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Sustainable greenhouse design

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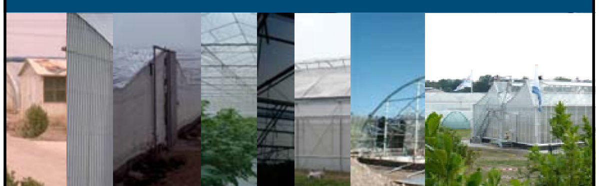
Trends in Horticulture

- 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

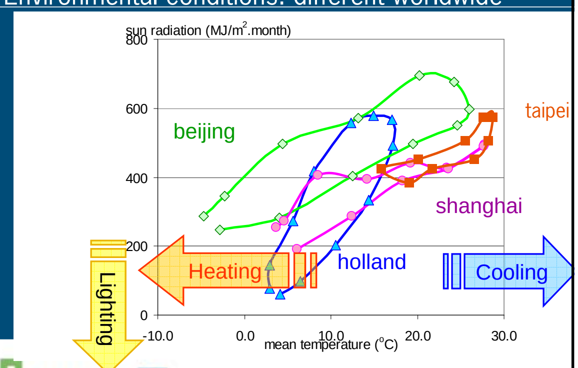
Major challenge

- 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"



Environmental conditions: different worldwide



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
  - …

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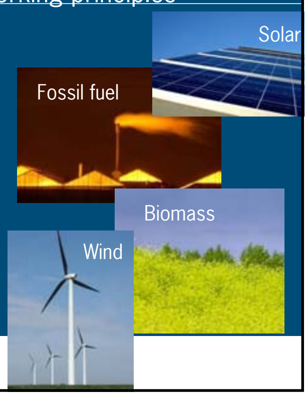
Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - …
  - …



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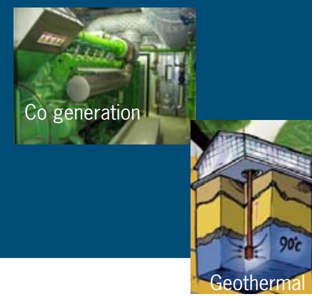
Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - …
  - …



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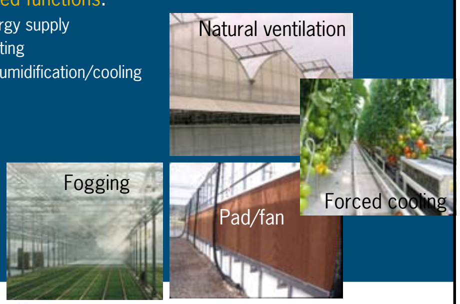
Step 2: Functions and working principles

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



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Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - …
  - …

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Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - …
  - …

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Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - …
  - …

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Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - Growing systems
  - …

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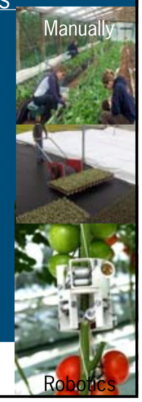
Step 2: Functions and working principles

- Required functions:
  - Energy supply
  - Heating
  - Dehumidification/cooling
  - CO_2 supply
  - Reduction of energy loss
  - Additional light
  - Growing systems
  - Labour



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Methodology

- Degree of technology
  - Covering plastic / glass / net
  - Heating
  - CO_2
  - 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

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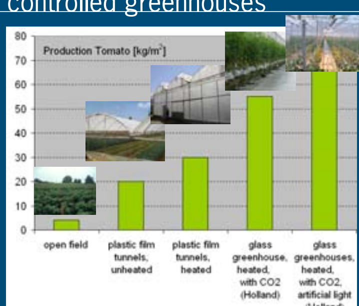
Climate controlled greenhouses



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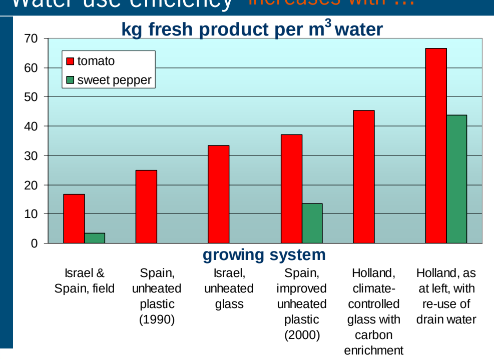
Water use efficiency increases with …



…increased controlled environment

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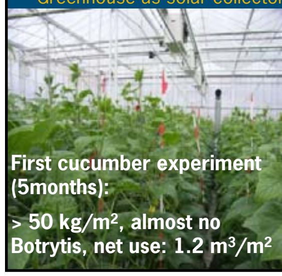
Design example: Energy saving greenhouses

Maximum use of solar energy
Greenhouse as solar collector

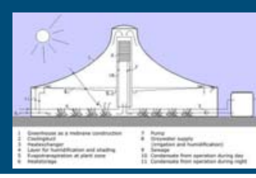


Design example: Electricity producing greenhouse

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

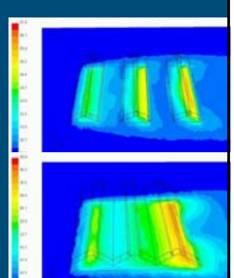
Design example: Water saving greenhouses

- Example WATER efficient greenhouse system
- Closed greenhouse for South Europe (Watergy)
  - 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

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Design example: Pesticide saving greenhouse

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Adaptive greenhouse design: for optimal results world wide

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