

SimRoom Handbook

Tools for energy balancing and sustainability

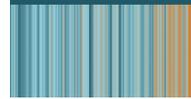
The image displays ten tool cards arranged in a grid. Each card represents a different simulation tool used for energy balancing and sustainability in buildings. The tools are:

- EWTcaIC Version 1:** Ein Lernwerkzeug zur Visualisierung von Luft-Freischicht-Wärmetauschern.
- IceCaIC Version 1:** Ein Lernwerkzeug zur Visualisierung von Eispeicher-Wärmepumpen-Systemen.
- nZEBcaIC Version 1:** Ein Lernwerkzeug zur Bestimmung der Eigenstromerzeugung von PV-Anlagen.
- EnerCaIC Version 6:** Ein Werkzeug zur erneuerbaren Energiebilanz in Anlehnung an DIN V 18539:2011-12 | 2016 | 2019.
- CO₂CaIC Version 1:** Lernwerkzeug zur Bestimmung der Raumluftqualität für verschiedene Lüftungsstrategien.
- NaBcaIC Version 1:** Ein Werkzeug zur Bestimmung der (brutto) Energie- und der Umweltauswirkung von Gebäuden für die Bewertung der Umweltqualität (EBC, GreenStar).
- EcoCaIC Version 1:** Ein Werkzeug zur ökonomisch-ökologischen Bewertung verschiedener Wärmevervorsorgungssysteme für die Bewertung der Umweltqualität (GreenStar).
- ResCaIC Version 1:** Ein Werkzeug zur Bestimmung der Eigenstromerzeugung von Gebäuden für die Bewertung der Umweltqualität (GreenStar).
- SimRoom Version 2:** Ein Lernwerkzeug zur Abschätzung von Überwärmung und Energiepotenzial.

Version 18. May 2021 | SimRoom 4.212

Source Markus Lichtmeß

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Dynamic analysis of the room temperature, room humidity and the air quality as well as the energy balance of a one-zone model

When evaluating the energetic behaviour of buildings, approaches based on monthly calculations are often insufficient, particularly with regard to a greater use of domestic/on-site power and for the evaluation of interactions with the power grid. Averaging monthly data does not sufficiently reflect the dynamics which generally are of essential relevance for designing storage systems or for load profile processes with short time intervals.

SimRoom offers you the possibility of computing room temperature, air quality and humidity based on hourly time steps for a zone with relatively little input effort. The simulation can either refer to an individual room, a zone, or a building as a one-zone model. An energy balance at a building level incorporates heat generation, cooling, PV installations and battery storage, as well as the electricity demand of the building and the users.

The energy balance takes into account the insulation, the building material masses, the glazing, the sun protection and the ventilation, and carries out the calculation based on climate data captured on an hourly basis. Internal heat sources and user behaviour regarding sun protection and the natural and mechanical ventilation are all included. Settings are suggested in numerous places and guidance is given for the user to select by tool tips, as well as default values. The basis of the programme is the spreadsheet programme Microsoft Excel.

Origin and target group

SimRoom was developed as an addition to the energy balancing tool EnerCalC by Markus Lichtmeß, which has already been available for several years¹. While EnerCalC deals with the energy balancing of buildings on a monthly basis as a multi-zone model, SimRoom addresses a single zone and its time-captured behaviour. Both tools are designed as teaching and learning tools and are made available by the developer free of charge for non-commercial use². The structure is arranged to particularly suit the subject-related didactic aspects of higher education teaching for architects and engineers, or further training. Experience from teaching, in particular at the University of Wuppertal, has influenced its further development. The programme is very well suited in connection to exercises and processing or elaborating on plans, and offers easy access to the complex subject.

How to receive the tool?

The software can be obtained from the homepage of the developer (<https://www.ingefo.de/>). There is a contact form on the homepage. Please send your request via this contact form, because the direct download of the tools is not offered. The link to the program download will be sent to the e-mail address you entered in the form.

¹ <https://www.ingefo.de/Werkzeuge/EnerCalC> and <https://projektinfos.energiewendebauen.de/projekt/enercalc-vereinfachte-energiebilanzen-nach-din-v-18599/>

² Commercial use includes all activities where a fee is levied, either directly or indirectly. This also applies if the activity does not generally serve to generate profit, the fee is used to merely cover costs and/or the fee is only levied on a small scale. This equally applies for direct and indirect results and findings which are generated or derived as a result of using the tool, in the case of a commercial, professional, institutional and/or private use. If commercial use is desired, a corresponding user license is required. In this case, contact the developer at <https://www.ingefo.de/>.

Important user information

- The tool can only be used **non-commercially**. A specific user licence is required for commercial use.²
- The tool is based on Microsoft Excel and uses macros. It is executable with the PC versions of Excel from 2010 upwards, the execution of macros must be permitted.
- Users of an older version of SimRoom shall receive the respective current version via the update function of their SimRoom software.
- SimRoom is not suitable for producing evidence of the fulfilment of legal standards (for example for summer thermal protection according to German DIN 4108-2:2013-02), for creating normative verifications, standard calculations, designs or dimensioning of structural and technical building systems and components or technical installations.

How do I activate SimRoom?

After the installation of the SimRoom setup file, the program must be licensed for the respective computer. For this purpose, a license request for the tool is necessary. This request can be generated from the tool. After the first start of the tool the following note appears.

In case of use for courses: Enter the **name of the university**. The other data is required so that the license can be assigned to a person. In the case of e-mail, a valid e-mail address must be entered that also allows files to be sent. In the case of student use, the **university address** must always be used so that an assignment can be made. Please pay attention to this, otherwise you might not get a license.

License request for SimRoom

Information on generating the license file

Company/Institution	Name of University
First name	Jean-Luc
Surname	Picard
Street, Nr.	Alpha-Quadrant
Postcode/Town	Risa
Phone	2152
e-mail	xxx@name-of-university.xx

delete entries

Create and save file for requesting a license file

Send LIZENZ.TXT online now

If you have problems sending the file via your browser, you can send the license file at any time later by email to <team@enec.de>.

Open license folder Start demo mode

Create the license file via the button 'Create and store file to request a license file'. It is a text file with the relevant information. The information is encrypted before sending.

Save the license request file. It will be saved on your desktop by default. However, you can change the location as you wish.

After successful saving the following message appears.

SimRoom

File creation successful, send the file directly online or manually by email to team@enec.de < C:\Users\Lichti\Desktop\LIZENZ.txt >

OK

Confirm with 'OK' and the input mask should change as follows.

License request for SimRoom

Information on generating the license file

Company/Institution: Name of University

First name: Jean-Luc

Surname: Picard

Street, Nr.: Alpha-Quadrant

Postcode/Town: Risa

Phone: 2152

e-mail: xxx@name-of-university.xx

delete entries

Create and save file for requesting a license file

Send LIZENZ.TXT online now

If you have problems sending the file via your browser, you can send the license file at any time later by email to <team@enec.de>.

Your license file is located in the following directory:
C:\Users\Lichti\Desktop\LIZENZ.txt

Open license folder Start demo mode

In the lower range in *blue writing* again the path is indicated, under which the license file "**LIZENZ.TXT**" was stored.

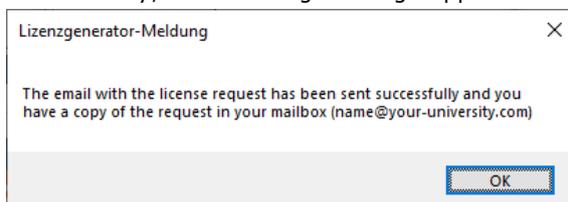
To send the license file now you have 2 options.

Option 1

Option 1

mail request directly from the tool

With the button "Send LICENSE.TXT now directly online" you can send the license file directly to Lernwerkzeuge@ingefo.de. You will get a copy of the mail request sent to the address given in the form. The generated license will always be sent to the address you entered in the form - please make sure that the spelling is correct, otherwise the license cannot be delivered. This function is available on most computer configurations. If this worked correctly, the following message appears:



In a confirmation email you will receive detailed information and the procedure for activating the license file. After that the tool is ready for use. Please note that the license is not created directly and fully automatically, but takes some time. So please be patient.

Do you have any questions?

If you have any questions, there is an [FAQ list](#) with the most frequently asked questions (see <https://ingefo.de/Werkzeuge/Tutorials>). Regular user support is unfortunately not possible due to resource reasons. Information's in case of problems or suggestions and feedback can be send to Lernwerkzeuge@ingefo.de - as far as possible, I will provide tips or assistance.

Option 2

manual request via a mail program

Open the location of the license file. You can navigate there directly via the button 'Open license folder'. Now write a mail with the mail program of your choice to Lernwerkzeuge@ingefo.de and request a license for the respective tool. Of course, it is important that you add the generated license file "LIZENZ.TXT" to the mail. The generated license and a reply to your request will always be sent to the address you entered in the form - please make sure that the spelling is correct, otherwise the license cannot be delivered.

Notes for the Operation of the Tool

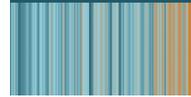
- Please note that a **commercial use** ^{*)}, ^{**)} of the programs is currently **not allowed** and for the use a registration with the appropriate license file is required. At the first program start you will be instructed how to request the license.
- The software is based on *Microsoft®Excel* and uses macros. It is executable with the PC versions from Excel 2010 on. The execution of macros must be permitted. To use the tools you need a licensed version of *Microsoft®Excel*, which is not part of the tools.
- The software does not run natively on *macOS* and is not compatible with *OpenOffice/LibreOffice*. You can find more information about this in the FAQ list.
- The software is designed and intended as a **learning tool** for teaching, training or education. The software is only used for the qualitative representation of selected energetic relationships and parameters in the context of the energetic evaluation of buildings and technical systems. This purpose also applies in the case of commercial use.
- The software is **not suitable** for producing evidence of the fulfilment of legal standards, for creating normative verifications, standard calculations, designs or dimensioning of structural and technical building systems and components or technical installations. It is expressly forbidden, and not intended as a purpose of the software, to use the software for this or for comparable applications, uses or scenarios and this also applies in the event of commercial use.
- Simplified calculation models are used for the calculation model and the software is in the development stage. Errors in the calculations cannot be ruled out.
- **Neither a warranty nor a liability** can be assumed for an error-free function or correct calculations of the software. Excluded is any liability for damages caused by the use of results or data and information from the tools. You can find more information in the license terms in German.
- If my time allows and if there is a relevant use of the software, the software will be further developed. However, further development and/or access to the software can be discontinued without prior notice and at any time.
- This translation has only an informative character and the reference language is German. For more information's, please take a look in the German license terms.

***) Notes for student use**

The use of the tools is only allowed as far as it is stated in the license conditions - i.e. no use with commercial background and only in the context of teaching/education. Therefore, please note the definition of what is meant by a non-permitted commercial use^{**)}. This concerns for example also the application and use, in the context of a study/bachelor/master thesis, which is accomplished in a company or in co-operation with a company. This application is in the sense of a commercial use, for which the company must apply for a license.

****) Definition of a commercial use**

A commercial use includes all activities with which either directly or indirectly a fee is charged. This also applies if the activity is fundamentally not for profit, the fee is only charged for pure cost recovery and/or only to a small extent. This applies equally to direct and indirect results and findings and representations generated or derived as a result of using the tools, in the case of commercial, professional, institutional and/or private use. If commercial use is desired, an appropriate use license is required. For more information, see the license terms in the program folder.



