Energy storage concrete

Thermal Activated Buildings

Information sheet Cooling

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Climate-neutral by 2040

„We need to use all our available resources to achieve climate neutrality in Austria by 2040. Hereby thermally activated building structures represent an important step in the right direction. Because emissions must be reduced to zero also in the building sector. Innovative technologies like this support this goal considerably.“

Minister for Climate Action Leonore Gewessler

Fig. 1 top left © **Centre for Solar Energy and Hydrogen Research** Baden-Württemberg

Fig. 2 Wind Lower Austria @ stock.adobe.com

Fig. 3 right **project Sommerein** @Christian Husar

Thermal activated building systems (TABs) support the use of renewable energy for heating and cooling thanks to its storage efficiency

In order to achieve the climate protection targets, the building stock must become CO2 neutral by 2040. This includes both - reducing overall energy consumption and replacing fossil fuels with renewable energy sources.

Climate scenarios indicate a significant increase in heat waves and extreme weather events. In particular in the Alpine region, there will be a steady increase in hot days, which will lead to a significant increase in building cooling energy requirements.

Utilising the capacity of existing building components to store heat is an essential contribution to the development of a renewable energy system, as this can make a significant contribution to balancing out the uneven distribution of energy production and consumption that is typical of renewable energies.

With the 'Cool*Alps - TABS goes Green Deal' project, the Interreg Alpine Space programme is supporting the application of the thermal storage capacity of building components to maximise the use of renewable energy for heating and cooling buildings with the aim of improving adaptability to climate change and energy security in the Alpine region.

This information sheet summarises basic findings from the project on the topic of thermal activated building systems in renovation.

What contribution can the construction industry make to achieving the climate targets?

Bmstr. Ing. Robert Jägersberger
Federal Guild Master in Building, @ Wilke – Das Fotostudio

The development towards sustainable buildings undoubtedly places new demands on the construction industry. Thermal activated buildings are a promising solution that offers both ecological and economic benefits. Its versatility in terms of heating and cooling makes it particularly attractive, especially in view of the increasing need for cooling during hot periods.

The fact that thermal activated buildings work with existing building elements also makes it financially attractive and facilitates integration into existing structures. The savings in operating costs and the possibility of integrating renewable energy systems make it an interesting option.

Solid buildings have a certain storage capacity regardless of the quality of the building and the type of heat emission system. The better the insulation standard, the longer the stored heat can maintain the room temperature in the comfort range. Studies have shown that - depending on the insulation standard of the building - a period of up to 5 days can be bridged without an energy supply. The technology can therefore be easily combined with renewable energy systems.

However, thorough planning is essential to ensure the full efficiency and functionality of this system. This information sheet is intended to supplement the planning guide 'Energy Storage Concrete - Thermal Building Element Activation' published by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology in 2016 by highlighting current developments and possibilities.

Overall, thermal thermal activated building systems is a promising technology that not only fulfils the current requirements for sustainable construction but can also make a significant contribution to achieving climate targets. It is encouraging to see how innovations in the construction industry can help to shape a more sustainable future.

Thermal activated building systems - what does that mean?

Thermal activated building systems (TABs) are a simple technology. They have been a standard system for heating and cooling in the commercial sector for many years and are also gaining ground in residential buildings. With climate change and the energy transition, the utilisation of the storage capacity of solid building components is becoming increasingly interesting.

