Integral planning of refurbishment measures University of Innsbruck according to EnerPHit standard

Your independent partner for outstanding energy efficiency in buildings

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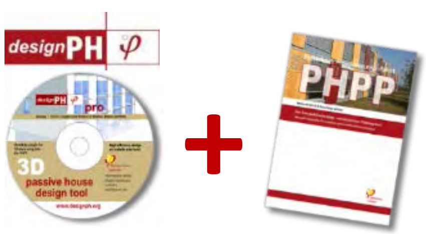

Network

International PASSIVE HOUSE Association iPHA
Since 2010

International Passive House network
Passipedia | Passive House promotion
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Worldwide Affiliates

Passive House Institute

Head of institute

Univ. Prof. Dr. Wolfgang Feist

since 1988 addicted to energy efficient buildings

Headquarter Darmstadt – www.passiv.de

54 people from the fields of
civil engineering, environmental engineering,
mechanical engineering, home automation,
physics, mathematics, architecture,
communication
(from more than **10 different countries**)

Department Innsbruck – www.phi-ibk.at

Harald Konrad Malzer

PHI project coordinator EU FP7 SINFONIA
designPH 3D software development
Building certification

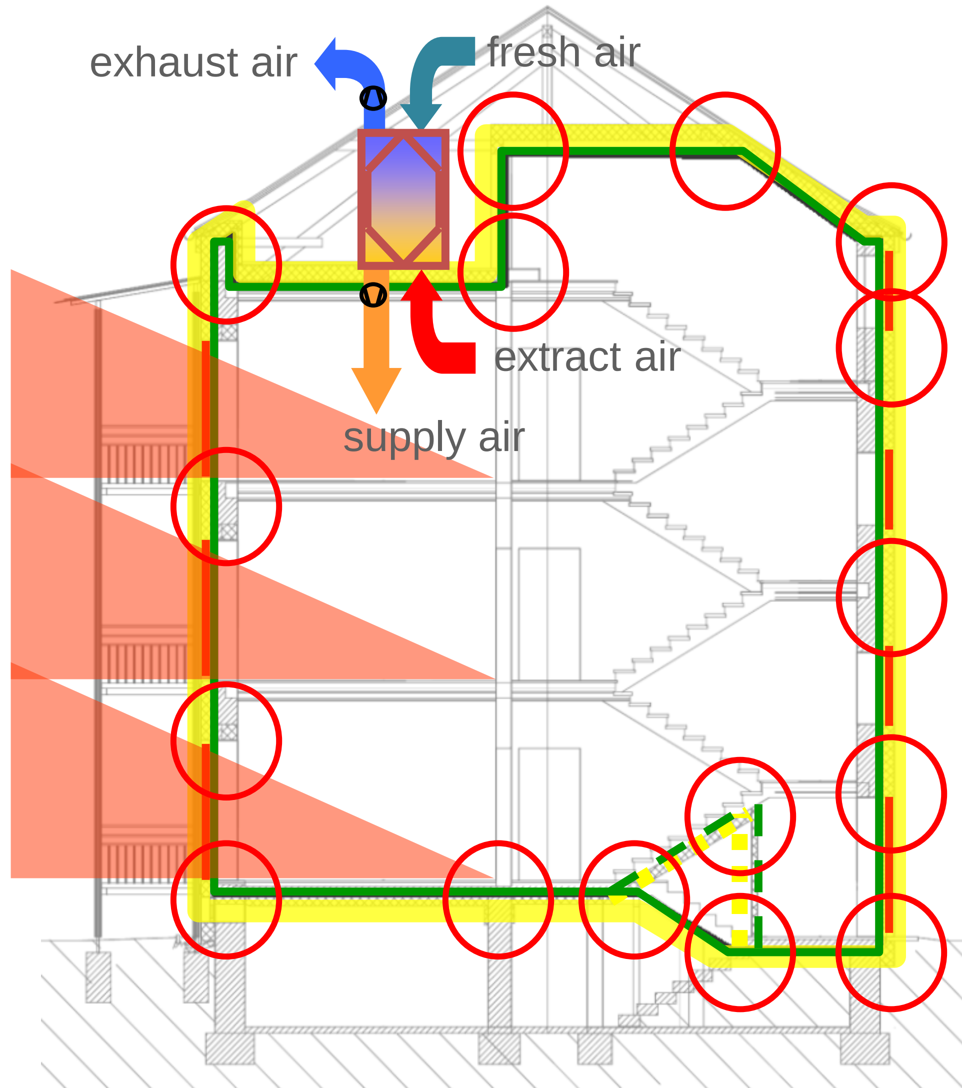
Passive House Standard in old buildings?

A possible approach:

- improve insulation
- improve windows
- avoid thermal bridges
- create airtight layer
- ventilation + heat recovery

„That´s like a Passive House!“

Almost!



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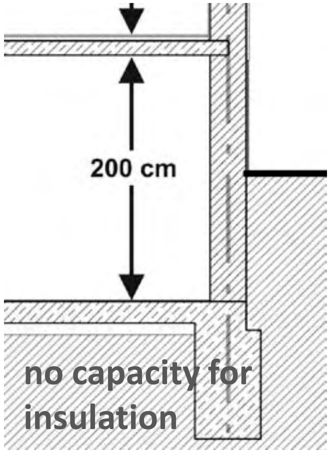
Passive House Standard in old buildings? - Difficulties



etc.

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Difference between Passive House Standard and EnerPHit Standard ?

Zertifiziertes Passivhaus
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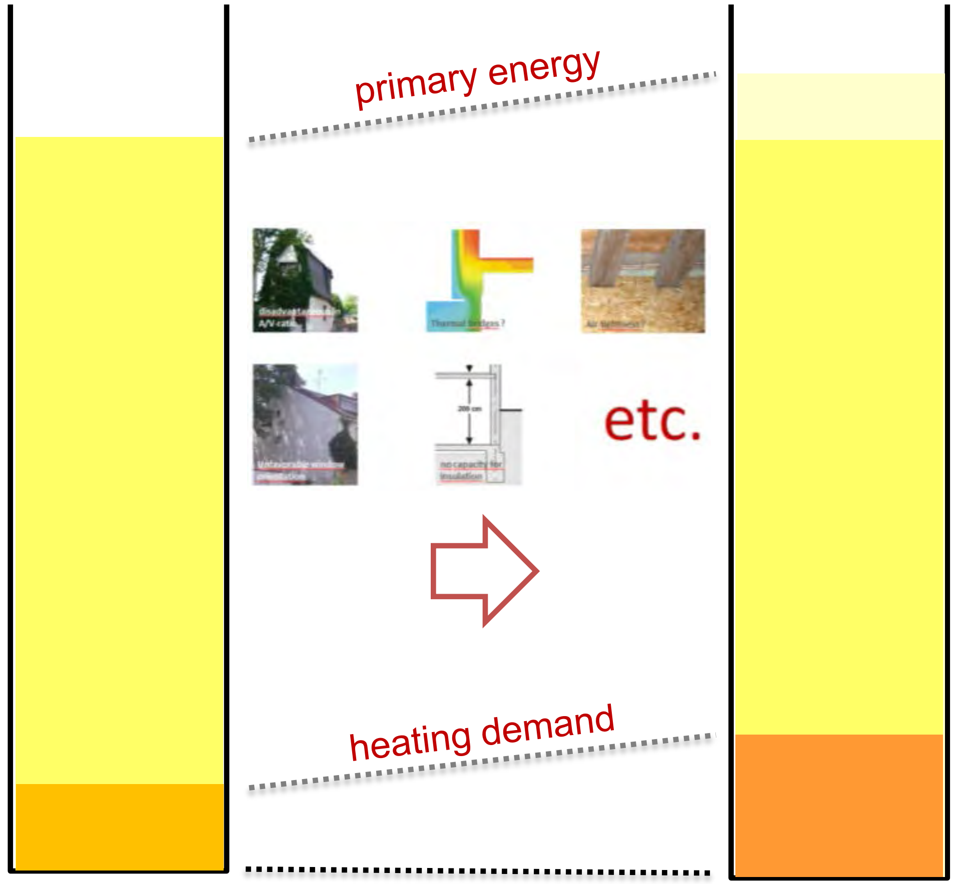
global standard on highly energy efficient buildings

max. 120 KWh/m²a

max. 132 KWh/m²a



max. 15 KWh/m²a

25 KWh/m²a
or component based

EnerPHit
Zertifizierte Modernisierung
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- cost efficient
- problem oriented
- realized in practice
- highly evaluated
- future-proof

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EnerPHit stands for

„Whatever you have to do,

do it the best way you can!“

Faculty of Technical Sciences University of Innsbruck

universität innsbruck

ATP architekten ingenieure

BIG Bundes Immobilien Gesellschaft

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Status analysis prior to refurbishment

