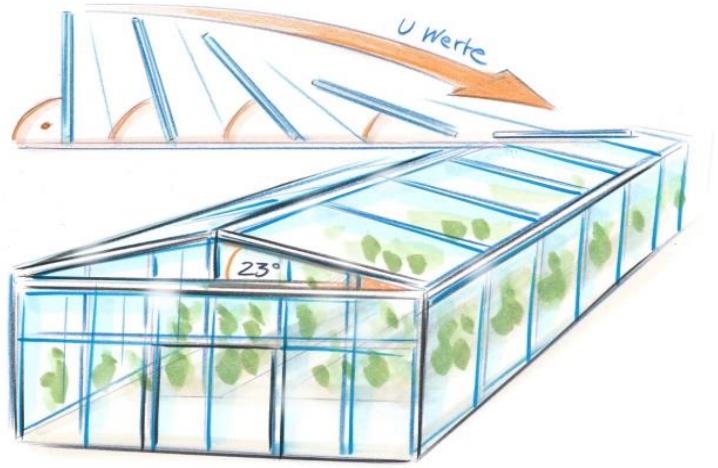
Greenhouse covering systems between energy efficiency and optimal conditions for plant growth - squaring the circle?



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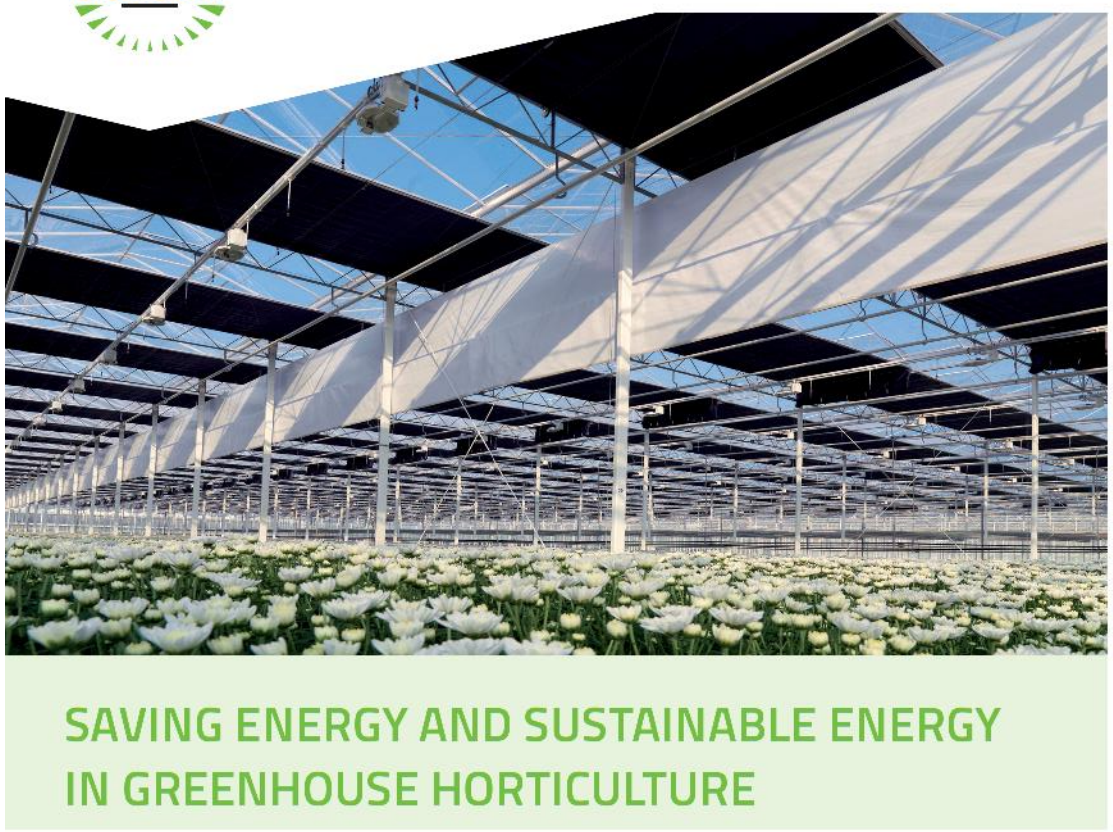


Kas als Energiebron (Greenhouse as a Source of Energy)

Beyond energy efficiency?

