The potential for energy efficient building design – differences between Europe and the Arctic

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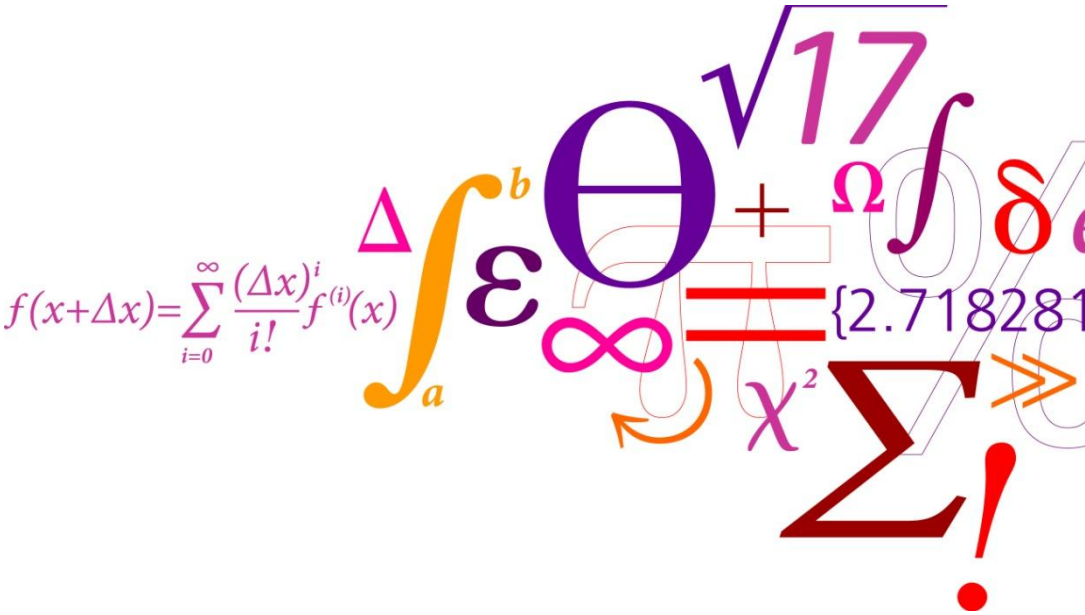

DTU Civil Engineering
Department of Civil Engineering

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Introduction

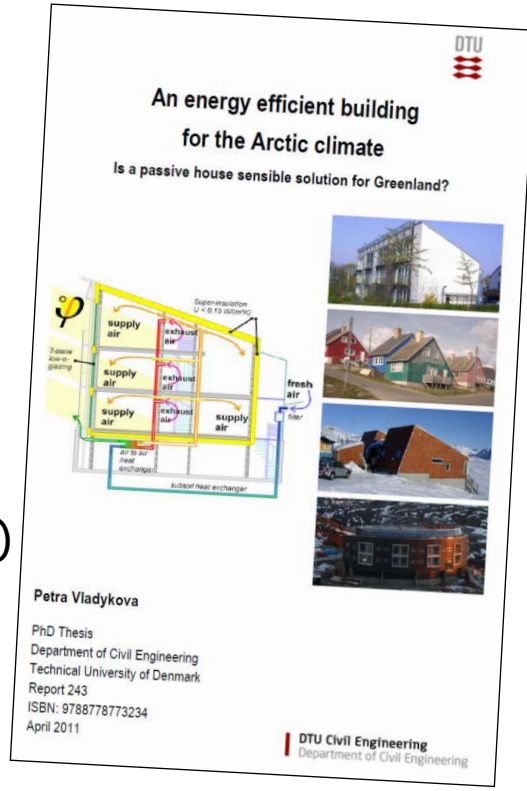
PhD candidate Petra Vladyková

Thesis: *An energy efficient building for the Arctic climate*
- Is a passive house a sensible solution for Greenland?