Westansicht (Campus) mit Haupteingang

Ostansicht mit den Hörsälen davor - Fotos

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Betonschäden:

Wärmebrückenfreie Ausbildung war in den 60ern scheinbar noch unbekannt

Eckausbildung der Fassade im EG

Provisorisch „geflickte" Betongeländer der Fluchttreppen

starke Frost-Wasserschäden mit Durchrostung der Bewehrung

Frostschäden durch Verunreinigung der Betonoberfläche

7 Fotos: H.K.Malzer, Innsbruck 2008

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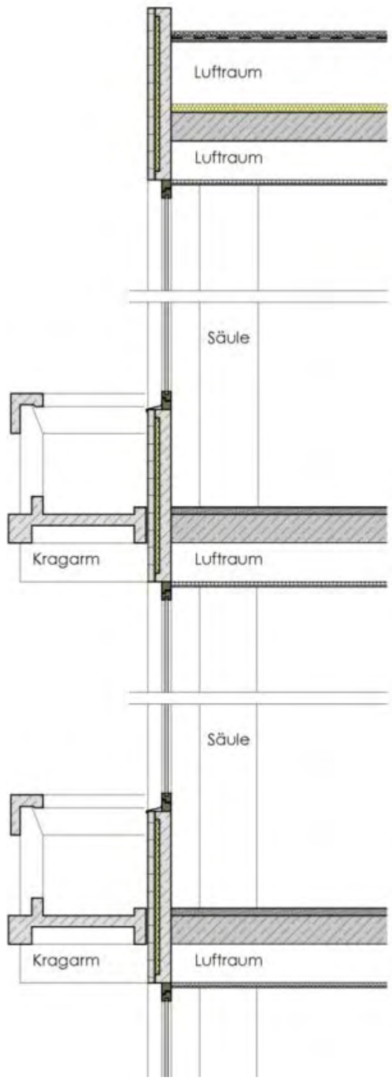
Die bestehende **Flachdachkonstruktion** weist einen U-Wert von **0,38 W/m²K** auf.

Die **Außenwand**-Betonfertigteilfassadenelemente weisen einen U-Wert von **0,719 W/m²K** auf.

Die U-Werte der **Fenster** kann ich hier nicht angeben, da sie aber zusätzlich zu ihrem schlechten Wärmedurchgangskoeffizienten auch noch mechanische und technische Mängel aufweisen, sind sie zu 100 % gegen aktuelle Fenstermodelle auszuwechseln.



Flachdachaufbau:

Rundriesel	5 cm
PE-Folie	
mehrlag. bituminöse Abdichtung	
Vordeckung Perrilex	
Rauhschalung	2,5 cm
Hinterlüftung	~ 50 cm
Mineralfaserdämmung	7 cm
bituminöse Notabdeckung	1 cm
STB Massivdecke	25 cm
Installationsraum & abgeh. Decke	~ 34 cm

Außenwandaufbau:

aussen

Waschbetonplatte	6 cm
Dämmung PU-Schaum	4 cm
Fertigbeton-Tragelement	10 cm

innen

Deckenaufbau

PVC Bodenbelag	1 cm
Verbundestrich	5,8 cm
STB Massivdecke	25 cm
Luftraum, Installationen	34 cm
Mineralwollauflage	3 cm
Gipskartonplatten	1,2 cm
abgehängte Decke aus verz. Stahlprofilen	
Mineralwollplatten	3 cm
ALU-Lochblech Langfeldkassette	

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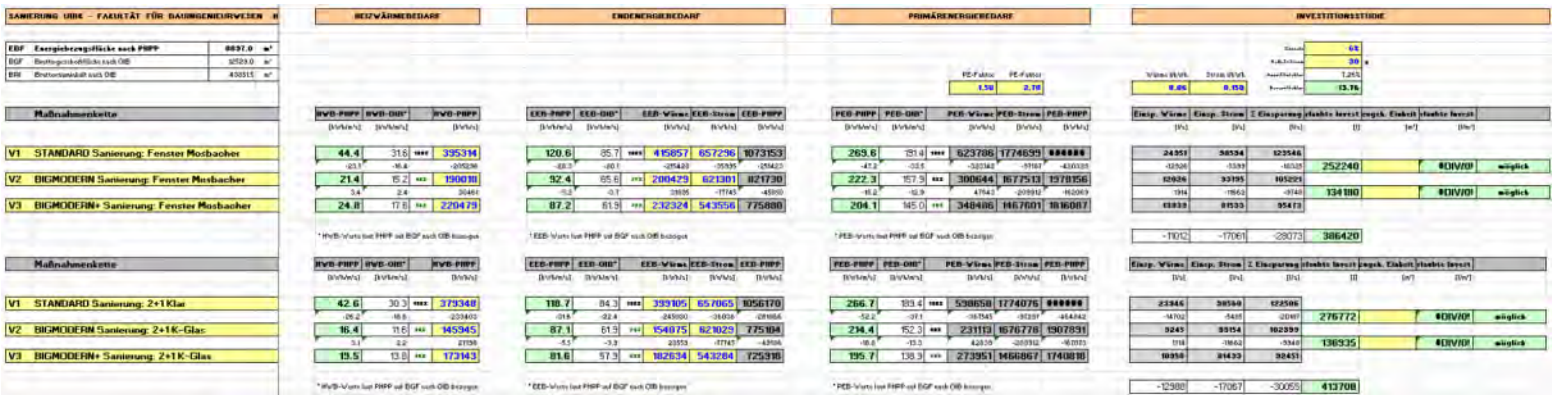
Parameter study to optimize refurbishment measures

An individual, project based parameter study for optimization of refurbishment measures, is important to give the right measures in the context of energy efficiency, energy savings and investment costs.



SANIERUNG UIBK – FAKULTÄT FÜR BAUINGENIEURWESEN

EBF	Energiebezugsfläche nach PHPP	8837.0	m²
BGF	Bruttogeschoßfläche nach OIB	12523.0	m²
BRI	Bruttorauminhalt nach OIB	433315	m³

Maßnahmenkette	HWB-PHPP [kWh/m²a]	HWB-OIB* [kWh/m²a]		HWB-PHPP [kWh/a]	EEB-PHPP [kWh/m²a]	EEB-OIB* [kWh/m²a]		EEB-Wärme [kWh/a]	EEB-Strom [kWh/a]	EEB-PHPP [kWh/a]	PEB-PHPP [kWh/m²a]	PEB-OIB* [kWh/m²a]		PEB-Wärme [kWh/a]	PEB-Strom [kWh/a]	PEB-PHPP [kWh/a]
V1 STANDARD Sanierung: Fenster Mosbacher	44.4	31.6	****	395314	120.6	85.7	****	415857	657296	1073153	269.6	191.4	****	623786	1774699	#######
V2 BIGMODERN Sanierung: Fenster Mosbacher	21.4	15.2	***	190018	92.4	65.6	***	200429	621301	821730	222.3	157.9	***	300644	1677513	1978156
V3 BIGMODERN+ Sanierung: Fenster Mosbacher	24.8	17.6	***	220479	87.2	61.9	***	232324	543556	775880	204.1	145.0	***	348486	1467601	1816087

* HWB-Werte laut PHPP auf BGF nach OIB bezogen; * EEB-Werte laut PHPP auf BGF nach OIB bezogen; * PEB-Werte laut PHPP auf BGF nach OIB bezogen

PE-Faktor 1.50 / PE-Faktor 2.70; Wärme [€/kWh] 0.06 / Strom [€/kWh] 0.150; 6% / 30 a / 1.25% / 13.76

Maßnahmenkette	Einsp. Wärme [€/a]	Einsp. Strom [€/a]	Σ Einsparung [€/a]	Investition [€]			
V1	24351	98534	123546				
	-12926	-5399	-18325	252240		#DIV/0!	möglich
V2	12036	93195	105221				
	1914	-11662	-9748	134180		#DIV/0!	möglich
V3	13933	81533	95473				
	-11012	-17061	-28073	386420			

Maßnahmenkette	HWB-PHPP [kWh/m²a]	HWB-OIB* [kWh/m²a]		HWB-PHPP [kWh/a]	EEB-PHPP [kWh/m²a]	EEB-OIB* [kWh/m²a]		EEB-Wärme [kWh/a]	EEB-Strom [kWh/a]	EEB-PHPP [kWh/a]	PEB-PHPP [kWh/m²a]	PEB-OIB* [kWh/m²a]		PEB-Wärme [kWh/a]	PEB-Strom [kWh/a]	PEB-PHPP [kWh/a]
V1 STANDARD Sanierung: 2+1 Klar	42.6	30.3	****	379348	118.7	84.3	****	399105	657065	1056170	266.7	189.4	****	598658	1774076	#######
V2 BIGMODERN Sanierung: 2+1 K-Glas	16.4	11.6	***	145945	87.1	61.9	***	154075	621029	775104	214.4	152.3	***	231113	1676778	1907891
V3 BIGMODERN+ Sanierung: 2+1 K-Glas	19.5	13.8	***	173143	81.6	57.9	***	182634	543284	725918	195.7	138.9	***	273951	1466867	1740818

