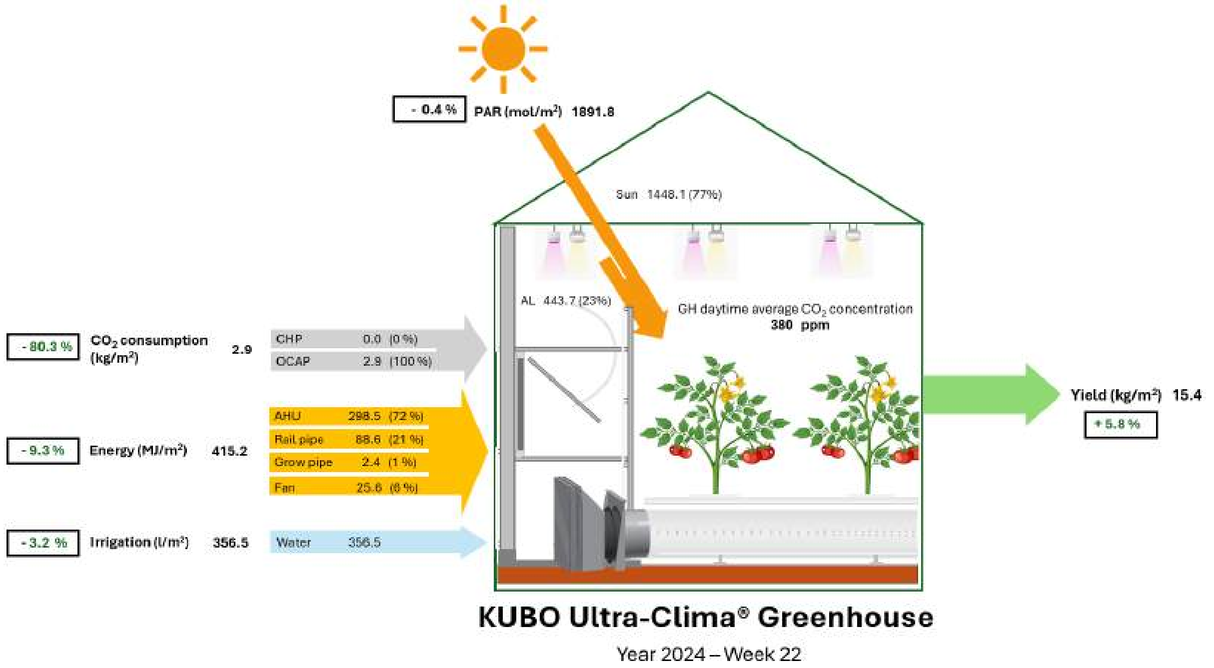
- Day and night average CO2 concentrations, CO2 fertilization.
- Photosynthetic active radiation (PAR) at the top, middle and bottom of the crop canopy.
- Electricity consumption.
- Heating energy consumption of each heating circuit.
- Irrigation water consumption.
- Harvesting data, yield, and average fruit weight.

The primary objectives are to validate: (1) Zero CO2 emissions to the external atmosphere in the Ultra-Clima® greenhouse by applying the "CO2 capture strategy," through precise measurements. (2) Overall higher energy use efficiency in the Ultra-Clima® greenhouse compared to the Venlo greenhouse, due to similar yield and quality but with reduced energy inputs.

KUBO BLUE LAB RESEARCH 2024: EXPLORING MIDTERM DISCOVERIES

Below two graphs illustrate the energy inputs and the yield of KUBO Ultra-Clima® greenhouse and commercial Venlo greenhouse, from 2024 week 1 till week 22.

Figure 13 The energy inputs (electricity, CO2, heating, irrigation) and the yield of KUBO Ultra-Clima® greenhouse, from 2024 week 1 till week 22.



PAR – photosynthetic active radiation, the radiation spectrum that plants use for photosynthesis.

AL – PAR contributed from the artificial lighting system; the AL is used to compensate for the light lost in the KUBO Ultra-Clima® testing facility – Blue Lab, because of the gable shading effects.

Sun – PAR contributed from the solar radiation.

