



# HyWin

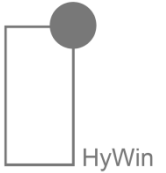
Aktive Hybridfassade für Glashochhäuser

**Energieforschungsgespräche 2019 Disentis**

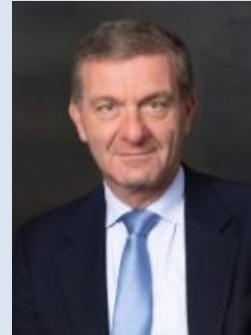
Claudio Meisser dipl.El.Ing.ETH/SIA

[www.hywin.ch](http://www.hywin.ch)

# Das HyWin Team



**R&D**  
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Fachhochschule FHNW  
Institut Energie am Bau

**2011** Roche high rise building (Rotkreuz)  
**Gartner Closed Cavity Façade**

**2013** Simulation HyWin Concept  
University of Applied Science Lucerne

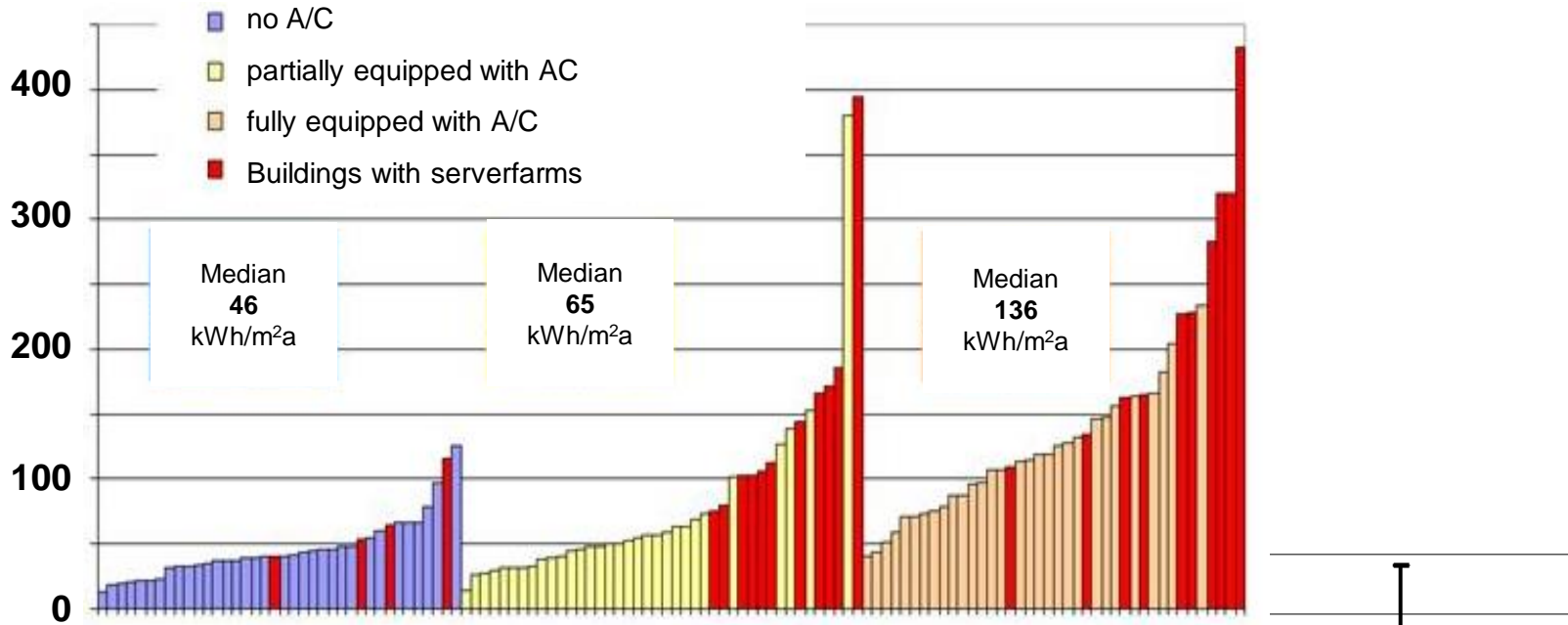
**2014 - 2017** Prove of Concept

**2017 - 2018** Two industry partners

**2016** PCT Patent application published

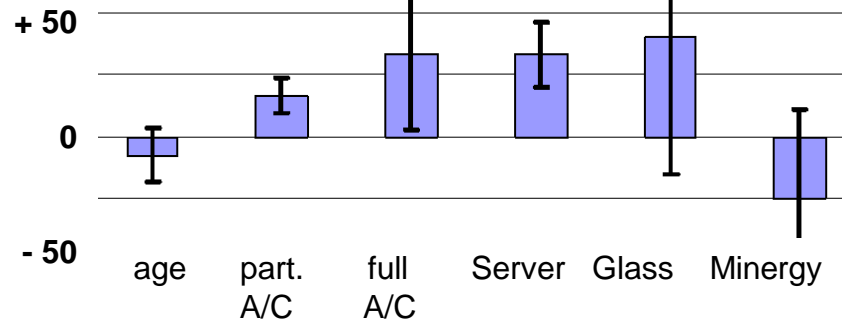
**2018** Successful outdoor test (HyWin V)

# Performance of office buildings



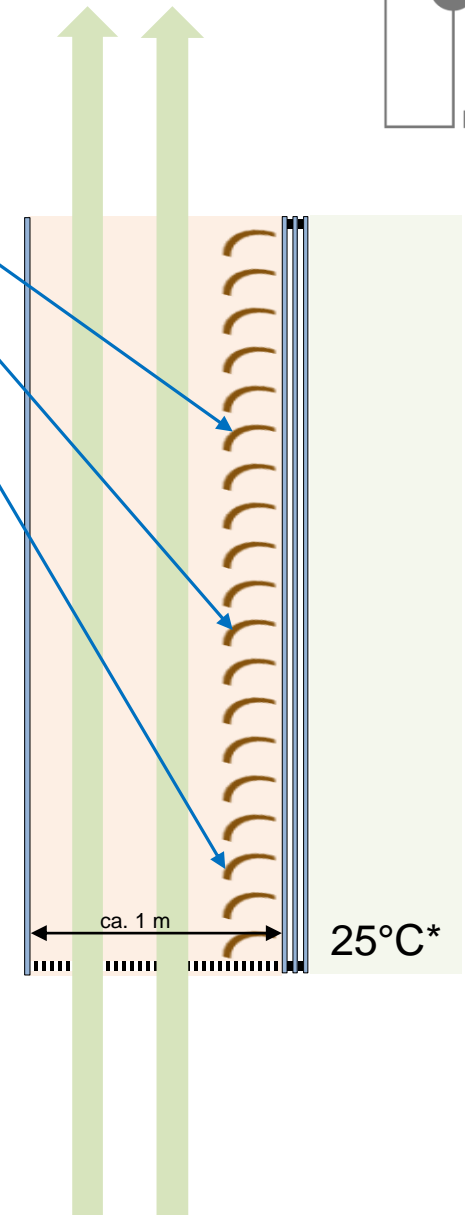
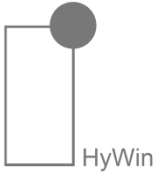
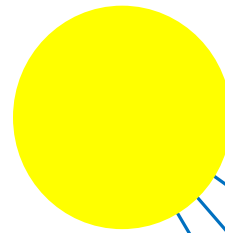
**kWh electrical energy per m<sup>2</sup> floorspace and year**

Thermal energy not included!  
Source: Swiss Energy Dept. (BFE)

