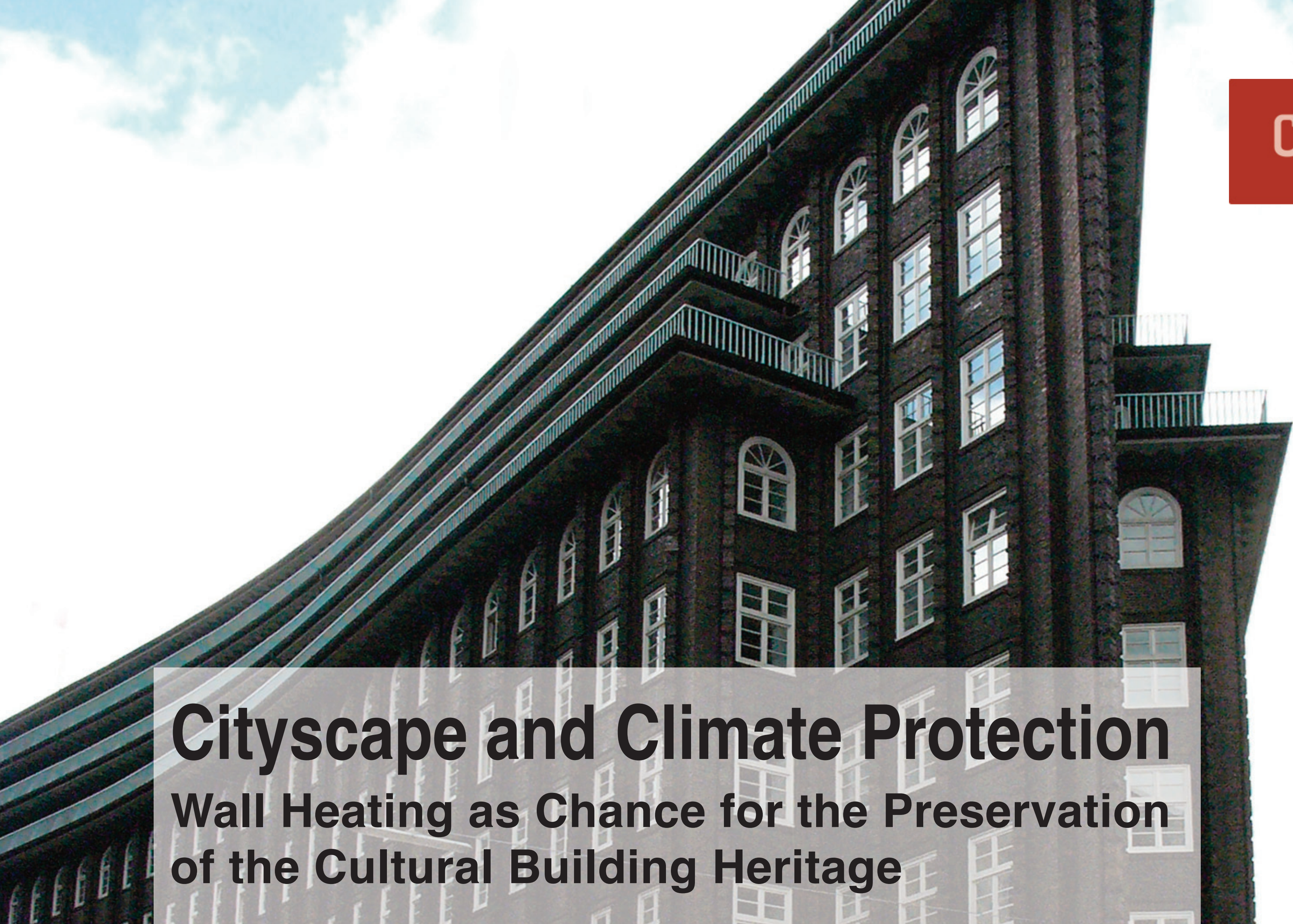

Co$_2$olBricks

Cityscape and Climate Protection

Wall Heating as Chance for the Preservation of the Cultural Building Heritage

A basic information for politicians, the public administration and the real estate industry

Supported by:

Baltic Sea Region
Programme 2007-2013

Part-financed by the European Union (European Region Development Fund)

Publisher:

Hamburg | Denkmalschutzamt

Hamburg
Leitstelle Klimaschutz

Cityscape and Climate Protection

Wall Heating as Chance for the Preservation of the Cultural Building Heritage

A publication in the context of the Interreg IV B project Co$_2$olBricks, January 2013

Initiator, lead partner and coordinator of Co$_2$olBricks is the Department for Heritage Preservation Hamburg, Germany.
Hamburg's Coordination Centre for Climate Issues is a partner of Co$_2$olBricks.
The German and English language versions of this brochure are available as PDF files at www.coolbricks.eu

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Preliminary Note

Project Co$_2$olBricks is devoted to the compatibility of climate protection and heritage preservation, especially technical solution approaches serving both goals.

In this brochure, Hamburg's Department for Heritage Preservation and Hamburg's Coordination Centre for Climate Issues deal with the topic of wall heating systems as a contribution to heritage preservation and climate protection.

The information presented here is the result of literature research and discussions with experts from practice and science.

The brochure is aimed at interested laypersons from administration, politics, economy and associations.

