Energy storage concrete

Thermal Activated Buildings

Information sheet Renovation

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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. 2 Wind Lower Austria @ stock.adobe.com

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

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.

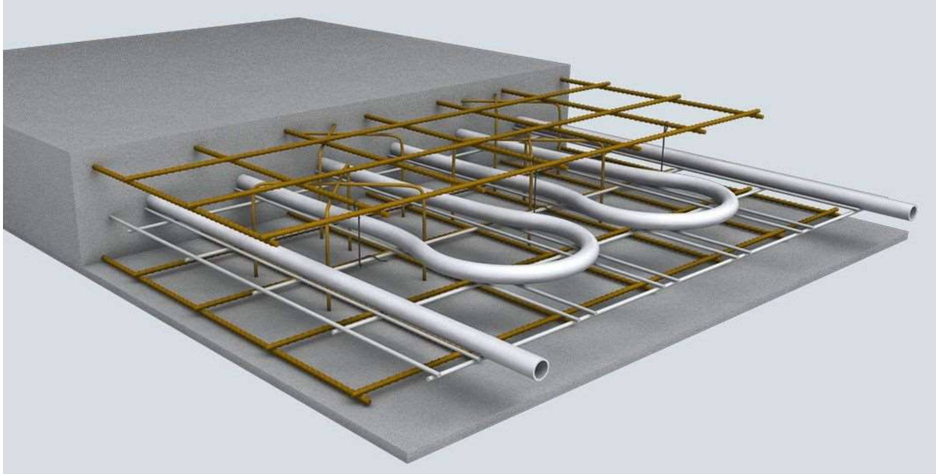


Fig. **4 Model of an activated concrete ceiling** - the pipe system is mounted in the centre of the component (@ Uponor)

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.

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.

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** <<

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

Can thermal activated buildings also realise its potential in renovation projects?

Climate change and, in particular, the careful use of existing resources require a change in the construction sector. Resources are limited, so it is important to utilise existing resources in the form of what has already been built and to make the building stock energy-efficient and fit for the future. More than 220 million buildings, 85% of the EU's building stock, were built before 2001 and 85-95% of existing buildings will still exist in 2050. A large proportion of these buildings are not energy efficient and rely on fossil fuels for heating and cooling.

The preservation and energy-efficient, in-depth refurbishment of existing buildings is therefore essential and requires suitable approaches and technologies. While TABs is now common practice in new buildings, the potential for refurbishment has not yet been recognised, or only in isolated cases. This is despite the fact that thermal activated building systems has been used for many years, particularly in thermally activated walls, as a suitable method for the refurbishment of old buildings.

Designed and planned accordingly, thermal activated building systems can be used to carry out a comprehensive and far-reaching thermal refurbishment including renewal of the heat emission system while the building is occupied.

One advantage of thermal activated building systems in refurbishment is the generally large heat emission surfaces available - a significant difference to the most common alternative in refurbishment, namely small radiators or convectors with high temperatures. The large heat emission surfaces make it possible to reduce the flow temperatures of the heat emission system, which opens up a wide range of alternative heat supply systems such as geothermal energy, solar energy and heat pumps. In addition, the same system can also be used for cooling without additional expense.

A common problem with existing buildings is mould infestation due to cold interior surfaces. Weak points in the building envelope and increasing airtightness because of renovation measures can lead to condensation on cold surfaces and, if it persists for a long time, mould. The thermal activation of building components, particularly in the area of weak points, can sometimes provide a remedy here. By thermally activating the building component, the surface temperatures rise, and mould formation is thus prevented.

> Mould problems can be solved by thermal activation of the building components. <<

How can thermal activated building systems be used in refurbishment?

Thermal activated building systems actively utilise the thermal storage masses of a building so that they can be used as storage and load peaks can be reduced or shifted. The existing building stock contains enormous storage potential. In particular, older buildings with solid components and often thick walls and ceilings have a high storage mass, which sometimes remains unutilised but can be upgraded through thermal activated building systems.

TAB from the outside makes the entire wall usable as a storage mass. <<

Although external systems have an inertia that should not be underestimated, they can also activate the entire existing storage mass of the external walls due to the external pipework and the existing masonry to be penetrated. In principle, the inertia increases with the increase in overlap (viewed from the interior), but the usable storage mass also increases. This means that most of the storage mass can be actively utilised with external TABs.

