Energy-efficient building

Improved Windows for Cold Climates

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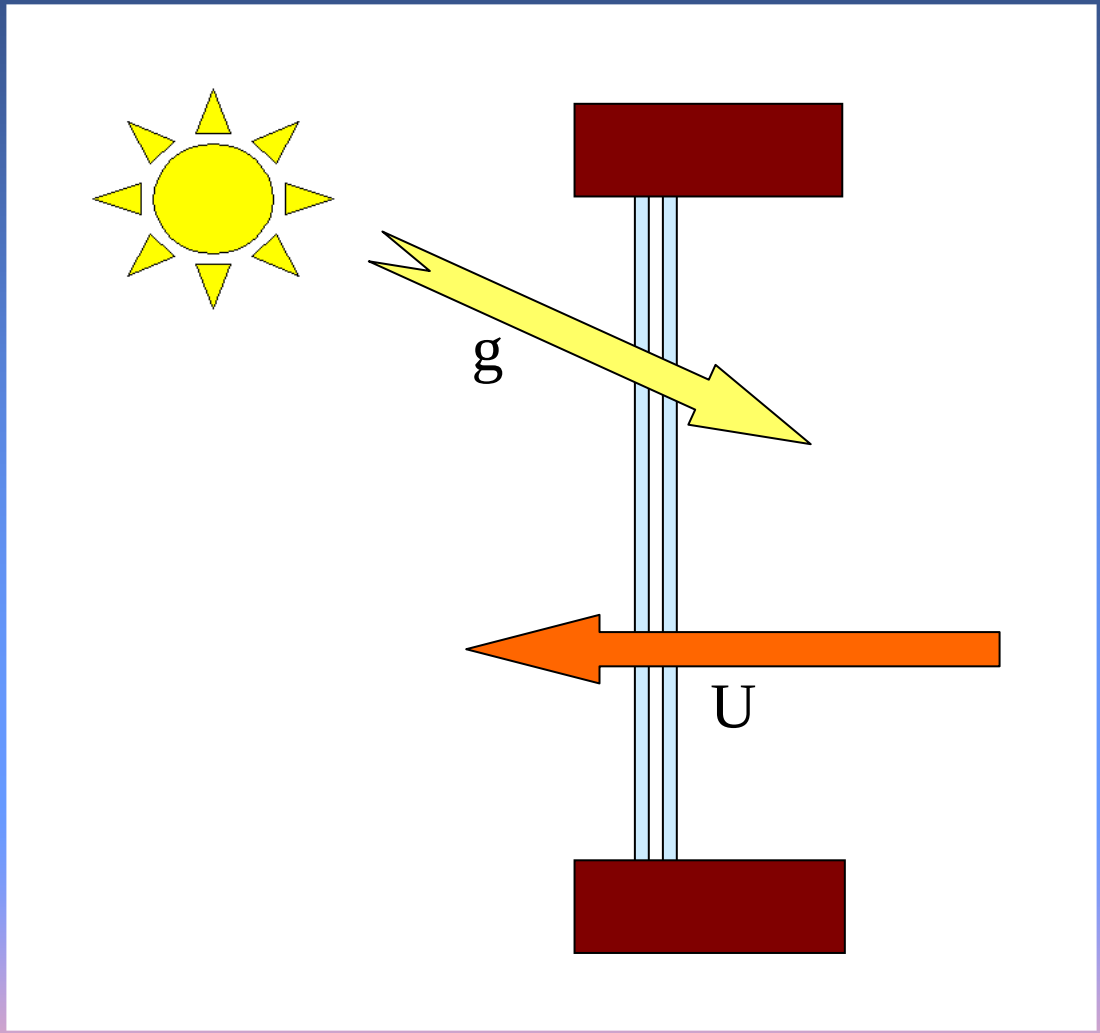
Aim of research project

Investigation of
possibilities for developing
windows
with improved energy performance
for cold climates.

Net Energy Gain



The Net Energy Gain

$$E = I \cdot g \quad - \quad U \cdot G$$

E	Net energy gain	[kWh/m^2]
I	Solar radiation	[kWh/m^2]
g	Total solar energy transmittance	
U	Thermal transmittance	[W/m^{2}K]
G	Degree hours	[kKh]

Net Energy Gain

Based on reference house

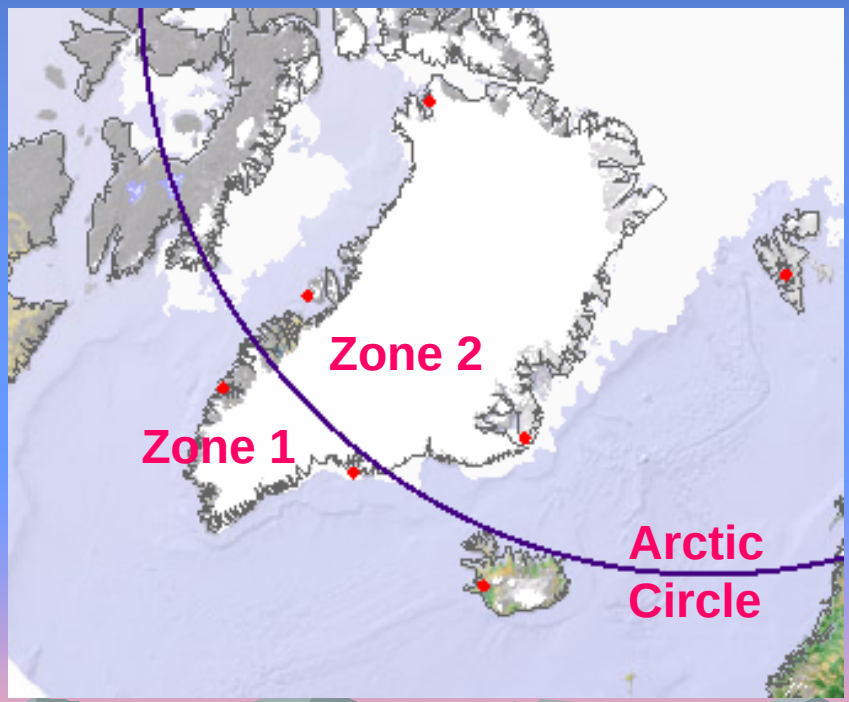
Window distribution:

South:	41%
North:	26%
East/West:	33%

Climate of Greenland

Divided into two zones:

- Zone 1 South of the Arctic Circle
- Zone 2 North of the Arctic Circle



E_{Gl_1} = 490 g – 186 U

E_{Gl_2} = 532 g – 223 U

Danish Climate

Heating season:

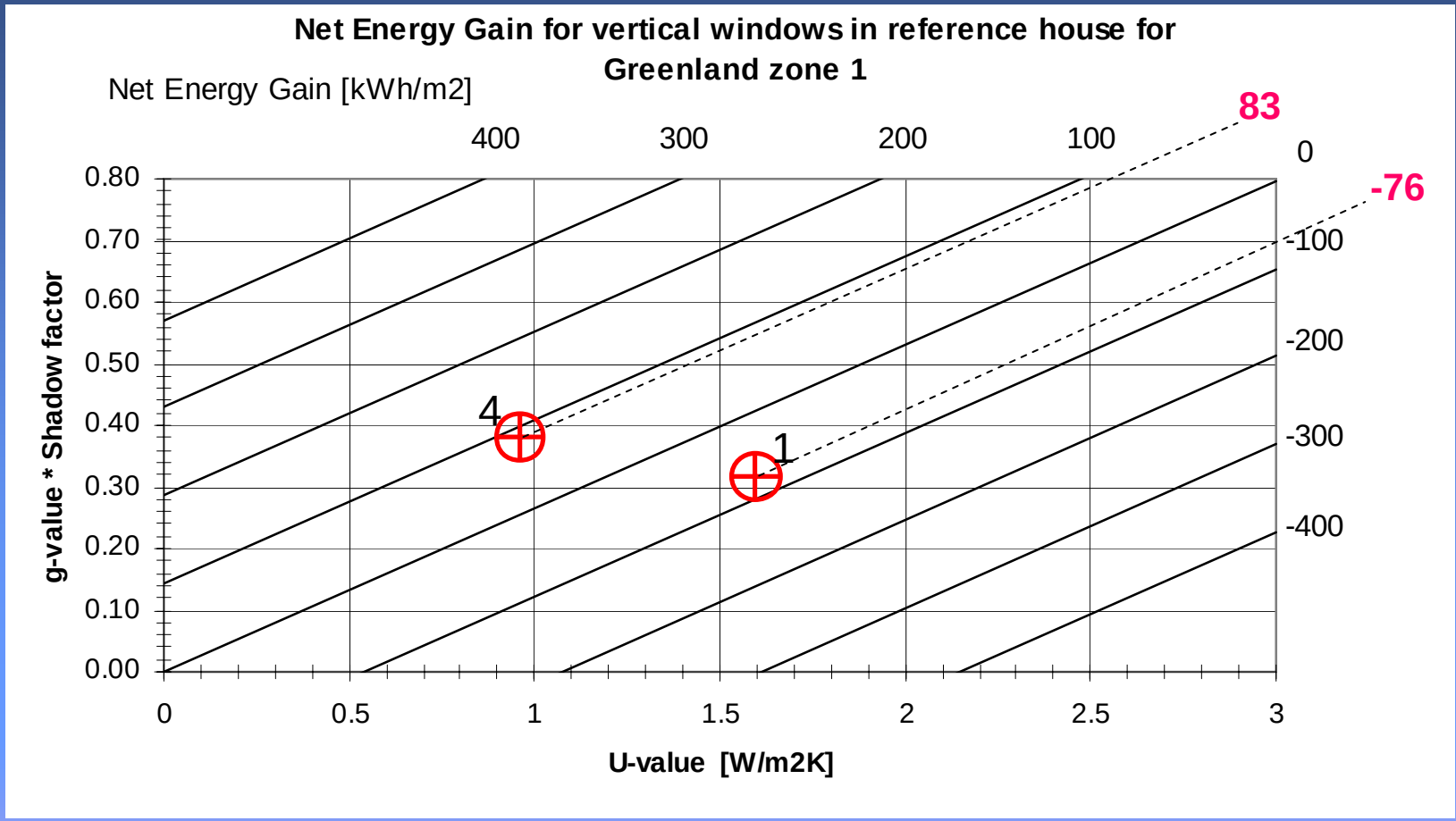
24 September to 13 May

Shadow factor of 0.7

Net Energy gain:

E_{Dk} = 196 g – 90 U [kWh/m^2]

Net Energy Gain Diagram

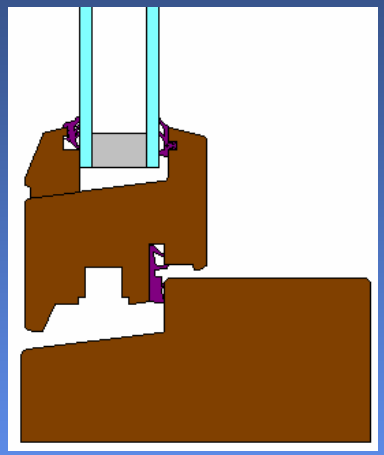


The g-value is multiplied by the shadow factor of 0.7 before it is used in the diagram

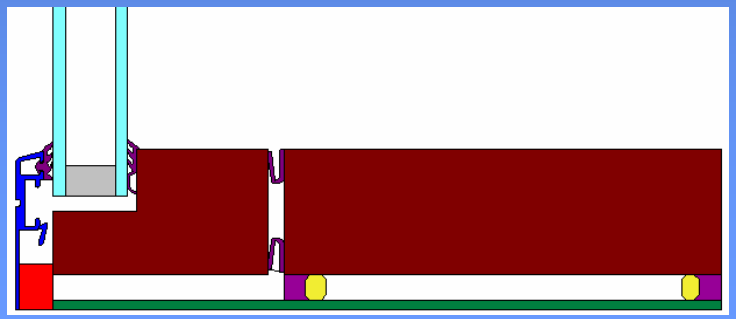
Window type 1	U = 1.61 W/m^{2}K	g=0.46	E = -76 kWh/m^2
Window type 4	U = 0.97 W/m^{2}K	g=0.54	E = 83 kWh/m^2

Window types

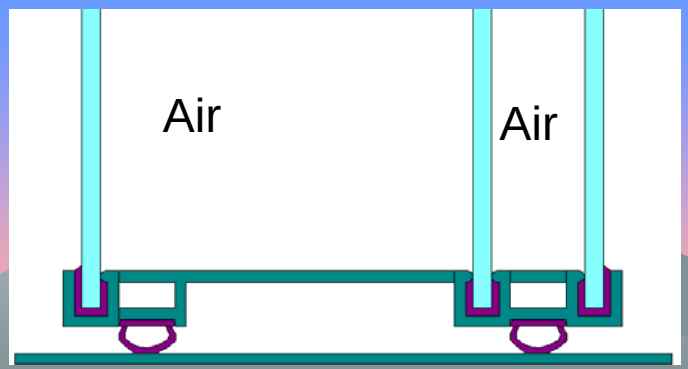
The energy performance was evaluated for 9 different windows



Type 1 and 2
Typical frame profile of Wood. Width 10 cm
Standard low energy glazing

