Greenhouse Horticulture: steps to an efficient use of energy

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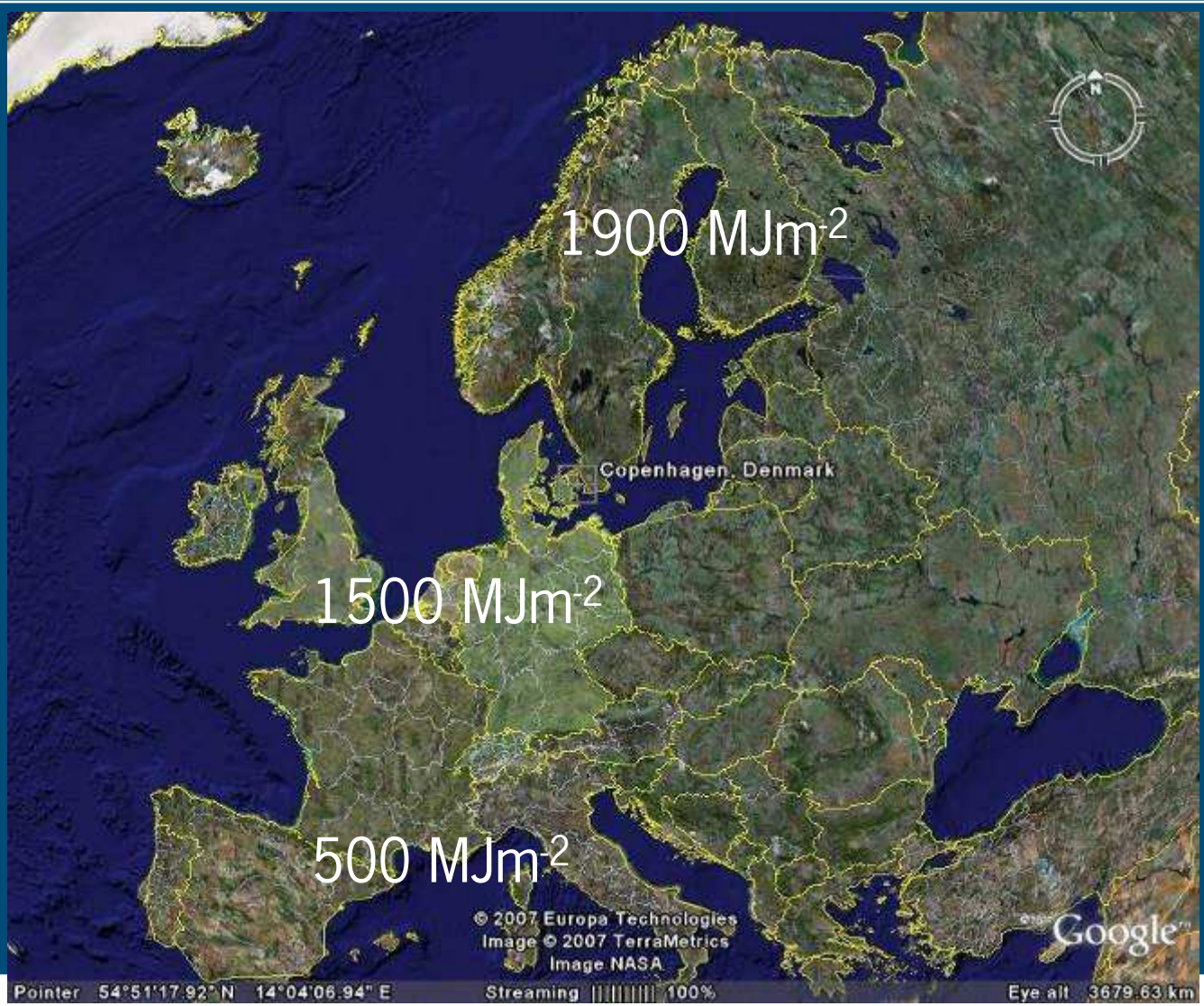
GLASTUINBOUW

Energy use in European greenhouse horticulture



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Trends in Horticulture

- Increase of production scale
- Cost increase (labour and energy)
- Year round crop production
- Total control of environmental conditions

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Reduction of fossil energy use

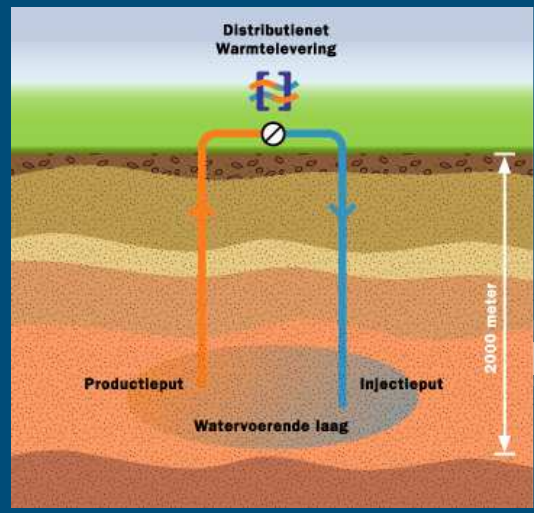
- Energy: 20-30% of production costs

- Targets Greenhouse sector in the Netherlands for 2020:
  - -48% CO_2 emission compared to 1990
  - new build greenhouses operate (almost) without fossil fuel
  - Greenhouse sector produces sustainable energy (heat and electricity)



