REPORT
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D6.3 Evaluation algorithms functional on dummy data sets

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OUTPHIT – DEEP RETROFITS MADE FASTER, CHEAPER AND MORE RELIABLE
outPHit pairs such approaches with the rigour of Passive House principles to make deep retrofits cost-effective, faster and more reliable. On the basis of case studies across Europe and in collaboration with a wide variety of stakeholders, outPHit is addressing barriers to the uptake of high quality deep retrofits while facilitating the development of high performance renovation systems, tools for decision making and quality assurance safeguards.
outphit.eu

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SUMMARY

The outPHit project aims to support building owners and housing companies in performing reliable, quicker and more cost-effective deep retrofits. Traditionally, buildings were left to their users and owners post occupancy. Faults and sub-optimal controls often went undetected, contributing to higher than expected energy use ("performance gap"), building fabric damage and unsatisfactory thermal comfort and indoor air quality. Performance verification serves to conclude the quality assurance process along the value chain of constructing a building and incorporates systematic commissioning and energy performance evaluation. In order to establish the actual building performance in the field, an evaluation method was devised that employs the detailed energy balance model that is available for each EnerPHit Standard building in a third-party assessed form.

The model is updated with the measured boundary conditions for the period under consideration and thus yields an expected energy consumption. If the measured energy consumption agrees with the expected consumption from the model within the inevitable measuring uncertainties (on the order of ±3 kWh/(m²a)) the building is working as expected and with high probability no major flaws in fabric and building services exist. Moreover, indoor air quality and essential thermal comfort parameters are monitored and statistical representations of key properties derived.

To make such performance monitoring easy to use for trained, but not expert users such as architects and engineers an on-line platform was developed that collects all data from the data acquisition system on site and evaluates them in a staged approach.

In a setup process the building object is created within the data base and all useful information is pulled in from the energy model. Then the building is zoned and further subdivided into rooms, each with their characteristic area.

Incoming Data is plotted and statistically analysed in order to facilitate near real time supervision and early detection of irregularities in operation. If enough data for evaluation has accumulated area weighted mean indoor conditions are derived. Further, the weather data is pre-processed for the energy balance calculations.

All data is then automatically transferred to the server-based energy balance calculation and the results read back to the data base for further assessment, plotting and, at a later stage, also report generation.

