

HEAT PROTECTION: MAKING BUILDINGS FIT FOR CLIMATE CHANGE

Study results/policy recommendations

Ingenieurbüro Prof. Dr. Hauser (2023):
Study on the integral evaluation of
summer heat behavior.
Thermal comfort and energy
performance.

KEY FINDINGS AND RECOMMENDATIONS

On behalf of the „Repräsentanz Transparente Gebäudehülle“ (Representative Office Transparent Building Envelope), the engineering firm „Ingenieurbüro Hauser“ (IBH) has simulated in a broad-based study for hundreds of thousands of room situations whether and how they will remain energy-efficient, healthy and comfortable to live in in an increasingly hot climate of the future.

RESULTS

1. A large proportion of both existing and new buildings are insufficiently prepared for the increasing and more intense heat waves caused by climate change. So far, building envelopes have not been designed towards a future with a hotter climate, neither in new buildings nor in renovations.
2. Numerous building solutions are available for improved protection from the summer heat – individually or combined. Solar shading glass, interior and outdoor solar protection on windows and glass surfaces – whether or not automated and enhanced night ventilation will continue to enable comfortable and healthy living and working at pleasant indoor temperatures in the future.
3. The use of air conditioning systems can thus be avoided in many cases. In a few cases, mechanical cooling remains necessary although solar shading is used. However, air conditioning systems should at best complement solar protection, not replace it. If not, cooling may result in an energy requirement that significantly exceeds that for heating.

RECOMMENDATIONS

1. The German government should press for a speedy revision of the DIN standard, which is relevant to solar protection. This standard is based on climate data from the past (1988 to 2007). Due to the change in climate, planning based on valid future data is required.
 2. In the next amendment to the Building Energy Act, solar protection should be given a clear, unrestricted priority over the use of air conditioning systems, both in new buildings and in comprehensive renovations.
 3. In the mid-term, solar protection must no longer be considered a mere comfort issue. On the contrary, it ensures future usability. It is necessary to develop an energy requirement that considers the cooling energy saved by solar protection. Considerations on this should be made within the framework of the update of the Building Energy Act.
- Given the high level of energy consumption, air-conditioning systems should be used only if structural solar protection is insufficient.

HEAT - HEALTH - BUILDING RESILIENCE

Germany must be prepared for more frequent, prolonged and more intense heat waves. Based on moderate future climate models, the German Weather Service (DWD) expects the number of summer days with temperatures above 25 degrees Celsius to rise from 40 degrees Celsius today to between 58 and 69 degrees Celsius in 2045. Today's five hot days above 30°C will turn into 10 to 26 days.

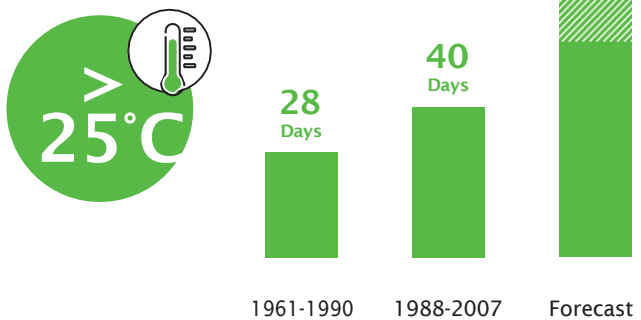
For the first time, the Federal Ministry of Health (BMG) wants to develop a national protection plan to avoid heat-related health problems - including deaths - as far as possible. The so-called vulnerable groups such as children, chronically ill or elderly people are particularly at risk. However, the negative effects

of excessive heat are felt by virtually everyone: cardiovascular diseases can increase, and performance suffers significantly. The consequential costs of heat-related illnesses and impaired performance are already in the billions.

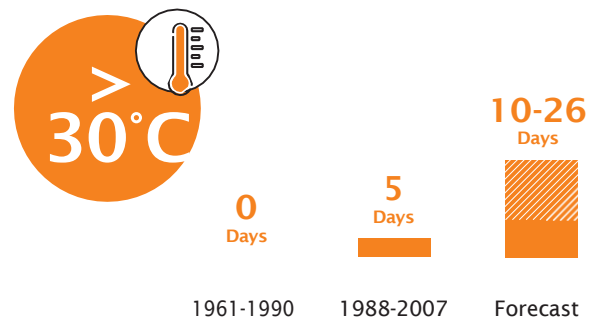
GERMANY IN THE FACE OF CLIMATE CHANGE

Development of summer days and hot days, example Potsdam (medium climate)

Summer days (outside temperature above 25°C)