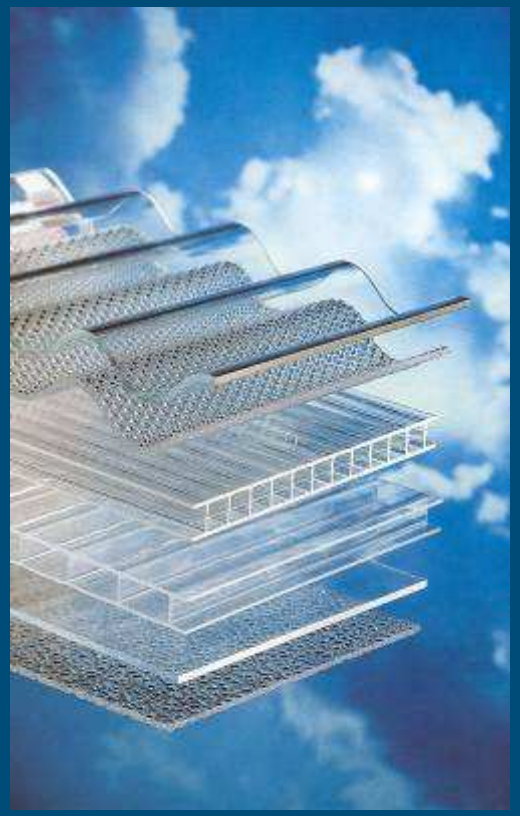
Towards energy producing/efficiënt greenhouse

- 1: Maximal use of solar energy
- 2: Reduction energy loss
- 3: Efficient environmental control and conversion solar energy
- 4: Storage and re-use heat
- 5: Replace fossil fuel by renewable sources



1. Maximal use of solar energy/ natural light

Maximal natural light: minimal construction parts and optimal transmission of the materials



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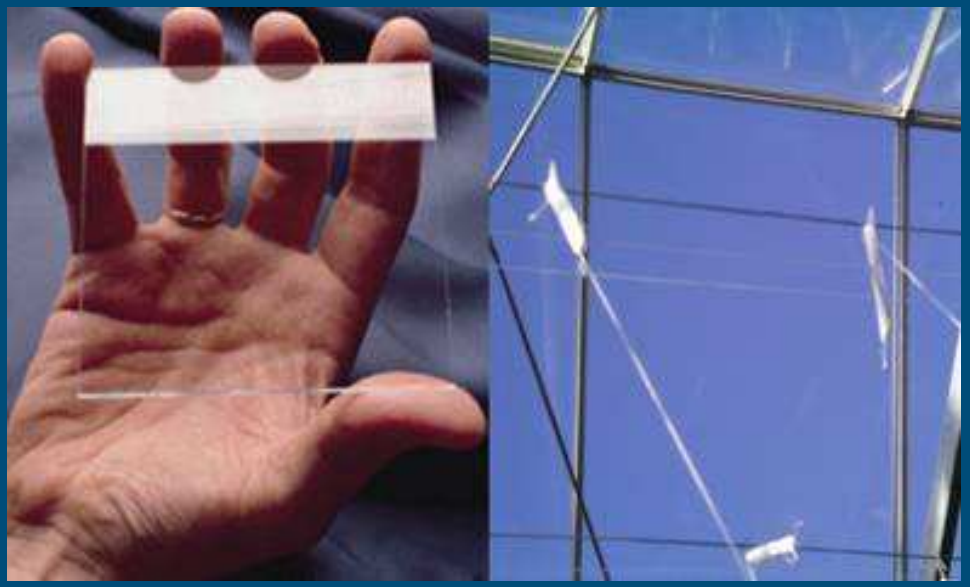
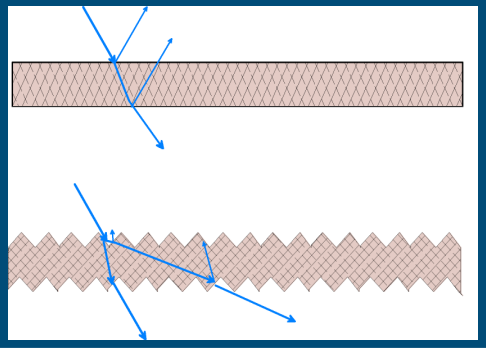
1. Maximal use of solar energy/ natural light

Covering materials:

- Anti reflex coating: +6%
- Shape of the material
  - V structure: material
  - Micro V: surface
  - Principle: multiple reflection increases light transmission