The positioning of the pipework is particularly important for materials with low thermal conductivity, whereas the influence on the inertia and the usable storage mass decreases for materials with high thermal conductivity.

Fig. 7 shows a schematic representation of different positioning of the pipework level in an existing wall and the resulting temperature distribution in the component.

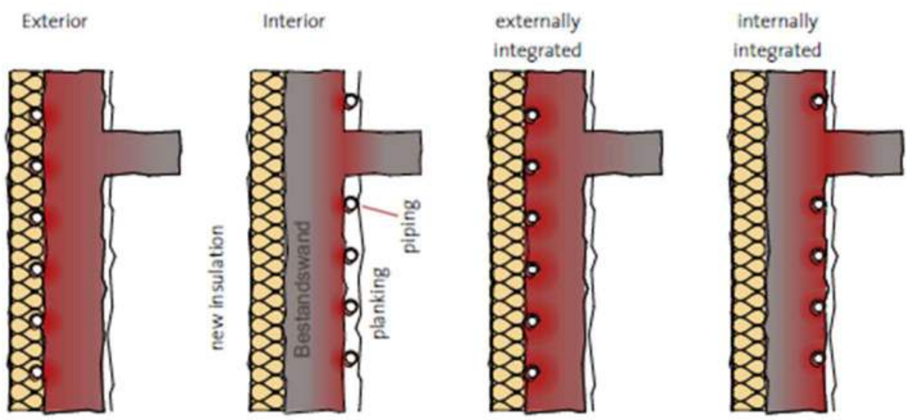


Fig.7 Comparison of different **positioning options** for the pipework in the existing wall @ FH Salzburg

When TABs is retrofitted into the building envelope, not only is the interior behind it heated, but there are also increased losses to the outside. If the outside temperature is below the room temperature, a temperature gradient is created in a non-activated external wall from the inside to the outside, with the room temperature being the highest temperature (Fig. 8 left).

In an activated external wall, on the other hand, the highest temperature is in the pipe level, which creates a temperature gradient both to the room inside and to the outside, and consequently a heat flow (Fig. 8, centre and right).

Fig. 8 shows an external wall with a U-value of 0.18 W/(m^{2}K) insulated as part of the renovation, a heat flow of 4 W/m^2 would result without activation, assuming a room temperature of 22° C and an outside temperature of 0° C.

External activation increases the heat flow to the outside to 6.9 W/m^2. With internal TABs, on the other hand, the heat flow to the outside would only increase to 4.7 W/m^2 with the same heat flow to the inside of 25.6 W/m^2. Consequently, the losses due to internal TABs are significantly lower than with external TABs (see also Fig. 8).

In addition to the heat losses, in this example the required (average) heating medium temperature is also reduced from 35°C (external TABs) to 25.6°C (internal TABs) for the given internal and external temperatures. The heating medium temperature has a significant influence on the choice of heat generator and the integration of renewable energies and should always be taken into account during planning.

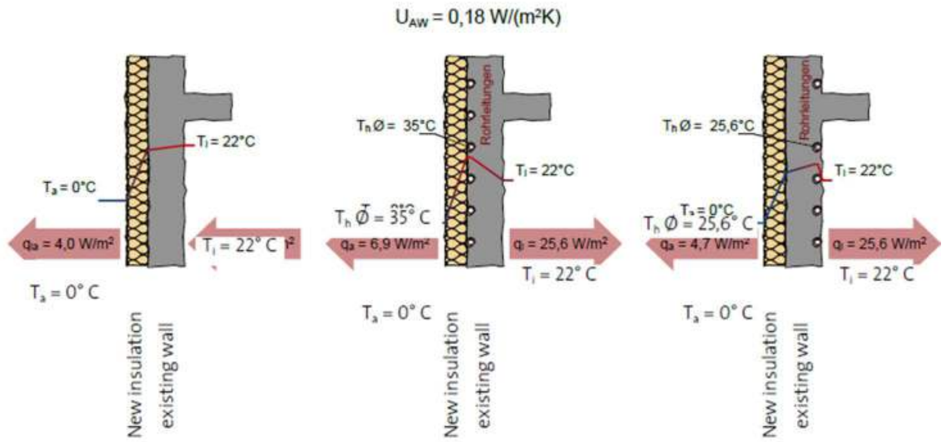


Fig. 8 **Comparison of the heat flows and temperature curves** of a non-activated existing wall (left) with a wall with external TABs (centre) and a wall with internal TABs (right) © FH Salzburg

The following figure illustrates the effect of the U-value of the existing wall and subsequently added insulation on the efficiency of external TABs. Good efficiencies of over 80 % can be achieved with a high U-value of the existing wall in combination with a thick layer of insulation added on the outside as part of the refurbishment.

