Solar City
Linz - Austria

SolarCity
PICHLING

7,3 kWh/m²a

13,5 kWh/m²a

lassyarchitektur + raumplanung

www.lassy.at

Overview

Introduction

- Design and development of the Solar City
- EnergyPass and building subsidy in Austria
- Technical overview

The Project in detail

- The optimized envelope
- Use of prefabricated Wall Units
- Decentral Ventilation
- High-Quality Windows
- Strategy for residual heat coverage

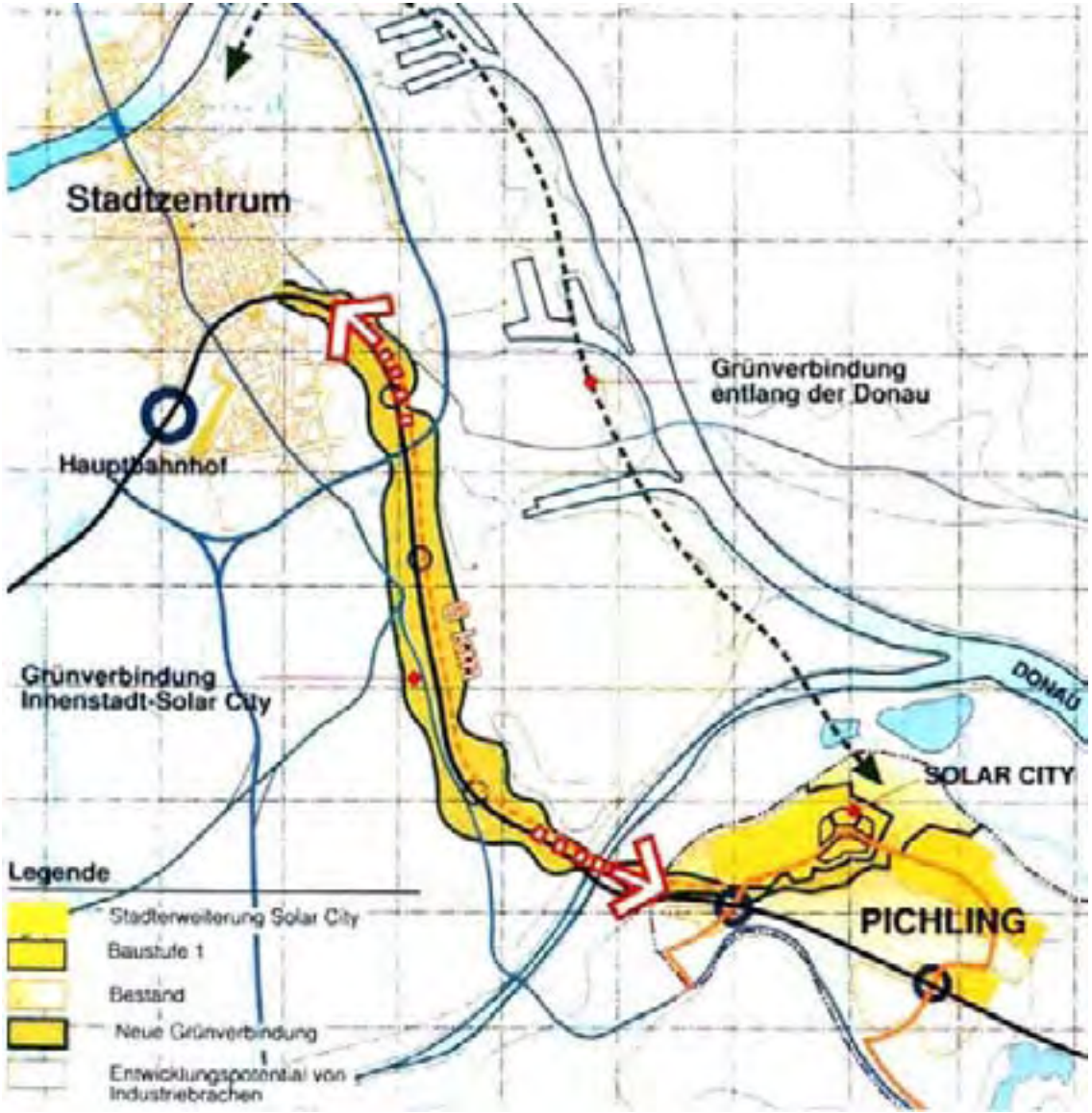
Summary, conclusion and outlook

- Post-Occupation-Evaluation and user habits


Gesamtprojekt
• Fläche Stadt Linz:
ca. 9.600 ha
• Fläche solarCity:
ca. 60 ha

Solar City
Linz - Austria

- **1992** Masterplan Prof. Rainer
- **1994** EU grant a subsidy for the residential area
- **1994** Local-Sustainable-Development-Planning (Lassy)
- **1996** Urbanistic ideas competion (Treberspurg)
- **1997** Landscaping ideas competion (Dreiseitl)
- **1998** Architectural competion
- **2005** Completion


Stadtzentrum
Grünverbindung entlang der Donau
Hauptbahnhof
Grünverbindung Innenstadt-Solar City
DONAU
SOLAR CITY
PICHLING
Legende
Stadterweiterung Solar City
Baustufe 1
Bestand
Neue Grünverbindung
Entwicklungspotential von Industriebrachen

Solar City
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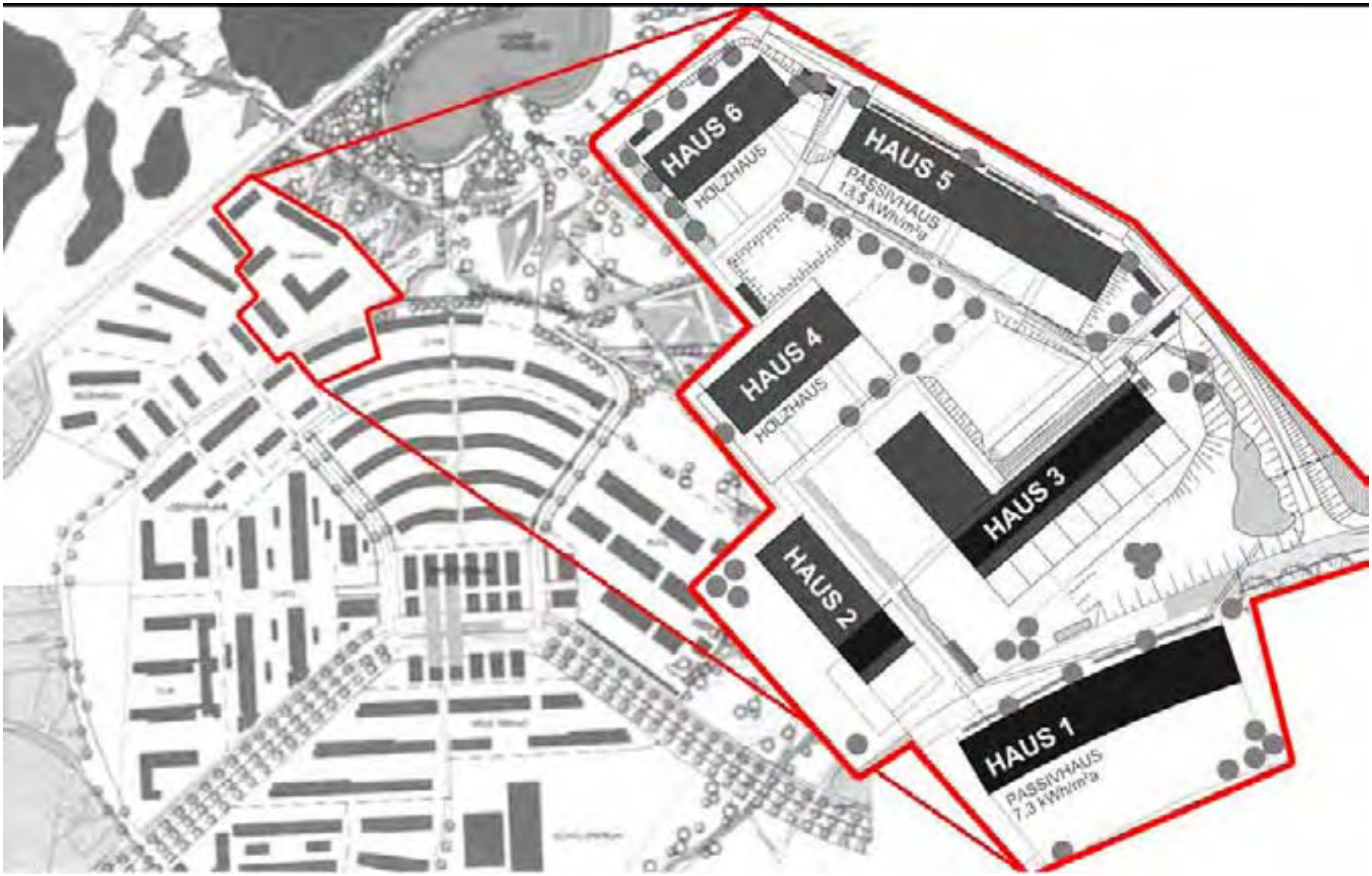
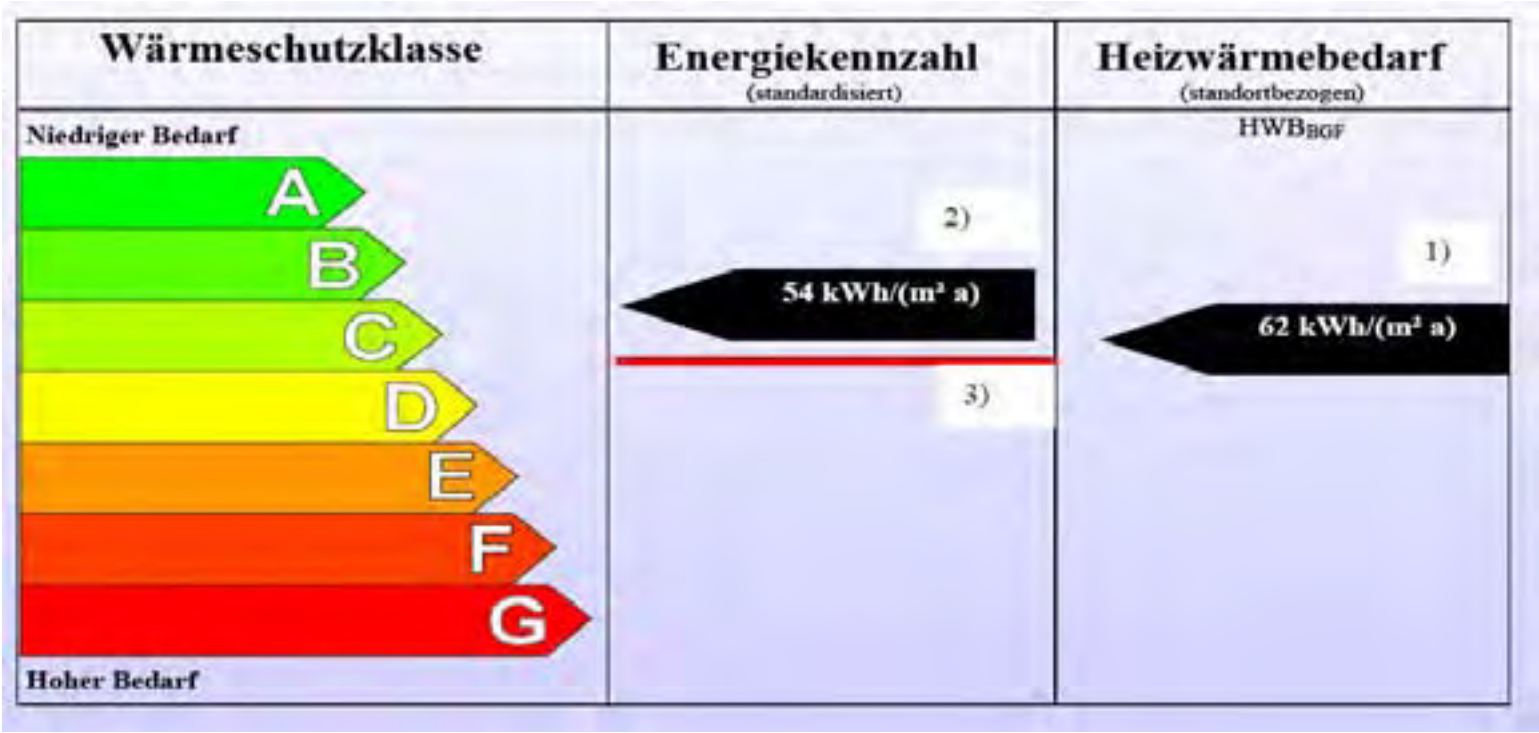


