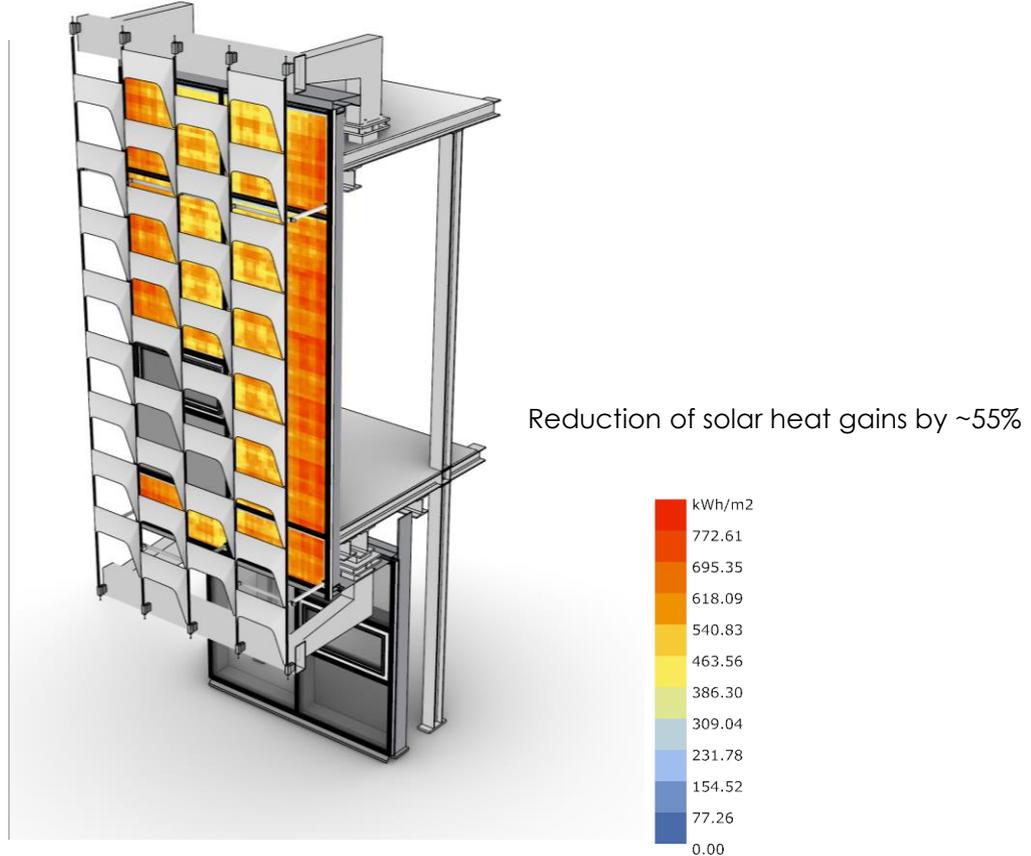
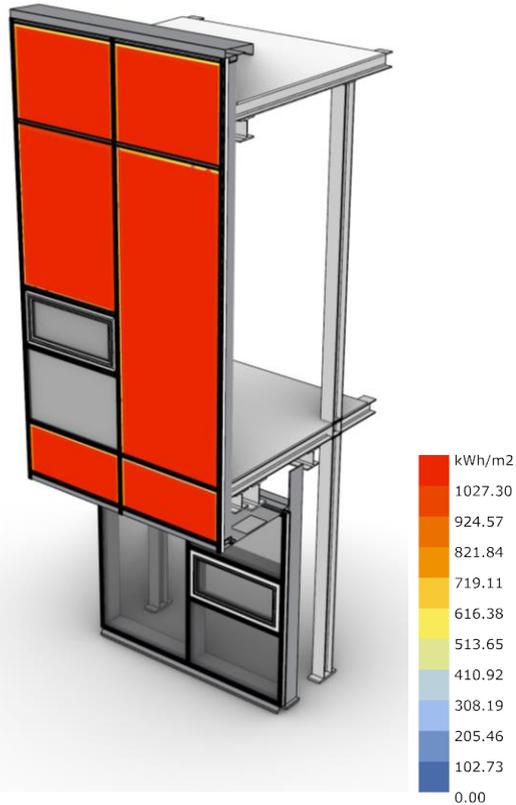


Global Radiation Study - South Facade (As-built panels / details)



PART 1: CO2 SAVINGS (DURING OPERATION)

How much does the shading screen reduce the energy (CO2) consumption during operation of the building?