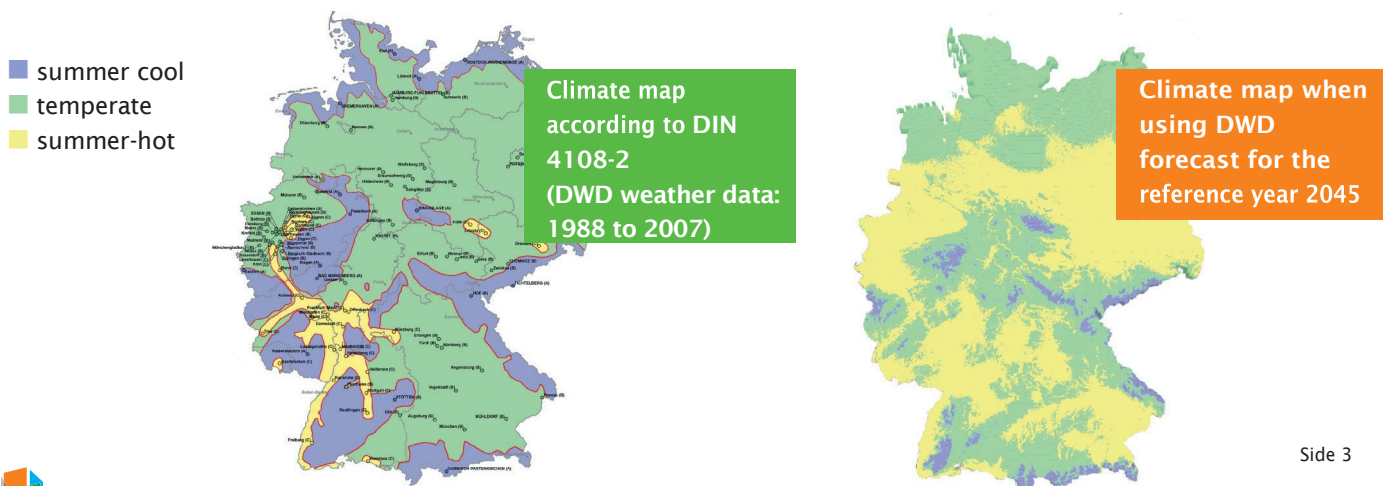
Hot days (outside temperature above 30°C)



Source: DWD-Klimadatensätze

PAST VERSUS FUTURE

From 1988 to 2007, a number of regions in Germany were still defined as "summer cool", many as "temperate" and only a few as "summer-hot". In 2045, Germany will be predominantly "summer-hot".



Especially during periods of intense heat, people seek shelter in buildings and spend less time outdoors. Therefore, a crucial question in this context is: What are the consequences of more frequent and intense heat waves for existing and new buildings?

In principle, new buildings must comply with thermal insulation standards to prevent both heat loss in winter and overheating in summer. These are established in laws (Building Energy Act) and standards. In view of climate change, the standards for summer are outdated.

For example, DIN 4108-2 stipulates that buildings must be planned in such a way that a specified indoor temperature may only be exceeded for a certain number of hours per year. However, firstly, a large part of Germany's building stock was built long before these regulations. And secondly, the standard is based on outdated climate data from 1988 to 2007 – although we know that it has become significantly hotter since then and that temperatures will continue to rise. This means that even new houses are not designed for the effects of ever-advancing climate change. Unless countermeasures are taken, our homes and workplaces will heat up increasingly – and will be much harder to use in the summer months. Unless they are cooled by systems, which usually is very energy-intensive.

In a broad-based and comprehensive study based on millions of data sets, the Hauser engineering office (IBH) has simulated for RTG whether and how our buildings can remain usable and offer people sufficient protection in the summer months, even as climate change progresses. Furthermore, the study was investigated how the use of air conditioning systems, which consume a lot of energy, can be limited. In focus:



■ **SOLAR PROTECTION:** If you shade windows on the outside, e.g. by a roller shutter or venetian blind, you can react very flexibly and effectively to sunlight. Ideally, the solar shading system is automated, which minimises usage errors and ensures the best effect.

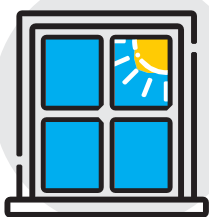
Solar protection on the inside of the window has a lower, but in many cases still sufficient, solar protection effect and can make the difference.



■ **NIGHT VENTILATION:** The day-time and night-time temperatures tend to fluctuate considerably during the summer months. Who can take advantage of this circumstance and brings the lower temperatures into the house, not only cools the rooms for a short time:

walls and soils act as temperature accumulators. The better they release their warmth at night, the longer they contribute to a comfortable indoor temperature during the day.

These three aspects have a decisive impact on the room temperature during hot phases. In many cases – especially in rooms exposed to strong solar radiation – they can make the decisive difference between healthy, comfortable usability and unhealthy overheating. And they can minimise the use of cost- and energy-intensive air conditioning systems.



■ **WINDOWS AND GLASS-PROPERTIES PROPERTIES:**

Radiant solar heat enters the rooms through windows and glass surfaces. It heats the indoor air as well as the floors and walls. While this effect is desirable in the cold

months, it must be limited in summer. This can be largely achieved by using windows with solar control glass, which however - dependent on the strength of the solar control effect - allows less of the desired solar heating in winter.