Maßnahmenkette	Einsp. Wärme [€/a]	Einsp. Strom [€/a]	Σ Einsparung [€/a]	Investition [€]			
V1	23346	98560	122506				
	-14702	-5435	-20187	276772		#DIV/0!	möglich
V2	9245	93154	102399				
	1918	-11662	-9948	136935		#DIV/0!	möglich
V3	10958	81433	92451				
	-12988	-17067	-30055	413708			

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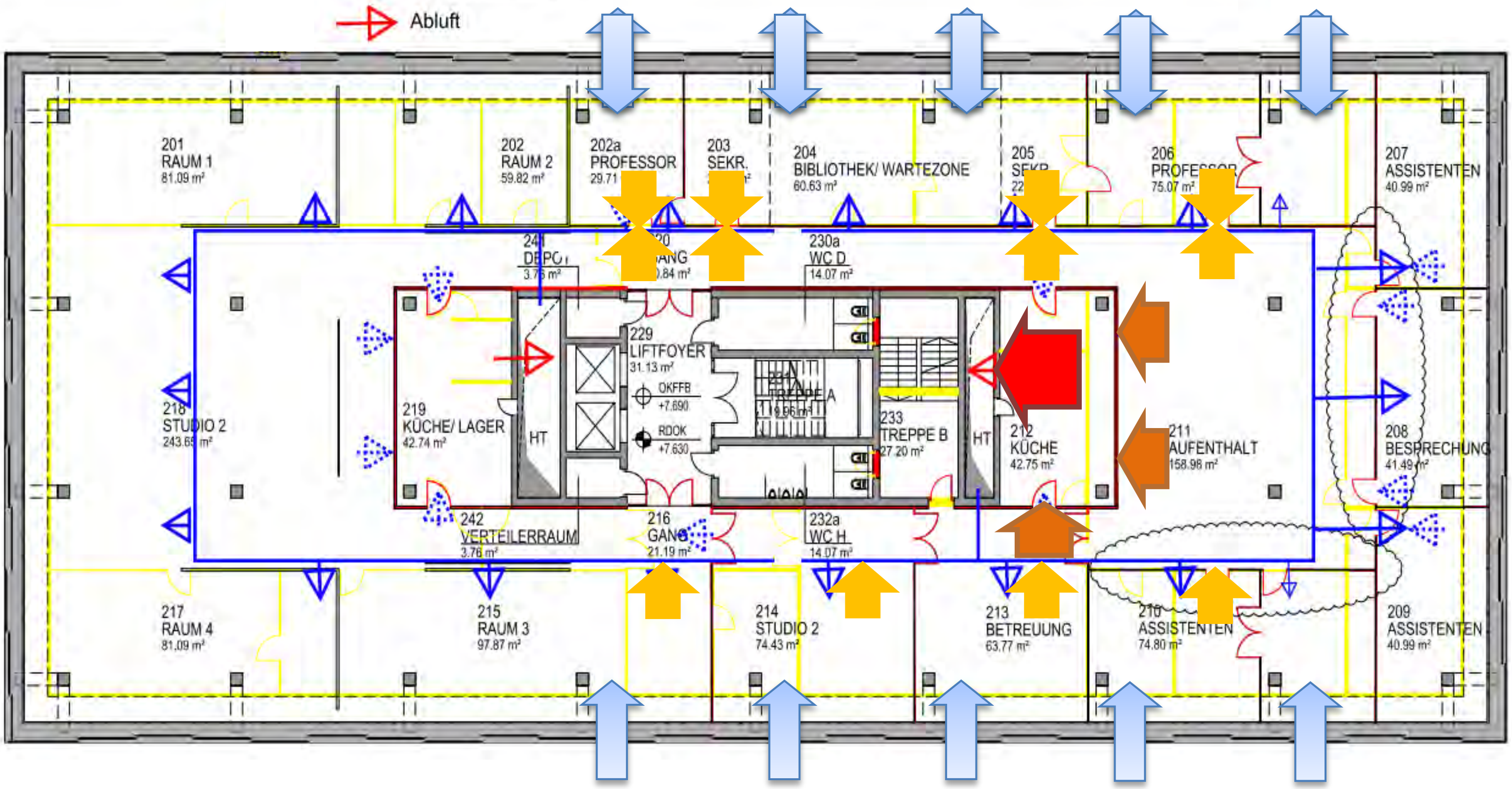
Draft concept ventilation …

Mechanical ventilation:

- Zuluftkanal
- Zuluft
- Überströmöffnung
- Abluft

Night ventilation:

Fresh air → Overflow → Overflow → Exhaust



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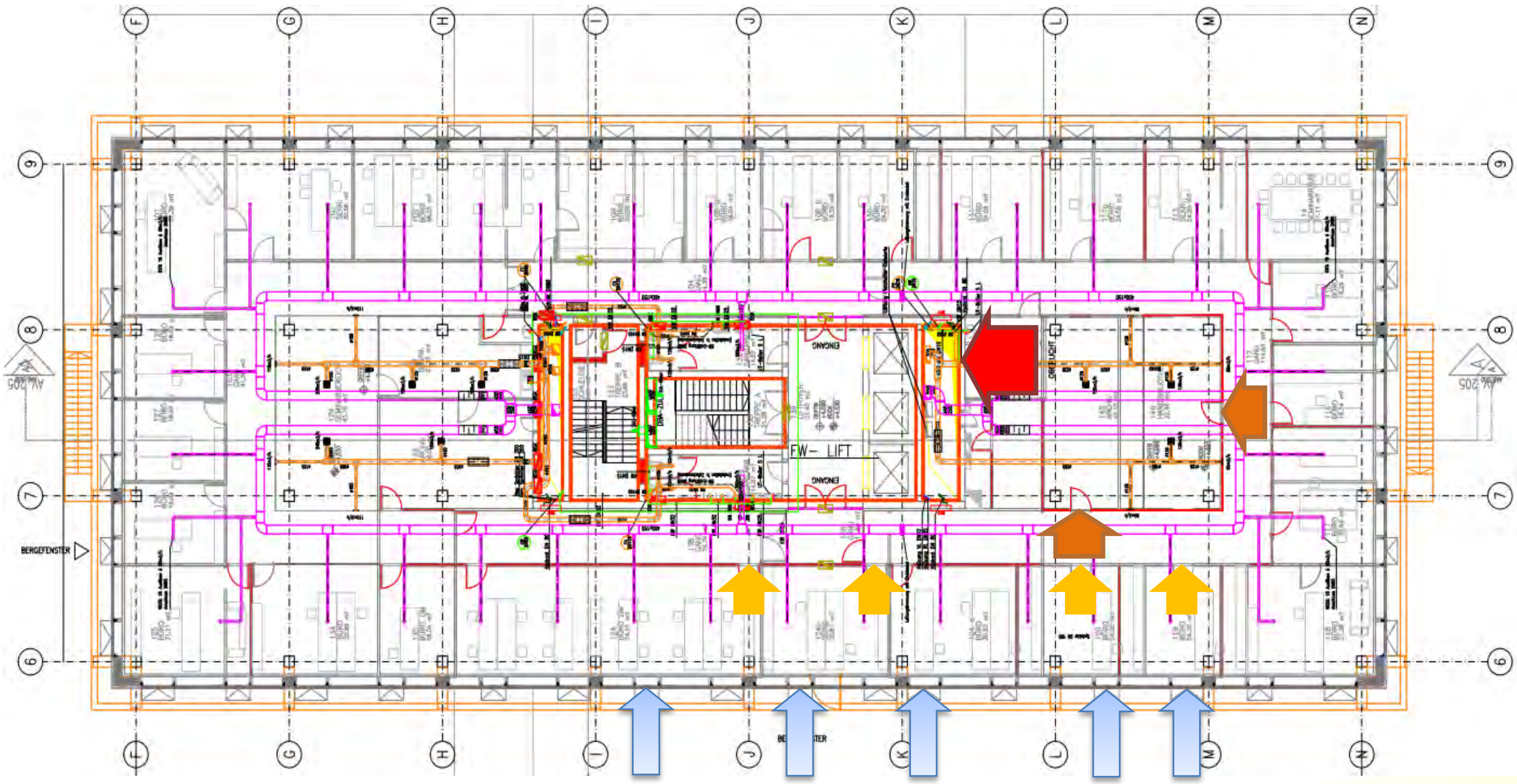
… turns into systematic ventilation design