Contents

From Convection to Radiation

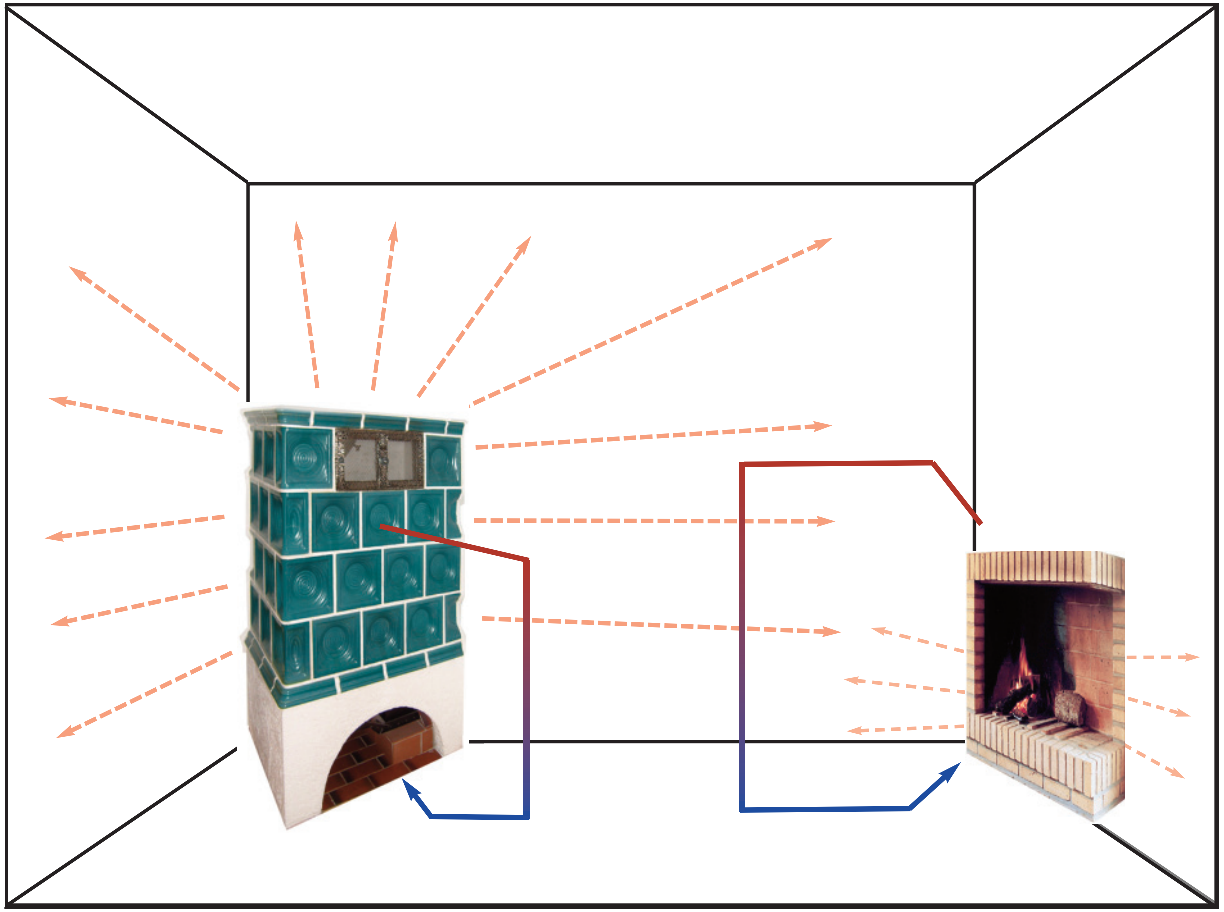
Until well into the 20th century, **fire-places** and **tiled stoves** were widely used for room heating.

Fireplaces need a constant oxygen supply for their burning process. Formerly, this was provided for by leaky windows. Due to today's highly sealed windows however, building regulations require that open fire-places must be equipped with an additional oxygen supply.

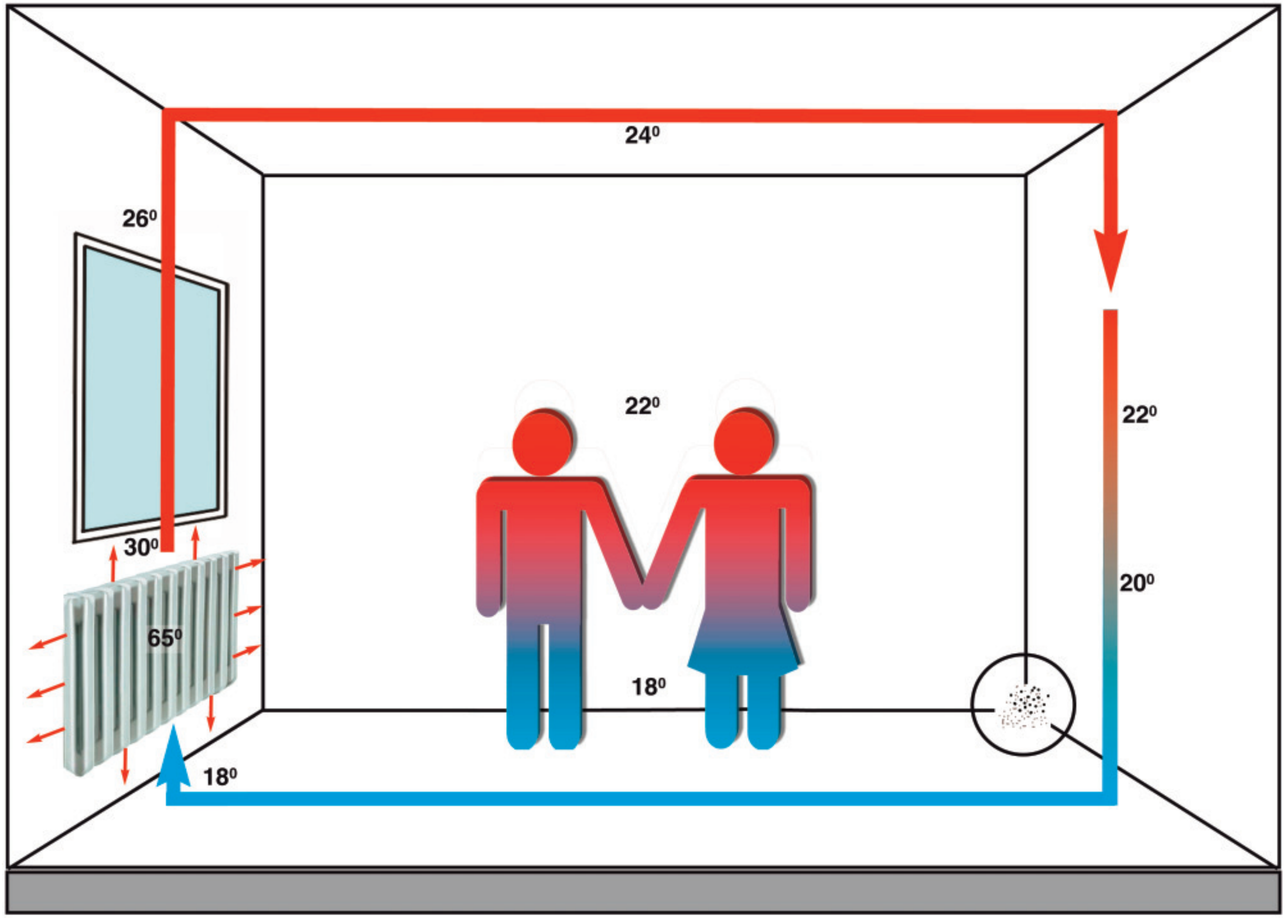
This also applies to tiled stoves. Here, the heating energy is emitted as radiant heat by the tiles' surface into the room.

