Investing in Control Environment Agriculture Technologies

Paul Selina, Vice President Applied Research, Village Farms
Introduction to Village Farms

- Village Farms
  - Vertically integrated year-round direct supplier to leading retail grocers
  - Fresh vine ripened tomatoes, bell peppers, eggplants & cucumber varieties
  - Greenhouse facilities owned – BC (110 acres), TX (130 acres)
  - New 30-acre GATES® greenhouse completed – fully operational 2012
  - Upgraded and refurbished 20 Acre greenhouse online spring 2014
  - VF Clean Energy power plant

- Research and Development Department
  - Modifying greenhouse systems according to local climates
  - All Year Round production – lighting for winter – cooling for summer
Village Farms GATES greenhouse - Texas
Greenhouses around the world
Culiacan, Sinaloa
Why do we build greenhouses?

We build greenhouses to protect the crop from the weather, prevent insects and diseases, and create conditions for improved photosynthesis and growth.

• The simplest greenhouses provide insulation from the cold, solar heating in daytime, protection from rainfall, and improved crop microclimate.
  • Drip irrigation and fertigation supplies the plants water and nutrition
  • Vine crops can be grown vertically for better light interception and clean fruit.
• Moving window systems allow variable rates of ventilation
• Shade screens reduce transpiration and temperature stress

• Hydroponic growing improves water and nutrient availability, root zone aeration, and reduces root disease.

• Pad / fan systems, and fog can provide cooling when outside humidity is low.

• Heating systems can be added to maintain temperatures and reduce humidity
  • When natural gas is the energy source the heating system can also supply CO2
These greenhouses all mix greenhouse air and outside air to delivery in tubes under the crop

- Cooling
- Humidification
- Positive/negative pressure

Kubo Ultraclima

INNOVATIVE CLOSED GREENHOUSE AIR EXCHANGE SYSTEM

Airflow pattern GATES

ModuAIR

The amount of windsom is maximized creating additional light.

The greenhouse maintains a high energy efficiency which creates a more homogeneous climate, critical for your cropping. While with heat and CO2.

Air preheating allows for more CO2, and heated air saving energy costs.

Additional heating/cooling modules.
Features of the new generation of CEA greenhouses

Cooling systems based on evaporation

• Cooling with plant transpiration, wet pad, fog system
• Correct temperature & humidity increases photosynthesis

Controlled airflows

• Greenhouse has no roof vents and volumes are controlled by the fans
• Maximizing latent energy in the air reduces ventilation volume
• Re-circulate heat / humidity / CO₂
• Higher CO₂ level increases photosynthesis

These types of greenhouses are favored in regions of high radiation and low humidity (monthly wetbulb temperatures <16°C)
100% insect exclusion is critical for long-term healthy crops
Evaporative cooling
Air moving systems
Features of the new generation of CEA greenhouses

Air moving and cooling systems create a very uniform climate.

• Average temperature differentials (horizontal & vertical) are always less than 1°C
• Special controls manage the temperature of the incoming air
• Accurate control of air mixing creates ideal temperatures at bottom of the plant
• Fog above the crop creates cool air movement
• Mass flows of air create mixing

Uniform temperatures, create a uniform crop, and optimize growing strategies
Air moving systems
The GATES greenhouse is capable of maintaining good humidity even in the hottest driest weather.
Prodrain measurements
cucumbers – growth & temp
Climate measurement and crop monitoring

Hortimax ProDrain

- Allows control based on actual water uptake
- Lets you monitor transpiration in real-time
- Lets you monitor plant growth
- Improves production planning
Prodrain measurements tomatoes – growth & transpiration
This is what we measure manually

- Growth
- Length, leaf, flowers, fruit
- Stem diameter
- Color and form
The range, and limits of greenhouse temperature for a tomato crop

39: absolute maximum hourly temperature

28: Preferred Maximum Hourly Temperature

27: absolute maximum daily average temperature

22: Preferred Maximum Daily Average Temperature

18: Preferred Minimum Daily Average Temperature

14: Preferred Minimum Hourly Temperature

12: absolute minimum daily average temperature

6: absolute minimum hourly temperature

Credit: Jouke Campen, WUR, Greentech presentation
Compare Texas Climate with Panama City