Possibilities and limits

An individual room, a group of rooms or a whole building can be examined as a one-zone model. Individual rooms or groups of rooms are particularly relevant. This can be a special characteristic room/group of rooms, in analogy with investigations for summer thermal protection certificates. If you simulate a whole building as a one-zone model, you must take into account that winter solar yields or summer thermal loads are distributed evenly across the whole interior area and passed on to the room air nodes. If the rooms are not part of the open-air flow system, possible temperature differences between different sides of the building are not reflected and possible extreme values are attenuated. In this case, the calculation result represents a rather average behaviour. The usage differences between individual areas often also require a differentiated examination (internal heat sources, layout). It is then better if the summer temperature behaviour in particular is examined using simulations at the level of a room or a group of rooms assigned to the respective use. The larger the building, and the more differentiated its usage, the less appropriate is a one-zone model seems for an overall evaluation.

The one-zone room model used in SimRoom is based on various experiments^{3,4,5,6,7,8,9,10} and makes use of the idea that part of the thermally effective storage mass of the exterior and interior building components can be allocated to room air. With further simplifications, for example with regard to considering the radiation exchange, the energy balance is reduced to an inhomogeneous, linear first-order differential equation, the solution of which is used as an algorithm in SimRoom. The calculated air temperature corresponds to the average node temperature of the room (\sim operative room temperature) because, in this case, radiative and convective energy output cannot be differentiated. As such, the result of the room temperature development has to be seen as an approximation, and is suitable for estimation and version comparison during the concept and draft phase. The essential physical and technical influencing factors are taken into account in the energy balance. Comparison calculations for selected cases with the dynamic simulation programme TAS showed a sufficiently high level of agreement¹¹. The SimRoom method can therefore be viewed as adequately precise for use in teaching, and to display the essential relationships there.

An optional 5R1C balancing model is integrated starting with version 4 which can determine the room air temperature and the surface temperature of the building components in a differentiated manner. You can switch between the balancing approaches quickly.

³ Lichtmeß, Markus. Ein Lernwerkzeug zur Überwärmung und Energiebilanz im dynamischen 1-Zonen-Raummodell. Goblet Lavandier & Associés, 2017.

⁴ Norford, Leslie K., Using simulation tools in a university laboratory course: assessing the performance of a health-care center in Lusaka, Zambia. Massachusetts Institute of Technology, Cambridge, MA 02139, 2006.

⁵ Clemens, Joachim. Entwicklung eines einfachen Modells zur Abschätzung der sommerlichen Überwärmung in Gebäuden. Universität - Gesamthochschule Siegen, Fachbereich Physik, 2000.

⁶ Burmeister, Harald und Keller, Bruno. Die gebäuderelevante, quantitative Darstellung von Klimata: ein neuartiges Planungs- und Dimensionierungsinstrument. Teil 1: Grundlagen, Berechnungsbeispiele. Schweizer Ingenieur und Architekt, Heft 21, 1995.

⁷ Keller, Bruno und Magyari, Eugen. Energieeffiziente Bauten: Grundlagen für intelligente Planer energiesparsamer Bauten. Schweizer Ingenieur und Architekt, Heft 7, 2000.

⁸ Burmeister, Harald und Keller, Bruno. Die gebäuderelevante, quantitative Darstellung von Klimata: ein neuartiges Planungs- und Dimensionierungsinstrument. Teil II: Strategische Überlegungen. Schweizer Ingenieur und Architekt, Heft 23, 1995.

⁹ Bödefeld, Sabine. Die massgebenden Klimagrößen für den Energiebedarf eines Raumes. Technische Wissenschaften ETH Zürich, Diss. ETH Nr.14010, 2001.

¹⁰ Huber, Arthur, Müller, Christoph und Berchtold, Oliver. Luftvorwärmung für Wärmepumpen in Erdregistern, Phase 1, Kosten - Nutzen - Analyse. Im Auftrag des Bundesamtes für Energiewirtschaft, Schweiz, 1996.

¹¹ Lichtmeß, M.: Vergleich einfaches Raummodell SimRoom mit edsITAS, 2017



The following can be determined with SimRoom:

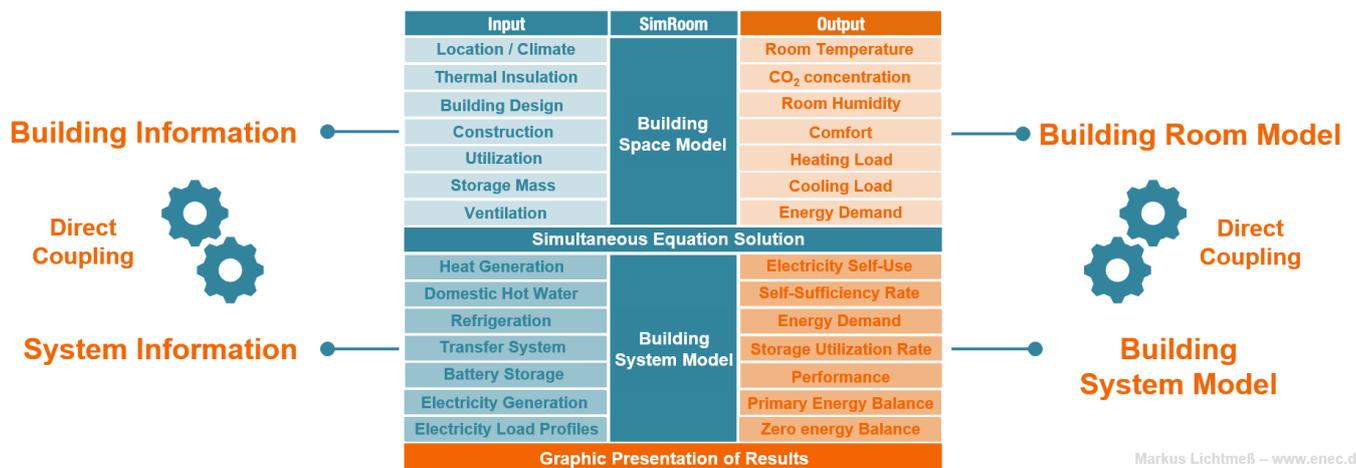
- Room temperature (with or without active heating and/or cooling)
- Room air quality (CO₂ concentration)
- Room humidity (relative and absolute humidity)
- Heating, cooling and zero energy hours
- Heating and cooling loads, heating and cooling demand
- Frequency of temperature excesses
- Excess temperature degree hours, following DIN 4108-2:2013
- Comfort evaluation according to the adaptive comfort model, following DIN EN 15251:2012
- Time profiles and air quantities in manual or mechanical ventilation
- Air flow rates at different passive cooling strategies
- Activation times and profiles of sun protection activation
- Electricity and energy balance at building level and characteristic map analyses of generators and storage systems
- Evaluation of selected technical systems for heat generation and cooling

The programme provides extensive graphics for the results prepared in a particularly didactic manner. Graphics and findings as hourly values can be exported simply for individual further processing. Weather data can be easily used from different locations around the world by importing in to the tool.

In the future, a connection with the CAD programme Rhinoceros from McNeel, and to Autodesk Revit will be possible via a tool developed by the University of Wuppertal. Input data can be taken from three-dimensional building models and can be imported to SimRoom. Findings from SimRoom, such as room temperatures or air quality indicators, can be exported to the three-dimensional building model and depicted. Information about this will be made available on the webpage of the department *Bauphysik und Technische Gebäudeausrüstung* under *Werkzeuge*: www.btga-arch.uni-wuppertal.de.

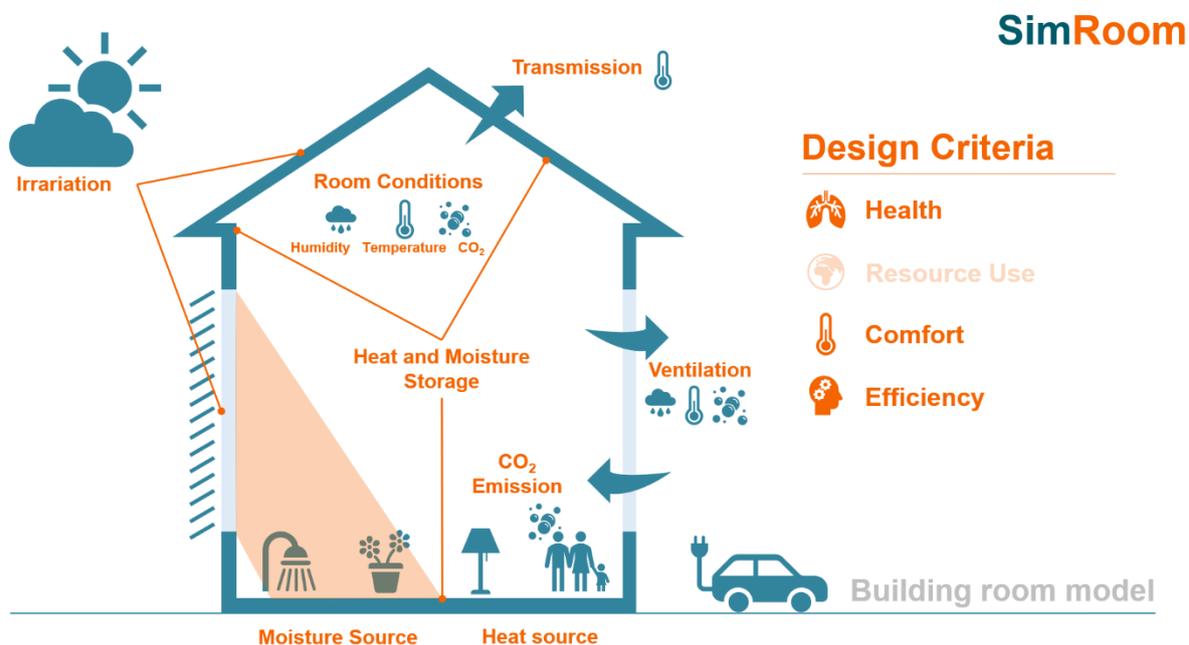
SimRoom balance model

An energy balance based on hourly time steps can be calculated using SimRoom. Here, a **building room model** and a **building system model** are used. The building room model is used to calculate room temperature, CO₂ concentration, and room humidity, as well as heating and cooling loads and the net energy demand. The building system model is based on the findings of the building room model. This can be used to make statements about the final energy demand and primary energy demand of technical systems. Both models are directly linked with one another. This means, for example, that a change to the building room model is also reflected directly in the building system model. The equations are solved simultaneously.