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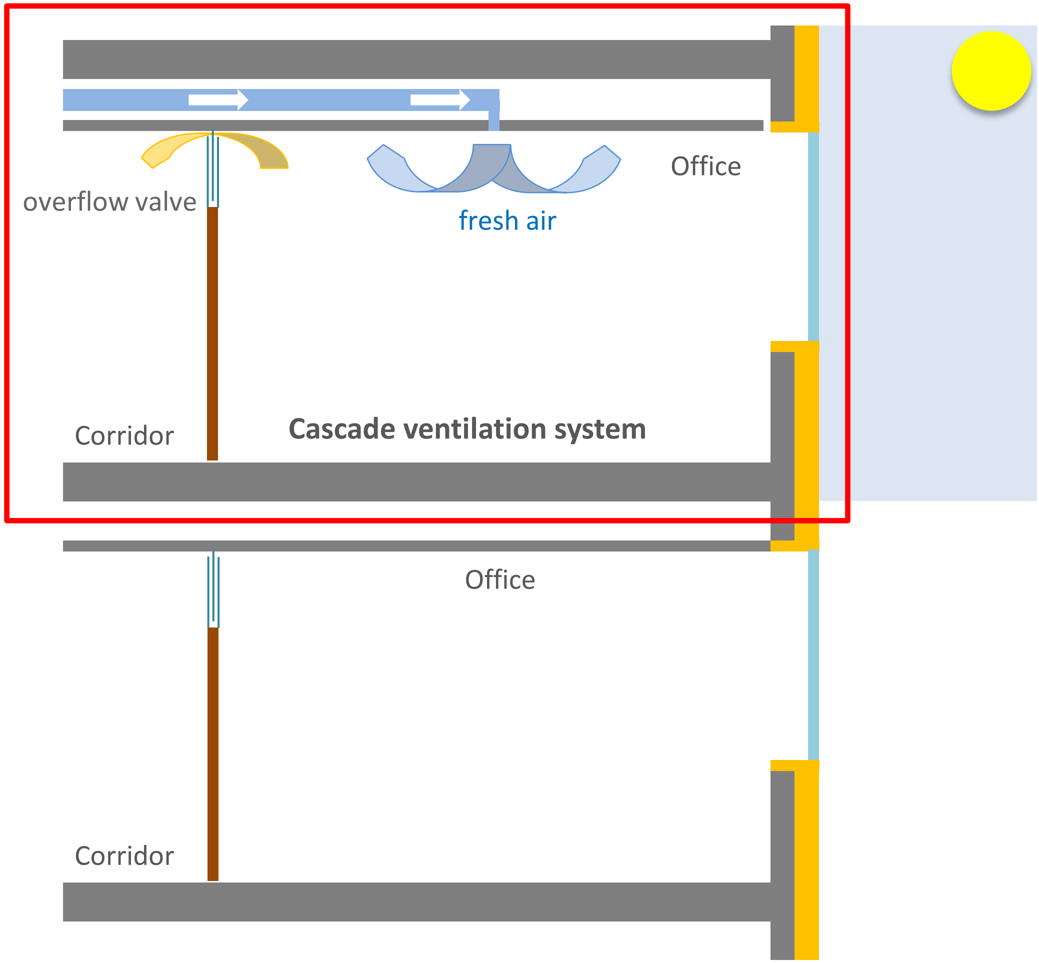
Excellent summer comfort without air conditioning



Throughout the daytime and in winter the whole day long, a **Cascade ventilation system** is used.

Windows stay closed during the day (due to noise and dust). Overruling of the automated process by the user is always possible.

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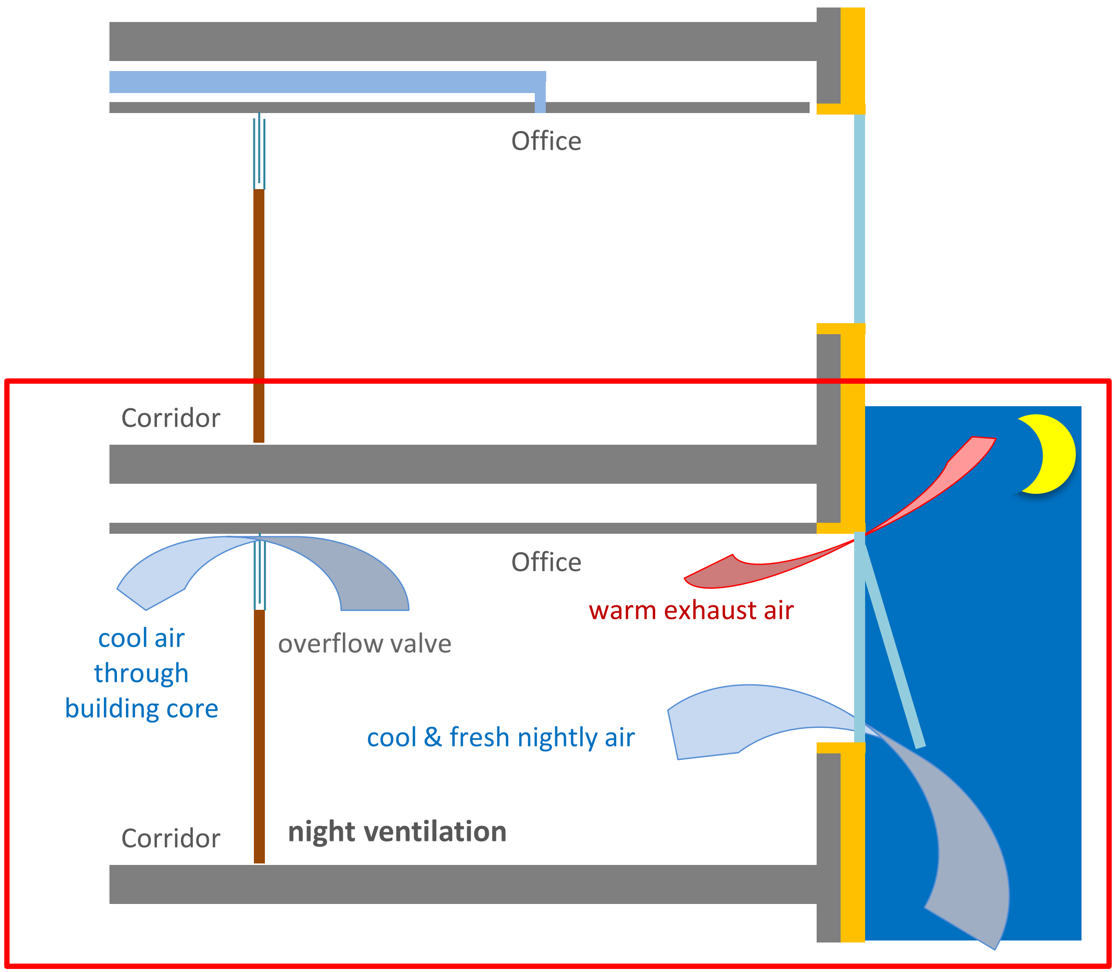
Excellent summer comfort without air conditioning



Cooling of building by automated night ventilation

Windows opening at a temperature difference In/Out of $\Delta T_{a,i} \geq 4$ K.

Cooling of the core is only possible due to the special design of the overflow valves, with a high air flow by low pressure loss.

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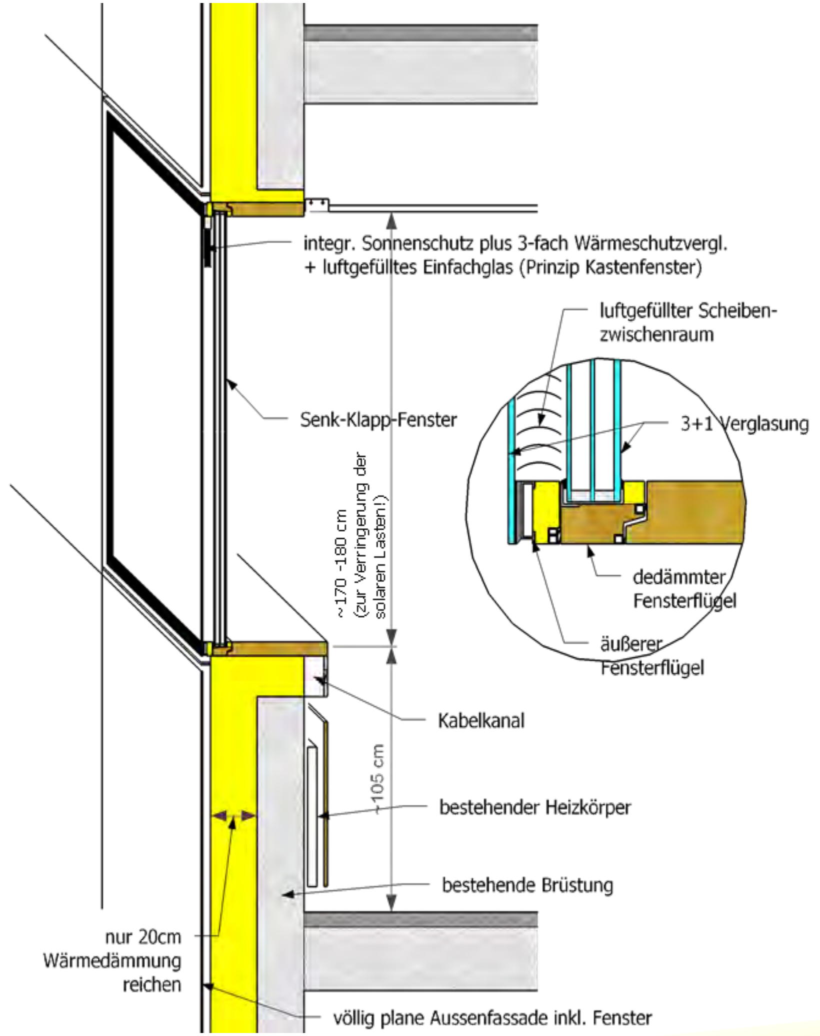
A smart new window had to be born

