New technologies developed for conventional growing systems: possibilities and limitations for application in organic systems.

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Outline

- Introduction
- Water use efficiency/ reduced water use
- Energy use efficiency/ reduced CO_2 emission
- Some new techniques and concepts
- Final remarks

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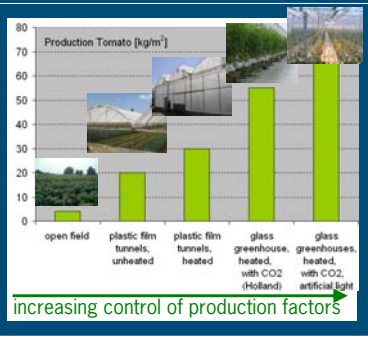
Challenges for Future Vegetable production:

- (Twice as much) with less ecological footprint
- Economically viable

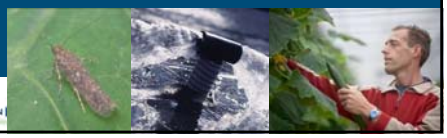
Twice as much: better controlled conditions



Reducing the ecological footprint (planet)

Optimize efficiency of (minimal) inputs:
- Energy
- Water, minerals } (Planet)
- Crop protection
- Labour (People)

within (economic) constraints
- Profit
  - Economically viable



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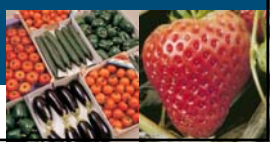
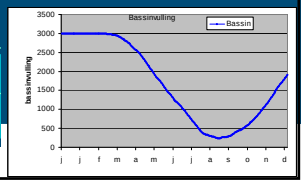


Water sources

- Rainwater
  - Very Low Chemicals
- Tapwater
  - Salts
- Surface water
  - Salts, pathogens, chemicals
- Groundwater
  - Salts
- Condensation water
  - Very Low Chemicals

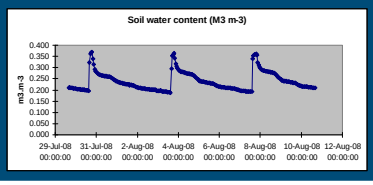

Optimal use of current techniques : Sustainable water use

Rainwater storage	rainwater	additional water
500 m^3/ha	43%	57
1500	63	37
3000	97	3



Efficient irrigation/ fertilization strategies

Sensor technology and combination of (soil) physics and physiological information

Efficient irrigation/ fertilization strategies



Lysimeters

Robust tensiometer


Water content meters

Water Use Efficiency: irrigation based on soil water content

Crop	*Water Use traditional (mm)*	*Water Use optimized (mm)*	*Marketable WUE (kg/m^3)*	*Water Saving Index (%)*
Ornamentals (Italy)	540	413	-	24
Cucumber (Turkey)	717	545	44 (35)	19
Tomato (Jordan)	425	275	8 (6)	25
Egg plant (Lebanon)	95	71	54 (36)	35
Lettuce (Netherlands)	186	66	73 (22)	69

From Balendonck et al., FlowAid

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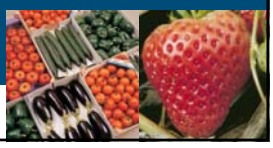
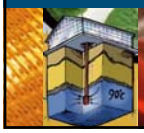


Reduction of Carbon footprint: reduction energy use (i.e. CO_2 emission)

Five steps:

1. Maximum use of solar energy
2. Reduction of energy use
3. Efficient conversion, heat storage and re-use
4. Efficient use: unit product per unit energy
5. Replace fossil fuel by other renewable energy sources

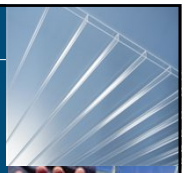


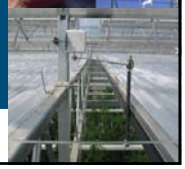



Reduction of Carbon footprint

Steps:

- Maximum use of solar energy
  - High light transmission of greenhouse (construction, covering, coatings, reduce screen use…): two effects: Energy↓, production ↑
- Reduction of energy use
- Efficient conversion of energy, heat storage and re-use
- Efficient energy use: unit product per unit energy
- Replace fossil by renewable energy