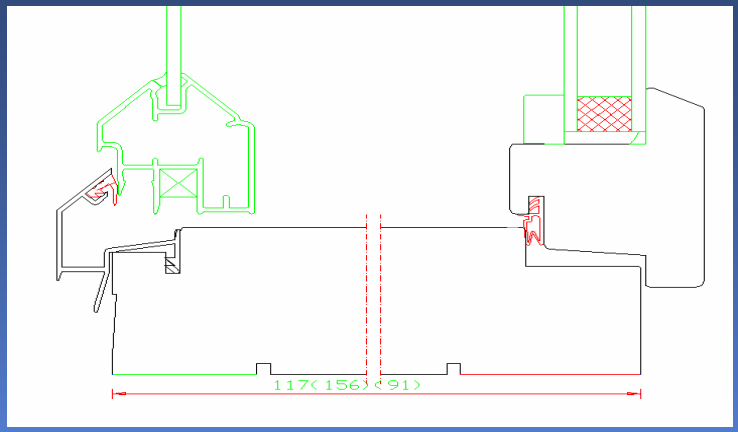


Type 3
Slim frame profile of Wood. Width 5 cm
Standard low energy glazing

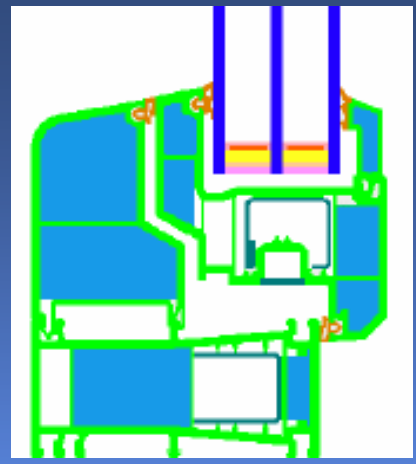


Type 4
Extra slim frame profile of fibre glass reinforced polyester. Width 2.5 cm.
Three layers of glass. Two hard low-e coatings

Window types

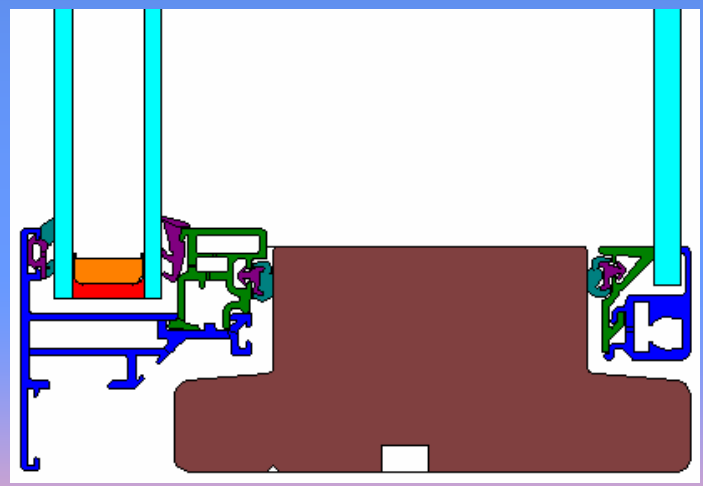


Type 6. Typical Finnish window. 1 + 2
Wood + aluminium. Frame width 11 cm



Type 7. Typical “Passivhaus” window
PVC + PU-foam. Frame width 13 cm

Type 8. Hybrid glazing
Low-energy + vacuum glazing

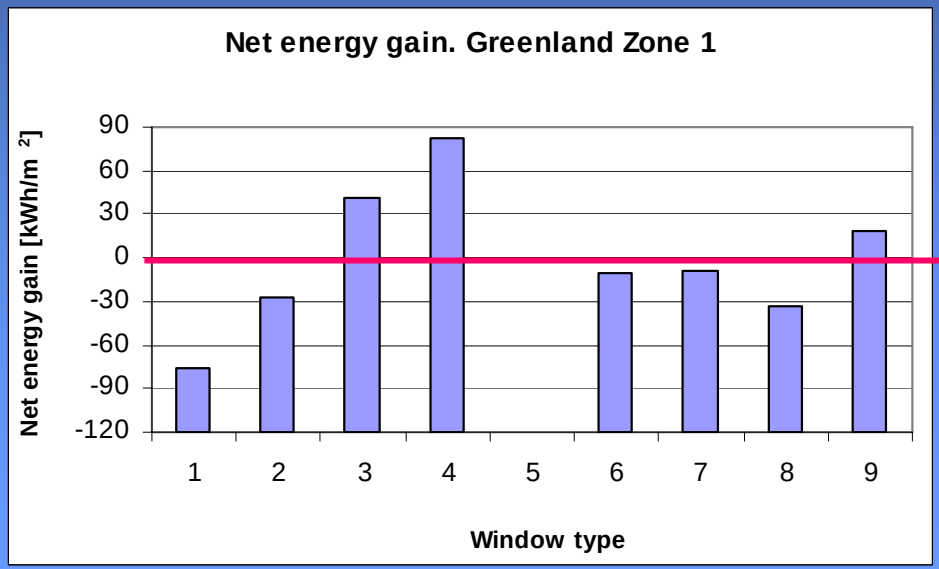


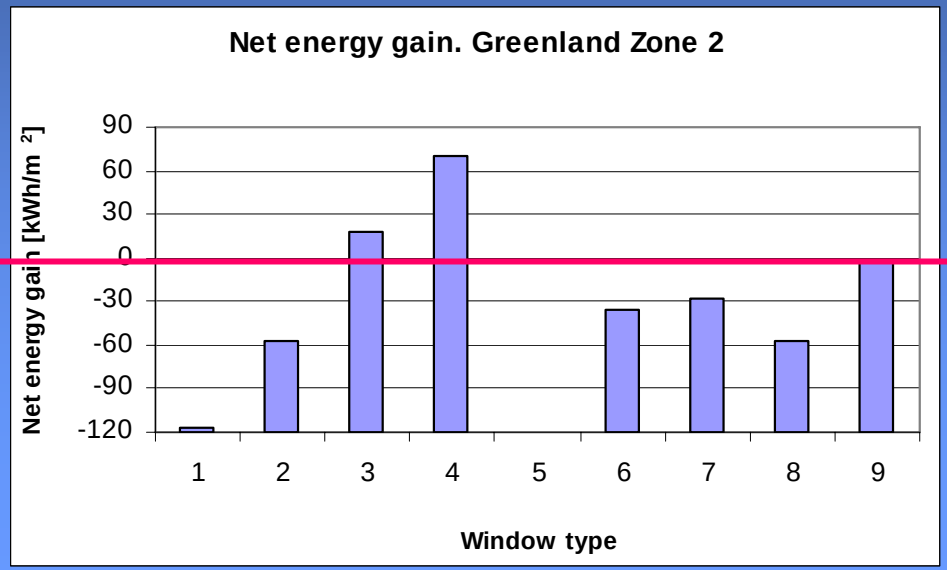
Type 9. Danish 2+1 window.
Wood + aluminium + PVC
Frame width 5.5 cm