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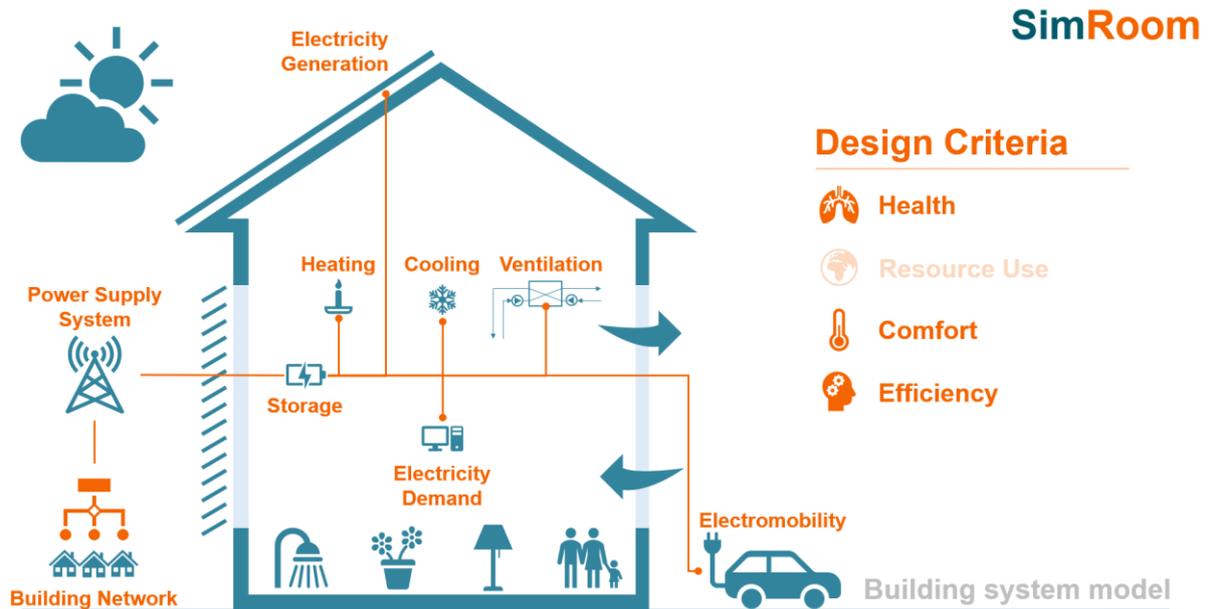
In the **building room model**, the room is balanced taking into account the transmission heat losses and the ventilation heat losses. Internal moisture and heat sources are considered, as well as the climate acting on the building. Incorporating the capacity of storing moisture and heat, the room humidity, room temperature and CO₂ concentration can be determined, as well as the heating and cooling requirements to maintain the target room temperature. These findings can be used to carry out extensive comfort evaluations. For example: how frequently the room temperature is above a certain comfort temperature of, for instance, 25 °C. The following image shows the room model schematically.



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With the **building system model**, the energy demand for heating, cooling, ventilating and the electricity demand of the building are determined at hourly increments, as well as the electricity generation via a photovoltaic system. In order to determine the effective use of resources, the generated electricity in the balance model is divided into two portions: one reflecting what is used in the building itself, and a second one which shows what is fed into the power grid. Battery storage helps to increase the proportion of electricity used in the building itself, as the excess electricity generated during the day can be fed into intermediate storage and then used outside of the solar radiation period. SimRoom has an integrated extensive

balance model to calculate these proportions. The final and primary energy demands are calculated for all technical systems and specific efficiency figures are displayed.



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Introduction

Start

SimRoom can be started directly after installation. When you open the programme, a security warning will appear stating that some content has been deactivated. Click on **"Activate content"** to be able to start editing.

In Excel, four additional worksheets, **"Eingabe (Input)"**, **"HeatMap"**, **"CarpetPlot"** and **"Wetter (Weather)"** are made available next to the **"Start"** sheet. The central sheet for processing is the **"Eingabe (Input)"**. Names of some worksheets are remained in German Language due to programming history, however all content is available in English. Also, command groups under SimRoom Tab on the Excel ribbon are only available in German (Please see English translation of ribbon below).

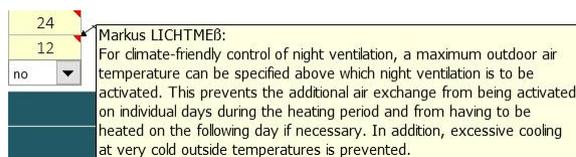
You have German and English language options on the **"Start"** worksheet. Press the language icon that you prefer **(0)**. On the starting sheet, you can start a new project via the large **"Start"** button **(1)** (= change to sheet "Eingabe").

Beforehand, you can display the currently installed version and check whether a more current version is available online via the "Update" button for **online updates (2)**. During the installation of the current version, the older version is automatically uninstalled and deleted.

SimRoom is an Excel-based tool, however the datasets are stored as text files (ending in ".txt"). This is why it is important not to use the standard Excel button to save it, but to rather save the project with the "Save" button in the SimRoom **"Project manager" (3)**. This generates a text file that can be reimported into SimRoom with the "Load" button.

Via Project management, there is an area for general **"Project data" (4)** with fields highlighted in yellow.

Also, you can find the numerous **tool tips** connected to the cells. If you move the cursor over the small red triangle in the corner of the cell, these comments automatically become visible.



The SimRoom calculations are carried out based on the weather data captured every hour. The weather dataset used should be checked before starting the simulation and adapted, if required. As well as the Project data, you can also load the **weather data (5)** from the start page. The German test reference years are already present in the corresponding SimRoom programme folder. A separate weather generator tool (for information, see page 28) allows the import of international weather data prepared for SimRoom. Note that only a German language edition of this tool is currently available.

Calculation results can be exported into a new workbook. For this, you must click on the button **"Export calculation results to a new Excel workbook" (6)**.

Carrying out a calculation

Calculations are carried out by the **"Run Simulation" (7)** button on the Start sheet, and also available on the top of each sheet. Typical simulation time range is range of a few seconds, depending on the hardware.

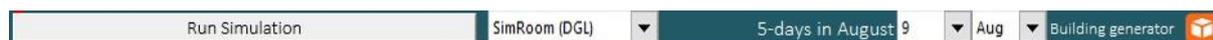


Table 1: Expected speeds of various system for a simulation run.

System	Technical specifications	SimRoom Time in s
Desktop PC, Windows 10	Intel(R) Core(TM) i7-8700 CPU @ 3.20GHz Excel 2016, Windows 10, 16 GB, 64 Bit	3.96
Laptop MAC, Bootcamp	Intel(R) Core(TM) i9-8950HK CPU @ 2.90GHz Excel 2019, Windows 10, 16 GB, 64 Bit	3.84
Laptop MAC, virtualised (Parallels® 14)	Intel(R) Core(TM) i9-8950HK CPU @ 2.90GHz Excel 2016, Windows 10, 16 GB, 64 Bit	5.58

Input

General information

- Input fields are always coloured yellow, which means that fields can be edited.
- Grey fields with red lettering are input fields which are filled automatically. For example, if the balance model is connected to the building generator. These can also be yellow input fields depending on the programme settings.
- Certain settings are filled out via combo boxes. You can click on the triangle symbol to select.
- Buttons allow you to display or hide more details of the program output.

Boundary conditions

Energy reference area m²
Room high, internal m

Boundary conditions

Energy reference area m²
Room high, internal m

Orientation | inclination PV

Type of heat generator

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Description of a project input

On the sheet "Eingabe", there are fields to **input building-related data (1)**. An example with default values is loaded automatically when SimRoom is started. The data can be deleted in "Project manager" via "delete" button in the Start sheet. The **results (2)** of the calculations can be displayed or hidden via the grey buttons "Show/Hide". Please note that, when you change any input, you should click the "Run Simulation" button to refresh the results.

The screenshot displays the SimRoom software interface. At the top, there's a navigation bar with 'Run Simulation', 'SimRoom (DGL)', and a date selector '5-days in August 9'. Below this is a table of building elements with columns for 'Element', 'Area', and 'U-value'. A red circle '1' highlights the first row of this table. To the right of the table are various input fields for 'Boundary conditions', 'Sun protection', 'Ventilation', 'Passive cooling', and 'Conditioning'. A red circle '2' highlights the 'General building characteristics' section at the bottom of the interface, which contains a list of 10 items with 'Show/Hide' buttons next to them.

We start with the input of the **building elements** and their type. Structural elements should be selected via drop-down menu and their area (m²) and the U-values (W/m²K) should be entered by typing in their input cells. They should be entered with their external dimensions. Building elements can be added or removed using the arrow buttons and the ones, which are adjacent to interior rooms, must be defined as "Interior component". This gives them adiabatic boundary conditions. No heat is transferred; however, the area and half the mass are taken into account. It is not necessary to assign interior building components in SimRoom, as these are estimated for the calculation.

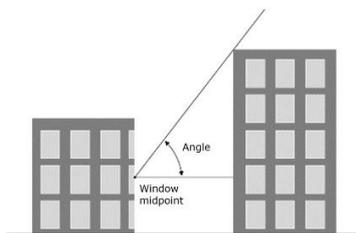
General **"Boundary conditions"** are added in the next section. Initial inputs are required for the energy reference area (floor area) and the internal room height. Details about occupancy or the specific general electricity demand (lights, IT equipment, household electricity, etc.) are either derived from the details in the "Building type" section (residential building, non-residential building).

The details about the specific domestic hot water demand, under **"Technical systems"** section, influence the evaluation of system technology as far as energy production is concerned, however does not influence the room thermal balance. Technical systems can be entered to examine this at a building level.

The information about moveable sun protection of the building can be entered under **"Sun protection"** section. Here, you can add details about glazing¹², the effects of the sun protection and the activation limit values of the sun protection based on the irradiation intensity (W/m^2) and outdoor temperature ($^{\circ}C$). Moveable shadings are considered by entering the resulting total solar energy transmittance taking in to account the glazing and the shading in operation. The details apply to all orientations; however, calculation of the irradiation intensity value is carried out for each orientation separately. Switch frequencies are evaluated accordingly (see section "Structural shading and activation of sun protection systems" – SS-active –).

As well as moveable sun protection systems, you can enter various situations of **structural shading** in regards to surrounding buildings (horizon), overhangs (e.g. balconies) and fins (e.g. vertical slats). Depending on the position of the sun and the shade angles entered, the influence of structural shading is determined for each hour and the following boundary conditions are applied. The **shading factor** ($F_{S(x)}$) corresponds to the ratio of the irradiation with building shading to the irradiation without building shading.

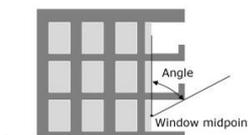
Horizon shading



The direct radiation is determined based on an (obstruction) angle. If the sun elevation (altitude) angle is below the stated shade angle, no direct radiation is recognised for the building component.

Diffuse and reflected radiation hit the building component unhindered.

Overhang shading

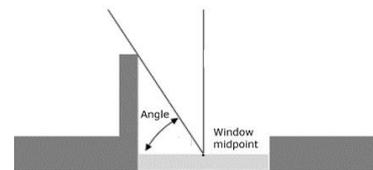


The direct radiation is determined based on an angle. If the sun elevation (altitude) angle is above the stated shade angle, no direct radiation is recognised for the building component.

The diffuse radiation is reduced depending on the position of the sun. Here, use is made of the idea that the side of the building component facing the sky is equal and corresponding to the proportion of diffuse radiation.

Reflected radiation hits the building component unhindered.

Lateral shading



The direct radiation is determined based on an angle. If the sun azimuth angle is below the stated shade angle, no direct radiation is recognised for the building component.

Diffuse radiation hits the building component unhindered.

Reflected radiation hits the building component unhindered.

For south-facing building components, the shade evaluation applies to two side panels to the east and west.

Moveable sun protection can be deactivated / activated separately for each orientation with "SS-aktive" option under "Structural shading" section with the arrow selections as "yes" or "no", if, for example, they are not present or not provided for a specific orientation.

¹² For the window area, a frame proportion of 20 % is assumed for calculating the solar gains.

Under "**Ventilation**" section, you can enter details about the airtightness of the building and the air exchange during use and outside use. The entries under "Ventilation" define a constant basic air exchange appropriate to the usage which occurs either manually via window ventilation or via a mechanical ventilation system. For mechanical ventilation systems, it is possible to take heat recovery into account ("0 %" heat exchange efficiency corresponds to an exhaust ventilation system or window ventilation). In the case of a heat recovery system, conditions for a summer bypass can be defined with an external temperature set point. Electricity consumption for the ventilation technology are incorporated into the electricity demand.

