



D 7.1 Calculation tool for the certification of historic buildings

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0 Preface (PHPP release history)

The new features described below have been built into the PHPP version 2007, which was the currently distributed version at the beginning of the 3encult project. In Sep. 2011 PHPP Version 6, the first of 3 major PHPP updates since, was released. In 2012 PHPP7 was released, which already included the EnerPHit verification for certification of historic buildings carried over from the 3encult PHPP 2007. The other two main new features, the Variants and the Comparison worksheet are still in version 2007 only, in which they originally have been developed. This version is also uploaded as final deliverable for 3encult. However, these two new features will not be abandoned, but will be integrated into the upcoming PHPP 9, which will probably be released in the second quarter of 2014. For this integration work no 3encult funds will be used.

1 The Passive House Planning Package (PHPP)

Does energy-conscious design require sophisticated simulations?

This was indeed the case for the first Passive Houses that were completed in 1991. Calculating the energy balance of buildings with very low energy consumption is a demanding task - existing regulations, standards and prestandards lack the required precision. Nevertheless, the Passive House Institute has identified the critical factors for preparing reliable balances - with tools that are simple to use and with acceptable effort in terms of data input. The Passive House Planning Package (PHPP) is a clearly structured design tool that can be used directly by architects and designers.

The PHPP includes tools for

- calculating the U-values of components with high thermal insulation
- calculating energy balances
- designing comfort ventilation
- calculating the heating load
- summer comfort calculations
- and many other useful tools for reliable design of Passive Houses and retrofits

PHPP was presented for the first time in 1998 and has since been continuously developed further. At the core of the package are worksheets for heating and cooling energy balances, heat distribution and supply, electricity demand and primary energy demand.

New design modules have been added successively, e.g. calculation of window parameters, shading, heating load and summer performance.

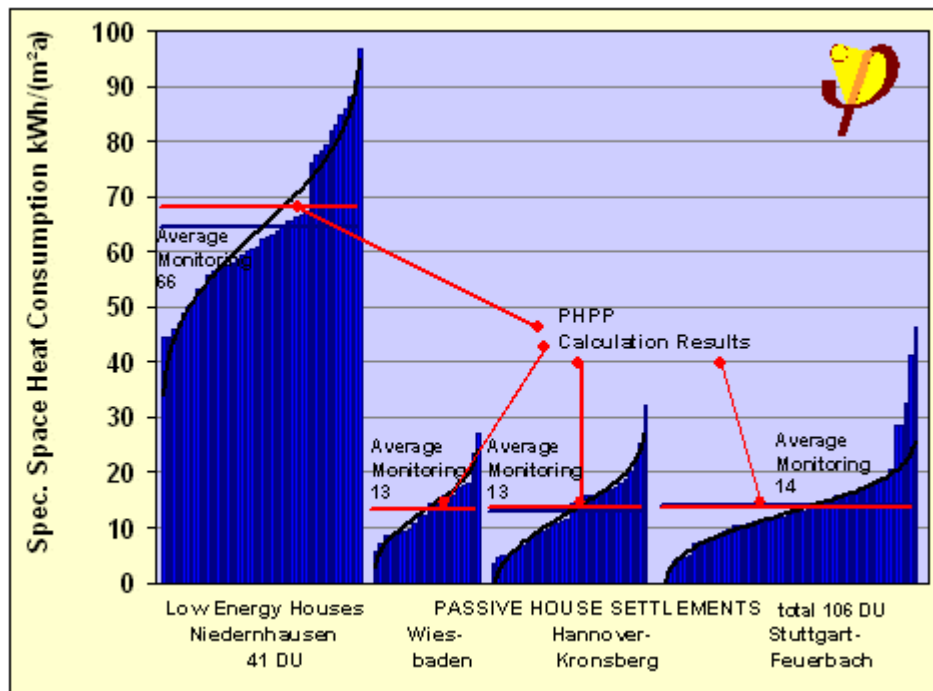


Figure 1 Diagram: Comparison of PHPP calculation with consumption measurements in housing developments with low energy and Passive Houses.