EVALUATION METHOD

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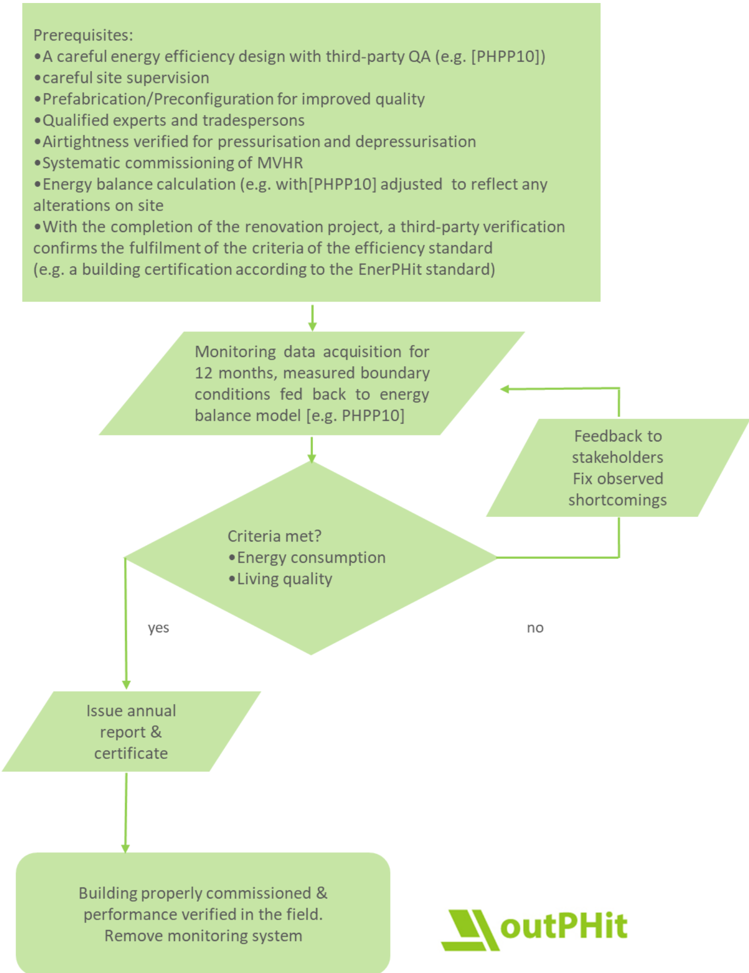
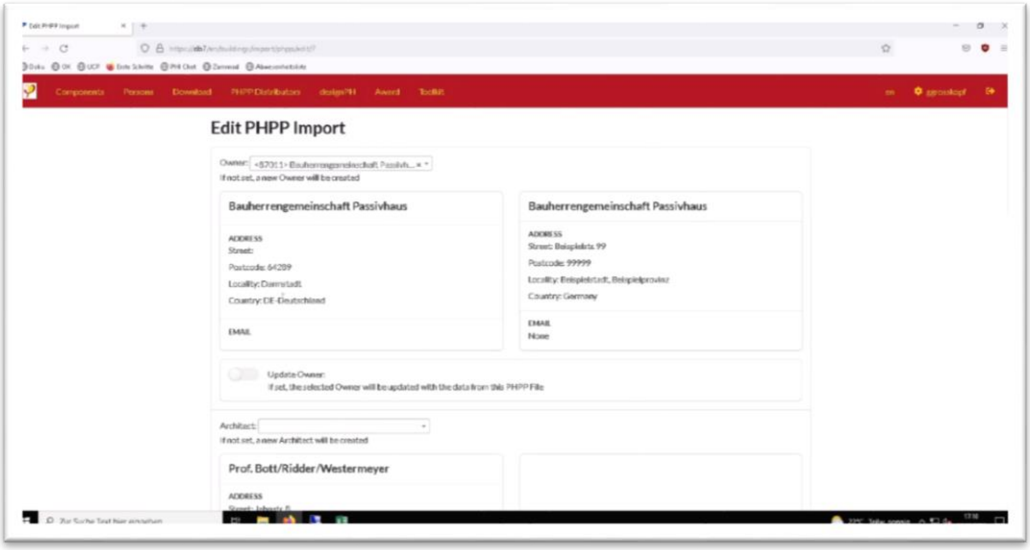


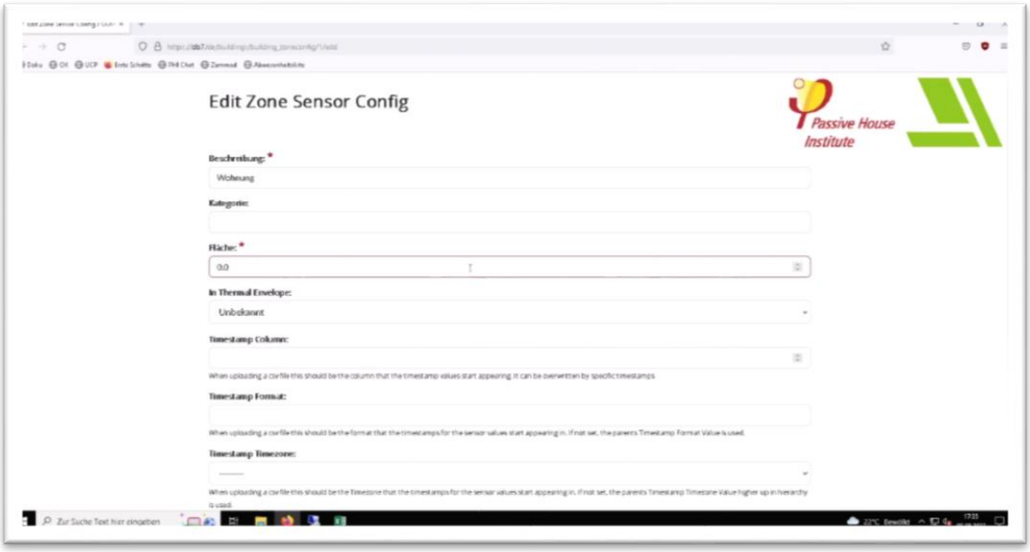
To make such performance monitoring easy to use for trained, but not expert, users such as architects an on-line platform was developed that collects all data from the data acquisition system on site and evaluates them in a staged and automated approach.