Research questions:

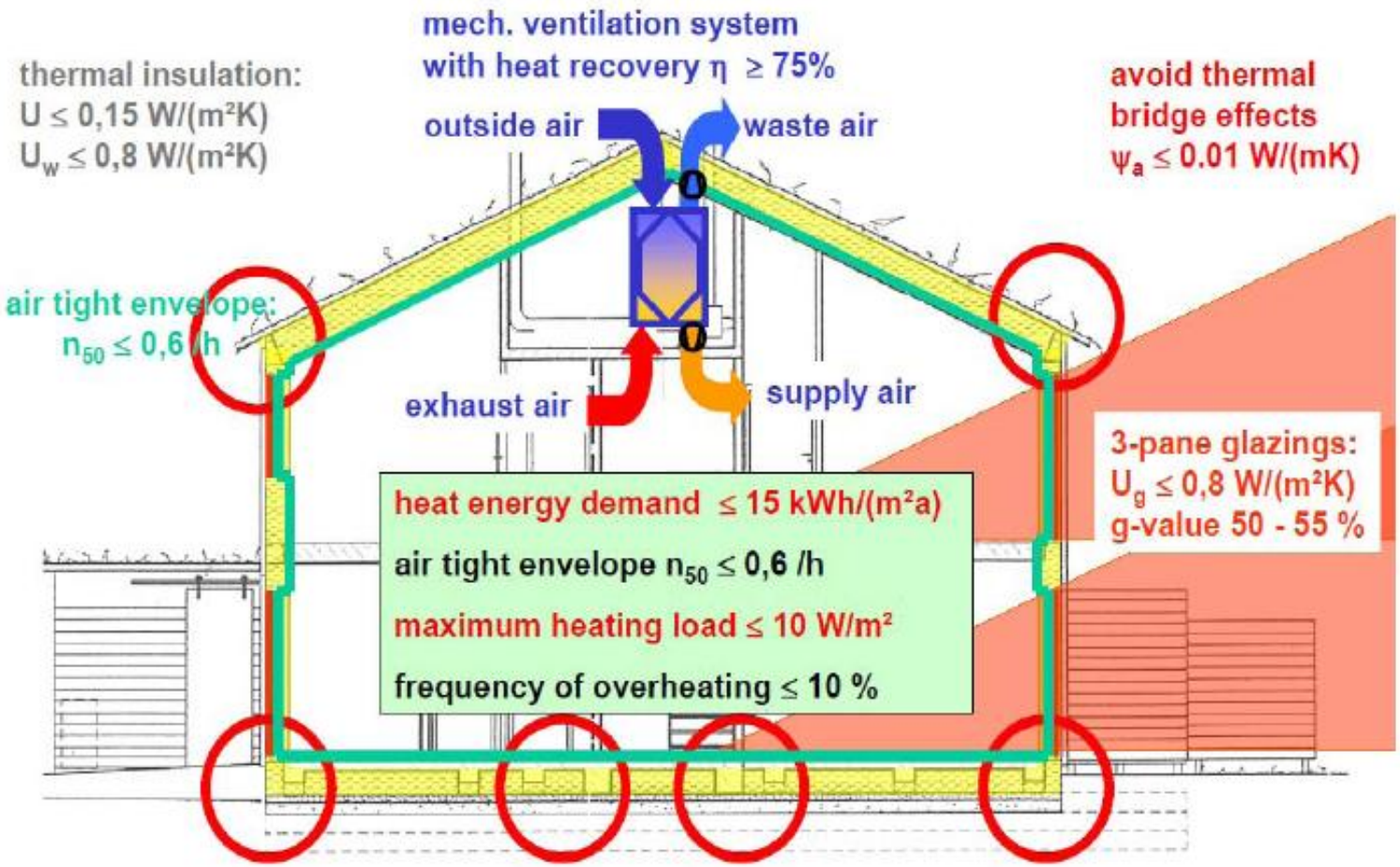
1. Can the European definition of a **passive house** make use and be applied in an Arctic country (Greenland)?
2. How will a European **passive house** perform in Greenland?
3. Could a **passive house** for an Arctic stimulate the development of low-energy building technology in other climates?
4. What would be an **energy efficient building** for Arctic climates?

(Defense: Friday 3 June 2011, Technical University of Denmark)



Passive houses

Requirements:



Climate

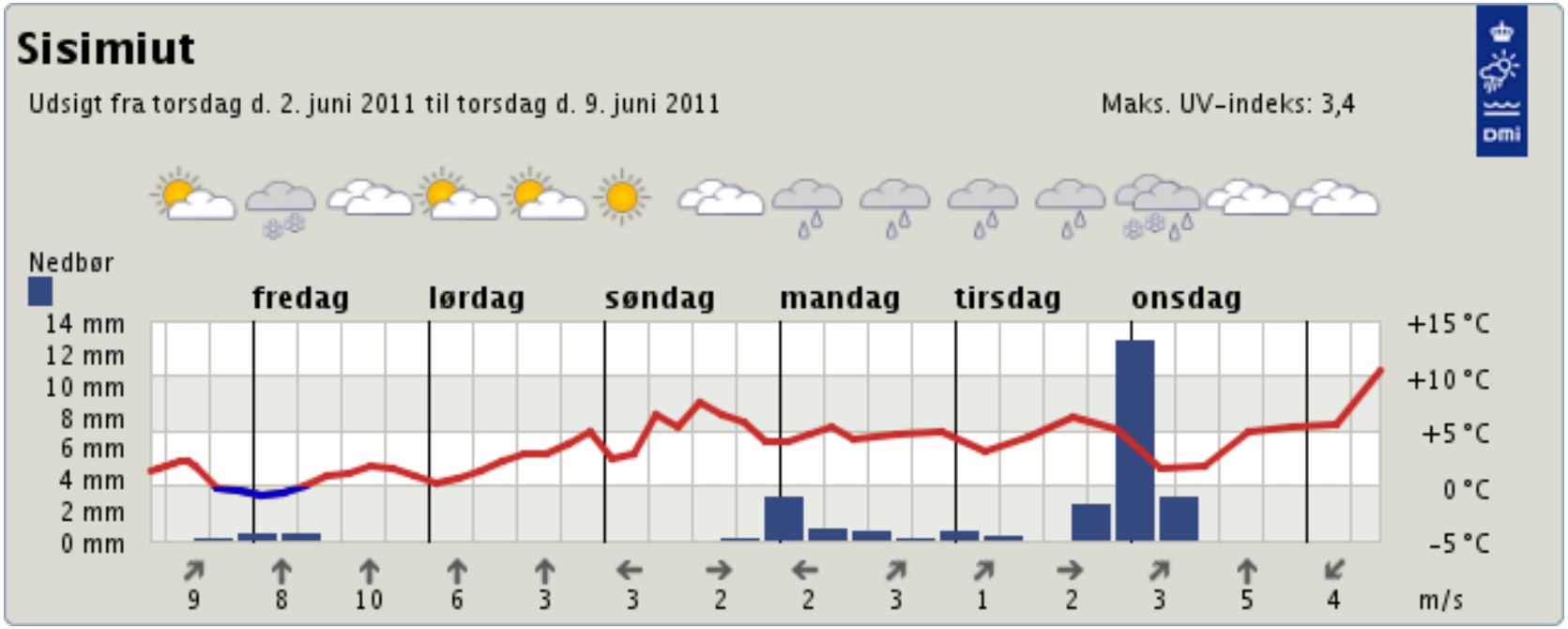
Kranichstein (Darmstadt, Germany)

- Latitude 49.5°
- Monthly mean temperature 0.7°C to 18.9°C
- Heating degree days: 3,325 K·days
- Solar radiation on southern facade 949 kWh/(m²a)

"Apisseq" (Sisimiut, Greenland)

- Latitude 66.6°
- Monthly mean temperature -14.0°C to 6.3°C
- Heating degree days: 6,100 K·days
- Solar radiation on southern facade 1,019 kWh/(m²a)

Weather in Sisimiut today

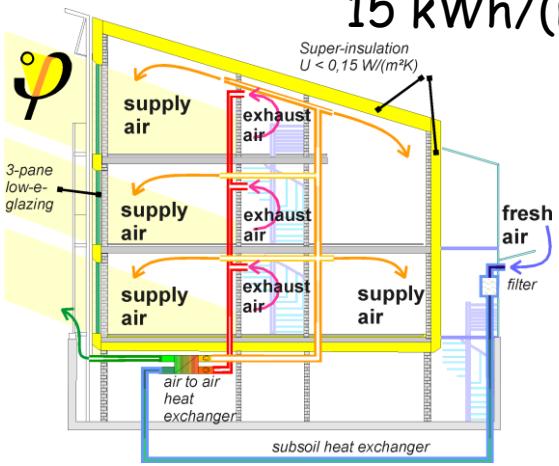


Buildings

Kranichstein (1991)

- A_{TFA} 156 m²
- U_{wall} 0.14 W/(m²K)
- U_{flor} 0.10 W/(m²K)
- U_{roof} 0.13 W/(m²K)
- U_{window} 0.70 W/(m²K)
- $\eta_{heat\ recovery}$ 0.80
- n 0.022 h^{-1}