The PHPP is continuously validated and refined based on measurements and new research results. As part of accompanying scientific research studies, measurements from more than 300 projects have so far been compared with calculation results. Of crucial significance was the CEPHEUS project undertaken as part of the European "Thermie" programme, during which housing developments were

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constructed according to passive house standards and scientifically accompanied at 14 different European locations (more).

The PHPP energy balance module was shown to be able to describe the thermal building characteristics of Passive Houses as well as buildings with poorer energy standards surprisingly accurately.

The diagram above shows the results of a comparison between measurements and PHPP calculations for different Passive Houses at different locations. It is interesting to note that in all cases, irrespective of the thermal insulation standard of the buildings, there is high (relative) scatter due to user behaviour, but the calculations were in excellent agreement with the average measurement results.


2 PHPP features, developed in 3encult

2.1 'Verification' Worksheet for Certification of Refurbishments

Former versions of the PHPP could only be used for Passive House verification and certification. A new feature which has been developed within the 3encult project and integrated into the general distribution version of PHPP, allows designers to verify the energy demand in modernised historic buildings or other refurbishment projects.

A dropdown menu in the Verification worksheet with the options "Passive House" or "EnerPHit" (Energy retrofit with Passive House components) can now be chosen. The energy performance of the building in question is subsequently rated according to the corresponding certification criteria.

EnerPHit Verification



Building:	End-of-Terrace Passive House Kranichstein	
Location and Climate:	Darmstadt Kranichstein	Standard Deutschland
Street:		
Postcode/City:	D-64289 Darmstadt	
Country:	Germany/Hesse	
Building Type:	Terraced House/Dwelling	
Home Owner(s) / Client(s):	Bauherrengemeinschaft Passivhaus	
Street:		
Postcode/City:	D-64289 Darmstadt	
Architect:	Prof. Bott/Ridder/Westermeyer	
Street:	Jahnstr. 8	
Postcode/City:	D-64285 Darmstadt	
Mechanical System:	Geb Dipl.-Ing. Norbert Stürz	
Street:	Bahnhofstr. 49	
Postcode/City:	D-64319 Pfungstadt	
Year of Construction:	1991	
Number of Dwelling Units:	1	Interior Temperature: 20,0 °C
Enclosed Volume V _e :	665,0 m ³	Internal Heat Gains: 2,1 W/m ²
Number of Occupants:	4.5	

Calculation Electricity / Internal Heat Gains

Building Type: Residential Building

Internal Heat Gains

Utilisation Pattern: Dwelling

Type of Values Used: Standard

Planned Number of Occupants: 4 Verification

Verification: Annual method

Specific Space Heat Demand, Annual Method	14,8
Specific Space Heat Demand, Monthly Method	14,8

Treated Floor Area:	156,0 m ²	Applied:	Annual method	Fulfilled?	n.a.
Specific Space Heat Demand:	15 kWh/(m²a)				n.a.
Heating Load:	12 W/m ²	10 W/m ²			n.a.
Pressurization Test Result:	0,6 h ⁻¹	1 h ⁻¹			yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	66 kWh/(m²a)	120 kWh/(m ² a)			yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	40 kWh/(m ² a)				
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	kWh/(m ² a)				
Frequency of Overheating:	5 %	over 25 °C			yes
Specific Useful Cooling Energy Demand:	kWh/(m ² a)	15 kWh/(m ² a)			-
Cooling Load:	10 W/m ²				

EnerPHit: Mittlere Bauteilkennwerte			
	Mittlere U-Werte	Requirement	
Exterior Wall Ambient	0,123 W/(m ² K)	0,15 W/(m ² K)	yes
Exterior Wall Ground	W/(m ² K)	0,252 W/(m ² K)	
Roof/Ceiling Ambient	0,130 W/(m ² K)	0,12 W/(m ² K)	no
Roof Terrace	W/(m ² K)	0,15 W/(m ² K)	
Floorslab/Basement Ceiling	0,114 W/(m ² K)	0,252 W/(m ² K)	yes
Thermal Bridges Δ _e	-0,008 W/(m ² K)		
Windows	0,789 W/(m ² K)	0,85 W/(m ² K)	yes
HRV	85 %	75 %	yes

EnerPHit building retrofit (acc. to component quality)	no
--	----

We confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The calculations with PHPP are attached to this application.