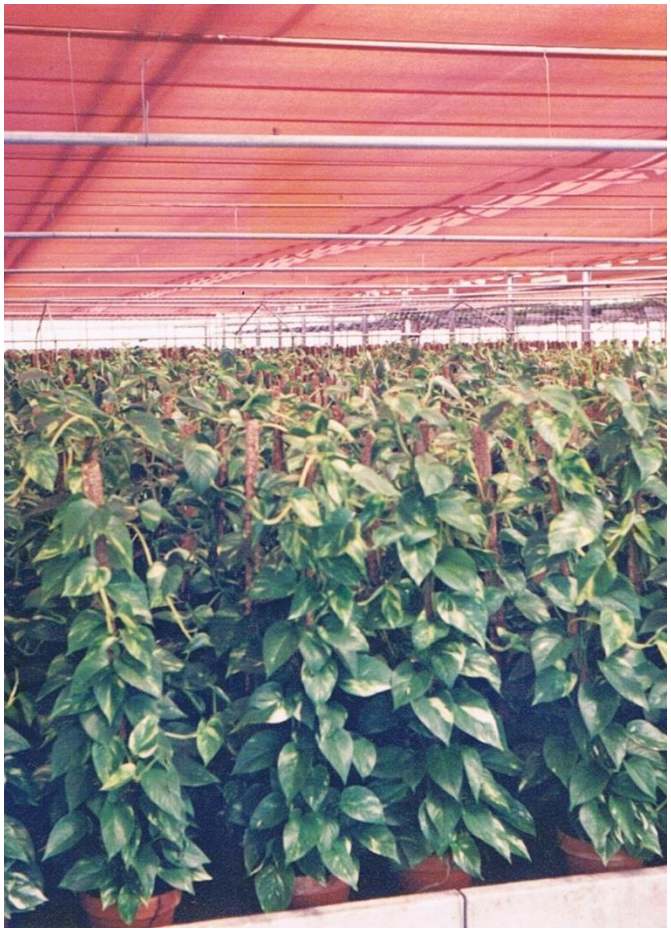
Just another example for marketing?

=> It's a good showcase, how complicated it is, to reach the global goals (energy, water, climate, feeding the world etc.)

Overview

1. About me
2. U-value
3. Adaptivity
4. Reinvent greenhouses

Production of ornamental plants



1 liter oil for
1 € turnover

Additional purchases: peat, pots, fertilizer and oil

3 customers, no own logistics

Even the toys have been reused...

Switch from production to retail

Lower oil consumption = energy efficient?