Reduction of Carbon footprint

Steps:

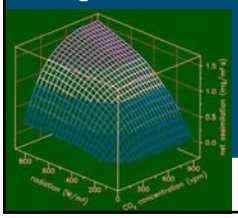
- Maximum use of solar energy
- Reduction of energy use
- Efficient conversion of energy, heat storage and re-use
- Efficient energy use: unit product per unit energy
  - Temperature integration, no lower heating, higher humidity, reduced transpiration, intelligent climate control, new crop limits…
- Replace fossil by renewable energy



Efficient use of energy: intelligent control strategies

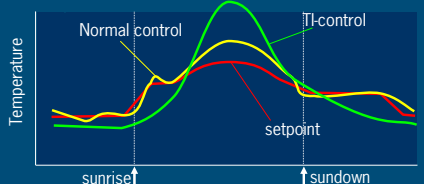
Aim: Optimize crop response (growth, production) with minimal (energy) input

The key: combine greenhouse physics (energy transfer) with physiological information (crop growth irt environment)




Intelligent control strategies: T- Integration

- Temperature: main factor determining energy use (75-90%)



- Temperature Integration: Principle: crop production related to average temperature

  Energy saving: up to 10% lower temperature during heating
  higher temperature during sunlight

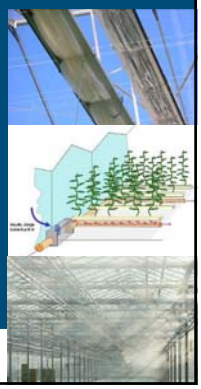
Optimal integration of techniques: new growing concept tomato

Target: 60 kg tomato with 26 m^3 gas

- high insulation (single glass + 2 screens)
  - transparent screen closed until 250 W/m^2
  - energy screen closed when $T_{outside} < 8^oC$
- 1°C lower heating temperature
- Increased ventilation set point → more CO_2
- Active cooling
- Humidity set point ventilation > VPD 1.5g/m^3, air circulation
- External CO_2


New growing concepts Cucumber and Sweet Pepper

- Double/Triple energy screens
  - XLS 18 Firebreak (72 %)
  - XLS 10 Ultra Revolux (47 %)
  - December-February AC foil (EH foil removed to AC)
- Crop ventilation with outside-air to control humidity
- High pressure mist/ evaporative cooling system
- External CO_2



Production of Cucumber (2009)

Crop	10 cm slab		
	Kg/m²	number/m²	Fruit Weight (gram)
1	25.1	58.4	430
2	27.2	57.8	471
3	21.0	48.0	438
Total	73.3	164.2	446

Overview results new growing concepts 2008-2010

	Goal	Results	CO_2 footprint
Crop	Production kg/m²		CO_2/kg
Cucumber (08)	80	73	
Tomato (09/10)	60/65	68/70	Ca 0.6
Sweet Pepper (10)	32	30 (prognosis)	(= 50% compared to normal)
	Energy m³ nat. gas (1 m³ = 31.6 MJ)		
Cucum/Tomato	26/25	25	
Sweet Pepper	20	22 (prognosis)	

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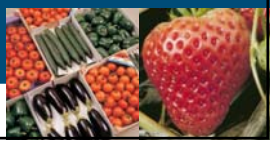
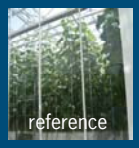


New techniques and concepts

Diffuse light

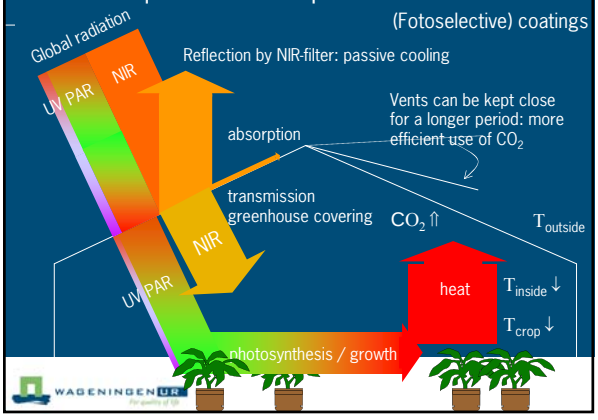


Spring crop 54.4 Kg/m²	+6.5%	+9.2%
	57.9	59.4
Autumn crop 2008	+8.8%	+9.7%
	No light loss	3% less light

Hemming et al.