- A. Cooling Loads
- B. Heating
- C. Lighting

Basic Data / Assumptions:

- 7,500 m² „Main Facade“ – curtain wall and shade panels in front (other wall types will be ignored at that time)
- Simplified assumption: 90% of heat gains are undesired. 10% desired. – **check with Transsolar.**
- Window-Wall-Ration (Weather Wall): 53% glass
- SHGC Glass: 0.24
- VLT: 0.48
- It is assumed that the glass specs would be the same without the screen – so the shading screen is considered being a „nice to have feature“
- It is assumed that 0.92 pounds of CO2 is emitted per kWh electric power (average US 2019) – **check actual energy mix / carbon footprint with Transsolar?**
- It is assumed that MEP efficiency is 70% and uses electric power – **check with Transsolar?**
- Average reduction of solar radiation on weather wall (due to screen) 550 kWh /m²a south facade; 380 kWh/m²a E-W facade; 290kwh/m²a north facade (could be refined with some more radiation studies on as built facade geometry)

PART 1: CO2 SAVINGS (DURING OPERATION)

A. Cooling Loads

Average reduction of global radiation due to shading screen	380 KWH / m ² a
Main facade surface area	7500 m ²
Window Wall Ratio	53 %
SHGC (vision facade)	24 %
Percentage of undesired heatgains (assumption)	90 %
Undesired heat gain in the building (per yr)	326.268 kwh/a

Assumption: Cooled with mechanical equipment, using electric power

Emitted CO2 per KWH (average US, 2019) 0.92 lbs

CO2 / kwh (metric) 0,417 kg CO2/kwh

Assumption: Efficiency and loss of mechanical equipment 40 %

CO2 not emitted due to shading screen	190.475 kg CO2 / a
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B. Heating

Not clear how heat is generated on the campus / how much CO2 is involved

The shading screen reduces heat gains in the heating season

C. Daylighting

Without the shading screen, more daylight would get into the building; less electric power would be needed for lighting.

Conclusion:

In order to take B. and C. into account it is recommended to reduce the CO2 savings by 20%

The overall CO2 savings due to the shading screen per year is approx. 152.000 kg CO2

PART 2: EMBODIED CO2

Facae Surface Area (Main facade)	7.500 m ²
One typical "bay" (surface area)	117,2 m ²
No of "bays"	64

Steel Framing

Per "Bay"	
2 outriggers (300/200/10 - 400/200/10)	0,04 m ³ mild steel 314 kg mild steel
12,8 linear meter steel beam (top / bottom) (300/200/10)	0,075 m ³ mild steel 588,75 kg mild steel
8 tension rods = 146,4m	0,066 m ³ mild steel 518,1 kg mild steel
3 transversal beams / pins	0,069 m ³ mild steel 541,65 kg mild steel

Total amount of mild steel per bay	1.963 kg mild steel
steel per m² facade surface	16,7449 kg steel /m² facade srf

Paint

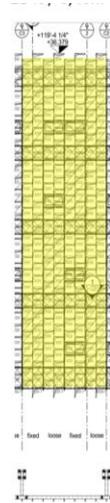
117m² overall surface area = paint surface area (assumption)

250g/m² surface	29,25 kg paint per bay
paint per m² facade surf	0,25 kg paint per m² facade srf

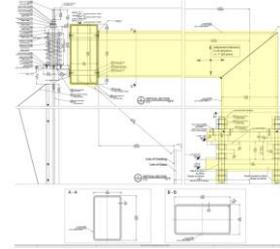
Shading Panels

Number (stainless steel; t=1.5mm) shade panels per "bay"	216
Size of stainless steel sheet before hydroforming:	1 m ²
Total surface of 1.5mm stainless steel sheet material	216 m ²
Total tonnage of stainless steel base material per "bay"	2.592 kg stainless steel
Stainless steel tonnage per m² facade srf	22,116

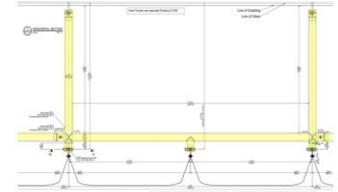
One „bay“



„Outrigger“

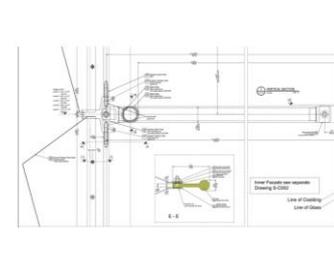


„transversal beam + pin“



60 ft / 18,3m

Tension rods



PART 2: EMBODIED CO2

Assumption: All material will be recycled by 100%; either waste during fabrication or at end of life

That's why GWP A1-A3 + D will be considered.