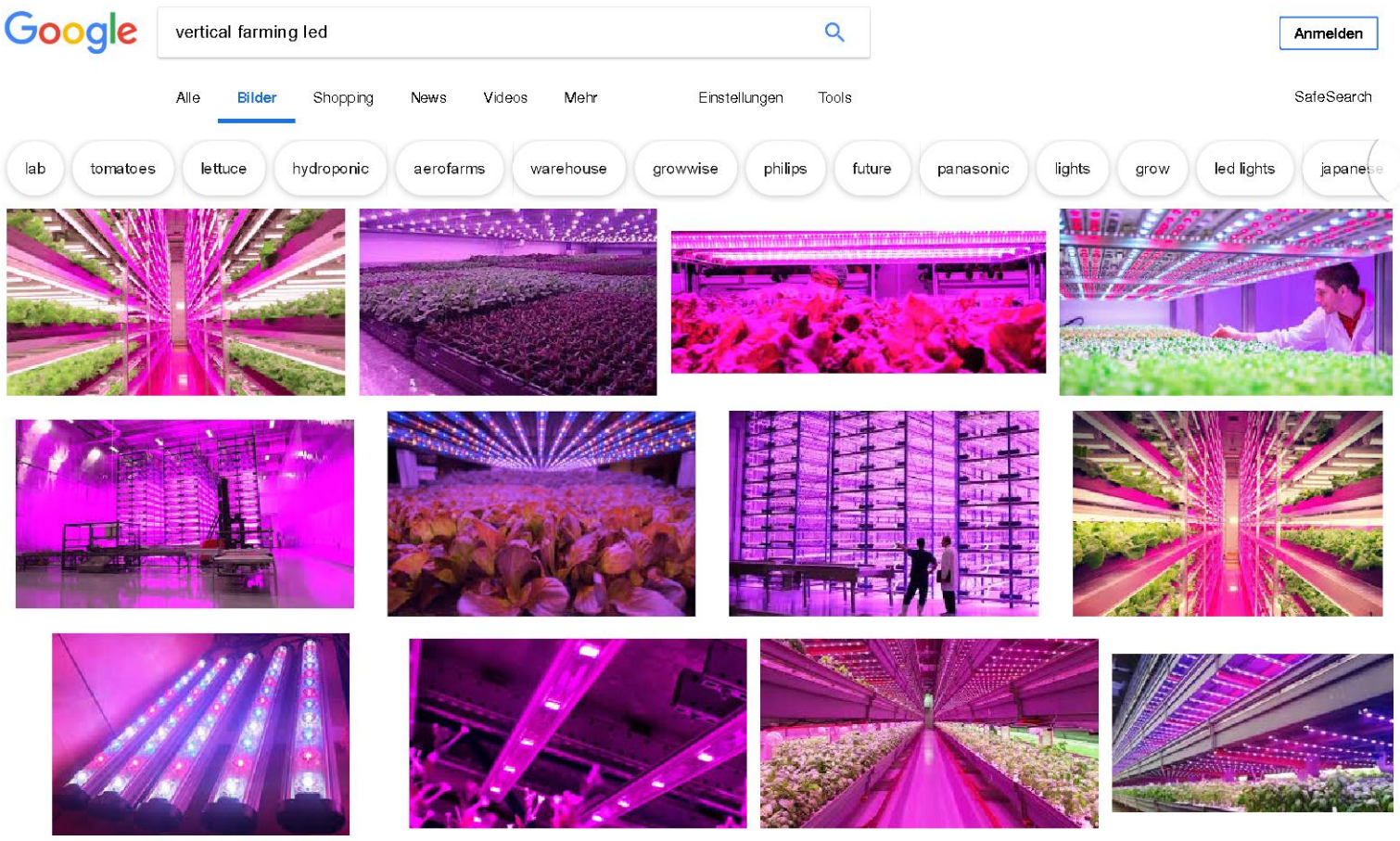
What does the u-value mean for the energy efficiency?

W / (m² x K) = Watt per m² (surface) and Kelvin (temperature difference)
Single glass: 7
Double glass: 3
Double ISO-glass: 1,2
Triple ISO-glass: 0,8
Passive house wall: 0,1
U-value rises, when glass is installed not vertical, but horizontal (convection)

14 hour night with -10°C outside and 20°C inside of a greenhouse with a total surface of 10.000m² uses:
U-value 7: 10.000m² x 30K x [7,0W / (m² x K)] x 14h = 29.400kWh
U-value 3: 10.000m² x 30K x [3,0W / (m² x K)] x 14h = 12.600kWh
U-value 1,2: 10.000m² x 30K x [1,2W / (m² x K)] x 14h = 5.040kWh
U-value 0,1: 10.000m² x 30K x [0,1W / (m² x K)] x 14h = 420kWh

=> Now it should be obvious, why the future of greenhouses looks like this:

vertical farming led - Google-Suche https://www.google.com/search?newwindow=1&client=firefox-b&biw=1280&bih=609&tbm=isch&s...