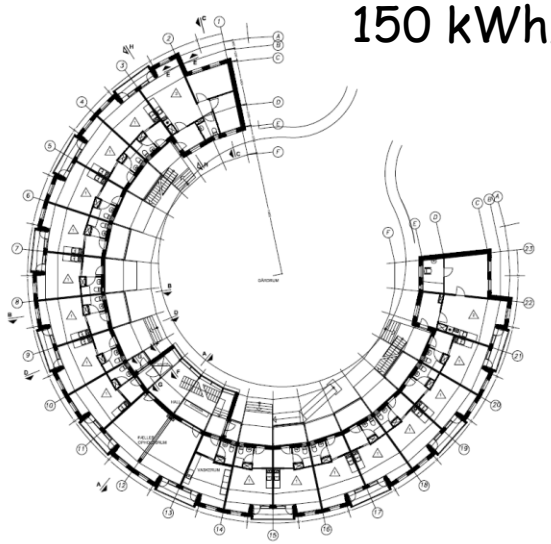
15 kWh/(m²a)



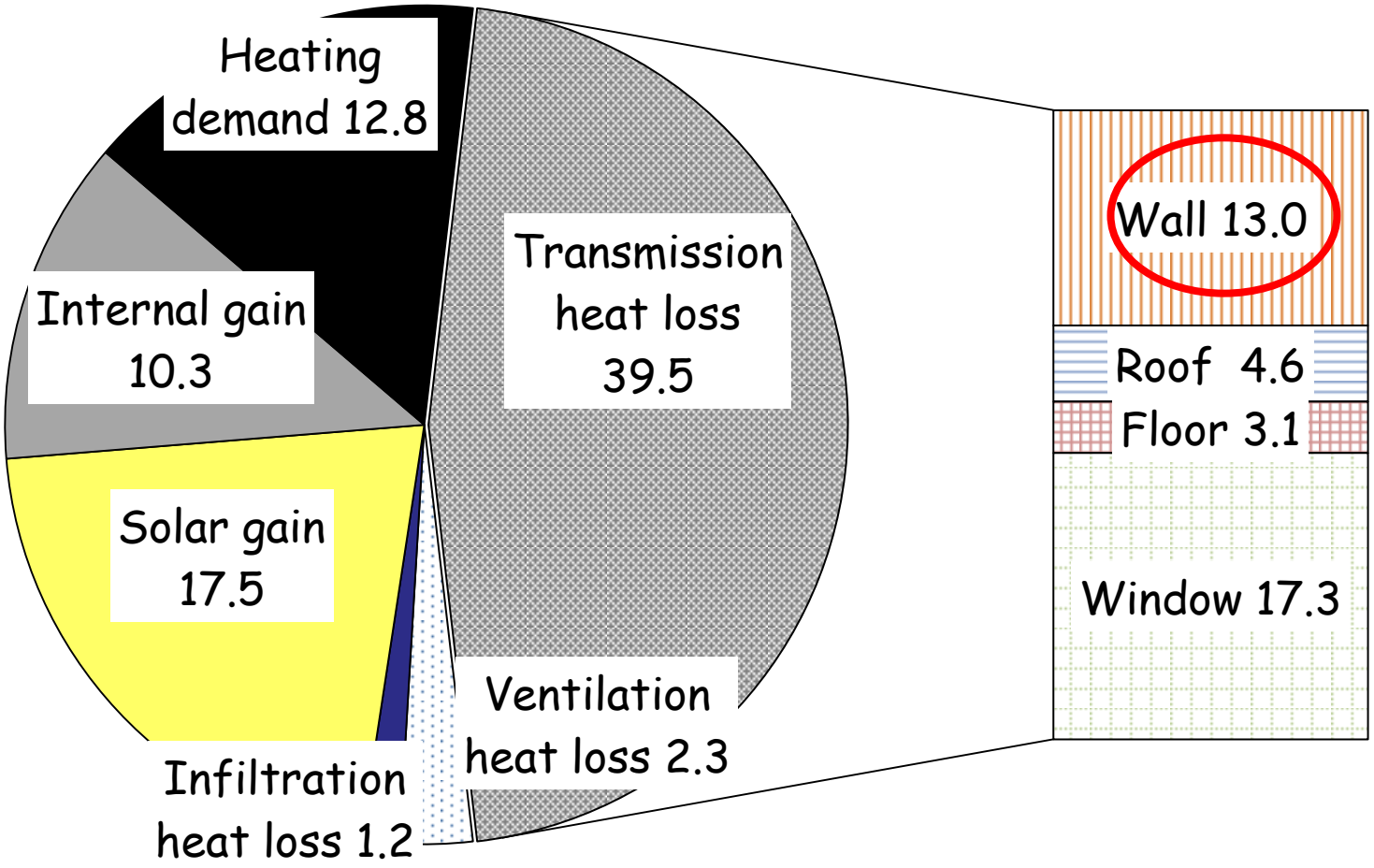
"Apisseq" (2010)