Estimated Total costs:

Residentail building	**125.000.000 €**
Infrastructer	**65.000.000 €**
Total	**190.000.000 €**

Energy Certification of Buildings in Austria

Classification



1 - Heat capacity
2 - Characteristic energy value
3 - Limit value for building subsidy

Energy Certification of Buildings in Austria

Building Regulations for Energy Certification

- since 1999
- obligatory for residential building cost subsidy
- obligatory for redevelopment as from 1.1.2006
- obligatory to let (rent) a house or flat as from 1.1.2006

Supplier of the Energy Certification

- Civil engineers
- Public Authorities
- Energisparverband (~Energy-Saving-Association)

Definition of the concept „Passive house“ summarized for constructical aspects

The residual heat can be supplied by the supply air (ingoing air).
To this the energy characteristic value (Energiekennzahl) must be smaller than 15 kWh/m²a

Passive house standard in numbers:

- energy characteristic value of thermal heat < 15 kWh/m²a
- Airtightness of the building cover with $n_{l50} < 0{,}6\ h^{-1}$

- Insulation values smaller than 0,15 W/m²K
- Thermal bridge free construction
- window complete U-values under 0.8 W/m m²K
- Efficient ventilation heat recovery (approx. 80 to 85%).

U-value = heat transition coefficient

Subsidy for residential buildings

Low-Energy-Building < 50kWh/m² (energy certification)

Minimum-Energy-Building <30kWh/m² (energy certification)

Passivhouse <15kWh/m² (energy certification)

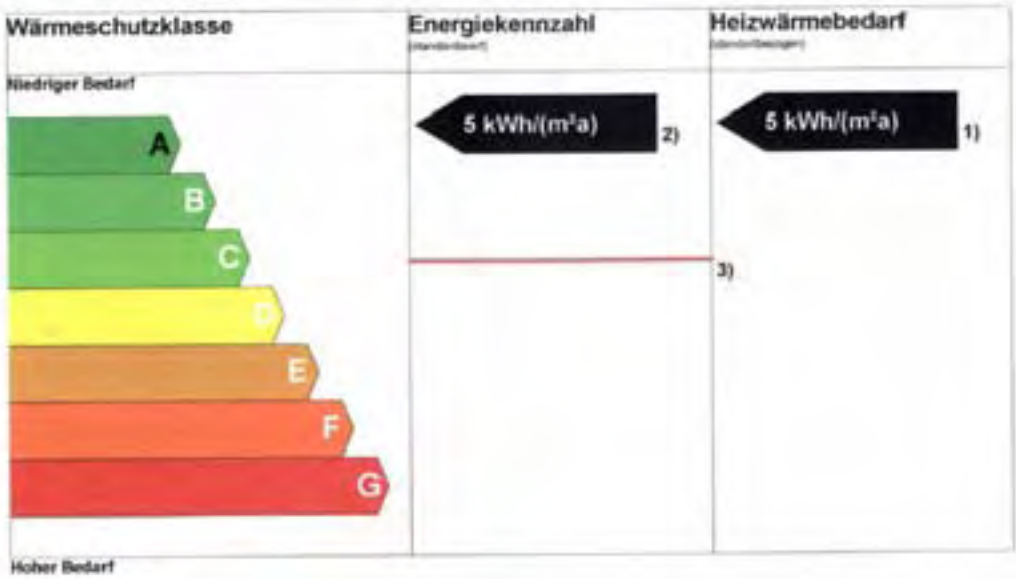
U-Value	Window	Exterior Wall	Top floor ceiling	Basment ceiling
Standardhaus (Bauordnung, keine Förderung)	1,9	0,5	0,25 (=ca. 18 cm insulation)	0,45
Oö. Energiesparhaus	1,2	0,3	0,2 (=ca. 24 cm insulation)	0,3
Oö. Niedrigenergiehaus	1,1	0,2	0,15 (=ca. 25 cm insulation)	0,25
Oö. Niedrigstenergiehaus	1,1	0,18	0,12 (=ca. 30 cm insulation)	0,25
Oö. Passivhaus	0,8	0,12	0,1 (=ca. 40 cm insulation)	0,15

U-value = heat transition coefficient

Energy Certification: Hous 1 SolarCity

OÖ. ENERGIEAUSWEIS

Gebäudeart	Mehrfamilien-Haus	Erbaut im Jahr	2004
Standort	4020 Linz	Grundstücksnummer	
Katastralgemeinde		Einlagezahl	
Eigentümer/Errichter (zum Zeitpunkt der Ausstellung)	SOLAR CITY GIWOG HAUS 1		



Energy Certification: Hous 1 SolarCity

ENERGIEAUSWEIS

Klimadaten — *Datenblatt*

Seehöhe	266 m
Heiztage HT	214 d
Norm-Außentemperatur θ_e	-12 °C
Mittlere Innentemperatur θ_i	20 °C
Heizgradtage HGT	3524 Kd

Strahlungsintensitäten [Beiblatt 1 a]	
Süden	165 kWh/(m²a)
Osten/Westen	81 kWh/(m²a)
Norden	59 kWh/(m²a)
Südost/Südwest	135 kWh/(m²a)
Nordost/Nordwest	59 kWh/(m²a)
Horizontal	136 kWh/(m²a)

Gebäudedaten

Beheiztes Brutto-Volumen V_B	7077 m³
Gebäudehüllfläche A_B	3230 m²
Brutto-Geschoßfläche BGF_B	2220 m²
Kompaktheit A_B/V_B	0,46 m⁻¹
Charakteristische Länge lc	2,19 m

Geographische Länge (optional):	14° 17'
Geographische Breite (optional):	48° 18'
Geographische Koordinaten (optional):	
.....	