Under "**Passive cooling**" section, further ventilation strategies are entered with the aim of avoiding summer excess temperatures. This is performed by way of increased ventilation by exceeding the entered room temperature (T_r) or external temperature (T_e) limit value. The air exchange set here is not constant. Instead, this is determined as an approximation from the percentage opening area and the temperature difference between inside and outside. The air exchange values to be set are evaluated in the section "Time and ventilation profiles".

Under "**Conditioning**" section, with regard to the **building type**, we distinguish between residential and non-residential buildings, although further details are pre-set (interior heat sources, rate of occupancy, layout profiles, ...). For non-residential buildings, the weekend is pre-set as time of non-use. The building element storage mass - thermally active storage capacity of the enclosing surfaces of a room / a zone, (Storage mass c) - can either be taken into account via 5 estimated classes of "very light" to "very heavy", or entered manually via the effective storage mass c_{eff} . Entering the capacity for moisture storage (Storage mass f) takes place analogously via 5 classes, or entering the dynamic capacity for moisture storage f_{MBV} . The tool tips contain explanations and information for determining the values c_{eff} and f_{MBV} .

With regard to **conditioning**, two variants can be entered and later compared directly with each other in the figures of evaluations. The input consists of the limit temperatures for active heating (e.g. 21 °C) and cooling (e.g. 25 °C), as well as a switch temperature difference if applicable (room thermostat = 0 means ideal heating/cooling according to the target value). For didactic reasons, a freely fluctuating variant – equilibrium – leads to idle temperatures with zero energy demands for heating and cooling; and a conditioned variant to examine the corresponding indoor comfort and energy demands. To compare two variants with different heating and cooling limit values, the freely fluctuating variant can be overwritten as another conditioned variant. Both variants are displayed in the evaluations. Via the arrow symbol under the variants, you can select whether the respective variants should be shown in the evaluations. Depending on the selection via yes/no arrow with "Show variant" section, both or one version is taken into account in the evaluations. The user can enter limits for heating and cooling capacities available. A Humidification / dehumidification can be switched on or off and set points can be defined.

The Building Generator (Optional Use)

2c 2b

Building generator

Energy reference area	200	m ²	Storeys	2	St.
Factor inside/outside fAn	0.79	-	Wall thickness	0.60	m
Room height, internal	3.0	m	Storey height	3.4	m
Max. building depth	8.5	m	Roof pitch	25.0	°
Char. facade perimeter	46.8	m	A_b.ar. out	127	m ²

2a

The 1-zone model is not fully linked to the envelope generator

Building envelope areas	Total	Thermal insulation level					U-value W/(m ² K)
		S	N	O	W	HO	
%Orientation (BE)	318	30%	30%	20%	20%	---	---
Area building (BE)	---	95	95	64	64	140	---
%Window at BW	---	35%	10%	5%	25%	0%	---
Windows	62	33	10	3	16	0	0.650
Wall area	256	62	86	60	48	---	0.110
Floor	127	---	---	---	---	127	0.120
Roof	140	---	---	---	---	140	0.100
Total	584	---	---	---	---	---	0.177

Model of the building generator

Specific window area = 0.31 m²Fe/m²An | Compactness = 0.679 1/m

Based on the floor area as the energy reference area and additional geometric details, building envelope surfaces can also be determined using the **"Building generator" (2)**. When you click the cube icon near to Building Generator, the input worksheet will be extended by new input options under Building generator. Tool tips explain the inputs required. The building generator can be connected with or disconnected from SimRoom. It is disconnected as a default. To connect the building generator with SimRoom, you can click the chain icon **(2b)**, then the data for the building elements are automatically connected and cannot be edited in SimRoom. In connected mode, the data input cells will become grey with red lettering for building elements manual input. The building generator should be disconnected via un-luck icon **(2c)**, which turns building element manual input cells into yellow with black lettering, if you want to manually adjust the building elements. If SimRoom is reconnected with the building generator, the previous building elements' data entered manually will be lost.

In addition, specifications for the **"Thermal insulation level"** in SimRoom **(2a)** can be made in the building generator. The corresponding values are

specified for the thermal transmittance value, the degree of energy transmittance of the glazing, the airtightness and the degree of heat recovery from the ventilation system. It is **"On"** as a default but, if individual values are to be added instead, the specifications for the "Thermal insulation level" should be set to **"Off"**.

If the building generator was used, the energy reference area and the clear room height under "Boundary Conditions" have already been carried over and their input cells have turned into grey with red lettering. Tool tips explain the inputs required.

Note that the graphical representation of the building changes not directly after a modified geometry input but when running a simulation.

Evaluation

By clicking on the respective grey switch field "Show/Hide" located on the right, individual evaluation areas can be shown or hidden to create a better overview. This function is available for all evaluations. The findings are divided into 11 categories:

- General building characteristics
- Power and energy balance (heat, evaluation for variant 2: conditioned)
- Power and energy balance (humidity, evaluation for variant 2: conditioned)
- Room comfort
- Room temperatures
- Room air humidity
- Room air quality
- Time and ventilation profiles
- Structural shading and activation of sun protection systems
- Plant Engineering (evaluation for variant 2: conditioned)
- Monthly results room balance (Evaluation for variant 2: conditioned)

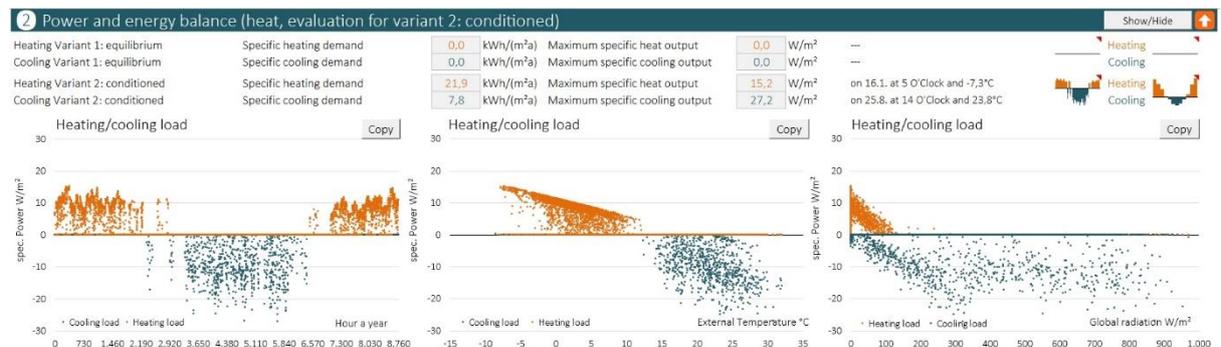
(1) General building characteristics

This section summarises key values for the weather, the building and its use.

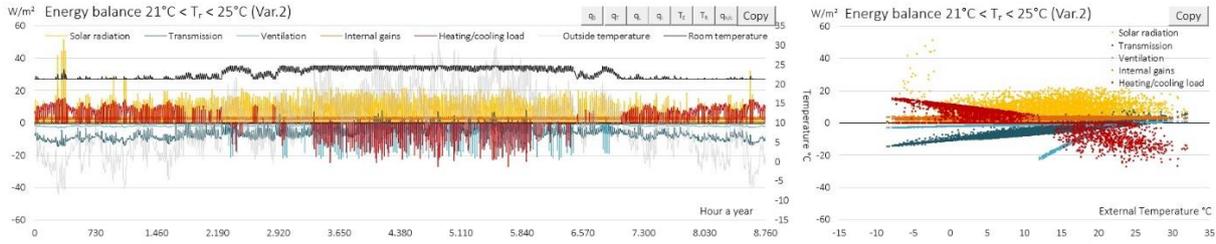
1 General building characteristics				© Markus Lichtmeß, Version 4.195 vom 27.9.2020		Show/Hide	
Weather data	Luxembourg	Structural characteristics		Energetic parameters		Further parameters	
Outdoor temp. min	-8.5 °C	Room air volume	600 m ³	Heat demand with losses	24.1 kWh/(m ² a)	Additional outside air exchange \dot{V} (T _i -T _e >2K)	1.37 [1.2] 1/h
Outdoor temp. ϕ	10.0 °C	Area of all exterior comp. $\sum EC_i$	584 m ² _{gr}	Loss/Transfer key figure	1.10 -	Type of ventilation in the building	Ventilation system
Outdoor temp. max	32.0 °C	Mean U-value of exterior comp.	0.173 W/(m ² ·K)	Efficiency number of generation	3.55 -	Efficiency of the ventilation system (SFP)	0.40 W/(m ³ /h)
Total irradiation	1,096 kWh/(m ² a)	Specific window area	0.310 m ² /m ² _{wa}	Cooling demand with losses	9.3 kWh/(m ² a)	Hygienic fresh air flow rate	180 m ³ /h
Hours < -10 °C	0 h/a	Specific solar transmittance t _{sol}	0.112 m ² /m ² _{wa}	Loss/Transfer key figure	1.10 -	Occupants in zone	3.1 Personen
Hours < -5 °C	123 h/a	Specific transmission loss h _T	0.506 W/(m ² ·K)	Efficiency number of generation	---	Person-related fresh air volume	58.1 m ³ /(h·P)
Hours < 0 °C	805 h/a	Specific ventilation loss h _V	0.105 W/(m ² ·K)	Hot water demand with losses	6.6 kWh/(m ² a)	CO ₂ Human emission rate	21.4 l/(h·P)
Hours > 20 °C	846 h/a	Specific total loss h _{TL}	0.611 W/(m ² ·K)	Loss/Transfer key figure	1.15 -	CO ₂ Fresh air concentration	400 ppm
Hours > 30 °C	8 h/a	Profit to loss ratio γ	0.183 (m ² K)/W	Efficiency number of generation	2.55 -	electricity demand for gen. use	2,968 kWh/a
Hours > 35 °C	0 h/a	Thermal inertia t	103.8 h	Personal DHW requirements	1.42 kWh/(P·d)	Personal general electricity demand	959 kWh/(P·a)
ϕ Wind speed	3.4 m/s	U _e effective component lower closure	0.111 W/(m ² K)	Primary energy demand	52.2 kWh/(m ² a)	total electricity demand	5,799 kWh/a

(2) Power and energy balance (heat evaluation for variant 2: conditioned)

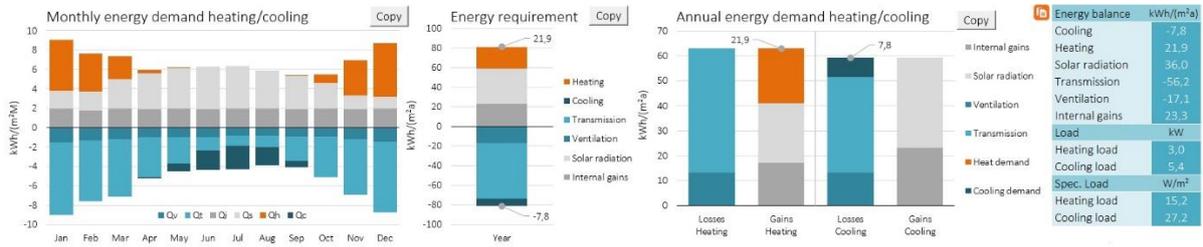
In this evaluation, the heating and cooling loads, as well as the energy demand for heating and cooling are depicted. In addition, the date and external temperature for the day are visible with the respective maximum output. The graphic depiction covers the findings of variant 2, as the calculation of variant 1 is typically freely fluctuating. The heating and cooling loads over the course of a year, and depending on the external temperature and global radiation can be viewed, as well as the energy balance of the room model.



