Zero Energy Greenhouses©

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Subjects
- Greenhouse concepts
- Airco Greenhouse; objectives and tools
- New growth insights
- Result from field trials
- Examples of up and running projects
- Aircomatic

Entrepreneurship and Creativity
- Dutch government has set the objective: *Horticulture should be an energy-neutral industry by 2020*
- New vision: greenhouse as energy source
- Ever-ongoing quest for cost reduction
- Trial and error approach (Innogrow, Knowhouse, etc.);
- Mutual effort: Synergie platform *(Growers, government, research, and suppliers)*

Greenhouse Concepts
- Closed greenhouse
- Aircokas semi-closed greenhouse

Required Investments
- Closed greenhouse (starting C$150/m²)
- Airco semi-closed greenhouse (starting C$7.50 to C$90/m²)

Advantages Closed Greenhouse
- Energy savings 20%–30%
- Almost full control over outside threats (pests and diseases)
- Excellent climate control
- Ideal summer climate
- Low CO_2 emissions
- Strong concept with respect to public opinion about our industry

Disadvantages Closed Greenhouse
- Limited application because of closed/non-closed ratio
- High cooling capacity required (700 W/m²) reducing radiation peaks
- High capacity aquifers required
- High investment, long pay-back time
- Not applicable in existing greenhouses
- High electricity costs

EXPERIMENTAL AIRCOKAS GREENHOUSE CAN BE FOLLOWED VIA INTERNET
- News Calendar Archive
- 3 July 2006

- Applied Plant Research (PPO) of Wageningen, UR <http://www.ppo.wur.nl/UK/newsagenda/news/Experimental_greenhouse_Aircokas_can_be_followed_via_internet.htm>
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The bio-optimal greenhouse of the tomato enterprise of Ruud van Schie in Ens is the first greenhouse in the Netherlands with a system enabling anyone to monitor the climate in the greenhouse via internet (www.aircokas.nl). This experimental greenhouse has a unique air cooling system in combination with atomization for climate optimization: the Airco greenhouse concept. This combination means that windows less frequently require opening than in a conventional greenhouse. This enables a more accurate match between greenhouse conditions and crop needs. Another aspect is a considerable cost saving in comparison with other (semi) closed greenhouse concepts.

The Aircokas is a joint project of researchers of Applied Plant Research (PPO) of Wageningen UR and the specialists of Wilk van der Sande technical contractors and Hoogendoorn Automatisering. Applied Plant Research acts as crop consultant and is responsible for the climate settings. The researchers also perform all plant measurements; they register the microclimate, and process, and interpret the results. Wilk van de Sande provides the heating and cooling expertise while Hoogendoorn Automatisering provides broad knowledge and experience for optimization and automation of all processes.

Cooling by Evaporation. A grower wants to keep the largest possible amount of CO_2 in the greenhouse. This is why he wants to keep his windows closed as much as possible. This, however, rapidly results in the temperature becoming too high. This is why recently closed greenhouses are constructed with an advanced but expensive cooling system where cold water is pumped up from the belowground aquifers.

The partners in the Aircokas project now investigate the perspective of a new, complementary cooling system that utilizes the cooling effect of water evaporation. In a (semi) closed greenhouse this system saves on pumping capacity, and thus on costs.

The Aircokas is fitted with a high-pressure atomization system that brings a fine water mist above the crop in case of much sunshine. This mist evaporates and then has a cooling effect on the environment. This means that windows need to be opened much less than in a conventional greenhouse. This reduces CO_2 loss by ventilation resulting in higher CO_2 concentrations in the greenhouse under conditions with much light. This benefits crop growth, resulting in higher yields.

A production increase of 10% is expected at a 30% reduction of CO_2 emission and 20% energy saving.

The Aircokas project will be running for 2 years. The partners will regularly inform growers and other interested parties about crop development and climate via the website and a newsletter. A number of open days will be organized as well.

WHAT DOES EVERY GREENHOUSE GROWER WANT?

- Increased production
- Reduced energy consumption
- Lower CO_2 emissions
- Fast return on investments

Increased Production.

- Create a better growing climate
- Higher CO_2 concentration
- Full control of the temperature
- Full control of humidity
- Optimum combination of growth factors PAR, T, RH, and CO_2
- Plant reaction determines what should be done

What Does the Plant Want.

