ZINEG – The future has arrived in German horticulture
Research greenhouses and pioneers in horticultural praxis

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Joint research project  (May 2009 – April 2014)

Main goal: reducing the use of fossil fuels and CO₂ emissions by 90% → interrelation of horticultural arrangements and technical innovations
ZINEG greenhouse Hanover
Greenhouse with maximum thermal insulation for pot plants
ZINEG subproject Hanover – working groups

**Technical research work**
Leibniz University of Hanover Biosystems & Horticultural Engineering Section (BGT)

Prof. Dr. H.-J. Tantau
Dipl. Ing. Klaus Knösel
M.Sc. Gökhan Akyazi

**Horticultural research work**
Chamber of Agriculture Lower Saxony Research Station for Horticulture Ahlem (LVG Ahlem)

Prof. Dr. B. Beßler
Dr. D. Ludolph
M.Sc. Melanie Horscht

**Economic evaluation**
Humboldt University Berlin Institute of Agricultural Economy

Prof. Dr. Wolfgang Bokelmann
M. Sc. Jochen Flenker
greenhouse concept for ornamental plant production

960 m² greenhouse surface, 2 sections

- in roof insulation double glazing, AR-coated
- PMMA-quadruple sheets (32 mm)
- 3 thermal screens
- using solar energy in a day-night storage heat pump, heat exchangers and water puffer tanks
- gas heating system
- (predominantly) closed ventilation
- supplement CO₂
greenhouse concept for ornamental plant production

3 thermal screens

- **day screen**
  20% shading/saving (SHS 15, B1, Co. Novavert)

- **thermal screen**
  50% shading/saving (PyroSilver 50, B1, Co. Reimann)

- **blackout system** with roll down twin system
  75% saving (XLS Obscura Revolux, Co. Svenson)
Reduction of fossil energy input by using solar energy

- Cooling + dehumidification
- Solar heat
  - 20 – 30°C
- Heat exchanger
- Heat pump
- Warm and cold water storage tanks
  - 38 – 40°C
  - 07 – 15°C
The low energy greenhouse – evaluation parameters

- **Thermal insulation**
  - (predominantly) closed ventilation
  - climate
  - light (reduction)

- **Using solar energy**
  - solar gain
  - cooling
  - dehumidification
  - energy balance

- **Plant quality**
  - cultivation
  - production time
  - diseases
  - stress compensation
### 1. Effects of thermal insulation measures

Energy savings (during night) in comparison with single glazing and single glazing + thermal screen

<table>
<thead>
<tr>
<th>measures to thermal insulation</th>
<th>U&lt;sub&gt;CS&lt;/sub&gt;-value</th>
<th>saving</th>
<th>saving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W m&lt;sup&gt;2&lt;/sup&gt; K&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>insulation glass</td>
<td>4,0</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>insulation glass + thermal screen</td>
<td>3,0</td>
<td>27</td>
<td>62</td>
</tr>
<tr>
<td>insulation glass + 2 thermal screens</td>
<td>2,1</td>
<td>47</td>
<td>72</td>
</tr>
<tr>
<td>insulation glass + 3 thermal screens</td>
<td>1,2</td>
<td>70</td>
<td>84</td>
</tr>
</tbody>
</table>

(Tantau, 2012)
3. Plant Quality

**Investigations with different ornamental crops**

<table>
<thead>
<tr>
<th>Year</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Petunia, Pelargonium</td>
<td>Helianthus</td>
<td>Poinsettia</td>
<td>Begonia</td>
</tr>
<tr>
<td>2011</td>
<td>Pelargonium</td>
<td>-</td>
<td>Poinsettia</td>
<td>Impatiens Neu-Guinea, Sunpatiens</td>
</tr>
<tr>
<td>2012</td>
<td>Streptocarpus, Capsicum, Hibiscus</td>
<td>-</td>
<td>Begonia, Hibiscus</td>
<td>-</td>
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<tr>
<td>2013</td>
<td>Canna, Gerbera</td>
<td>-</td>
<td>Poinsettia</td>
<td>-</td>
</tr>
</tbody>
</table>

- Heat consumption measuring
Investigations with *Euphorbia pulcherrima* (July – December 2011)

'PLA Eckespoint Freedom Early'

<table>
<thead>
<tr>
<th>ready for selling</th>
<th>31.10.</th>
<th>28.11.</th>
<th>31.10.</th>
<th>21.11.</th>
<th>11.11.</th>
</tr>
</thead>
</table>

- 12°C HT
- 12°C HT
- 16°C HT
- 16°C HT
- standard

*picture 30.11.2011*
Thermal insulation
- energy saving up to 84%
- very good \( (U_{cs} = 1.2) \)
- (predominantly) closed ventilation
- reduced heating energy input
- decreased PAR transmittance