	Ergebnisse		Beiblatt
1	Leitwert L_T	487 W/K	3 a
2	**Heizlast P_{tot}**	**22,9 kW**	**3 a**
3	**Flächenbezogene Heizlast P_1**	**10 W/m²**	**3 a**
4	Transmissionswärmeverluste	26656 kWh/a	2 a
5	Lüftungswärmeverluste	39977 kWh/a	2 a
6	Passive solare Wärmegewinne	9118 kWh/a	2 a
7	Interne Wärmegewinne	19643 kWh/a	2 a
8	**Heizwärmebedarf (standortbezogen)**	**12086 kWh/a**	**2 a**
9	**Flächenbezogener Heizwärmebedarf (standortbezogen) HWB_{BGF}**	**5 kWh/(m²a)**	**2 a**
10	Wärmegewinne durch Teilbeheizung, Nachtabsenkung und temporärem Wärmeschutz (optional)	0 kWh/a	
11	Wärmerückgewinnung (optional)	0 kWh/a	
12	Aktive solare Gewinne Raumheizung (optional)	0 kWh/a	
13	Heizwärmebedarf unter Berücksichtigung von 10,11,12	12086 kWh/a	

Anzahl der Beiblätter: 3

Energy Certification: Hous 1 SolarCity

Projekt: **Solar_City_Haus_1_und_5** Datum: 2. Februar 2004 Blatt 1

Bauherr:
Bezeichnung: **Solar_City_Haus_1_und_5**

Adresse:
Standort: **4020 Linz**
Höhe: **266** Norm-Außentemperatur: **-11**
Windlage des Gebäudes: **x** windschwache o windstarke Gegend
o normale **x** freie Lage
Windgeschwindigkeit: **4**
Grundrißtyp: **Mehrfamilienhaus**
Grundlage: **Einreichplan - Polierplan**

Verwendete Bauteile:

Bezeichnung	Fläche/Stück	U-Wert
AW1-S	508,36 m²	0,01 W/m²K
AW1-N	483,83 m²	0,06 W/m²K
AW1-W	143,31 m²	0,04 W/m²K
AW1-O	130,56 m²	0,04 W/m²K
IW1-gg-StH	529,88 m²	0,20 W/m²K
DE1- gg Keller	555,05 m²	0,13 W/m²K
Trenndecke	1.665,15 m²	0,90 W/m²K
DE1- gg Dachraum	555,05 m²	0,10 W/m²K
AF1-Süd verschattet	1 Stk	0,69 W/m²K
AF1-Süd unverschattet	1 Stk	0,70 W/m²K
AF1-Nord unverschattet	1 Stk	0,78 W/m²K
IT 90x200	18 Stk	1,70 W/m²K

Energy Certification: Hous 1 SolarCity

Projekt: **Solar_City_Haus_1_und_5** Datum: 2. Februar 2004 Blatt 18
Beiblatt: **2 a**

Monatliche Berechnung des Wärmebedarfs:

Berechnete Heizperiode: 4.11. bis 7.3.

Die Bilanzierung des Heizwärmebedarfes erfolgte nach dem Monatsbilanzverfahren. Der jährliche Heizwärmebedarf errechnet sich durch Summierung der monatlichen Werte, sofern diese positiv sind.

Monate	Trans.-verluste [kWh/a]	Lüft.-verluste [kWh/a]	Wärme-verluste [kWh/a]	Innere Gewinne [kWh/a]	Solare Gewinne [kWh/a]	Gesamt-gewinne [kWh/a]	Gewinn/ verlust Verhältn.	Nutz.-grad	Wärme-bedarf [kWh/a]
Jänner	7473	3978	11451	4955	1945	6900	0,60	1,00	4550
Februar	6238	3321	9558	4476	2569	7045	0,74	1,00	2519
März	1211	645	1856	1119	927	2046	1,10	0,89	30
April	---	---	---	---	---	---	---	---	---
Mai	---	---	---	---	---	---	---	---	---
Juni	---	---	---	---	---	---	---	---	---
Juli	---	---	---	---	---	---	---	---	---
August	---	---	---	---	---	---	---	---	---
September	---	---	---	---	---	---	---	---	---
Oktober	---	---	---	---	---	---	---	---	---
November	4825	2569	7394	4316	1936	6253	0,85	0,99	1179
Dezember	6910	3678	10588	4955	1824	6780	0,64	1,00	3808
Gesamtwert	**26656**	**14191**	**40847**	**19822**	**9201**	**29023**	**0,71**	**0,99**	**12086**

Der flächenbezogene Heizwärmebedarf beträgt: **5 [kWh/(m²a)]**

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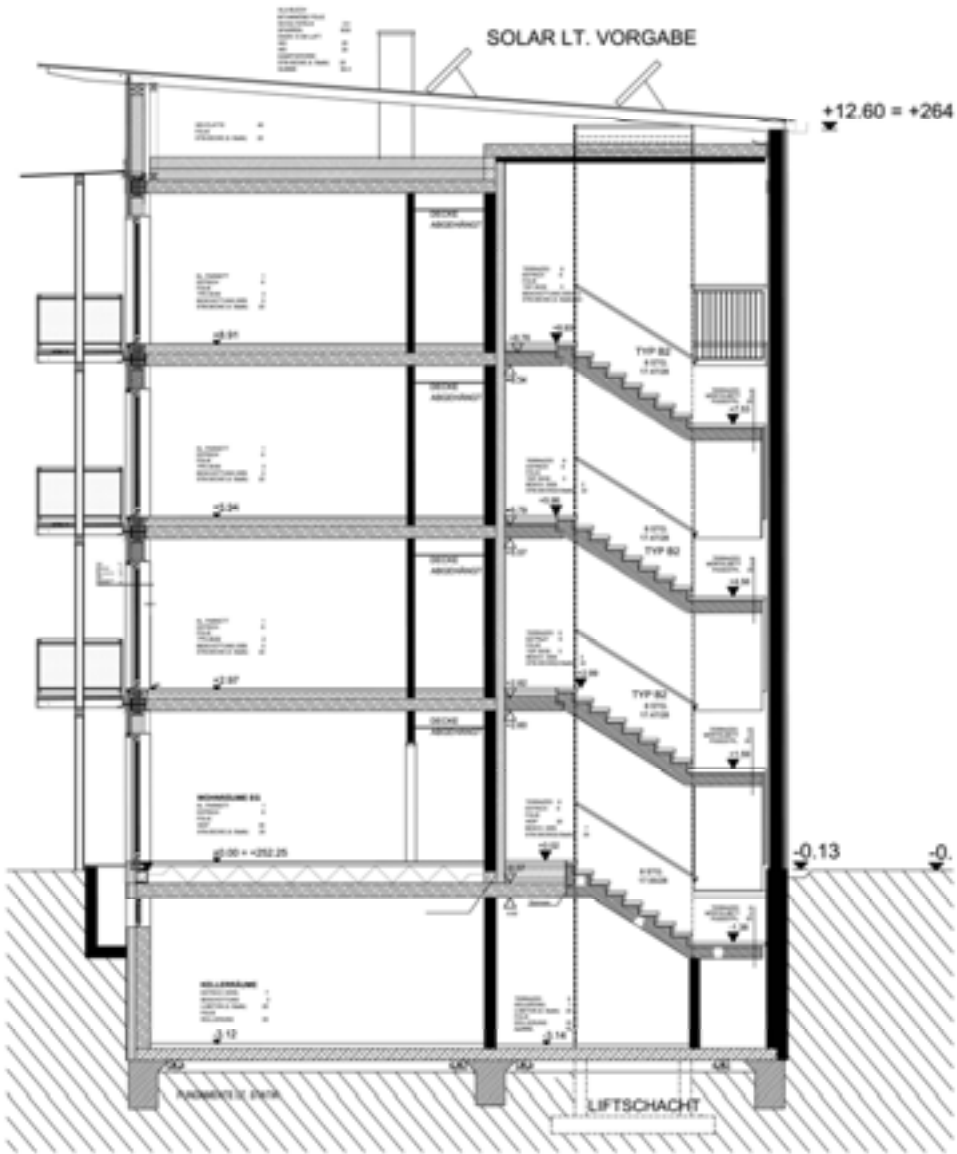
Building Data – Passivhous SolarCity

	House 1	House 5
storys	4	3
apartments	**24 about 78 m²**	**18 about 78 m²**
external walls	**Wooden frame 22 cm + Cellulose** **Facing layer 8 cm +** **Mineral Wool**	**Wooden frame 14 cm + Cellulose** **Vertically perforated brick 30cm**
window	**Passivhouse-window Wood/Alu**	**Passivhouse-window** **Plastic**
OGD	**28-40 cm insulation**	**28-40 cm insulation**
UGD	**30 cm insulation**	**22 (14+8) cm insulation**
ventilation	**decentral, 3 devices/AP**	**decentral, 3 devices/AP**
EKZ PHPP	7,3 kWh/m²a	14,8 kWh/m²a

