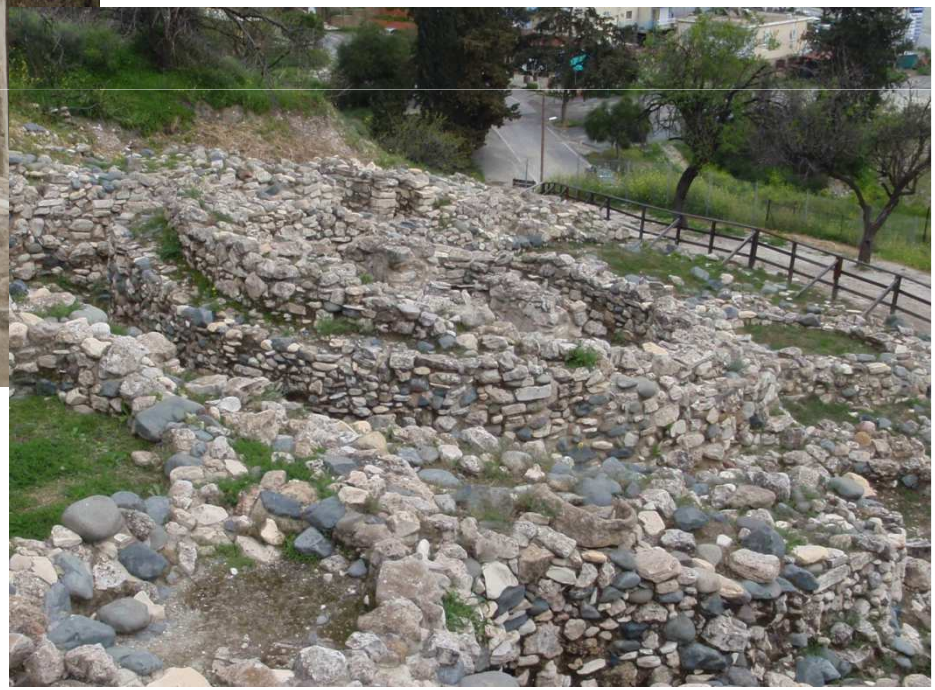
Simple and Economic Passivhauses
Project Examples

Arguments for Energy Efficient Buildings: History and Mission, Customized Design - CYPRUS - 6000 BC

Climate-friendly, resource-saving circular design, double skin brickwork, lots of storage mass, reduced to the optimum apertures, effective insulation and cooling grass roof



Bretzke 2012

Building Bronze Age 1400 BC, Isolation Steinheile, hill near Langenselbold, Main-Kinzig-Kreis, Germany

Bronze Age, reconstructed double wall with grass filling (~ 0,2 m) and daub.

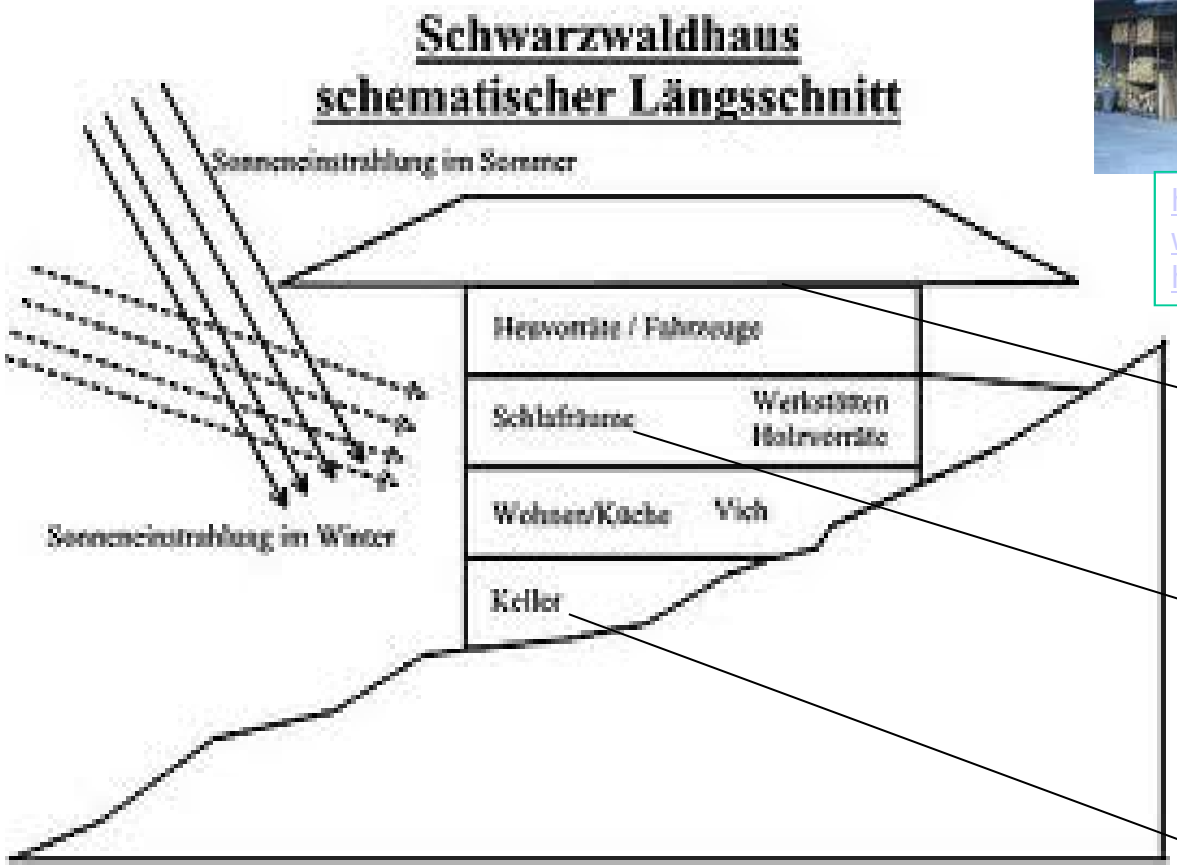
U_{AW} ~ 0,5 W/m²K,

UK standard 19 . .:	$U_{AW} \leq ?$
UK standard 20 . .:	$U_{AW} \leq ?$
Windows:	$U_W \leq ?$

Source: Dr. H.-O. Schmitt, Staeves, Irene, u.a. in "Ein Energiesparhaus vor 3500 Jahren“

Energetic and User – Customized Design in the Middle Ages. . .

http://www.schwarzwald.com/typisch/schwarzwaldhaus.html
http://de.wikipedia.org/wiki/Schwarzwaldhaus



1- 5 m hay Seasonally adjusted super insulation

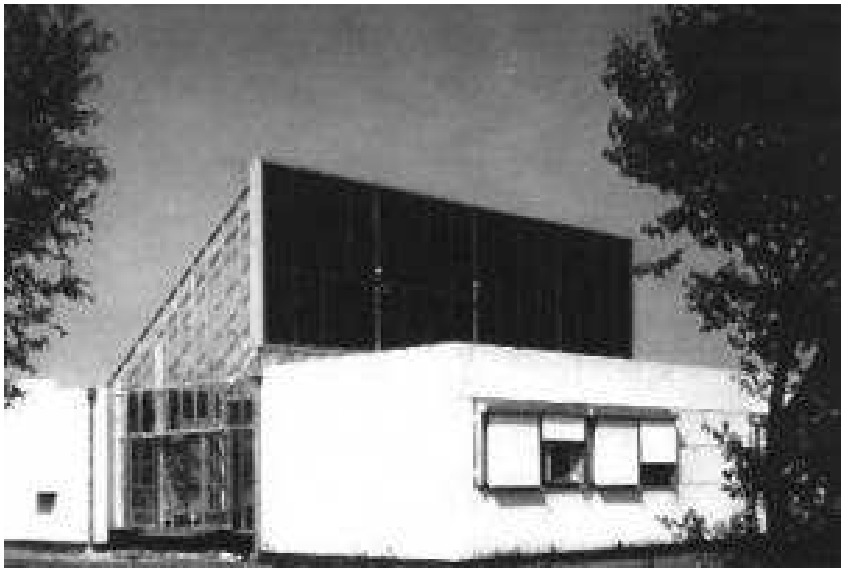
Cooler sleeping and working space, living area with internal heat source cattle

Cool damp cellar for food and as decoupling living area

Fram, First PassiveHouse-ship in 1883, DTH Zero - Energy house in 1973

The walls are covered with tarred felt, it follows cork filling, then a wainscoting of fir wood, then again a thick layer of felt, then air-tight linoleum, and finally again a wainscot. The ceiling ... they have all in all, a thickness of about 40 cm. The window through which the cold could very easily penetrate, was protected by **three panes** and in other ways. (Here) is a warm, cozy place to stay.

Fridtjof Nansen



Korsgaard et al 1978 DTH-Nul-Energihus; Technical University of Denmark, 1978

Source: http://passipedia.de/grundlagen/anmerkungen_zur_geschichte

Erweiterung der Realschule Mölln im Passivhaus-Standard

Architektonische und technische Umsetzung - erste Betriebserfahrungen

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www.kaplus.de

Erweiterungsbau und Bestandsgebäude der A.-Paul-Weber Realschule in Mölln

Second PH - School Waldshut Energy - Saving School 2003 Labarotories

Volker Weiß und Dr. Wilhelm Stahl
Stahl, Büro für SonnenEnergie
Bertoldstr. 45, 79098 Freiburg
T: 0761 / 38909-30, F: 0761 / 38909-39
www.stahl-sonnenenergie.de

Ansicht der Justus-Liebig-Schule in Waldshut, Bauzustand November 2002

First Passivhaus-school with Kindergarden Frankfurt – Riedberg 2004

From SW

First PH-School Frankfurt – Riedberg 2004

Entrance at the North Corner

First PH-School Frankfurt – Riedberg 2004

Schoolyard

What Does a Highly Energy-efficient Building Need?
No Complex Building Concept!