SVR HEALTH:

ENABLE SHADING, ADAPT THE PLANNING OF BUILDINGS

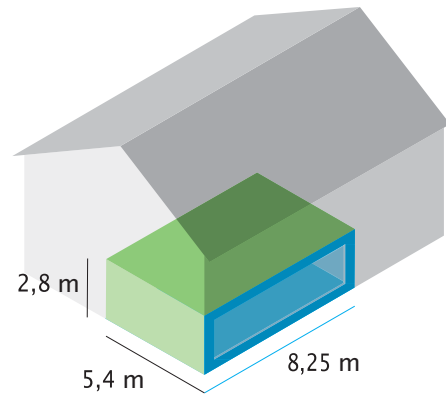
In January 2023, the German Council of Economic Experts (Sachverständigenrat zur Begutachtung der Entwicklung im Gesundheitswesen und in der Pflege, SVR) presented its latest report. Topic: Resilience in the health care system. One of the focal points: Climate change as the greatest global threat to human health.

In the report, construction measures - especially shading options and building design - are named as important components of a nationwide framework legislation.

THE WAY ROOMS REACT TO HEAT, SHADING AND NIGHT VENTILATION

The following illustrations show how climate change affects indoor temperatures – and what can be done about it.

All graphics were based on a 45 m² room in an energy-efficient new building (efficiency house level 55) in the moderate German climate region (reference climate Potsdam), whose window area accounts for 70 percent of the façade and faces south. The room can thus serve as an example for a living and dining room in a currently built single-family house. The calculation of the room temperature is initially based on the current climate data (period 1988-2007) and, in the course of the simulations, on forecast data from the German Weather Service (DWD). Based on the climate scenarios, the DWD has created a climate data reference model based on moderate global warming.

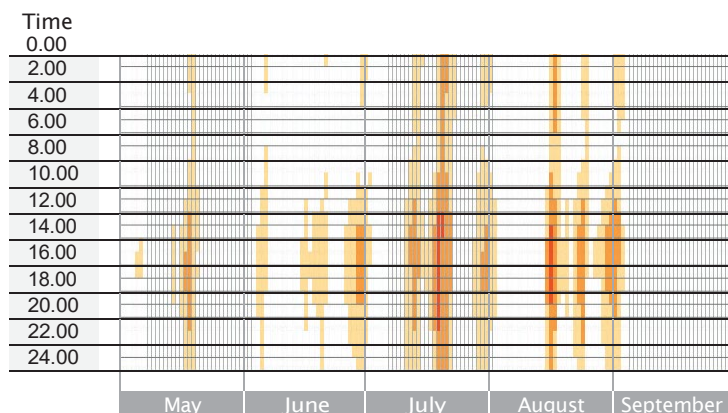


LEGEND FOR THE FOLLOWING HEATED CARPETS

These temperature charts show for each day of the hotter months of a year in which day and night hours the room temperature of ■ 26 °C, ■ 28 °C and ■ 30 °C is exceeded.

Part 1: Overheating and sun protection in new buildings

SITUATION: CURRENT CLIMATE DATA - INTERIOR SOLAR PROTECTION



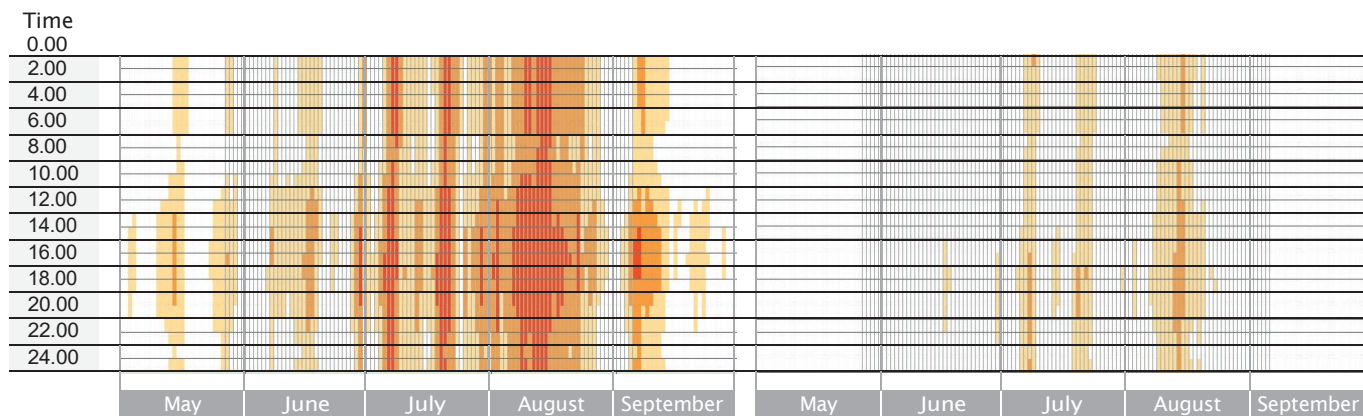
If this room is equipped with the best possible interior solar protection so that it just barely meets today's requirements of the DIN standard, it becomes clear that on the basis of the climate data used today, the temperature can be expected to exceed 28 °C on more than 20 days. The 30 °C mark is rarely exceeded. It gets warm regularly, but remains within a reasonable temperature range.