SETUP

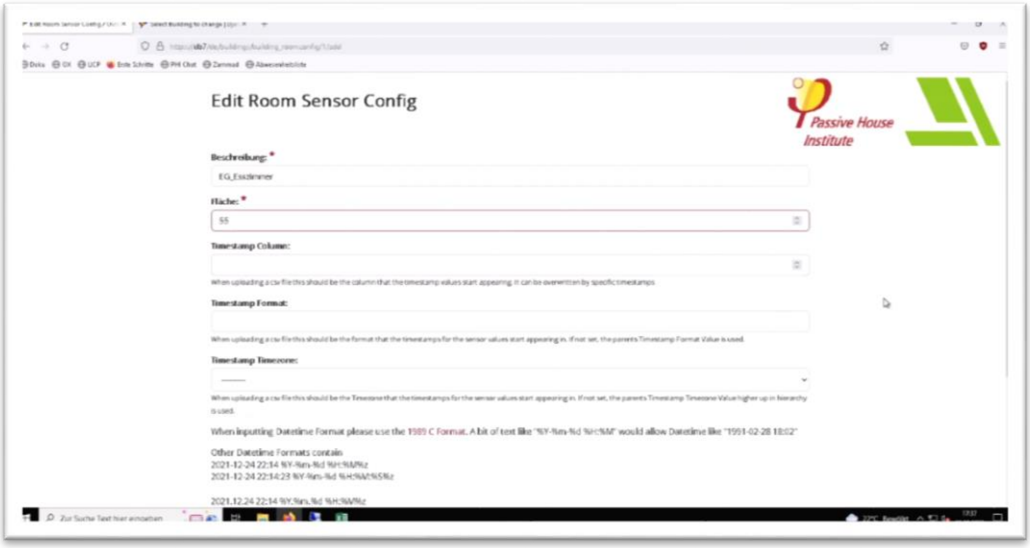
In a setup process the building object is created within the data base and all useful information is pulled in from the energy model. Then the building is zoned and further subdivided into rooms, each with their characteristic area. An assortment of sensors may then be attributed to each room.



Import of building characteristics, using data already compiled in PHPP

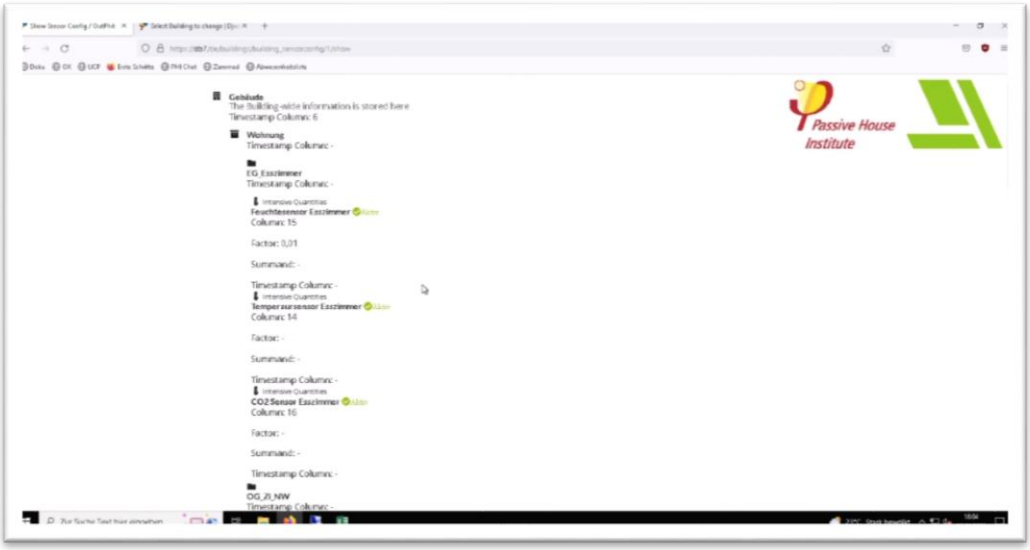


Zoning of building and room definitions, each with characteristic area



One or more sensors are attributed to a room

As this tree can be quite complex for a large building a visual tree-representation is also available.