Fan – the electricity consumption of the Air Handing Unit Fan.

CHP – the by-product CO2 from the co-generator heat production.

OCAP – the waste CO2 from industrial plants.

AHU – the heating consumption of the Air Handing Unit Heat Block.

Rail pipe – the heating consumption of the rail pipe.

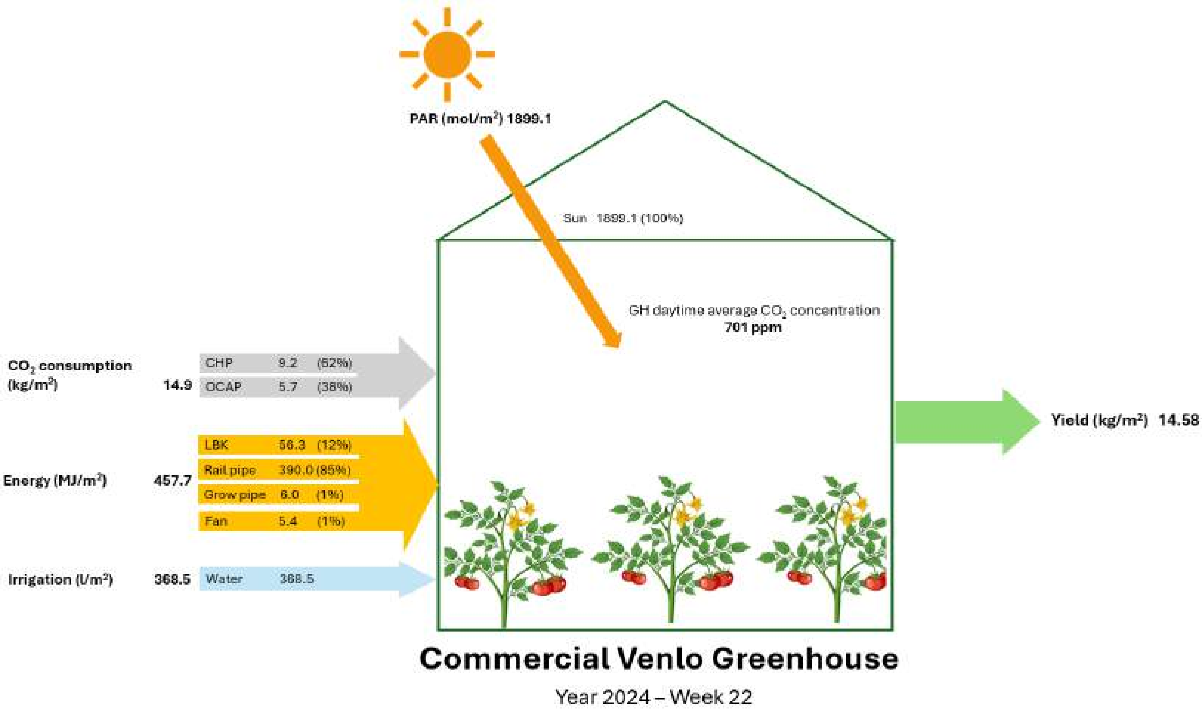
Grow pipe – the heating consumption of the grow pipe.

Gable – the heating consumption of the side gable heating pipe. The number is modified based on the cover ground ratio of the Blue Lab area and a commercial greenhouse size of 2.5 ha.

Water – the water consumption for irrigation.

Yield – the harvested yield per m^2 growing area.

Figure 14 The energy inputs (electricity, CO2, heating, irrigation) and the yield of Commercial Venlo greenhouse, from 2024 week 1 till week 22.



Fan – the electricity consumption of the LBK Fan.