- A_{TFA} 1,134 m²
- U_{wall} 0.15 W/(m²K)
- U_{flor} 0.13 W/(m²K)
- U_{roof} 0.13 W/(m²K)
- U_{window} 1.10 W/(m²K)
- $\eta_{heat\ recovery}$ 0.75
- n 0.135 h^{-1}

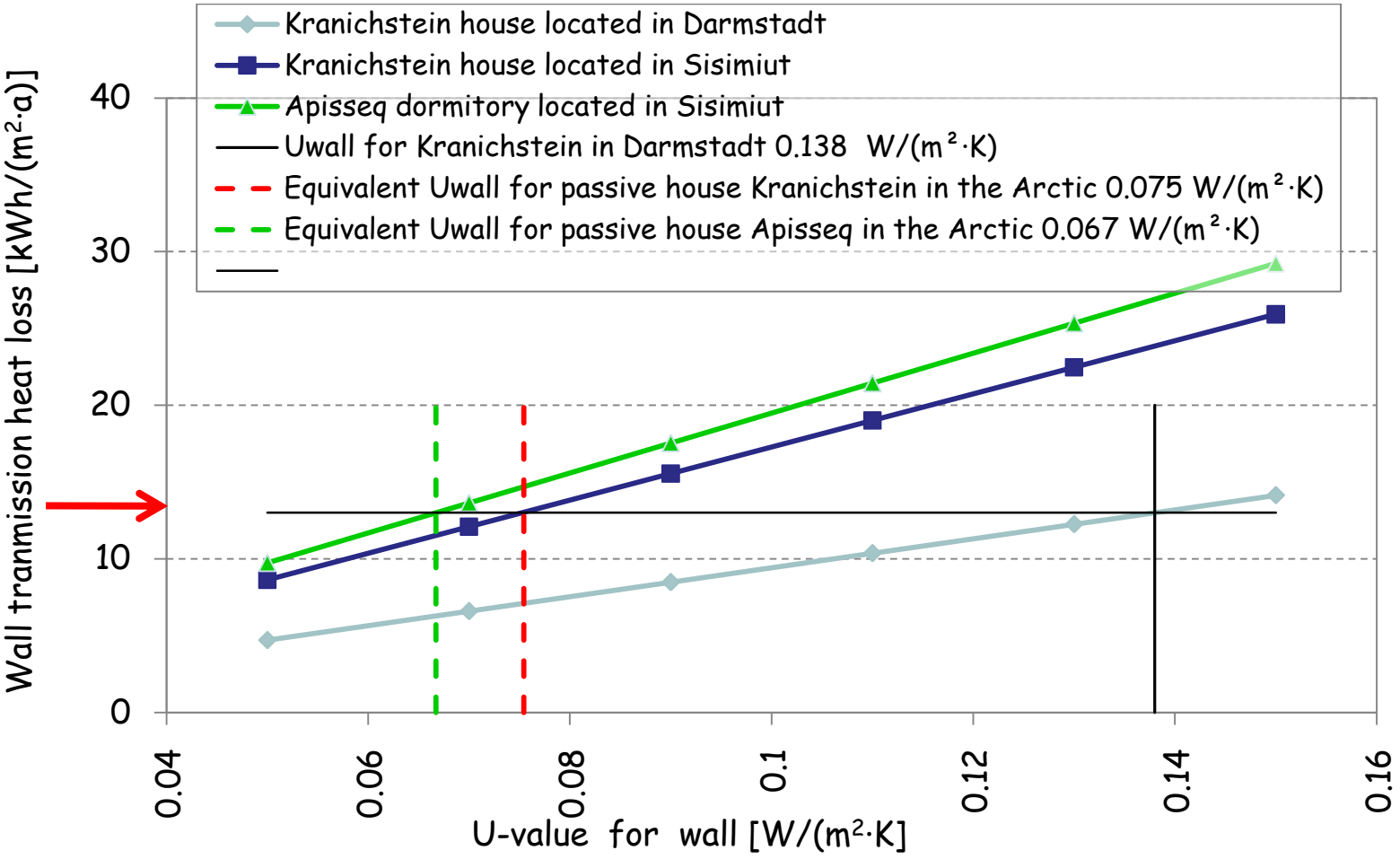
150 kWh/(m²a)