Both heating methods also cause a certain amount of warmed air convection which may contribute to dust turbulence in the room.

The disadvantage of fireplaces and tiled stoves is, that they have to be fed their burning material by hand.



To alleviate the transport issue, central **heating systems** were introduced since about 1900. These generally used convec-tion radiators in the individual rooms (heating predominantly by means of air convection).



In a central heating system with **convection radiators**, energy transport is achieved by means of heated water. The water fed into a radiator is called “flow”, the water exiting the radiator is called “return”.

The flow water has a temperature of typically about 60°C. The room air passes along the radiator ribs and hereby gets warmed. Following the laws of physics, it rises up, cools down at the ceiling, windows and walls, and sinks back to the ground again. This generates an air circulation in the room. **The heat energy carrier in the room is the air.**

Convection heating immanently leads to zones of differently warm air in the room. In the head areas, the temperature is higher than in the foot areas.

An average temperature of 22°C has to be achieved, in order to be perceived as comfortably warm by the inhabitants.

The air roll picks up dust and spreads it in the warm air sea below the ceiling. From there, it trickles down onto the room occupants.

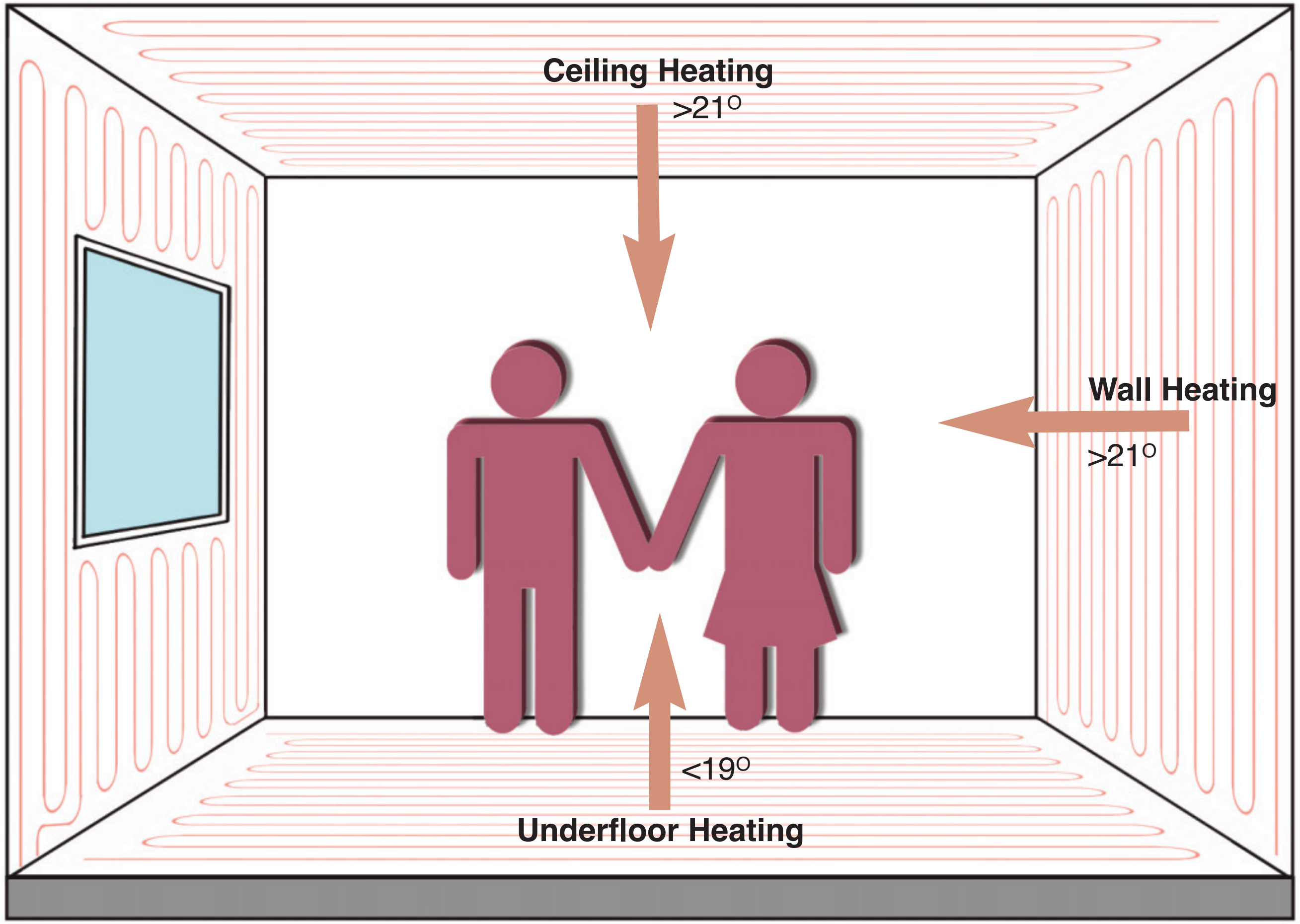
This may cause health impairments (allergies).