1. Interior sun protection

In the climate forecast for 2045 (DWD forecast for medium climate data for the period 2030-2060), the same room with the same sun protection leads to strong and regular overheating in the summer months.

2. Improved sun protection (external)

With external sun protection (window awning, roller shutters, external blinds), the subsequent temperature distribution can be achieved. It is clearly visible that the currently required level of sun protection can even be significantly improved.



3. Additional option: Increased night ventilation

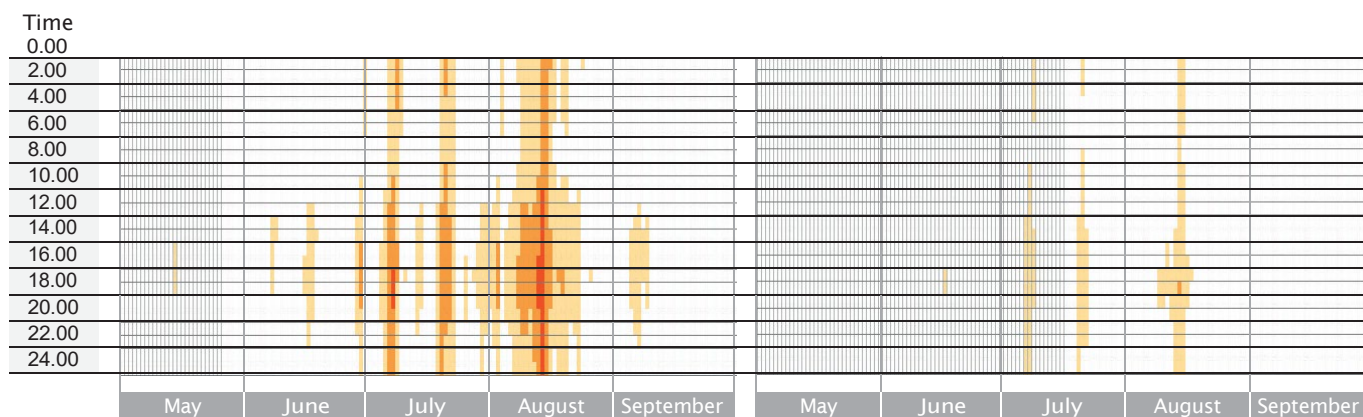
One option to further improve the situation in summer is to use increased night ventilation. The heat stored in the house during the day is removed through open windows during the cooler night hours. The two examples below show how sufficient to comfortable indoor temperatures can be achieved in this way.

3a. Best internal sun protection plus night ventilation

With additional night ventilation, the best possible interior sun protection can provide a sufficient temperature level in the future.

3b. External sun protection plus night ventilation

If the use of window awnings, roller shutters or external blinds is combined with increased night ventilation, the result is an optimal temperature picture.



4. Additional option: Earlier activation of sun protection

Another option for more effective thermal insulation in summer is to activate the external sun protection during the hot period even at lower solar radiation levels. Usually, the automated sun shading system is only activated at irradiation levels above 300 W/m². The following two charts illustrate the results when the sun protection is activated at 200 W/m², so that it shades more frequently.

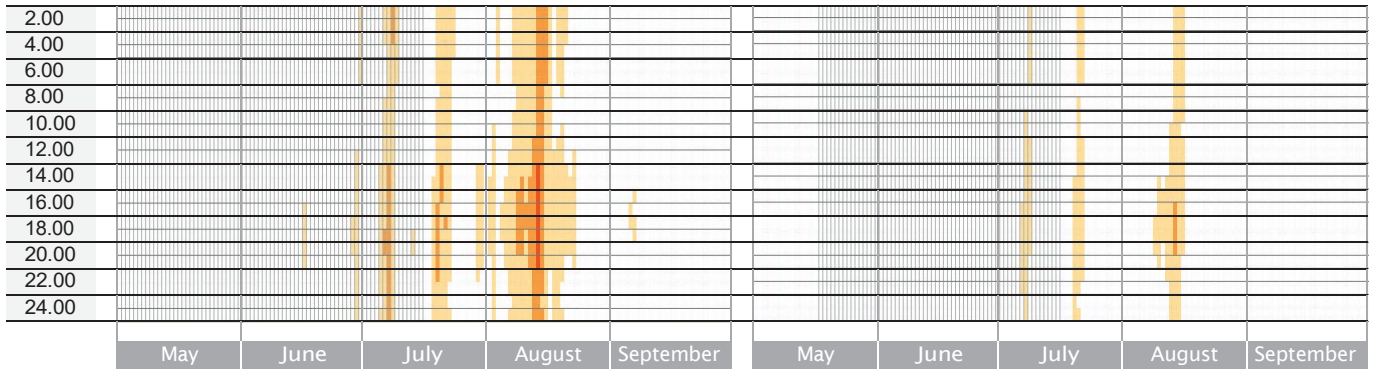
4a. Outdoor sun protection (light-coloured window awning) with early activation

If this external sun protection system is activated even at a lower level of irradiation, it offers sufficient comfort.

