Future Technologies for High Tunnels

Cary A. Mitchell

Gioia D. Massa

Department of Horticulture &
Landscape Architecture

Indiana Horticultural Congress & Trade Show

Adam's Mark

January 31, 2007

Alternative Title:

Tunnel Vision from Purdue

HT Advantages for CEA

- Inexpensive construction
  - no permanent infrastructure
  - minimal utilities
  - reduced labor
- Creates favorable microclimates
  - Extends growth seasons & zones
  - moderates daily / seasonal temperatures
  - avoids wind-induced mechanical stress
  - prevents wind-induced tissue desiccation

Manipulating the Cardinal Factors of Plant Growth for CEA

- Temperature – max, min, ADT, RZ
- Light – intensity, quality, duration
- Atmosphere – CO_2, H_2O_v, VOCs
- Nutrients – macros, micros, organics
- Water – quality, quantity, aeration issues

Smart Films

- Multi-layer films
- Incorporate anti-fogging, anti-dripping, UV stability, durability against wind-shear, resistance to sulfur
- Enhance IR absorbance or reflectance for climate-specific heating or cooling
- UV filters deter harmful insects while allowing wavelengths for pollinators
- Gas micro-bubble layer promotes light diffusion for greater uniformity
- Spectral selection to enhance crop growth or shape

Future Technologies for HT CEA

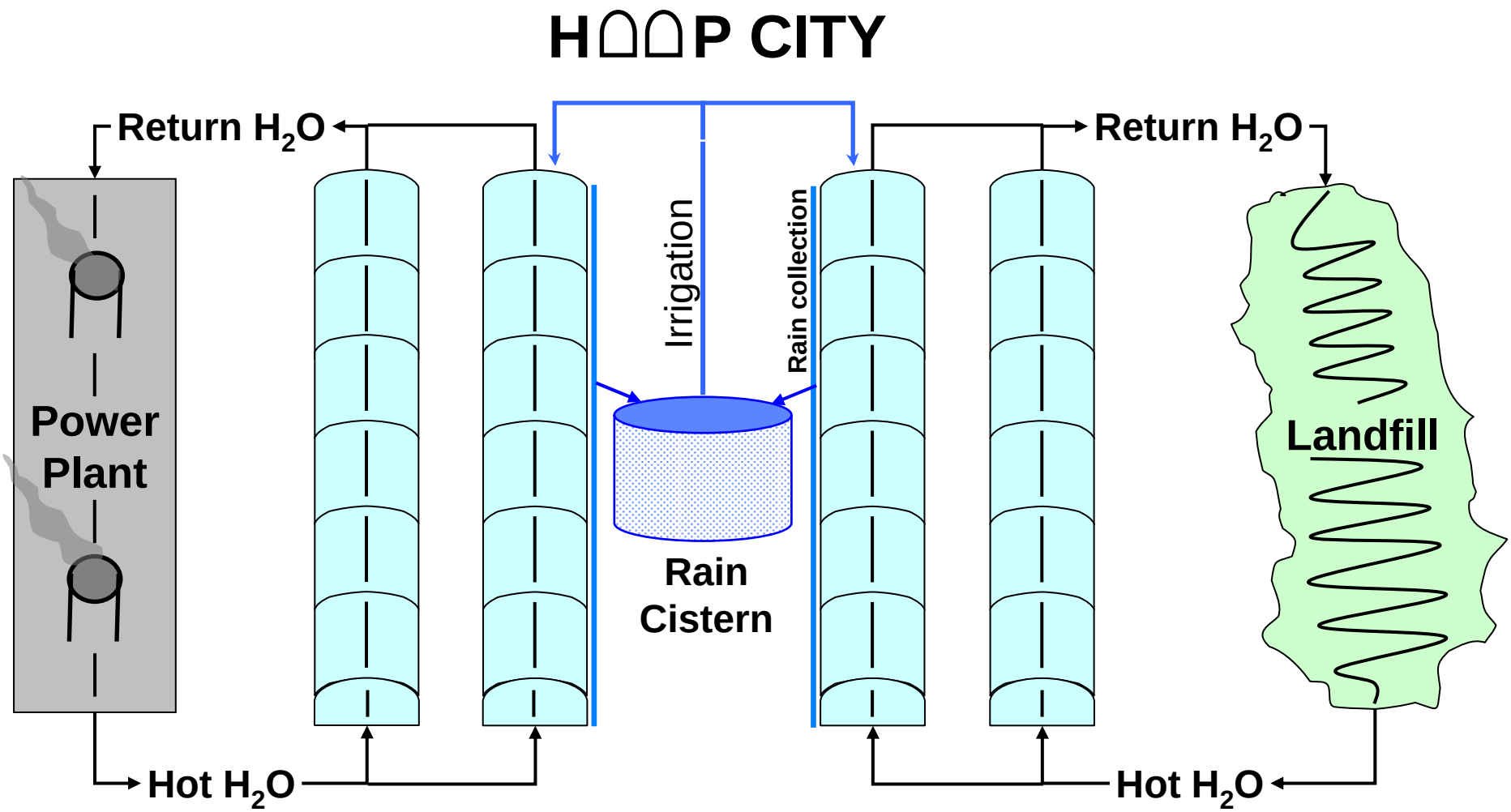
- **Extend production throughout cold season**
  - Locate near power plant, landfill, waste-biomass source
  - Pipe hot water through raised beds from / to heat source
  - Auto-control inside temp with sensors, valves, control loop
  - Backup heat source powered by waste-generated CH_4
- **Enhance natural lighting within tunnels**
  - Line lower inside hoop surfaces with reflective film (mylar?)
  - Reflective A-frames / hanging strips between beds
  - Reflective mulches covering raised beds
  - Use more transparent covering films (future, nanotech)