Measures for praxis:
- roof – coated double layer plates (Alltop) or insulation glass with AR-coating
- side walls - triple layer plates
- three thermal screens
  - small screen packages
  - wire supported push-pull system using racks and pinions
Using solar energy

- 4 - 6 weeks in spring and autumn
- 30 – 100% substitution of fossile heating energy
- 5 - 25% electric energy for solar heat storage

Measures for praxis:

- heating system for using solar heat is economically unviable (at the moment!)
  - high power consumption
  - terms are too short

→ choose alternative heating systems/green fuels
Plant quality
- high air humidity but no increased in plant diseases
- decreased plant transpiration
- CO₂ concentration decreased (< 200 vpm)
- no differences to conventional greenhouse plant quality

Measures for praxis:
- reducing irrigation intervals
- increased fertilizer concentration
- air circulation by fans
- closed ventilation → CO₂ supplementation
Thermal insulation
- very good \( (U_{cs} = 1,2) \)
- (predominantly) closed ventilation
- reduced heating energy input

Using solar energy
- 4 - 6 weeks in spring and autumn
- 30 – 100% substitution of fossil heating energy
- 5 - 25% electric energy for solar heat storage

plant quality
- no differences to conventional greenhouse plant quality
- high air humidity but no increased in plant diseases
- \( \text{CO}_2 \) concentration decreased (< 200 vpm)
- modification in cultivation

50 – 95% energy saving in ornamental crop production
Has ZINEG arrived in German horticulture praxis?
government aid „Bundesprogramm Energieeffizienz“ (2009 - 2012)
(Federal Office for Agriculture and Food)

aid requirements:
• rata grants were awarded up to a max. investment of 2,0 million Euro
• minimum investment volume 10,000 Euro
• maximum grant 400,000 Euro

modernization existing greenhouses
• minimum 30% or 50% decrease of energy consumption compared to reference greenhouse
• 30% saving → 20% grant  or  50% saving → 30% grant

new low energy greenhouses
• minimum 35% or 50% decrease of energy consumption compared to reference greenhouse, 35% saving → 20% grant  or  50% saving → 30% grant
• 80% of heat consumption in new greenhouses must be covered by renewable energy
• heat meter must be installed
Transfer into praxis

government aid „Bundesprogramm Energieeffizienz“

**Number of applications: 58 greenhouses**
(as at September 2012)

- **modernisation**
  - existing greenhouses (28)
  - vegetable growing: 6
  - floriculture: 17
  - marketing: 5

- **new construction**
  - low energy greenhouse (30)
  - vegetable growing: 9
  - floriculture: 14
  - marketing: 7
Pioneers in praxis  Nursery Kern (Bavaria)
young plant and finished products
main crops: bedding plants, chrysanthemum, poinsettia

2.380 m² new greenhouse surface for ornamentals
startup April 2013

thermal insulation
• Alltop (Co. Evonik) in roof
• two-layer thermal screen, 63% shading (Co. Reimann)
• greenhouse can be divided into 3 climate compartments by roll able foil screens

heating systems
• 450 KW wood chip furnace
• solar heating system
  • heat pump (100 KW, 50°C flow temperature, COP controlled)
  • 12 x heat exchangers
  • 2 x 70 m³ heat storage water tanks (above ground)

2 x 430 m³ water buffer tanks, subsurface
Pioneers in praxis

Nursery Kern (Bavaria)
young plant and finished products
main crops: bedding plants, chrysanthemum, poinsettia

heating systems

• 450 KW wood chip furnace
• solar heating system with
  • heat pump (100 KW, 50°C flow temperature, COP controlled)
  • 12 x heat exchangers*
  • 2 x 70 m³ heat storage water tanks (above ground)

three heat distribution systems

• curing bags in table (low temperature heating, 25°C)
• under-bench heating system (Ø water temperature 42,5°C)
• *12 x bivalent ceiling heat exchangers (heating, cooling and dehumification; 80°C flow temperature)

→ 86% of average annual total heat demand could be covered by solar heat and heat pump
Pioneers in Praxis Co. Kientzler GmbH & Co. KG (Gensingen, Rhineland-Palatinate)
plant breeding, jung plant production

2,6 ha new Venlo-greenhouse, 6 m side walls

thermal insulation
- tempered safety glass in the roof
- 3 screens: day screen, transparent thermal screen, shading screen
- side walls quintuple PC-sheets
- greenhouse can be divided into five climate compartments by roll able foil screens

alternative energy sources
- 70% of energy demand is covered by wood pellets
- oil and gas heating system
- frequency controlled pumps

→ calculated energy saving up to 44%!
Zineg – The low energy greenhouse

Project grant