Ground-floor plan House 1

Section House 5



The way to the passive house
development background and boundary conditions

Energy reduction >>> airthigtness of the building envelope >>> mechanical ventilation

- Hygienical necessary air change (of CO^2 30 m^3/h/Person)
- Centralized / Semicentralized or Decentralized Ventilation System
  - continuous supply
  - planning of air vent - heat vent

Ambition: Reduce the energy requirement, so that the ventilation system can take on the residual heat

Conditions:

- efficient ventilation system with heat recovery
- checking and optimizing insulation layers values of the complete building envelope
- thermal bridge free construction

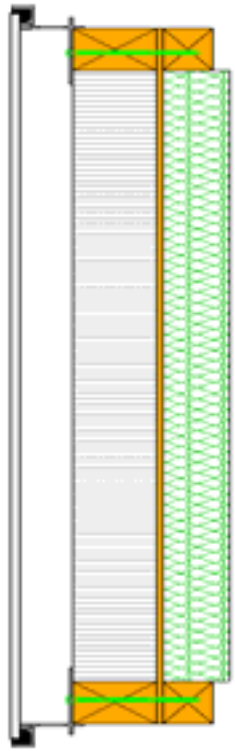
Construction facade panel

Wall Construction from outside to inside:

- Glass ESG, 6-8 mm
- Air layer, 31 mm
- Solarwabe (honeycomb), 50 mm
- Panel rear, 4 mm
- Levelling insulation, 40 mm

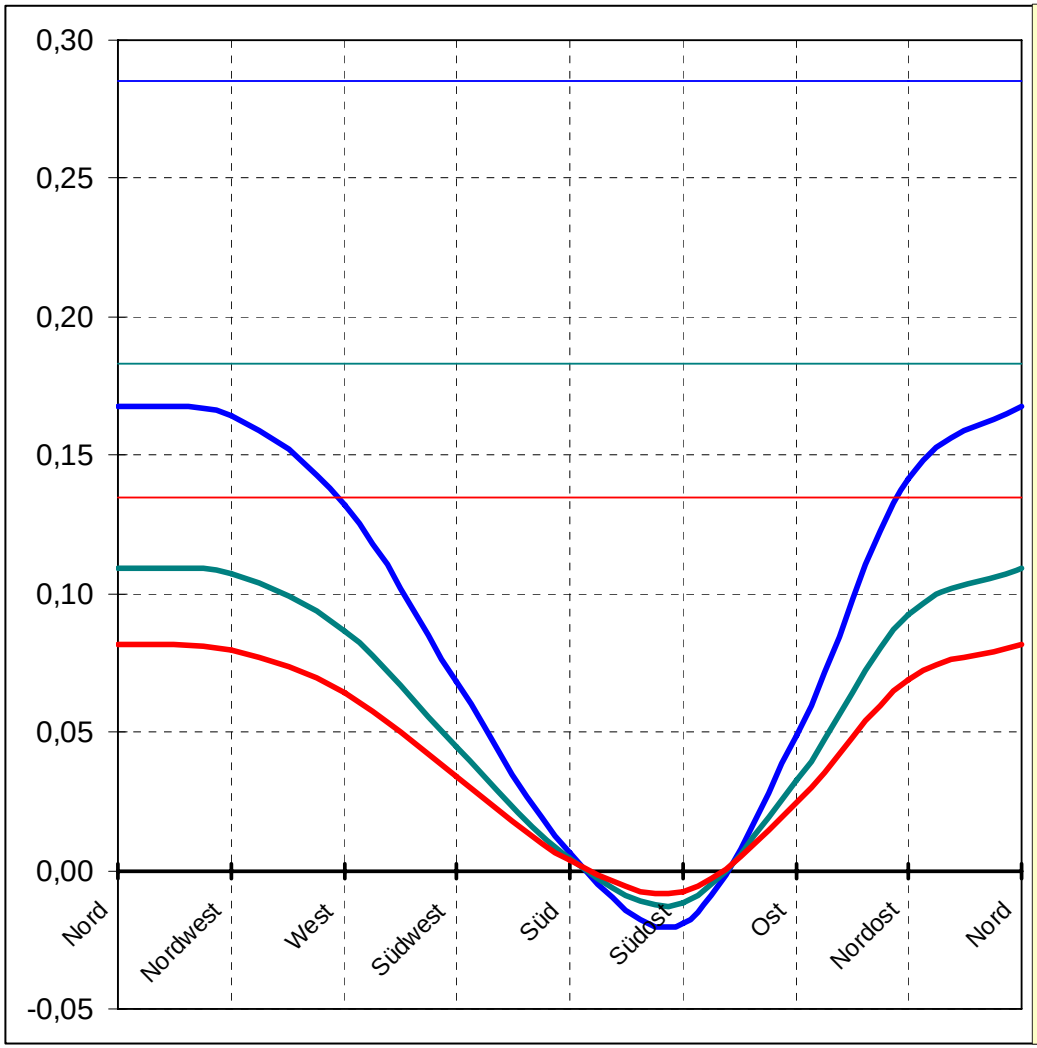
for maximum format 1,250 x 3,050 mm
high and oblong format possible
coloration of the solar honeycomb as required
glass with or without texture

ESG = single safety glazing



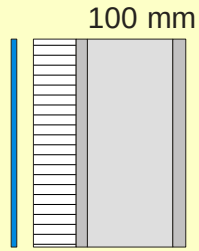
Integration into framework construction

Effective U-values of the gap solar facade.



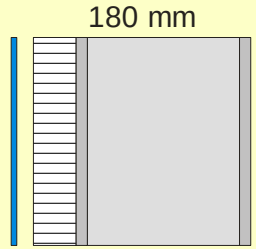
Dämmstandard 1

Ständerdämmung 100 mm
Solarwabe 50 mm
Luftspalt 20 mm
Glas 5 mm
U-Wert=0,285 W/m²K



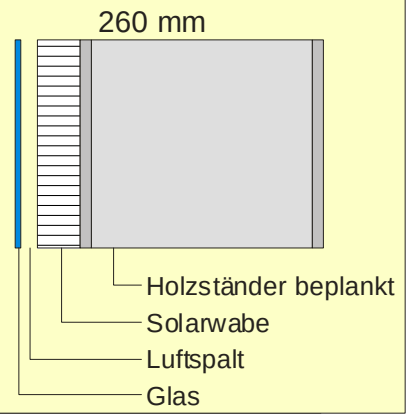
Dämmstandard 2

Ständerdämmung 180 mm
Solarwabe 50 mm
Luftspalt 20 mm
Glas 5 mm
U-Wert=0,183 W/m²K