Sufficient insulation is essential to minimise heat loss through the external walls and increase the efficiency of the TAB. <<

The efficiency (see Schmidt et al., 2017) is defined as follows:

$$\eta_{TABS} = \frac{q_i}{q_i + q_a} \times 100$$

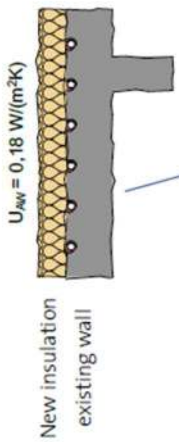
q_i Heat flow inwards

q_a Heat flow to outside

An external pipe register should only be considered if the U-value of the existing wall is greater than or equal to 1 W/(m²K). <<

The figures given in Fig. 9 are based on an average temperature in the pipe level of 35 °C, an outside temperature of 0 °C and a room temperature of 22 °C. As a guide value, the U-value of the existing wall should not fall below approx. 1 W/(m²K) for external TABs, even though the efficiency drops to 65 % with 20 cm of insulation (corresponds to a new U-value insulation of 0.2 W/(m²K)).

The U-value stated here does not describe the U-value of the entire wall, but only the internal layers (U-value* existing) or external layers (U-value* new insulation) as viewed from the pipework level.



U-Wert* Bestand [W/m²K] \ U-Wert* Dämmung neu [W/m²K]	0,10	0,20	0,30	0,40	0,50	0,60	0,70	0,80	0,90	1,00
0,50	65%	48%	38%	32%	27%	24%	21%	19%	17%	16%
0,60	69%	53%	43%	36%	31%	27%	24%	22%	20%	18%
0,70	72%	57%	46%	39%	34%	30%	27%	25%	22%	21%
0,80	75%	60%	50%	43%	37%	33%	30%	27%	25%	23%
0,90	77%	63%	53%	46%	40%	36%	32%	29%	27%	25%
1,00	79%	65%	55%	48%	43%	38%	35%	32%	29%	27%
1,10	80%	67%	58%	51%	45%	41%	37%	34%	31%	29%
1,20	82%	69%	60%	53%	47%	43%	39%	36%	33%	31%
1,30	83%	71%	62%	55%	49%	45%	41%	38%	35%	33%
1,40	84%	72%	63%	57%	51%	46%	43%	39%	37%	34%
1,50	85%	74%	65%	58%	53%	48%	44%	41%	38%	36%
1,60	86%	75%	66%	60%	54%	50%	46%	43%	40%	37%
1,70	86%	76%	68%	61%	56%	51%	47%	44%	41%	39%
1,80	87%	77%	69%	63%	57%	53%	49%	46%	43%	40%
1,90	88%	78%	70%	64%	59%	54%	50%	47%	44%	41%
2,00	88%	79%	71%	65%	60%	55%	51%	48%	45%	43%
2,10	89%	80%	72%	66%	61%	57%	53%	49%	46%	44%
2,20	89%	80%	73%	67%	62%	58%	54%	51%	48%	45%
2,30	90%	81%	74%	68%	63%	59%	55%	52%	49%	46%
2,40	90%	82%	75%	69%	64%	60%	56%	53%	50%	47%
2,50	90%	82%	76%	70%	65%	61%	57%	54%	51%	48%
2,60	91%	83%	76%	71%	66%	62%	58%	55%	52%	49%
2,70	91%	83%	77%	71%	67%	63%	59%	56%	53%	50%
2,80	91%	84%	78%	72%	68%	63%	60%	57%	54%	51%
2,90	92%	84%	78%	73%	68%	64%	61%	57%	54%	52%
3,00	92%	85%	79%	74%	69%	65%	61%	58%	55%	53%

Fig.9 **Efficiency η_TABS of external TABs as a function of the U-value of the existing wall and the subsequently added insulation** (assumptions: average temperature of the pipe level = 35 °C, room temperature = 22 °C, outside temperature = 0 °C), based on Schmidt et al. 'External wall temperature control' (Bauphysik 39, Issue 4, 2017) © FH Salzburg