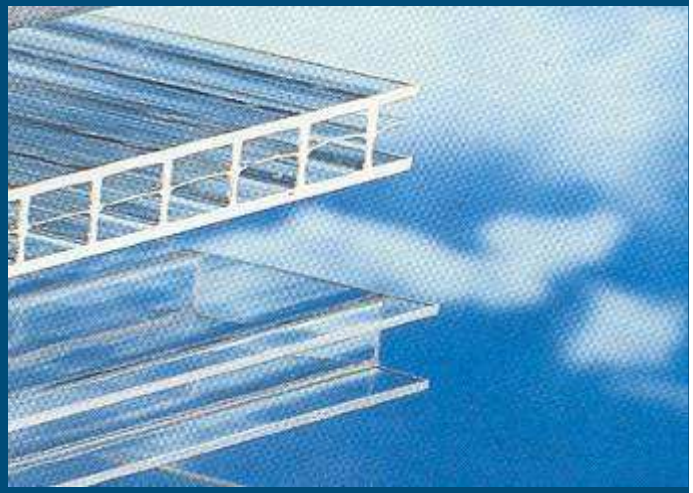


2. Reduction of energy loss

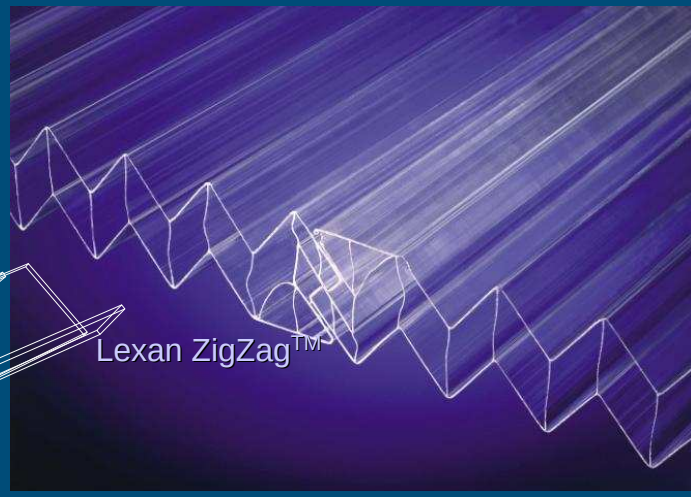
- Screens
  - Theoretical energy reduction >30%, practice: 20-25%)
  - Main effects: higher humidity and less light
  - Energy efficiency: + ca 20%

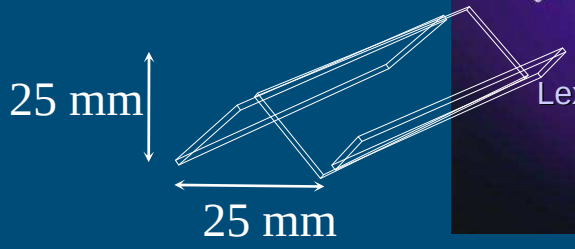
2. Reduction of energy loss

- Decreasing U value:
  - Double or triple cover
- Reduction of radiation loss:
  - Low emission coatings



- To maintain light transmission, combine with
  - Anti reflex
  - V structure





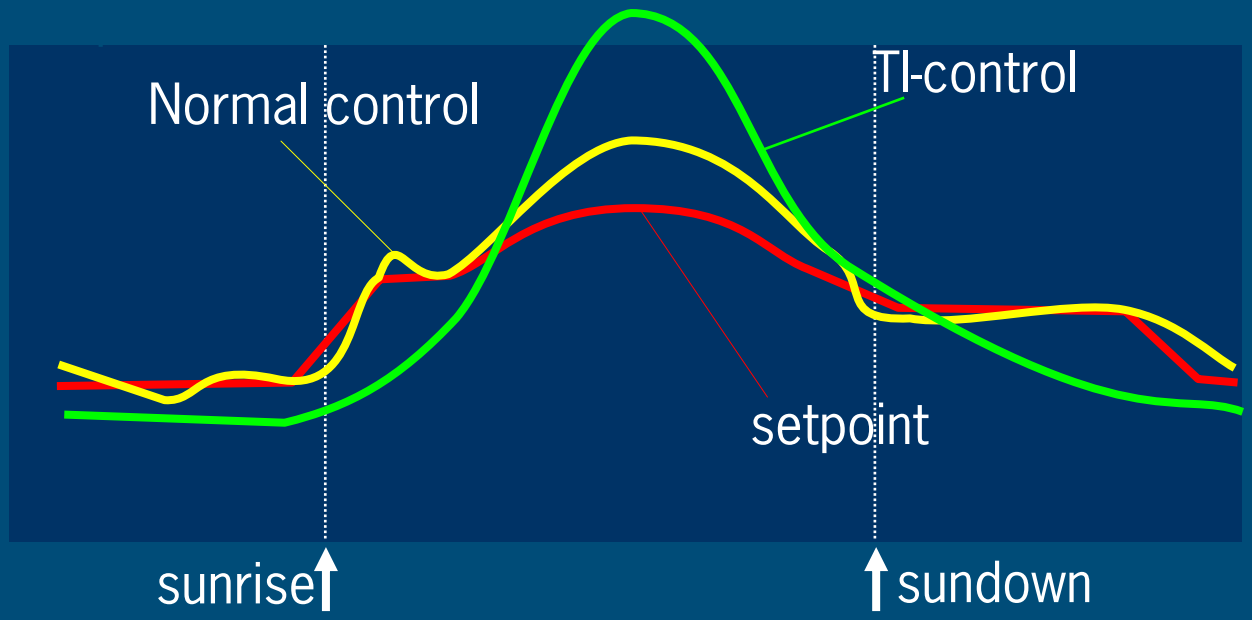
2. Reduction of energy loss

Greenhouse cover	*relative energy use m^3 natural gas/m^2*
Single glass	**100 %**
Single glass + screen	**75 %**
Double cover (Zigzag)	**75 %**
Double + screen	**62 %**
Double with low emission	**53 %**
Three layer with low emission	**49 %**

Source: the Solar greenhouse, G.P.A. Bot et al.