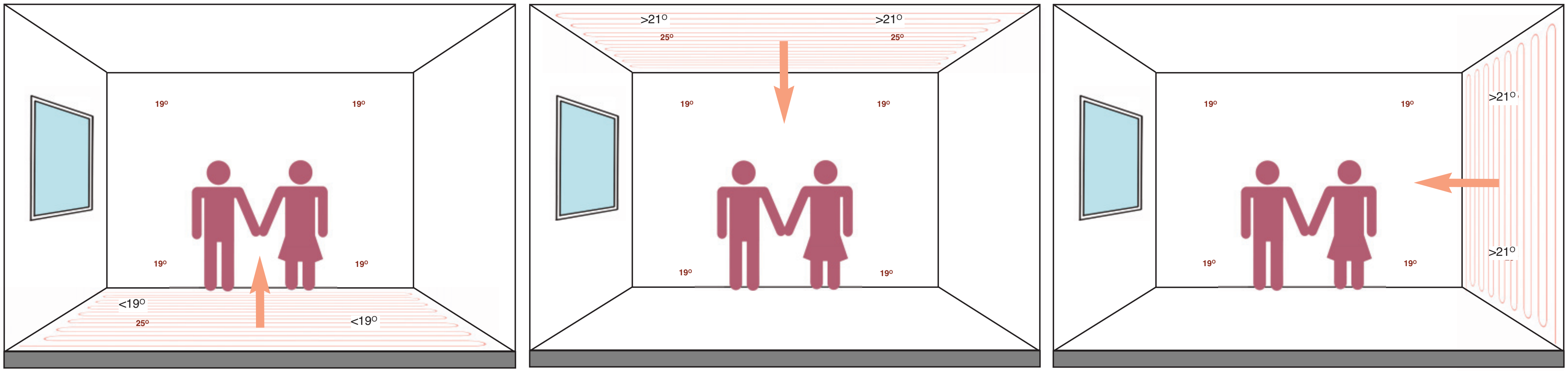
Water-based radiant heating systems are classified by their place of installation in floors, ceilings or walls.

They work through the **surface** of their place of installation. Their heat radiation directly warms the physical bodies it reaches. The room air is only warmed indirectly by heat transport from surfaces warmed by radiant heat.

The heating water is transported through a system of pipes made of copper, aluminium or plastic. These are laid out in about 15-25 cm distant lines by specialised craftsmen. The pipes are then covered by plaster or similar material, which adds up to a layer of in total about **30 mm**.

Since the flow temperature of radiant heating systems is only about 35°C, their heating boiler can, for comparable water amounts, be dimensioned smaller than for convection heating systems. The surface temperature of the wall should be at least 21°C and not exceed 24°C. With underfloor installations, the ground temperature should not exceed 18°, in order to avoid health impairments.





With convection heating systems, room ventilation leads to energy losses, because the heat carrier air escapes.

Since radiant heating systems primarily warm the surfaces of irradiated bodies, and only secondarily the air, the energy loss by room ventilation is smaller.

Ceiling heating systems are mainly used in the commercial sector, since their buildings usually offer load reserves for the integration of such systems into the ceilings. In private households, ceiling heating is less recommended, because then the occupants' heads are closest to the location of the energy emissions.

A similar disadvantage is the case with **underfloor heating**.

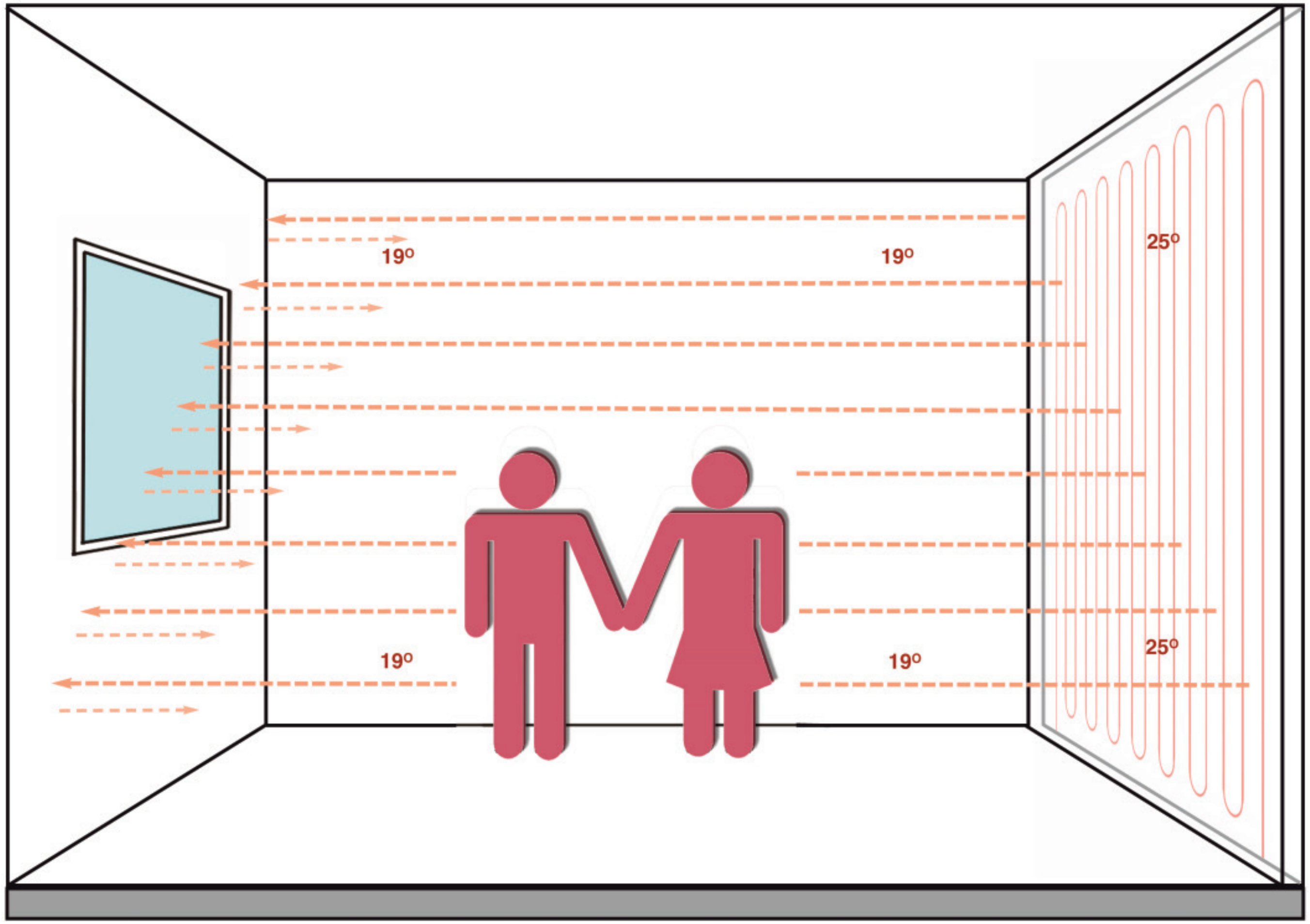
These kinds of heating systems have been becoming increasingly popular in new house construction for about 10 years. Former problems, such as too high floor temperatures or thermal inertia, have meanwhile been solved by system and layer structure changes.