4b. Best outdoor sunshade (roller shutters, venetian blinds, dark outdoor awning) with early activation

If a very effective external sun protection system is activated earlier, this provides optimum protection against overheating.

Time
0.00



RESULT

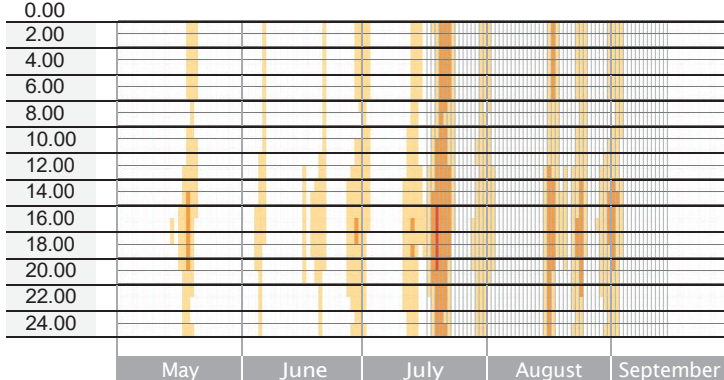
All graphics clearly show: Without additional measures, our rooms will overheat, they will hardly be comfortable to use or in some cases will already be hazardous to health. With sun protection, automation and night ventilation, comfortable indoor temperatures can be guaranteed in the future even without mechanical cooling.

Part 2: Overheating and sun protection in existing buildings

INITIAL SITUATION: TODAY'S CLIMATE DATA - LIGHT SOLAR PROTECTION

The below results apply to a renovated existing building with structural thermal insulation that roughly corresponds to an Efficiency House 70 or Efficiency House 55. However, structural thermal insulation is fundamentally of secondary importance for the summer heat behaviour. In this respect, the results shown can also be applied to buildings with a poorer level of thermal insulation.

Time

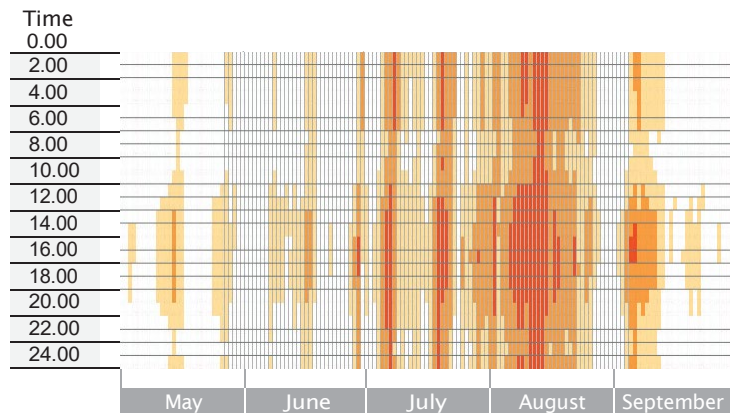


So far, there are no legal requirements for sun protection in existing buildings. In the evaluation, a similar room as before is now considered in the new building – a typical living room –, but with a smaller proportion of window area of 50 percent instead of 70 percent of the façade area, which is typical in existing buildings. In order to make the today's

To comply with the current DIN standard (based on climate data 1988 -2007), this room would have to be equipped with a medium interior sun protection system. The temperature chart shows : With today's climate data, a sufficient level is reached.

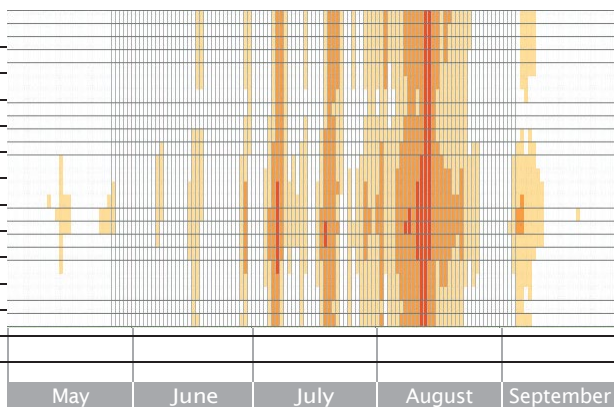
1. No sun protection

Without sun protection measures – which is not uncommon in existing buildings – this room will look like this in the climate forecast for 2045. Constant overheating is inevitable.



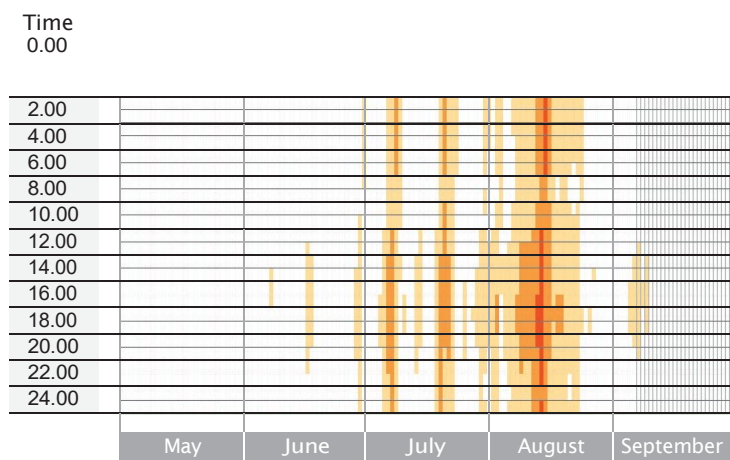
2. Medium internal sun protection

Even with medium-grade internal sun protection measures, it still remains far too hot in July and August.