Assumptions for maintenance and project specific transportation will be made.

Stainless Steel Sheet GWP A1-A3 (Ökobaudat 2018)	3,427 kg CO2/kg Stainless steel (sheet)
Stainless Steel Sheet GWP D (Ökobaudat 2018)	-0,663 kg CO2/kg stainless steel (sheet)

Mild steel GWP A1-A3 (Ökobaudat 2018)	0,994 kg CO2/kg mild steel
Mild steel profiles GWP D (Ökobaudat 2018)	-0,223 kg CO2/kg mild steel
Surcharge due to hydroforming, overseas transportation etc.	10%

Corrosion protection / paint	4,7 kg CO2/kg paint
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Mild steel	16,74 kg mild steel / m ² facade srf
	7.500 m ² facade srf
	125.586,60 kg overall mild steel (entire shading screen)
	96.827,27 kg CO2 - A1-A3, D entire mild steel framing

Paint	0,25 kg paint / m ² facade srf
	7.500 m ² facade srf
	1.875 kg overall paint (entire shading screen)
	8.812,50 kg CO2 - A1-A3 paint

Shading Panels	22,12 kg stainless steel sheet / facade srf
	7.500 m ² facade srf
	165.870 kg overall stainless steel (entire shading screen)
	458.448,94 kg CO2 - A1-A3, D entire mild steel framing

Subtotal	564.089 kg CO2 - A1-A3, D entire shading screen
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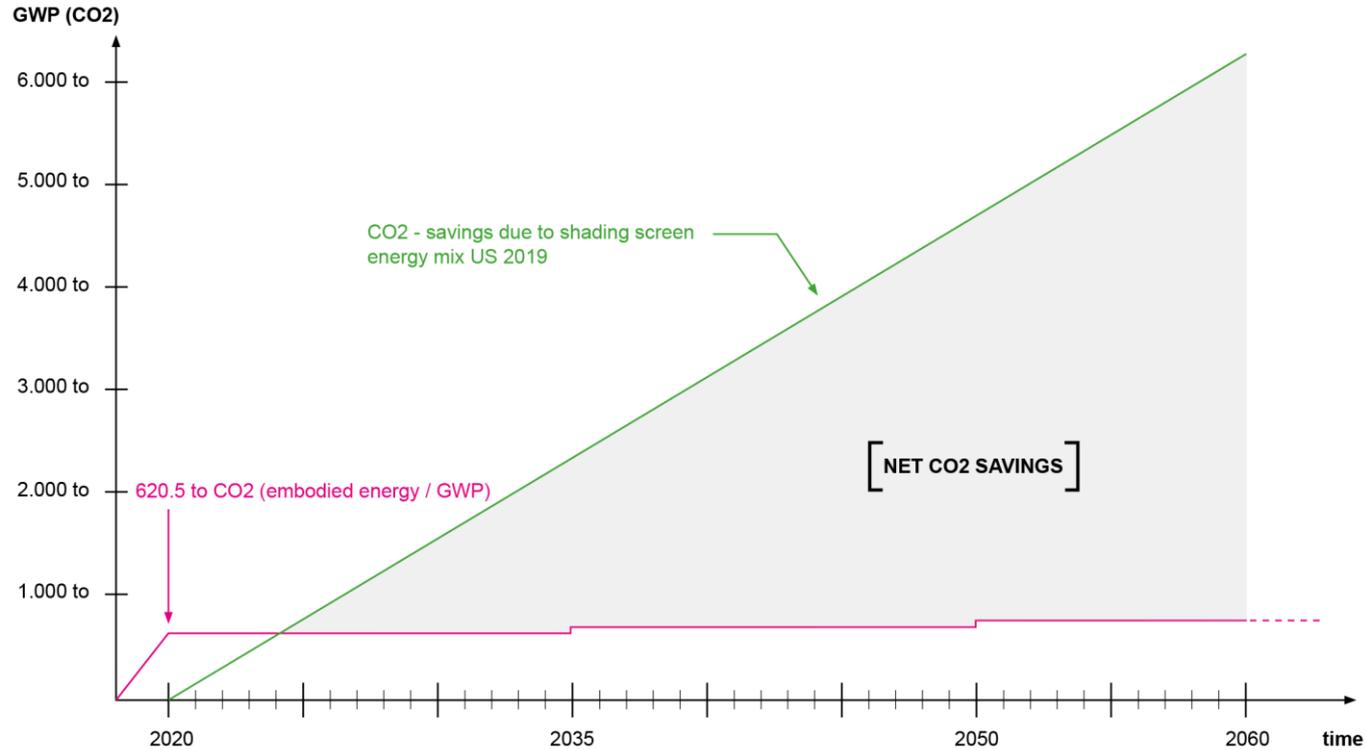
It is recommended to add 10% for custom fabrication hydroforming, laser cutting, oversea transportation)