3+1 Pane lowering-folding-wings with **increased air change rates per window** for a very good cooling of the building with night ventilation and **integrated, automated sunblinds** between the outer panes.

The 3+1 glazing, out of inexpensive standard components leads to an U-value of **Ug=0,63 W/m²K**.

For thermal but also for aesthetic reasons, the **frame geometry** was conceptualized in a lying position.
This results in **better thermal performance** combined with a **higher solar gain** and more **daylight in the offices**.



Schematischer Fassadenschnitt mit Senk-Klapp-Fenster und Detail zur Fensterrahmenausbildung bei 3+1 Verglasung; Quelle: H. K. Malzer

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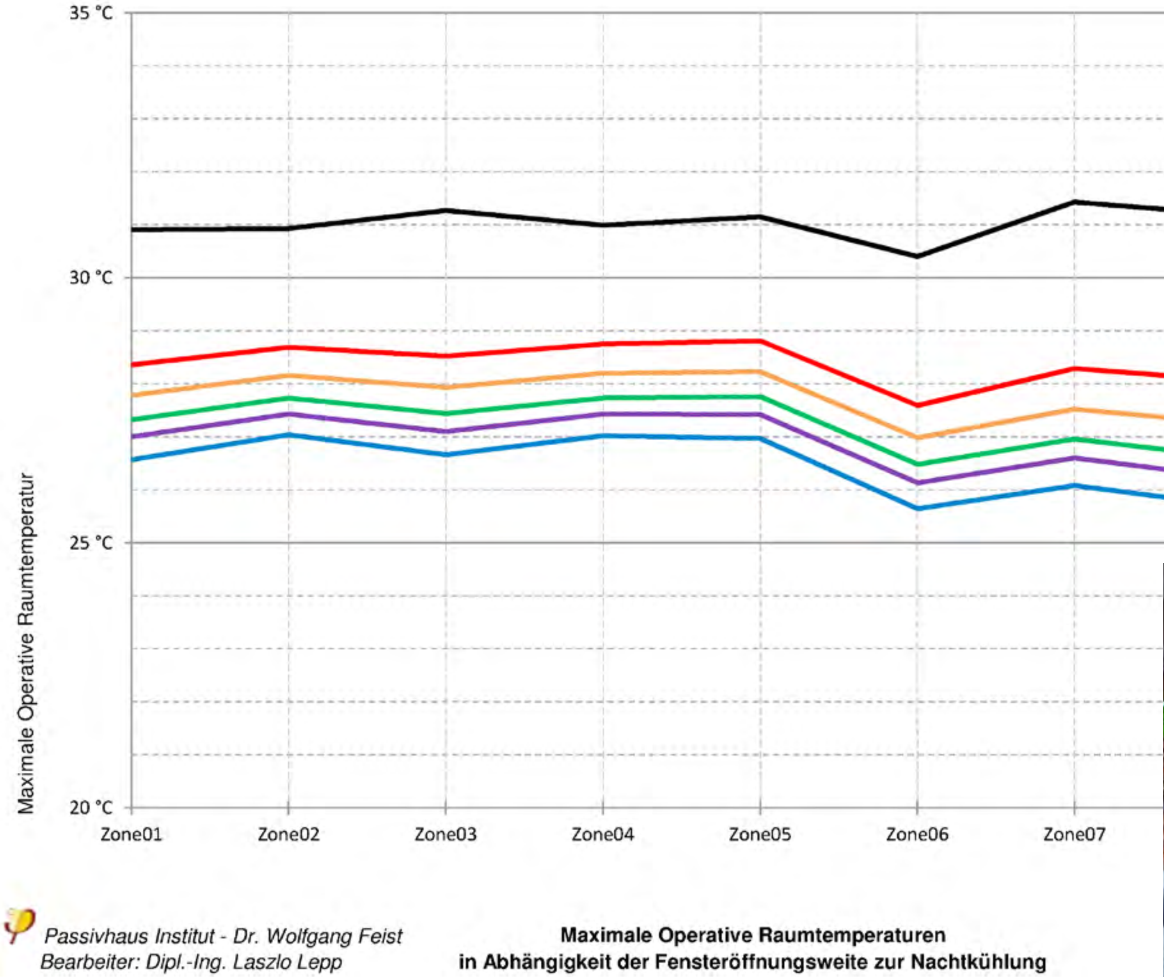
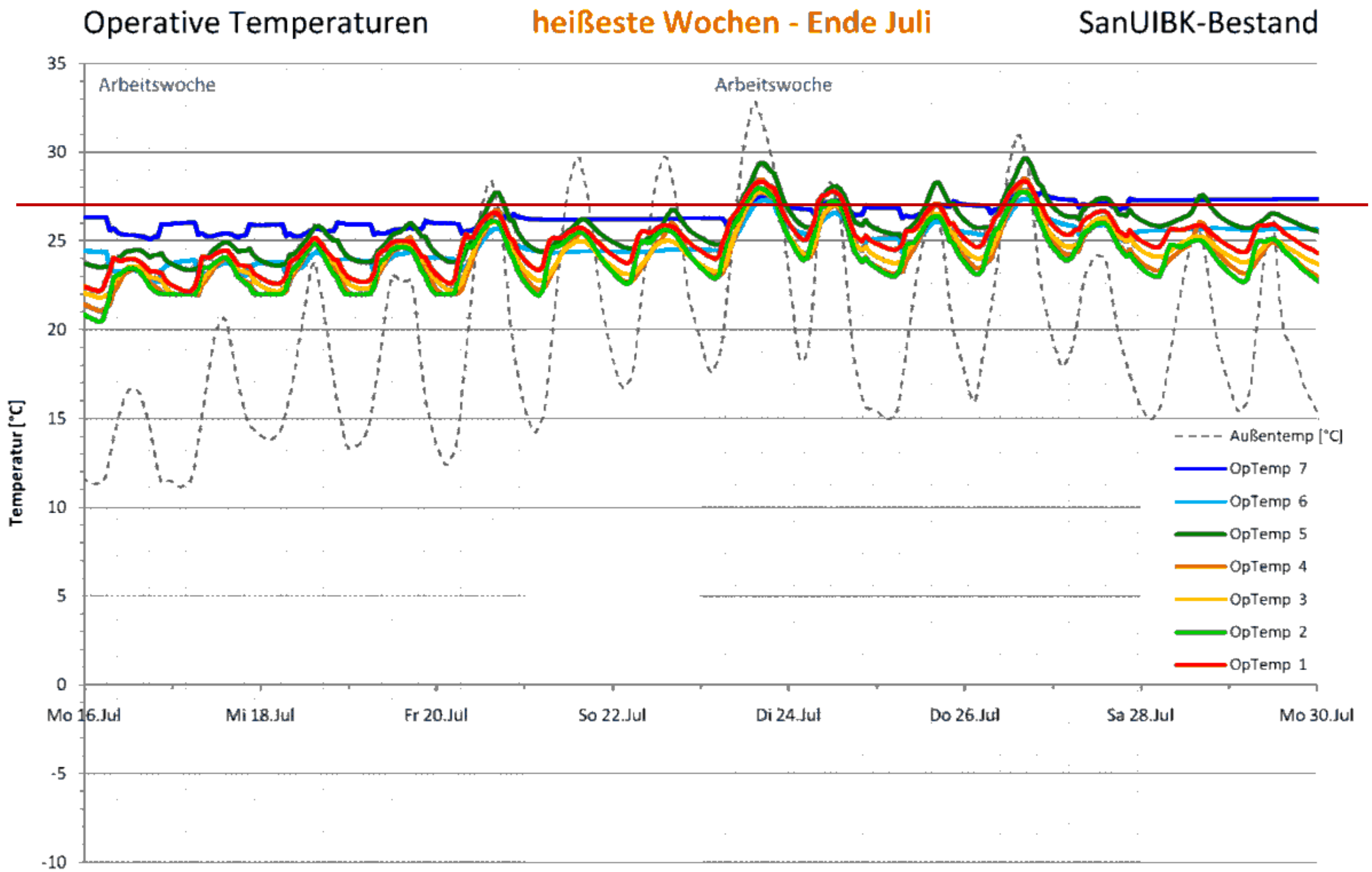
Dynamic simulation for needed opening width of window