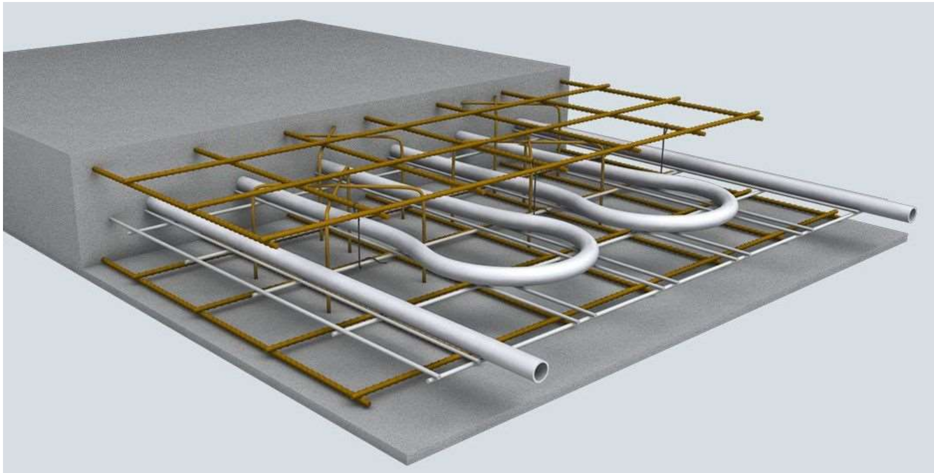


Fig. 4 Model of an activated concrete ceiling - the pipe system is mounted in the centre of the component (@ Uponor)

TAB is a surface heating and/or cooling system in which pipes are integrated into solid building components through which water flows as a heating or cooling medium. The component is thermally activated and releases heat over its entire surface or absorbs it again - depending on the heating or cooling mode.
In contrast to underfloor heating, which is laid in the screed, with TAB the pipes are laid close to the surface or in the core of concrete ceilings or walls before the concrete is poured.

You can find more information on the prerequisites and general requirements in the planning guide Energy Storage Concrete: Thermal thermal activated building systems: **nachhaltigwirtschaften.at** <<

A good thermal building standard is a prerequisite if the TAB is the only heating system, and the activated components are to be sufficient and no other heat dissipation systems such as radiators or underfloor heating are required.
From a structural point of view, no changes are necessary, as the usual concrete slab thicknesses are sufficient to integrate the pipe system.

The system temperatures can be kept very low due to the large transfer surfaces. The temperature difference between the surface and the room air is approx. 1°- 6°C. Building thermal activated building systems is therefore very well suited to the utilisation of renewable energies.

In addition to the release of heat for heating, the activation of ceilings is ideal for room temperature control in the warmer months of the year. Cooling via the activated components is perceived as particularly pleasant, scores highly in terms of energy efficiency and ensures optimum comfort for the occupants.

Fig. 5 **Refurbishment project** in Vienna @ Florian Frey

Fig. 6 Thermal activated building systems was installed in the walls and ceilings of the **'Tante Käthes Grätz'l' apartment** block. © Baumschlager Hutter Partners / Lukas

The advantages of the system summarised:

- Heating and cooling with one system
- Energy flexibility through storage efficiency
- Low investment and operating costs
- Can be easily combined with renewable energy
- Low, energetically favorable flow temperature level
- Low surface temperatures
- High level of comfort in the room climate and no draughts