3. Efficiënt environmental control

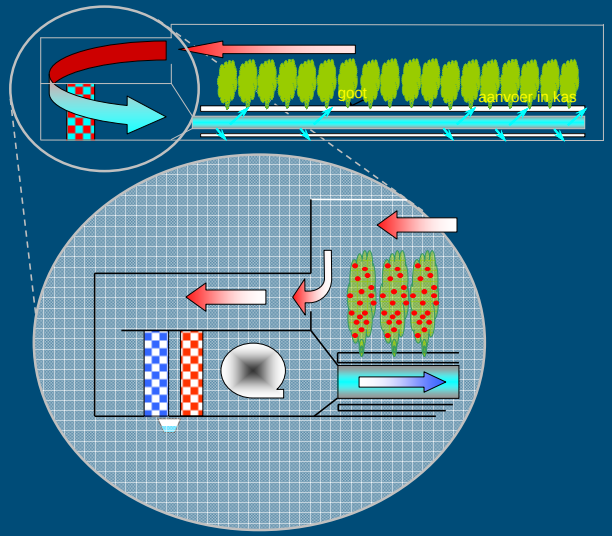
Temperature integration



Principle: crop production related to average temperature between given limits

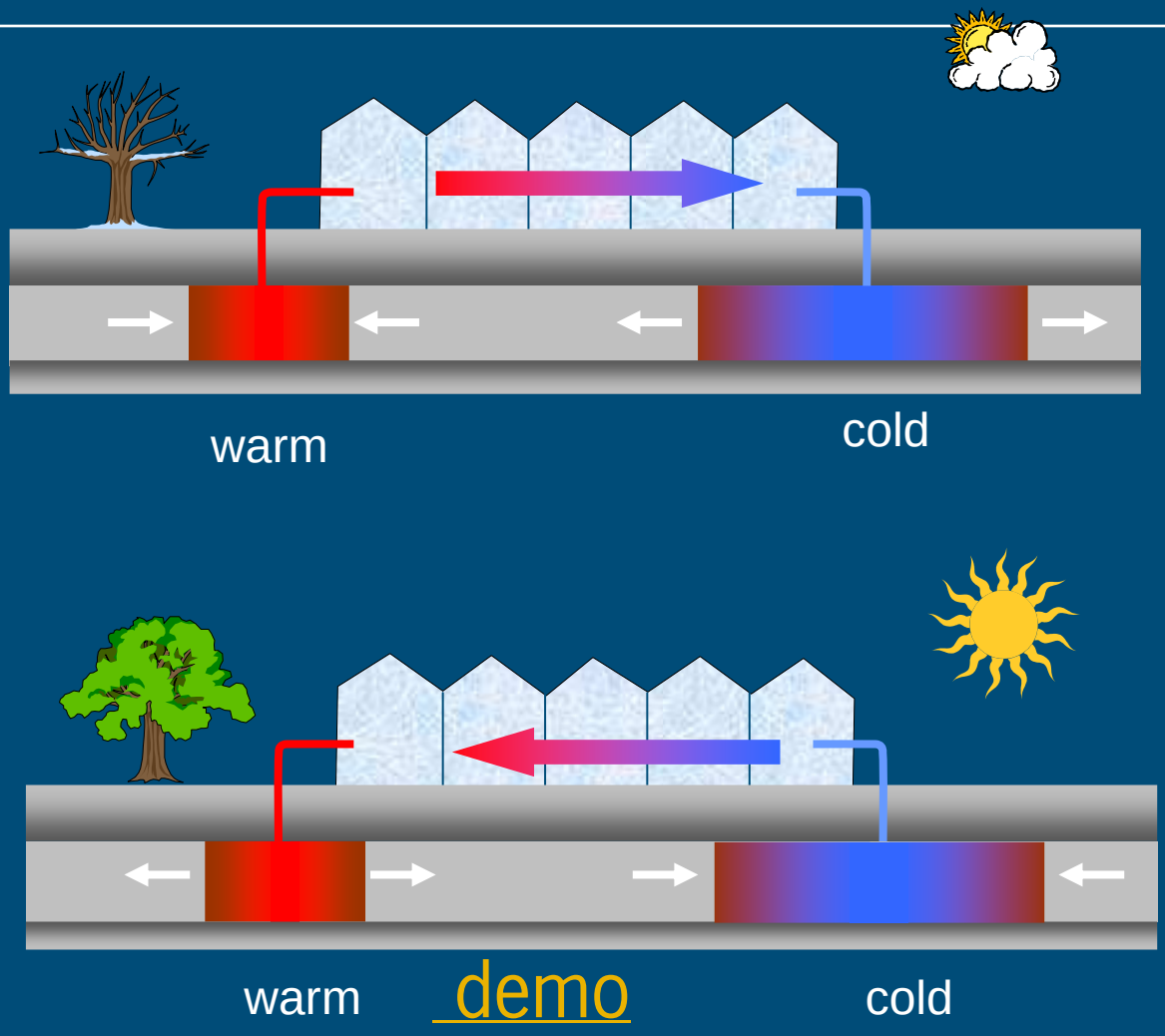
Energy saving: lower temperature during heating
higher temperature during sunlight