- Reduce influence from out- and inside on room conditions, PH is simpler and gets better economy with better adopted construction
- More insulation from 5 to 30 cm (wall-roof, 0,032 W/mK) depend on climate
- typical triple glazing windows (U_w 0,8 instead of 1,3 W/m^{2}K), not more than necessary for lighting, much heat/cold storage mass
- Mechanical basic ventilation (20 m^3/h per person, only frech air)
- Vent heat recovery > 75% and efficiency (SFP 1-2 acc. EN 13779 ~ 0,45 Wh/m^3), relation of electricity for recovery to heat/cold 1:10, Moisture and odor removal only with exhaust air,
- Airtight construction (as standard, but more careful execution)
- Fewer, smaller simply technical systems, substantially (x 1/5) smaller heating and cooling system (10W/m^2)
- Control is simplified (thermostatic valve, time control, more is often not efficient) with much better user acceptance, heating/cooling costs negligible

Primary School Riedberg, Ffm, Results

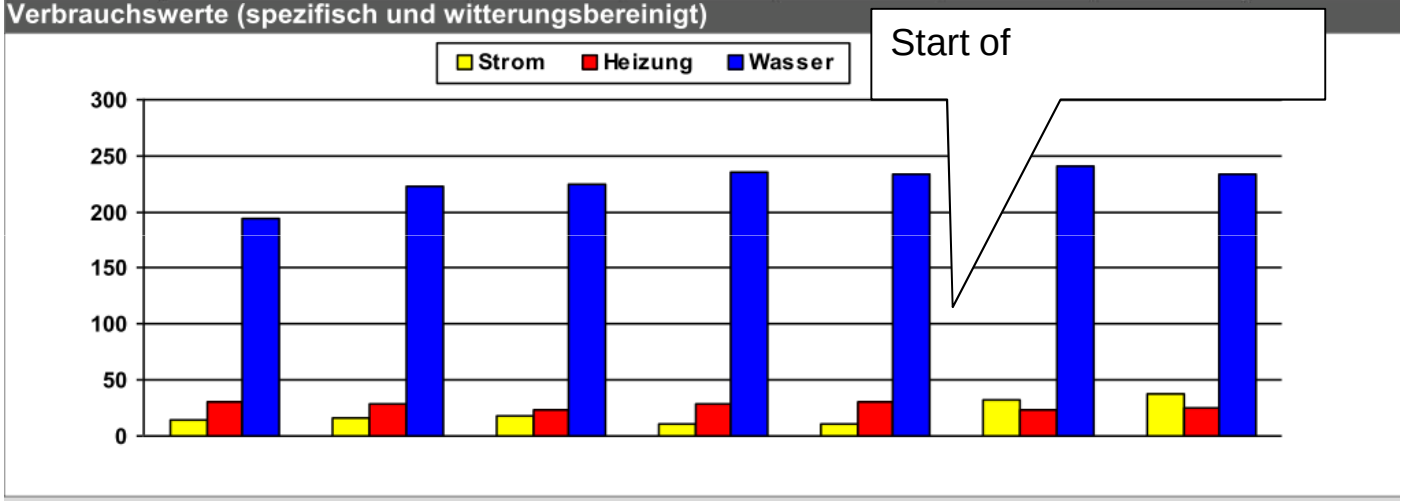
Verbrauchswerte und Kosten aus EVU-Rechnungen

Gebäude	Grundschule Riedberg und KT		Bauherrenamt	40.4	Dez 4
Straße, Nr.	Zur Kalbacher Höhe	15	Stadtbezirk	650	OBZ 12
Nutzung	Grundschulen		Bauwerkzuordnung		4110

Nettogrundfläche (beheizt)

	2007	2008	2009	2010	2011	2012	2013	
NGF (beh.)	7.670	7.670	7.670	7.670	7.670	7.670	7.670	m²

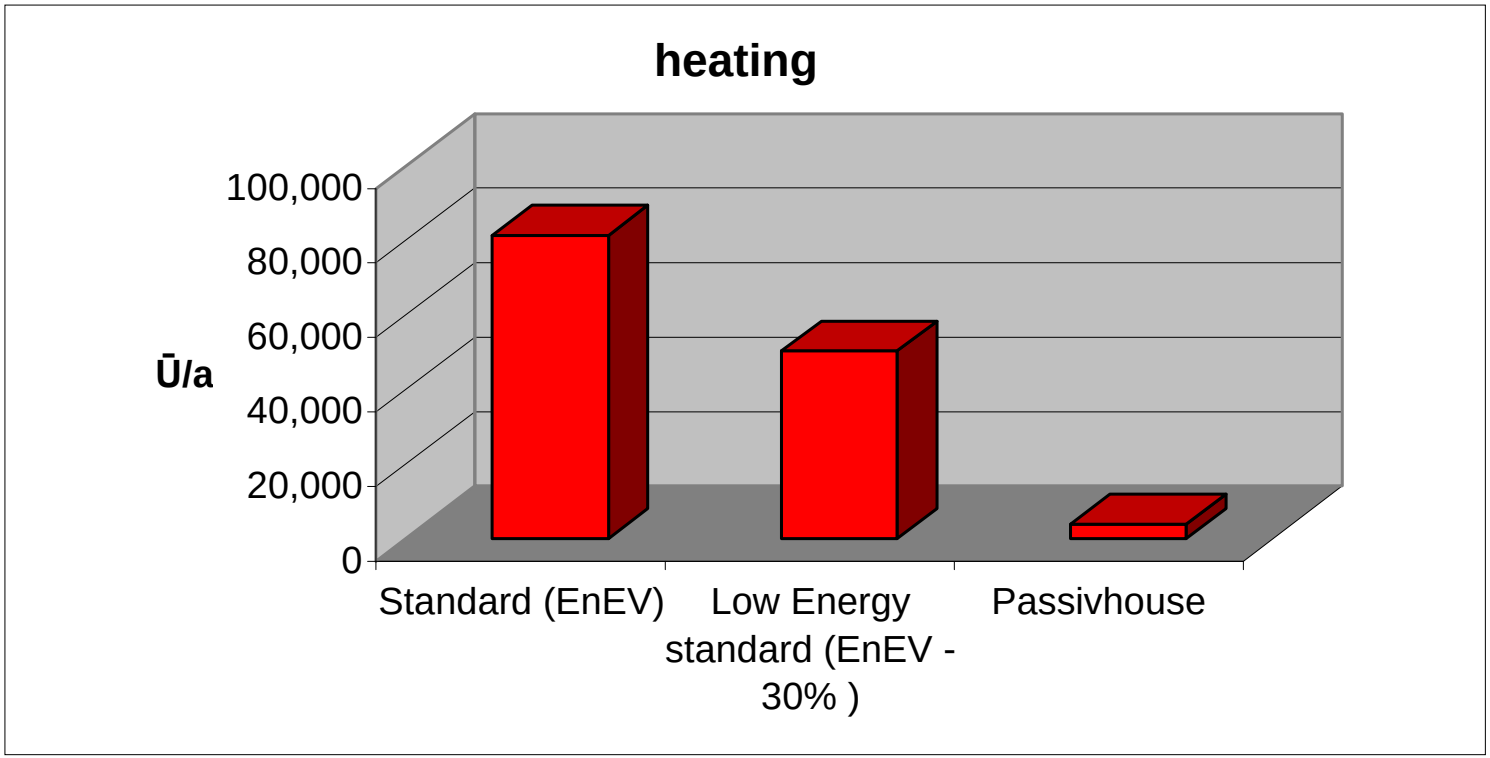
Verbrauchswerte (spezifisch und witterungsbereinigt)



	2007	2008	2009	2010	2011	2012	2013	
Strom	15	17	17	10	10	32	38	kWh/m²a
Heizung	31	28	23	28	30	23	26	kWh/m²a
Wasser	195	223	226	235	234	240	233	l/m²a
Strom	22.129	25.855	26.789	19.488	18.982	56.106	72.302	€/a
Heizung	9.423	7.747	6.429	10.331	8.780	7.067	9.725	€/a
Wasser	5.678	6.496	6.566	6.850	6.851	5.214	5.625	€/a
Summe	37.230	40.098	39.784	36.669	34.613	68.387	87.652	€/a

Red: heating+ ww

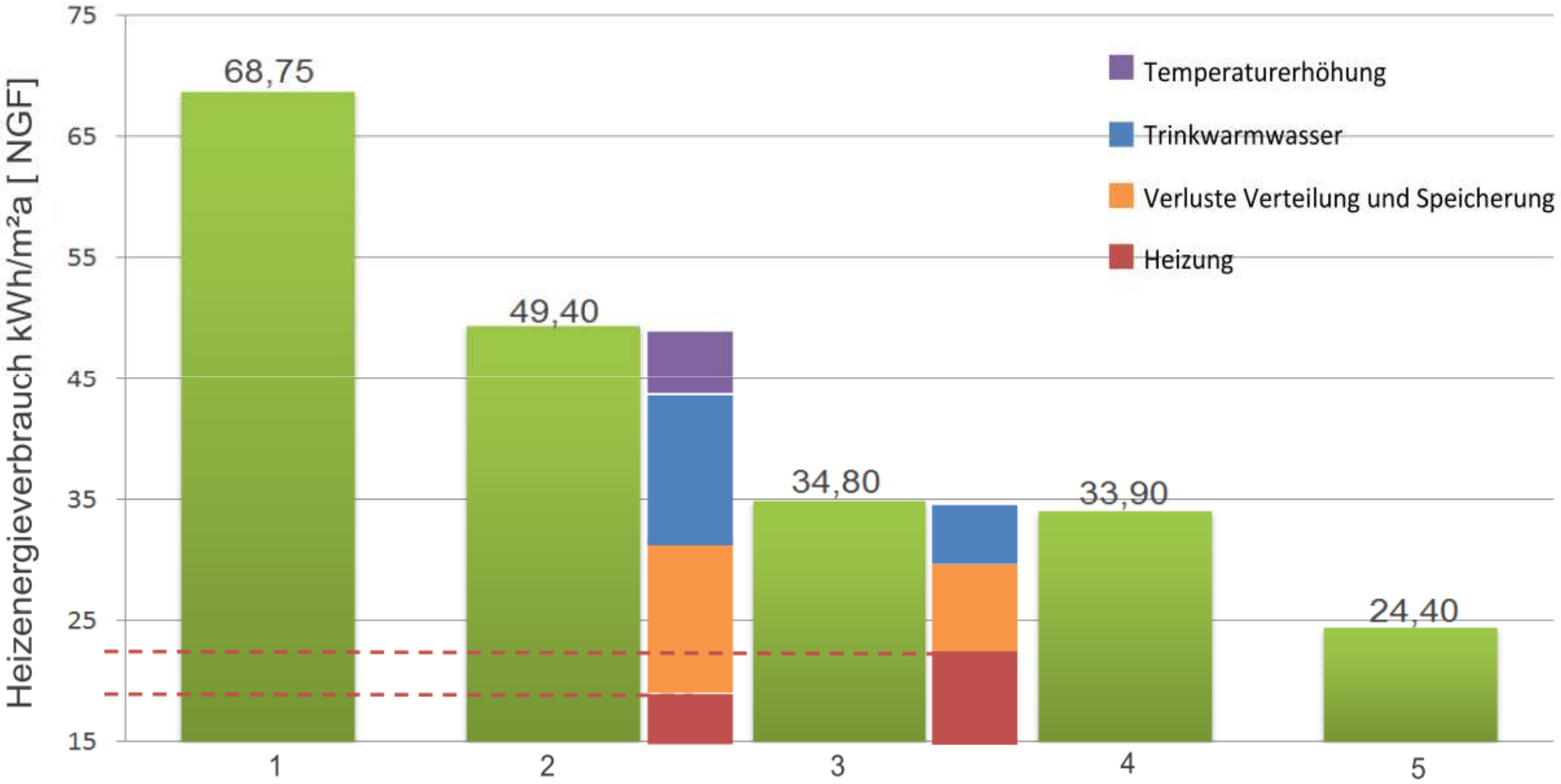
Heating Costs for Primary School at Preungesheim



reduced energy-costs over lifetime = amount to pay more for PH-quality:

$$\text{value}_{\text{Standard (kWh/m2a)}} \times \text{value}_{\text{PH(15kWh/m2a)}} \times \text{GFA}_{\text{(m2)}} \times \text{energyprice}_{\text{(€/kWh), Ø40a!)}} \times \text{lifetime}$$