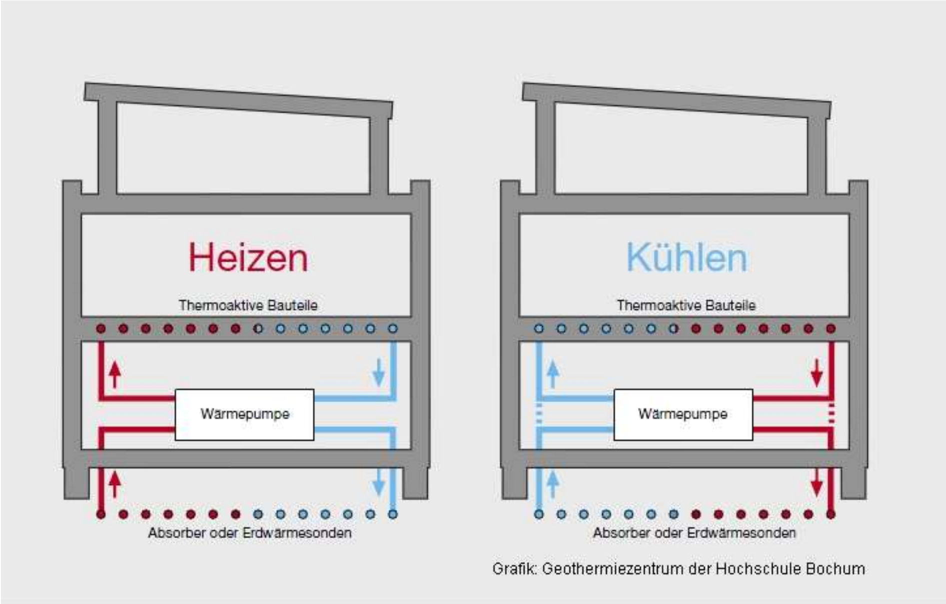


Fig. 7 **Heating and cooling with thermal activated building systems** @ Bochum University of Applied Sciences Geothermal Centre

Heating and cooling with one system - is that possible?

In view of global warming and the increase in the temperature and number of hot days as well as longer periods of heat in the summer associated with this, the importance of cooling in residential buildings increases significantly. A reason for this is that night-time ventilation and passive measures in urban regions will no longer suffice in the future to achieve a comfortable temperature (below 26° C) for residents in the summer. Against this background, thermally activated building systems can establish themselves as an important part of future orientated planning and building. The thermal activation of floor slabs provides technical as well as physical benefits in terms of construction which should be consciously used.

If the rooms of a building will be cooled solely by means of thermal activation, it is possible, depending on the building shell quality and required cooling load, to achieve room temperatures of between 24 and 26° C which are perfectly sufficient for residential buildings. The cooling output of a thermally activated building component should not be randomly increased as there is a risk of condensation if the flow and surface temperatures are too low. For this reason, the thermally activated building structures should operate with higher flow temperatures (from 18° C) which leads to a limitation of the maximum cooling efficiency and possible room temperature. With thermally activated building structures we therefore also have room conditioning/temperature control in cooling operation in contrast to active cooling.

Low flow temperatures in heating operation and comparatively higher temperatures in cooling operation leads to very good synergies with renewable energy concepts.

Geothermal energy concepts combined with heat pumps and photovoltaic systems offer many benefits. In the winter, the minimal temperature difference between target temperature and flow temperature means it is possible to achieve a high level of heat pump performance. With the possibility of passive / free cooling via geothermal energy it is not only possible to provide cooling energy with minimal input, but the geothermal field is also regenerated. An example of a large-scale residential building project is Breitenfurterstraße with 265 flats.

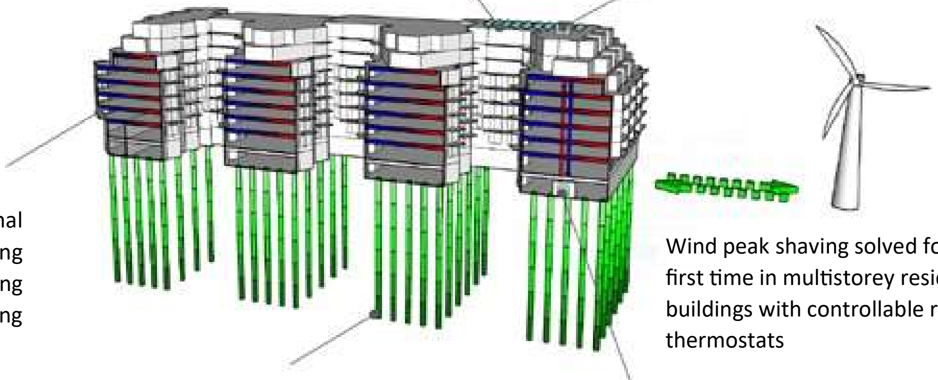


Fig 8: **Visualisation and energy concept in the housing complex at Breitenfurterstraße** in Vienna.

The ceilings are thermally activated for heating and cooling and probe fields with geothermal heat pumps and photovoltaic systems provide the required heat in an environmentally friendly way.