3. Efficient conversion of solar energy



Heat exchangers: hot air to hot water

4. Storage and re-use heat



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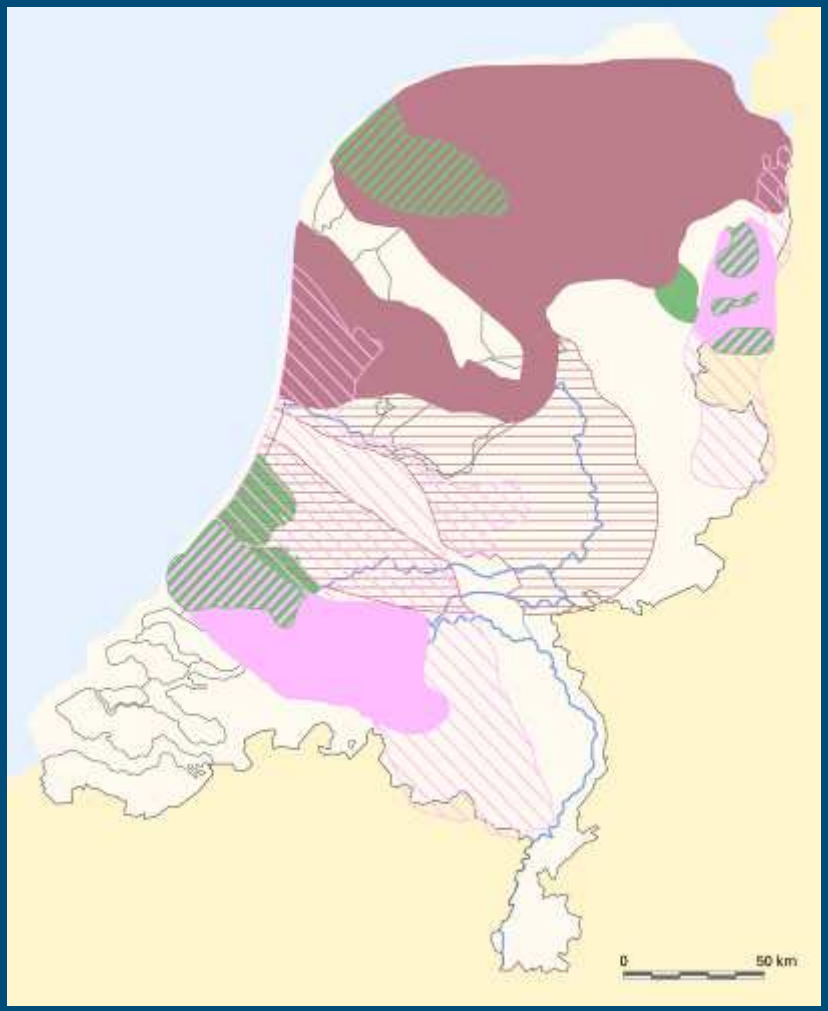
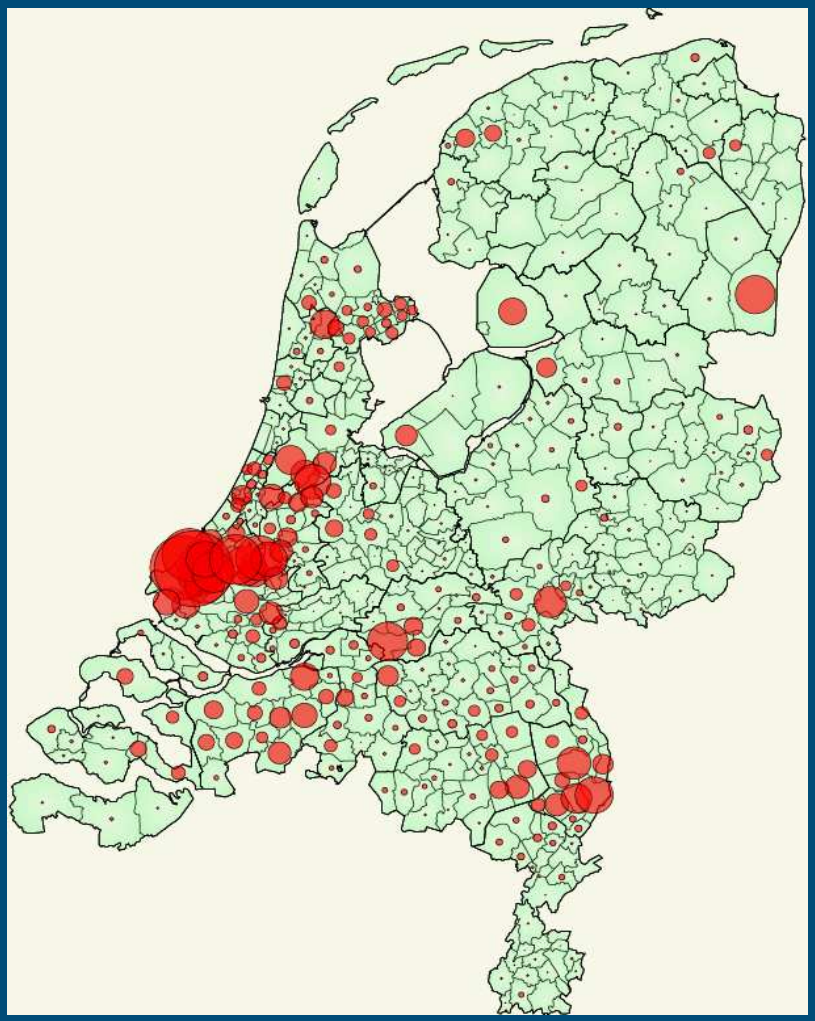
5. Replacement fossile fuel by sustainable sources