- Optimum combination of temperature, light, CO_2, humidity, water, and fertilizer

Reduced Energy Consumption.

- Requires better humidity control
- Vertical temperature regulation
- Air movement without minimum pipe
- Optimum control with plant sensors and plant condensation model

Lower CO_2 Emissions.

- Aligned with government regulation
- Less ventilation/higher average CO_2 level
- Better use of CO_2 (plant reaction/stomata)
- Higher CO_2 concentration with identical dosing costs

Airco Greenhouse Tools.

- Adiabatic cooling / misting
- Accurate ventilation
- Dehumidification
- NIR (near infara-red reflections) screen
- Roof sprinklers
- Vertical fans
- Cooling with Airco-units
- Heat/cold storage (aquifer)
- Combination of tools depends on crop and economic yield

Adiabatic Cooling.

- An adiabatic process is one in which no heat is gained or lost by the system.
- This process produces cool air by evaporating water within a uniquely engineered greenhouse

Misting.

- Misting as a "natural" addition to crop transpiration
- Effective control of greenhouse temperature and humidity
- Cheapest "cold" both with respect to investment and in use (C$7.50/$m^2$)

Misting Design.

- Old systems caused problems with wet crops and diseases (e.g., botrytis)
- Micro-fog system 100–120 bar, direct evaporation
- No dripping nozzles in between
- Water capacity at about 0.4–0.5 $L \cdot m^{-1} \cdot h^{-1}$
- Good experiences in tomatoes, cucumbers, and peppers.
- Vertical air movement

Vertical Air Movement.

- Hoogendoorn Airco Breeze
- 1 fan per 200 m²
- Costs per m² = C$2.25
- Capacity 1 watt/m²
- Substantial energy saving
- Software controls ventilators

Other Equipment.

- ATU = air transfer units
- Shade screen
- Thermal screen

Airco Greenhouse, Relevant Sensors.

- PAR sensor
- IR plant temperature
- CO_2 and temperature around the plant at multiple vertical heights

Aircokas Concept.

- Feasibility study
- Software: Aircomatic
- Hardware: Plant sensors + Aircobreeze
- Letsgrow Aircosense live
- Consultation, on site, remote, in close cooperation with research institutes,
- in close cooperation with crop advisors

Airco Results; Research Project 2006.

- Tomato (organic) in the Airco greenhouse
- Extensive monitored by plant sensors
- Misting got the first priority of all cooling options
- Vertical ventilators applied
- Dehumidification with air treatment units (ATUs)
- Results: 40% reduction in CO_2 emissions, 30% energy savings, 10% higher production

Observations.

- Growing climate with optimum combination of PAR, temperature, CO_2, and RH, controlled by plant sensors
- Good horizontal temperature distribution without high electricity costs, control units distributed throughout the house
- Vertical temperature balance, vertical air movement prevents dead climate and condensation without minimum pipe
- Better climate for biological control

Greenhouse as Source of Energy.

- Kwekerij Stef Huisman
- Tropical pot plants
- Eb and flood containers
- 5.400 m²
- ½ trial and ½ reference
- Design:
  - Compact heat exchange systems
  - High level of heat exchange — large contact surface (threads)
  - Heat pump, no cooling tower

Optiflor.

- 10 ha *Phalaenopsis*
- Aquifers and cooling unit
- Approach:
  - Summer, cooling from the 'cold' source
  - Winter, heating to create the cold source, Energy Cluster

Kwekerij de Grevelingen.

- Thorough research for more than one year
- 5 ha Aircokas (tomato crop)
- 6 ha traditional greenhouse
- 248 (scattered) ATUs + HP + Aquifers
- Cooling capacity 180 W/m2 at max
- Cooling through misting 0.4 $L \cdot m^{-2} \cdot h^{-1}$
- Focus on increased crop yield and quality

Hoogendoorn Aircomatic.

- Control based on plant requirements
- Adiabatic cooling / misting
- Cooling with Airco-units
- Dehumidification
- Heating
- Ventilation and air movement
- Control via plant sensors with optimum combination of PAR, temperature, RH, CO_2
- User defined priorities
- Higher production, lower energy consumption

SUMMARY:

- Quest for energy neutrality or even better energy supply role
- Aircokas: modular set up
- Aircokas: applicable to existing situations
- Choose for the total concept to avoid failures and disappointment
- A new industry revolution not seen since the introduction of soiless culture