Quality-check - Low To Optimal - Results To Final Energy



1: Kindergarten Schwanheim; 2: Kindergarten Altkönigsblick/Mobilé; 3: Liesel- Oestreicher-School; 4: gym Bonifatiusschule; 5: primary school Riedberg . www.energiemanagement.stadt-frankfurt.de/

Additional Investment Result for PH - Quality, Compilled for a (Low Energy) Grant for the Riedberg Primary School, No Real Additional Costs

Component	nett	design 18%	tax	Comments
footing	43.900	7.900	8.300	insulation
facade	124.800	22.500	23.600	2160 m^2, insulation and structure
windows, glazing	137.000	24.700	25.900	1780 m^2, PH-glazing, 75-100€/m^2
suspended ceiling	47.700	8.600	9.000	2560 m^2
roof	148.500	26.700	28.000	3600 m^2 , insulation
ventilation, heating	156.700	28.200	29.600	3 extra ventilation plants, but less heating and central building control
Total	**658.600**	**118.600**	**124.400**	**approx. 900.000 €**
Part				5.3 % of 16.7 million €

(First architectural Design: 25 mio €)

Montessori Primary and Secondary School in Aufkirchen (Munich) 2004, No Additional Costs in Relation to Bavarian Standard

www.architekten24.de/projekt/montessorischule-aufkirchen

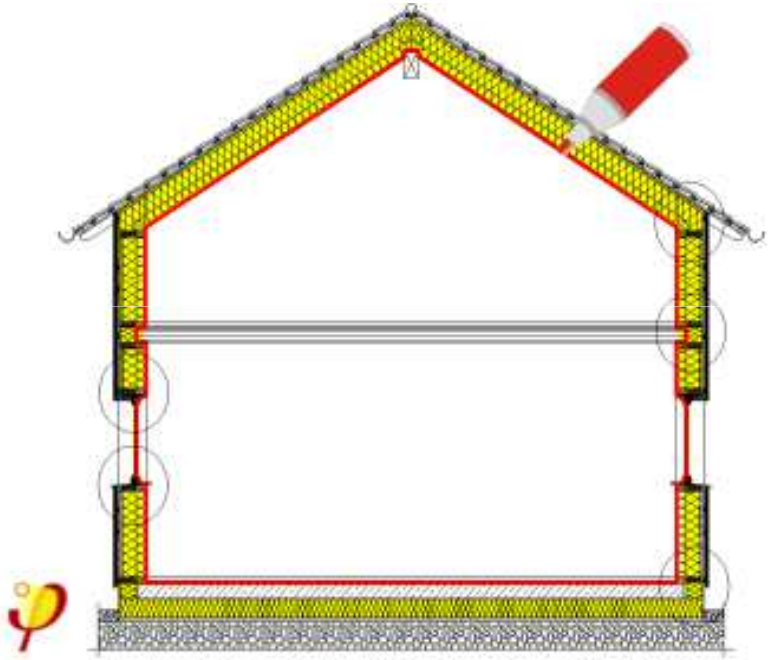
Components , What Additional Invest? German Window Market

Offer in german building stores 2008/2010:
“Get triple glazing for the price of double”

Window market 2013:	Ug > 1,1	0%;
Germany	1,1 < Ug < 0,8:	45%,
	Ug < 0,8:	55%

VFF: Mehr Energie sparen mit neuen Fenstern

Isolation, 10 cm More, Not Expensive, Good Comfort!



Maße in mm	Stärke in mm	Art-Nr.	Pack	entspr./ m²	(Pal.-Abn.) Pack	(Pal.-Abn.) entspr./m²
4.400 x 1.200	140	*8761644*	**44.45** (5,28 m²)	8.42	**39.95**	(18 Pack) 7.57
3.900 x 1.200	160	*8761645*	**44.65** (4,68 m²)	9.54	**39.95**	(18 Pack) 8.54
3.500 x 1.200	180	*8761646*	**45.15** (4,20 m²)	10.75	**39.95**	(18 Pack) 9.51
3.100 x 1.200	200	*8761641*	**43.95** (3,72 m²)	11.81	**39.75**	(18 Pack) 10.69
2.800 x 1.200	220	*8761642*	**44.25** (3,36 m²)	13.17	**39.95**	(18 Pack) 11.89
2.600 x 1.200	240	*8761643*	**44.95** (3,12 m²)	14.41	**39.95**	(18 Pack) 12.80

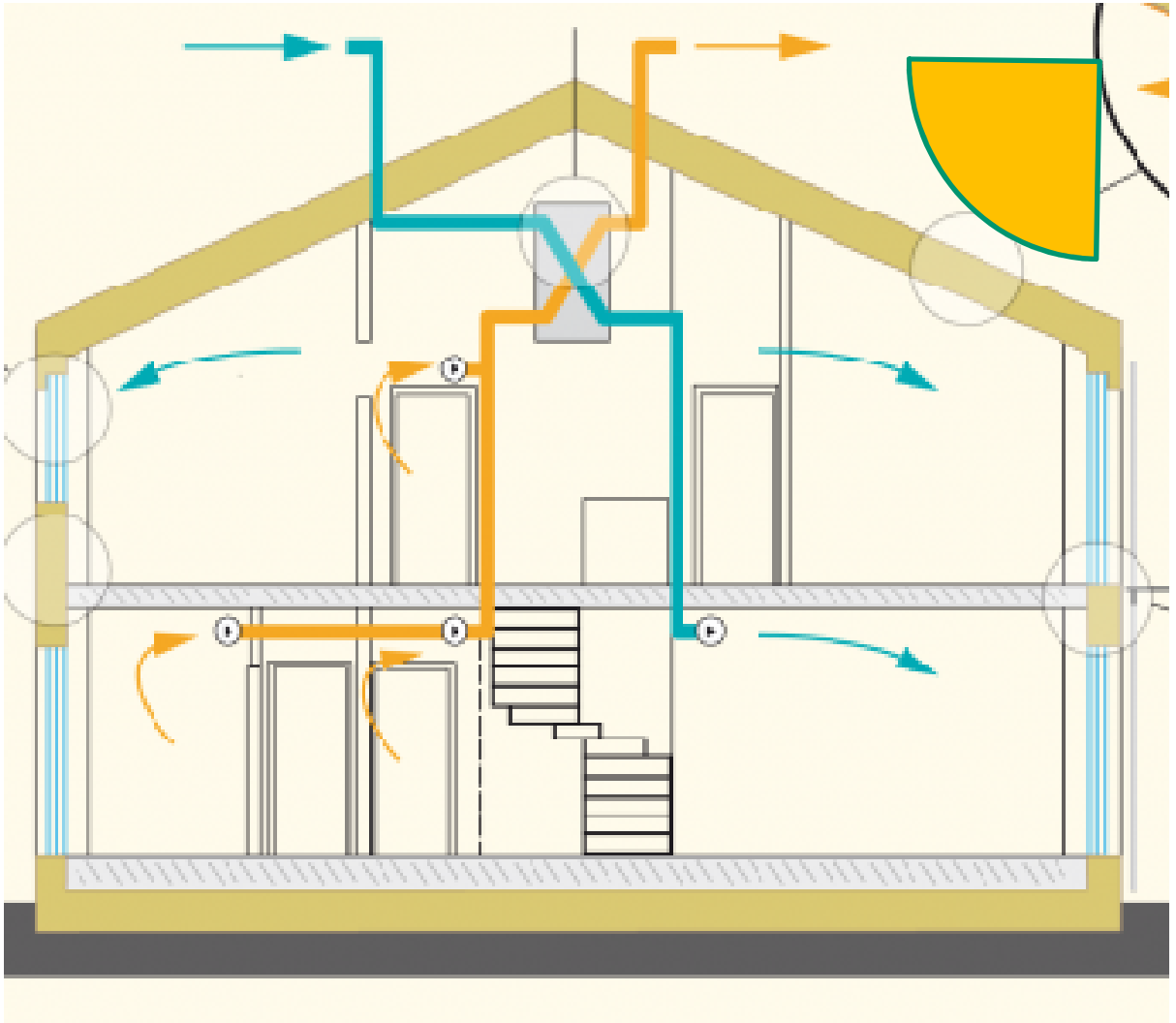
www.passipedia.org/planning/thermal_protection

about 60 €ct /cm/m²

Mechanical Ventilation As Simple As Possible, 20-30 m³/hP

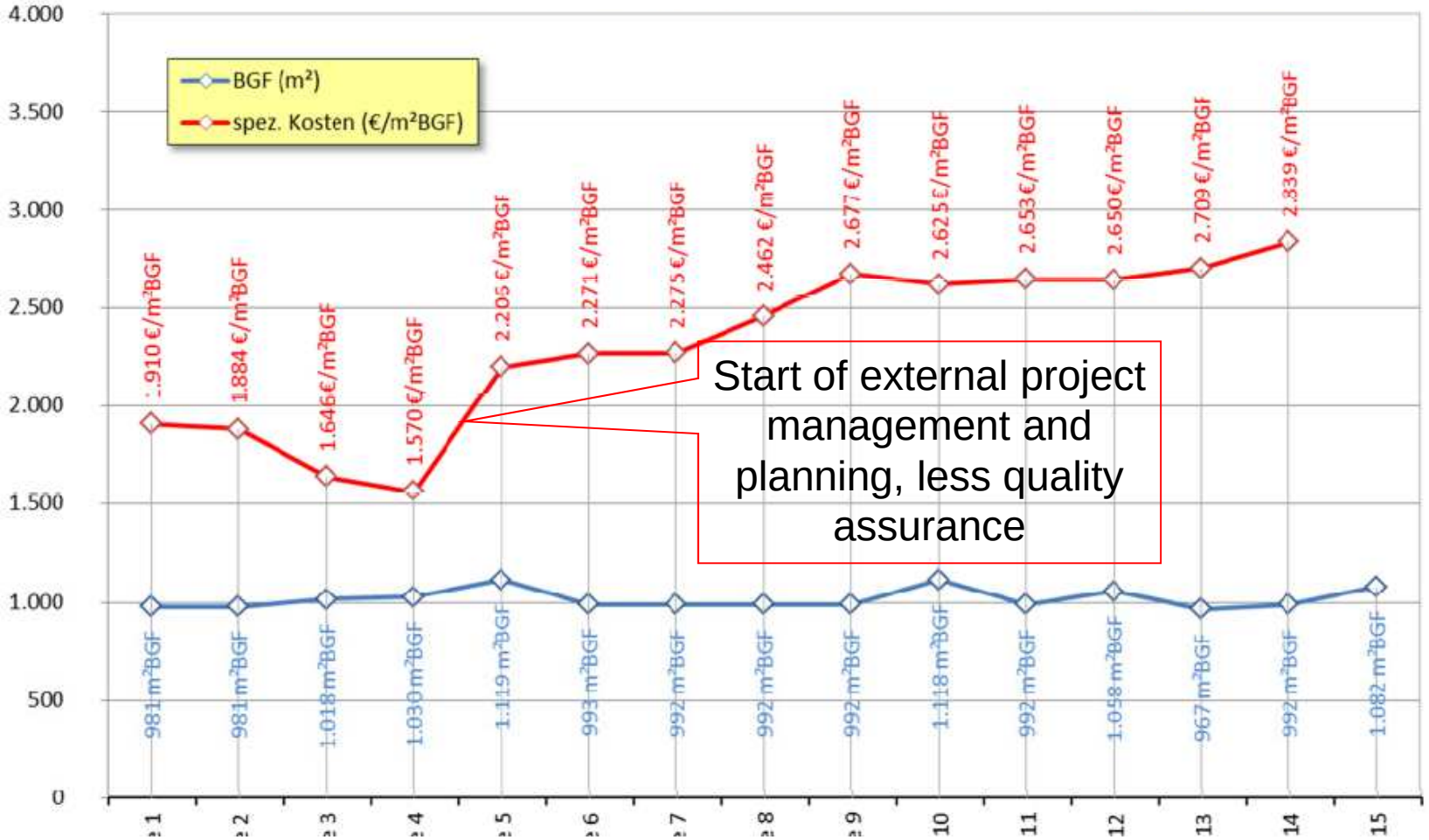
Running only during heating and cooling season (very short in PH), most of the year window-ventilation, even in winter with some more friends in the house a.s.o.!