TOTAL	620.498 kg CO2 - A1-A3, D entire shading screen
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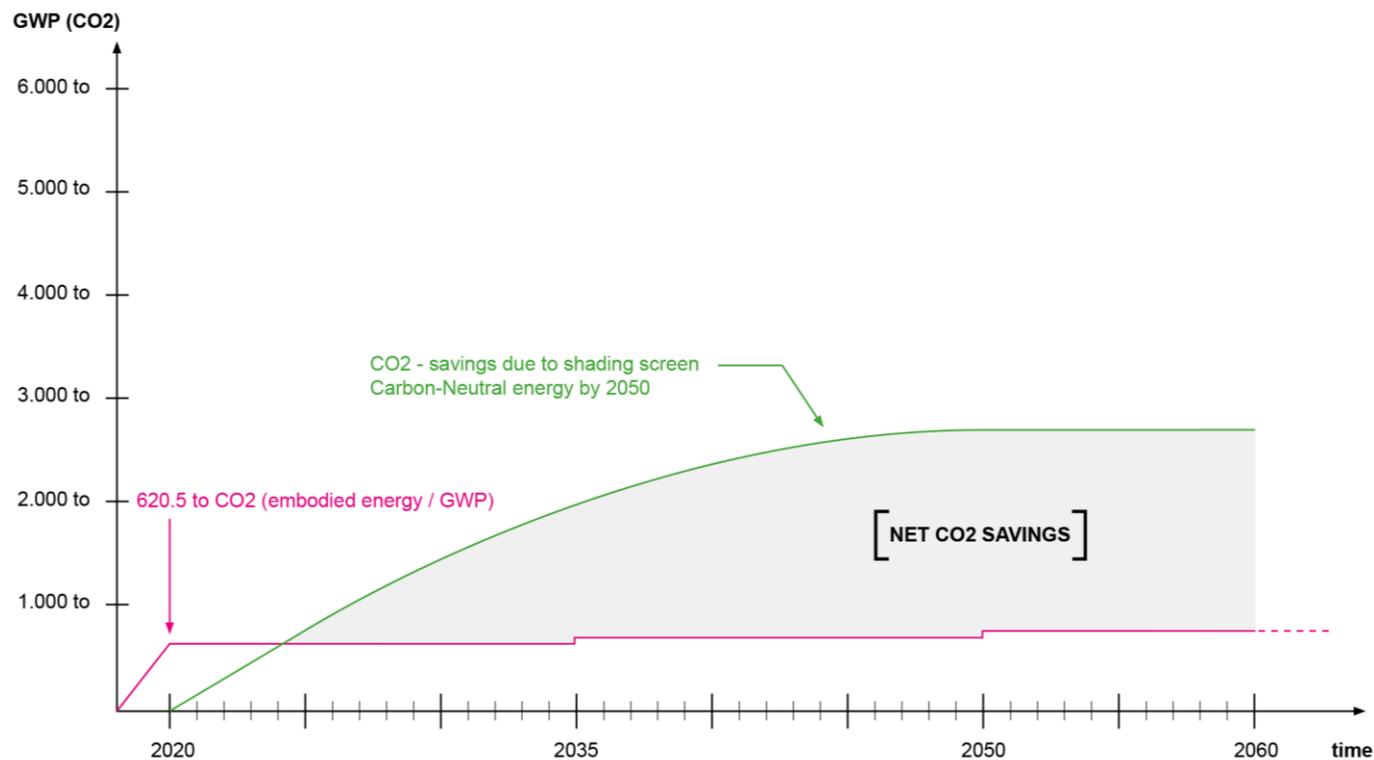
The overall GWP (~CO2 Emissions) for the shading screen is ~ 620.498 kg CO2

Further it is recommended to add the CO2 emissions for the "paint" all 15 years for maintenance.

Summary Diagram: „Embodied Carbon vs. Carbon savings“ – constant CO2 savings: energy mix US 2019



Summary Diagram: „Embodied Carbon vs. Carbon savings“ – energy carbon-neutral by 2050



Summary Diagram: „Embodied Carbon vs. Carbon savings“ – energy carbon-neutral by 2035