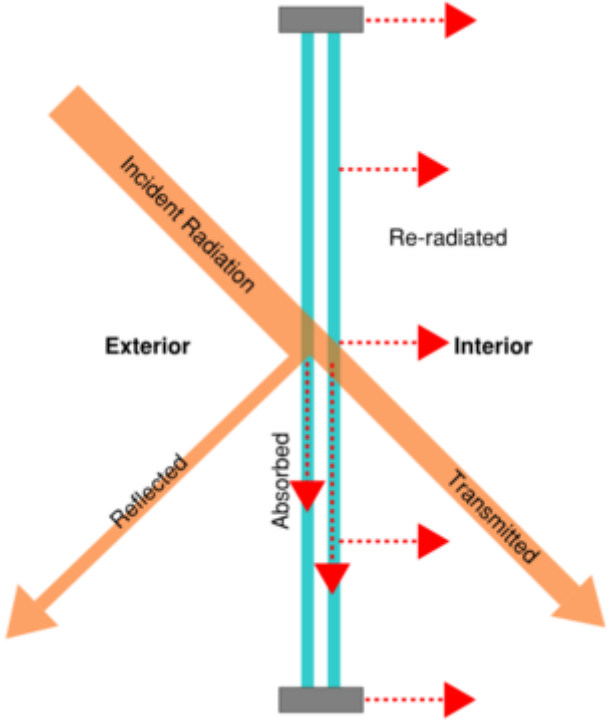


⇒u-value is only one of many factors

- Useful for the estimation of the energy demand without solar wins
- Not useful for the estimation of the energy demand for cooling
- Not useful for the estimation of the energy demand during cold and sunny days

Additional factor: g-value

- Includes all solar gains (all wavelength)
- Value is between 0 and 1
- Switchable value would be perfect
- Electrochromic or photochromic glazing is switchable, but too expensive and has too low g-values for greenhouses (< 0,5)

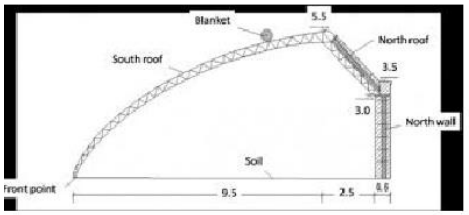


Energy efficient greenhouses have to be switchable /adaptive

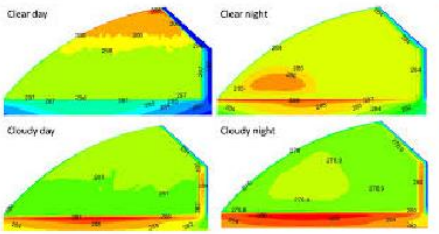
- Compared to massive buildings, greenhouses have nearly no thermal mass
- Direct influence of outdoor conditions to indoor climate
- Solar heat gains during daytime are not usable during the night (without additional technologies, which also have an energy demand
- Natural cooling during nighttime has nearly no effect for daytime temperature







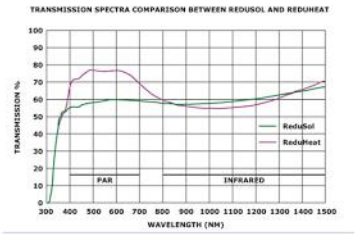


Shading mesh outside and energy screens inside as a solution

- Theoretically an ideal combination for heat protection and energy efficiency
- Snow, wind and costs are a problem for (moveable) shading mesh outside
- Energy screens don’t deliver heat protection

Low tech, but smart and adaptive – colour instead of mesh

- Low investment costs, high labour costs
- No wind loads, no problems with snow, also useable for existing greenhouses