www.passipedia.org/_detail/picopen/5ph_grundprinzipien_07.png?id=basics

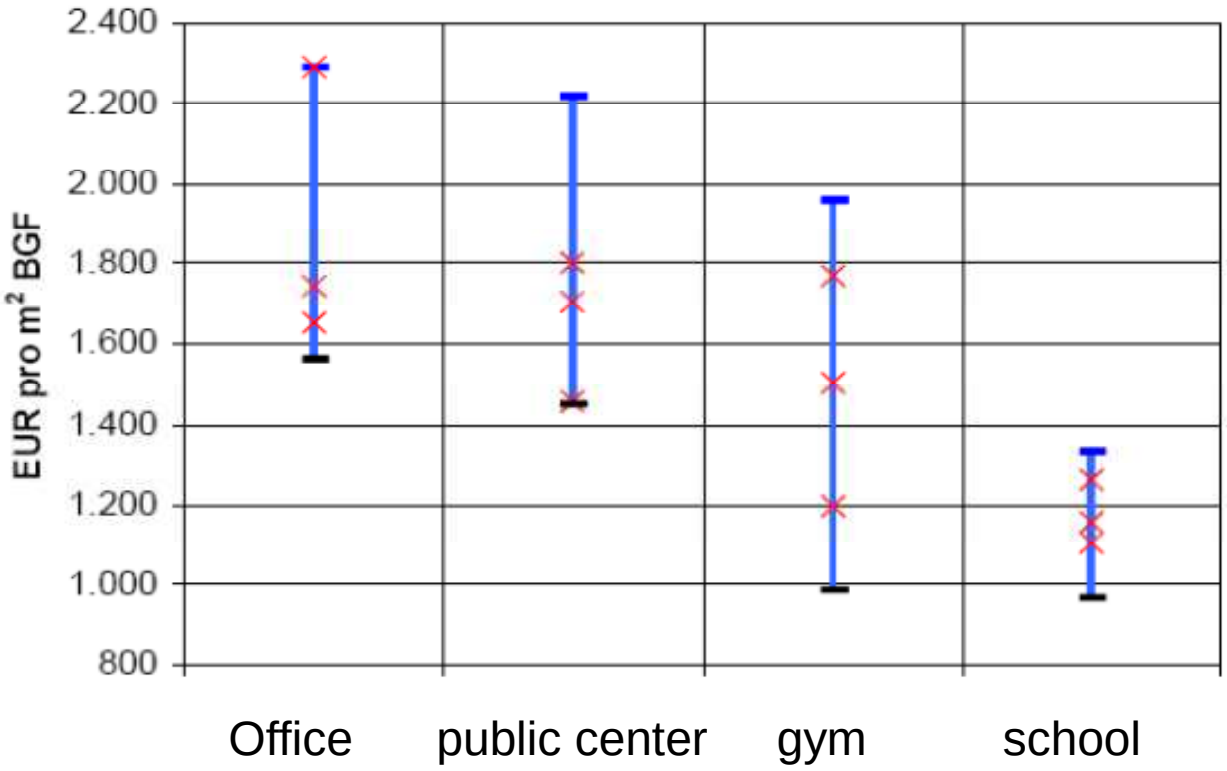


Influence Of Project Management, Tender Time and Lack Of Quality Assurance On Spec. Invest (for PassiveHouse Gym)

Cost group 300 + 400, €/m² total floor area



Range of Specific Capital Costs for Different Architectural Designs for the Same Building Task In €/m² in Relation to High Energy Efficient Additional Costs (Evaluation Of Competitions, Ebök 2004)



Relation:Additional investment for PH . .

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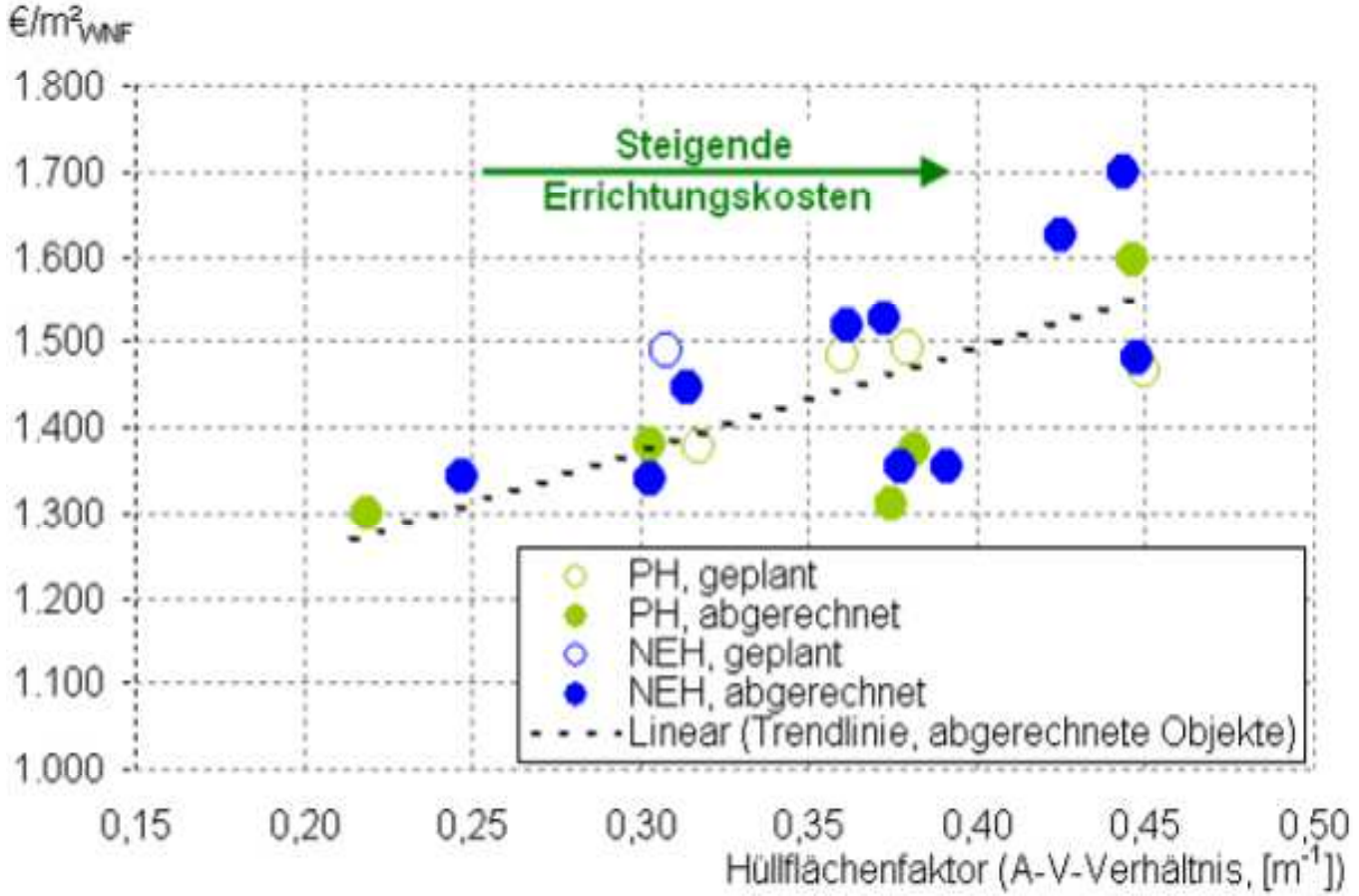
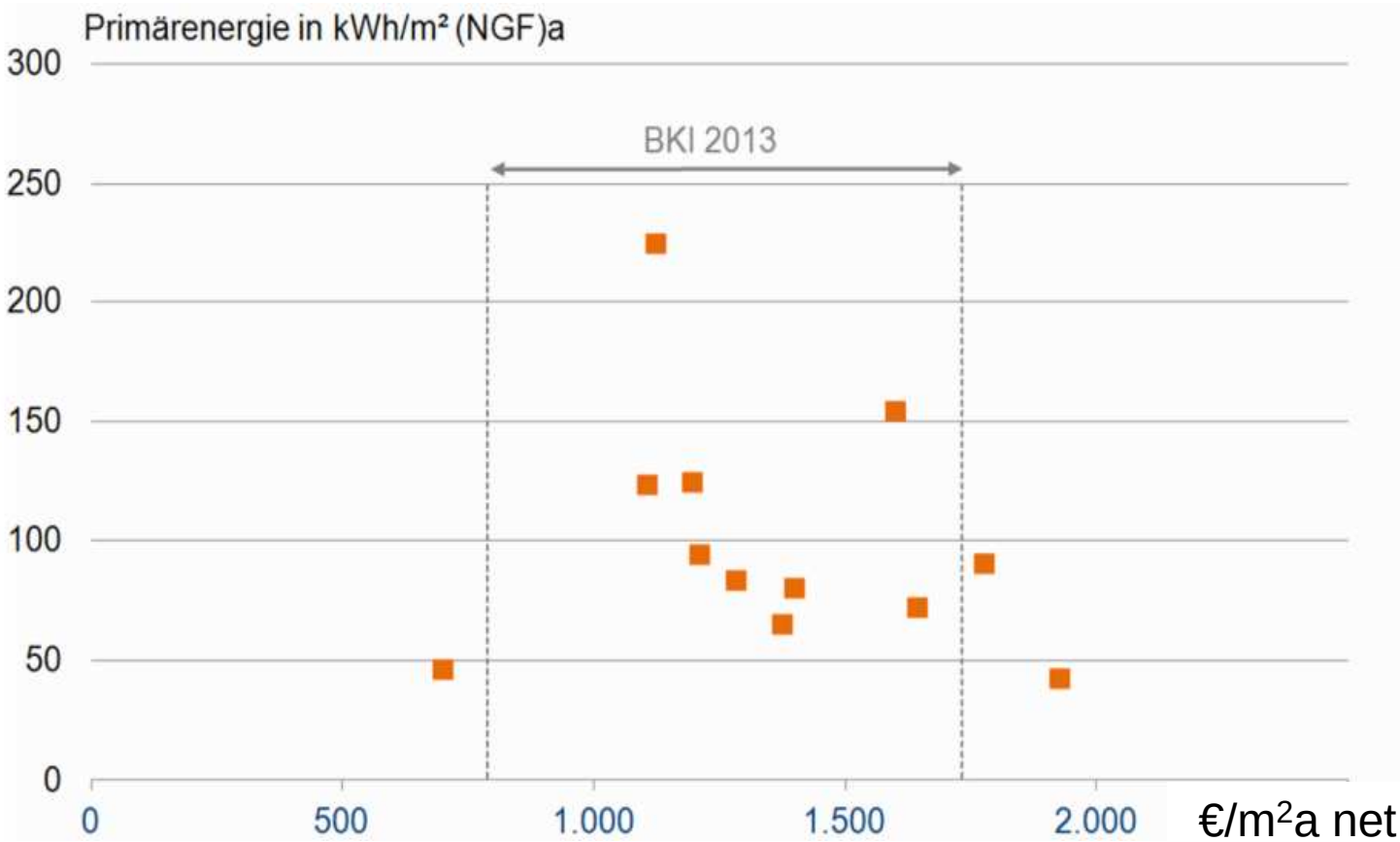
Compactness and Building Costs, Comparing Normal Low-energy (NEH) and Passivhauses, Quality and their Assurance Pays - Efficient is Cheaper!