Issued on: _____
signed: _____

Figure 2 Screenshot of the new "Verification" worksheet, which also allows for certification of refurbished historic buildings.

Variants Worksheet

2.2 Variants Worksheet

When new Passive Houses are built, there is generally one consistent planning design, which is realized continuously during a limited time span. Therefore the existing PHPP was able to consider only one version of a building, e.g. only one assembly and U-value for a specific part of the exterior wall. This has been sufficient for new buildings.

In refurbishments of historic buildings there are at least two versions, that have to be considered. These are the states before and after refurbishment. Frequently refurbishments are not carried out as a complete renovation at one point of time. Instead the different energy saving measures are carried out step by step at the moments when the component in question has to be overhauled anyway. An important improvement is the possibility, to parallelly represent each stage of the refurbishment process with the corresponding calculation results.

For this a new “Variants” worksheet has been created within 3encult. The worksheet allows for the representation of different refurbishment stages or also of different variants of the same stage. In the top row of the worksheet, the different stages are denominated and numbered. One of the variants can be chosen and “activated”; i.e. the values of this variant are used in the other PHPP worksheets. In the brown area of the worksheet the calculation results for annual heating demand etc. are shown parallelly for each variant. In the rows below the specific values for each variant and component can be entered, e.g. the wall insulation thickness. The value for the “activated” variant is displayed under ‘active’.

An earlier version of the PHPP updated with the new Variants worksheet and including the necessary instructions has been send to the Local Case Study Teams.

		active			
		Passive House - Components	Existing	Standard renovation	Passive House - Components
V A R I A N T S					
Results	3 Passive House - Components	3	1	2	3
Energy demand for space heating (Annual method)	kWh/(m ² a)	15	512	77	15
Energy demand for space heating (Monthly method)	kWh/(m ² a)	15	512	73	15
Heating Load	W/m ²	12	208	39	12
Pressure test- results	h ⁻¹	0,6	5,0	3,0	0,6
Primary Energy value (DWH, Heating, Colling, Aux Electricity, Household electricity)	kWh/(m ² a)	67	680	64	67
Primary Energy value (DWH, Heating and Aux Electricity)	kWh/(m ² a)	40	651	39	40
Primary Energy value (Savings through solar energy)	kWh/(m ² a)				
Frequency of overheating	%	5	0	0	5
Usefull cooling energy value	kWh/(m ² a)				
Cooling Load	W/m ²	10	36	11	10
Certified as Passive House?	yes / no	no	no	no	no
User defined	Units	Link	Link	Link	Link
Input variables			1	2	3
U-Value	Value				
Thermal bridges	Value				
Windows	Typ/Value				
Ventilation	Value				
PE- Value/Heat generation	Typ / %				
User defined					

Figure 3 Screenshot of the new “Variants” worksheet, developed within 3encult

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Existing construction (optional)	λ_{eff} [W/(mK)]	Thickness [mm]	Assembly No.	Building Assembly Description
c2) Exterior wall 38 cm, solid	0,909	380	1	Exterior wall

Heat Transfer Resistance [m ² K/W]				
interior R _{si} :	0,13			
exterior R _{se} :	0,04			

Area Section 1	λ [W/(mK)]	Thickness [mm]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Interior plaster	0,350	15					15
EXISTING	0,909	380					375
b) Exterior insulation	0,040	300					275
	0,800	20					20
	0,000	0					
	0,000	0					
	0,000	0					
	0,000	0					