Temperature [°C]

January
February
March
April
May
June
July
August
September
October
November
December

-10 0 10 20 30 40
Potential “low cost” solutions to improve productivity of tropical highlands greenhouses

• Build higher greenhouses, for improved ventilation, and more uniform climate at crop level

• Use heating to manage humidity and reduce fungal diseases, also could be a source for CO2.
Increase in gutter height has improved greenhouse climate management, and provided a more uniform temperature within the plant canopy.

Harrow research station, Ontario
Air assisted fog system provides cooling and the velocity helps push the air to the top ventilation
Build a taller greenhouse - India
Compare Texas Climate with Panama City
Closed greenhouse for Panama

Closed greenhouse systems in more detail

The sun’s energy is very powerful. Even though we can reflect a lot that is not required by the plant, it requires a large cooling installation to maintain the greenhouse climate.

Closed Greenhouse Concept

Growing light transmitted

Infra red reflected

Air handler

Energy removed by heat pumps
Advantages of a closed greenhouse

• Because there is almost no air exchange, very high levels of CO2 can be maintained with small introductions

• High levels of CO2 greatly increase the production potential

• Always have complete control of temperature and humidity
Quick history of “Closed Greenhouses”

• Built in 2003, the Themato project was a pioneer in creating a closed greenhouse environment.
  • Heat pumps to create warm and cold water.
  • Hot and cold water stored in different parts of the aquifer – *(not proposed for Panama)*
  • Airhandling units in the greenhouse and air tubes under each crop gutter

• Many subsequent greenhouses were built with smaller cooling capacity, combined with traditional ventilation. “These semi-closed greenhouses” were the precursors of today’s large CEA greenhouses.

• “Closed Greenhouse” designs are included in two new research greenhouses in Estidamah, Saudi Arabia, and Al Ain, in the Emirates.

• Cooled greenhouses built in other markets, and air conditioned greenhouses are widely used by orchid growers to initiate flowering throughout the year.
Korea - greenhouse air conditioning units
• Building an economical closed greenhouse
  – Shading systems – thermal barrier
  – Wavelength specific reflection
NIR reflecting screens

This part of the spectrum is reflected
The film transmits the growing light and reflects most of the heat portion
**Cooling System Diagram and Unit Capacities**

Remove heat and humidity from greenhouse air and add heat to the water.

- **Air handlers in greenhouse**
  - per m²: 500 W/m²
  - Per hectare: 5MW
  - Per hectare (tons cooling): 1,400 tons

- **Chillers - 24 hr operation**
  - per m²: 250 W/m²
  - Per hectare: 2.5MW thermal (~800KW electrical)
  - Per hectare (tons cooling): 700 tons

- **Cold Water Storage**
  - 2.5 KWhrs
  - 25MWhrs
  - Per hectare (tons cooling): 7,000 tons
Greenhouse cogeneration. What is it?

Natural gas is used to generate electrical power for onsite use or sale. The heat and CO2 are used in the greenhouse.
• Total solar radiation for Panama City is lower than Marfa, but without a large seasonal pattern.

• Panama has many more cloudy days and more diffuse light.

• However, with higher CO2 levels production per mol of PAR light will be greater

• Production potential for TOV tomatoes could be >90kg/m²
• Economics

• I will include capital cost and electrical cost information
• Our tomato crops already are a vertical farming system

• *Here I want to include a short video*
Closing suggestions

• Develop an understanding of the climate constraints in your area and decide if you should be looking to develop in another area

• Schedule a visit to Expo Agro in Irapuato, Nov 24-27, to see the range of greenhouses and technologies currently available.
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• Schedule a visit to Expo Agro in Irapuato, Nov 24-27, to see the range of greenhouses and technologies currently available.

• Secure the high value market, local or export.

• Find a technology partner

• Remember the economies of scale
Thank you

www.villagefarms.com