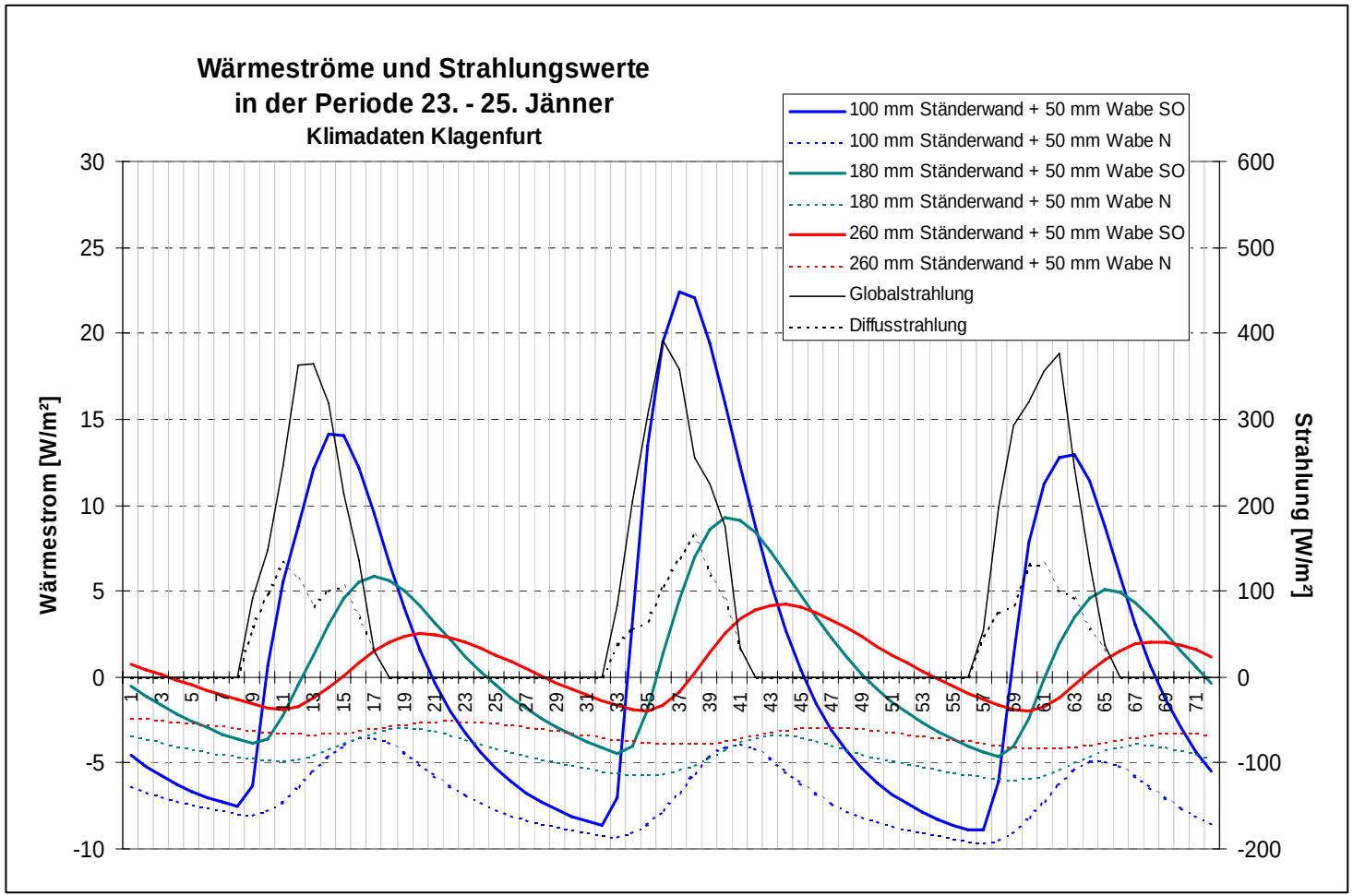


Dämmstandard 3

Ständerdämmung 260 mm
Solarwabe 50 mm
Luftspalt 20 mm
Glas 5 mm
U-Wert=0,135 W/m²K

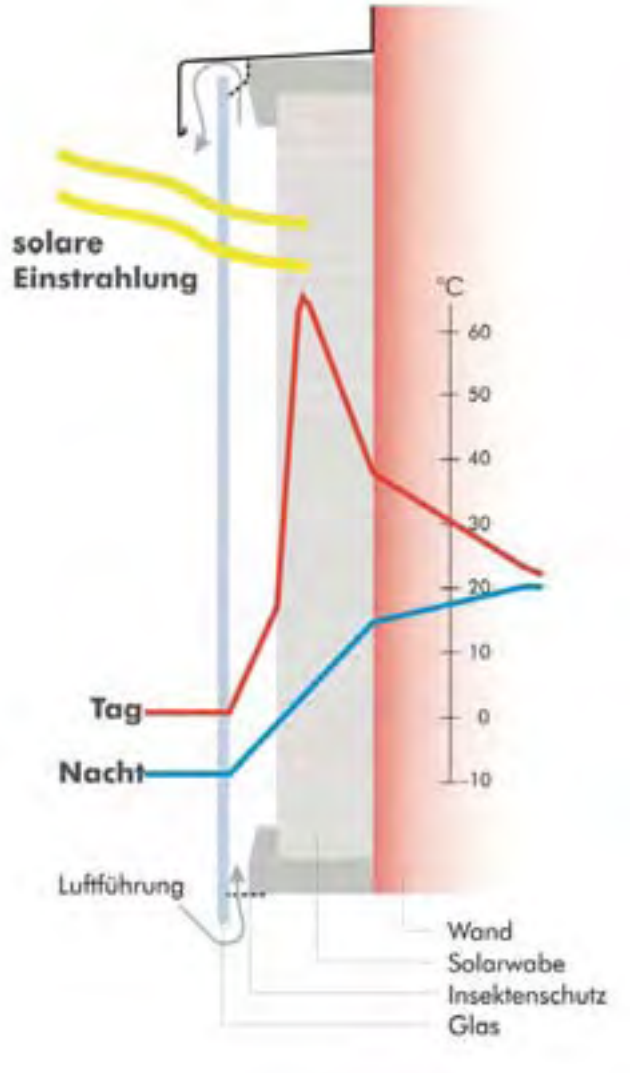


Heat flow and phase shift in detail

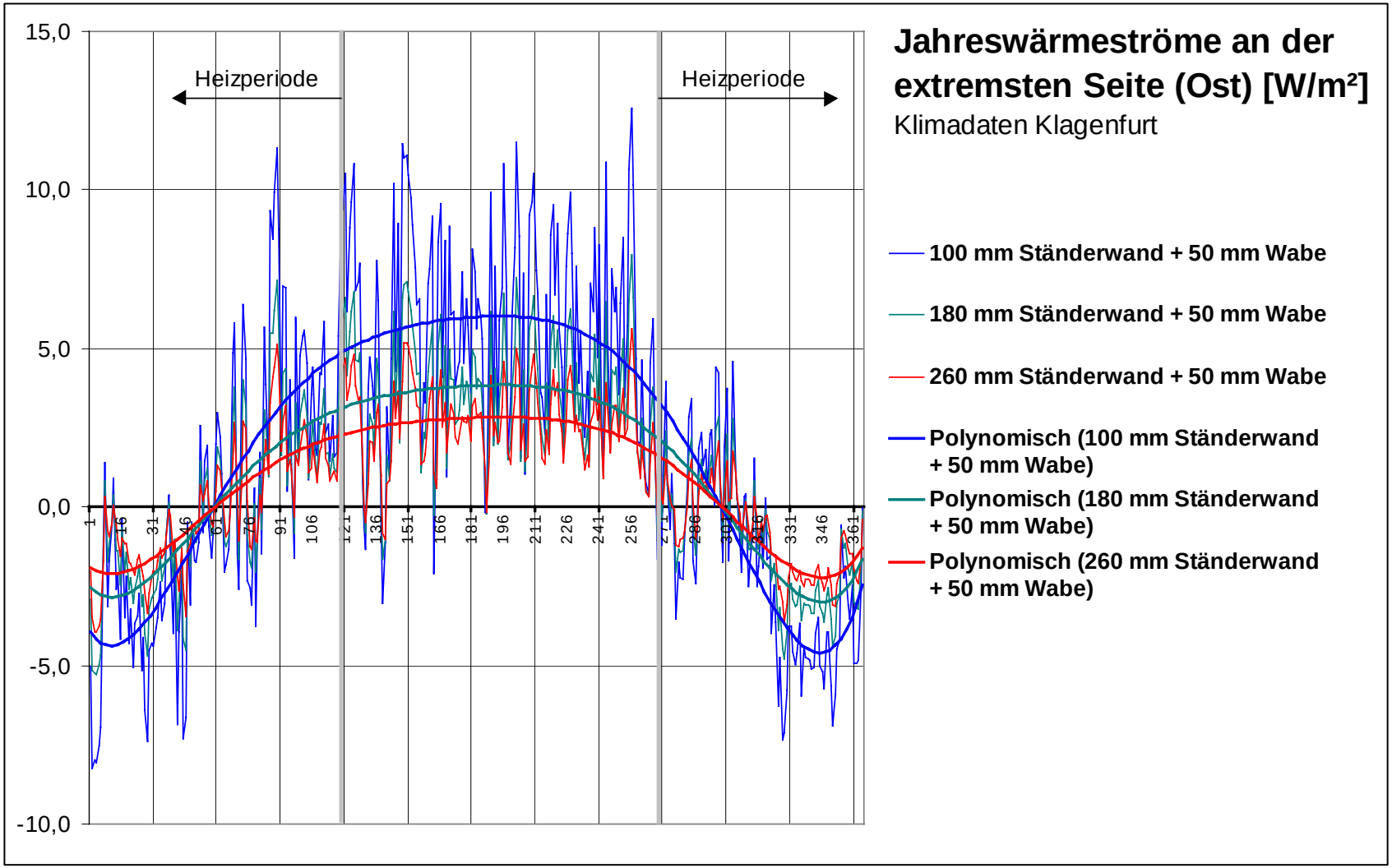


The solar facade
functional principle

- **The honeycomb cellulose act as a solar absorber**
- **At low position of the sun (winter) the solar load penetrates into the solar honeycomb and heat up**
- **At high position of the sun (summer) the honeycomb shade itself**
- **An additional mechanical sun-shading isn't needed**
- **The temperature difference between living space to outer climate is balanced**



Heat flow in a year



Wall Units

- **Quick progress of construction work**
- **Parallel production in the work**
- **Delivery of the envelope, incl. windows**
- **No building moisture in the exterior wall.**