Percentage of Sec. 2	Percentage of Sec. 3	U-Value: [W/(m ² K)]
		0,123

	Glazing	Frame	Window Rough Openings		Orientation	Installed		Glazing	Frame			
			Quantity	Description		Width	Height					
a) Opening casement	4)37 iPlus 3S - INTERPANE	33)PRE Passive House frame.	4	S Ground Fl.	180	90	South	1,100	2,120	1)Exterior wall so...	3)Triple-low-e-Ko...	1)standard PU on w...
b) Fixed glazing	1)Triple-low-e-Ki08	1)standard PU on wood	4	S First Fl.	180	90	South	1,140	2,120	1)Exterior wall so...	3)Triple-low-e-Ko...	1)standard PU on w...
c) Skylight	4)37 iPlus 3S - INTERPANE	34)PRE Passive House frame.	4	S Second Fl.	180	90	South	1,120	2,550	1)Exterior wall so...	3)Triple-low-e-Ko...	1)standard PU on w...
b) Fixed glazing	1)Triple-low-e-Ki08	3)wide PU on wood	2	N Ground Fl.	0	90	North	1,200	2,300	2)Exterior wall no...	3)Triple-low-e-Ko...	3)wide PU on wood
b) Fixed glazing	1)Triple-low-e-Ki08	1)standard PU on wood	1	West	270	90	West	0,910	2,200	3)Exterior wall we...	3)Triple-low-e-Ko...	1)standard PU on w...
c) Skylight	4)37 iPlus 3S - INTERPANE	34)PRE Passive House frame.	2	N First Fl.	0	90	North	1,200	2,300	2)Exterior wall no...	3)Triple-low-e-Ko...	3)wide PU on wood

Figure 4 Screenshots of the adapted U-Values (top) and Windows (bottom) worksheets, with new columns for the Parameter worksheet data.

Existing construction (optional)	λ_{eff} [W/(mK)]	Thickness [mm]	Assembly No.	Bu
c6) Roof - plaster on laths	0,970	150	1	Ex
--SFH massive until 1918--				
b1) Exterior Wall - 38 cm solid brick				
b2) basement straight ceiling, with sand bed on				
b3) basement ceiling with wooden beams and cla				
b4) arched basement brick ceiling, topside sand t				
b5) wooden beam ceiling with false bottom and 2				
b6) Roof - plaster on the lath				
	λ [W/(mK)]	Thickness [mm]	Area Section 1	
	0,350	15	Interior p	
EXISTING	0,970	150	Calcium Si	
b) Exterior insulation	0,040	300	Polystyren	
	0,800	20	Exterior R	

Figure 5 Existing wall, roof, basement ceiling and window constructions from different construction ages with their respective thermal properties can be chosen from a large included database.

2.3 ‘Comparison’ worksheet

In the new ‘Comparison’ worksheet it is possible to calculate the economics of energy retrofit measures for insulation of the opaque building shell and thermal bridge reduction as well as for new windows. The calculation is based on the inputs made in the ‘Variants’ worksheet. The results include the calculated yearly net profit generated by the measure as well as the cost for 1 saved kWh of energy. The maximum investment sum, at which the energy saving measure will still be profitable, is also given.

The user is also shown the calculated energy savings as usable energy, final energy, primary energy and the corresponding CO₂-emissions.

The results for interior surface temperatures help the user evaluate, if a construction fulfils minimum requirements regarding thermal comfort and prevention of mould growth.

Comparison of Two Variants

Type	U-Value		▼	1				
Component	1) Exterior wall		▼	1				
Execution according to variante	Poorer heat protection	Better heat protection	Differences / Savings / Gains					
	1 Existing	3 Passive House - Components	▼	1				
U-Value	1,524	0,123						
Minimum internal surface temperature								
on the surface	13,9	19,5		°C				
behind cabinets/curtains	10,2	19,1		°C				
Heating energy								
	per m ² TFA	Building	per m ² TFA	Building	per m ² Building asser	whole component		
Treated floor area	1,00	156,00	1,00	156,00	1,00	184,28	m ²	
Annual Heat Demand	152,0	23714	14,8	2309	116,2	21405	kWh/a	
Final energy demand	160,3	25006	19,3	3012	119,4	21994	kWh/a	
Primary energy demand	183,6	28638	26,0	4053	133,4	24585	kWh/a	
CO ₂ - Output	42,2	6576	6,2	965	30,4	5611	kg/a	
Economy								
	per m ² Building asser	Entire building	per m ² Building asser	Entire building	per m ² Building asser	whole component		
Area of building components	1,00	184,28	1,00	184,28	1,00	184,28	m ²	
Investment costs	40,00	7371	110,00	20270	70,00	12899	€	
Investment costs minus gov. aids	40,00	7371	100,00	18427	60,00	11056	€	
Heating costs/year (whole building)	2614		375		12,15	2239	€/a	
Heating costs (sum of calculation period)	52275		7503		242,96	44772	€	
					Gov. Aid (Present value)	10,00	1843	€
					Yearly profit	9,84	1814	€/a
					Profit (sum of calculation period)	196,84	36273	€
					Economic maximum investment costs	316,09	58247	€
					Costs of saved kWh final energy	1,9		Cent