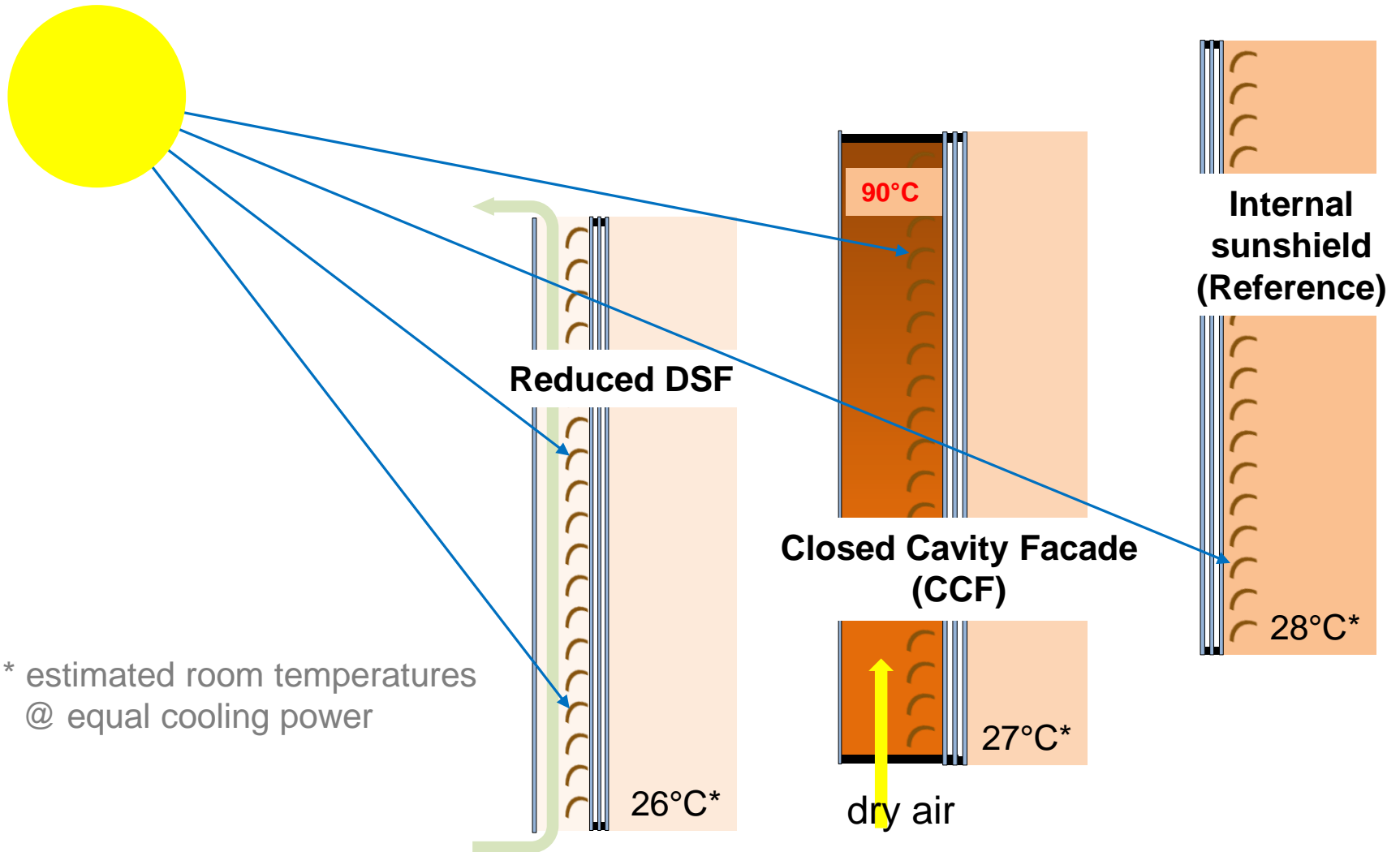


# Double Skin Façade (DSF)

The optimal solution



# Typical solutions for high rise buildings





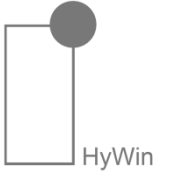
Shard London



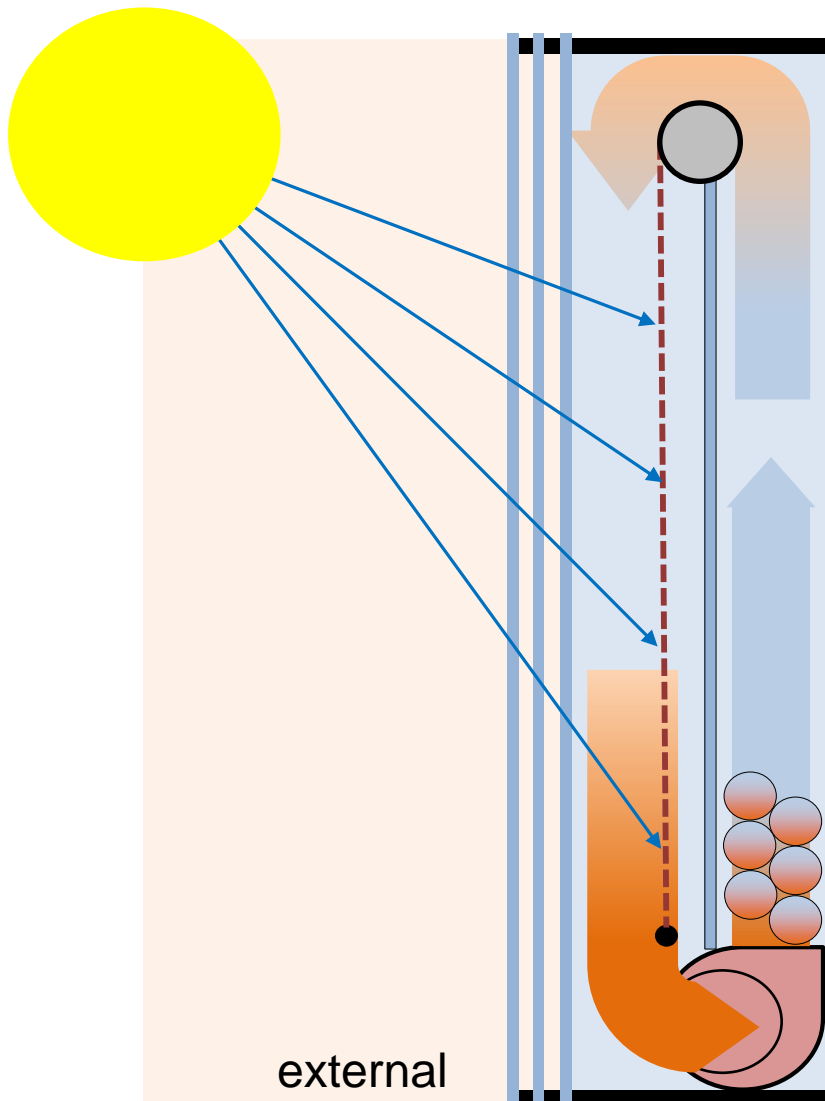
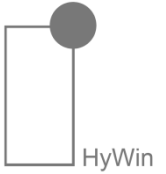
Roche Tower Rotkreuz



Primetower Zürich

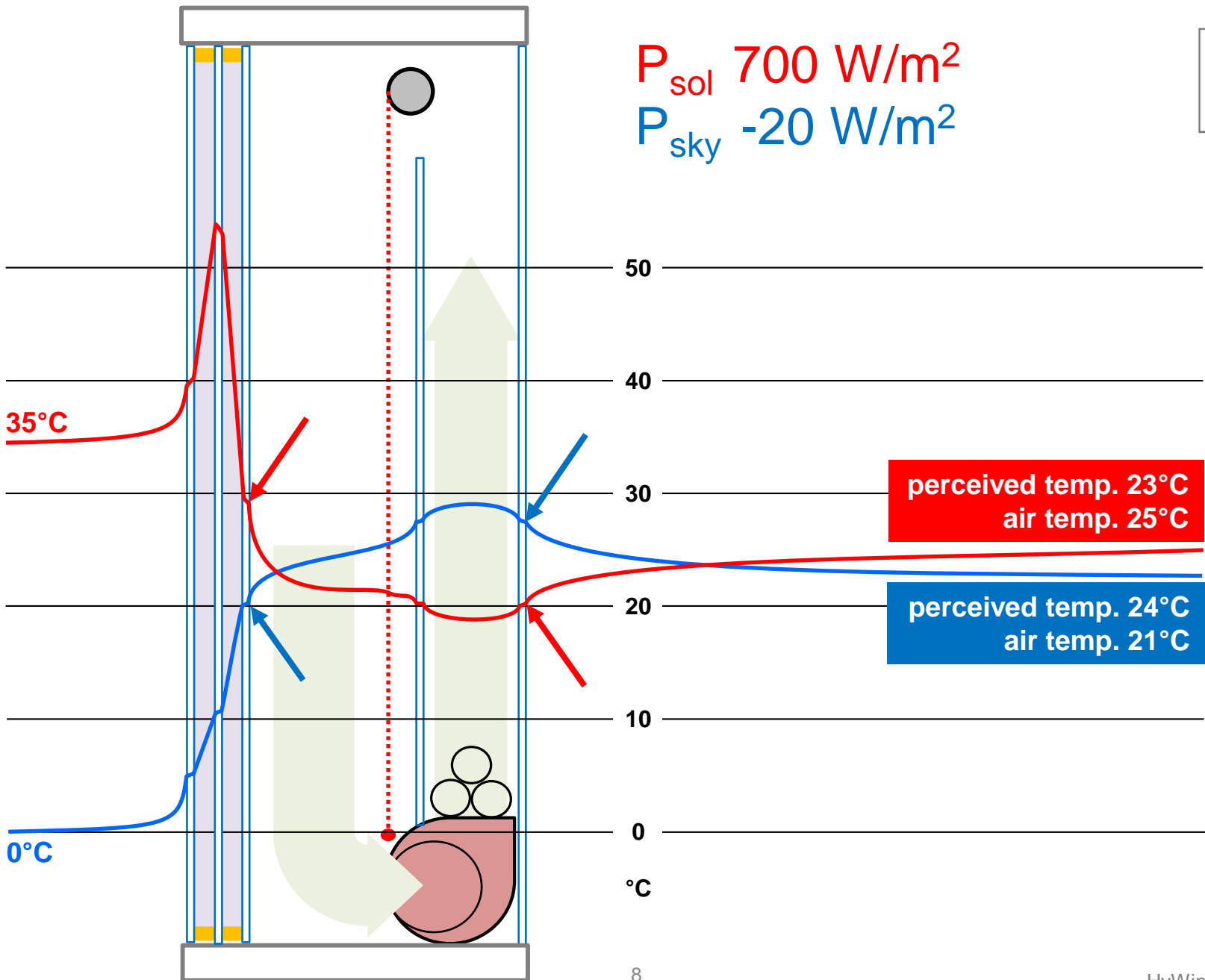


# HyWin solves the problem where it starts



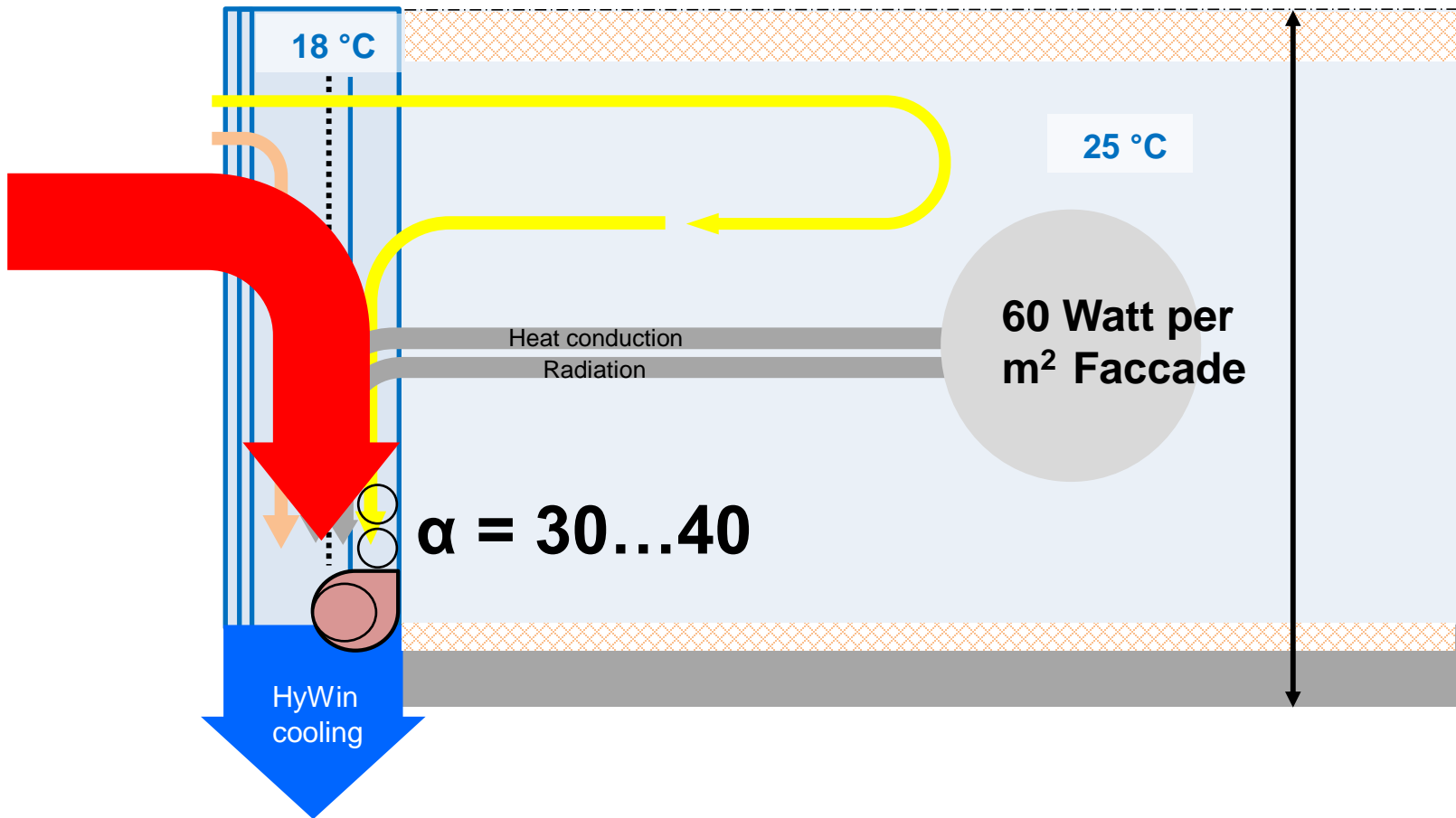
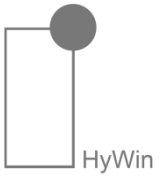
- **Summer: HyWin replaces free cooling**
- **Winter: HyWin replaces floor heating**
- Regeneration of geothermal probes
- No aging of the sunshield
- No condensation risk

$P_{sol} 700 \text{ W/m}^2$   
 $P_{sky} -20 \text{ W/m}^2$





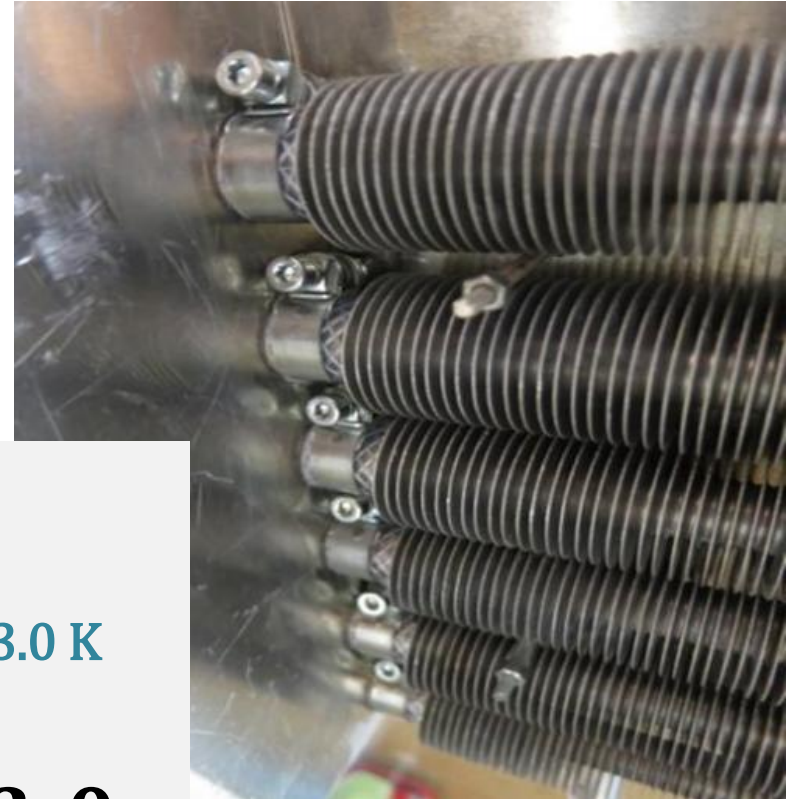
# HyWin with «cavity-integrated» sunshield