Form design with glass

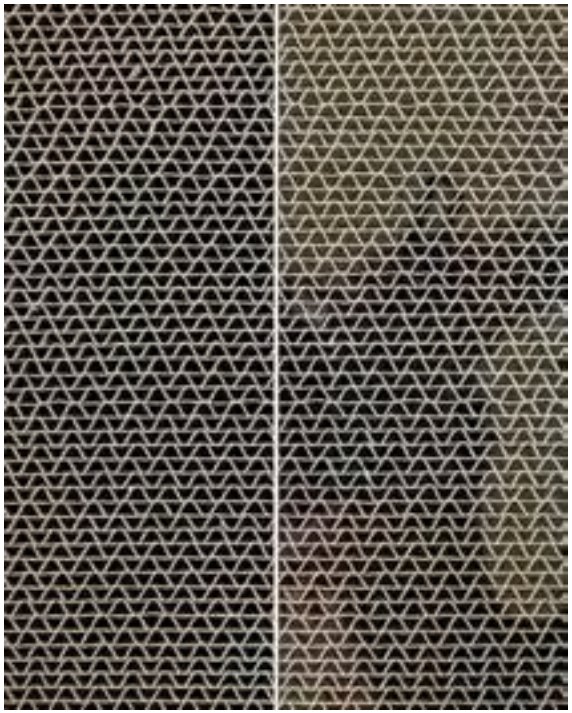
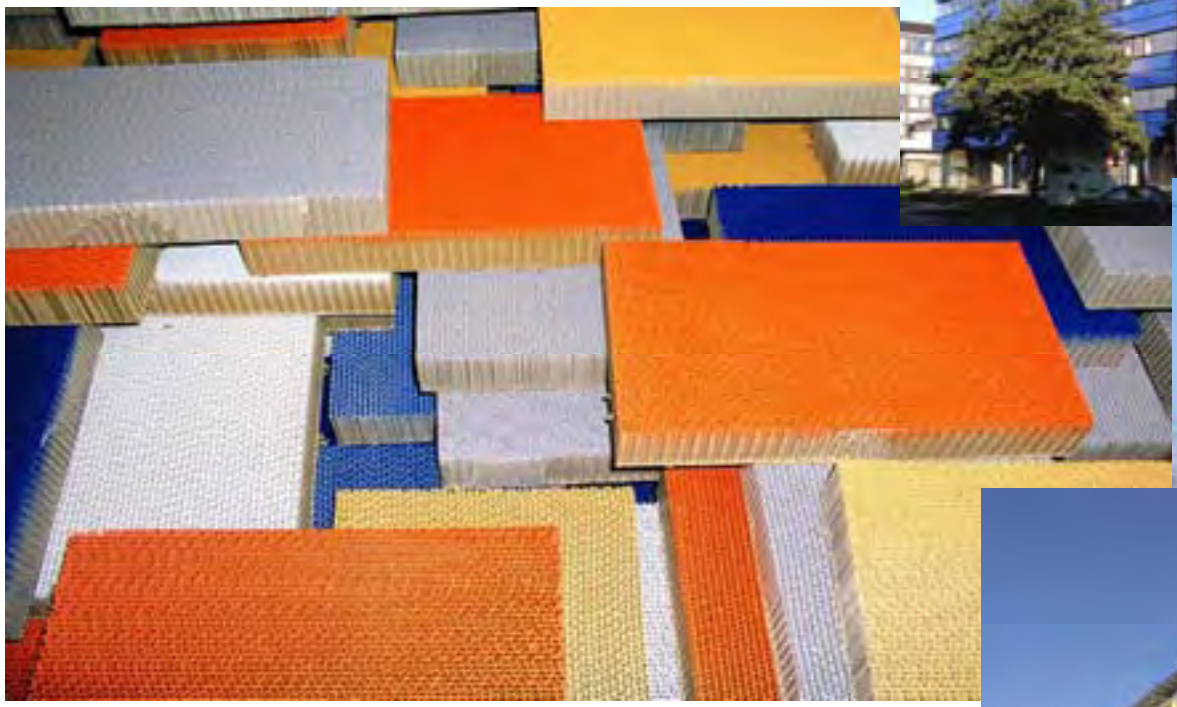


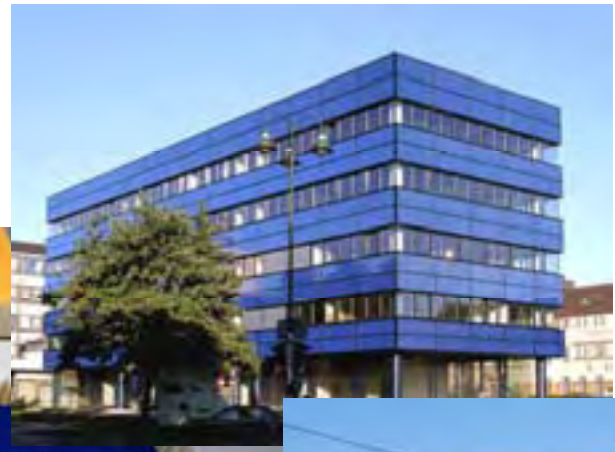
Plate glass

Patterned glass

Texturized glass

Form design with color





Practical every color is possible!

Soundproofing

Wooden Framework 16 cm

without Solarfacade R_w 44 dB

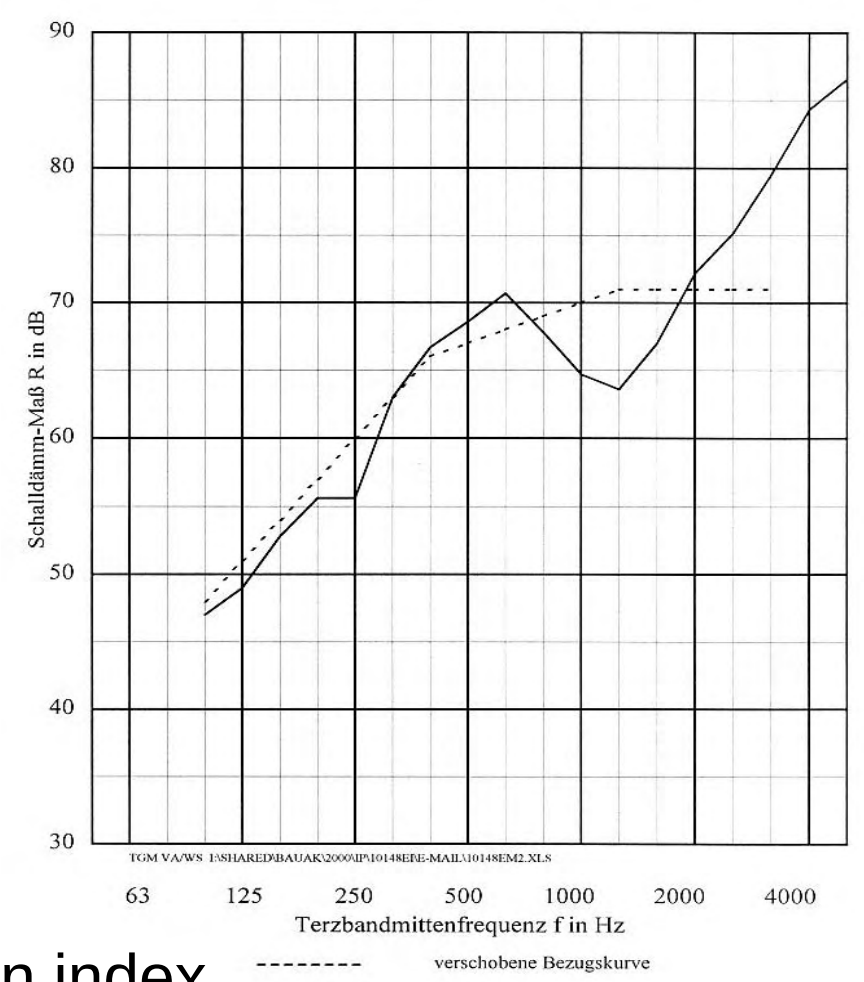
with Solarfacade R_w 50 dB

with SF + Installation Layer Rw 59 dB

Brick Wall 38 cm, double-sided plaster

without Solarfacade R_w 49 dB

with Solarfacade R_w 67 dB



Rw = (airborne) sound reduction index

Fire protection and Fire behavior

- **After approx. 4 minutes the flames beat from the window area on the facade**
- **The fire-proofing coat at the surface of the solar honeycomb foamed up and formed a protective layer**
- **After approx. 8 minutes the aluminum parts started to melt**
- **After 24 minutes the glazing of the panel directly over the window shattered.**
- **An independent spread of fire couldn't be established after 30 minutes, the examination was positive.**