Wall heating systems are the most appropriate choice for retrofitting those buildings with a radiant heating system, that are to accommodate people.

In **old buildings**, the installation location “wall” is most often less problematic than the installation location “floor”.

The heating-induced increase of the surface temperature additionally dries the wall, and thereby has a beneficial effect on the U-value (thermal transmittance).

During installation, it is vital to ensure a close contact between heating pipes and surrounding plaster.

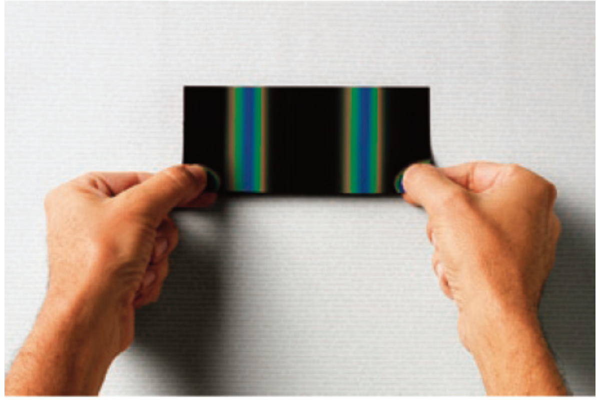


A **disadvantage** is, that furniture placed in front of a heating wall, such as book shelves, impair the heating function.

Another disadvantage is, that drilling the wall or driving in nails might damage the heating system mechanically.

For the latter purposes, there now exists a simple remedy: Placing thermal-sensitive paper onto the wall reveals exactly where the heating pipes are located.

Where conventional radiators are removed, additional wall space is freed.



	Convection Heating	Wall Heating
Energy consumption	High, due to flow temperature 65°C and room temperature 22°C	About 20% lesser, due to a maximal flow temperature of 40°C and a lower room temperature
Energy source	Coal, gas, oil, bio-fuels, electricity	As with convection heating, plus low-temperature systems such as solar thermal, and heat pumps
What is heated?	Air	Surfaces; the air only indirectly
Heat losses by ventilation	High	Low
Room temperature	Fluctuating, due to air circulation	Almost identical throughout the room, possible impairment by blocking furniture
Health	Dust turbulence by air roll (allergy sufferer)	Lesser dust turbulence, “standing air”
Well-being	Head and feet in different temperature zones	Uniform heat sensation
Humidity / Mould	Hazard sources: 1. Room areas with surface temperature below dew point 2. Improper ventilation habits	Surface temperature above dew point, wall is kept dry, risk of mould reduced

Project Co$_2$olBricks

Interreg IV B project **$Co_2olBricks$** (project term 2011–2013) deals with the **compatibility of climate protection and heritage preservation**.

It involves 18 cities and institutions from 9 countries of the Baltic Sea region. Its goal is a CO_2 reduction in heritage and historical buildings.

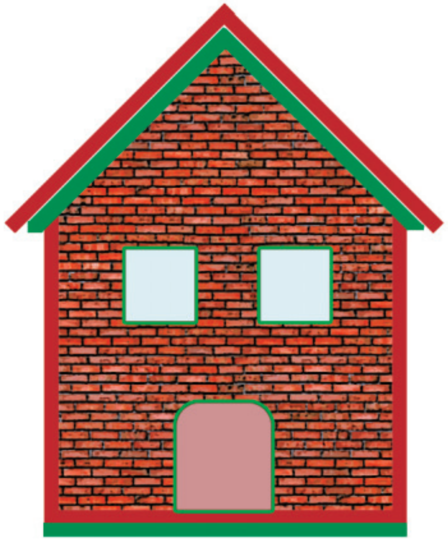
Project coordinator is Hamburg's Department for Heritage Preservation.

The core question is, how CO_2 goals can be achieved without changing the aesthetic appearance of the buildings.

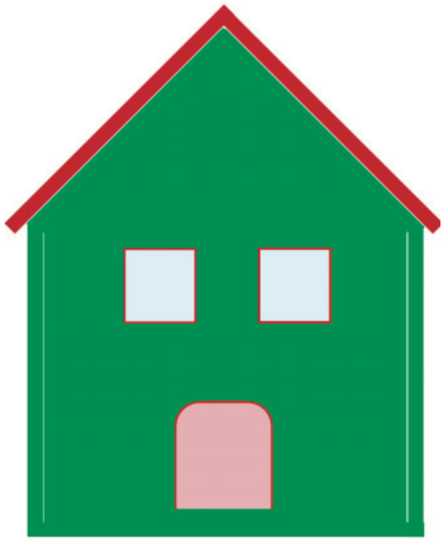
Heritage buildings are only a minor fraction of cities' buildings stocks (ca. 5%), but milieu-protected buildings, which are particularly formative for the cityscape, constitute up to one third of the total buildings stock of cities.

Technical solutions for heritage buildings, which do not impair the facade, are therefore important for the preservation of the cityscape.

Partner of $Co_2olBricks$



Partial insulation (cellar, roof, doors, windows) without exterior insulation



Full insulation with facade insulation

Buildings important for the cityscape shall be, by means of appropriate technical solutions, exempted from any facade-changing encroachment.

In addition to impairing the cityscape, wrongly calculated facade-changing measures can cause the following problems:

- Fungus and **mould formation** in case of temperature drops below dew point and improper ventilation habits
- **Fire hazards** of insulation materials
- Washing out of **pesticides** (integrated/composite external thermal insulation systems)
- **Decoupling** of the building from the solar thermal radiation
- Danger of **algae growth** on facade surfaces in case of thick insulation layers
- **Birds nesting** in the externally applied insulation layers

Technical solutions, such as the wall heating system tested in a Co$_2$olBricks pilot project, can be a contribution to climate protection.