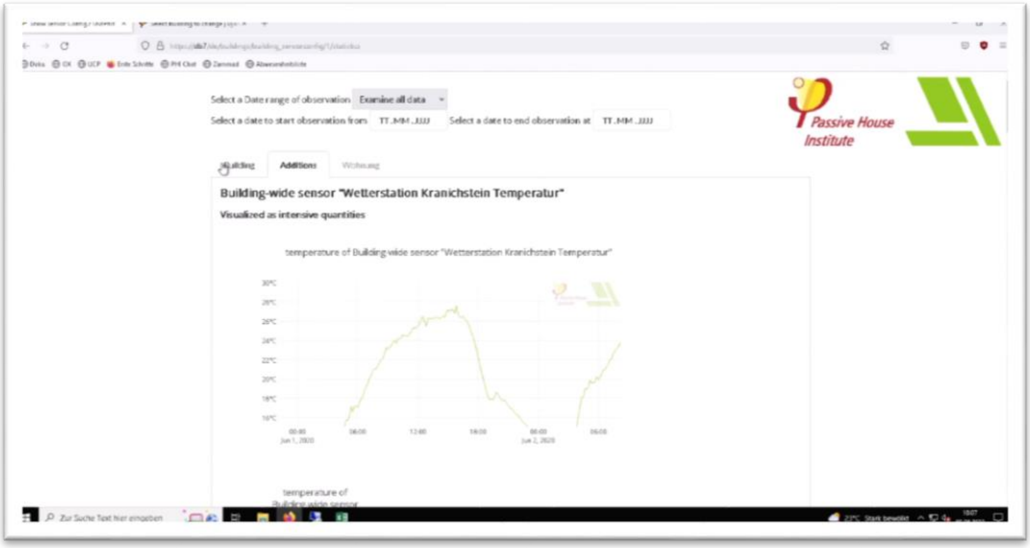
Tree-structured overview of building, zones and rooms

PLOTTING AND STATISTICAL ANALYSIS

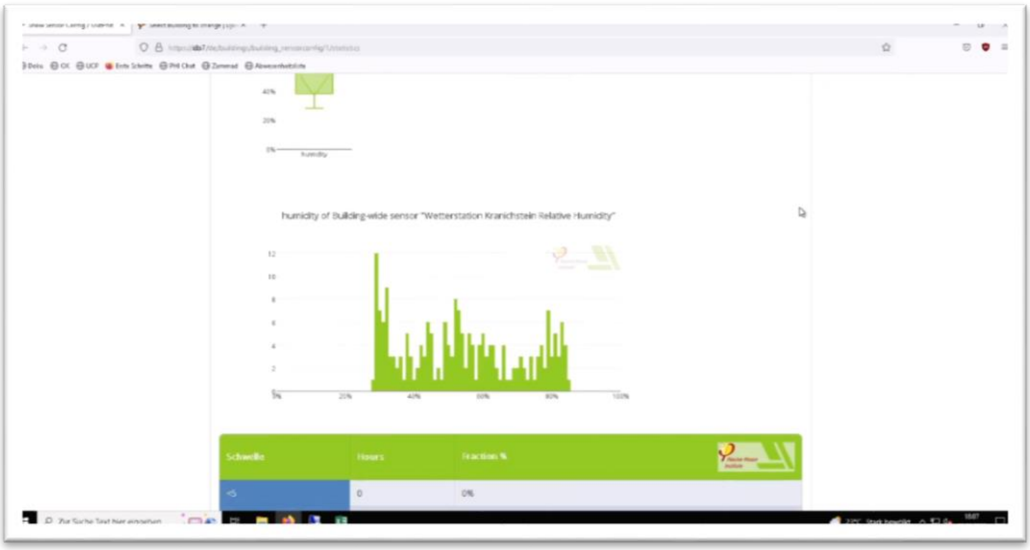
Incoming Data is plotted and statistically analysed in order to facilitate near real time supervision and early detection of irregularities in operation or living quality.