Geothermal:

- High sustainability
- Application at area's >10 ha
- Economic feasible at gasprice > €0.25 per m^3

Potential area's: geothermal energy and greenhouses





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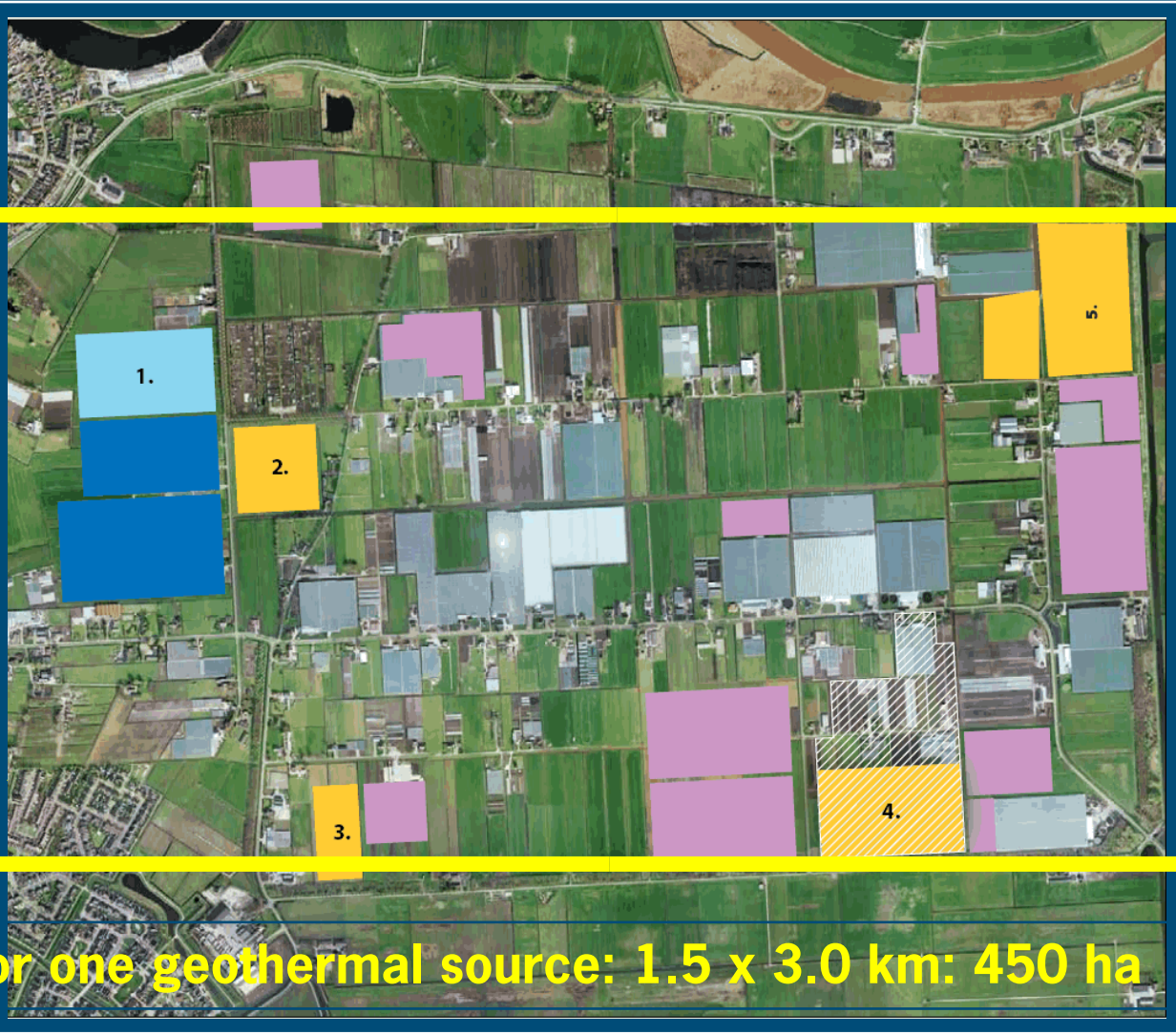
Disadvantage: one geothermal source requires 450 ha



Area for one geothermal source: 1.5 x 3.0 km: 450 ha

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Major trend energy efficient greenhouses:

Completely controlled / (semi) closed

Advantages:

- Independent control of environmental conditions
- Cooling and dehumidification
- Higher CO_2 concentration and related production increase (up to 10-20%)
- Energy saving (+30%)

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Controlled greenhouses: different systems

- Central or de-central heat exchangers
- Cooling from below or above
- With or without additional ventilation with outside air
- Forced cooling or evaporative cooling