Energy balance, individual curves can be shown or hidden to increase clarity, is displayed over the course of a year. Energy balance can also be seen in relation with external temperature.

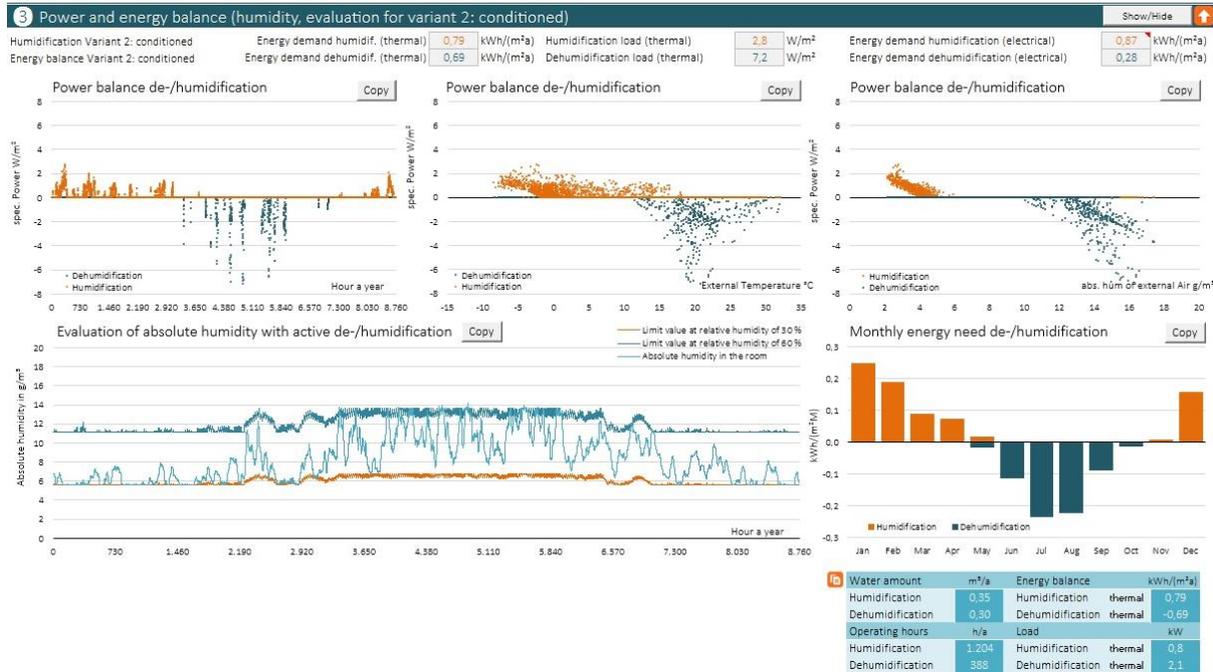


The energy balances for heating and cooling are also displayed at a monthly and annual time scale.



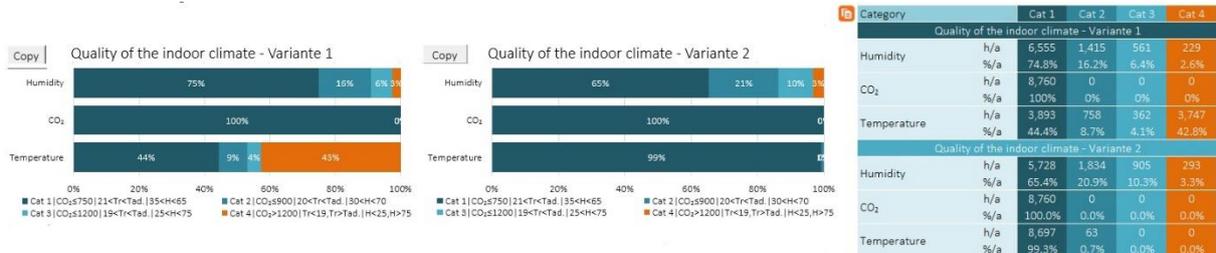
(3) Power and energy balance (heat evaluation for variant 2: conditioned)

The figures illustrate the power demand for humidification and /or dehumidification based on the set points defines on hourly basis. The resulting humidity data are presented and as well as annual energy needs are listed monthly.

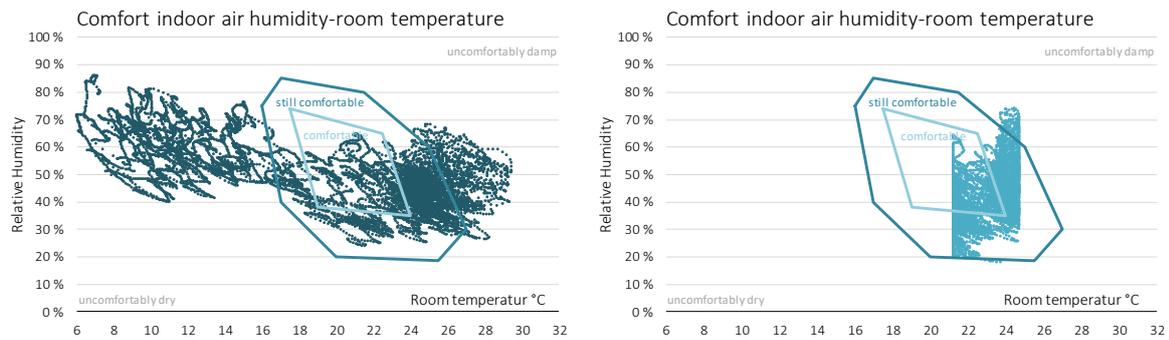


(4) Room comfort

The temperature frequencies, the room temperature plot, the comfort evaluation for air-conditioned and non-air-conditioned rooms, the quality of the room climate and the excess temperature hours according to DIN 4108-2:2013 are displayed. Room temperature, CO₂ emission and relative humidity are represented as indoor air quality indicators via 4 categories for each of them (Cat 1, Cat 2, Cat 3 and Cat 4).



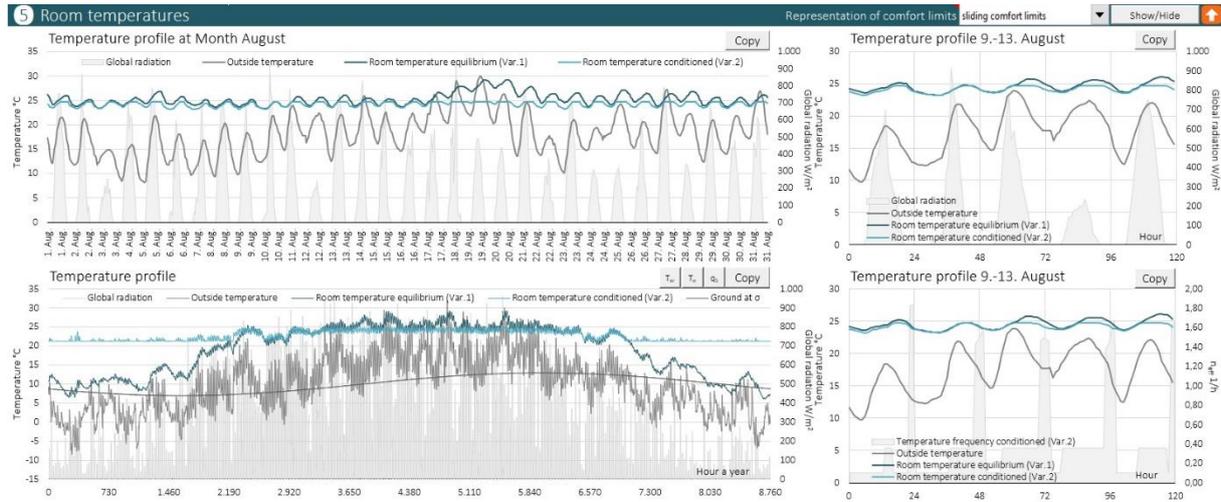
The adaptive comfort model is based on DIN EN 15251. This temperature -humidity comfort model shows the hours over the course of the year in relation with room relative humidity and room operative temperature via three categories as comfortable, still comfortable and not comfortable.



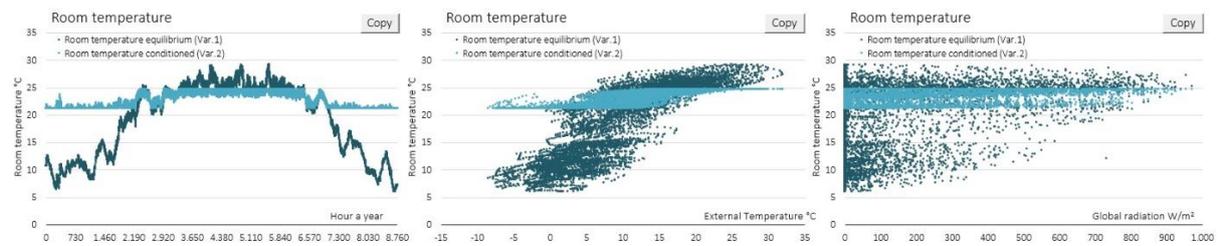
This evaluations on room comfort allows us to check whether the selected ventilation strategy not only just optimizes the energy demand and room temperatures, but also ensures a sufficient level of air quality and humidity. You can find other detailed evaluations in the area "Room air quality", "Room temperatures" or "Room air humidity".

(5) Room temperatures

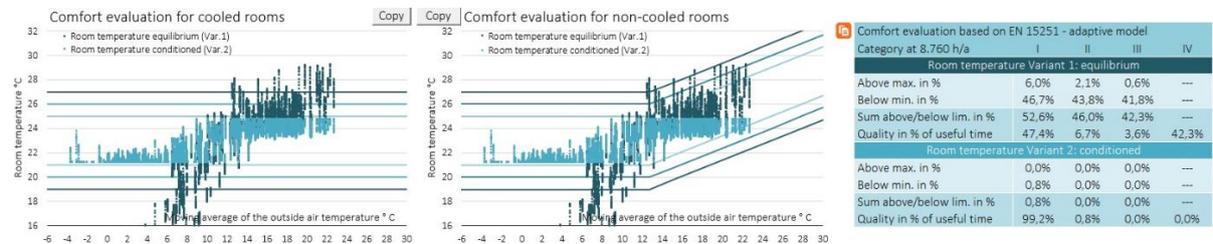
Here, temperature processes captured every hour are visualised. The results of the calculations are shown on an annual, monthly and weekly scale. The month and starting day of a 5-day plot can be freely selected in the header to be examined. The diagrams can be copied onto the clipboard and reused by clicking on the "Copy" button. It is possible to adjust the axis intercept of the market diagram. These functions are available for all diagrams in SimRoom.



Beyond the course of time, the room temperatures are displayed in relation to the external temperature and the global radiation.

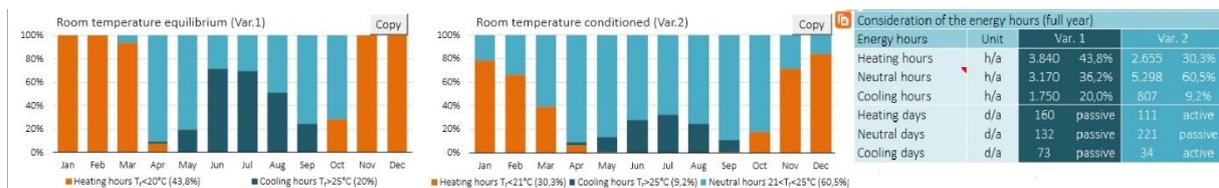


To assess the thermal comfort, you can categorise according to the evaluation following EN 15251.