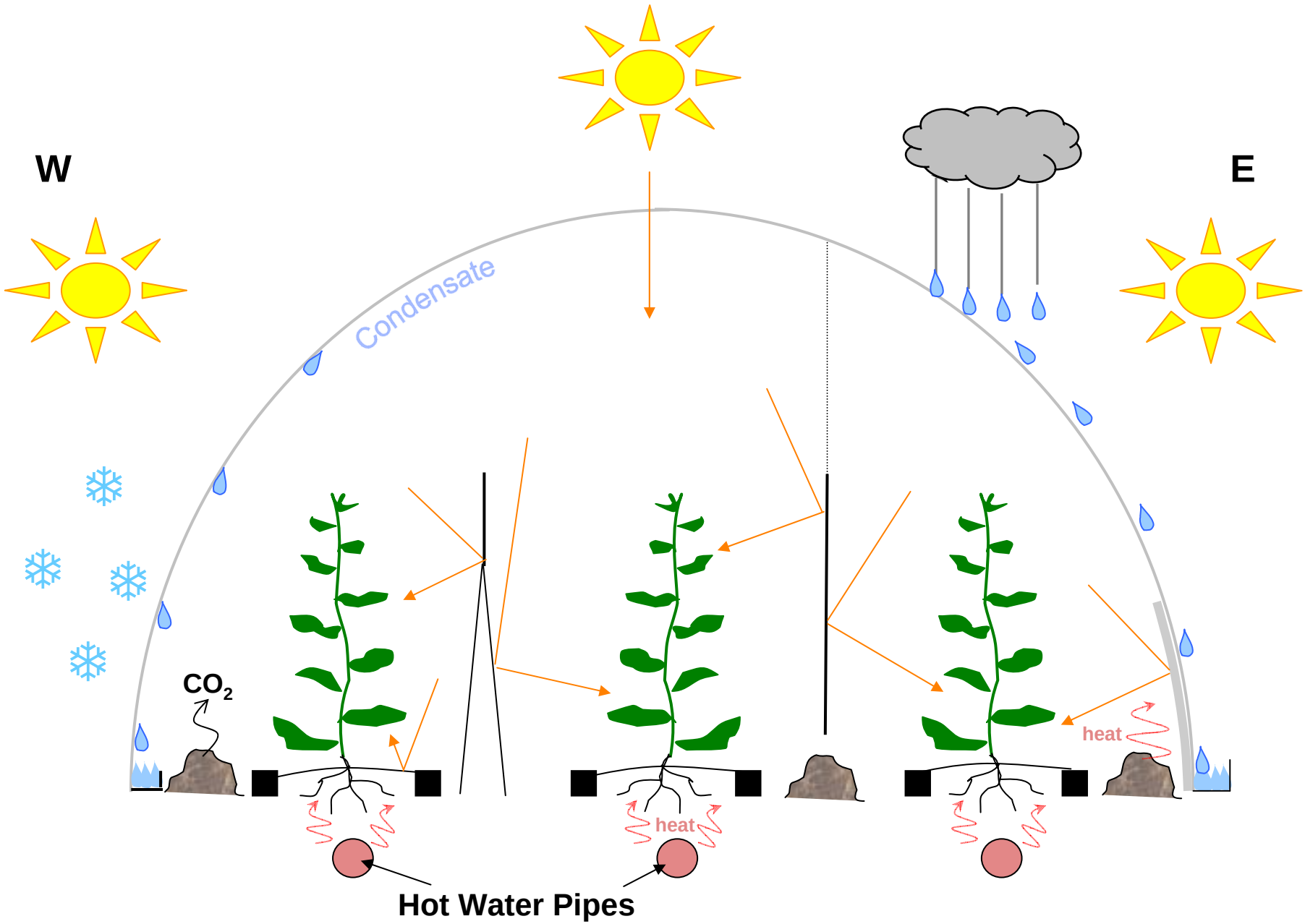
Modify HT Atmosphere with Local Resources to Enhance Crop Growth

- Enrich closed headspace with CO_2 in winter
  - Compost organic waste within hoops but not in plant beds
  - Inject filtered combustion by-products of CH_4 / LFG
- Passive humidification of incoming dry winter air
  - Leverage convection of bottom heat up through moist beds
  - Recycle internal condensate
- Avoid accumulation of volatiles in closed HTs
  - Ventilate as needed for GH effect
  - Maintain slow-leak, positive-pressure construction