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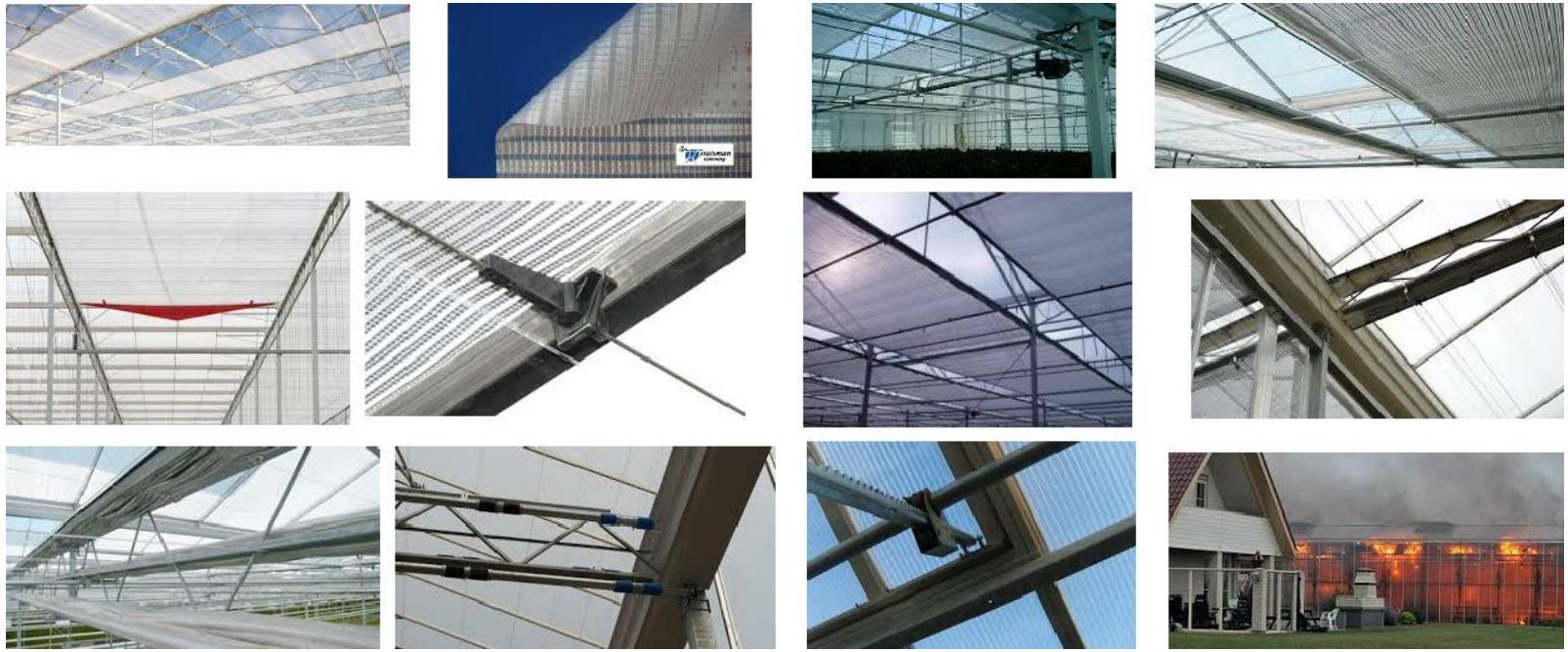
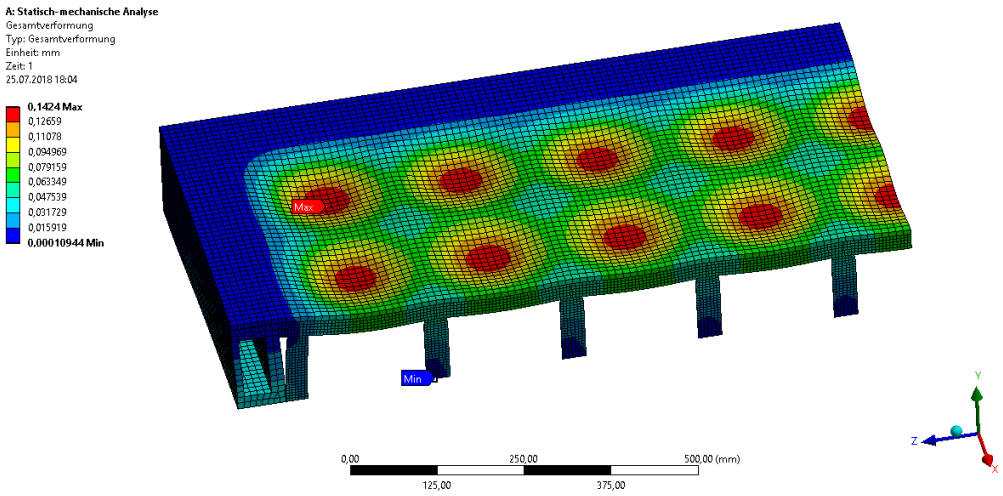
Energy screens: from zero to three – more hours, higher savings