The frequency of exceeded room temperatures can also be added as a benchmark in relation with moving average of the outside temperature, based on EN 15251 – adaptive model (excess indoor temperature hours).

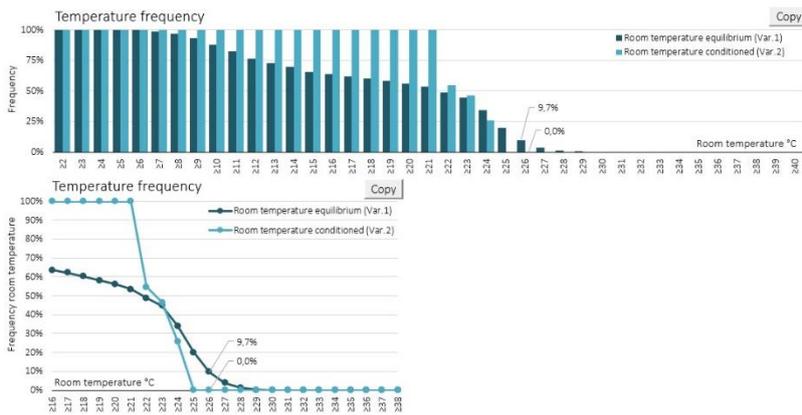
As well as the thermal comfort and the air quality, there is another quality of “robustness” of the space being examined against influences caused by the climate and use. Thereby, conditioning hours are displayed. This is the percentage of the time in which the building must be heated or cooled, or the neutral area, which is a case when neither heating nor cooling is required.



The aim of the energetic optimisation of a building plan is to maximise the percentage of neutral hours. In addition, the table “Conditioning hours” compiles the percentage of heating, neutral and cooling hours. For

this, the hours over the course of a year are quantified, where, corresponding to the entered set points T_r heat and T_r cool under "Conditioning", the building must be heated or cooled. The percentage of neutral hours states how frequently the room or building "fluctuates" between the set points without having to be heated or cooled actively. The freely fluctuating version refers to a temperature band of 20 to 25 °C.

The rating process according to DIN 4108-2 is also stored. Here, it is not just the frequency of exceeding temperatures which are incorporated, but also the amount the temperature is exceeded by. The requirement value is then the excess temperature degree hours.



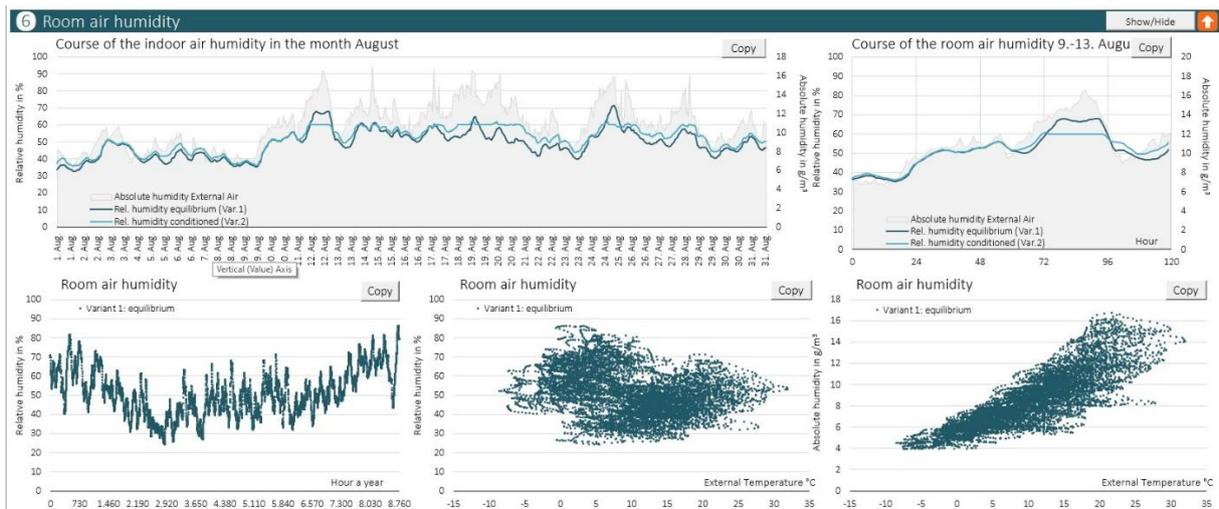
Evaluation of excess temperature degree hours at (8.760 h/a)			
Summer climate A, B, C	Ref. T_r °C	Value Kh/a	Requirement 4108-2 in Kh/a
Excess temperature degree hours Variant 1: equilibrium			
Climate agion A	25	2.117	
Climate agion B	26	854	1.200
Climate agion C	27	284	
Excess temperature degree hours Variant 2: conditioned			
Climate agion A	25	0	
Climate agion B	26	0	1.200
Climate agion C	27	0	

Evaluation of room temperatures			
	Var. 1	Var. 2	Unit
Minimum room temperature	6.0	21.3	°C
Average room temperature	19.1	22.7	°C
Maximum room temperature	29.3	24.8	°C

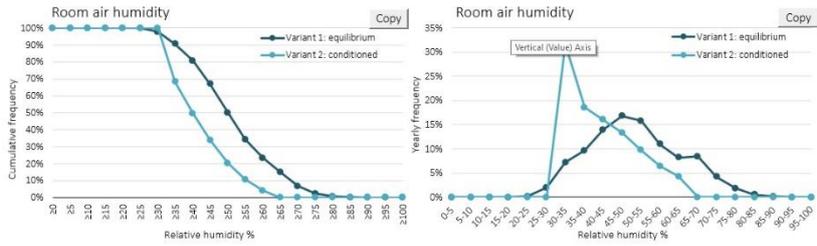
Excess temperature hours at 8.760 h/a				
	Var. 1	Var. 2	Limit	
Share of hours with $T_r > 24$ °C	34,0%	26,0%	---	
Share of hours with $T_r > 25$ °C	20,0%	0,0%	---	
Share of hours with $T_r > 26$ °C	9,7%	0,0%	< 10 %	
Share of hours with $T_r > 27$ °C	3,8%	0,0%	---	
Share of hours with $T_r > 28$ °C	1,3%	0,0%	---	
Share of hours with $T_r > 29$ °C	0,2%	0,0%	---	
Share of hours with $T_r > 30$ °C	0,0%	0,0%	---	

(6) Room air humidity

As well as temperature and air quality, the humidity also represents a third indicator for room comfort. This evaluation is also captured in hours. The details about occupancy and ventilation as well as the moisture storage capacity of building components are the essential factors that effect the quantity of room humidity. With regard to the building components, on the one hand, the available component surface, estimated using the floor area, and on the other hand, the moisture storage capacity of the material, expressed via the moisture buffer value f_{MBV} are important.



The air humidities are displayed as a cumulative value, similar to the temperature evaluation as well. This allows us to derive statements about the frequency of room humidity and corresponding statements about comfort.

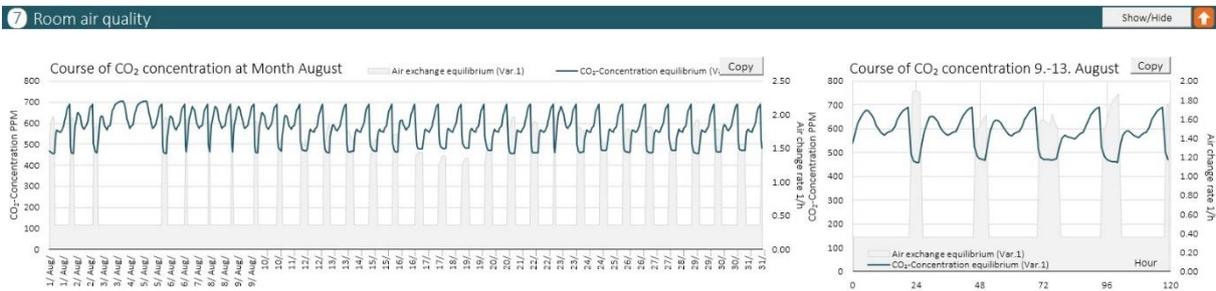


Moisture sources	g/h	g/d ₃₆₅	kg/a
Humidity output occupants (70 g/(P.h))	217	4.345	1.586
Humidity output general (0,5 g/(h.m²))	100	2.400	876

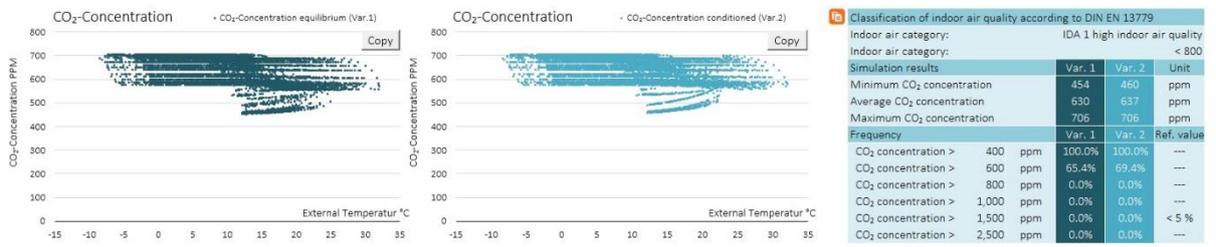
Evaluation of humidity	Var. 1	Var. 2
Rel. humidity betw. 0 %	10 %	0 %
Rel. humidity betw. 10 %	20 %	0 %
Rel. humidity betw. 20 %	30 %	2.1 %
Rel. humidity betw. 30 %	40 %	16.9 %
Rel. humidity betw. 40 %	50 %	20.8 %
Rel. humidity betw. 50 %	60 %	26.8 %
Rel. humidity betw. 60 %	70 %	16.6 %
Rel. humidity betw. 70 %	80 %	6.0 %
Rel. humidity betw. 80 %	90 %	0.7 %
Rel. humidity betw. 90 %	100 %	0.0 %

(7) Room air quality

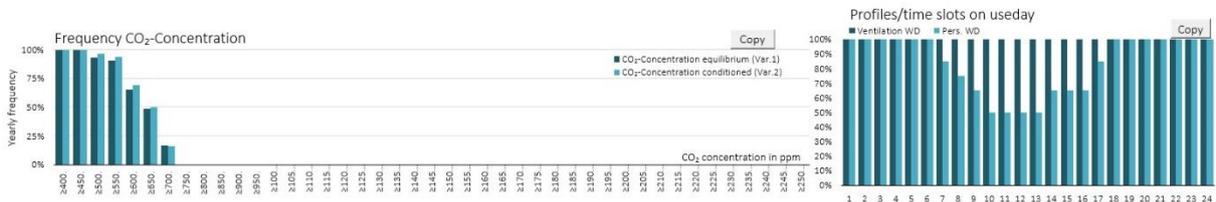
The CO₂ concentration as an indicator of air quality takes place along with the room comfort diagrams and the ventilation profiles. This evaluation captured in hours is represented through the month and the week of choice for both of the variants.



The room air quality is classified according to DIN EN 13779. The inputs about occupancy and ventilation represents the essential influence factors for the development of CO₂ concentration.