Wall Heating: FAQ

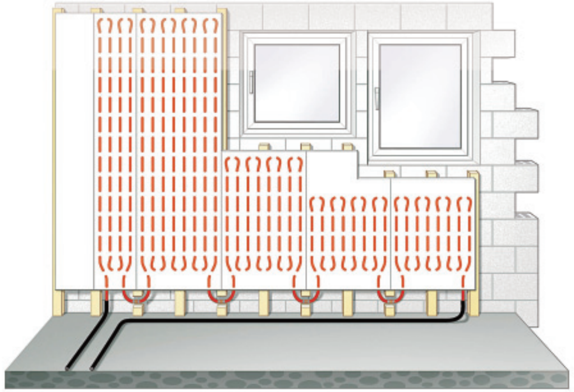
Retrofitting an old building with an **underfloor** heating system may lead to the loss of the existing finished floors.

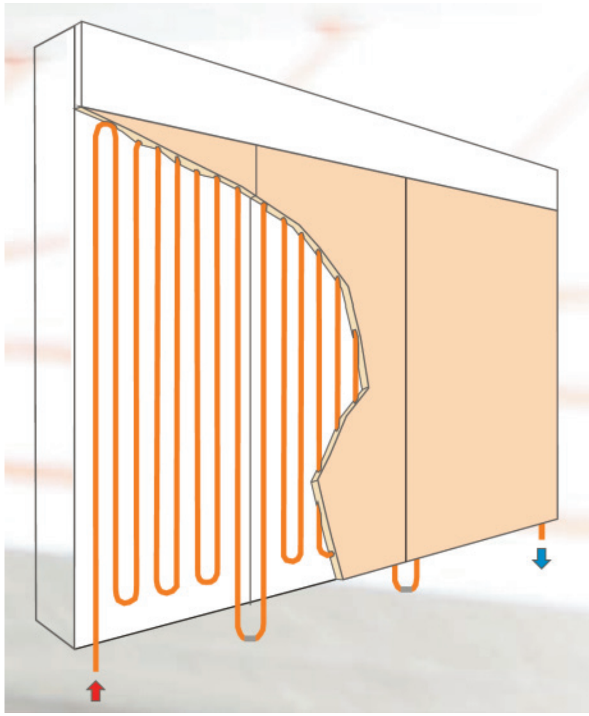
A **wall heating system** is better suited for retrofitting.

Temporary dust protection walls seal off the rest of the living area.

Inlet/outlet pipes have a standard diameter of 15 mm and can be installed along the baseboards.

Existing radiators are removed, the existing pipe system can be sealed off or removed.





Wall heating modules from companies Viega (above) and Variotherm (below). (Excerpt from the supplier list in the appendix)

Besides by installation location, heating systems are classified according to their installation method: dry or wet construction.

With the **wet construction** method, the wall heating tubes are mounted directly onto the wall and subsequently covered with plaster.

Many commercial suppliers have developed wall heating systems for **dry construction** installation which consist of connectable panels of various sizes and can hereby be adjusted to the conditions of the premises.

A cost comparison for dry and wet assembly, based on internet research and expert inquiries, showed that the installation costs of both methods amount to about 65 € per square metre of plastered and/or painted wall.

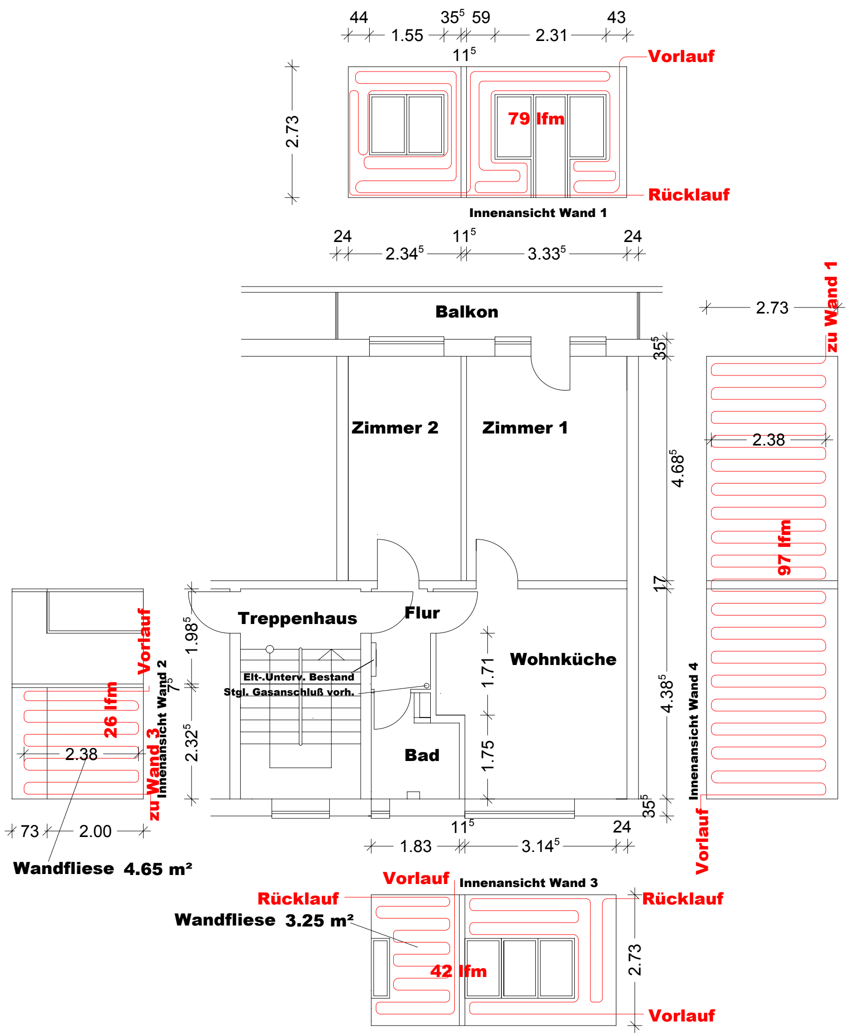
In unison, scientists emphasise that low-temperature radiant heating systems facilitate the use of renewable energies (solar thermal, geothermal) for heating purposes and create a healthy indoor climate (IBN, Lehrheft 8, 2013, table in appendix).

They also concur that radiant heating, due to lower room temperatures (19°C instead of 22°C) and less frequent ventilation needs, achieves energy savings of about 6% per degree Celsius: in total 3 x 6 = 18%.