Solarcity House 1

House 1

Assembly

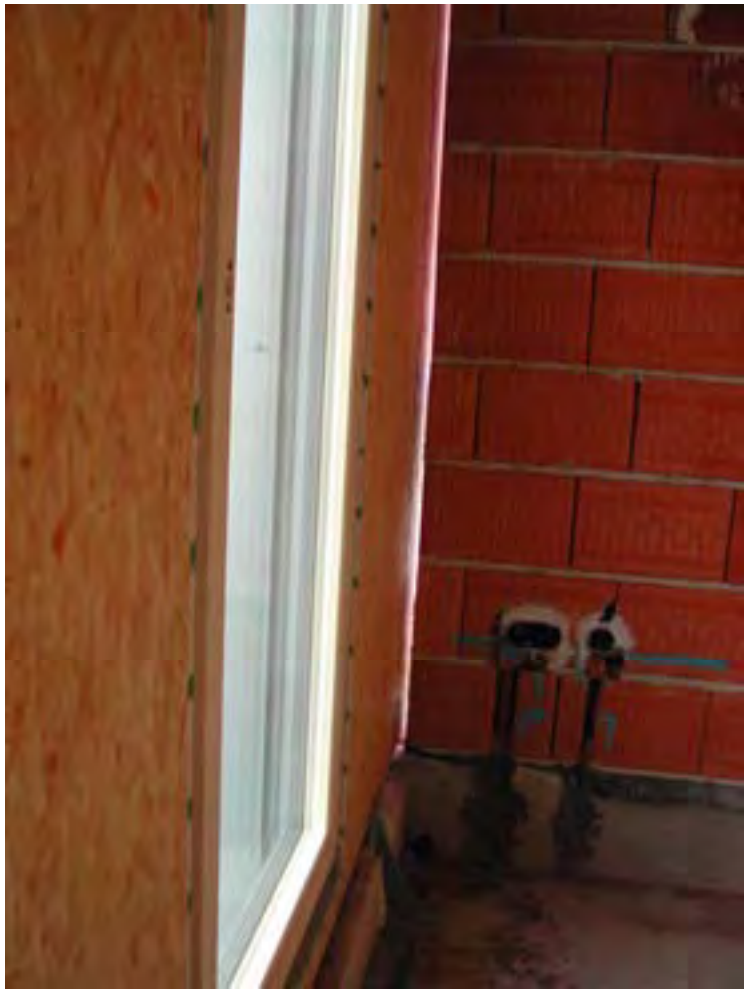
Assembly

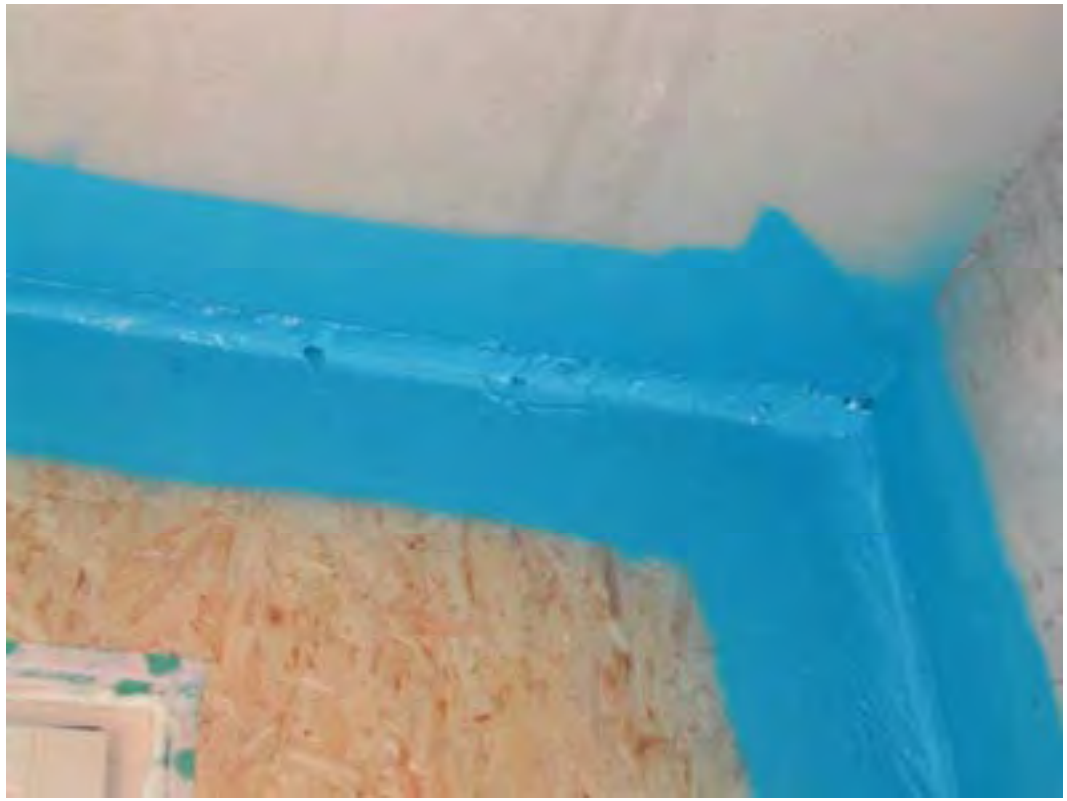
Mounting

Mounting

Air thightness

Air thightness





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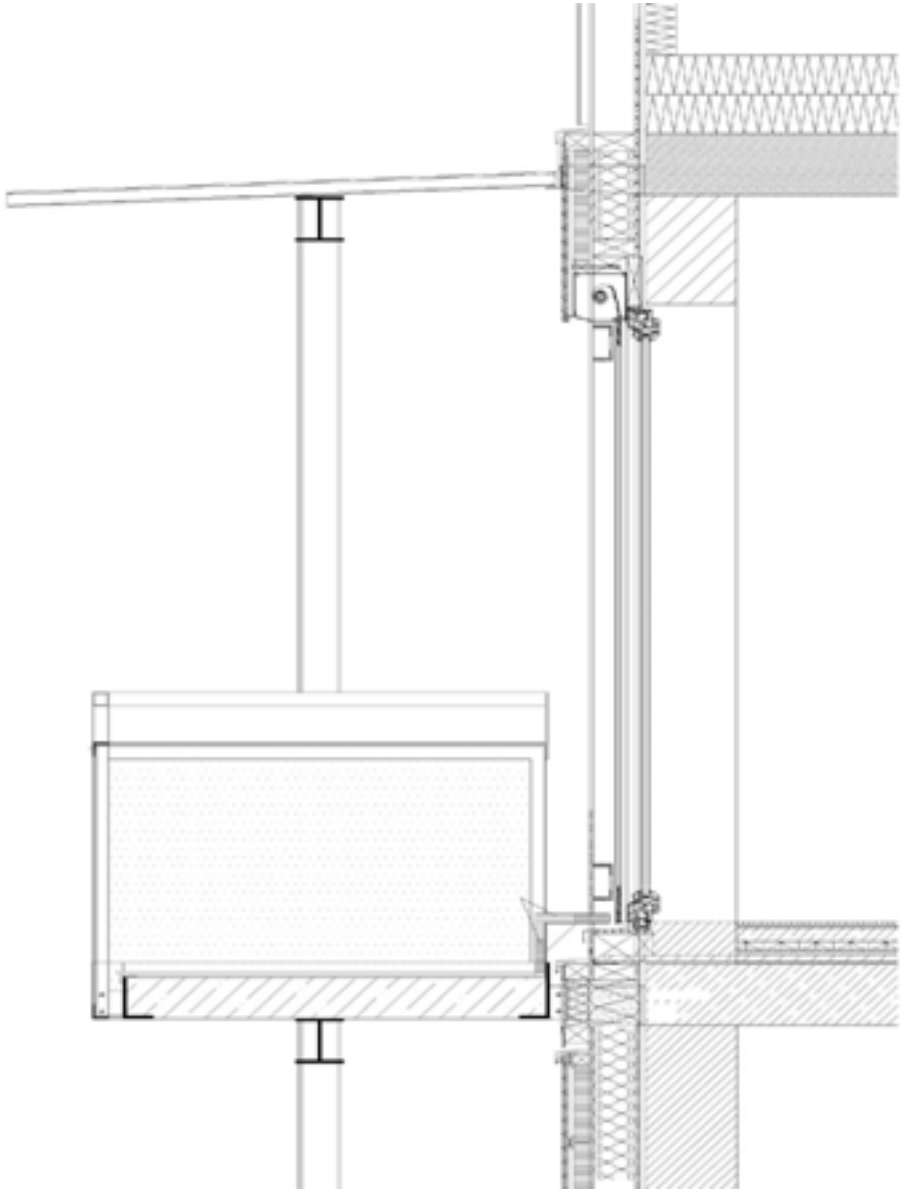
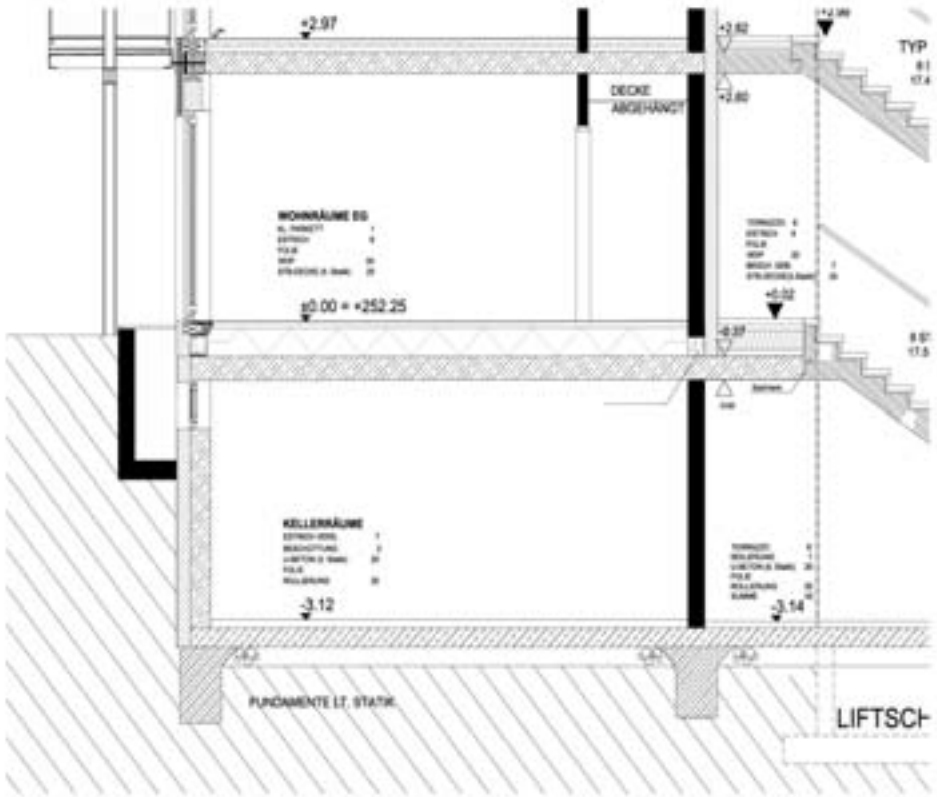