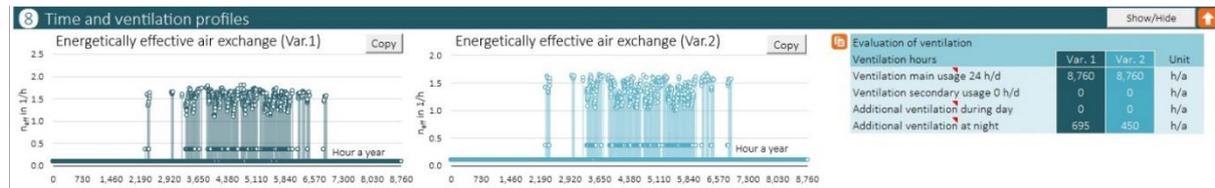


As in the other comfort evaluations, frequencies are determined where the CO₂ concentration is found to be within specific areas.



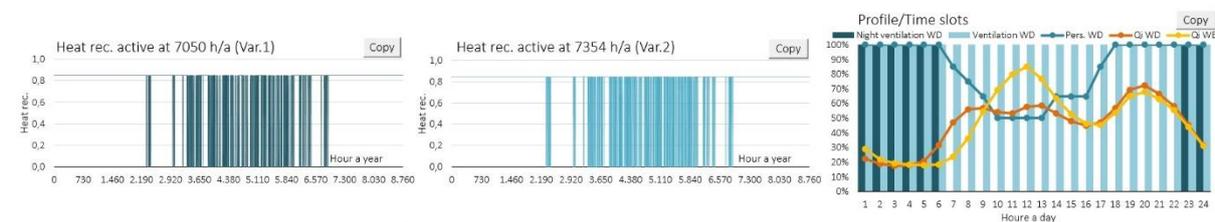
(8) Time and ventilation profiles

This section allows us to check whether the settings for controlling the ventilation and the information about heat recovery lead to the desired results. A critical examination is recommended, particularly with the settings for the additional window and night ventilation.

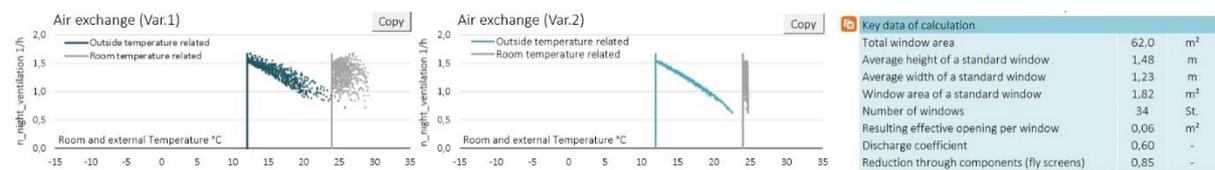


The following must be noted for the depiction of an energetically effective air exchange: Heat recovery removes a part of the energy from the waste air which has been heated in the room, and adds this to the supply air. Compared to a window ventilation with the same amount of air, mechanical ventilation with heat recovery helps to decrease the heating load by reducing energy loss. This rate can be specified between 0% and 100%. Rate of 0% corresponds to pure window ventilation or an exhaust air system without heat recovery. The higher the degree of air recovery is, the lower the energetically effective air exchange will be: the same volume of air is exchanged for indoor air quality but the energetic effect is decreased. The actual air exchange is depicted in a graphic in the area "Room air quality".

In the graphics named "**Heat recovery active**", you can see both the rate of heat recovery and the hours with deactivated heat recovery via the bypass for both variants. The illustration "**Profiles/Time Slots**" visualises the ventilation profiles and internal loads based on the building type. The abbreviations "**WD**" and "**WE**" indicate days of use and days of non-use

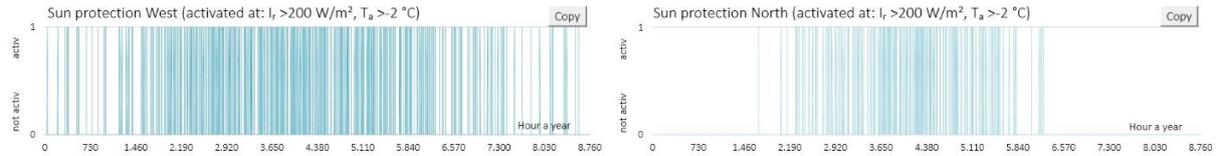


When evaluating the window air exchange, the target air exchange is displayed via the window night ventilation. On one hand, this serves to rate the selected openable window area regarding the target air exchange, and on the other hand, to display the influence of the control parameters.



(9) Structural shading and activation of sun protection systems

The limit value of solar Irradiation, I_r (W/m²), for activating the moveable sun protection represents an essential influence factor on the summer room comfort of the freely fluctuating model or the cooling load (input under "Sun protection" in the project input). At the same time, an activated sun protection depending on the selected system is linked with limited transparency. High proportions of glass surfaces and/or warm climates typically require low threshold values, which lead to long activation times.



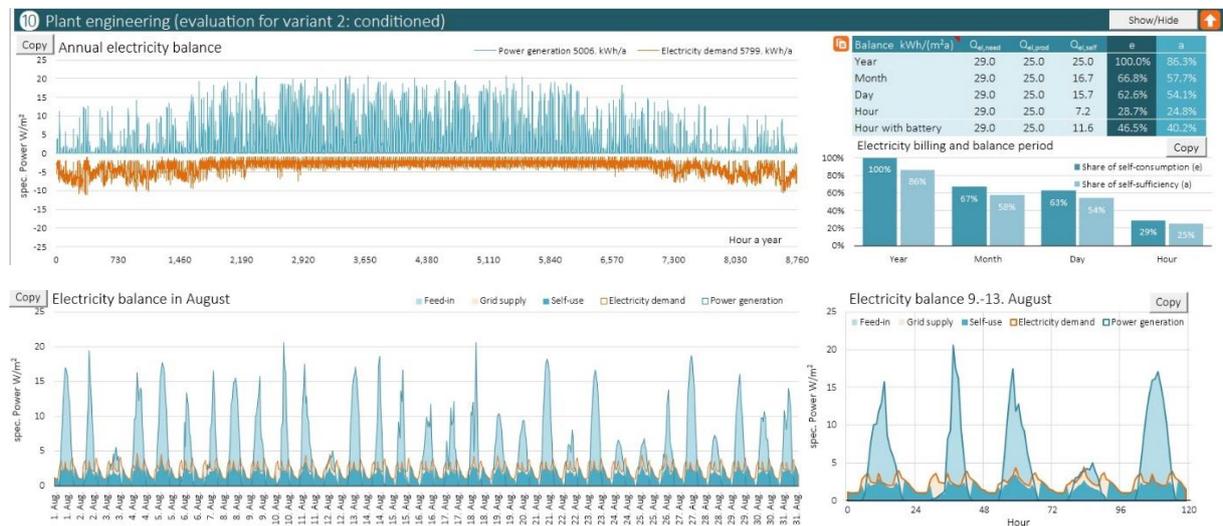
In this context, the activation times (h/a) of the sun protection system are depicted for different orientations over the course of a year. The information indicates times with reduced visual outer cover (=limitations to visual comfort).



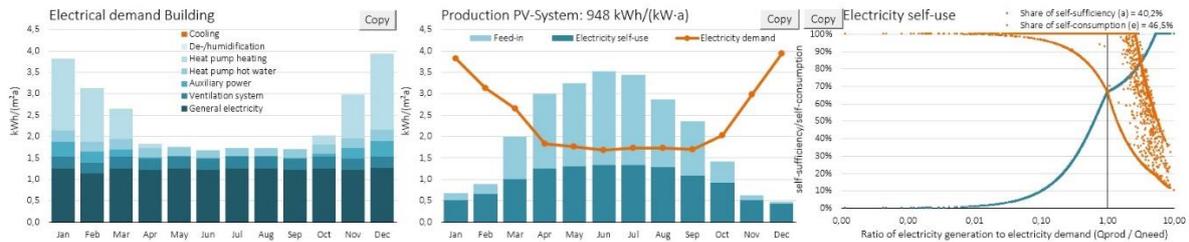
This is not differentiated for variants, as no varying inputs can be made for the moveable sun protection and/ or structural shading.

(10) Plant Engineering (evaluation for variant 2: conditioned)

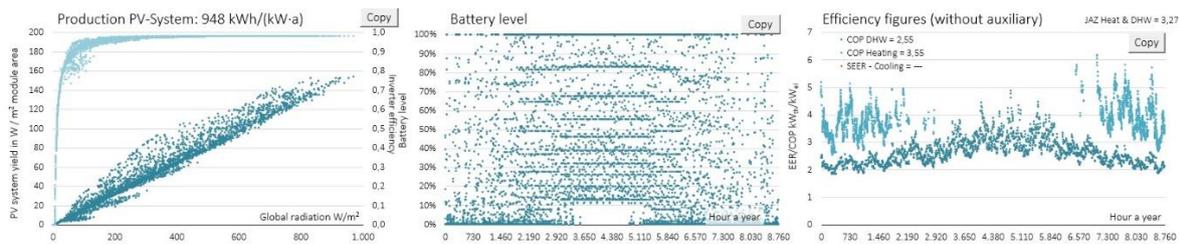
Based on the inputs under "Technical Systems", it is possible to calculate a one-zone model at building level. The graphic evaluation covers electricity balances on an annual, monthly and weekly scale, as well as characteristic map analyses of the PV system triggered on an hourly basis, the battery storage system as well as the heat generator and cooling system.



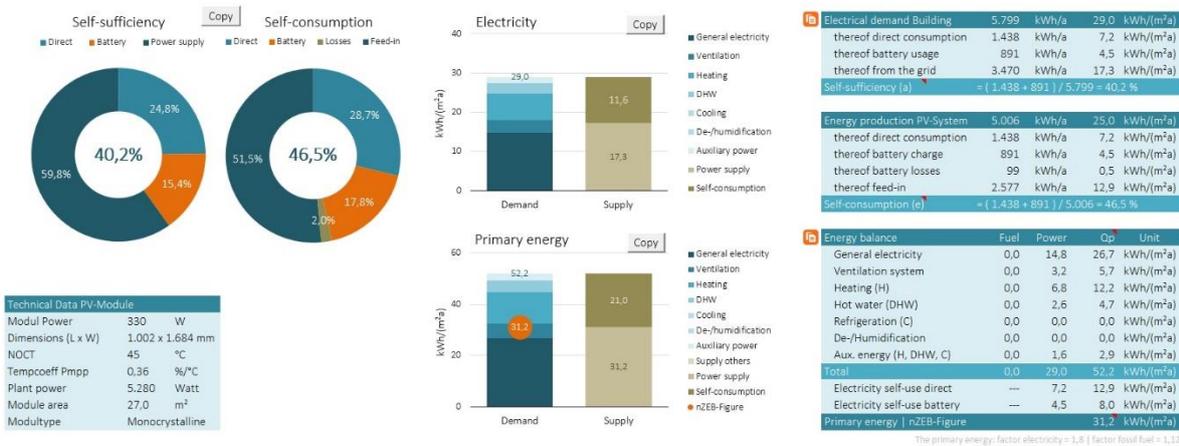
Monthly representation of the energy demands for heating, cooling, de-/humidification, general power, auxiliary energy, ventilation and warm water production, as well as a characteristic map for the use of domestic/on-site power.



Characteristic map analysis for the PV system, energy storage and heat generator and cooling system.



The depiction of electricity self-sufficiency and the use of domestic/on-site power are known from EnerCalC. EnerCalC uses an adapted process where the domestic/on-site power use can be carried out based on a monthly energy balance¹³. However, the results in SimRoom are more precise due to the hourly calculations.



¹³ M. Lichtmeß, C. Armbrorst, Vorschlag zur Erweiterung der Bilanzmethode DIN V 18599 um die Anrechnung der Eigenstromnutzung, Bergische Universität Wuppertal (Hrsg.), 2018.