Loop Closure for Water & Nutrients in HT Production

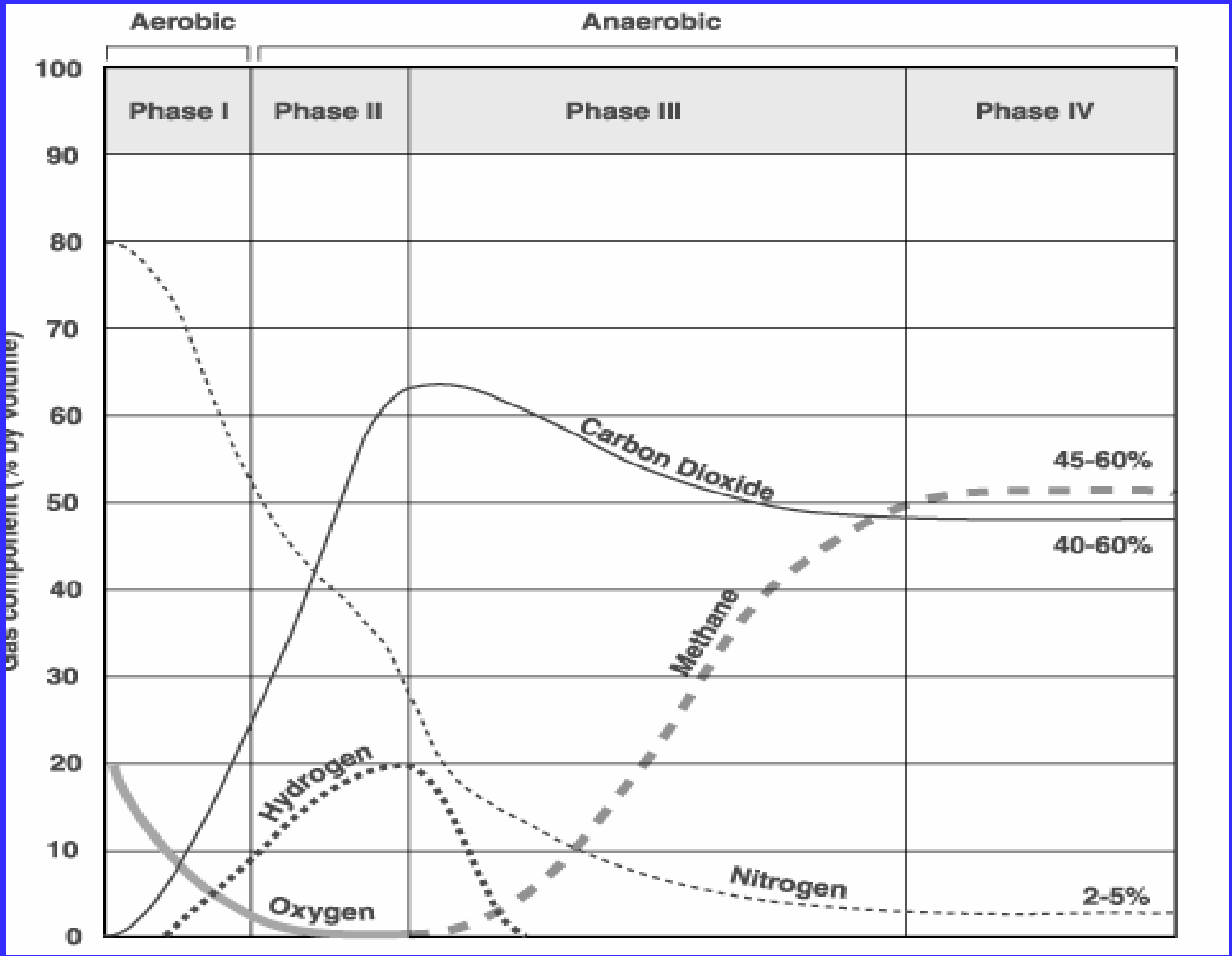
- Collect outside-hoop rainwater runoff and condensate in cisterns to supplement irrigation
- Recycle nutrients from completely composted (mineralized) crop biomass into plant beds


HOOP CITY
Return H_2O
Return H_2O
Power Plant
Irrigation
Rain collection
Rain Cistern
Landfill
Hot H_2O
Hot H_2O


W
E
Condensate
CO_2
heat
heat
Hot Water Pipes

Future HT Technology Objectives

- Do not reinvent the greenhouse
- Leverage availability of local cheap-energy resources
- Leverage opportunities afforded by local climate
- Implement use of sensors, actuators, and computer-control systems


Aerobic
Anaerobic
Phase I
Phase II
Phase III
Phase IV
100
90
80
70
60
50
40
30
20
10
0
Carbon Dioxide
45-60%
40-60%
Methane
Hydrogen
Nitrogen
2-5%
Oxygen