Incoming data is first subject to graphing the history as well as statistical evaluation. This data is available from the very beginning and informs on the elementary comfort parameters and air quality indoors. As monitoring campaigns frequently also serve to assist the commissioning of buildings, eyeballing performance and the quality of the indoor environment is the first tangible benefit.

The standard set of plots includes a history lines plot, a box plot with quartiles/min/max as well as arithmetic mean and standard deviation, a histogram and a table of hours outside the comfortable range.

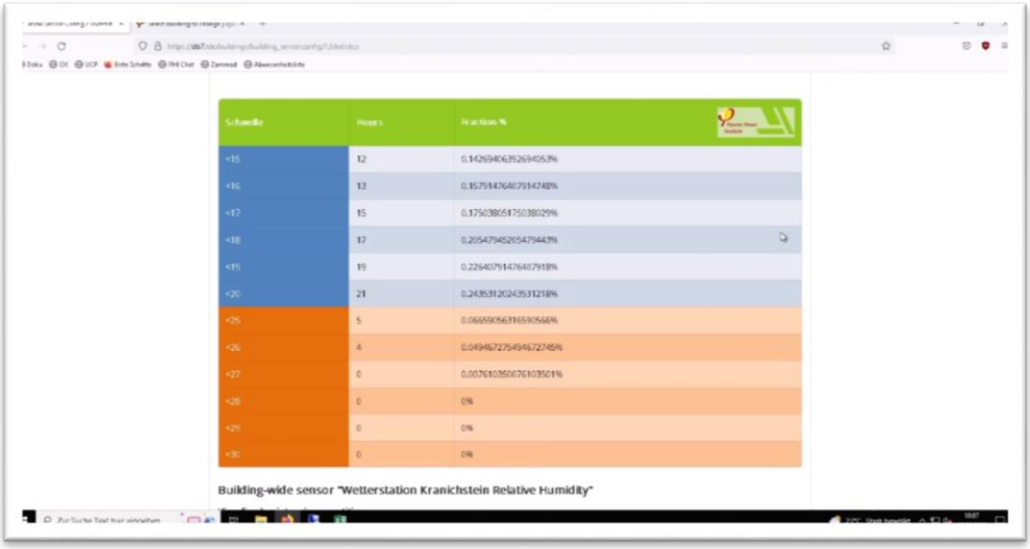


History of measured relative humidity



Elementary statistical values of measured relative humidity, given as quartiles, arithmetic mean with standard deviation and outliers