Results

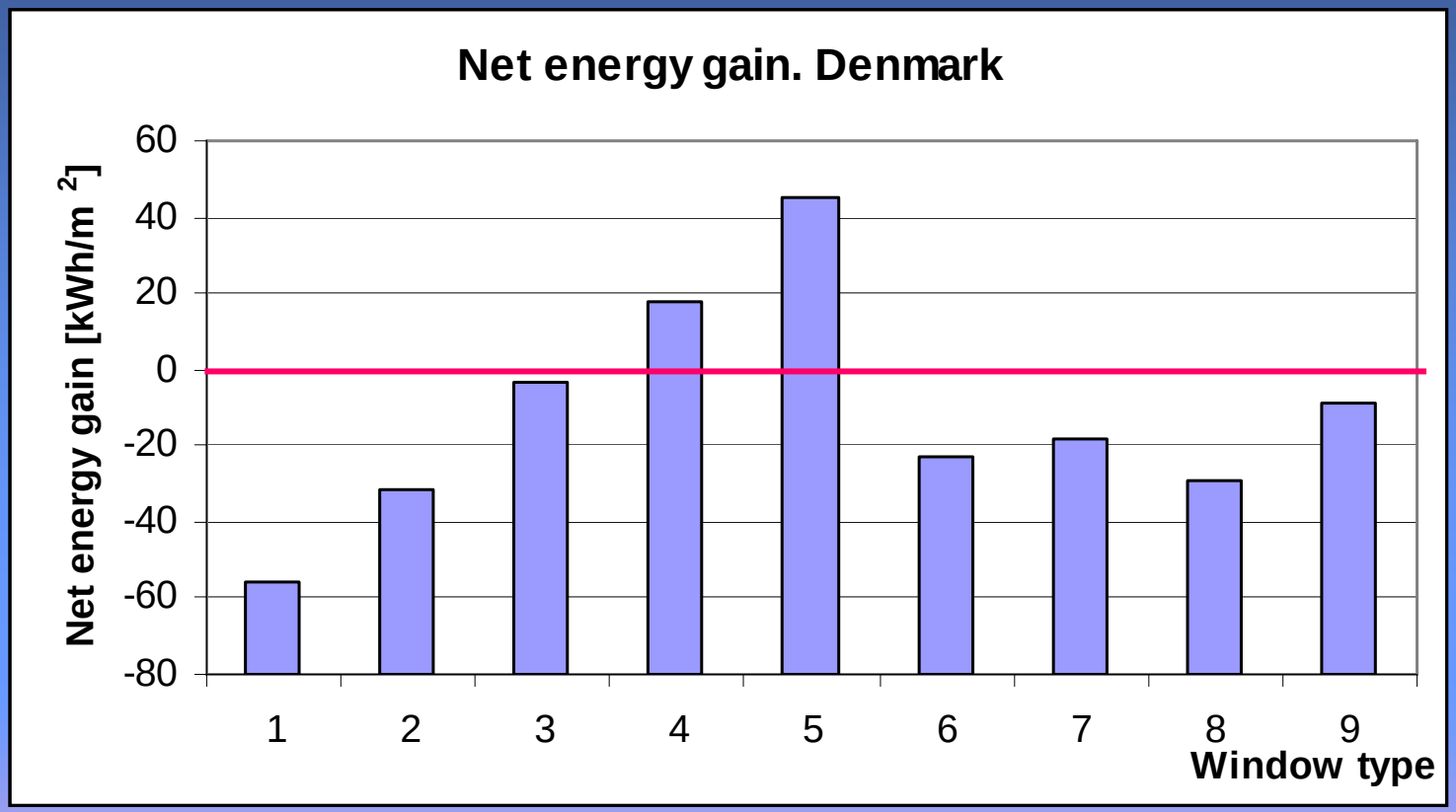
	Glazing		Frame			Window 1.48 x 1.23 m		Net energy gain		
	U_g	g	Width	U_f	Ψ	U_{tot}	g_{tot}	E_{ref} Dk	E_{ref} Zone 1	E_{ref} Zone 2
Type	W/m^2K		m	W/m^2K	W/mK	W/m^2K		kWh/m^2	kWh/m^2	kWh/m^2
1	1.28	0.63	0.10	1.30	0.128	1.61	0.46	**-56**	**- 76**	**- 116**
2	1.17	0.63	0.10	1.37	0.047	1.34	0.46	**-32**	**-26**	**-57**
3	1.15	0.67	0.054	1.33	0.034	1.27	0.58	**-2**	**41**	**18**
4	0.93	0.58	0.025	1.49 *)	-	0.97	0.54	**18**	**83**	**70**
5	0.93	0.58	0.025	1.49 *)	-	0.97 0.49**)	0.54 0.0**)	**45**		
6	1.01	0.60	0.11	1.32	0.040	1.20	0.43	**-23**	**-10**	**-36**
7	0.70	0.52	0.13	0.75	0.030	0.79	0.33	**-6**	**16**	**0**
8	0.70	0.43	0.10	1.30	0.05 ***)	0.99	0.31	**-39**	**-33**	**-57**
9	0.72	0.51	0.055	2.71	-	1.03	0.43	**-9**	**18**	**-2**

Net energy gain in Greenland



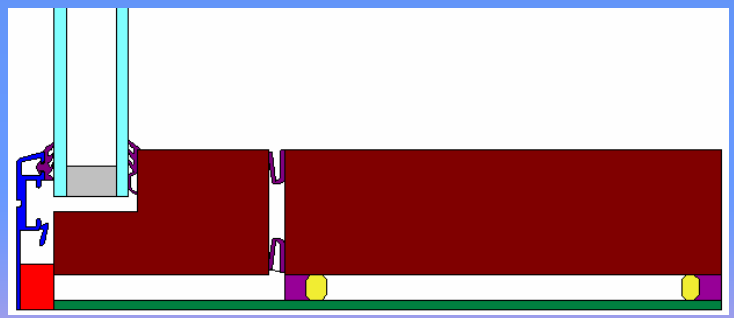


Net energy gain in Denmark



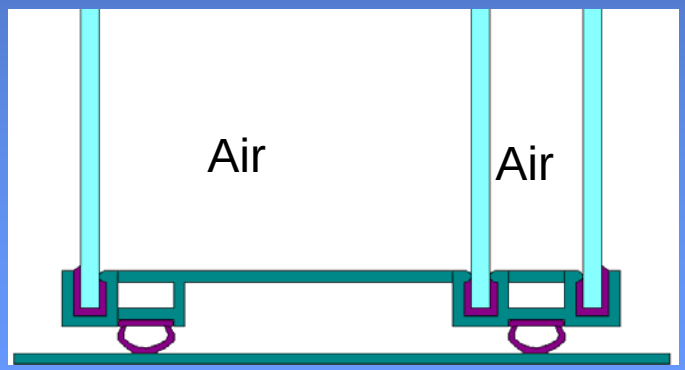
Window With Positive Net Energy Gain Type 3