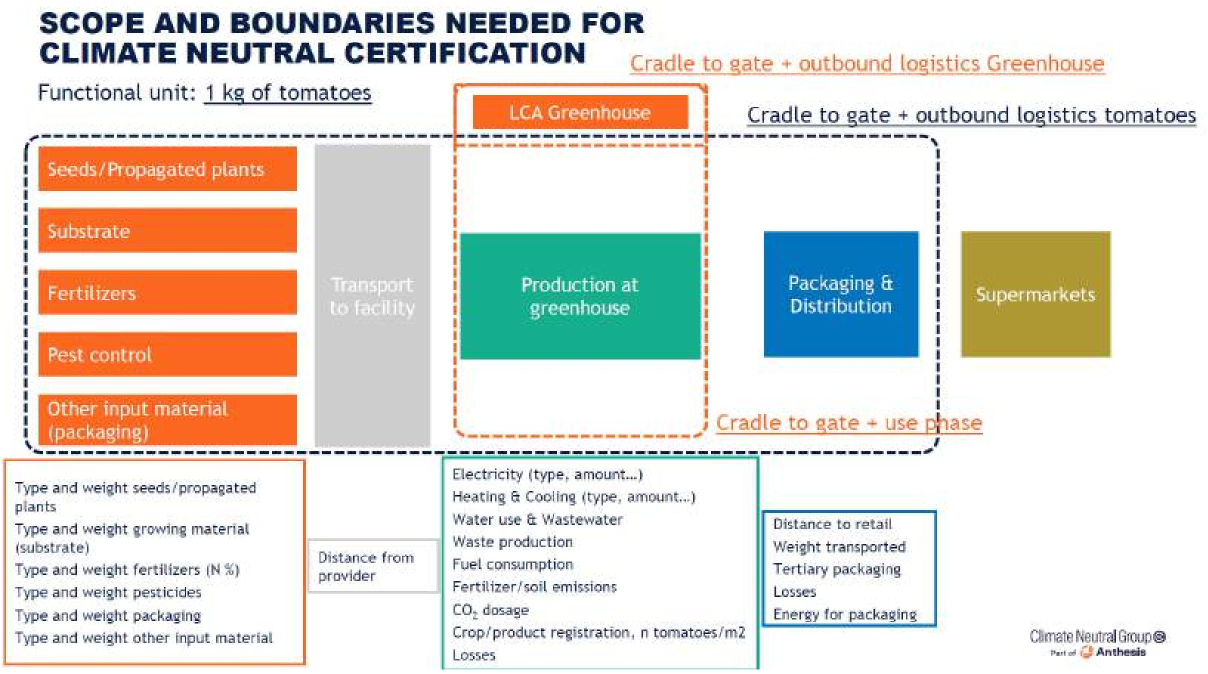
LBK – the heating consumption of the luchtbehandelingskast (Air Handing Unit in Dutch).

KUBO BLUE LAB RESEARCH 2024: VALIDATION BY THE CLIMATE NEUTRAL GROUP

Additionally, to enhance the credibility of this research, a third-party Climate Neutral Group (CNG) is validating the entire research and the results and conducting a life cycle analysis of these two greenhouses (Fig. 15).

CNG was founded in 2002 by Triodos Bank, with participation from DOEN, to assist organizations in achieving a 'Net Zero carbon economy' by 2050 in accordance with the Paris Agreement. In 2022, CNG merged with the Anthesis Group and now offers services in more than 23 countries with approximately 1300 Net Zero experts. They have supported over 4000 organizations, compensated for over 15 million tons of CO2, and contributed to improving the quality of life for millions of people by contributing to various sustainable development goals.

Figure 15 The scope and boundaries needed for climate neutral certification.



The European Union has introduced initiatives to cut CO2 emissions, urging industries to reduce or offset their emissions. One key initiative is the Emission Trade System (ETS), aiming to eliminate emissions by 2057. Under ETS, major polluters must surrender emission allowances, pushing them toward sustainable practices. As costs for allowances rise, sustainable business becomes more appealing. Additionally, a voluntary market for CO2 certificates has emerged, offering companies another way to offset emissions. Investing in sustainability can also lead to loan rewards, as seen with ABN AMRO's transition loan program. These initiatives highlight the growing importance of Environmental, Social, and Governance (ESG) practices in industry. The involvement of CNG reflects a broader commitment of KUBO to sustainability and aligns with global efforts towards achieving a net-zero carbon economy by 2050.

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