Histogram of measured relative humidity



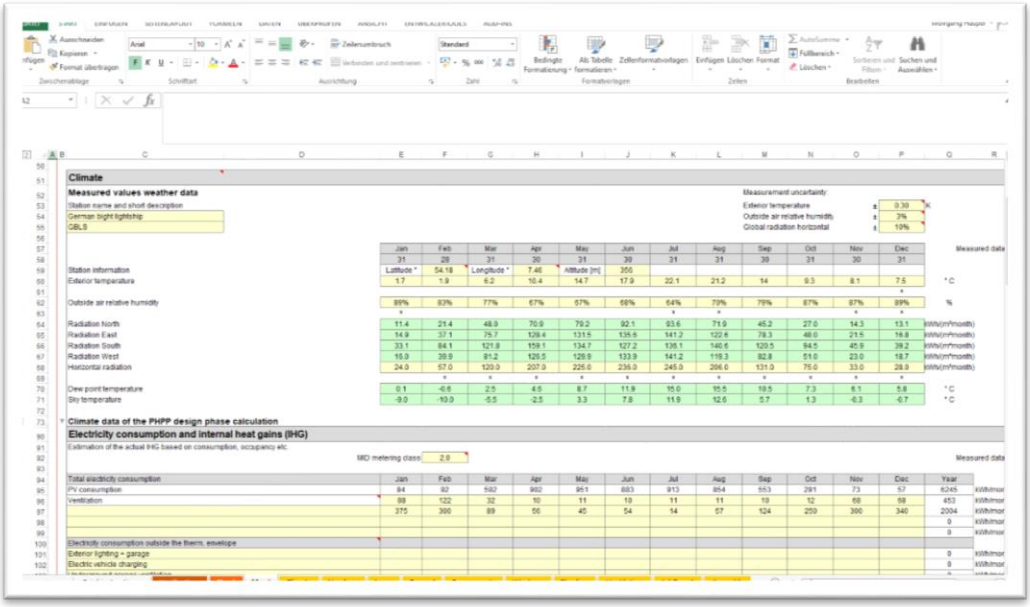
Schwelle	Hours	Fraction %
<15	12	0.14269406392694053%
<16	13	0.15791476407914748%
<17	15	0.17503805175038029%
<18	17	0.2054794520547943%
<19	19	0.22640791476407918%
<20	21	0.24353120243531218%
<25	5	0.06659056316590566%
<26	4	0.04946727549467274%
<27	0	0.007610350076103501%
<28	0	0%
<29	0	0%
<30	0	0%

Cumulated hours of conditions outside defined comfortable range

PRE-PROCESSING FOR QUANTITATIVE ASSESSMENT

Once a sufficient observation time has passed, typically a few months to one year, data can be aggregated into monthly mean indoor conditions and internal heat gains, representing the usage, and weather data. Generally an area-weighted mean is used for indoor conditions, based on the areas of zones and rooms as defined in the data base setup. This has proven itself as a practical approximation of the real conditions. The typical measuring uncertainty for each sensor type is part of the data set.

Irradiation data is processed based on a sky model according to Perez/Ineichen (1990) in order to derive the global radiation on the vertical for the cardinal directions in addition to the original global horizontal irradiation. Data is then aggregated into monthly integrals. This method were far too complicated for a non-expert user but can be provided within the platform in an automated way.



Weather data visualised in PHPP

The monthly data is also available for further, user-defined evaluation as a CSV file download option.

UPDATING THE ENERGY MODEL

All data is automatically transferred to the server-based energy balance calculation and the results read back to the data base for further assessment, plotting and, at a later stage, also report generation.

As of its recent version 10 the Passive House Planning Package (PHPP) contains a separate worksheet to compile, pre-process and evaluate measured data. It recalculates the monthly balances based on the measured values characterising usage and weather conditions for three cases: First the nominal values of all figures are used, disregarding the effects of measuring uncertainty. In the following two iterations limits of uncertainty are derived for cumulative effects of all individual measuring uncertainty values for measured quantities. As a result a plausible range of possible results is obtained.