Validation of the cooling concept **with PHI-Software Dynbil**



Dynamic building simulation – prior to retrofit



Validation of the cooling concept based on night ventilation **with PHI-Software Dynbil**

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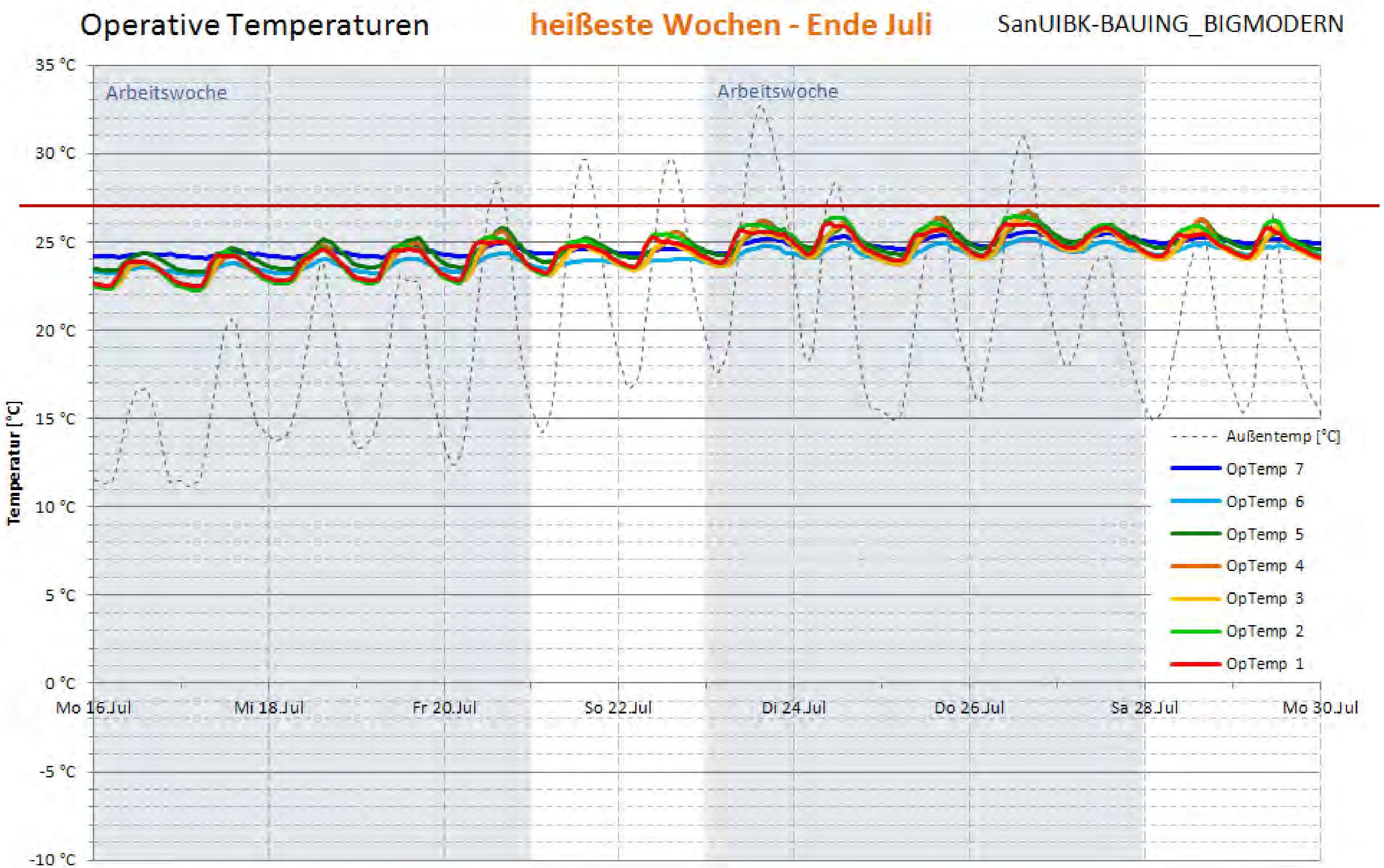
Dynamic building simulation – after retrofit



$OpTemp_{max}$ = 27°C (for just 4h per anno!), Daily middle temp.$_{max}$ = 26,2°C

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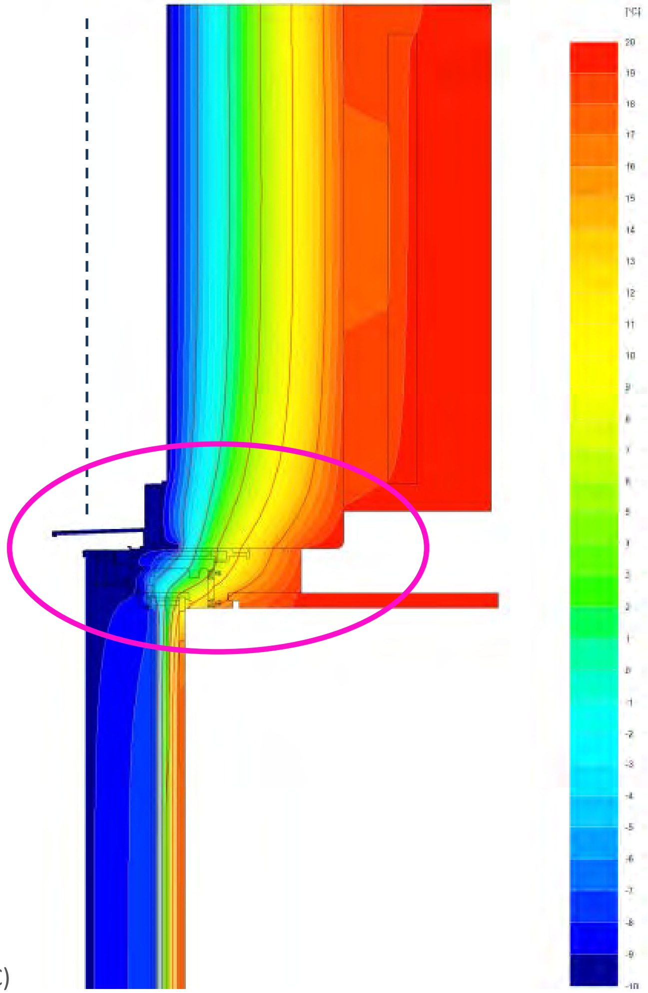
Little details often need most tinkering

For an even facade optic, the installation of the window had to be located at the outside of the insulation layer.

This design is not optimal and results in a higher Ψ-value.
The PHI usually recommends a window position within the insulation layer.

Thermal bridge coefficient
Window/facade: **Ψ = 0,049 W/mK**
(this is quite good)

(we suggest Ψ <= 0,025 W/mK)



Quelle: PHI, DI Laszlo Lepp; berechneter Temperaturverlauf im Fenster (blau: -10°C, rot: +20°C)

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Little details often need most tinkering

Window manufacturer

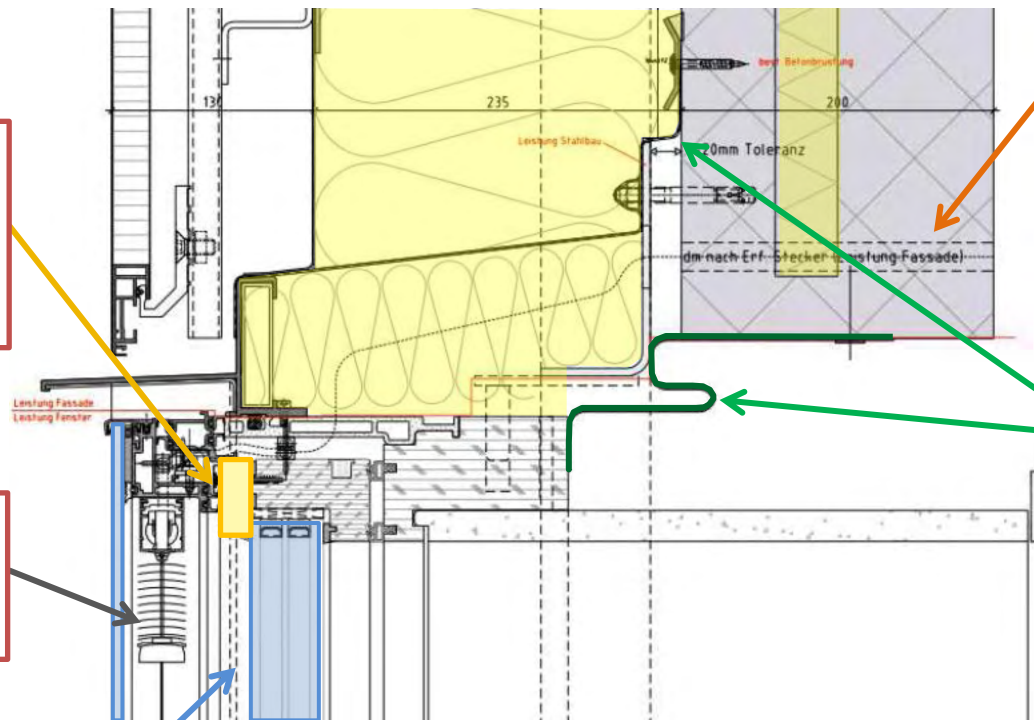
thermal decoupling in the frame with Compacfoam as glass strip