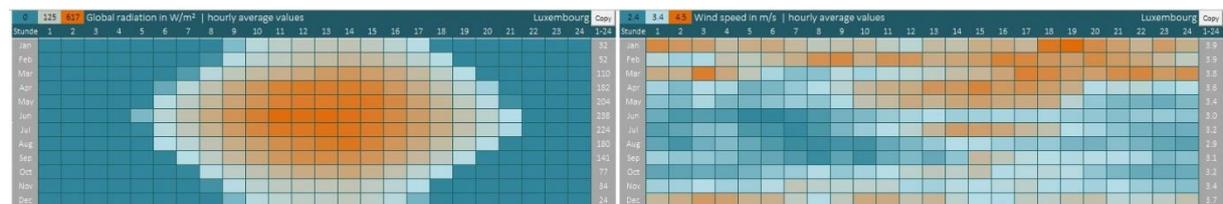
Monthly results room balance (Evaluation for variant 2: conditioned)

This section provides data for the month chosen for the analysis.

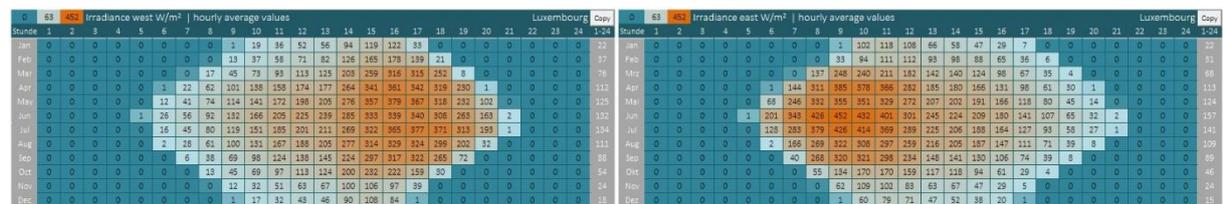


HeatMap

The calculated hourly values are displayed in this tab as HeatMaps. All graphics can also be copied as a high-resolution image in this area and reused. The calculation of the HeatMaps is complex and does not occur automatically. After a change, this must always be triggered via the button "Refresh HeatMap". This evaluation allows plausibility checks of the project inputs and the building model, and to display relationships.



The results can be adjusted visually via show / hide grid and figures buttons.



The results are present for the essential room balances. The following images shows the time distribution of room temperatures in the zone being examined.

Weather

The hourly weather data can be viewed in this tab. The table contains data about the external temperature, radiation values in the compass directions and the horizontals, as well as the wind speed and relative humidity. The fields highlighted in yellow can be edited manually, which allows individual adjustments. Worksheet must be updated after manual changes of the data via button "Refresh after changing data". Your own weather data file can be implemented via the "Weather" button on the "Start" sheet. To use your own weather data in SimRoom, first you are required to convert the data into .txt format via the "weather data generator" tool, which is an additional tool for SimRoom, automatic stored in the program folder. Note that this tool is currently only available in a German language edition, see below.

SimRoom – Climate Data
Refresh after changing data

Designation		Luxembourg					Latitude	49,6 °
h/a	T _e	HO _{ges}	HO _{diff}	V _{wind}	RF	Longitude	6,2 °	
1	-	0°	90°	10 m	-	GMT time	1,0 h	
8760	°C	W/m ²	W/m ²	m/s	%	Time offset	-0,5 h	

	°C	W/m ²	W/m ²	m/s	%
1	9,3	0,0	0,0	2,5	67
2	8,8	0,0	0,0	1,9	70
3	8,4	0,0	0,0	1,6	69
4	8,1	0,0	0,0	1,9	70
5	7,9	0,0	0,0	1,9	69
6	7,6	0,0	0,0	2,2	72
7	7,5	0,0	0,0	1,8	71
8	7,3	0,0	0,0	2,6	70
9	7,3	1,0	1,0	2,2	72
10	8,2	57,0	37,0	3,7	68
11	9,0	118,0	89,0	3,2	59
12	9,6	143,0	119,0	3,0	57
13	10,0	155,0	131,0	3,5	55
14	10,3	139,0	124,0	4,0	53
15	10,3	107,0	94,0	3,2	54
16	10,0	52,0	50,0	4,7	57
17	9,5	2,0	2,0	3,5	60
18	9,0	0,0	0,0	4,0	62
19	8,5	0,0	0,0	3,2	62
20	8,0	0,0	0,0	3,2	63
21	7,5	0,0	0,0	3,2	64
22	7,0	0,0	0,0	2,5	63
23	6,5	0,0	0,0	1,9	58
24	6,0	0,0	0,0	1,8	61
25	5,0	0,0	0,0	1,9	62
26	3,9	0,0	0,0	3,0	63
27	2,8	0,0	0,0	4,4	68
28	2,3	0,0	0,0	4,0	70
29	1,7	0,0	0,0	4,7	73
30	1,1	0,0	0,0	4,0	76
31	0,6	0,0	0,0	4,4	77
32	0,2	0,0	0,0	2,7	74
33	0,1	1,0	1,0	3,0	72
34	1,4	87,0	30,0	2,8	75
35	2,8	189,0	43,0	3,0	70
36	4,0	258,0	45,0	2,5	68
37	4,9	291,0	49,0	3,5	63
38	5,4	273,0	47,0	3,7	62
39	5,4	212,0	44,0	2,8	65
40	4,8	115,0	33,0	3,5	70
41	3,6	5,0	5,0	2,8	76
42	3,3	0,0	0,0	3,2	83
43	3,0	0,0	0,0	2,2	78

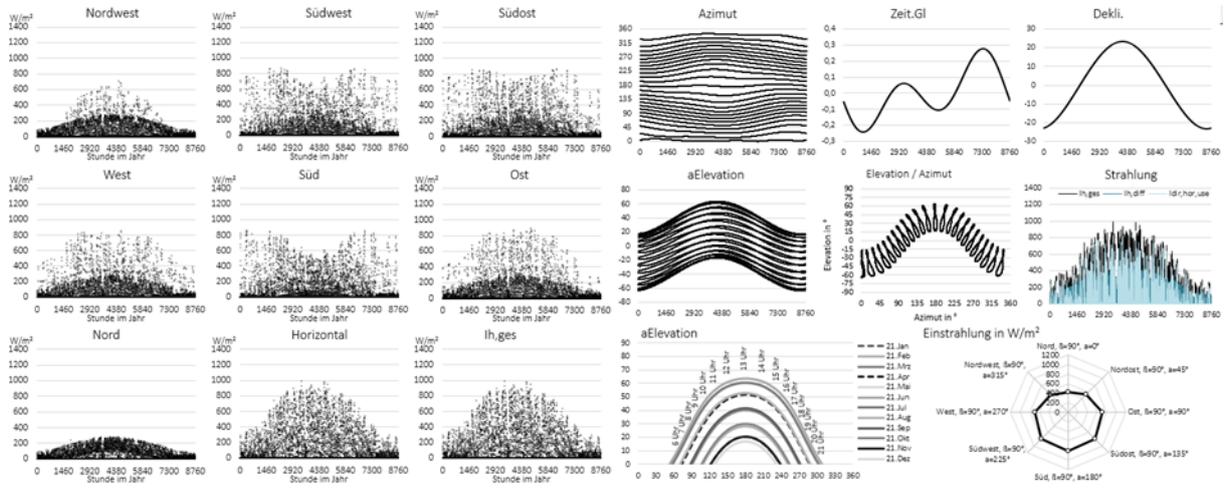
Outside air temperature

Relative humidity

Global radiation

Wind speed

Luxembourg Gh = 1.096 kWh/(m²a)

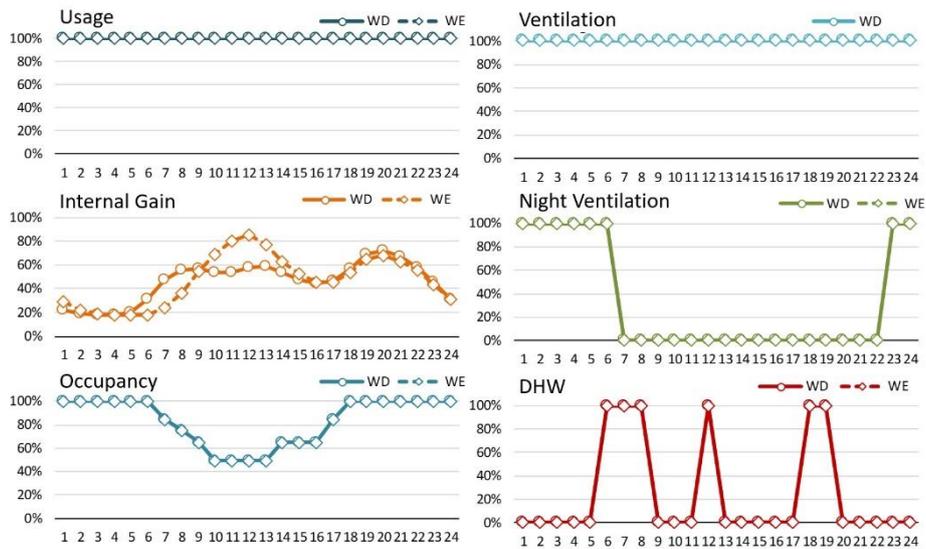


Appendix

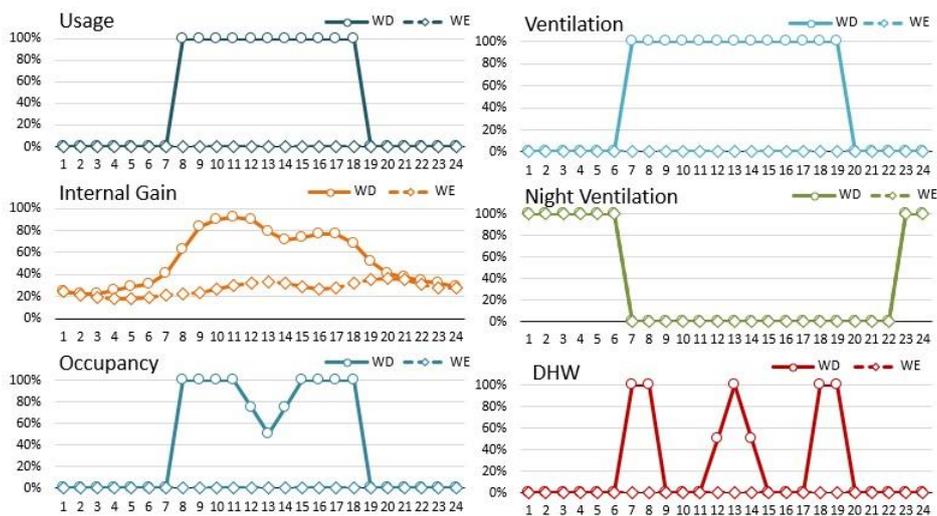
Usage and ventilation profiles

The yields from internal loads ("specific general electricity demand") include the shares for lighting and IT equipment. The profiles are comprised of power load profiles (standard power profile SPP) for residential and non-residential uses^{14,15}. The profiles for persons, ventilation, night ventilation and hot water represent a typical use.

Residential building



Non-residential building



WD = use-day, WE = non-use-day

¹⁴ <https://www.bdew.de/energie/standardlastprofile-strom/>

¹⁵ <https://pvspeicher.htw-berlin.de/veroeffentlichungen/daten/lastprofile/>