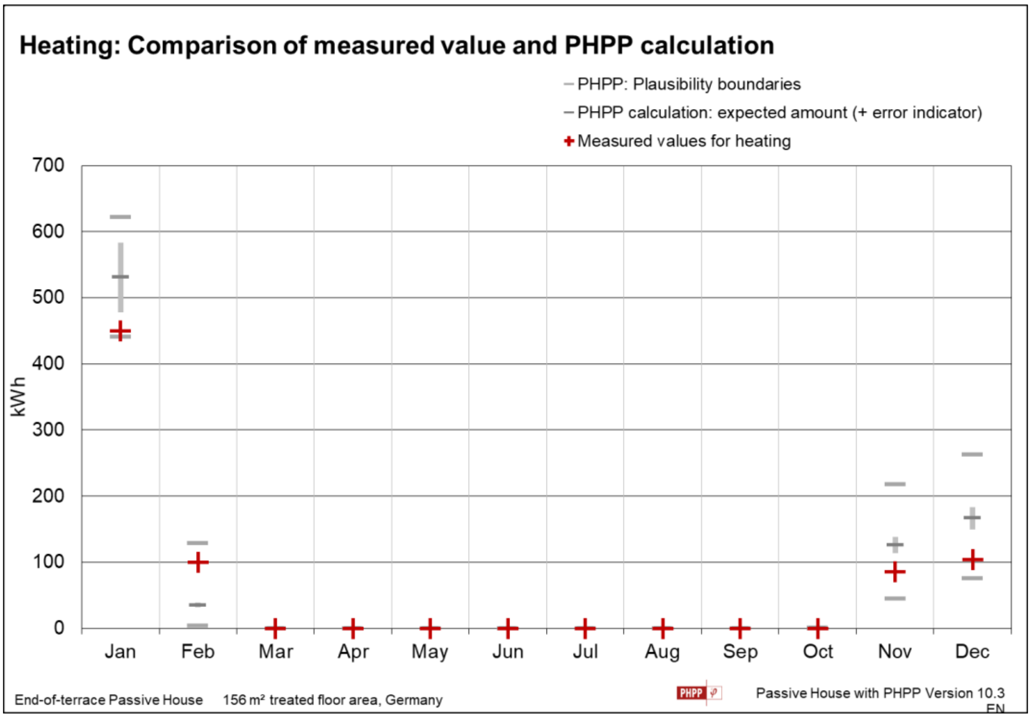
Upper and lower limits

			Active case	Expected amount	Expected amount, plausibility limit +heating/-cooling	Expected amount, plausibility limit +heating/-cooling
			0	1	2	3
M1	Heating January - 01	kWh	620	531	623	441
M2	Heating February - 02	kWh	250	35	129	4
M3	Heating March - 03	kWh	87	0	0	0
M4	Heating April - 04	kWh	0	0	0	0
M5	Heating May - 05	kWh	0	0	0	0
M6	Heating June - 06	kWh	0	0	0	0
M7	Heating July - 07	kWh	0	0	0	0
M8	Heating August - 08	kWh	0	0	0	0
M9	Heating September - 09	kWh	0	0	0	0
M10	Heating October - 10	kWh	1	0	0.9	0
M11	Heating November - 11	kWh	342	126	218.3	45
M12	Heating December - 12	kWh	621	166	263	76

Boundaries of plausibility, visualised in PHPP

RESULTS

Linked with the outPHit monitoring database, the monitoring worksheet of the PHPP running in a server-side, headless instance of LibreOffice is automatically populated with the pre-processed data. Results can either be downloaded and studied using the plots and figures generated in the spreadsheet, but are also be fed back into the database for plotting and further evaluation. As a measure of quality assurance the completed calculations are crosschecked by human intervention and can then be cleared for further uses such as display as an additional section in a public on-line building database. This database could, over time, present data of in-situ performance of a large number of buildings, all evaluated and normalised to the same yardstick, including sound estimates of uncertainty.



Expected monthly space heating consumption as per energy balance calculation with uncertainty limits (dashes) against metered space heating consumption (crosses), visualised in PHPP. A 10% Error bar is also given.

CONCLUSION

The proposed data processing and evaluation scheme was implemented and is functional with dummy data. Ongoing work is focused on improved presentation of final results and, later, generation of building blocks for a report skeleton.

All partners have access to the data base and can create the required building objects. An instructional video to this end is being prepared at the time of reporting and will be useful also for the training materials (D6.15).

The first Case Study projects in Greece and Spain are imminent to begin data acquisition. The monitoring platform is ready to receive and process the data. Full sets of measured data, ready for final, quantitative evaluation are expected to be available by the end of 2023 the earliest. Meanwhile the data visualisation and statistical analysis tools within the monitoring platform will pay dividends in closely observing the building's performance and detect possible shortcomings early on.

REFERENCES AND FURTHER READING

(click the links)

D6.5 Description of a certification scheme on verified building performance

The process for verified building performance was presented at the peer-reviewed **BauSIM 2022** conference held on Sept. 20-22, 2022 at the Bauhaus University Weimar, Germany, with the title “SEMI-AUTOMATED BUILDING PERFORMANCE EVALUATION”