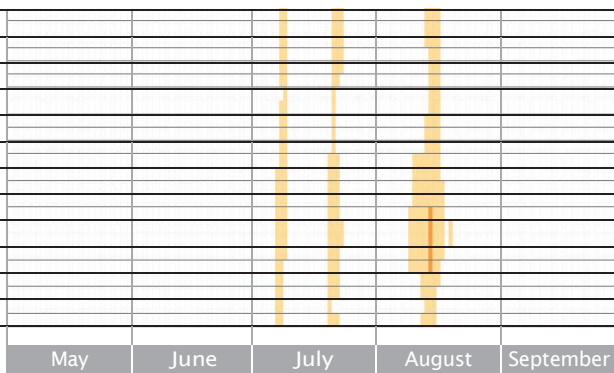
3. Best possible internal sun protection

In the future, only with the best possible internal sun protection, a level, that is comparable to today's requirements and enables good usability, can be achieved.



4. External sun protection

Optimal comfort can be achieved through external sun protection (roller shutters, external blinds, dark window awning).



RESULT

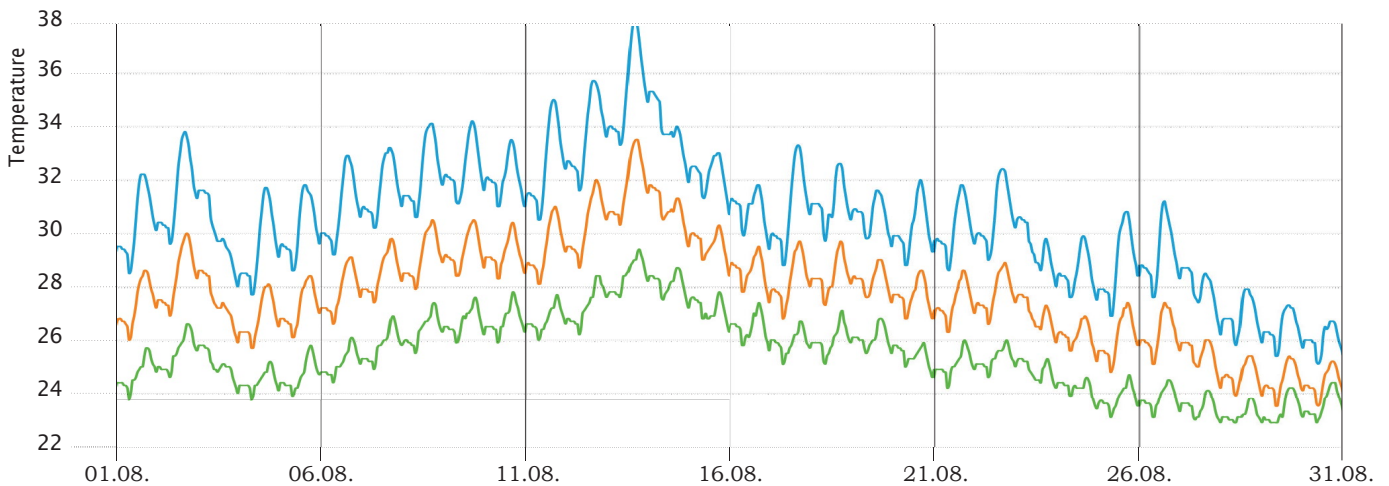
Appropriate sun protection is therefore also an absolute must in existing buildings, otherwise the rooms will become almost uninhabitable during summer. However, the graphs also show that the situation is quite manageable with moderate measures and without the use of mechanical cooling. Again: the following applies: Comfort can be increased even further by consistent night ventilation – if possible – or by activating the sun protection earlier. Here, in particular, the earlier activation of the sun protection only leads to the most effective results when combined with automated control system.