- High transparency with daylight screens or opaque against artificial light emission
- High potential in combination with Next Generation Growing (Het Nieuwe Telen)
- Up to 4.000 hours per year closed (pepper, Netherlands)
- Performance of the screens decreases relatively fast



R&D project GIFpro

GIFpro - Prefabricated low vacuum insulating glass construction system: prototypical implementation and evaluation of a roofing system for greenhouses (and other buildings with daylight utilization)



This project (HA-Project No.: 493/16-05) is funded within the framework of HessenModellProjects from funds of LOEWE - national offensive on the development of scientific and economic Excellence, funding line 3: SME joint project

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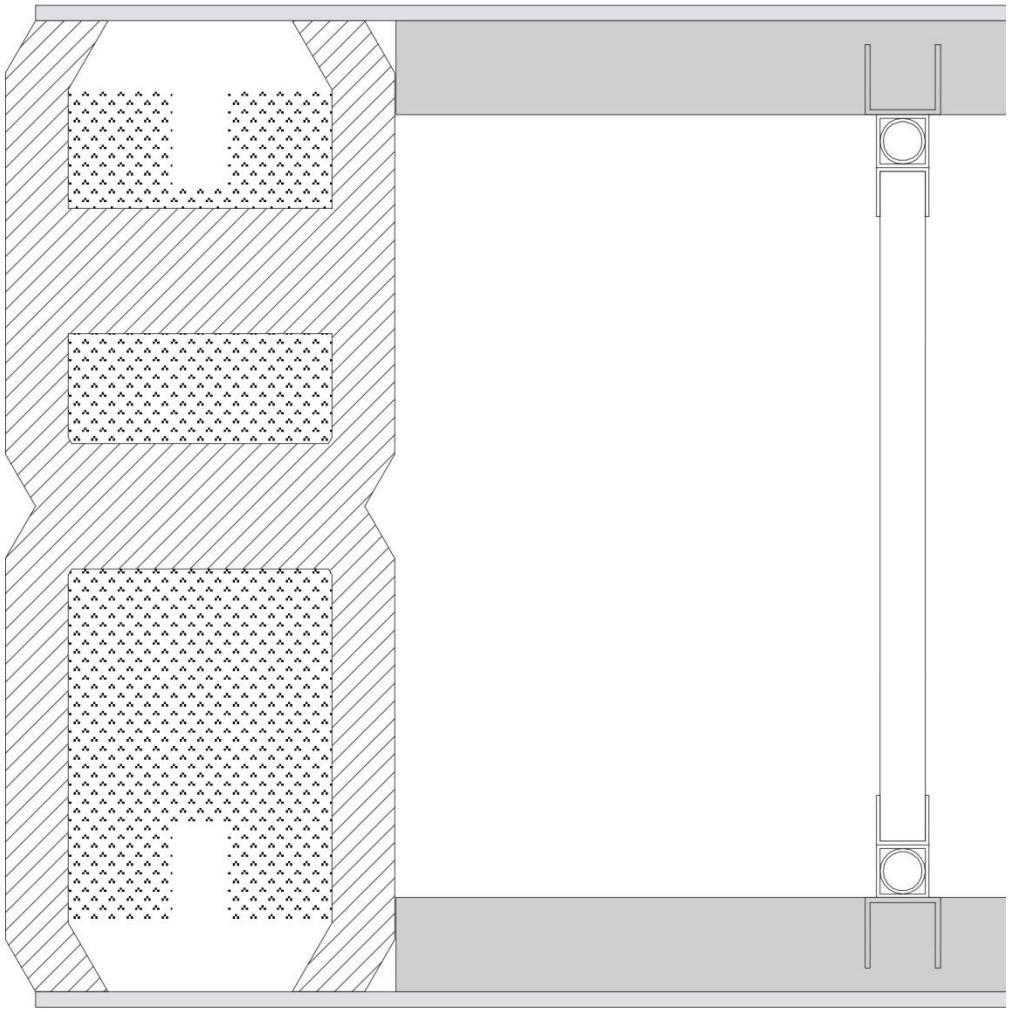