A further possibility is the use of anergy networks (comprises of heat sources, heat storage and heat consumers)/cold district heating networks as a source for heat pumps. An anergy network is a heating network which supplies buildings with heat on a very low temperature level (up to 20 °C).

After the heat carrying medium has been transported to the buildings by the collector through the network the temperature is raised to the desired level with decentral heat pumps. The cold district heating network allows cooling to be provided also in the summer which like other geothermal applications, can be used to control the temperature of residential buildings with passive cooling and TABs.

Already completed projects highlight the possibilities and their applications (see Fig. 9). Climate-friendly thermal energy for entire housing developments and densely populated residential areas can be provided with cold district heating networks with the aid of geothermal heat collectors near the surface. The 11,000 m² area-wide collectors serve as energy source, sink and storage. With the low system temperatures in the cold district heating network, energy is supplied almost entirely without any loss.

Fig. 9: Drone image **geothermal heat collector**

Passive cooling with thermal activated building systems

A basic distinction can be made between passive and active cooling in thermal activated building systems. As no reversible heat pump or chiller is operated, but only circulation pumps are required, the power requirement for passive cooling is extremely low.

There are essentially two energy sources available for passive cooling. By utilising groundwater, high outputs can be dissipated over longer periods of time if there is sufficient flow and a correspondingly low temperature level. In addition to groundwater, geothermal energy, i.e. geothermal heat, can also be utilised as a source. Flat-plate collectors (ground collectors) are a very simple and economical solution here. To ensure the full efficiency of the ground as a heat sink over many years, care must be taken to maintain a balance between heat input and heat extraction. Caution: The efficiency of passive cooling via the ground decreases with longer periods of sole cooling operation.

By alternating heating in winter and cooling in summer or by storing excess heat excess heat in summer supports the natural regeneration of the subsoil is supported. <<

When using large-area room heating surfaces, the minimum surface temperature is limited and therefore also the possible maximum cooling capacity. If the dew point is considered, cooling capacities of up to approx. 43 W/m² can be achieved with thermal activated building systems (this corresponds to a temperature difference of 4 K between the surface and room air temperature).

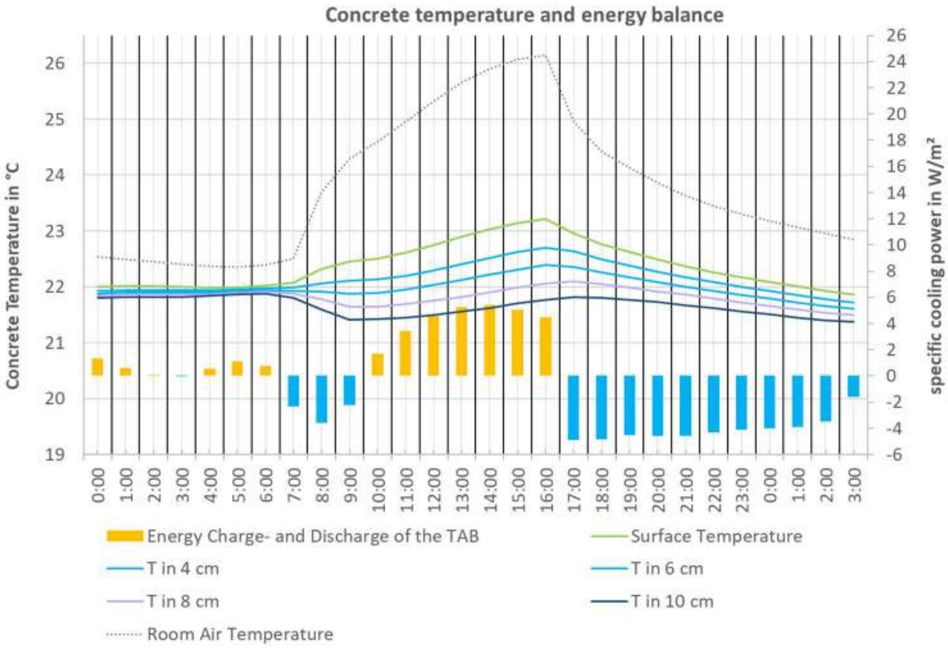


Fig. 10 **Heat flow balance (simulated) and component temperatures of a thermal activated building systems in the cooling case** (high internal loads 8:00-17:00, constant air exchange without heat recovery, flow temperature of the thermal activated building systems 18° C, Innsbruck site) © TH Rosenheim