# Test unit

## Data logging and results

# Hi-efficiency bimetal finned-tube cooler



$$P = \alpha \times F \times \Delta T$$

1.0 m<sup>2</sup> Facade    2.0 m<sup>2</sup> HE     $\Delta T = 3.0$  K

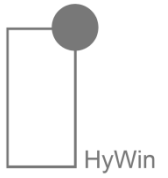
Power of heat exchanger:

$$180 \text{ W} = 30 \times 2.0 \times 3.0$$

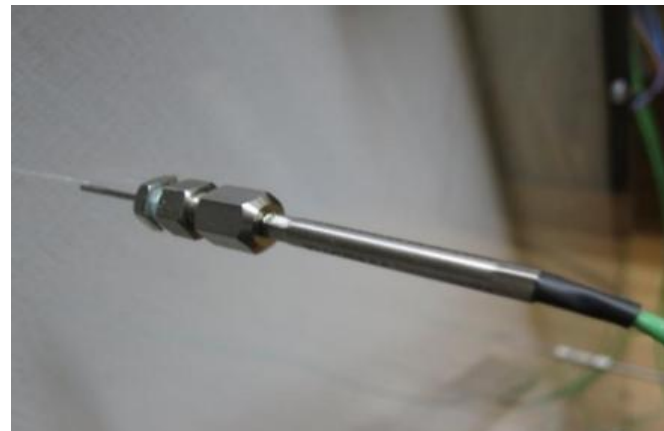
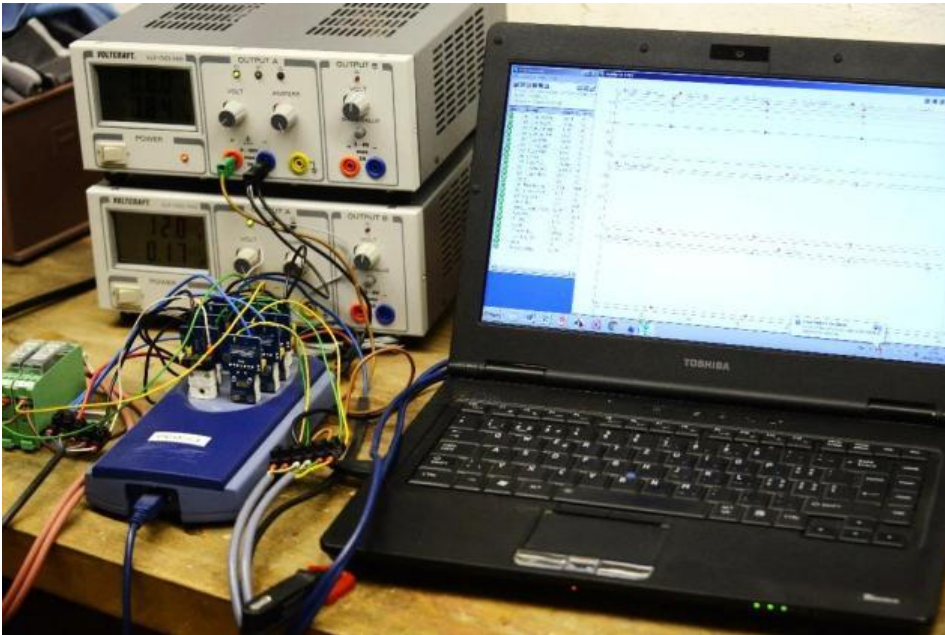
Heat transfer coefficient  $\alpha$  [W/m<sup>2</sup>K] > 30

airspeed required > 3 m/s

# Test unit 0.55 m<sup>2</sup> - Indoor setup with halide lamps

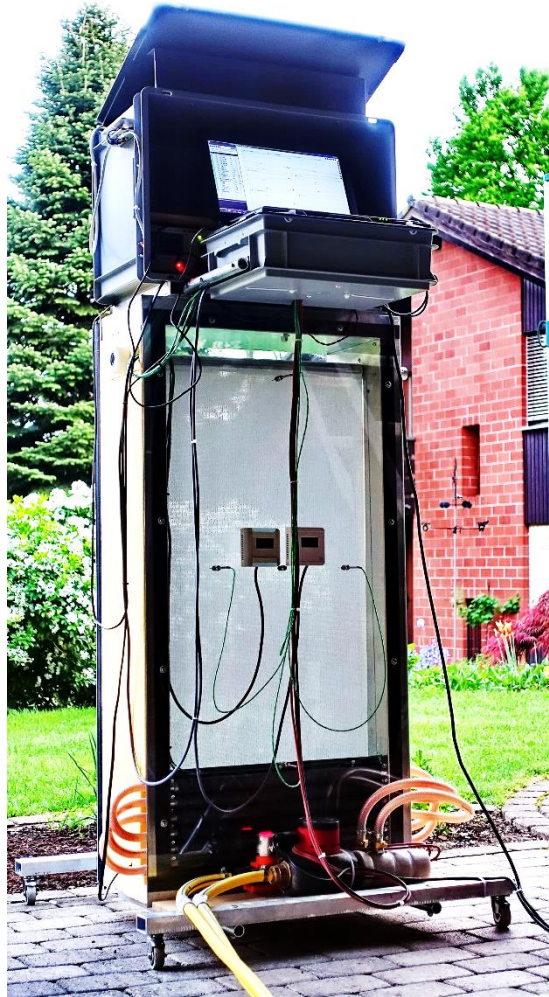


# Measuring technology



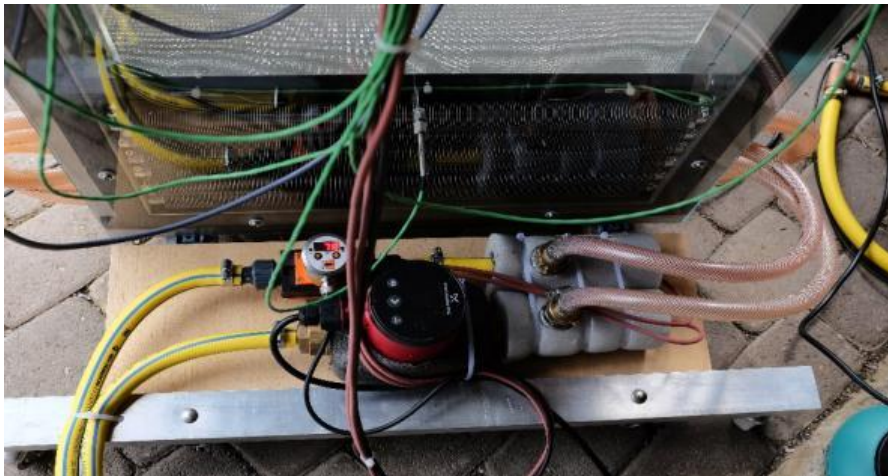
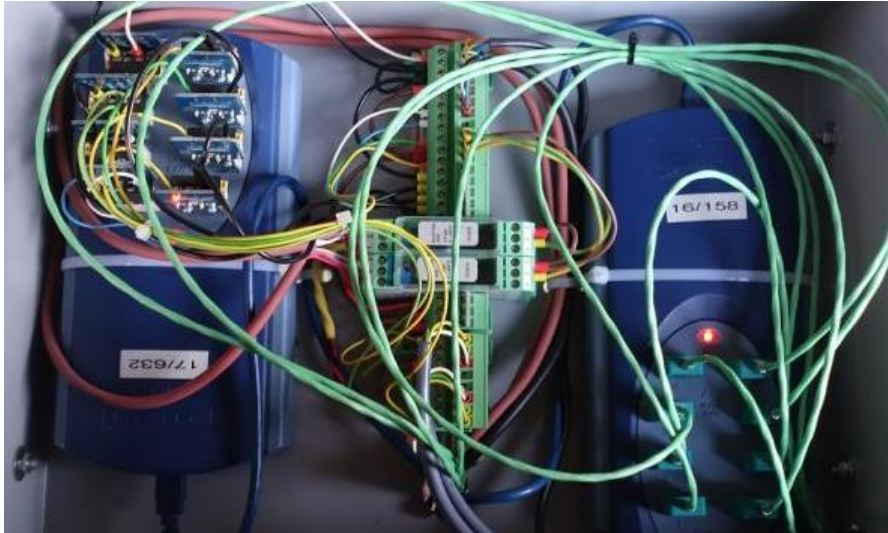


# HyWin VII - Outdoor test (Cham)





# HyWin VII - Outdoor test (Cham)



# Data acquisition and calculated values

Alarm	Channel	Reading	Units
●	A1 T_air_in_right	20.77	°C
●	A2 T_air_in_left	20.54	°C
●	A3 T_air_out_right	20.25	°C
●	A4 T_air_out_left	19.96	°C
●	A5 T_i_bottom	19.83	°C
●	A6 T_i_mid_right	20.21	°C
●	A7 T_i_mid_left	20.43	°C
●	A8 T_i_top	20.62	°C
●	B1 T_water_in	19.4139	°C
●	B2 T_water_out	19.4063	°C
●	B3 T_room	20.1	°C
●	B4 T_j	19.7	°C
●	B5 flowrate_mag	2.60	l/min
●	B6 rh_room +0.9	50.4	%
●	B7 rh_j +0.9	50.6	%
●	B8 P_fan	4.2	Watt
●	delta_T_water -0.025	-0.0174	K
●	P_HyWin	-3.2	Watt
●	T_i_avg	20.27	°C
●	T_j_dp	9.2	°C
●	T_water_avg	19.410	°C
●	T_air_avg -0.9	19.479	°C
●	alpha	-38	-
●	dp_aux function	0.641	-

## Data acquisition

- Intervall: 3 s
- Period: several hours
- Up to 96'000 measurement points
- Transfer from xls to data base

## Calculated values

- P\_HyWin
- T\_i\_dp (dew point)
- alpha (heat transfer coefficient)

69	18.50	-88	20.62	20.39	20.09	19.68	19.52	21.04	20.99	20.94	20.06	20.99	20.28	1.52	1.78
70	18.50	-88	20.63	20.39	20.10	19.68	19.51	21.04	20.98	20.94	20.06	20.99	20.28	1.53	1.78
71	18.50	-88	20.63	20.40	20.10	19.68	19.50	21.04	20.98	20.94	20.06	20.99	20.27	1.54	1.77
72	18.50	-88	20.62	20.39	20.09	19.67	19.49	21.03	20.97	20.94	20.05	20.98	20.26	1.54	1.76
73	18.50	-88	20.62	20.39	20.09	19.67	19.50	21.03	20.97	20.94	20.05	20.98	20.27	1.53	1.77
74	18.50	-88	20.62	20.39	20.09	19.68	19.50	21.03	20.97	20.94	20.06	20.98	20.27	1.53	1.77
75	18.50	-88	20.63	20.39	20.10	19.68	19.51	21.03	20.98	20.94	20.06	20.98	20.27	1.52	1.77
76	18.50	-88	20.62	20.39	20.09	19.68	19.51	21.02	20.97	20.94	20.06	20.98	20.27	1.51	1.77
77	18.49	-88	20.62	20.39	20.08	19.68	19.51	21.02	20.97	20.94	20.06	20.98	20.27	1.51	1.77
78	18.49	-88	20.62	20.39	20.09	19.67	19.50	21.02	20.97	20.95	20.05	20.98	20.26	1.52	1.77
79	18.49	-88	20.62	20.39	20.09	19.68	19.50	21.02	20.98	20.94	20.06	20.98	20.26	1.52	1.77
80	18.49	-88	20.62	20.40	20.09	19.68	19.50	21.03	20.98	20.94	20.06	20.98	20.27	1.53	1.77
81	18.49	-88	20.62	20.40	20.09	19.67	19.49	21.03	20.97	20.93	20.05	20.98	20.26	1.54	1.77
82	18.49	-88	20.62	20.39	20.09	19.67	19.49	21.03	20.97	20.93	20.05	20.98	20.26	1.54	1.77
83	18.49	-88	20.62	20.39	20.09	19.67	19.50	21.03	20.97	20.94	20.05	20.98	20.27	1.53	1.77
84	18.49	-88	20.62	20.39	20.09	19.68	19.50	21.02	20.96	20.93	20.06	20.97	20.26	1.52	1.77
85	18.49	-88	20.62	20.39	20.09	19.68	19.50	21.02	20.97	20.93	20.06	20.97	20.26	1.52	1.77
86	18.49	-88	20.62	20.39	20.10	19.67	19.50	21.02	20.97	20.93	20.06	20.97	20.26	1.52	1.77
87	18.49	-88	20.62	20.38	20.08	19.67	19.49	21.02	20.97	20.93	20.05	20.97	20.26	1.53	1.77
88	18.49	-88	20.62	20.39	20.09	19.67	19.50	21.03	20.96	20.93	20.05	20.97	20.27	1.53	1.78
89	18.49	-88	20.62	20.39	20.09	19.68	19.50	21.03	20.96	20.93	20.06	20.97	20.27	1.53	1.78
90	18.49	-88	20.62	20.38	20.08	19.67	19.49	21.02	20.95	20.92	20.05	20.96	20.26	1.53	1.77
91	18.49	-88	20.62	20.38	20.08	19.67	19.49	21.03	20.96	20.92	20.05	20.97	20.26	1.54	1.77