Sunblinds & BCS

window integrated motorized sun protection

Window manufacturer & BCS

conventionally 3S-glazing
U = 0,7 W/m²K



Electrician

caution on airtight connections of cable penetrations

Window-& facade builder

air-tight, permanently elastic and tension-relieved gluing of the frame with the existing masonry

Detail of window head reveal

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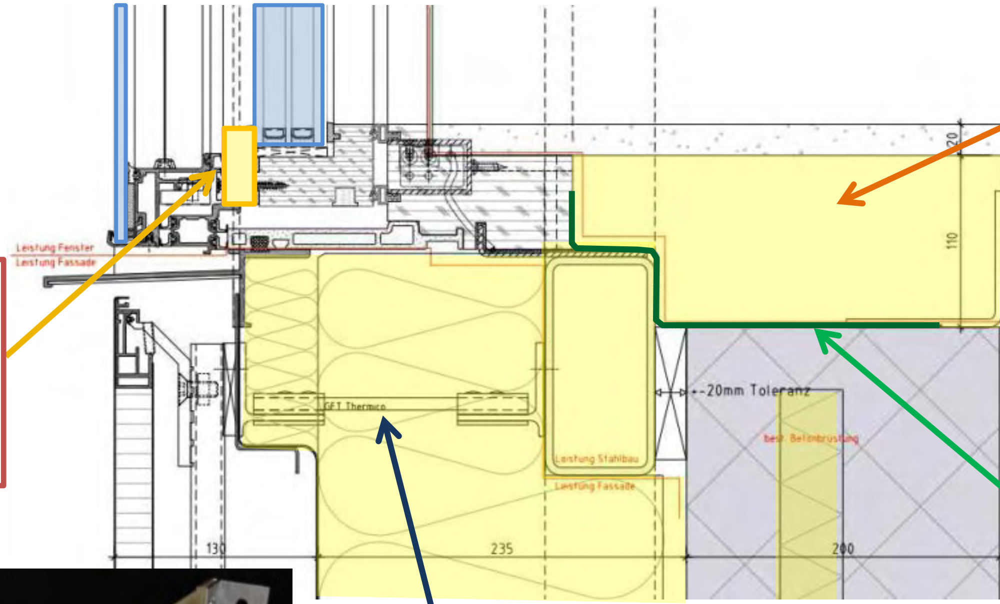
Little details often need most tinkering

Detail of window sill



Window manufacturer

thermal decoupling in the frame with Compacfoam as glass strip

Plaster bord builder

window sill and insulation of the cavity

Window-& facade builder

air-tight, permanently elastic and tension-relieved gluing of the frame with the existing masonry

Facade builder

heat-bridges-free installation of the aluminum facade on the existing façade by means of GRP spacers

ATTENTION: conventional ALU mount = thermal bridge surcharge !!!

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Smart overflow valve was developed

Only adequately sized **overflow valves** allow the huge ventilation rate needed for **night ventilation**.

Additionally these valves are used as **fanlight elements** to **reduce the artificial lighting** demand of the corridors behind.

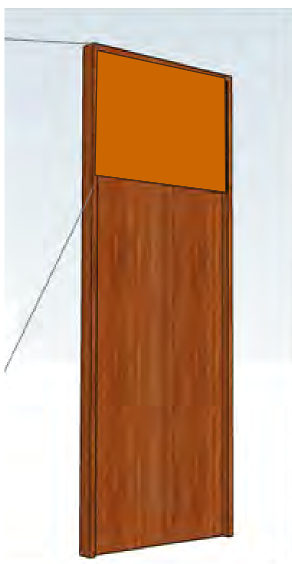
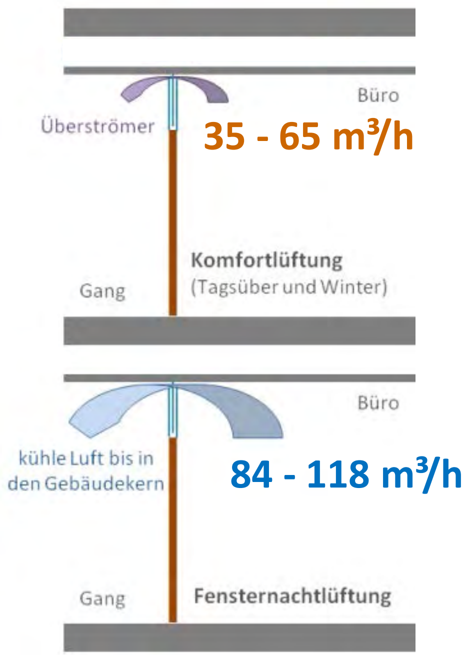


Abbildung1: Überströmöffnung als Oberlicht mit Mehrwert über den Bestandstüren „getarnt"; Quelle: PHI, Harald Konrad Malzer



Überströmer (Prototyp) am Schallprüfstand der Uni Innsbruck; Foto: H.K. Malzer

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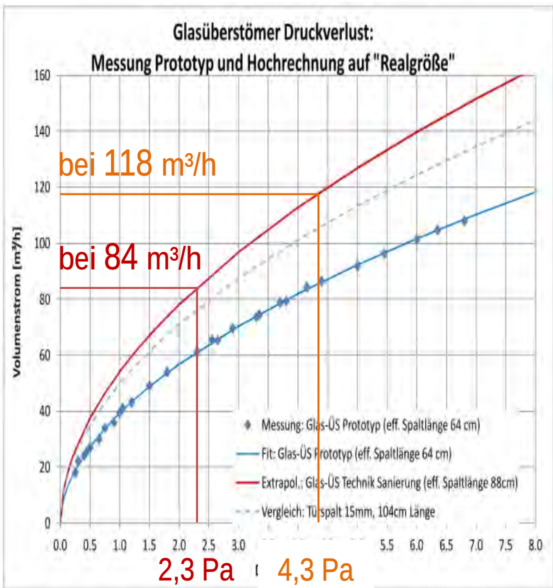
Smart overflow valve was developed

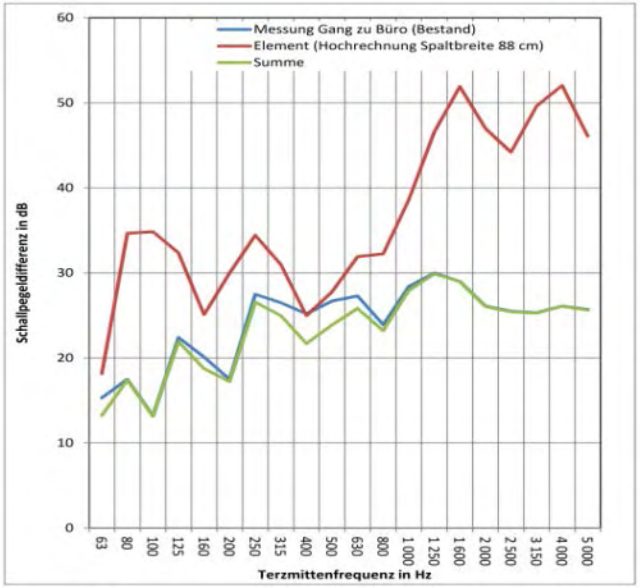
In this construction, special attention must be paid to the **sound-proof design**.

Therefore, we installed a prototype in the **acoustic laboratory** of the University of Innsbruck for measurements.