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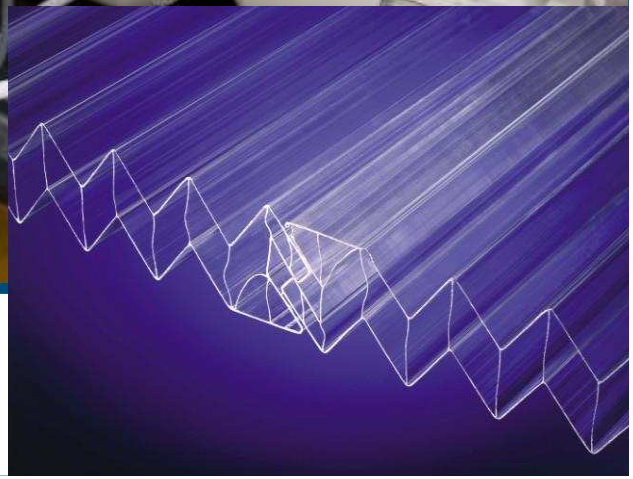
Controlled greenhouse with minimized energy loss and optimal efficiency: “The energy producing greehouse”



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Results “Energy producing greenhouse”

- Energy balance:
  - Low energy use (16m3/m2)
  - Net heat production possible
- Crop production:
  - Equal or better quality
  - Estimated production increase: 8%
- Economic feasibility
  - Pay back time still too long (14 years), for application in commercial practice higher production increase and cost reduction needed


Anthurium


Dracaena


Croton

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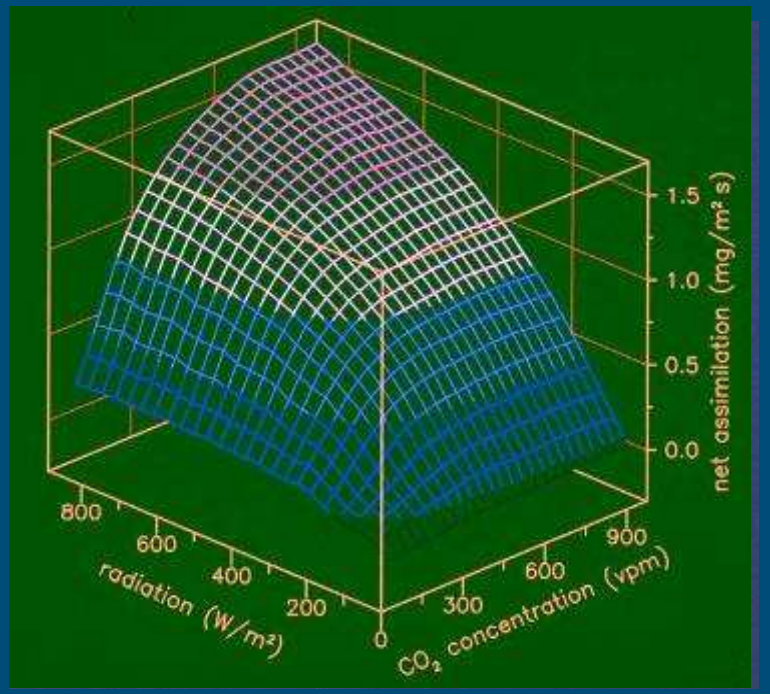
Completely controlled / energy efficient greenhouses

New Environmental conditions

- Traditional:
  - High radiation = high ventilation = low CO_2 and low humidity and high temperature
- Controlled environment:
  - High radiation + high CO_2, low temperature and high humidity
  - Higher air velocity inside
  - Different fractions direct/ diffuse light
  - PAR/NIR balance



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New developments

- Electricity producing greenhouse: NIR reflecting greenhouse cover:
  - Better summer conditions
  - Possibilities for electricity generation if combined with photo voltaic cells (Estimated electricity production: 16-28 kWh/m^2 per year)