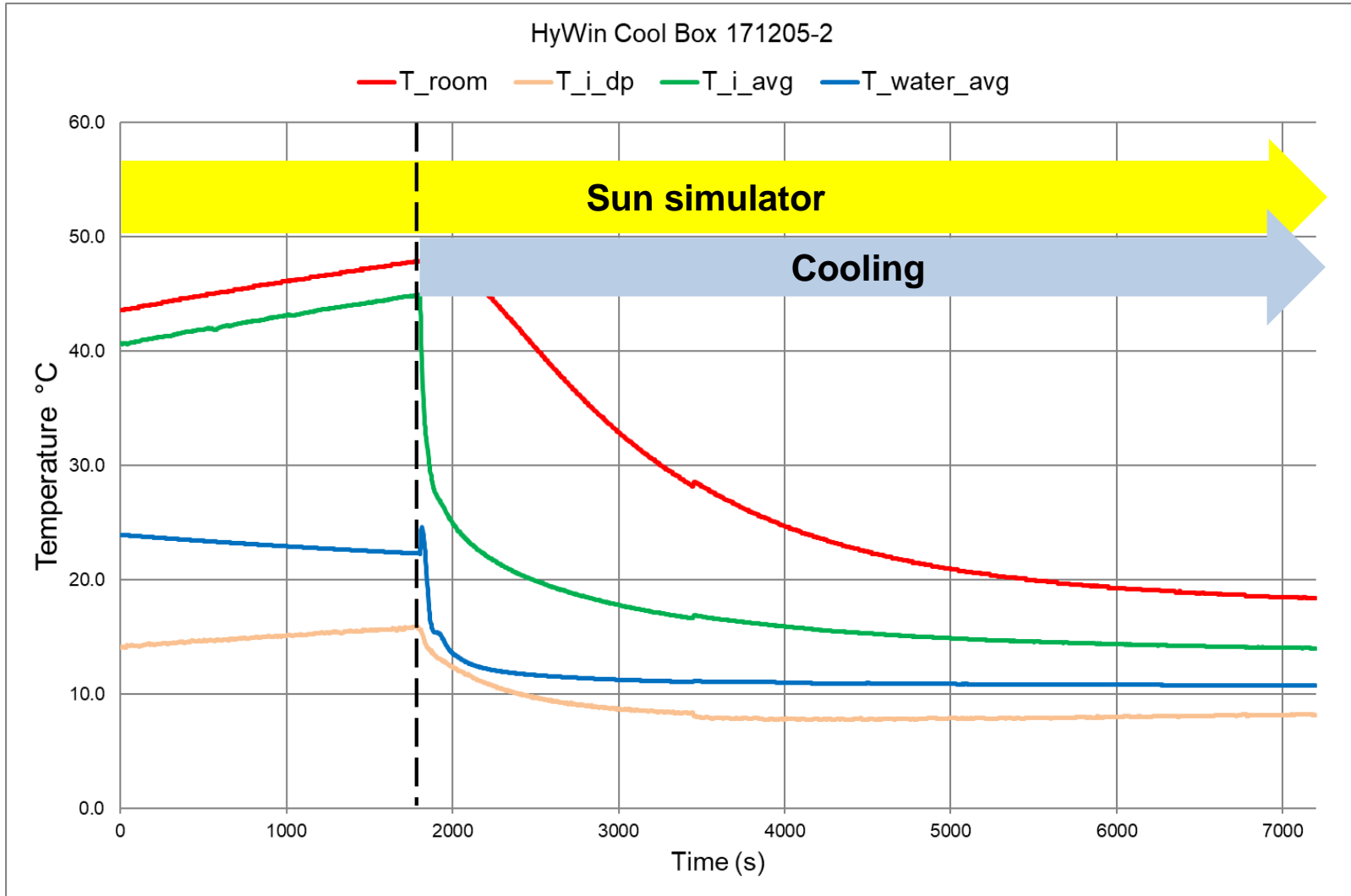
Chart Labels

Normal	Bad	Calculation
Neutral	Calculation	

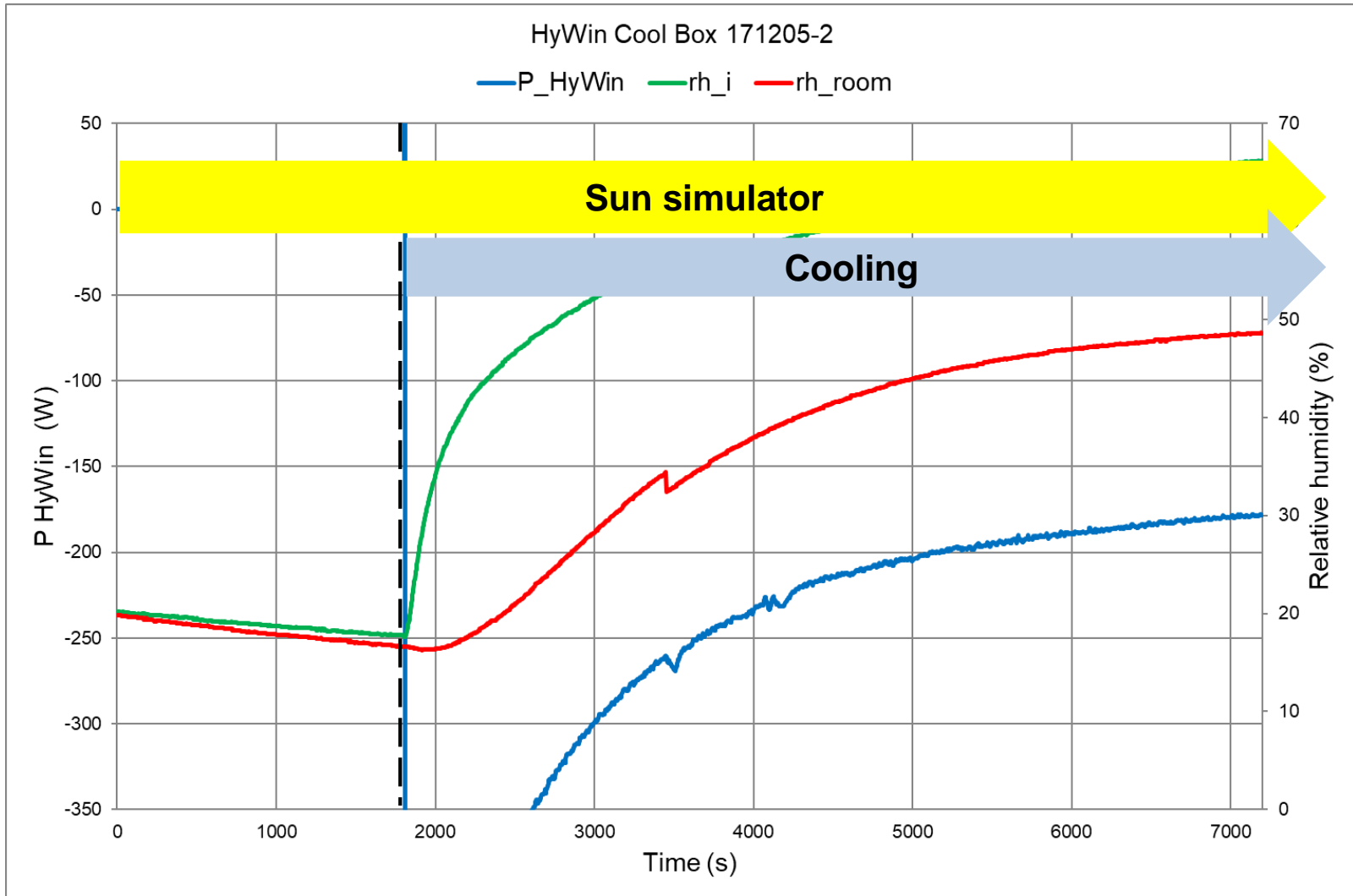
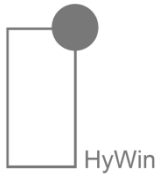
Styles

H	AI	AJ	AK	AL	AM
avg	T_a_avg	T_b_avg	Delta_T_L	Delta_T_K_AVG	Alpt
0.07	21.00	20.28	1.56	1.78	
0.07	21.01	20.29	1.57	1.78	
0.07	21.00	20.29	1.54	1.79	
0.07	21.00	20.29	1.53	1.78	
0.07	21.00	20.29	1.53	1.78	
0.07	21.00	20.28	1.54	1.78	
0.07	21.00	20.28	1.54	1.78	
0.06	20.99	20.28	1.54	1.78	
0.06	20.99	20.28	1.52	1.78	
0.06	20.99	20.28	1.53	1.78	
0.06	20.99	20.27	1.54	1.77	
0.05	20.98	20.26	1.54	1.76	
0.05	20.98	20.27	1.53	1.77	
0.06	20.98	20.27	1.53	1.77	
0.06	20.98	20.27	1.52	1.77	
0.05	20.98	20.26	1.52	1.77	
0.06	20.98	20.26	1.53	1.77	
0.05	20.98	20.26	1.54	1.77	
0.05	20.98	20.26	1.54	1.77	
0.05	20.98	20.27	1.53	1.77	
0.05	20.98	20.26	1.54	1.77	
0.05	20.98	20.27	1.53	1.77	
0.06	20.97	20.26	1.52	1.77	
0.06	20.97	20.26	1.52	1.77	
0.05	20.97	20.26	1.53	1.77	
0.05	20.97	20.27	1.53	1.78	
0.05	20.97	20.27	1.53	1.78	
0.05	20.96	20.26	1.54	1.77	