Univ. Prof. Arch. DI Dr. Martin Treberspurg, DI Roman Smutny, DI Roman Grünner ANALYSE DER BENUTZER-ZUFRIEDENHEIT UND ENERGIEPERFORMANCE ausgewählter Wiener Passivhaus-Wohnhausanlagen, Reader 14. Internat. PH-Tagung Dresden 2010

Energy - Optimized Office Building (ENOB) - Net Construction Costs (300 + 400) In Relation to Primary Energy Consumption

"It is therefore recommended to give up the identification and designation of energy-related costs"



Aus: Lützendorf u.a.: Baukosten von energetisch optimierten Bürobauten, ENOB, 2014

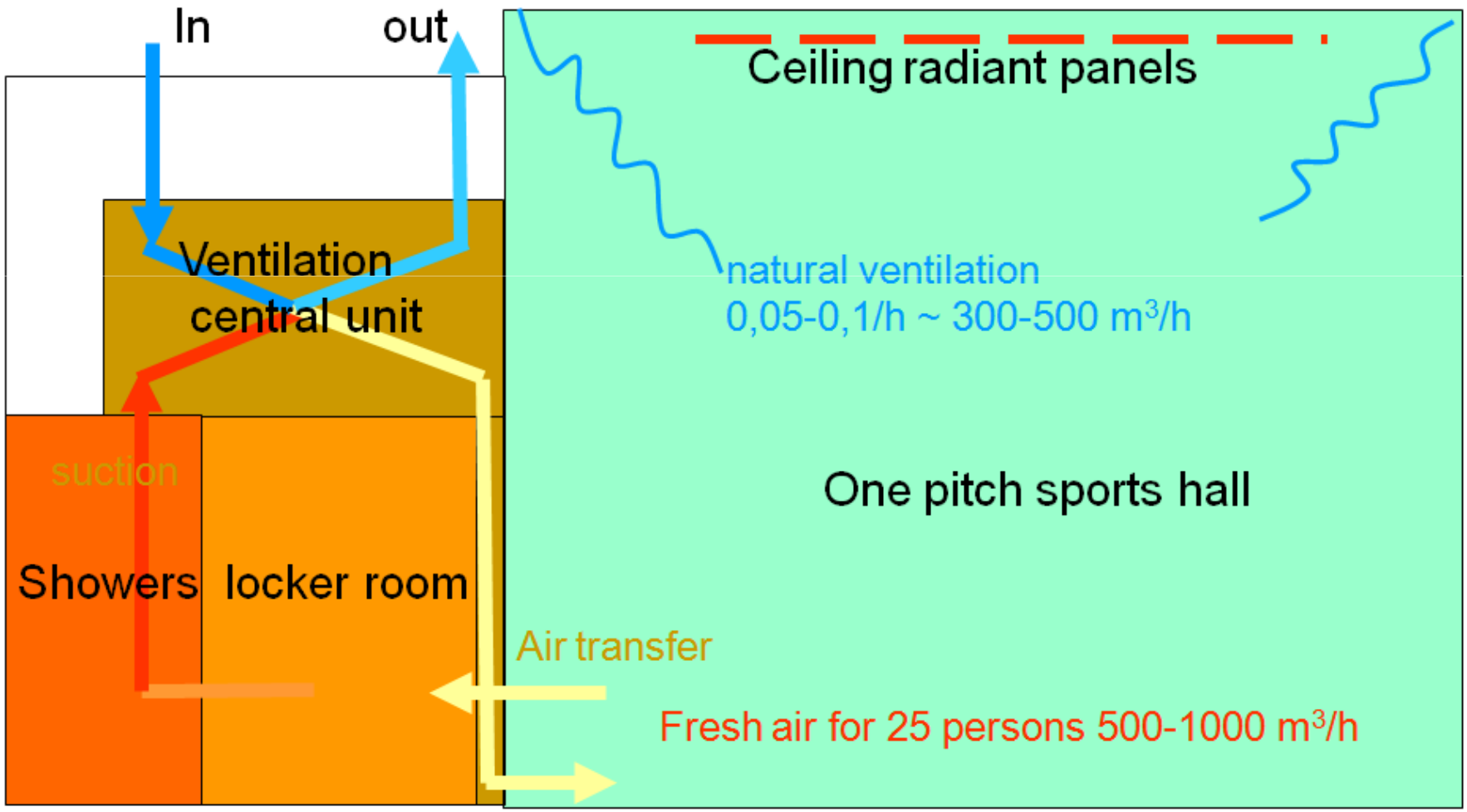
What‘s the problem?

- Higher profits per building with complex solutions and systems for industry and planning, export model Europe is expensive, complex technology
- Missing insight of industry and planning for the possibility for significantly higher revenues by significantly simpler, more acceptable systems for young and old instead of expensive solutions for a few
- Complex systems mean a lower risk of copying in contrast to simple and inexpensive solutions
- Missing incentive for simple solutions in the promotion by industry and public sector cause of pretended not innovative approaches
- Complex solutions are used for planning errors other trades
- Missing mainstream in the culture for the small and simple as a challenge for science and technology, wasteful is "in" (SUV instead of Tesla)
- Missing quality assurance in education, planning and workmanship, not only in high energy efficient buildings. Here it is even more striking . . .

Examples for Simple Solutions
Simple and Cheap Ventilation System

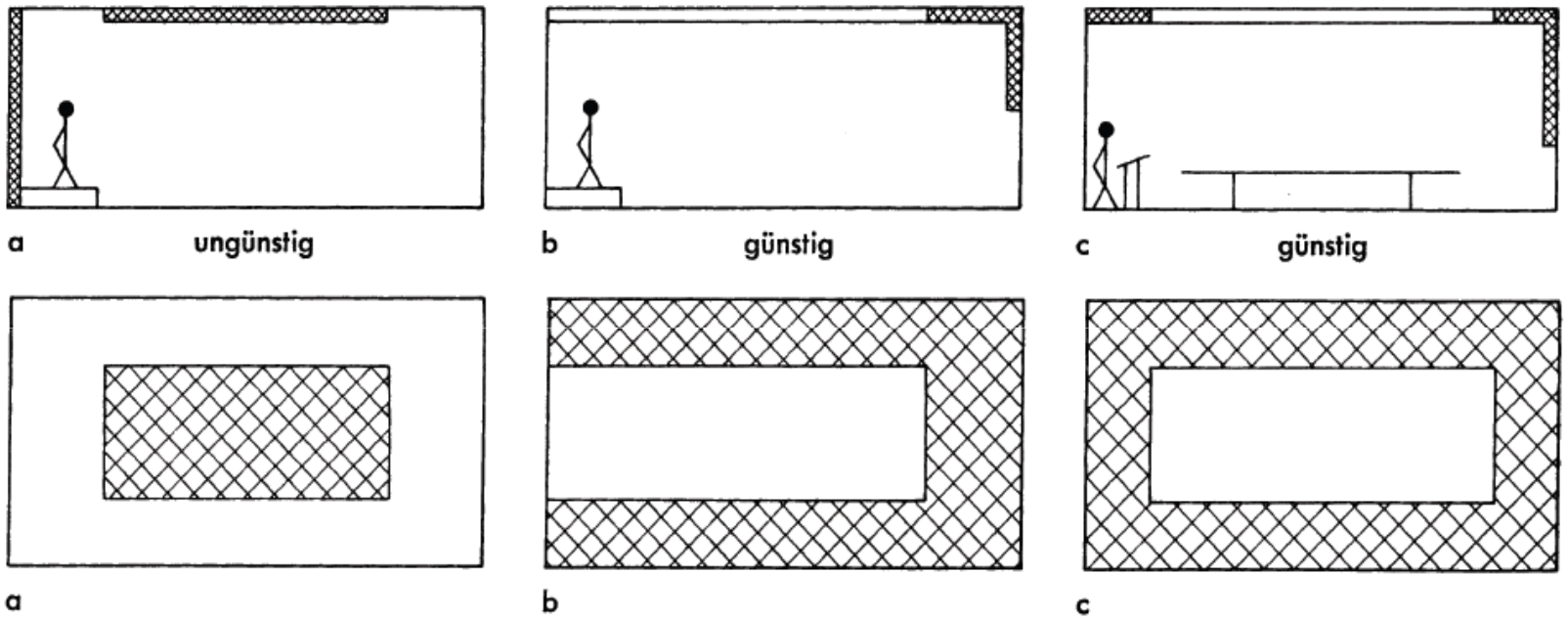
- The building services engineer and architect must coordinate planning the system for rooms, with provision for fresh ingoing and outgoing exhaust air and optimising the space for ducts.
- Calculate the plant and air volume only for the air that is absolutely necessary to meet the requirements (e.g. size systems to provide the fresh air requirements for the user only: so for 500 people, provide for 20 m^3/h each = 10,000 m^3/h + 10% ~ 11.000 m^3/h, not more!)
- Therefore use fresh air only for persons, and exhaust air to remove moisture and odours. Heating or cooling is better done with separate systems, so that you can have simple controls for ventilation and heat
- The simple mechanical ventilation has to be not much more than opening a window, but with heat recovery. A slot in the wall for fresh and exhaust air that is open and closed by a timer can be enough.
- Reduce effort for fire protection

Example of a Simple System
Ventilation for a Gym



Acoustic and Heat/Cold Storage / Night Cooling

DIN 4108

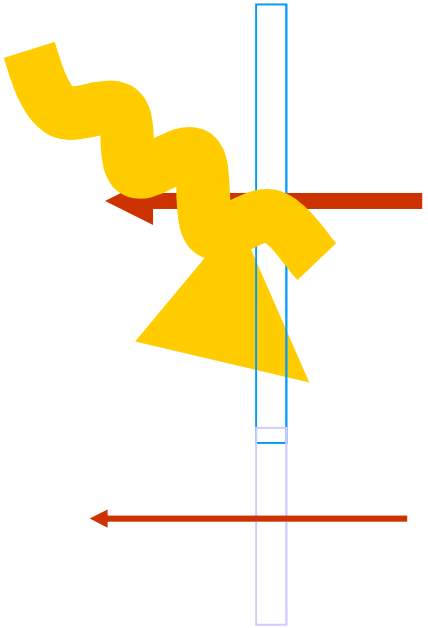


As good acoustics as needed! But: As much (non-insulated) thermal reactive heat storage mass to activate as possible, wood-, plasterbords and acoustic panels don't have enough!