A **dispute** prevails, whether the energy conservation potential of lower flow temperatures (35°C instead of 65°C) and the mostly smaller heating water volume lead to additional energy savings, because there also are energy losses due to heat dissipating into the surrounding building parts (plaster, wall etc.).

Picture: BHW Bausparkasse/Viega

How much wall space is necessary?



Pilot dwelling in Hamburg-Veddel
Here, wall heating is mounted to 50% of the available wall space.

When installed according to workmanship standards, wall heating systems currently make use of **30% to 50%** of the total wall space in a dwelling. The inner surfaces of all outer walls must always be fully covered.

If the outer walls comprise too many glass areas, additional inner walls can be used.

In **wet rooms** (bathroom, kitchen), it can make sense to install the wall heating on even further inner walls.

Payback calculation (sample):

Dwelling 100 m²

Heating costs 180 € per month, 2,160 € per year

Wall heating with tempered water 50 m²

Installation costs (50 m2 x 65 € per m²) 3,250 €

Savings 18% of heating costs = 390 € per year

Payback: 3250 : 390 = 8.3 years

Several new publications point out that the DIN-standardised heat demand compensating for ventilation is often assessed **too high** for radiant heating systems. The computed heating energy demand therefore mostly substantially exceeds the actual consumption.

Clarification can here only be provided by empirical studies.

In the context of project Co_2olBricks, appropriate measurements are being executed by the Dresden University in Hamburg's **Veddel** quarter until December 2013.

Measurements for a Department for Heritage Preservation project in **Hamburg-Bahrenfeld** are starting in December 2013.

The Fraunhofer Institute is taking comparative measurements in a historical building in **Benediktbeuern**, since 2008 (until June 2013).

Benediktbeuern

Hamburg-Veddel

Together, these studies will contribute to review the experiences gained from practice.

Wall Heating and Climate Protection

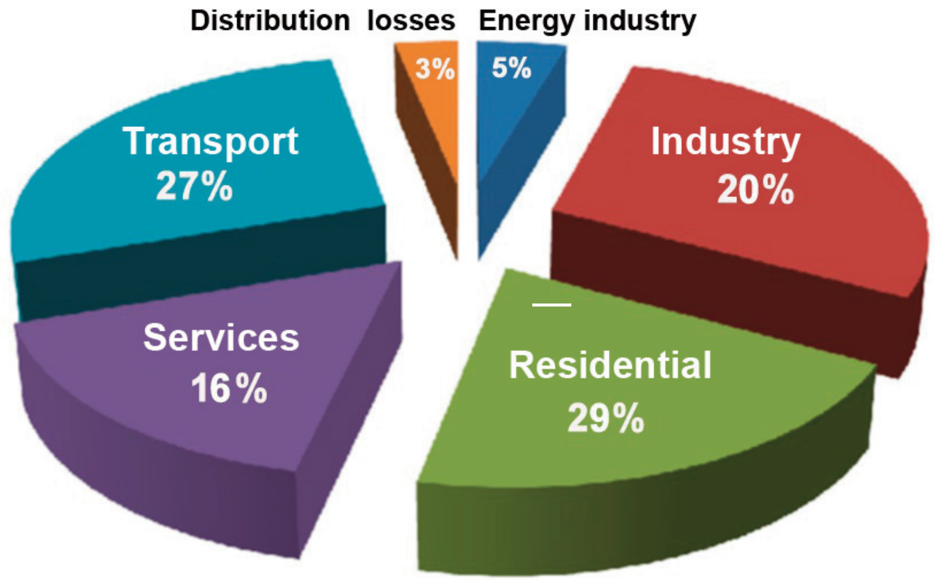
EU regulations demand that CO_2 emissions must be reduced by 80% until 2050. Baseline for the calculation of these CO_2 reductions is the year 1990.

On European average, the buildings sector (private households and services) accounts for about 40% of the overall CO_2 emissions.

The consumption of electrical energy causes about 33% of the buildings sector's total CO_2 emissions (households: 30% / services: 40%).

Assuming that 80% of Europe's electricity will be generated with renewable energies in 2050, this alone would save about 25% of the buildings' emissions.

Which means that "only" 55% CO_2 have to be reduced by the building's non-electrical energy consumption (for heating and warm water).



Energy consumption sectors in 2005, European average
source: Carney, Sebastian: Greenhouse Gas Emissions Inventories for 18 European Regions, Manchester/Hamburg 2009 (www.euco2.eu)

Contributions hereto can be achieved by insulation measures of all kind, by the use of renewable energies, and of more efficient heating systems.

That's why assessment of the savings potential of wall heating systems is of climate-political importance.

What does savings percentage mean?

	Heating Energy Demand
Unrenovated residential house, construction year 1960-80	300 kWh/m²a
Unrenovated residential house 1990	150-250 kWh/m²a
New residential house Germany 1999	75-90 kWh/m²a
New residential house Germany 2010	50 - 65 kWh/m²a
Low-energy house	20 - 50 kWh/m²a
Passive house	<15 kWh/m²a

Classification according to subsidy levels of KfW Bank Group; comparable data are valid for Austria and Switzerland.

In the buildings sector, energy consumption is measured in **kWh/m2a**, in kilowatt-hours per square metre per year (annum).

If in 2012, a building having undergone an energy-related renovation consumes 50 kWh/m2a, it is – from a climate protection viewpoint – compared with the consumption of a similar building in 1990.

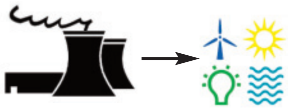
For a residential building, this would be about 200 kWh/m2a. The non-electrical energy savings compared to 1990 would therefore amount to 75%.

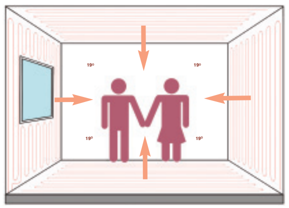
Since non-electrical energy accounts for about 66% of a building's overall energy consumption, the CO2 reduction achieved in the non-electrical energy sector amounts to 50%.

Hereto, we must add the effects of a largely CO_2-free power grid in the target year 2050 (see previous page), and the possible use of regenerative energies for heating and warm water.

Calculation model for possible CO_2 reductions

Partial insulation	**-20%**
New heating boiler or **Heating with solar thermal energy and/or heat pump**	**-20%**
80% CO_2-free power grid	**-25%**
Subtotal	-65%
Radiant heating	**-18%**
Total maximal:	**-83%**





Thermal insulation measures at cellar ceilings and roofs as well as the replacement of windows and doors achieve a CO_2 reduction of about 20% (calculation result from analysis of expert publications).