# Indoor cooling: Temperatures

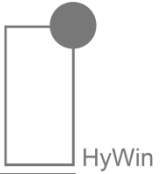


# Indoor cooling: Power and rel. humidity (rh)

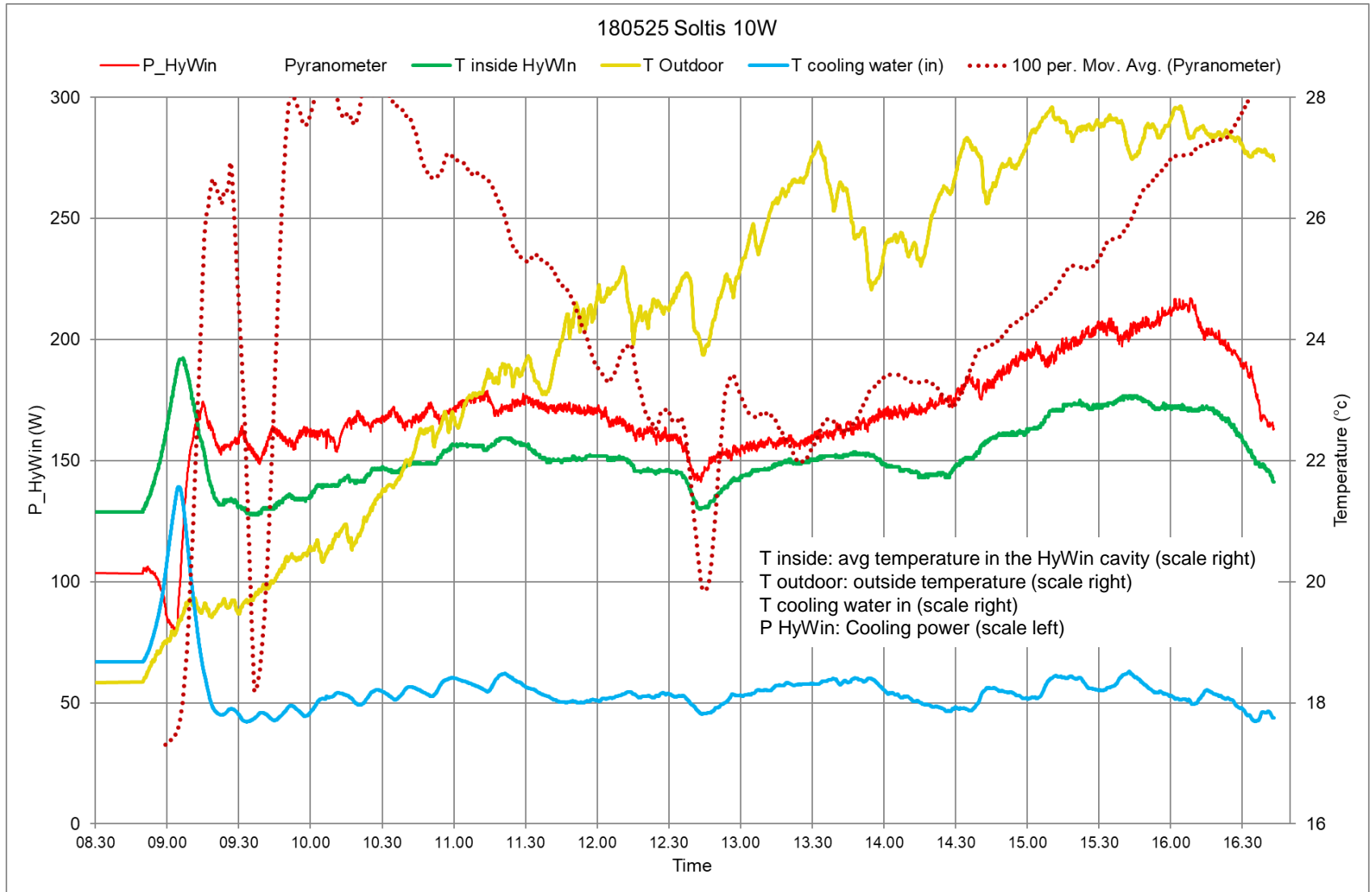




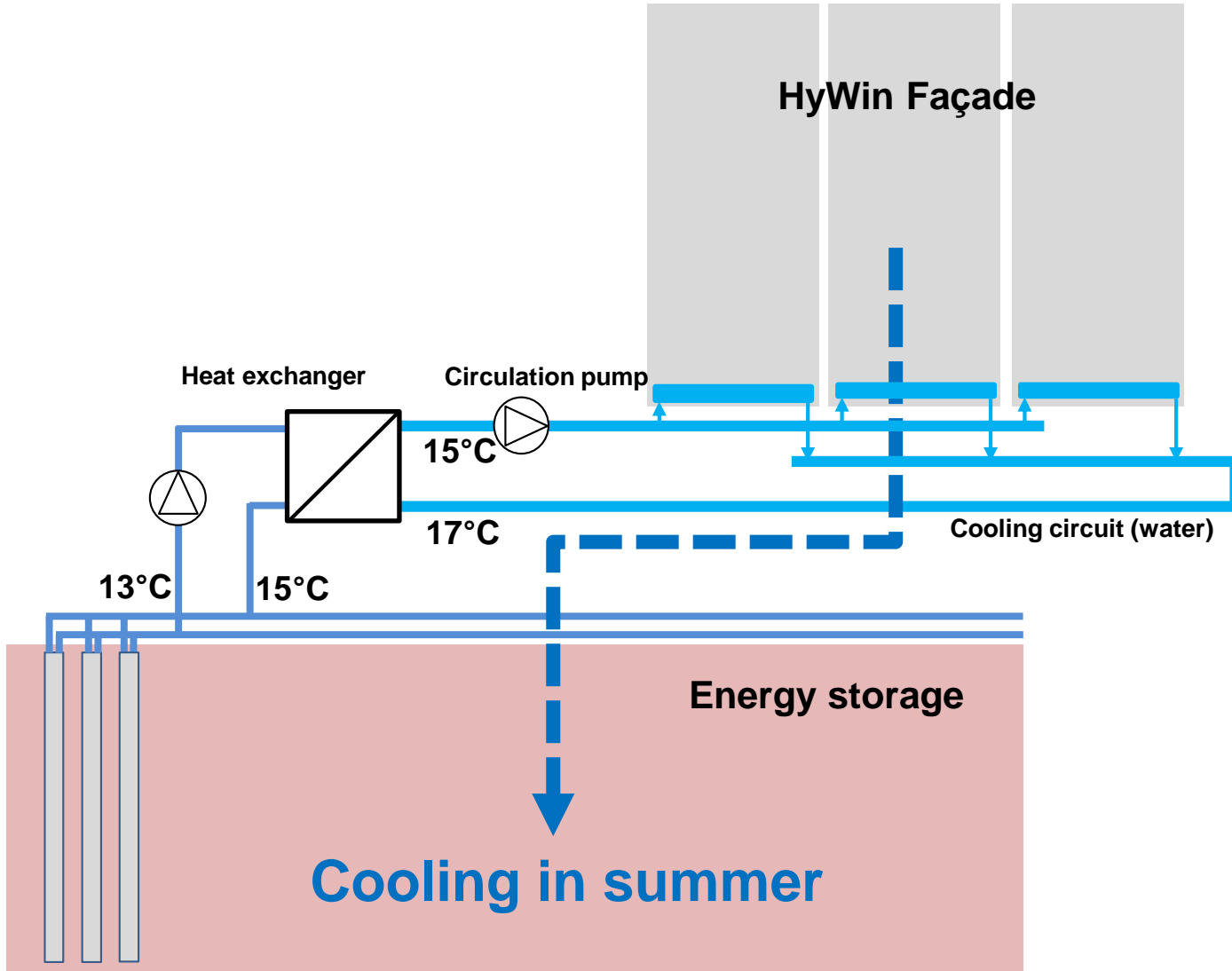
# Outdoor 180525 (0.55 m2, g = 0.5 sunny day, global radiation max 750 W/m2)

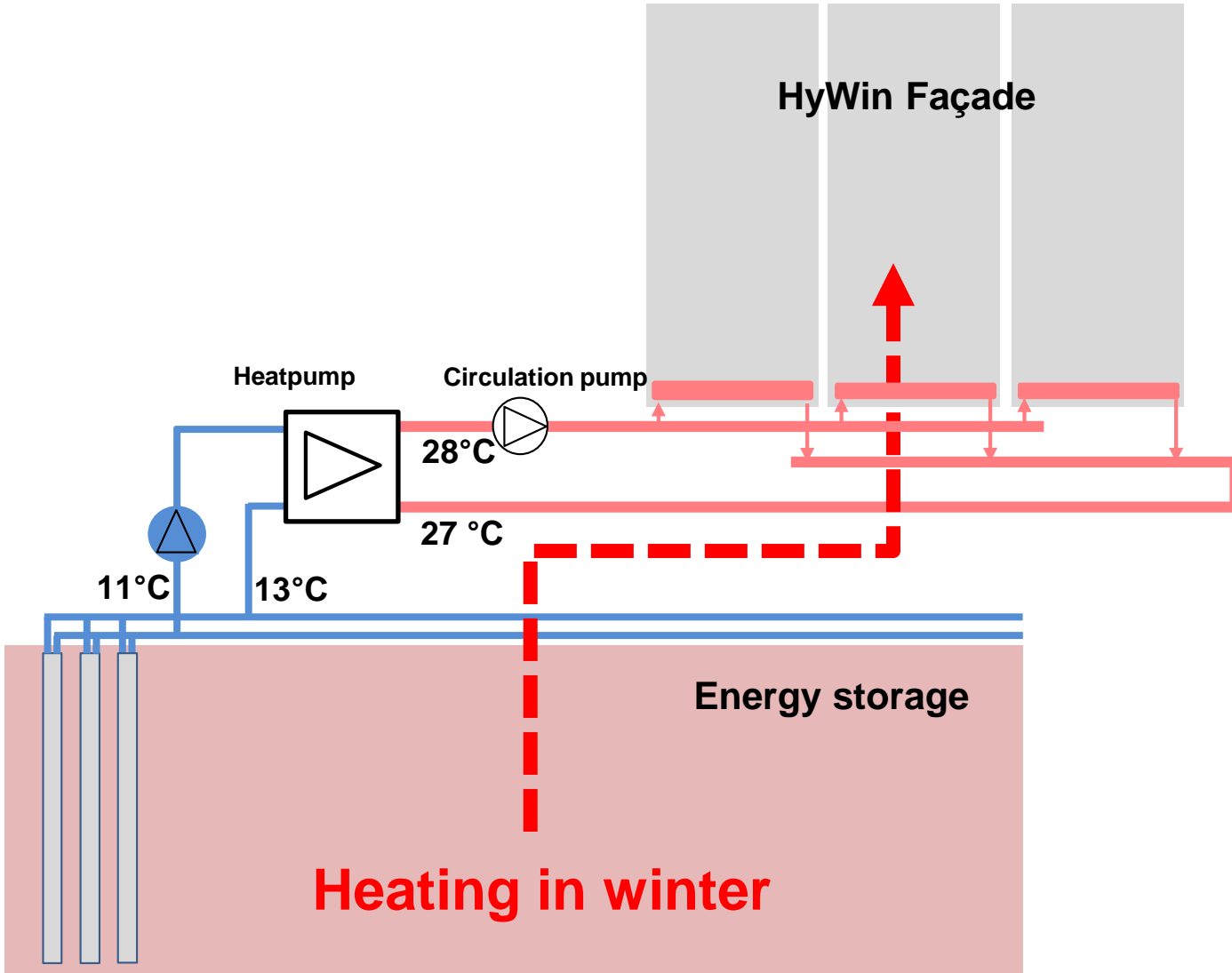


180525 Soltis 10W

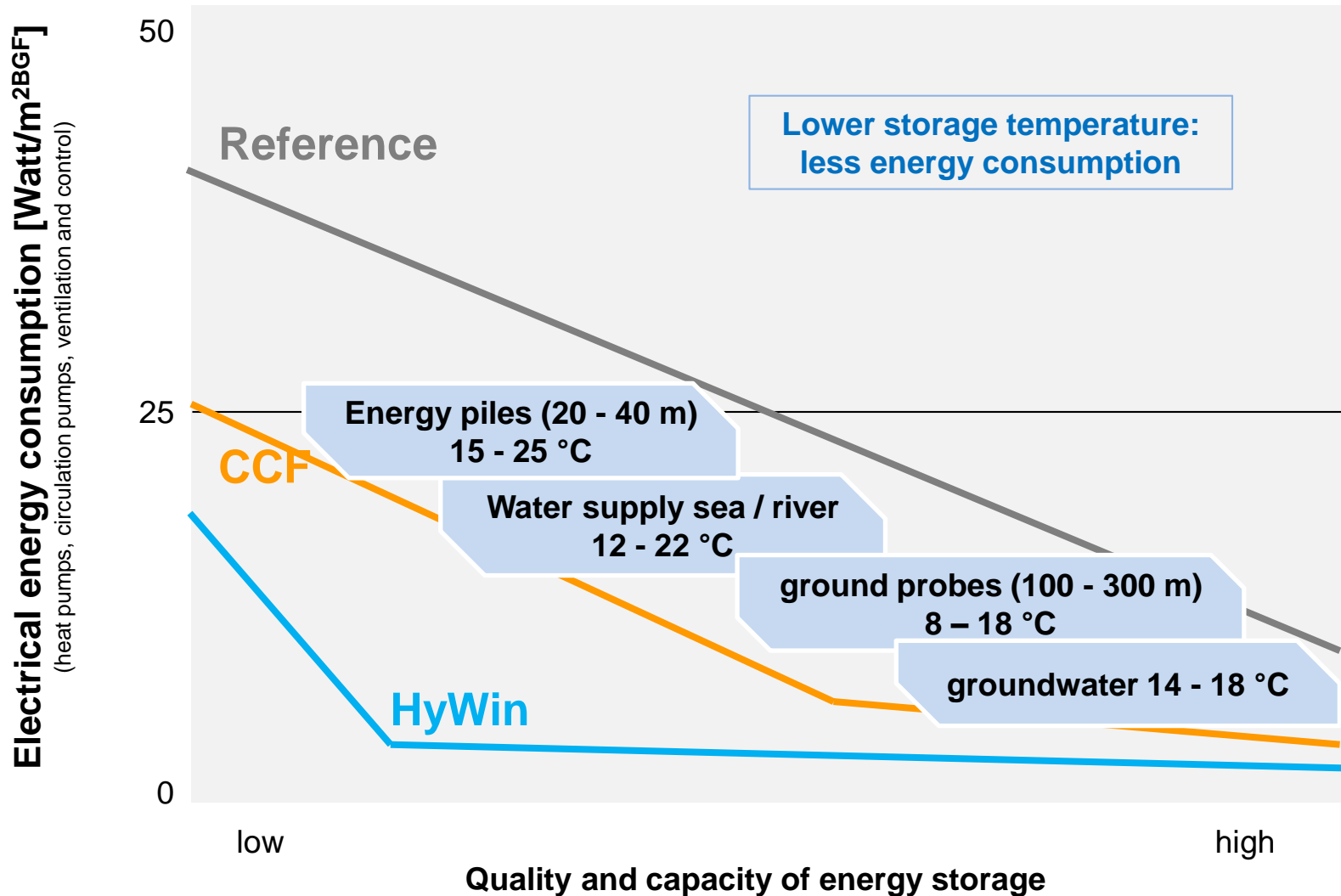
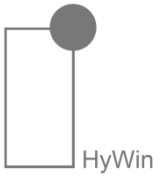