Fig. 10 shows the result of a component simulation in a room with very high internal loads to illustrate an extreme situation. Such high internal loads occur extremely rarely in residential buildings. This should therefore demonstrate the high potential (spec. cooling load is above the spec. cooling capacity of the concrete core activation) of suitability for cooling applications. As expected, the room temperature rises during the day, but the increase remains within the desired range due to the temperature-controlled concrete masses. The performance of the thermal activated building systems (pipe level with 10 cm concrete cover) is regulated both with the flow temperature and with the regulation of the mass flow.

The room air temperature, surface temperature and concrete temperatures at a depth of 4 cm, 8 cm and 10 cm are shown. The room temperature is consistently above the component surface temperature, so the room is cooled 24 hours a day due to thermal inertia. During the periods marked in yellow, more energy is supplied to the concrete core than the thermal activated building systems can dissipate. During this time, the thermal storage mass acts as a buffer, with a continuously degressive cooling capacity, until the room temperature has adjusted to the surface temperature and the thermal storage is thus exhausted. In periods marked in blue, more energy is dissipated by the thermal activated building systems than is extracted from the room via the concrete ceiling. During these periods, the building component is therefore "cooled down" and regenerated in order to be ready for the next cooling requirement. This can be seen in the graph by the falling component temperatures in the area of the pipe level.

The high heat storage capacity of the storey ceiling means that the heat from the rooms is absorbed by the ceiling over longer periods of time without increasing its temperature too much. The stored heat can then be dissipated by flowing through the pipe register if renewable energy is available to operate the circulation pump and cooling system. This means that the conditions for utilising renewable energy in systems with TAB are met to a high degree all year round.

If thermal activated building systems are compared with an air-cooling split unit, it can be seen that temperatures can be maintained within the comfort band despite the lower cooling capacity (Fig. 11).

The air conditioning split unit keeps the room temperature comparatively constant and conditions the room stably with only slight temperature fluctuations and a high cooling capacity. The concrete ceiling cooled by the thermal activated building systems cools with a slight time delay, but constantly (blue), even in periods without an actual cooling requirement (aftercooling).

Temperature control via a TAB ceiling is much more convenient than via an air conditioning split unit. <<

