


Sustainable greenhouse design


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Trends in Horticulture



- Increase of production scale/intensity
- Control of environmental conditions
- Predictability of production
- Increase crop quality
- Reduction of energy and water use
- Reduction of pesticide use

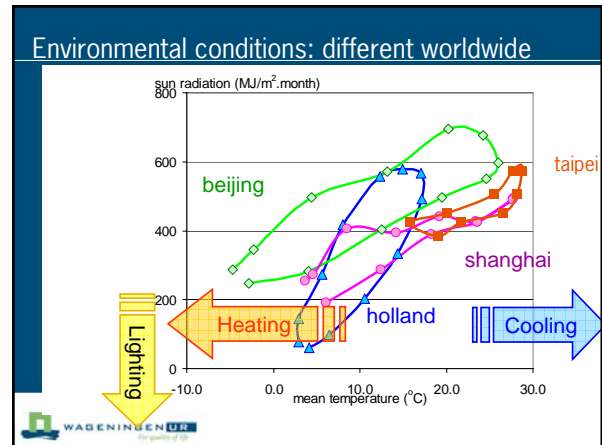


Major challenge

- Design greenhouse systems which combine (economic) production efficiency with minimal input of energy, water and nutrients for different regions in the world:

The "Adaptive Greenhouse"






Step 1 Requirements and objectives

- Requirements*:
 - Market size and regional infrastructure
 - Local climate
 - Availability, type and costs of fuels and electric power
 - Availability and quality of water
 - Soil quality and topography
 - Availability and cost of land, zoning restrictions
 - Availability of capital
 - The availability and cost of labour and the level of education
 - The availability of materials, equipment and service level
 - Legislation in terms of food safety, residuals of chemicals, the use and emission of chemicals to soil, water and air

*Hanan, 1998 and Van Heurn and Van der Post, 2004



Step 1 Requirements and objectives

- Objectives:
 - Reduction of energy
 - Minimal water use
 - Economic production with high quality
 - Healthy food
 - ...



Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - ...
 - ...

Solar
Fossil fuel
Biomass
Wind

Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - ...
 - ...

Co generation
Geothermal

Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - Dehumidification/cooling
 - ...
 - ...

Natural ventilation
Fogging
Pad/fan
Forced cooling

Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - Dehumidification/cooling
 - CO₂ supply
 - ...
 - ...

Natural gas
Liquid CO₂

Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - Dehumidification/cooling
 - CO₂ supply
 - Reduction of energy loss
 - ...
 - ...

Insulating materials
Thermal screens


Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - Dehumidification/cooling
 - CO₂ supply
 - Reduction of energy loss
 - Additional light
 - ...
 - ...


LED
Traditional SON-T

Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - Dehumidification/cooling
 - CO₂ supply
 - Reduction of energy loss
 - Additional light
 - Growing systems
 - ...

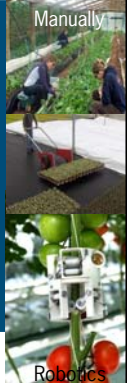


Soil
Soilless
Automated




Step 2: Functions and working principles

- Required functions:
 - Energy supply
 - Heating
 - Dehumidification/cooling
 - CO₂ supply
 - Reduction of energy loss
 - Additional light
 - Growing systems
 - Labour



Manually
Robotics



Methodology

- Degree of technology
 - Covering plastic / glass / net
 - Heating
 - CO₂
 - Fogging
 - Soil / Soilless culture
 - Open / closed water cycle
 - Light control
 - Cooling


- greenhouse climate
- crop response
- economic result

→ Design greenhouse system
→ Climate crop interaction

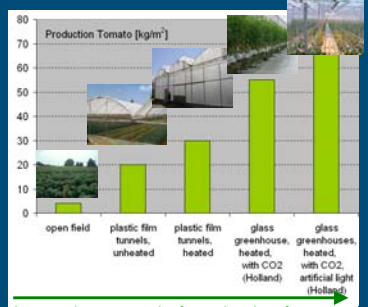



What is a sustainable greenhouse design?

- Design greenhouse systems which combine (economic) production efficiency with minimal input of energy, water and nutrients for different regions in the world
- Low energy input, use of sustainable energy sources
- High water use efficiency, low nutrient losses
- Low pesticide use, high food safety
- High production, product quality, predictability
- High ratio benefit – costs of the production system




Climate controlled greenhouses



Production Tomato (kg/m²)

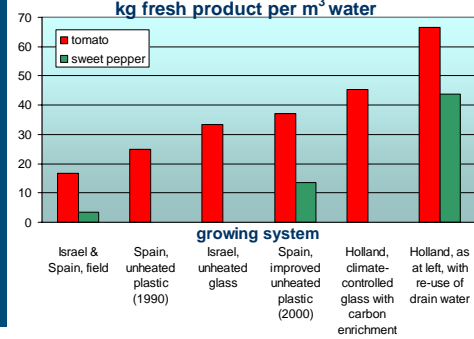
open field plastic film tunnels, unheated plastic film tunnels, heated glass greenhouse, heated, with CO₂ (Holland) glass greenhouses, heated, with CO₂, artificial light (Holland)

increasing control of production factors



Water use efficiency increases with ...

kg fresh product per m³ water




■ tomato
■ sweet pepper

growing system

Israel & Spain, field Spain, unheated plastic (1990) Israel, unheated glass Spain, improved unheated plastic (2000) Holland, climate-controlled glass with carbon enrichment Holland, as at left, with re-use of drain water

...increased controlled environment

Stanghellini



Innovation and Demonstration Centre IDC

Flowdeck

ZonWind

Sunergy

Design example: Energy saving greenhouses

Maximum use of solar energy
Greenhouse as solar collector

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

Tomato experiment:
76.2 kg, planting 16 dec. 2008

Design example: Electricity producing greenhouse

Concentration of direct light
→ PV cells produce electricity
→ (50-100 kWh/m² per year)

Fresnel lens greenhouse

Design example: Water saving greenhouses

- Example WATER efficient greenhouse system
- Closed greenhouse for South Europe (Watery)
 - Maximum water use efficiency

Design example: Low cost passive greenhouses

- Example Asia (Indonesia)
 - Unheated
 - Low cost
 - Tropical lowland conditions
 - Reduced water use
 - Reduction of plant diseases
 - Improved quality


Design example: Low cost passive greenhouses

New plastic films:
high light transmission, diffuse

Tight for insects by nets

Good greenhouse climate by maximum ventilation and chimney effect

Design example: Pesticide saving greenhouse



WAGENINGEN UR
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Adaptive greenhouse design:
for optimal results world wide



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