Nightcooling does not make sense without enough heat storage mass!

Riedberg School, Classroom with Long Throw Ventilation Slot, Acoustic Ceiling, Acoustic Pinup Wall, Efficient Lighting

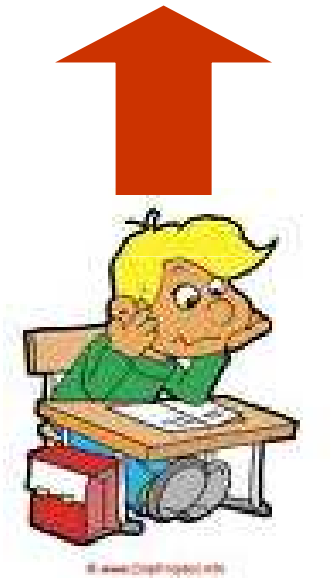
Summer Heat Protection



Solid Wall 10 m²

P = 2 kW

Window with shading fc 0,2 10 m²



P = 2 kW

25 – 30 pupils with max. 80 W

Problem:

- Even with shading 5 times more solar and internal gains comes in than you need in winter for transmission losses
- Much less is going out through fabric transmission, in both, standard and PH buildings

Therefore:

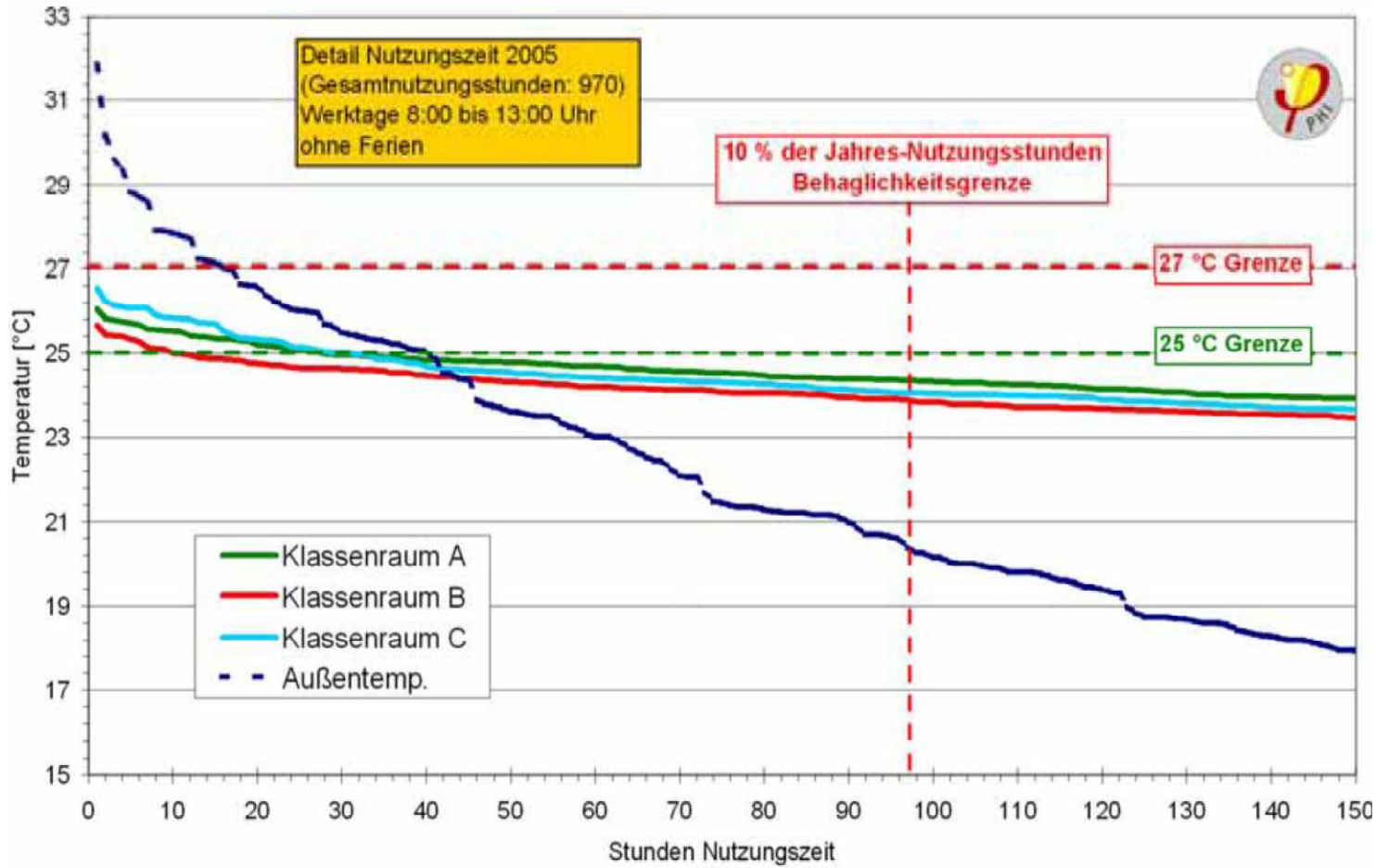
- Store the heat in the floor, ceiling and wall
- let it out by ventilating at night

Night Ventilation and Cooling, Examples

Nightcooling does not make sense without enough heat storage mass!

- Manual regulation possible for most control systems (lighting, sunshading, night-ventilation for day use, thermostatic valve), overdrived automaticly after programmable time (central lighting switch of, sunshading, night-ventilation)
- Much more cold air exchange than ventilation systems, a lot of good experience!

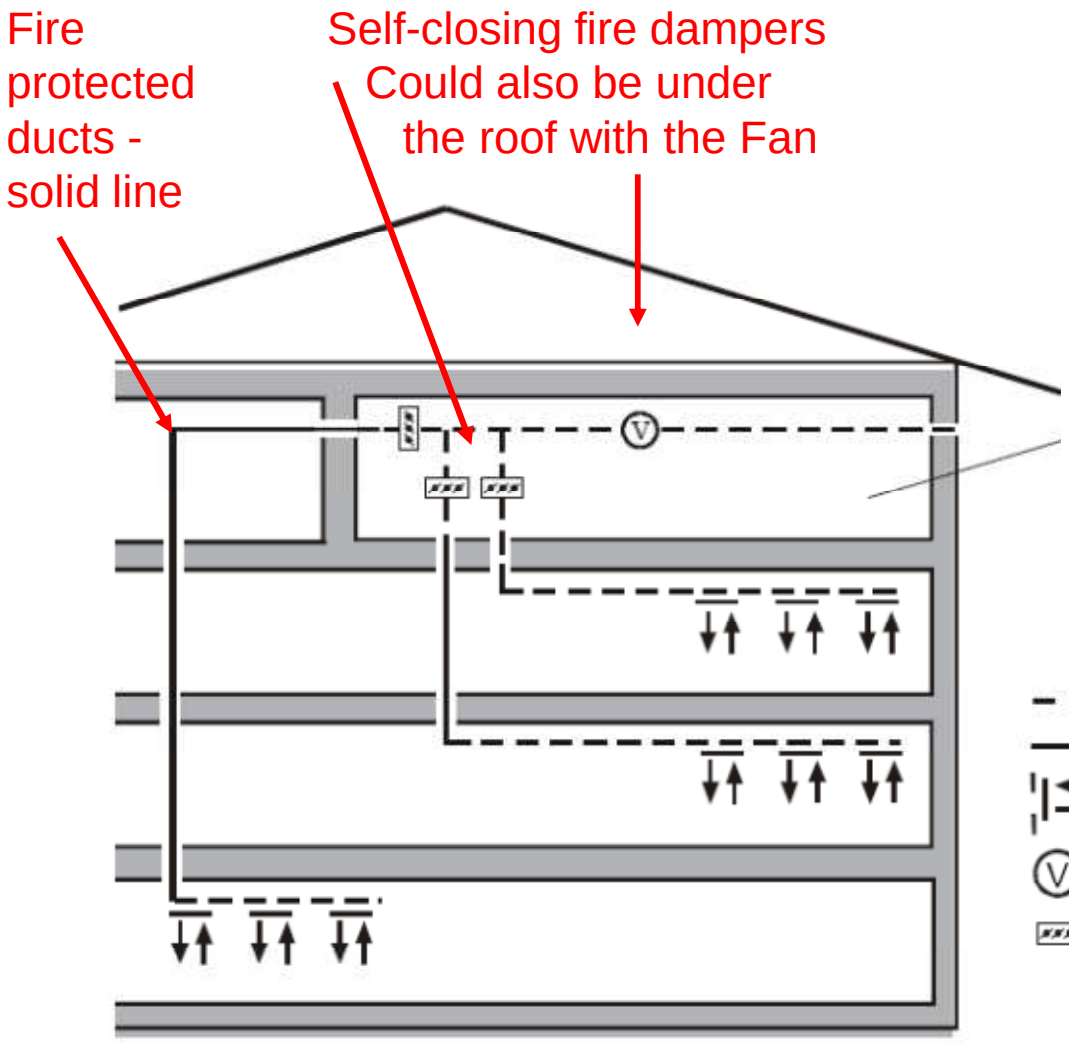
Annual Load Duration Curve Room Temperatures Elementary School Classrooms
Only Night Air Flaps - Pleasant Summer



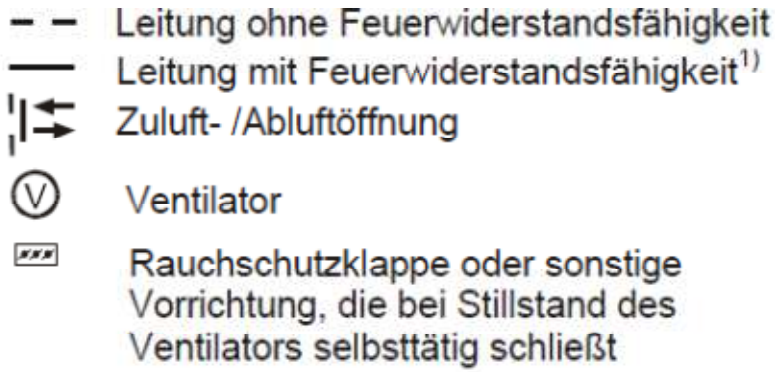
Peper, S., Kah, O., Pfluger, R., Schnieders, J.: „Passivhausschule Frankfurt Riedberg Messtechnische Untersuchung und Analyse“,