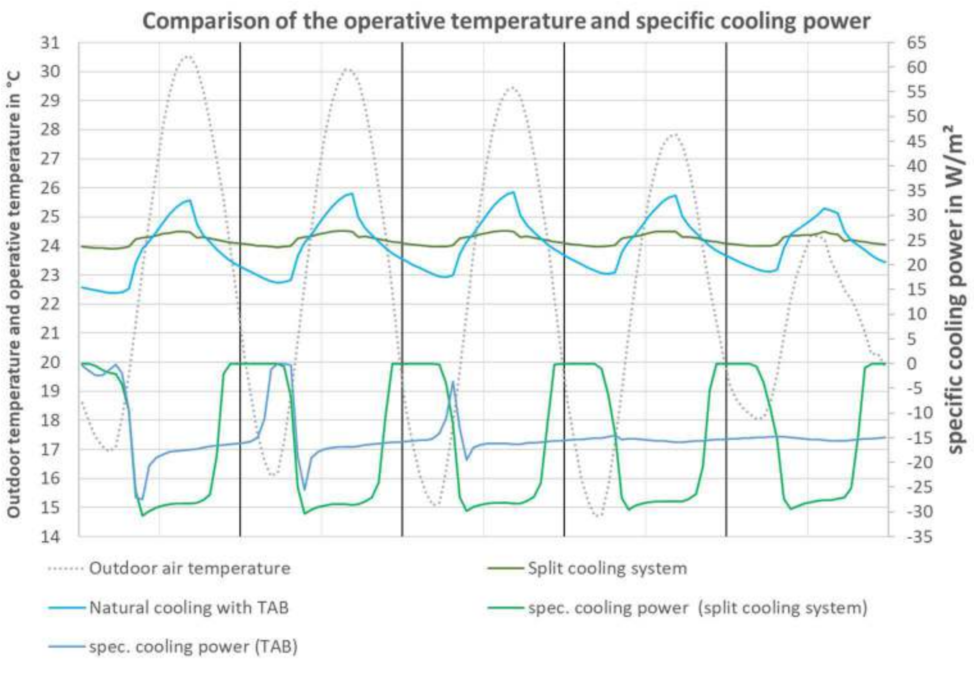


Fig. **11 Comparison of the operative room temperature and specific cooling capacity for an air conditioning split unit and thermal activated building systems** ©TH Rosenheim

Thermal activated building systems can maintain the same temperature with less cooling capacity. <<

The energy assessment of active and passive cooling technologies is clear. In the case of compressor-driven ‘active cooling’ using a heat pump or an air conditioning split unit, the electricity requirement is significantly higher. With ‘passive cooling’, the compressor power requirement can be dispensed with, so that only the circulating pump power of the heat source pump and the heating circuit pump is utilised. This pays off in terms of energy and results in a significantly lower power requirement.

Passive cooling consumes almost ten times less power than active cooling! <<

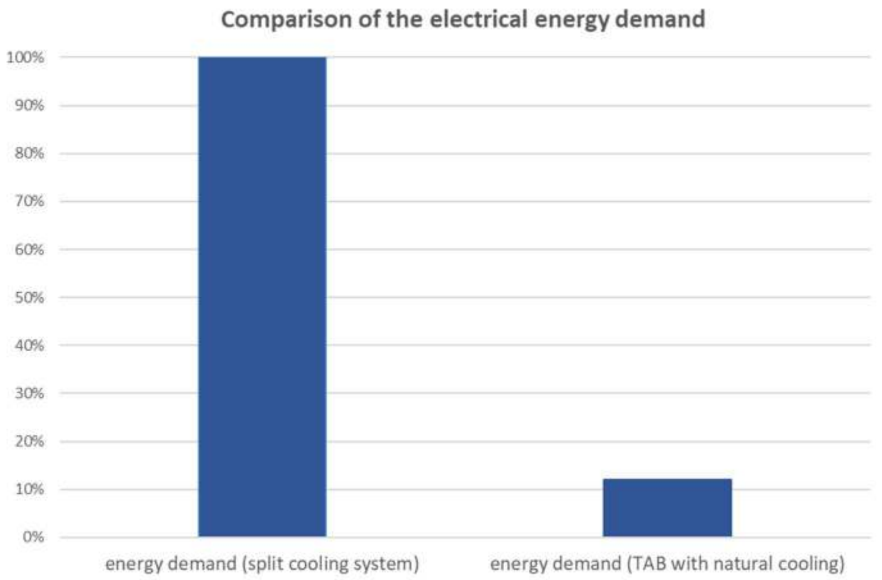


Fig. 12 **Final energy comparison** of electricity consumption split air conditioning unit active cooling and electricity consumption TAB with passive cooling © TH Rosenheim

The recording of year-round measurements of the 'Viertelhäuser' residential complex in Tonpfeifengasse in Theresienfeld (Fig. 13) shows how well cooling via building thermal activated building systems works in reality. The housing project consists of a total of 28 flats, which were built as 3- and 5-room flats.