Energy balance, Kranichstein, kWh/(m²a)



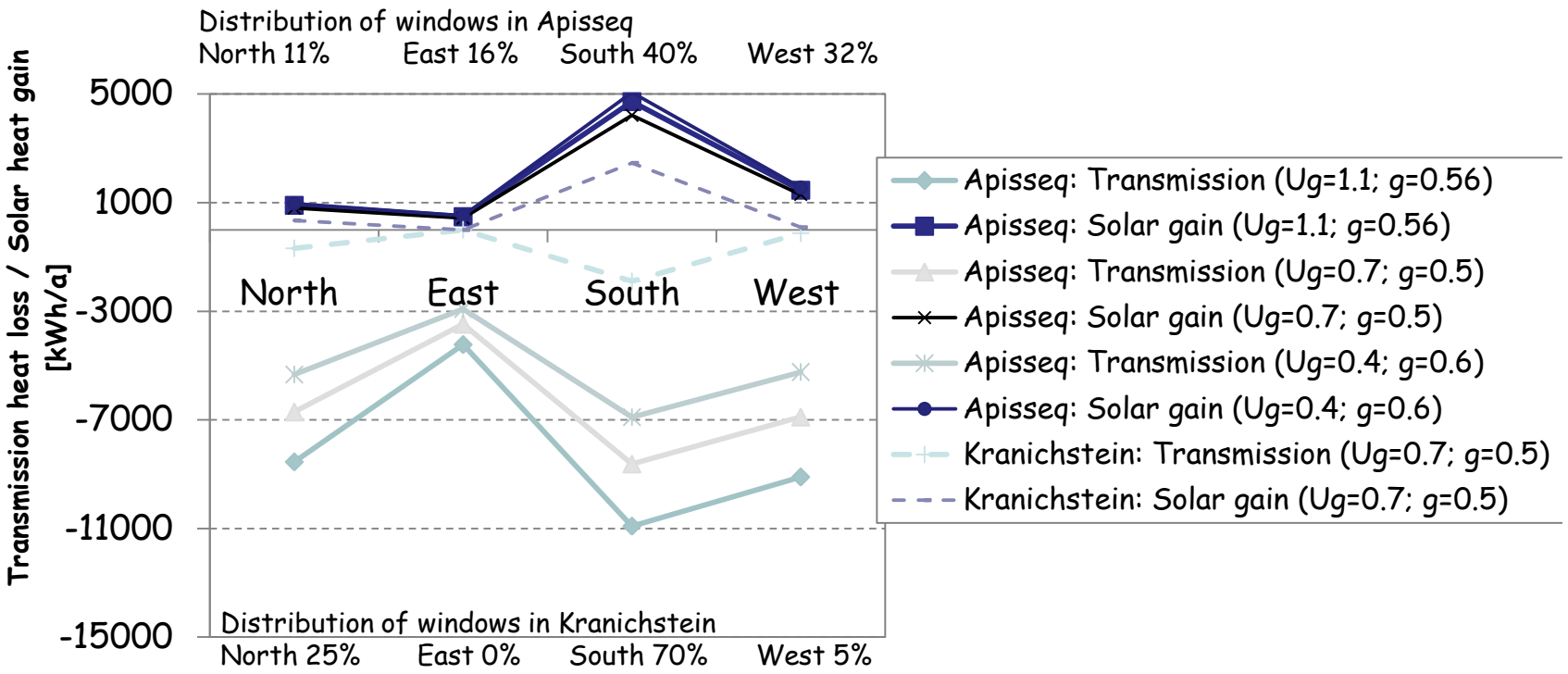
Let's move the Kranichstein house to Sisimiut… Wall:



Transposition of all the components

State	Current state		Passive house	
Location	Kranichstein Darmstadt	Apisseq Sisimiut	Kranichstein Sisimiut	Apisseq Sisimiut
U_{wall}[W/(m^2·K)]	0.138	0.150	0.075	0.068
U_{floor} [W/(m^2·K)]	0.131	0.130	0.041	0.038
U_{roof} [W/(m^2·K)]	0.108	0.130	0.069	0.059
$\Psi_{window,/foundation}$ [W/(m·K)]	0.010	0.03/0.25	0.010	0.010
Air tightness [h^{-1}]	0.022	0.135	0.022	0.012
Heat exchanger [%]	80	75	90	90
Windows				
U_g [W/m^{2}K]		1.1		0.40
g		0.56		0.60
Heat loss, kWh		32,800		
Heat gain, kWh		7,600		