1. Auflage, Passivhaus Institut, 2007

Space For a Fresh Air Duct you Find In Every Building



e.g. separate individual ducts in a common duct and smoke dampers in the roof.
Often used in old buildings: Old ventilation ducts
§ 9 of the official school decree "To achieve the necessary renewal of air, ventilation chimneys must be build" (Royal Government of Oberpfalz 1884)



Frankfurt Guidelines for economic Buildings

Content: guidelines for economic buildings

www.stadt-frankfurt.de/energiemanagement/english/english.htm

Total Cost Calculation for the City of Frankfurt

www.energiemanagement.stadt-frankfurt.de/Englisch/English.htmenergiemanagement/pro.htm

1. Life cycle costs

Konzeption und Gestaltung: Hochbauamt der Stadt Frankfurt, Abteilung Energiemanagement

A.	General data						
A1	name of building	Preungesheim Ost			A2 Unterab.		
A3	type	Grundschule, KT, JH, TH			A4 Str.-Nr.		
A5	road				A6 Haus-Nr.		
A7	period	40	a	A8 Währung	€		
A9	interest	3,5%		A10 Annuitätsfaktor	0,05		
A11	rise in price all/energy	5%	3%	A12 Mittelwertfaktor Energie/A	2,55	1,70	

B.	different solutions	Bezeichnung
B0	**Standard**	**EnEV**
B1	**Standard - 30%**	**EnEV - 30%**
B2	**PH**	**PH**
B3		
B4		

C.	values	Standard	Standard - 30%	PH	0	0	
C1	Gross floor area (GFA)	6.723	6.723	6.723	6.723	6.723	m²
C2	persons	550	550	550	550	550	P
C3	demand of heat	172	104	17			kWh/m²a
C4	value boiler	96%	96%	91%			%
C5	power consumption	14	13	13			kWh/m²a
C6	CO2-emission	47	32	11			kg/m²a
C7	water supply	3,87	3,87	3,87			m³/P a

D.	cost of capital	Standard	Standard - 30%	PH	0	0	
D1	Invest (DIN 276)	19.671.071	20.109.911	21.846.895			€
D2	promotion						€
D3	own capital	19.671.071	20.109.911	21.846.895	0	0	€
D4	**capital cost**	**921.143**	**941.692**	**1.023.031**	**0**	**0**	€/a
D5	**spez. capital cost**	**137**	**140**	**152**	**0**	**0**	€/m²a

E.	running costs	Standard	Standard - 30%	PH	0	0	
E1	Cleaning and labor	81.477	81.477	81.477			€/a
E2	maintenance	203.053	207.036	223.423			€/a
E3	heating	84.007	52.900	5.349	0	0	€/a
E4	power consumption	27.030	24.460	24.800			€/a
E5	water supply	8.246	8.246	8.246			€/a
E6	admin and insurance						€/a
E7	**running costs today**	**403.812**	**374.118**	**343.293**	**0**	**0**	€/a
E8	**average running cots**	**780.552**	**701.422**	**608.843**			€/a
E9	**spez. running costs**	**116**	**104**	**91**	**0**	**0**	€/m²a

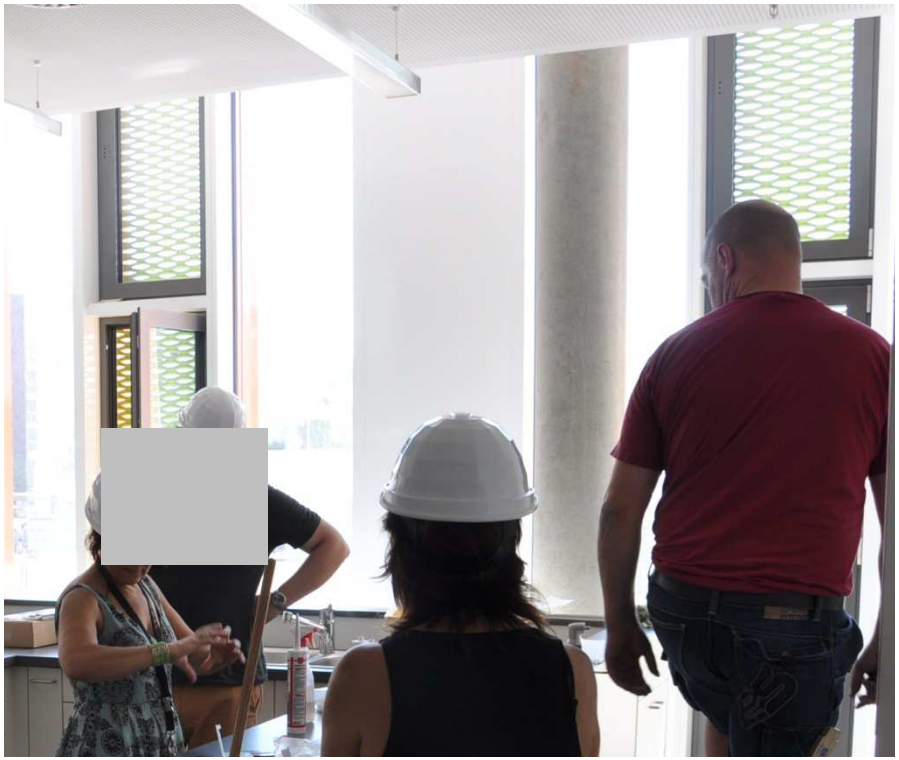
F.	environment pollution c	Standard	Standard - 30%	PH	0	0	
F1	CO2-emission (50 €/to)	15.802	10.717	7.099	0	0	€/a
F2	water (1 €/m³)	2.130	2.130	2.130	0	0	€/a
F3	**env. pollution costs**	**17.933**	**12.847**	**9.229**	**0**	**0**	€/a
F4	**spez. Pollution costs**	**3**	**2**	**1**	**0**	**0**	€/m²a

G.	total lifecycle costs	Standard	Standard - 30%	PH	0	0	
G1	**total lifecycle costs**	**1.719.627**	**1.655.962**	**1.641.103**	**0**	**0**	€/a
G2	**spez. life cycle costs**	**256**	**246**	**244**	**0**	**0**	€/m²a

Highly Efficient Building - Complex Building Concepts - Declining Acceptance - Increasing Energy Consumption – A Sustainable Business Models ??? Negative Examples

- **Research project EnBOB:**
  "The performance of buildings often remains far behind the targets set in the planning phase This is not surprising, because today's non-residential buildings are - especially for high level of comfort. . . - Increasingly complex "systems“ **EnBob**
- **New building of the federal environmental department:**
  “The running processes of a number of technical systems were less than ideal and the interaction between individual systems left much room for improvement” . . . “the target value was exceeded by around 30% . .” **BBR (2009)**
- **Model building of the federal government Efficiency House Plus, Berlin**
  "The first data are made for some surprises. The heating jumped on even in the summer and the heat pump was operated at lower efficiency than expected . . “ **Gebäude Energieberater 02/2013**
- . . . the plan unchanged - except for a self-closing glass door against cool air currents. . . .and the complex control technology revised . . . **(A. Morhart, Plusenergie-Magazin 27.5.2014)**

Energy Efficiency - What‘s Wrong With This Facade?



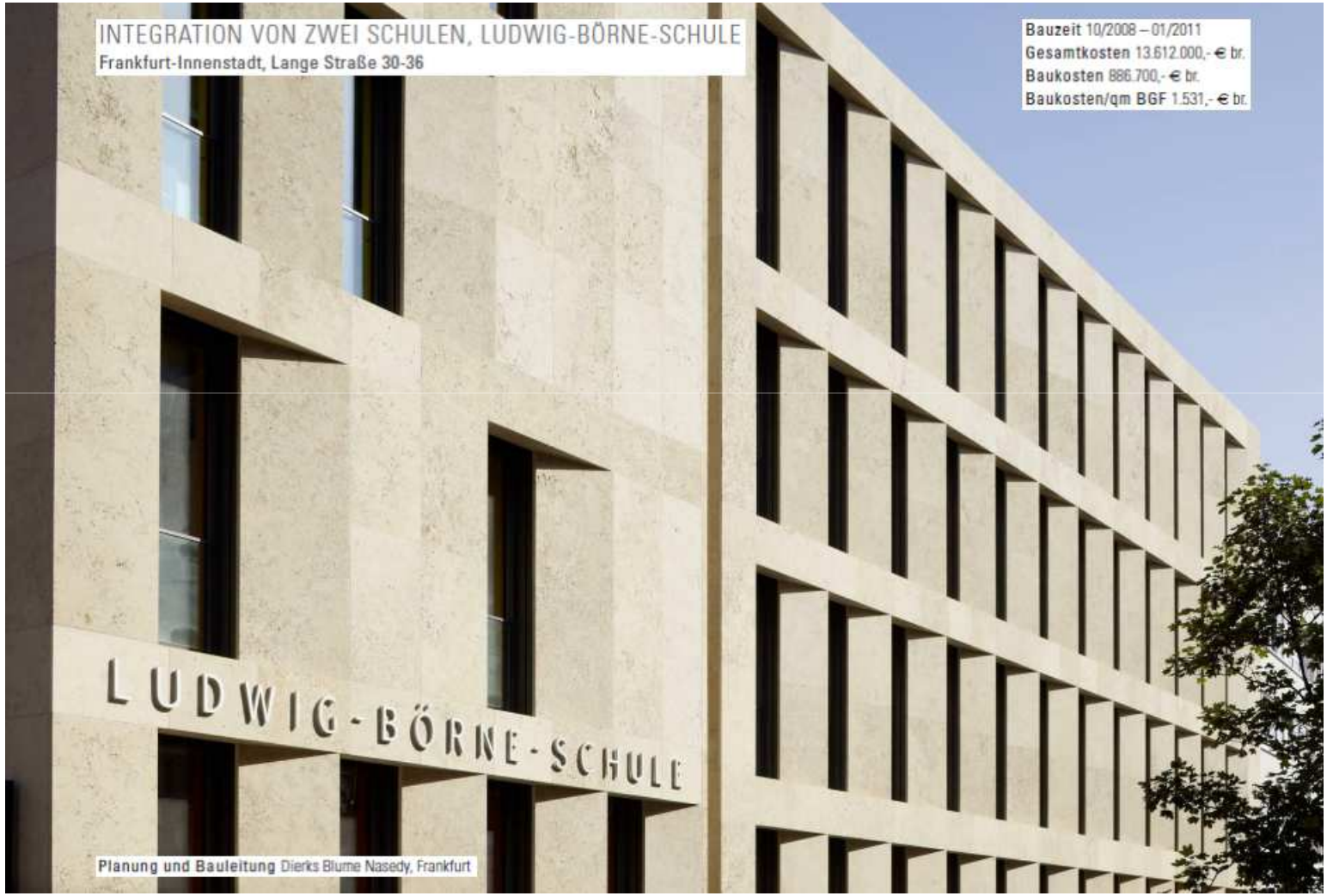
High Efficient Buildings – Passivhaus Costs and Planning

- Economy has been proven in several cases (by total cost computation), the extra capital cost is about 5-10%, depending on the size and architectural design.
- To calculate a PassiveHouse, take the nett present value of the saved running costs (energy, maintenance etc. over 20-40 years), and look, what you can get for it at the actual market (insulation, PH-windows, mechanical ventilation). For free and additional you get a better climate (internal and global) and your building has a higher market value
- The energy costs are reduced to 1/5-1/20. In relation to a new and existing buildings, they are negligible
- You need architects and other design team members with an obsession for good quality, simple and creative solutions, a knowledge of building physics and some prior experience of energy efficient buildings.