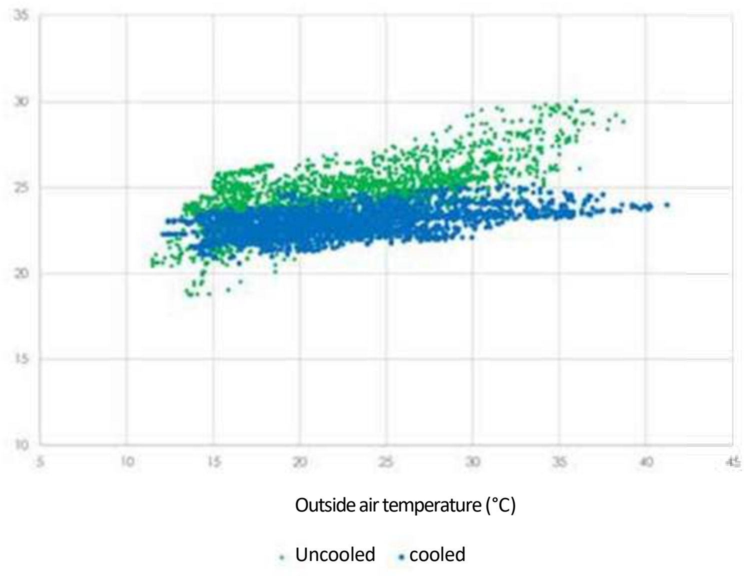
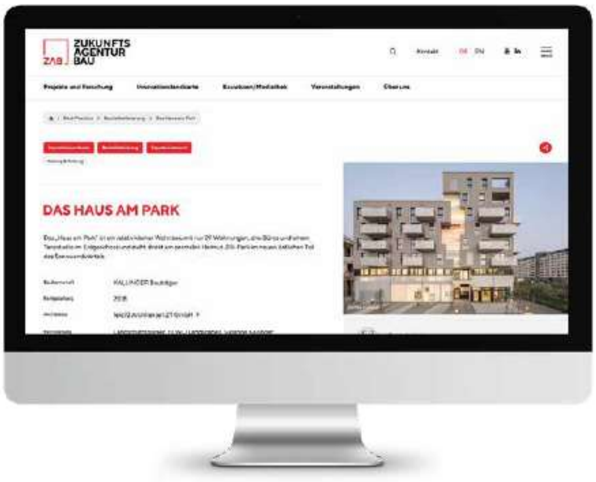


Fig. 13 **Hourly values for the room air temperature** of a kitchen (June uncooled, July cooled), monitoring apartment blocks 'Tonpfeifengasse' © Simon Handler

The figure shows the measured air temperature of a room in two different summer months with similar outside temperatures. The non-cooled room (green) is significantly above the measured room temperatures of the cooled room (blue) in the point cloud. On a daily and weekly average, thermal activated building systems can achieve similar indoor temperatures to those achieved with air conditioning units. The gentle cooling via the building components is completely silent and can therefore also be operated at night on hot summer days.

Where can I find information on realised projects?

The innovation map of the ZAB Zukunftsagentur Bau offers a collection of of innovative construction projects in various subject areas. Over 120 projects from 4 countries have already been entered on the topic of 'thermal activated building systems'. The projects range from refurbishments with retrofitted pipes and the construction of new apartment blocks to public buildings such as schools, university buildings and offices.
For each project there is an info box with the most important data, a few photos and a short description. This gives you a good overview of the many possibilities of thermal activated building systems, details worth knowing, companies carrying out the work or experts involved!
www.zukunft-bau.at/innovationslandkarte



Where can I find more details on thermal activated building systems?

Interreg Alpine Space project
« alpine-space.eu/project/coolalps

Planning guide for thermal activated building systems
« zement.at

Climate and Energy Fund
« klimafonds.gv.at

Salzburg University of Applied Sciences
« fh-salzburg.ac.at

Project partners

ZAB Future agency of construction
« zukunft-bau.at

BETONSUISSE Marketing AG
« betonsuisse.ch

KlimaHaus
« klimahaus.it/

Innovation Salzburg GmbH
« innovation-salzburg.at

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Technical university Rosenheim
« th-rosenheim.de