The construction:

Concrete frame with stiffeners and cavities (left)

Glass (top and bottom)

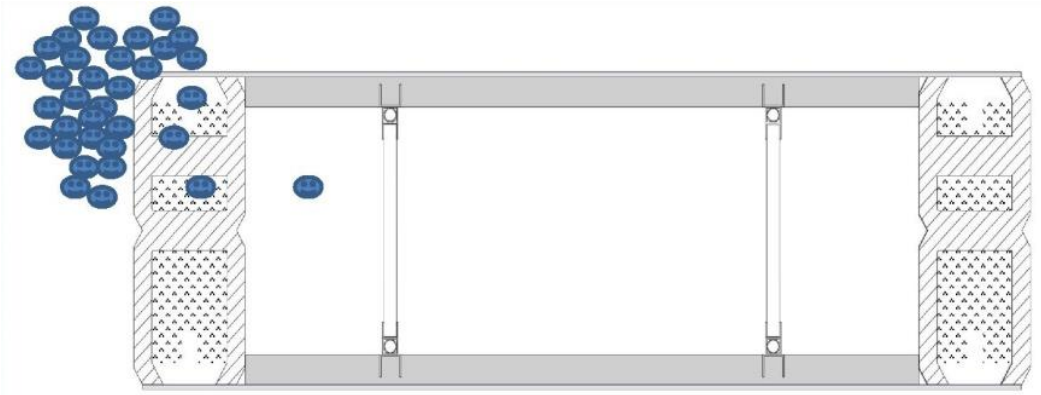
Lamellas for glass bedding (top and bottom)

Supports (right)

Tubes for thermal activation of the glass surfaces inside and outside (on the right, between support and slats)

The sealing:

The decisive factor for the success of the GIFpro elements is the maintenance of the vacuum. In the frame there is a protective vacuum (approx. 1 to 10mbar), which can be improved by a vacuum pump when the pressure rises.



This means that elastic seals can be used which are not only cheaper and easier to process than glass/metal seals, for example, but can also compensate for different material expansions.

Unexpected result of the project:

Instead of 3.2mm better use 8mm low-iron ESG:
Internal construction can be reduced, the light transmission of the glass is reduced only slightly, hail is no longer an issue.

Outlook:

Prefabricated construction and easy re-usability of the elements (size for the complete element is 600cm x 300cm x 30cm) in combination with an u-value from about 0,2 W/(m² x K) will change the market for greenhouses. Mass production – due to the big sizes of this market – will lead to a very good cost/performance ratio and make this building system attractive for other building sectors.

Thank you for your attention

and please:

Use natural light for your crops whenever possible!

Even in Germany we get every year about 1.000 kWh/m² sunlight delivered free greenhouse.

(This year perhaps a lot more…)