Every Journey Begins with a First Step, Redevelopment Tevestr. Frankfurt to Passivhaus Standard in 2005

Passivhaus-Institut

Ludwig-Börne School, Frankfurt



Primary School Kalbach, City of Frankfurt, New and Reconstruction

Primary School with Kindergarten, Youth Centre and Gym in Frankfurt-Preungesheim

PH- Building System for 23 Gym, City of Frankfurt

Refactory Carlo-Mierendorf School, City of Frankfurt

Refactory and Renovation Integrated School Nordend, City of Frankfurt

www.energiemanagement.stadt-frankfurt.de/

High School Beasweiler, Renovation to PassiveHouse Standard 2009

Refurbishment Church from 1950 to PH-Standard
Heinsfeld North-Rhein-Westfalia

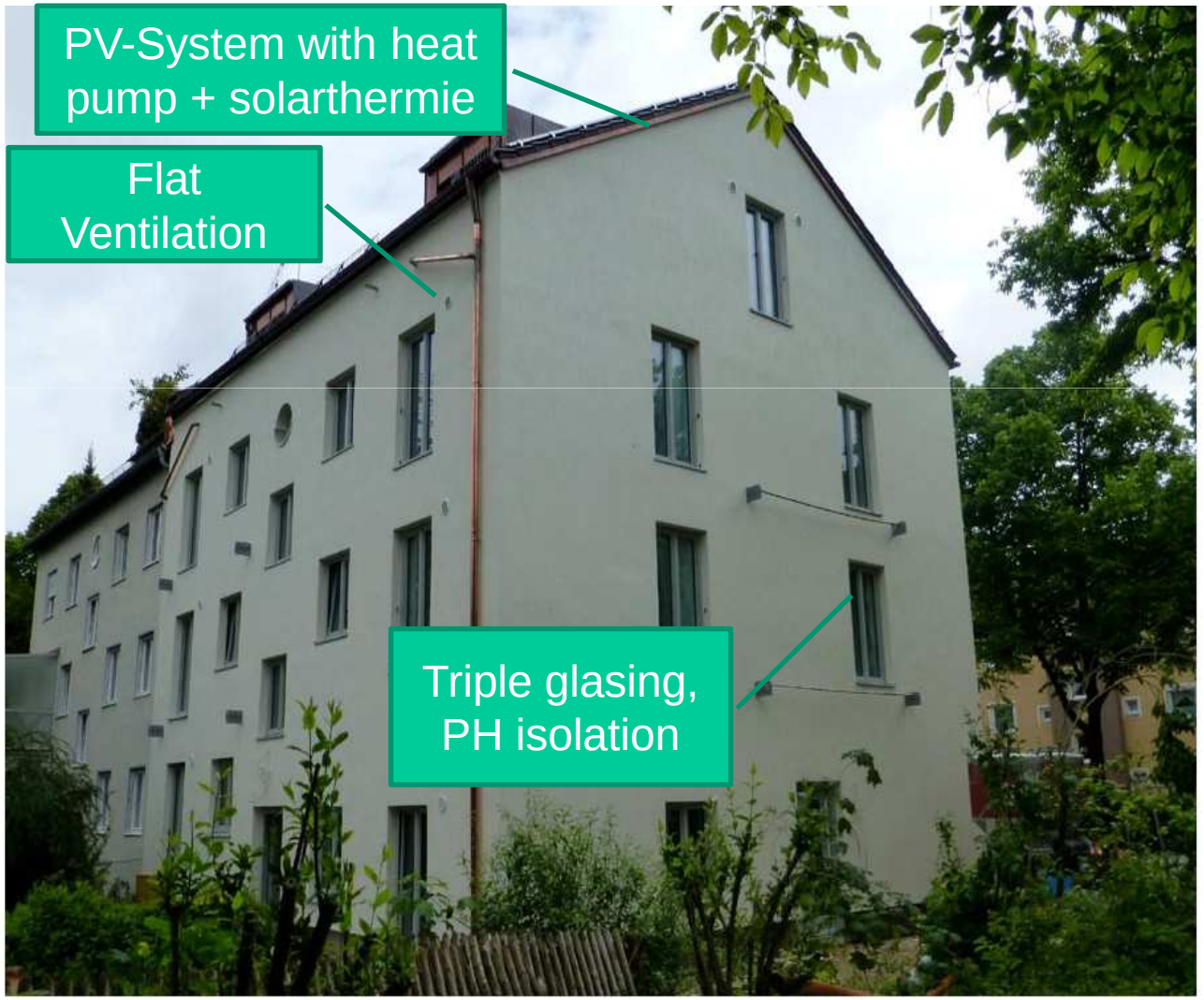
More Examples

- PH-factories
- PH office building
- PH nursing home
- PH police station
- PH fire station
- PH church
- PH hotel
- PH gym
- PH clinic

- Sorry but this link is not very up to date: www.passivhausprojekte.de/projekte.php

Refurbished with PassiveHouse Components to Energy Plus

Energy plus old building programm, Germany, BMVBS



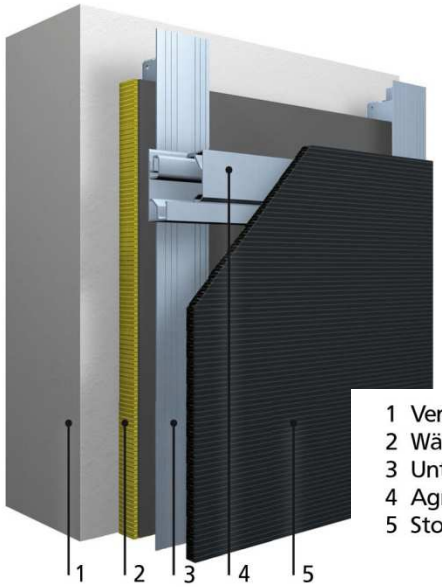
Munich Sendlingen, built 1938, refurbished 2013

www.paleoapartments.de/paleo_cms/die-entstehung/

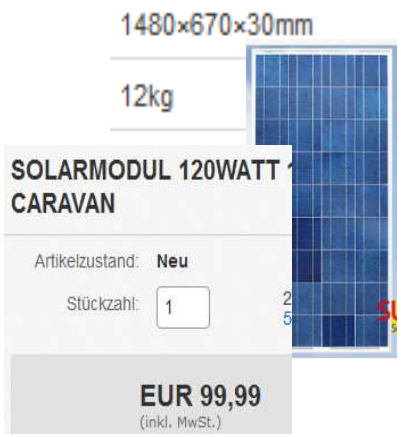
Energy Efficient Plus Renovation, Modell-projects Germany Example Nuwog Company,/BMVBS Pfuhler Str. 6 Neu-Ulm

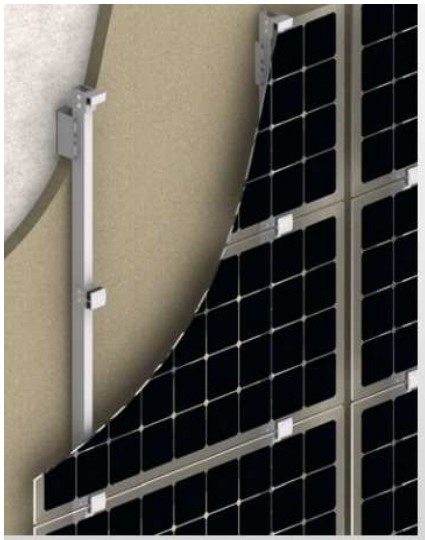
www.forschungsinitiative.de, www.forschungsinitiative.de/effizienzhaus-plus/modellvorhaben/netzwerk

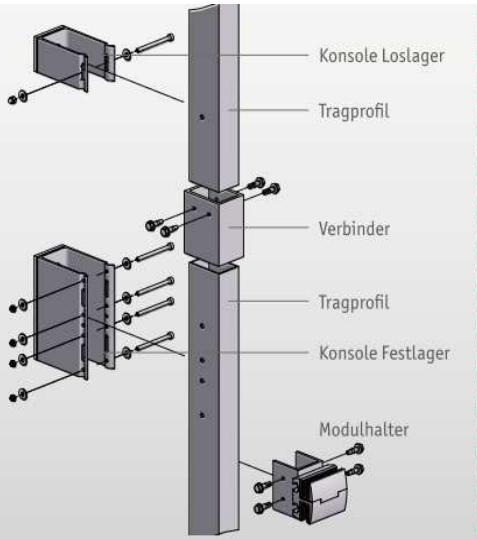
Additions to Energy - Plus Facade

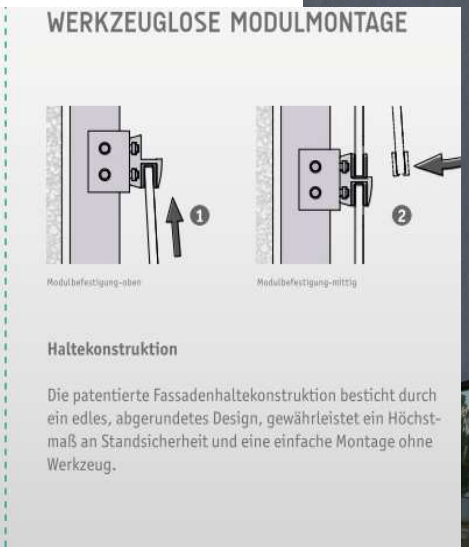


1 Verankerungsgrund
2 Wärmedämmung (vlieskaschiert)
3 Unterkonstruktion
4 Agraffenprofile
5 StoVentec ARTline Invisible Panel









Frankfurt, ABG - Public Building Company: Standard PH Since 2004 (also Partly For Renovation)

Active residential Cityhouse 2015,

Architect Hegger et. Al.

PH-Standard and better
PV - roof and facade

Energyconsumption per year < 0
For all energy incl. Power for electric cars

Other E-Plus-buildings:
www.forschungsinitiative.de/effizienzhaus-plus/modellvorhaben/netzwerk/