Figure 2 Screenshot of the new ‘Comparison’ worksheet

3 Brief instructions

In order for the variant calculation to work, automatic calculation of tables has to be activated. Otherwise the variants will only be recalculated during opening and saving of files.

3.1 Variants Worksheet

In row 4 names for up to 10 variants can be entered (for more variants the worksheet can be extended easily. However this will increase calculation time proportionally).

Results for all variants and for the active variant selected in cell D5 are shown in rows 6 to 16.

The parameters for the individual variants are entered from row 112 downwards. For this each section can be opened by clicking on the plus symbol at the left margin. All important parameters are already pre-linked to the individual PHPP worksheets. A basic rule is: if there is no entry for a parameter in the Variants worksheet (empty cell), the value which has been manually entered “the normal way” in the corresponding entry cell is used for calculation. If there is an entry for this parameter for the active variant and variant calculation is activated in the corresponding worksheet, the value from the Variants worksheet “overwrites” the value in the PHPP (it appears brown and crossed out).

3.1.1 Links into the individual PHPP worksheets

Wherever variant calculation is provided, a section for variant calculation can be made visible by clicking on the plus symbol at the top margin. When variant calculation is not active, no difference to earlier PHPP versions is noticeable.

3.1.1.1 Areas worksheet

Psi values can be carried over from the Variants worksheet. For this to function, an X has to be entered in column B next to the thermal bridge.

3.1.1.2 U-values worksheet

In column A individual assembly layers, which have been defined in the Variants worksheet can be selected. Lambda value (only area section 1) and thickness from the corresponding variant are used. As an additional feature, for each assembly an existing construction can be chosen (based on a catalogue). In the layer corresponding to the existing construction “EXISTING” is chosen.

3.1.1.3 Windows worksheet

A window as combination of frame and glazing, which has been predefined in the Variants worksheet, can be selected in column A.

3.1.1.4 Shading worksheet

For each of the predefined windows a shading situation can also be defined (reveal and overhang shading, only)

3.1.1.5 Ventilation worksheet

The values are carried over from the variants worksheet, if cell A4 is activated.

3.1.1.6 PE value worksheet

The values are carried over from the variants worksheet, if cell A4 is activated.

3.1.1.7 Compact/Boiler/District Heat worksheets.

The values are carried over from the variants worksheet, if activated in column A.

3.2 Comparison worksheet

Two variants, which have been predefined in the Variants worksheet, can be compared regarding energy demand and economic viability. Additionally the surface temperature of standard assemblies is given.

Select the type of component to be compared in cell D5: U values (assemblies from the U values worksheet), thermal bridges or windows. Additionally two variants can also be compared as complete buildings. If “manual input” is selected a simplified calculation is carried out, which is more or less independent from the building entered in the PHPP.

In cell D7 the component to be compared from the category chosen above is selected. In row 10 select which variants should be compared.

If single components are compared, a complete PHPP is calculated in the background for each of the two variants. For this calculation the two buildings only differ in the selected component. All other components are as in variant “Better heat protection”. This includes the heating system. The results of this calculation are shown in cells D27:I31.

In columns L and M the results of the comparison between the two PHPPs are shown for the component and for the whole building.