The effects of the positioning of the pipework level on the storage mass and the losses that occur also apply to all other components of the thermal building envelope if they are equipped with TABs. In principle, any building component can be equipped with TABs, including walls, ceilings (or roofs) and floors (Fig. 10), regardless of whether the component is part of the thermal building envelope or an interior component. With regard to efficiency, losses and storage mass, the following rule of thumb can be used as a guide: The more surface area and storage mass I use for TABs, the better. A larger activated area increases the usable storage mass on the one hand and reduces the necessary flow temperatures on the other. Lower flow temperatures in turn have a positive effect on the overall system, especially in conjunction with heat pumps, and at the same time result in a reduction in losses.

A larger activated area increases the usable storage mass on the one hand and reduces the necessary flow. <<

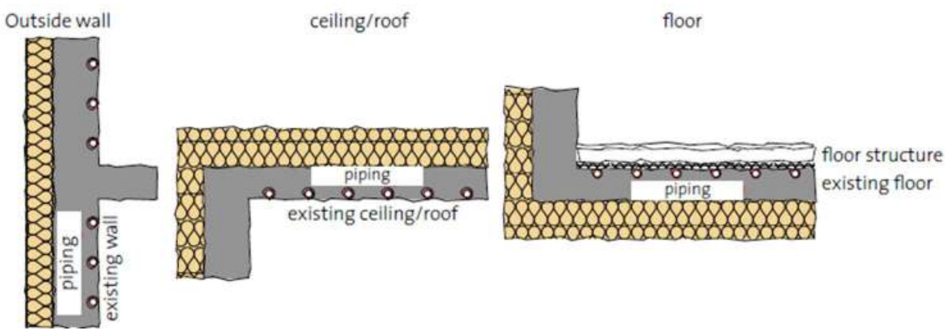


Fig. 10 Comparison of the **various options for thermal activation of components** ©FH Salzburg

In principle, all materials can be equipped with TABs and used as storage, be it concrete, brick, wood or other materials found in the building. In this context, there are various differences in the properties of the materials that need to be taken into account for the TABs to function as expected. Concrete has a very high thermal conductivity, which means that high heat dissipation rates can be achieved with TABs in concrete. Wood, on the other hand, has a comparatively low thermal conductivity, which means that significantly higher flow temperatures are required for the same heat output.

In contrast to the proven TABs in concrete, its use in refurbishment is not yet common practice and therefore requires planning and investigation of any special conditions. <<

Are there any practical examples of refurbishment that have already been implemented?

Fig. 11 "**Wohnen findet Stadt**" project Existing building

In the **'Wohnen findet Stadt'** project, a multifunctional façade with external TABs was developed and realised. The existing building, an apartment block with 12 flats, is located in the municipality of Hallein in Salzburg. The existing exterior walls were made of solid brickwork, making it easy to realise external TABs. The main motivation for the external TABs in this project was the continuous habitability of the building, which meant that the residents did not have to be relocated.

In the first step, the pipes were attached to the existing masonry. When laying the pipework, care must be taken to avoid high points (horizontal laying of the pipework is preferable to vertical laying), as this can lead to air pockets and, as a result, to a loss of air.

Fig. 12 Project 'Wohnen findet Stadt" **Fixing the pipes to the existing masonry** @ FH Salzburg

Then the prefabricated façade elements with insulation were attached and the resulting cavity between the existing masonry and the façade element was backfilled with a liquid mortar. Finally, in this case, sound-absorbing elements were attached to the outside.