- Energy glazing with low iron glass
- Warm edge
- Slim frame of wood



- Low heat loss
- High solar gain
- Positive net energy gain

Window With Positive Net Energy Gain
Type 4

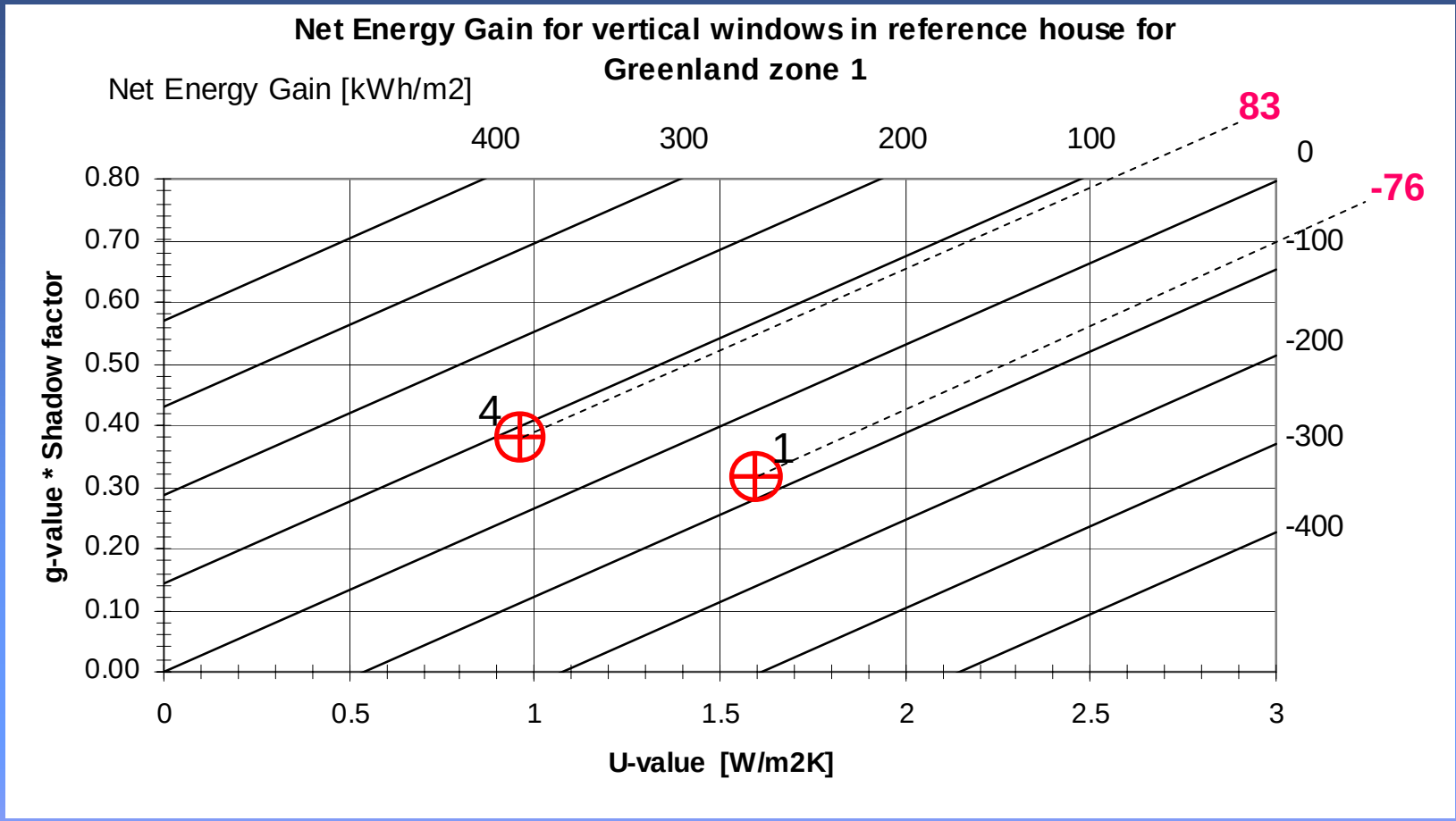


Extra slim frame profile of 2.5 cm.
Fibre glass reinforced polyester.
Three layers of glass.
Two hard low-e coatings
Air gabs sealed but micro ventilated
Air pressure neutralized through tubes with filters to outside

Non-sealed air gabs in glazing → longer service life

Large air gaps → integration of solar shading in glazing

Net Energy Gain Diagram



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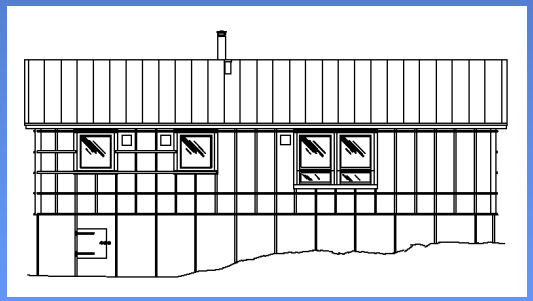
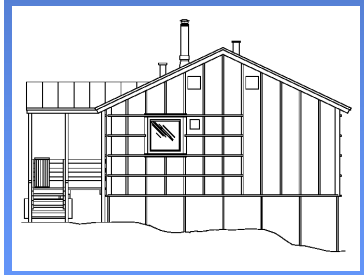
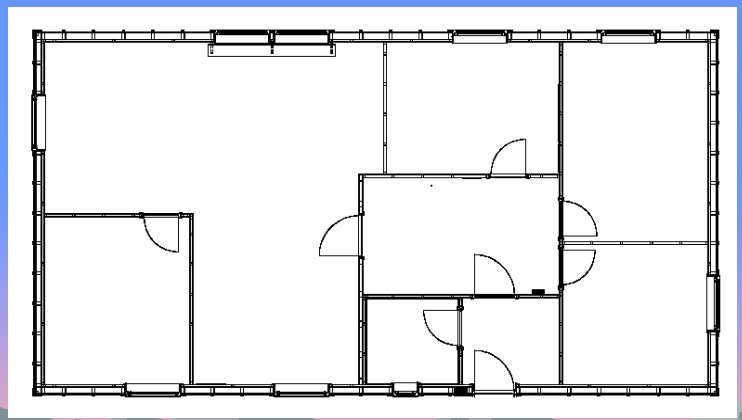
Simulations in BSim 2002