# Cooling and Heating Modes System Design and Efficiency





# Electrical energy consumption





# Design Proposals

# Robust HyWin key components



## Sun shield :

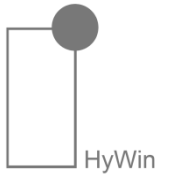
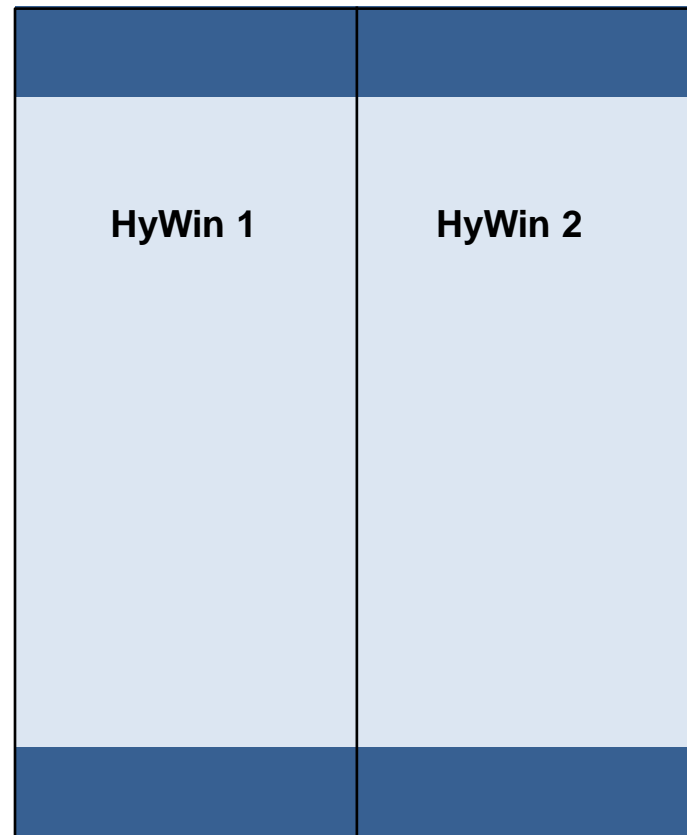
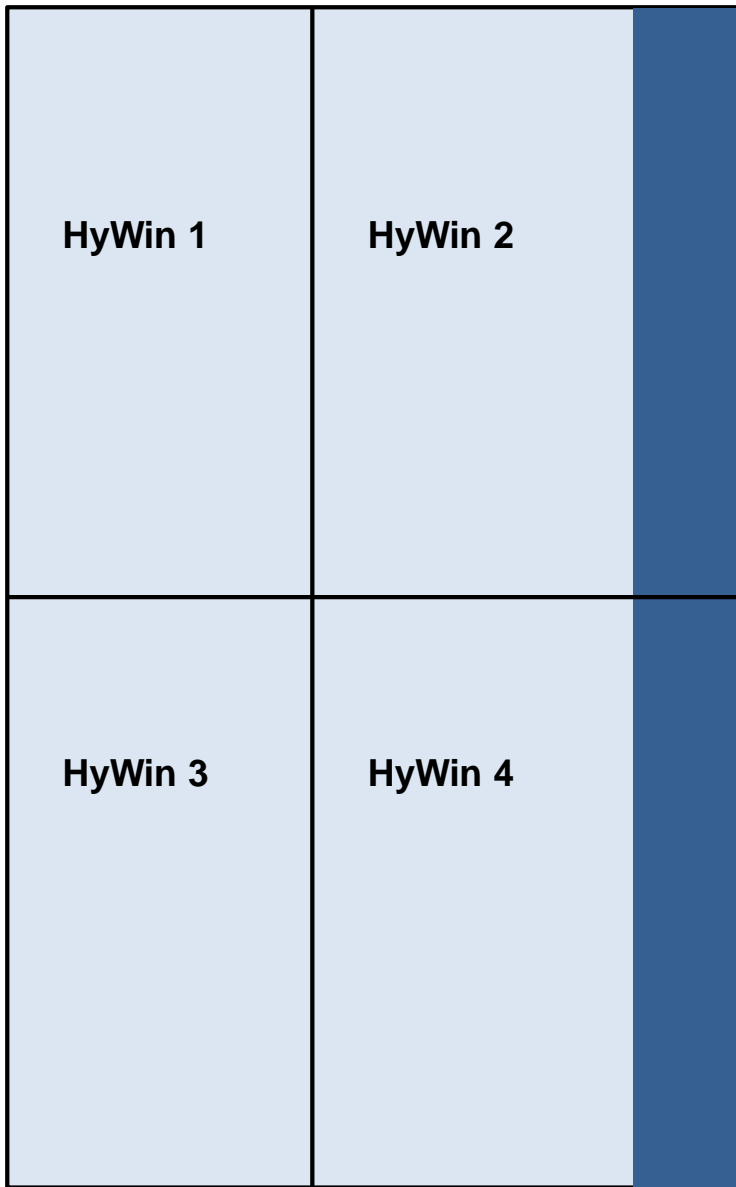
- simple textile sunshield
- dual sunshield
- horizontal blinds
- vertical blinds
- switchable glass
- Daylight Microfoil (BASF)

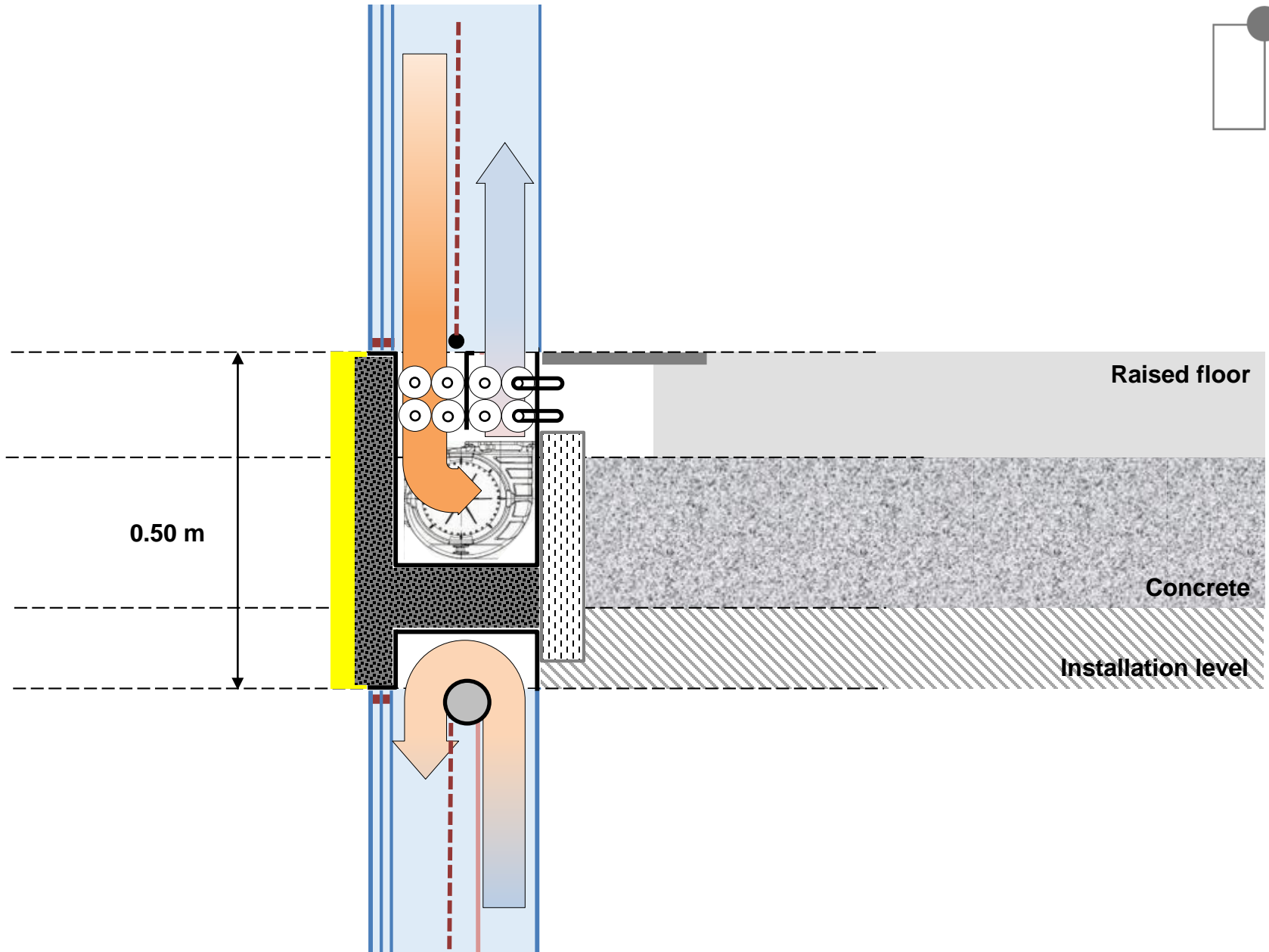


**Cross flow fan with diameter Ø 100 mm**

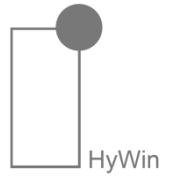
**Dual, radial blower with 4 axial inlets Ø 160 mm**







# HyWin Instant Simulator



## HyWin Instant Simulator (version outdoor)

### Input

Ro air	kg/m3	1.18
cp air	J/kg.K	1005
Ro water at 20°C	kg/m3	998
cp water	J/kg.K	4184
Width	m	0.55
Height	m	1
Cap over the heat exchanger	m	0.017
HyWin glasss area	m2	0.550
Heat exchanger surface	m2	1.1935
g-Value isolating glass (transmission)	W/m2.K	0.5
U-Value isolating glass glass (thermal conductivity)	W/m2.K	0.7
g-Value safety glass	W/m2.K	0.9
U-Value saftey glass	W/m2.K	5
Temp cooling water IN	°C	18.3
Temperature room	°C	25.0
Temperature outdoor	°C	25.0
Solar Radiation on vertical face	W/m2	600
Solar Radiation into HyWin	W	165
Radiation through sunshield to room	W	10
Power Fan (5-15 W)	W	10
Flow cooling water	l/min	2.87
Flow cooling water	m3/s	0.000048
Heat transfer coeff heat exchanger experimental	W/m2.K	41
Air flow experimental	l/s	28.2
Air flow experimental	m3/s	0.02821
Air speed calculated	m/s	3.017