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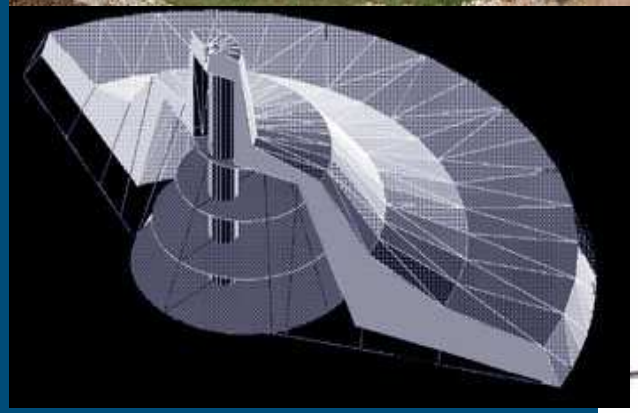
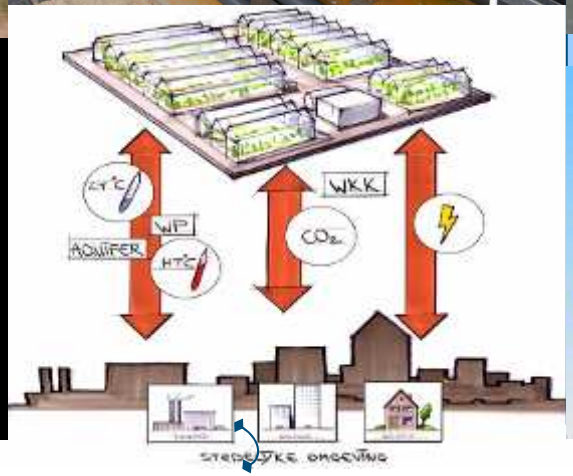
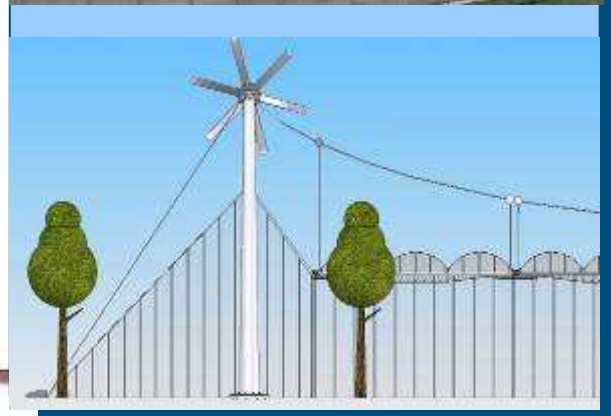
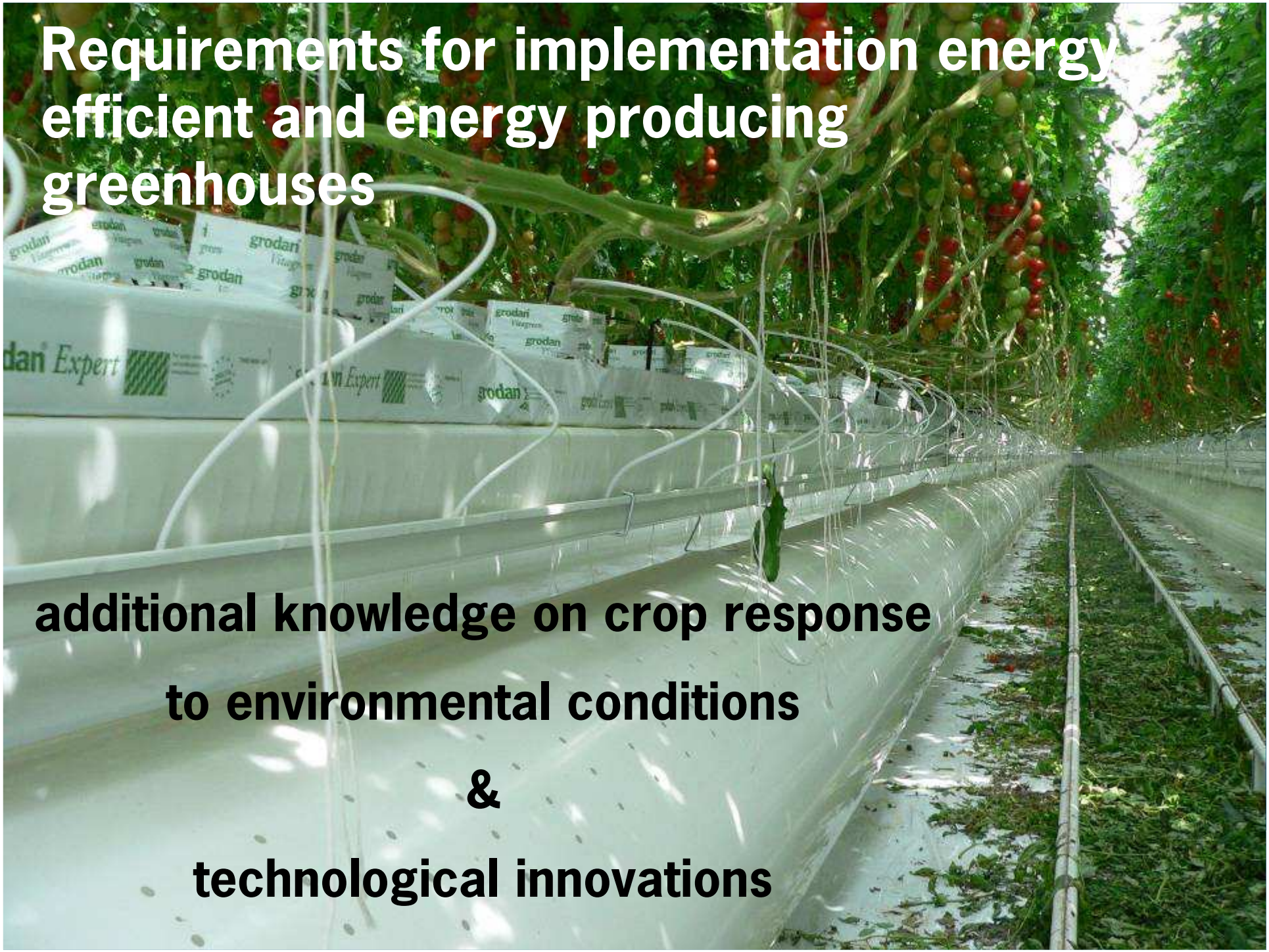
Integral design of energy conservative greenhouses







Requirements for implementation energy efficient and energy producing greenhouses



additional knowledge on crop response

to environmental conditions

&

technological innovations