New techniques and concepts:

(Fotoselective) coatings



New techniques and concepts

(Semi) closed/ completely controlled greenhouses:

- No or minimum ventilation openings
- Independent control of Temperature, humidity and CO_2
- Water recovery
- Less crop protection
- Higher CO_2 concentration, production increase (to 10-20%)
- Energy saving (+30%)
- Bijo door marcel

Semi-closed greenhouses

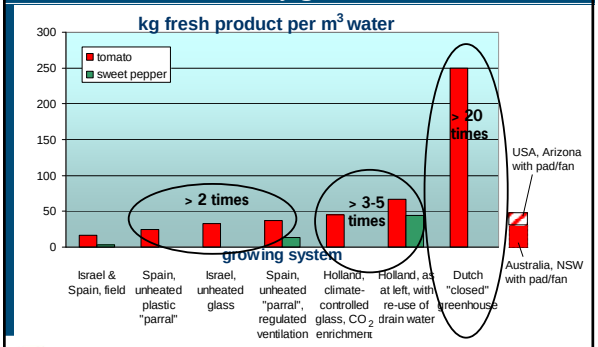
Effects active cooling on CO_2 concentration

Supply capacity: 230 kg CO_2 ha^{-2} h^{-1}	Open greenhouse	Semi-closed (150 W/m^2)	Semi-closed (350 W/m^2)	Completely closed greenhouse
CO_2 concentration (ppm)	600	730	950	1100
CO_2 supplied (kg/m^2/y)	54.7	46.1	29.6	14.4

- Increased CO_2 concentrations → 10-20% higher yield

Quian, 2008

Water use efficiency greenhouses



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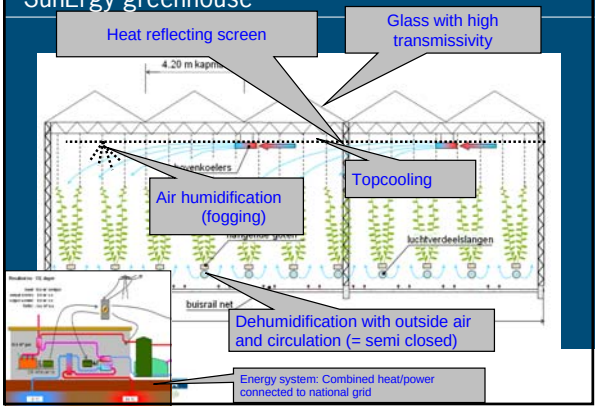
Exploring new techniques and concepts

- Innovation and Demo Centrum IDC: three demo greenhouses (500m^2 each):

SunErgy greenhouse



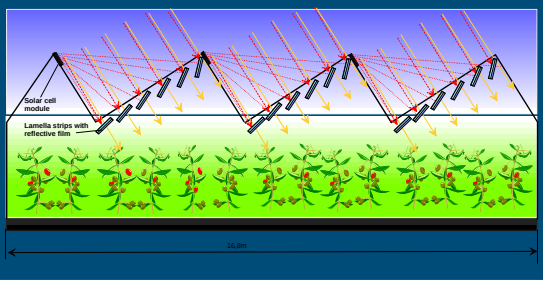
Results SunErgy Greenhouse

Cucumber (5 months):
> 50 kg/m², almost no Botrytis, net use: 1.2 m³/m²

Tomato: 76.2 kg/m², energy < 16 m³/m² (60% saving)

Pepper: prognosis: 32kg/m², 25 m³/m²

Second generation Electricity producing greenhouses



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Exploring new techniques and concepts :

Advanced sensor technology: Multiple Imaging Plant Stress: MIPS as early warning system

- Multiple chlorofyl fluorescence, colour, Infra red
- Imaging time samples
- Plant leaf, plant, crop
- Stress biotic en a-biotic

chlorofyl fluorescence | colour | IR

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Exploring new techniques and concepts:

- Combination of organic greenhouses and other organic (agro) activities (e.g. livestock farming, fish,)
  - Alternative sources of CO_2, heat, minerals, waste

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