### INPUTS in Red

### CALCULATED in Green

### CHECK Values in Grey

+ Energy inflow

- Energy outflow

### Output

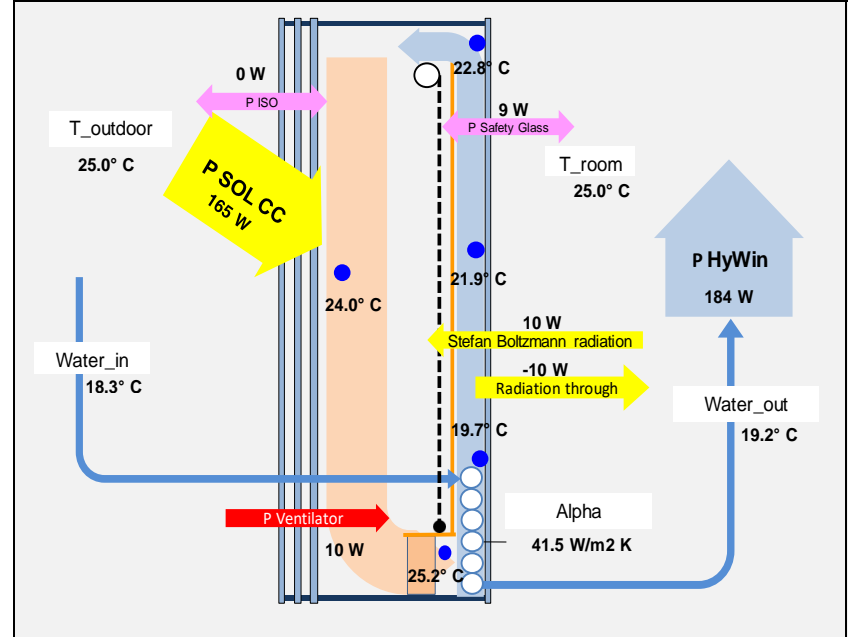
T_i_bottom	19.7 °C
T_a_bottom	25.2 °C
T_w_out	19.2 °C
Delta T water	0.92 K
Delta T air	5.51 K
Delta T water_air	3.72 K
Delta T i_room	3.15 K
Delta T a_outdoor	1.00 K
<b>Target Variables</b>	
Heatflow HyWin to air	184.28 W
Heatflow air to water	184.28 W
Heatflow watercooling	184.28 W
Energy balance Hywin to air	0.00 W
Energy balance air to water	0.00 W
Energy balance HyWinto water	0.00 W
<b>Elements of heat flow</b>	
P from sun radiation	165 W
P from fan	10 W
P from heat flow through isolating glass	0 W
P from heat flow through safety glass	9 W
P from visible light to room	-10 W
P from S.Boltzmann radiation outdoor safety glass	10 W
<b>P Total</b>	184 W
Check Balance	184.3 W

### Temperature Distribution in HyWin

Ti_bottom	19.7 °C
Ti_center	21.9 °C
Ti_Top	22.8 °C
Ta_bottom	25.2 °C

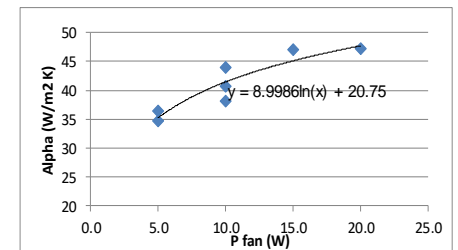
Mean air temp at heat exchanger	22.5 °C
Mean water temperature in heat exchanger	18.8 °C

### Graphics

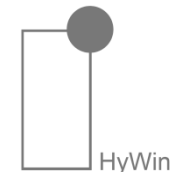


### Experimental Data

P fan (W)	air flow (l/s)	Alpha (W/m2 K)
5	21.2	34.7
5	21.1	36.3
10	27.8	38.1
10	28.3	40.6
10	28.5	43.9
15	33.7	46.9
20	37.3	47.2



# Energy balance on a monthly basis

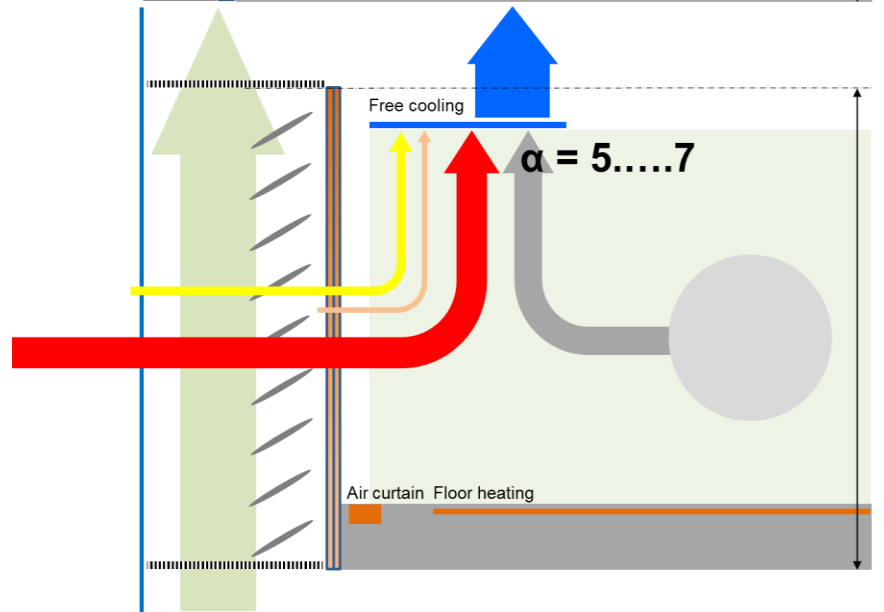
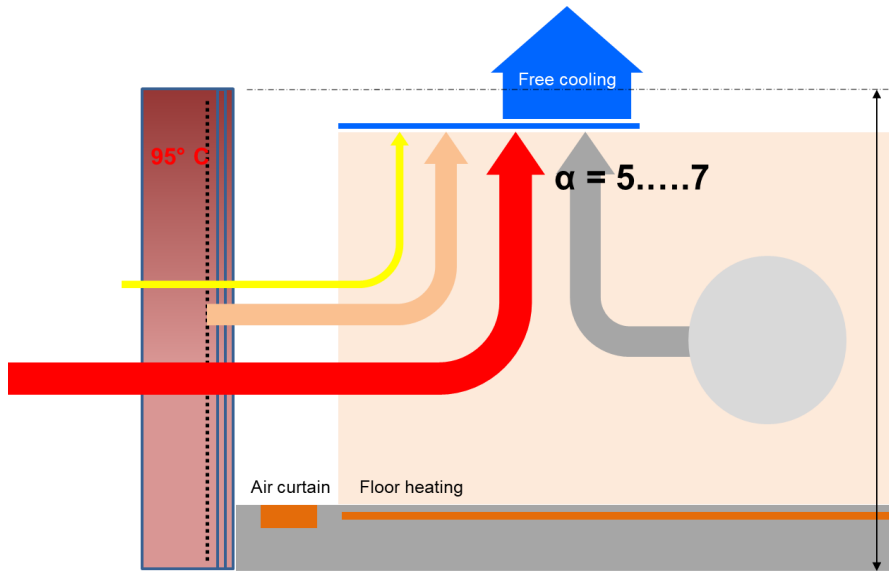
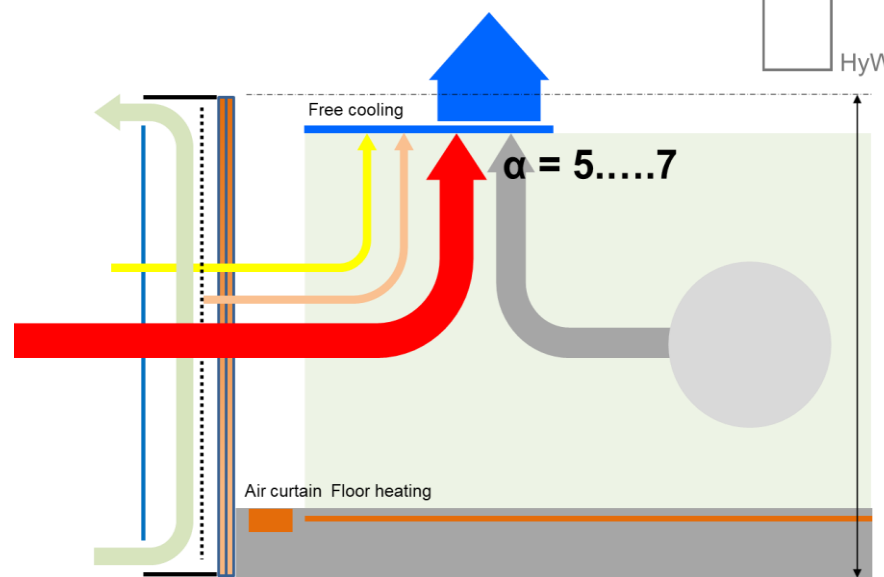
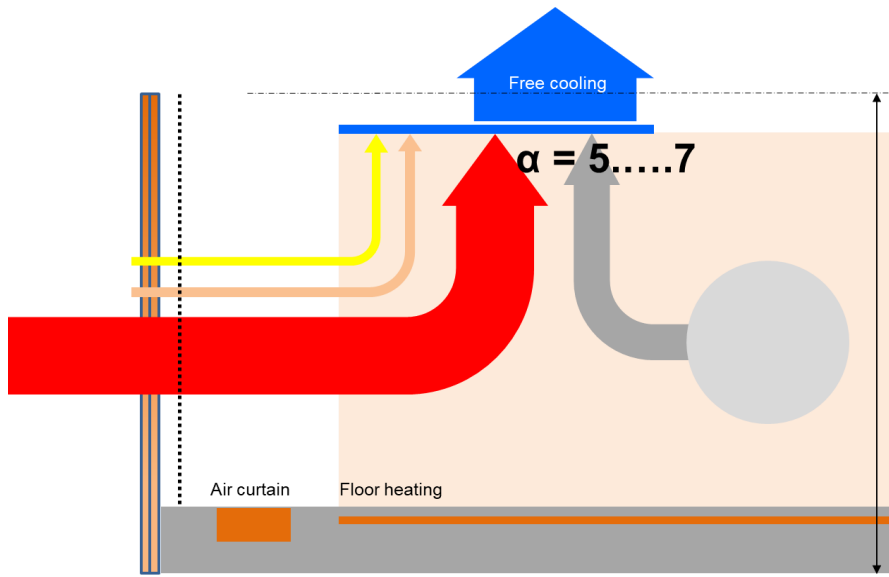