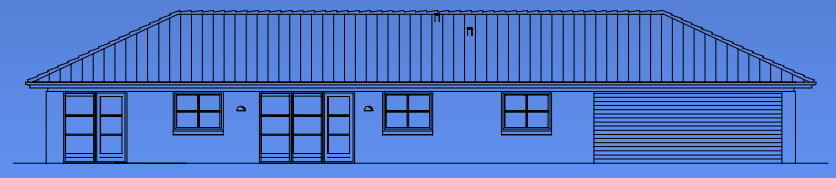
Energy consumption for heating and ventilation were determined for the windows used in typical houses in Greenland and Denmark

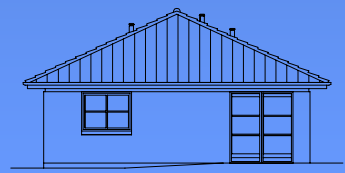


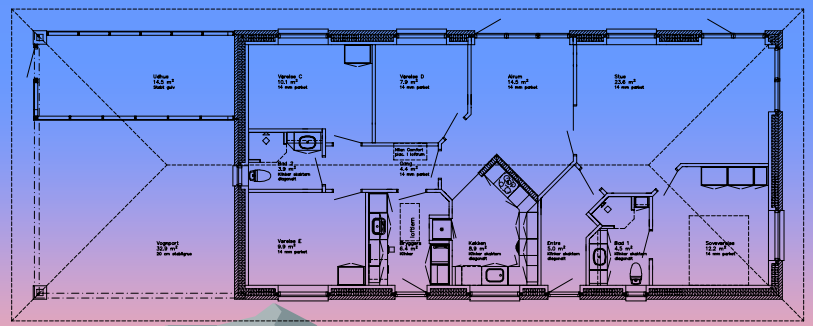




House A: (Arctic climate, Greenland)
Illorput







House B: (Danish climate)
Snekkersten

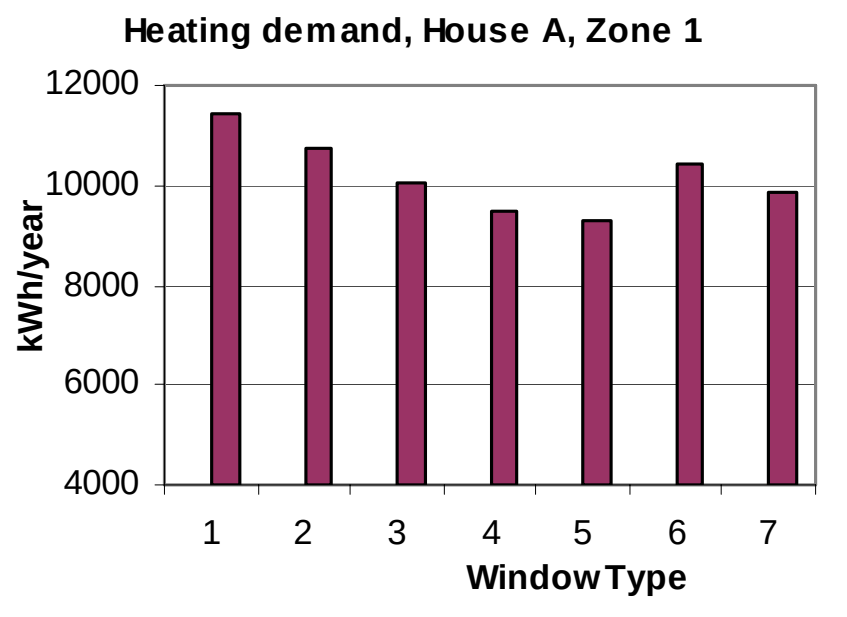
Energy consumption in Greenland

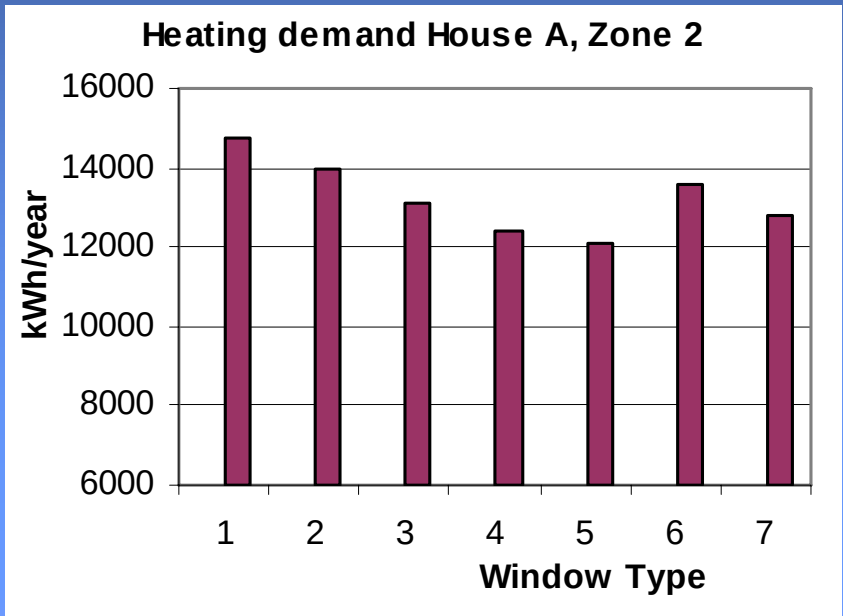
Based on heating of building with the window types

Building simulations performed in BSim 2002

Window			Zone 1			Zone 2		
Type	U_{tot} W/m^{2}K	g_{tot}	Heating kWh/year	Solar gain kWh/year	Venting kWh/year	Heating kWh/year	Solar gain kWh/year	Venting kWh/year
1	1.61	0.46	11427	3016	-247	14751	3324	-200
2	1.34	0.46	10744	3016	-275	13930	3324	-230
3	1.23	0.58	10024	3830	-558	13254	4107	-460
4	0.97	0.54	9488	3578	-498	12434	3956	-462
5	0.97– 0.49	0.54– 0.0	9294	3536	-498	12090	3896	-459
6	1.20	0.43	10455	2872	-252	13580	3166	-210
7	0.79	0.33	9830	2204	-136	12811	2426	-113