SUN PROTECTION: POTENTIAL IN THE MONTHLY VIEW

A glance at the development of the indoor temperature of the room (EH55, 70% of the façade area as windows) in August with climate data set for 2045 illustrates the effect of the individual sun protection measures:

Indoor temperature curve

- without sun protection
- with the best internal sun protection
- with very good external sun protection (dark window awning, external blinds, roller shutters)

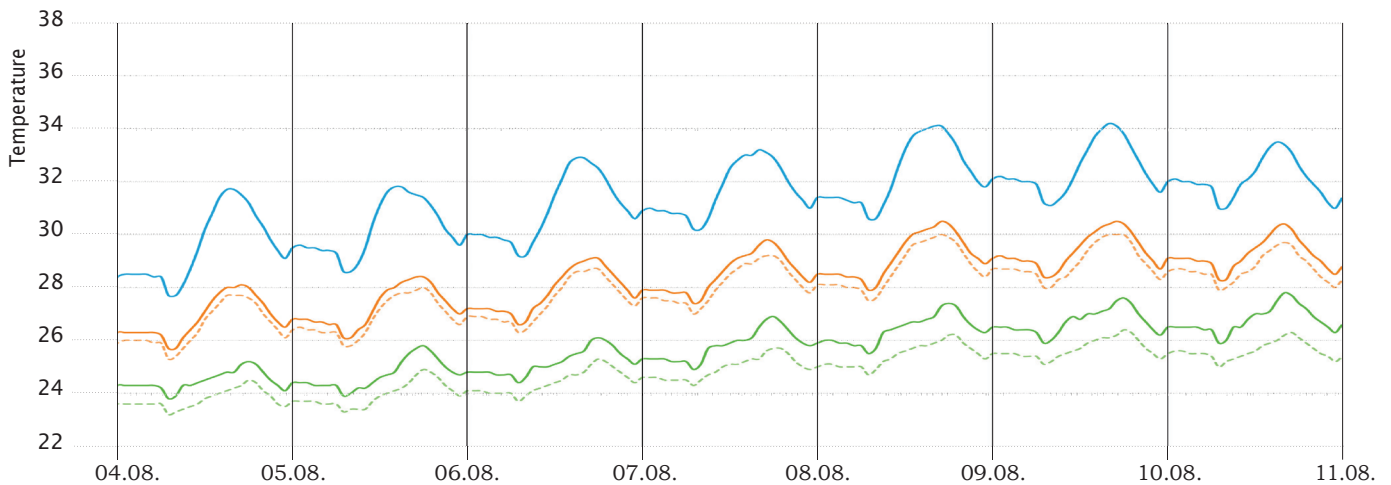


SUN PROTECTION: POTENTIALS WITH EARLIER ACTIVATION IN THE WEEKLY VIEW

A closer look at a single week of August (04-11 August) shows how the technical options can be further optimised:

Indoor temperature curve

- without sun protection
- with the best possible internal sun protection
- - - with the best possible internal sun protection with earlier activation
- with the best possible external sun protection
- - - with the best possible external sun protection with earlier activation



**STRUCTURAL SUMMER THERMAL INSULATION:
AVOID UNNECESSARILY HIGH ENERGY EXPENDITURE FOR COOLING**

Besides structural design measures, technical cooling systems can achieve comfortable room temperatures. However, air conditioning systems massively increase energy consumption and make climate protection more difficult. The use of green electricity is also not a real solution, as this energy can be put to use more sensibly elsewhere.

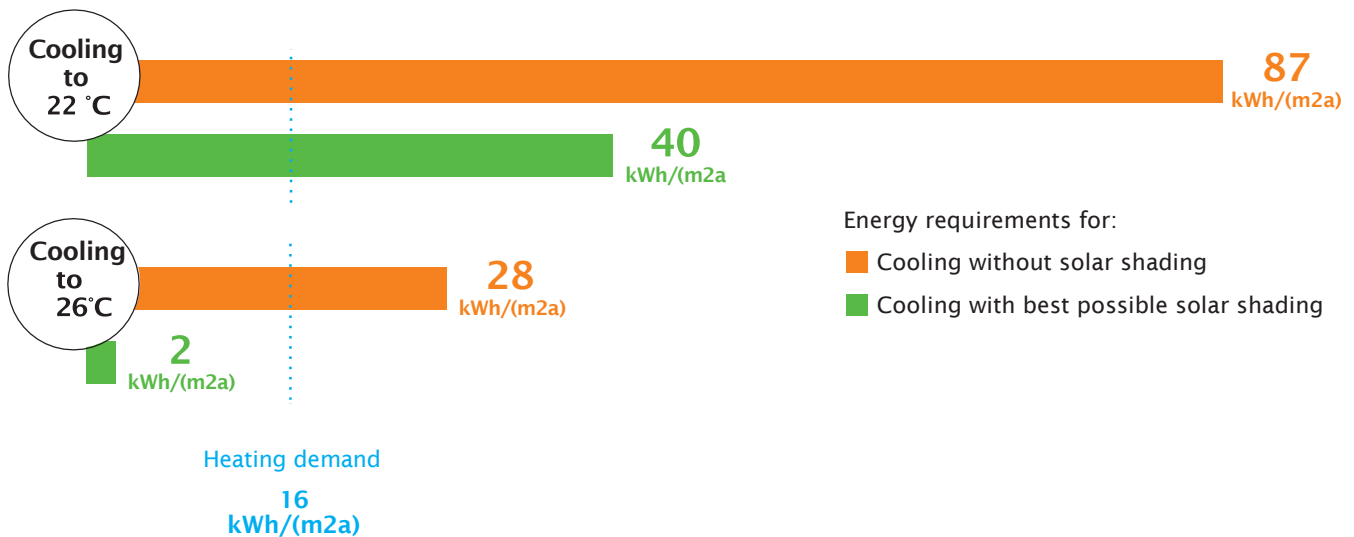
To illustrate the relevance, the study compares the annual energy demand for heating with the cooling demand. For example, if you want to

cool the room described above to 22 °C in summer, the energy requirement for cooling exceeds the heating energy requirement by more than five times. Sun protection can reduce this energy requirement by more than half. Still, such intense cooling should be avoided in midsummer.