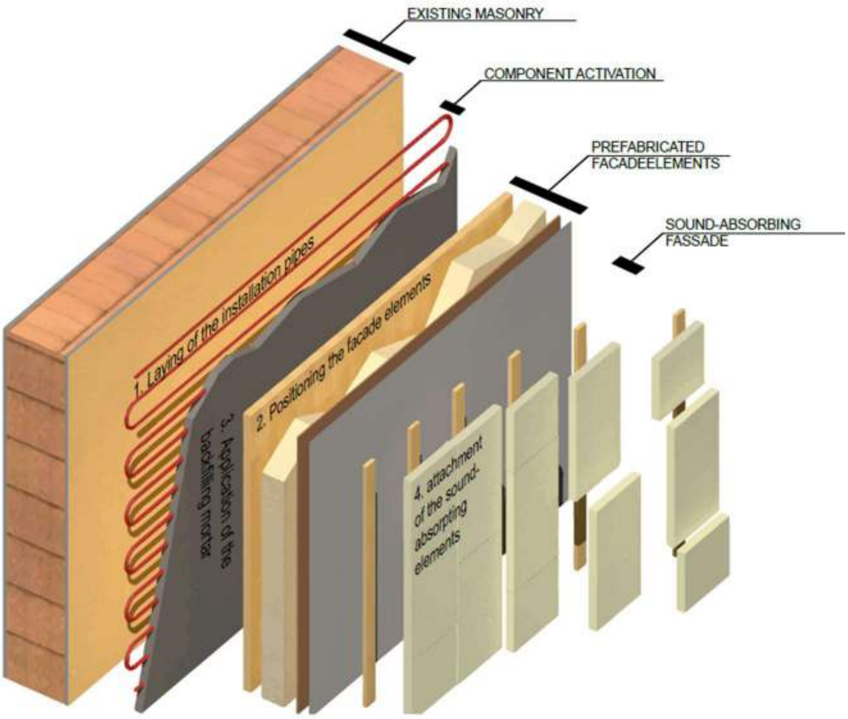


Fig. 13 M**ultifunctional façade**: Structure of the façade with external TABs developed in the 'Wohnen findet Stadt' project © FH Salzburg

Fig. 14 'Wohnen findet Stadt" **Installation of the prefabricated façade elements with insulation** © FH Salzburg

Fig. 14 shows the building after the prefabricated façade elements have been installed. Also shown here, starting from the cellar, is the routing of the distribution lines via the outer wall.

Fig. 15 shows the building in its finished state, including sound insulation elements.

Fig. 15 **Façade of the 'Wohnen findet Stadt' project** © FH Salzburg

The 'Sani60ies' project by the Institute of Building Research & Innovation with Sozialbau AG, Vasko+Partner and the University of Natural Resources and Applied Life Sciences IVET, a research project funded by the BMK as part of the City of the Future programme, is pursuing a similar approach with external TABs. So far, two properties have been equipped with the system, one with an existing wall made of shell concrete and one made of vertically perforated brickwork. The pipes were milled into the masonry (Fig. 16), levelled and insulated.

Fig. 16 **Milling in the pipes** into the concrete blocks @Sozialbau AG

Despite the milling work on site, the system proved to be practical and cost-effective. However, the heat distribution in the surface is challenging and performance-limiting, especially with the concrete blocks. In the third object of the research project, a variant without milling but with plastering of the pipe layer is being realised.

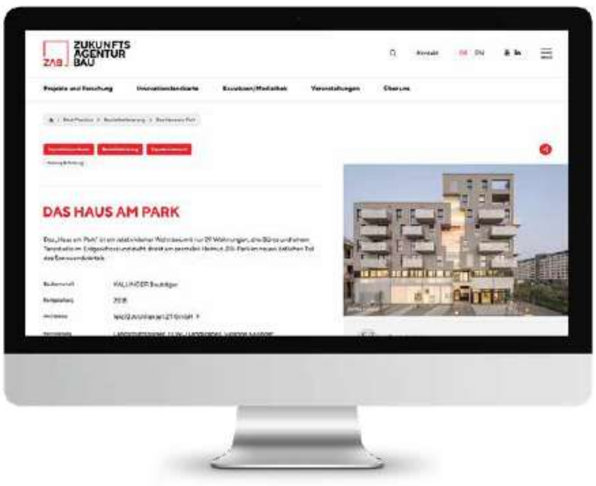
Fig. 17 'Sani60ies' project: Milling the pipes into the concrete blocks © Institute of Building Research & Innovation ZT GmbH

In a refurbishment project in Hallein's old town, partial TABs was realised on the inside of the existing wall, particularly around the windows (Fig. 18). Subsequent monitoring confirms that TABs can withstand strongly fluctuating outside temperatures even with subsequent wall temperature control. In the old town house in Hallein, the solid walls proved to be valuable energy stores during a cold spell. They naturally equalise surface temperature and air temperature and thus ensure a comfortable indoor climate. In addition, the moisture problem was solved with the renovation.

Fig. 18 **Refurbishment of the old town centre of Hallein:** Installation of copper pipes on the inside of the wall and around the windows @Habersatter Lindner

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

BI Bavaria innovative GmbH
« bayern-innovativ.de/de

Technical university Rosenheim
« th-rosenheim.de