Transpositon of Windows



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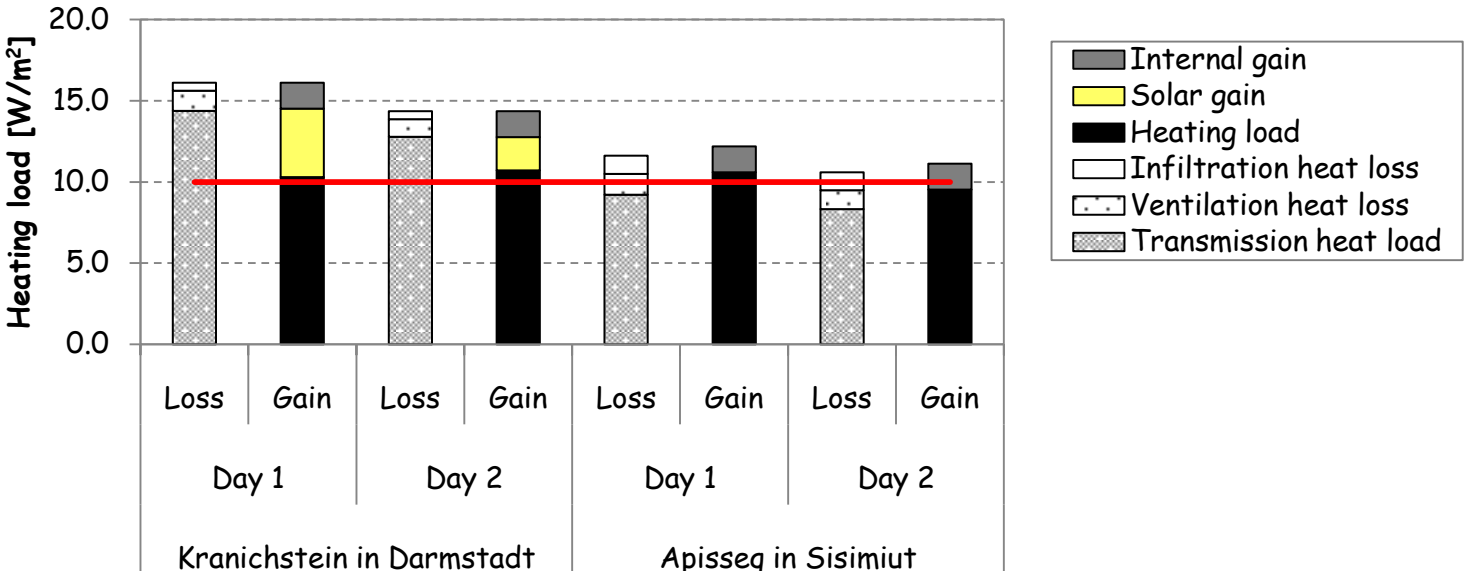
Heat loss, kWh		32,800		
Heat gain, kWh		7,600		
Internal gains				
Gain [W/m^2]	2.1			5.0

Peak heating load – 10 W/m²

"Day 1" – a cold day with clear sky

"Day 2" – a moderately cold day with overcast sky



Requires:

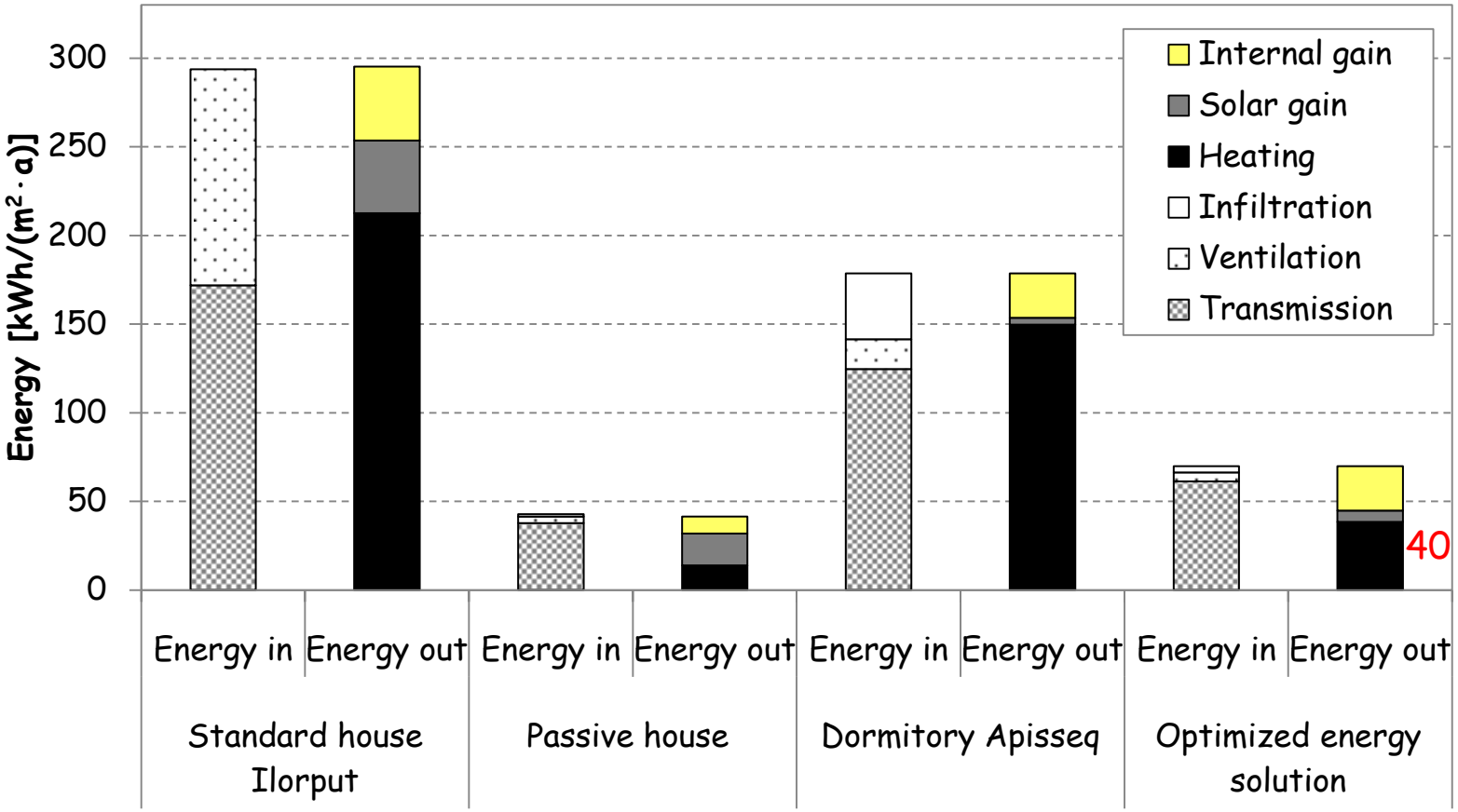
U_{window} = 0.492 W/m²K

Requires (other components)...

	Kranichstein in Darmstadt		Apisseq in Sisimiut	
	Day 1	Day 2	Day 1	Day 2
Design temperature [°C]	-11.4	-7.5	-32.2	-26.9
Solar gain (North, East, South, West) [W/m^2]	11, 35, 90, 35	15, 20, 40, 25	0, 0, 0, 0	0, 0, 0, 0
U_{wall} [W/(m^2·K)]	0.138		0.042	
U_{roof} [W/(m^2·K)]	0.108		0.035	
U_{floor} [W/(m^2·K)]	0.131		0.035	
U_{window} [W/(m^2·K)]	0.777		0.492	
Infiltration [h^{-1}]	0.019		0.030	
Heat exchanger efficiency [%]	80		91	

d_{wall} = 900 mm, λ = 0.037 W/(m·K) or
d_{wall} = 550 mm, λ = 0.025 W/(m·K)

Optimized energy design for Sisimiut



Optimized energy design for Sisimiut

• U_{wall}	0.07 W/(m²K)	(0.15)
• U_{flor}	0.08 W/(m²K)	(0.13)
• U_{roof}	0.08 W/(m²K)	(0.13)
• U_{window}	0.80 W/(m²K)	(1.10)
• g_{window}	0.60	
• $\eta_{heat\ recovery}$	0.90	(0.75)
• n	0.021 h^{-1}	(0.135)
Energy demand	40 kWh/(m²a)	(150)

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Photo: Egil Borchersen