Air shaft – connecting joint -basement



Ventilation with heat recovery – installation example

Ventilation with heat recovery – installation example

Ventilation with heat recovery – installation example

Ventilation with heat recovery

Determination of the heating capacity for the necessary hygienical air change:

Necessary air change per person: **30 m³/h**
interior air temperature: **Ti = +20°C**
outer air temperature: **Ta = -10° C**

d = 30K (P = 30 m³/h * 0.33 Wh/K/m³*30K)

>>>> heating capacity **297 W**

detto at use of a ventilation device with heat recovery

assumption heat recovery of **75%** **>>>>** heating capacity = **75W**

For ventilation devices with heat recovery the resduial heat capacity for the necessary hygienical air change could be coverd by the thermal discharge of one person

Fixed glazed window parapet

Fixed crossbar window parapet

Passivehouse envolope

- **Passive solar energy recovery - solar façade:**
  - Effective U-values between 0.02 to 0.15 W/m²/K
- **Decentralized ventilation devices (wall integrated):**
  - With heat recovery
- **High-quality windows (wall integrated):**
  - Wood/aluminum or synthetic material
  - If possible - integrated window shutter
- **Wall units prefabricated**
  - Air thightness
  - thermal bridge free

Calculating Example House 1

33 kg x 12,87 kWh/kg = 425 kWh
425 kWh / 7,3 kWh/m²a = 58 m²

The energy contents of a 33 kg gas canister suffice to cover the annual heating demande for 58 m² living area (at 100% degree of effectiveness).

24 apartments x 78 m² x 7,3 kWh/m²a = 13.665 **kWh/a**
Detached house: 150 m² x 90 kWh/m²a = 13.500 **kWh/a**

The annual heating demand of house 1 (with 24 AP) corresponds approximately to one typical detached house from the 90´ies.

Aspects to take into account for the efficent passive house

The passive house only works if you live-in!

- The internal heat gains amount to 10 kWh/m²a
- consequences for vacation in winter!

The comfort (cosiness) is not only a question of the temperature!

- A warm corner can be in demand!
  (planning the installation of a radiator!)
- Too high air change rates bring very dry air conditions!

User guide for the resident

User guide about 30 pages

General Information
Contact Person, cleaning ...

Room-by-room Decentralized ventilation devices

Filter maintenance
Ventilation Description

Living in a Passivhouse

Passivhouse details

Post-Occupancy-Evaluation House 1

Wohnung	Straße	Nr.	Ablesedatum	Zählerstand	Bezug	WNFl [m2]	HGT	Verbrauch kWh/m²a
1	Suttnerstraße	32	31-Jul-05	2,203	21.10.2004	78,32	3.303,00	30,31
2	Suttnerstraße	32	31-Jul-05	2,381	21.10.2004	79,65	3.303,00	32,21
3	Suttnerstraße	32	31-Jul-05	2,401	21.10.2004	78,16	3.303,00	33,10
4	Suttnerstraße	32	31-Jul-05	1,210	21.10.2004	79,50	3.303,00	**16,40**
5	Suttnerstraße	32	31-Jul-05	0,869	21.10.2004	78,01	3.303,00	**12,00**
6	Suttnerstraße	32	31-Jul-05	0,607	21.10.2004	79,34	3.303,00	**8,24**
7	Suttnerstraße	32	31-Jul-05	1,255	21.10.2004	77,85	3.303,00	17,37
8	Suttnerstraße	32	31-Jul-05	2,059	21.10.2004	79,18	3.303,00	28,02
9	Suttnerstraße	34	31-Jul-05	2,769	21.10.2004	78,05	3.303,00	**38,23**
10	Suttnerstraße	34	31-Jul-05	1,894	21.10.2004	78,02	3.303,00	26,16
11	Suttnerstraße	34	31-Jul-05	0,677	21.10.2004	77,89	3.303,00	**9,37**
12	Suttnerstraße	34	31-Jul-05	1,351	21.10.2004	77,86	3.303,00	18,70
13	Suttnerstraße	34	31-Jul-05	0,992	21.10.2004	77,73	3.303,00	**13,75**
14	Suttnerstraße	34	31-Jul-05	0,613	21.10.2004	77,70	3.303,00	**8,50**
15	Suttnerstraße	34	31-Jul-05	1,944	21.10.2004	77,57	3.303,00	27,00
16	Suttnerstraße	34	31-Jul-05	3,052	21.10.2004	77,55	3.303,00	**42,41**
17	Suttnerstraße	36	31-Jul-05	1,317	21.10.2004	79,64	3.303,00	17,82
18	Suttnerstraße	36	31-Jul-05	2,623	21.10.2004	78,39	3.303,00	**36,05**
19	Suttnerstraße	36	31-Jul-05	0,835	21.10.2004	79,49	3.303,00	**11,32**
20	Suttnerstraße	36	31-Jul-05	2,022	21.10.2004	78,23	3.303,00	27,85
21	Suttnerstraße	36	31-Jul-05	0,508	21.10.2004	79,33	3.303,00	**6,90**
22	Suttnerstraße	36	31-Jul-05	0,956	21.10.2004	78,07	3.303,00	**13,19**
23	Suttnerstraße	36	31-Jul-05	1,155	21.10.2004	79,17	3.303,00	**15,72**
24	Suttnerstraße	36	31-Jul-05	2,202	21.10.2004	77,92	3.303,00	30,45
				37,895		1.882,62	3.303,00	21,69
				-				0,00

Post-Occupancy-Evaluation House 5

Wohnung	Straße	Nr.	Ablesedatum	Zählerstand	Bezug	WNFl [m2]	HGT	Verbrauch kWh/m²a		
1	Forellenweg	42	31-Jul-05	2,530	18.11.2004	76,37	2.928,00	40,27		
2	Forellenweg	42	31-Jul-05	1,736	18.11.2004	64,03	2.928,00	32,96		
3	Forellenweg	42	31-Jul-05	0,857	18.11.2004	76,09	2.928,00	**13,69**		
4	Forellenweg	42	31-Jul-05	3,471	18.11.2004	75,75	2.928,00	55,70		
5	Forellenweg	42	31-Jul-05	3,889	18.11.2004	76,09	2.928,00	**62,13**		
6	Forellenweg	42	31-Jul-05	2,665	18.11.2004	75,75	2.928,00	42,76		
7	Forellenweg	44	31-Jul-05	0,660	18.11.2004	76,37	2.928,00	**10,50**		
8	Forellenweg	44	31-Jul-05	1,765	18.11.2004	64,03	2.928,00	33,51		
9	Forellenweg	44	31-Jul-05	0,328	18.11.2004	76,09	2.928,00	**5,24**		
10	Forellenweg	44	31-Jul-05	1,878	18.11.2004	75,75	2.928,00	30,13		
11	Forellenweg	44	31-Jul-05	3,413	18.11.2004	76,09	2.928,00	54,52		
12	Forellenweg	44	31-Jul-05	2,144	18.11.2004	75,75	2.928,00	34,40		
13	Forellenweg	46	31-Jul-05	1,674	18.11.2004	76,37	2.928,00	26,64		
14	Forellenweg	46	31-Jul-05	0,232	18.11.2004	60,11	2.928,00	**4,69**		
15	Forellenweg	46	31-Jul-05	1,688	18.11.2004	90,00	2.928,00	22,80		
16	Forellenweg	46	31-Jul-05	2,647	18.11.2004	59,84	2.928,00	53,77		
17	Forellenweg	46	31-Jul-05	3,369	18.11.2004	90,01	2.928,00	45,50		
18	Forellenweg	46	31-Jul-05	1,849	18.11.2004	59,84	2.928,00	37,56		
				36,795		1.324,33	2.928,00	33,77		