Energy consumption in Greenland

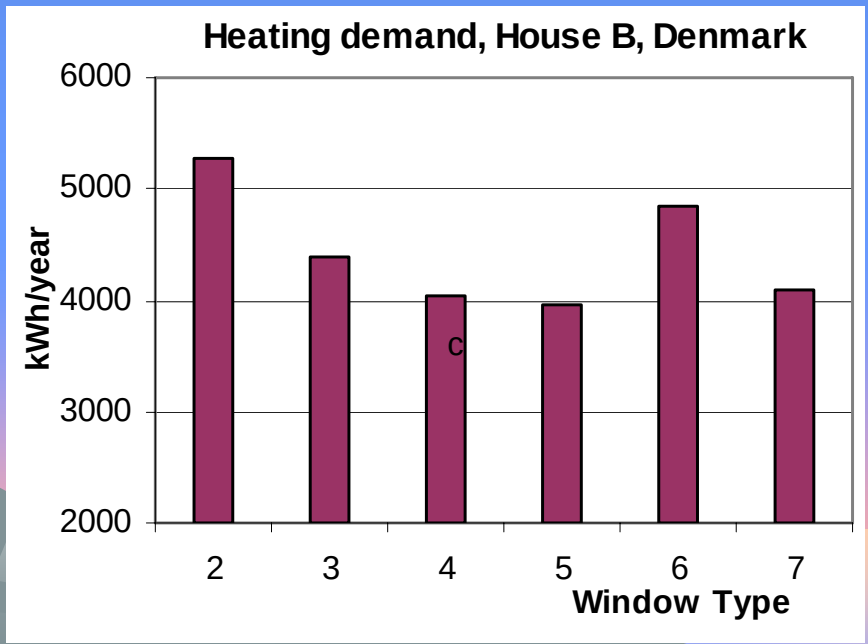


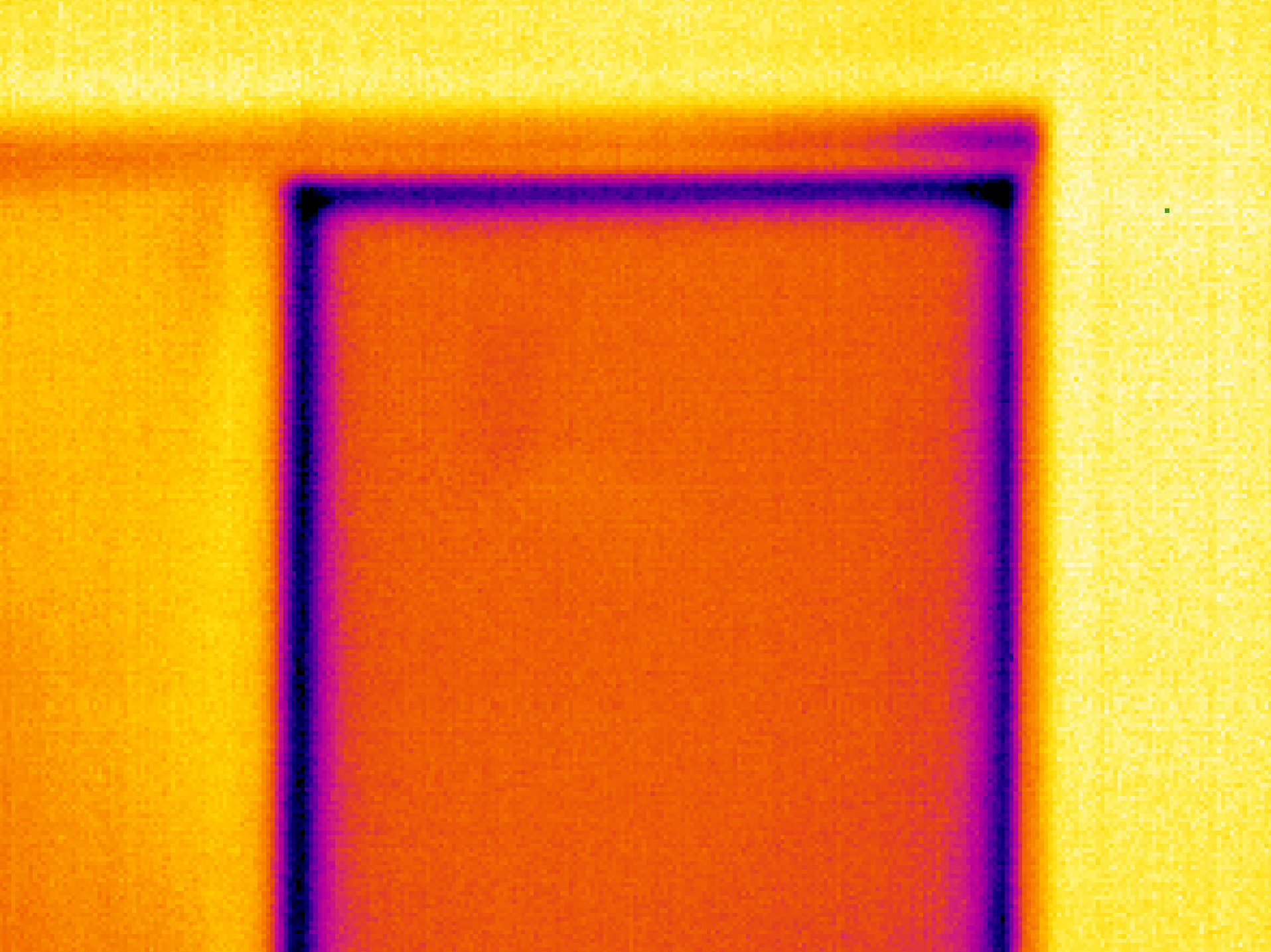


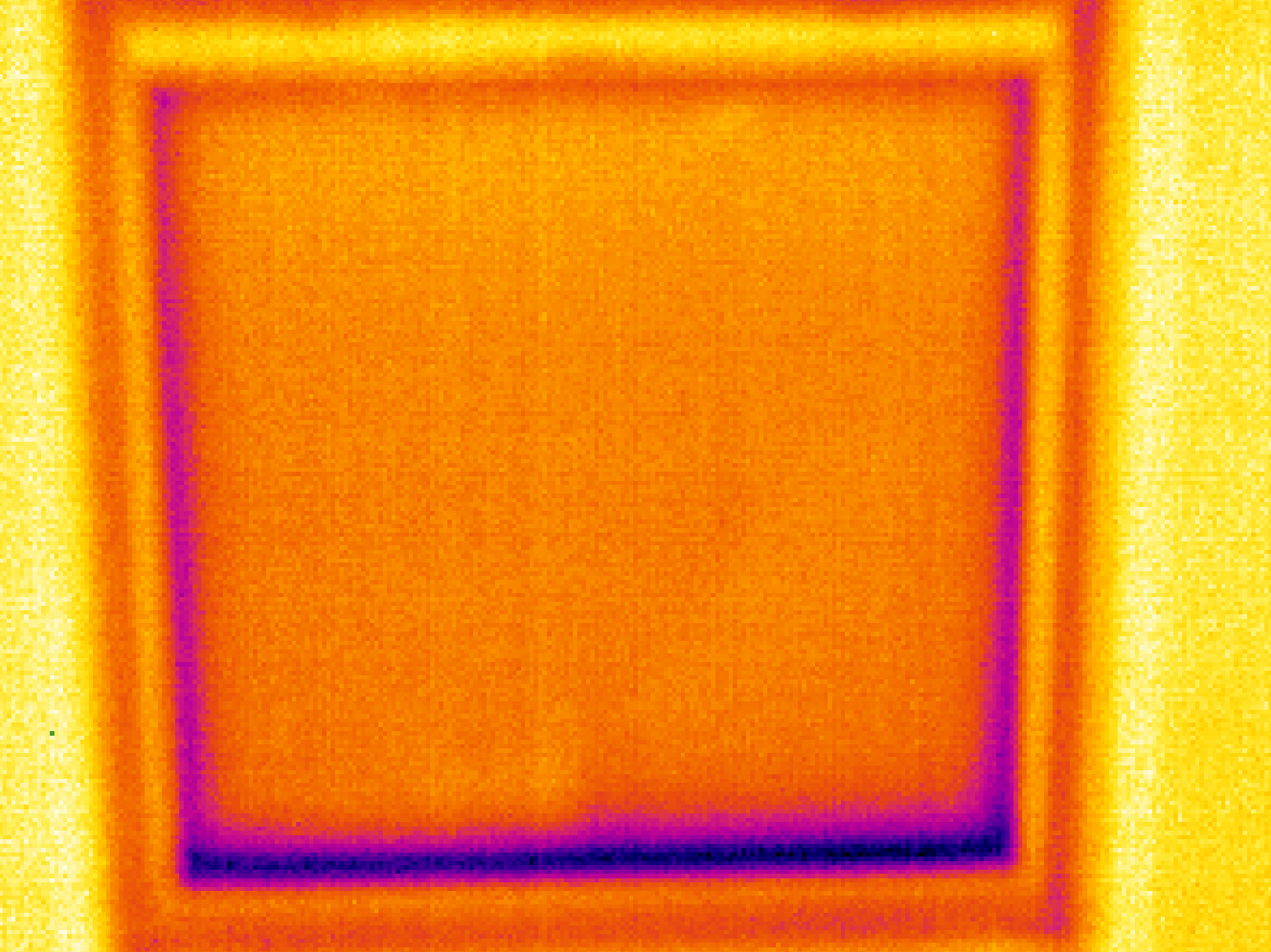
Energy consumption Denmark

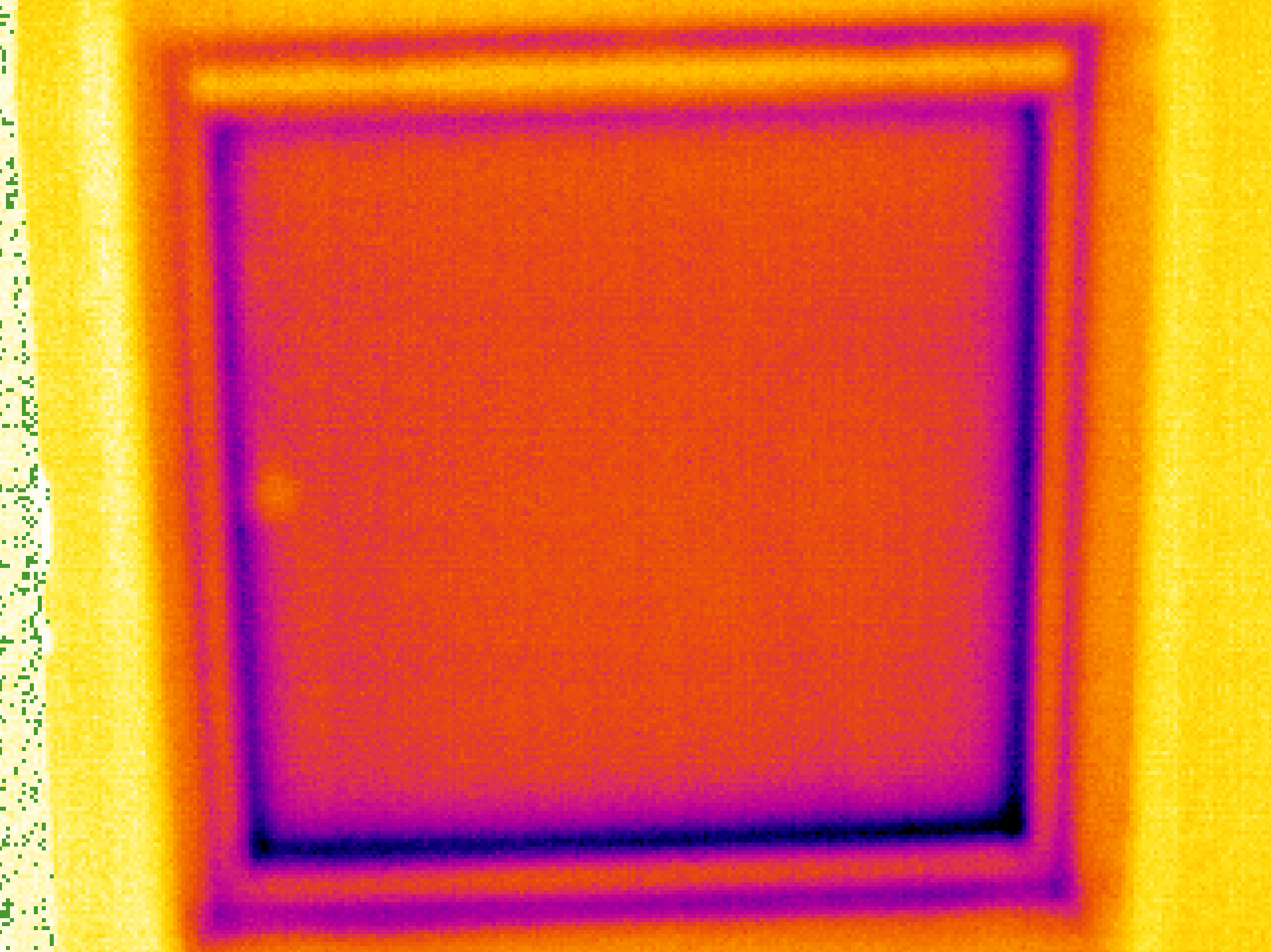
Building simulations performend in BSim 2002

Type	U_{tot} W/m^{2}K	g_{tot}	Heating kWh/year	Solar gain kWh/ year	Venting kWh/ year
2	1.34	0.46	5274	1891	-136
3	1.23	0.58	4401	2705	-423
4	0.97	0.54	4032	2373	-344
5	0.97 – 0.49	0.54 – 0.0	3949	2349	-353
6	1.20	0.43	4836	1901	-162
7	0.79	0.33	4093	1582	-131









Conclusion

- It is possible to develop windows with positive net energy gain in cold climates
- Improvements of existing window types
- Further improvements possible based on new window types