Druckverlustmessung; UIBK, DI Gabriel Rojas-Kopeinig

Überströmer (Prototyp) am Schallprüfstand der Uni Innsbruck; Foto: H.K. Malzer



Schallpegeldifferenzmessung; UIBK, DI Mathias Rothbacher

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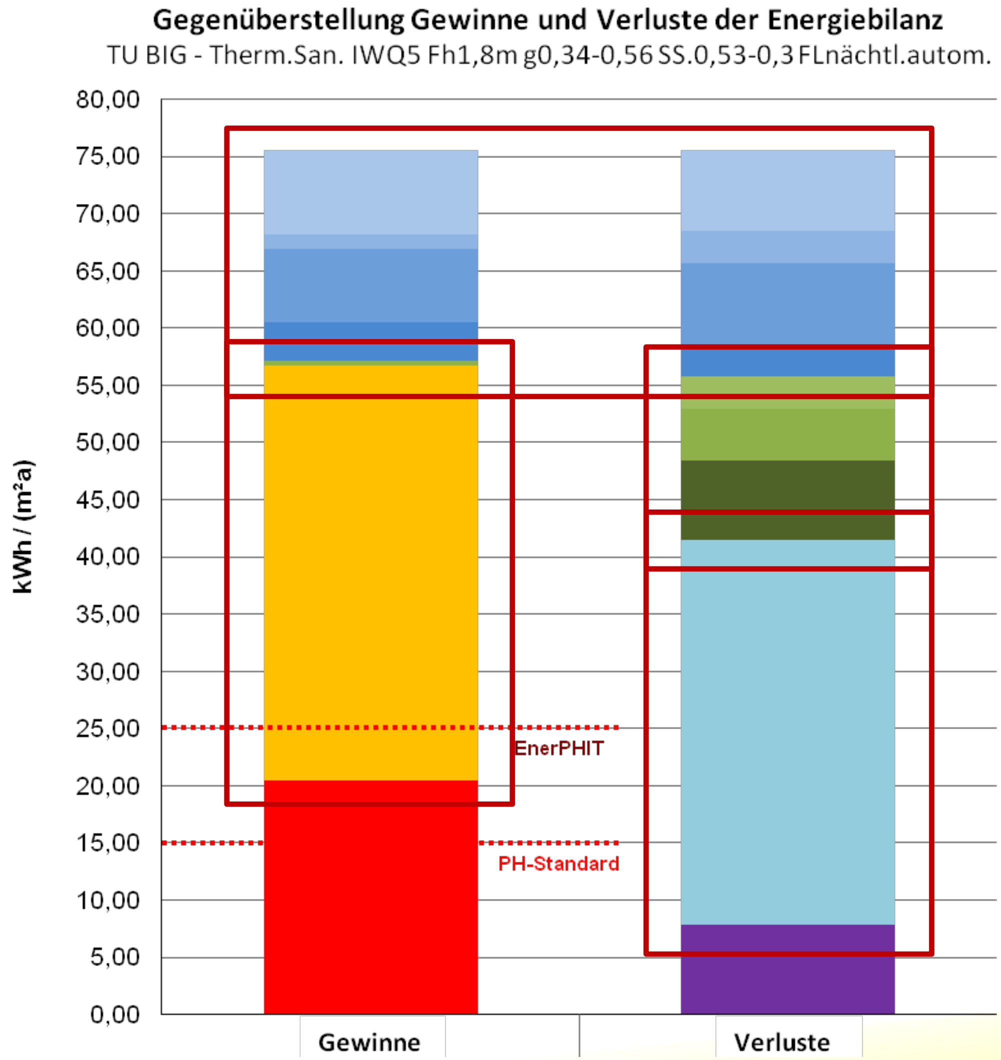
Energy efficiency obtained by planning with PHPP

- the energy balance of the **transparent components** is balanced
- highly insulated, thermal bridge free, **opaque building envelope**
- high **internal heatgain** by IT, high staff density (720 pers.) and artificial lighting
- **ventilation losses** by large air volume due to very high number of people

	Gewinne	Verluste
Fenster Ost	7,34	6,99
Fenster Nord	1,20	2,81
Fenster West	6,47	7,23
Fenster Süd	3,34	2,67
Fenster Horizontal	0,00	0,00
Opak Solar	0,37	
Opak Dach		2,88
Opak Fassade		4,51
Opak Außentüren		0,00
Opak Erdreich		0,00
Opak Bodenplatte		6,92
Lüftungsverluste		33,65
nicht nutzbare Gewinne		7,84
Interne Wärmequellen	36,33	
Heizwärme	20,43	

kWh / (m²a)



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Energy efficiency obtained by planning with PHPP

- **Refurbishment to highest energetic refurbishment and indoor quality level**
- **Thermal refurbishment with factor 9**

Heating demand – prior to retrofit: >180 kWh/m²a

Heating demand – after retrofit: **20 kWh/m²a**

Kennwerte mit Bezug auf Energiebezugsfläche

Energiebezugsfläche:	8897,0	m²	Bruttogeschossfl.	12.529 m²
	Verwendet:	**Monatsverfahren**		**PH-Zertifikat:**
Energiekennwert Heizwärme:	**20,4**	**kWh/(m²a)**		**15 kWh/(m²a)**
Drucktest-Ergebnis:	**1,0**	**h⁻¹**		0,6 h⁻¹
Primärenergie-Kennwert (WW, Heizung, Kühlung, Hilfs- u. Haushalts-Strom):	**118**	**kWh/(m²a)**		120 kWh/(m²a)
Primärenergie-Kennwert (WW, Heizung und Hilfsstrom):	**84**	**kWh/(m²a)**		
Primärenergie-Kennwert Einsparung durch solar erzeugten Strom:		**kWh/(m²a)**		
Heizlast:	**21**	**W/m²**		
Übertemperaturhäufigkeit:	**3,6**	**%**	über	25 °C
Energiekennwert Nutzkälte:	**2,2**	**kWh/(m²a)**		15 kWh/(m²a)
Kühllast:	**9**	**W/m²**		

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Life cycle cost analysis

Life cycle costs of air conditioning (40 years)

Comparison between cooling concepts:

SS = Standard-refurbishment according to OIB with active air conditioning

BM = Automated night ventilation

5. Kostenvergleiche der beiden Systeme über 40 Jahre:

SS = Kosten Standardsanierung OIB mit Klimaanlage (angesetzt als 100%)

BM = Kosten Bigmodern mit Fensternachtkühlung

SS Investitionskosten Anlage	23090 €/40a	100.0%
BM Investitionskosten Anlage	124362 €/40a	538.6%
SS Kältekosten (Strom Kälteenergie)	481392 €/40a	100.0%
BM Kältekosten (Strom Steuerung und Fenstermotoren)	1979 €/40a	0.4%
SS Kosten Warten/Bedienen	6644 €/40a	100.0%
BM Kosten Warten/Bedienen	91047 €/40a	1370.4%
SS Summe Kosten 40a	**511126** €/40a	100.0%
BM Summe Kosten 40a	**217388** €/40a	42.5%

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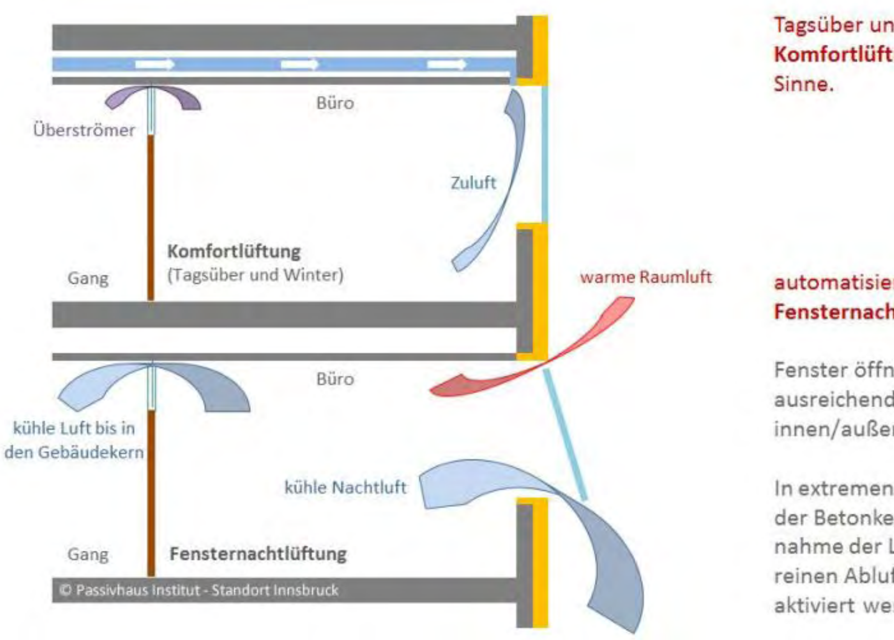
Conclusion of EnerPHit - Passive House standard for retrofit



A lot of different measures lead to cost-optimal success

- free night ventilation possible by means of special window construction
- preservation and smart update of the existing ventilation system
- overflow valves with additional use as artificial light saver

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