				Januar	Februar	März	April	Mai	Juni	Juli	August	Septem.	Oktober	Novem.	Dezem.	12 Mt				
Lufttemperatur Zürich (K = Klima)		TK	°C	0.4	1.6	5.5	8.4	13.4	16.2	16.4	16.4	14.0	9.9	4.2	1.6	9.00	Fassadenlänge	m	25.0	
Temperatur CC_ISO (A = Aussen)	2) Z4=Z3	TA	°C	21.18	21.85	22.37	22.98	23.43	23.95	24.47	23.89	23.31	22.77	22.31	21.75		Geschossfläche	BGF	m2	625
Zwischenresultat		TA	°C	21.87	22.30	22.49	22.76	22.85	23.16	23.70	23.13	22.79	22.60	22.59	22.29		Geschossfläche	NGF	m2	525
Temperaturdifferenz CC_ISO - CC_VSG		ΔTAI	K	-0.76	-0.64	-0.28	0.00	0.45	0.68	0.67	0.66	0.44	0.02	-0.51	-0.72		Anzahl HyWin Fenster pro Fassade	-		15
Temperatur CC_VSG (I = Innen)	1) Z31=0	TI	°C	22.63	22.94	22.77	22.76	22.40	22.48	23.03	22.47	22.35	22.58	23.10	23.01		HyWin Raster	Breite	m	1.667
Raumsollwert (R = Raum)		TR	°C	22.0	22.5	23.0	23.5	24.0	24.5	25.0	24.5	24.0	23.5	23.0	22.5		HyWin Raster	Höhe	m	3.40
																	Lichtmass pro HyWin Element	Breite	m	1.5
Speichertemperatur unbelastet (U)		TU	°C	10.00	9.00	8.00	7.00	6.30	6.50	7.00	8.00	9.50	10.50	11.50	12.00	11.00	Lichtmass pro HyWin Element	Höhe	m	2.85
Speichertemperatur belastet (B)		TB	°C	10.00	8.53	7.14	5.97	5.27	5.74	6.66	8.07	9.97	11.24	12.25	12.44	11.00	Transparente Fassadenfläche	m2	64.13	
																	Gesamte Fassadenfläche	m2	85.00	
Süden Direktstrahlung			kWh/m2vd	1.00	1.30	1.30	1.20	1.10	1.00	0.95	1.00	1.70	1.80	1.30	1.00		ISO (Dreifachverglasung)	U Wert	W/m2K	0.6
Süden Diffusstrahlung @ η	0.70		kWh/m2vd	0.50	0.70	1.10	1.60	1.80	1.90	2.05	2.10	1.40	0.70	0.30	0.30		Einfachverglasung innen	U Wert	W/m2K	6.0
Süden nutzbar pro Monat			kWh/m2vMt	40.5	53.7	62.1	69.6	70.8	69.9	71.6	74.1	80.4	68.7	45.3	36.3	743	Opake Elemente	U Wert	W/m2K	1.5
Südfassade nutzbar pro Monat			kWh/Mt	2'597	3'444	3'982	4'463	4'540	4'482	4'588	4'752	5'156	4'405	2'905	2'328		Interne Wärmequellen IQ	W/m2		30.0
Ost / West Direktstrahlung			kWh/m2vd	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.80	0.60	0.40	0.20		Belegungszeit	%		30
Ost / West Diffusstrahlung @ η	0.70		kWh/m2vd	0.40	0.70	1.10	1.70	2.20	2.20	2.10	1.60	1.30	0.80	0.40	0.40		Luftwechselrate	1/h		0.30
Ost / West nutzbar pro Monat			kWh/m2vMt	14.4	23.7	35.1	50.7	64.2	67.2	68.1	60.6	51.3	34.8	20.4	14.4	505	Solare Einstrahlung in die CC	g Wert		0.10
Ostfassade pro Monat			kWh/Mt	923	1520	2251	3251	4117	4309	4367	3886	3290	2232	1308	923		Solare Einstrahlung in den Nutzraum	g Wert		0.09
Westfassade pro Monat			kWh/Mt	923	1520	2251	3251	4117	4309	4367	3886	3290	2232	1308	923		Querschnittsbreite Luftkanal	m		0.10
Norden Diffusstrahlung @ η	0.70		kWh/m2vd	0.30	0.60	1.00	1.40	1.70	1.90	1.90	1.50	1.10	0.70	0.40	0.30		Geschwindigkeit Luftkanal	m/s		0.5
Norden nutzbar pro Monat			kWh/m2vMt	6.3	12.6	21.0	29.4	35.7	39.9	39.9	31.5	23.1	14.7	8.4	6.3	269	Speicherqualität	kWh/m3K		2.0
Nordfassade pro Monat			kWh/Mt	404	808	1347	1885	2289	2559	2559	2020	1481	943	539	404		Speicherhöhe pro Stockwerk	m		5.0
Alle Fassaden einer Etage pro Monat		E SOL	kWh/Mt	4'848	7'291	9'830	12'851	15'063	15'659	15'881	14'544	13'216	9'811	6'060	4'579	129'632	PV Fläche pro HyWin Element	m2		0.5
																	PV Effizienz	%		17.5
Interne Wärmequellen IQ		E IQ	kWh/Mt	3'402	3'402	3'402	3'402	3'402	3'402	3'402	3'402	3'402	3'402	3'402	3'402	40'824	Anzahl Fassaden	-	-	4
Energiefluss opake Bauteile (OP > Klima)		E OP	kWh/Mt	-1'948	-1'885	-1'578	-1'362	-956	-748	-776	-730	-902	-1'226	-1'695	-1'885	-15'691	Bruttogeschossfläche	BGF	m2	
Lüftungsverluste [1/h] > Klima		E AIR	kWh/Mt	-2'300	-2'225	-1'863	-1'608	-1'129	-884	-916	-862	-1'065	-1'448	-2'002	-2'225	-18'525	Closed Cavity	CC	-	
Energiefluss HyWin > N		E VSG	kWh/Mt	698	488	-255	-820	-1'773	-2'238	-2'183	-2'249	-1'828	-1'019	111	565	-10'505	Dreifach-Isolierverglasung	ISO	-	
Solare Einstrahlung im Nutzraum		E SOL N	kWh/Mt	145	219	295	386	452	470	476	436	396	294	182	137	3'889	Energie	E	kWh	
Bilanz Nutzraum N		E N	kWh/Mt	-2	-2	1	-2	-3	1	4	-4	4	3	-2	-5	-8	Interne Wärmequellen	IQ	-	
Energiefluss Nutzraum > HyWin		E VSG	kWh/Mt	-698	-488	255	820	1'773	2'238	2'183	2'249	1'828	1'019	-111	-565	10'505	Kompensierende Wärmenutzung	KW	-	
Strahlungseintrag		E SOL CC	kWh/Mt	485	729	983	1'285	1'506	1'566	1'588	1'454	1'322	981	606	458	12'963	Luftdichte		kg/m3	1.18
Energiefluss Klima > HyWin (ISO)		E ISO	kWh/Mt	-2'303	-2'244	-1'869	-1'616	-1'111	-859	-894	-830	-1'032	-1'426	-2'007	-2'233	-18'423	Monat	Mt	h	720
Ventilator		E FAN	kWh/Mt	180	150	130	100	150	240	280	240	150	100	150	160	2'030	Nettogeschossfläche	NGF	m2	
Bilanz HyWin		E HyWin	kWh/Mt	-2'336	-1'852	-501	589	2'318	3'185	3'157	3'114	2'268	674	-1'362	-2'180	7'075	Nutzraum	N	-	
Wärmeübertrag durch Wärmetauscher		E HyWin	kWh/Mt	-2'336	-1'852	-501	589	2'318	3'185	3'157	3'114	2'268	674	-1'362	-2'180	7'075	Nutzungsgrad Diffusstrahlung	η	-	
Speicherentladung WW		E WW	kWh/Mt	-590	-590	-590	-590	-590	-590	-590	-590	-590	-590	-590	-590	-7'080	Opaker Fassadenanteil	OP	m2	
Kompensierende Wärmenutzung		E KW	kWh/Mt	0	0	0	0	0	0	0	0	0	0	0	0	0	Photovoltaik	PV	-	
Bilanz Storage		E STO	kWh/Mt	-2'926	-2'442	-1'091	-1	1'728	2'595	2'567	2'524	1'678	84	-1'952	-2'770	-5	Storage (Energiespeicher)	STO	-	
Photovoltaik Produktion N, O, S und W		E PV	kWh/Mt	99	149	201	263	308	321	325	298	271	201	124	94	2'653	Tag (day)	d		
																	Verbundsicherheitsglas	VSG	-	
																	vertikale Fläche	v	-	
																	Warmwasserbereitung	WW	-	
																	Wärmekapazität Luft	cp	Ws/kgK	1005

Alle Monatsmittelwerte sind lediglich Durchschnittswerte.  
 Tagesspitzen können extrem stark nach oben resp. unten ausschlagen.

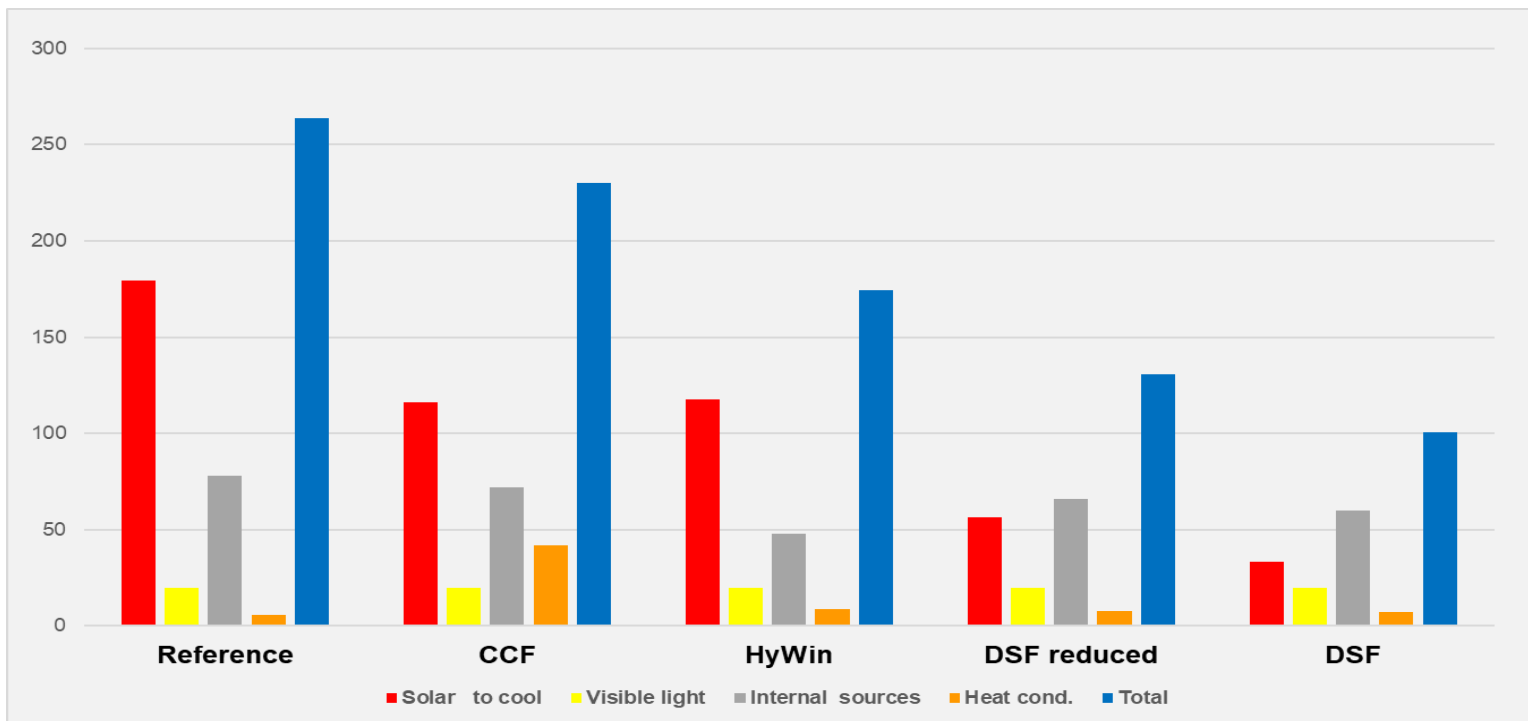


# Comparison

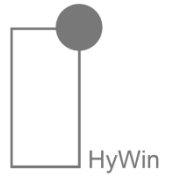


# Five Façades - Components of power

	W	-	-	-		W	W	W/m <sup>2</sup>	m <sup>2</sup>	-	W	K	W/m <sup>2</sup> K	W	W
	Solar vert.	g <sub>WIN</sub>	sun shield	shadow factor	g <sub>TOT</sub>	Solar to cool	Visible light	EBF	EBF	skin factor	Internal sources	ΔT	Lambda	Heat cond.	Total
Reference	700	0.3	0.90	0.95	0.257	180	20	30.0	2.0	1.3	78	10	0.6	6	264
CCF	700	0.3	0.65	0.85	0.166	116	20	30.0	2.0	1.2	72	70	0.6	42	230
HyWin	700	0.3	0.70	0.80	0.168	118	20	30.0	2.0	0.8	48	15	0.6	9	175
DSF reduced	700	0.3	0.30	0.90	0.081	57	20	30.0	2.0	1.1	66	13	0.6	8	131
DSF	700	0.3	0.20	0.80	0.048	34	20	30.0	2.0	1.0	60	12	0.6	7	101



# Additional cost and cost reduction



## HyWin additional cost compared to CCF

- Additional Glass separating level per **m<sup>2</sup> façade**
  - Heat exchanger, fan, electronic unit, connectors per **m façade**
- Additional cost per m<sup>2</sup> facade**

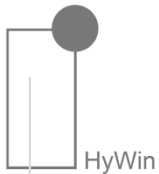
CHF 40  
CHF 550  
CHF **190**

## HyWin cost reduction compared to CCF

- Dry air per **m<sup>2</sup> facade**
  - Free Cooling per **m<sup>2</sup> net floor space**
  - Floor heating per **m<sup>2</sup> net floor space**
  - Zone regulation per **m<sup>2</sup> net floor space** (w/o room controllers)
  - Trench heating/cooling per **m façade** (Luftvorhang)
- Cost reduction per m<sup>2</sup> facade**

CHF 5  
CHF 50  
CHF 50  
CHF 10  
CHF 120  
CHF **210**

**Building:** Footprint building 25 m x 25 m = 625 m<sup>2</sup>, façade perimeter 4 x 25 m = **100 m**, usable space = **525 m<sup>2</sup>**  
**Façade structure:** horizontal: 1.66 m, vertical 3.4 m, one façade element **5.64 m<sup>2</sup>**, façade surface per floor **340 m<sup>2</sup>**  
**Energy price:** 0.20 CHF/kWh



Introduction barrier (HLK is part of facade)

Power to be removed by cooling

Net available floorspace

Total Investment

Energy savings, energy mgmt, response time, geothermal probe regeneration

Comfort

■ HyWin ■ DSF ■ CCF ■ Reference

*Others are better*

*HyWin is best in class*

**Best in class**