Even cooling down to 26°C in midsummer requires a considerable amount of energy without sun protection. On the other hand, with sun protection, a maximum of 26°C is feasible at all times with low energy requirements.

ANNUAL ENERGY DEMAND FOR COOLING COMPARED TO HEATING

Room new building (standard EH55, window area 70%, south orientation), sun protection activation at 300 W/m², without night ventilation



Automated solar shading and increased night-time ventilation offer considerable energy and climate policy advantages: on their own they can safely reduce the use of energy-intensive air conditioning systems - with the same comfort for people and low energy costs. As a rule, they can make air conditioning superfluous and ensure indoor temperatures that only exceed 26 to 28 °C in isolated cases, even during intense heat phases.

RECOMMENDATION

In the course of the next revision of the Building Energy Act, we therefore urgently recommend tackling §14 on summer thermal insulation. In principle, it is regulated here that a building must be equipped with suitable sun protection in accordance with the DIN standard. However, this regulation is put into perspective in paragraph 4: If an air conditioning system is used, sun protection must only be provided to the extent that it is economical in addition to cooling. But, this makes no sense in terms of energy requirements and is an unnecessary loophole for prioritising air conditioning. In addition, the evaluations show how important it is to no longer regard sun protection as a mere comfort issue in the medium term.

It would make sense to develop an energy requirement parameter that balances the cooling energy saved by sun protection. This should be considered when updating the Building Energy Act.

THE STUDY TAKES INTO ACCOUNT THE FOLLOWING PARAMETERS:

- **ROOM STRUCTURE:** The simulations were designed for four typical models of rooms, including an attic room.
- **WINDOW AREAS:** The proportion of window area covered by the façade varies between 30 and 70 percent.
- **ORIENTATION:** It makes a significant difference whether a window façade faces east, south or west.
- **CLIMATE DATA:** After consultation with the German Weather Service, its forecast data for 2045 were used for the study. For the current initial situation, the reference cities of Rostock (climate region A, summer-cool), Potsdam (climate-region B, temperate) and Mannheim (climate-region C, summer-hot) were examined. For 2045, Rostock was replaced by Hof due to climate change.
- **USE:** Residential and non-residential buildings are considered separately.
- **U-VALUE WINDOW:** The U-value indicates how high the heat loss is. It is varied between 1.30 W/(m²K) and 0.70 W/(m²K). The lower the value, the less heat loss in winter. For comparison: The current value in subsidies for existing buildings is 0.95 W/(m²K).
- **g-VALUE WINDOW:** The g-value indicates how much solar energy is allowed to pass through. The value varies between 0.60 (= 60 % of the incident energy reaches the room) and 0.06 (= 6 % of the solar energy is transmitted). Today's usual value for heat-insulating glazing: 0.50.
- **Fc VALUE:** This value refers to sun protection and varies between 1 (= no sun protection), 0.7 (medium internal sun protection, also referred to as light sun protection in the text), 0.5 (best possible internal sun protection), 0.3 (light window awning) and 0.10 (external blind, roller shutter, dark window awning).
- **CONTROL SUN PROTECTION:** A distinction is made between manual and automated control and three different activation levels (300, 200, 100 W/m²). Common: 300 W/m².
- **NIGHT VENTILATION:** In the case of night ventilation, a distinction is made between no night ventilation and increased night ventilation (2-fold air change per hour).

This summary is based on the following study:

Ingenieurbüro Prof. Dr. Hauser (IBH), 2023,
Studie zur integralen Bewertung des sommerlichen
Wärmeverhaltens.
Thermischer Komfort und energetische Performance
(Study for the integral evaluation of summer heat
behavior. - Thermal comfort and energy performance)

Download at
www.transparente-gebaeudehuelle.de.

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DIE REPRÄSENTANZ TRANSPARENT E GEBÄUDEHÜLLE (RTG) (THE REPRESENTATIVE OFFICE TRANSPARENT BUILDING ENVELOPE)

The Bundesverband Flachglas (German Flat Glass Association), the industrial association for roller shutters, solar shading automation and the Verband Fenster + Fassade (Window + Façade Association), together with the companies Hunter Douglas, Roma, Somfy, Veka, Velux and Warema, are responsible for the Repräsentanz Transparente Gebäudehülle (RTG) (Transparent Building Envelope representative office). Together, we want to create optimal conditions for buildings in which we can live in a climate-friendly, healthy, comfortable and affordable way. The RTG is a source of inspiration and dialogue partner for all political actors and stakeholders who shape the building and energy policy framework.



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