The **replacement** of outdated heating and warm-water boilers increases energy efficiency by 20% with a subsequent CO_2 reduction of 20% (see above). If the radiant heating systems are powered with solar thermal energy or heat pumps, this also saves 20% (see above); but then the 20% for new boilers may not be taken into account.

A **power grid** which is 80% CO_2-free would reduce the emissions of private households by approximately 25%, on European average.

The use of **radiant heating systems** instead of traditional **convection heating** would save about 18% of CO_2 emissions (see page 20).

Hamburg's International Maritime Museum is located in a **heritage-protected** former warehouse finished in 1884 and renovated and energy-optimised in 2004-08.

Since the interior walls are heritage-protected as well, a **radiant heating system** was installed in the ceiling of this non-residential building.

A water-based heating and cooling system was constructed, with **copper panels** being used as radiation emitters.

In addition, the windows were equipped with a second **inner glass pane with ventilation**, so that the air is being warmed prior to inflowing into the building.

After the renovation and according to several years of heating-cost billing, the heating energy consumption is established to be **50 kWh/m2a**, that is 50 kilowatt-hours per square metre per year.

This meets the standard of a low-energy house (see table on page 25).

In the context of a **Co_2olBricks** pilot project, four apartments in Hamburg's city quarter Veddel were renovated as model dwellings for a comparative study, in autumn 2012.

The apartments were not inhabited during the conversion. So the wall heating systems could be installed without difficulty using the conventional wet-construction method.

The flats were equipped with:

No. 1: Convection heating without interior thermal insulation

No. 2: Convection heating with interior thermal insulation

No. 3: Wall heating without interior thermal insulation

No. 4: Wall heating with interior thermal insulation

The Dresden University is executing measurements since November 2012 and until December 2013.

These shall research the heat transition of the building component ”outer wall“ in dependence of its moisture.

During the procedure, the energy consumptions will be determined, too.

Co2olBricks

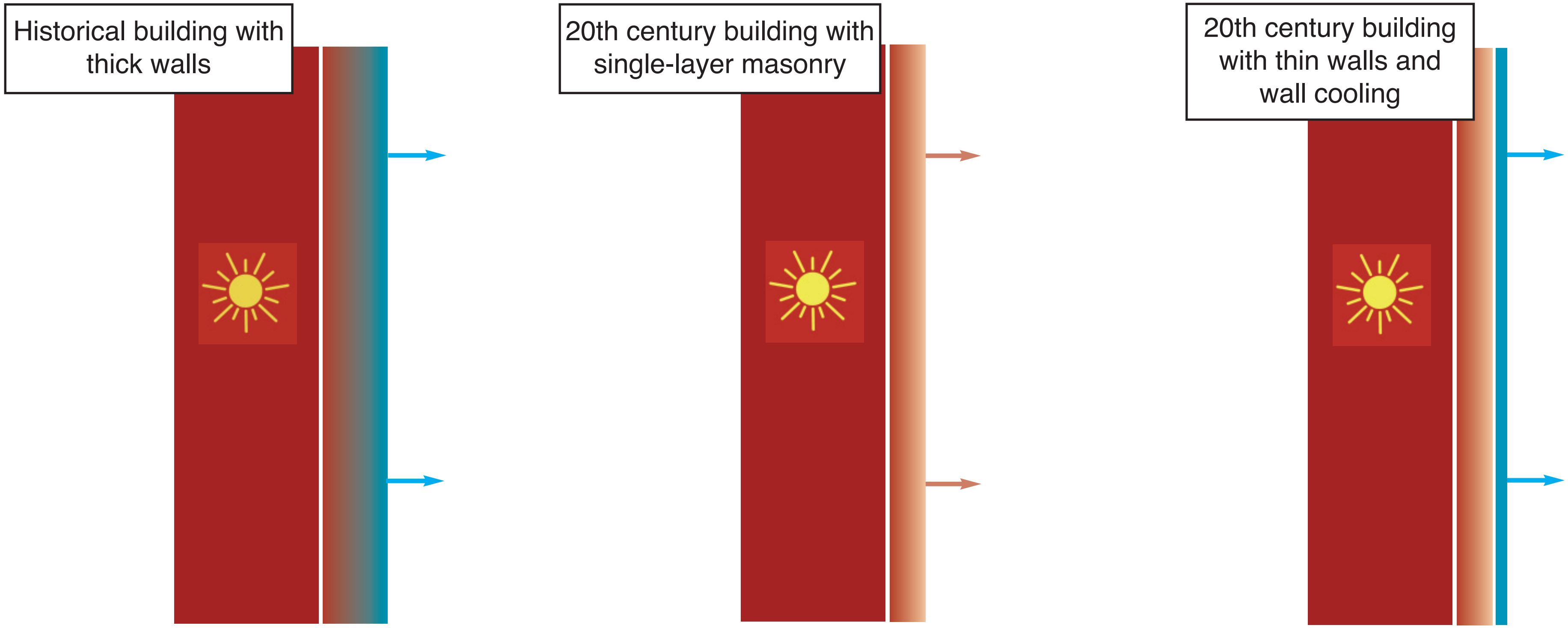
Wall Tempering as Cooling System

Remark

Room cooling by wall tempering is not a core subject of project Co$_2$olBricks, because all project partners are located in the Baltic Sea region with its moderate climate.

However, Hamburg's Coordination Centre for Climate Issues is also in charge of disseminating the results of the project within the METREX network. METREX is an organisation of 55 European metropolitan regions and areas.

Numerous discussions with representatives from southern metropolitan regions/areas have revealed that the topic wall tempering/cooling meets with great interest there. For this reason, it is being included here.



Single-layer masonry has the capability to store solar thermal input.

This stored energy is transferred indoors as radiant heat. It does therefore make sense to install a wall cooling system at the location of the energy transmission (the inner surface of the wall), in order to prevent thermal influx to interior spaces.

Conventional air conditioning systems don’t inhibit the thermal energy input at its place of intrusion, but simply siphon off the heated air and substitute it by cold air.

Air conditioning systems therefore **fight the energy stored in the wall**.

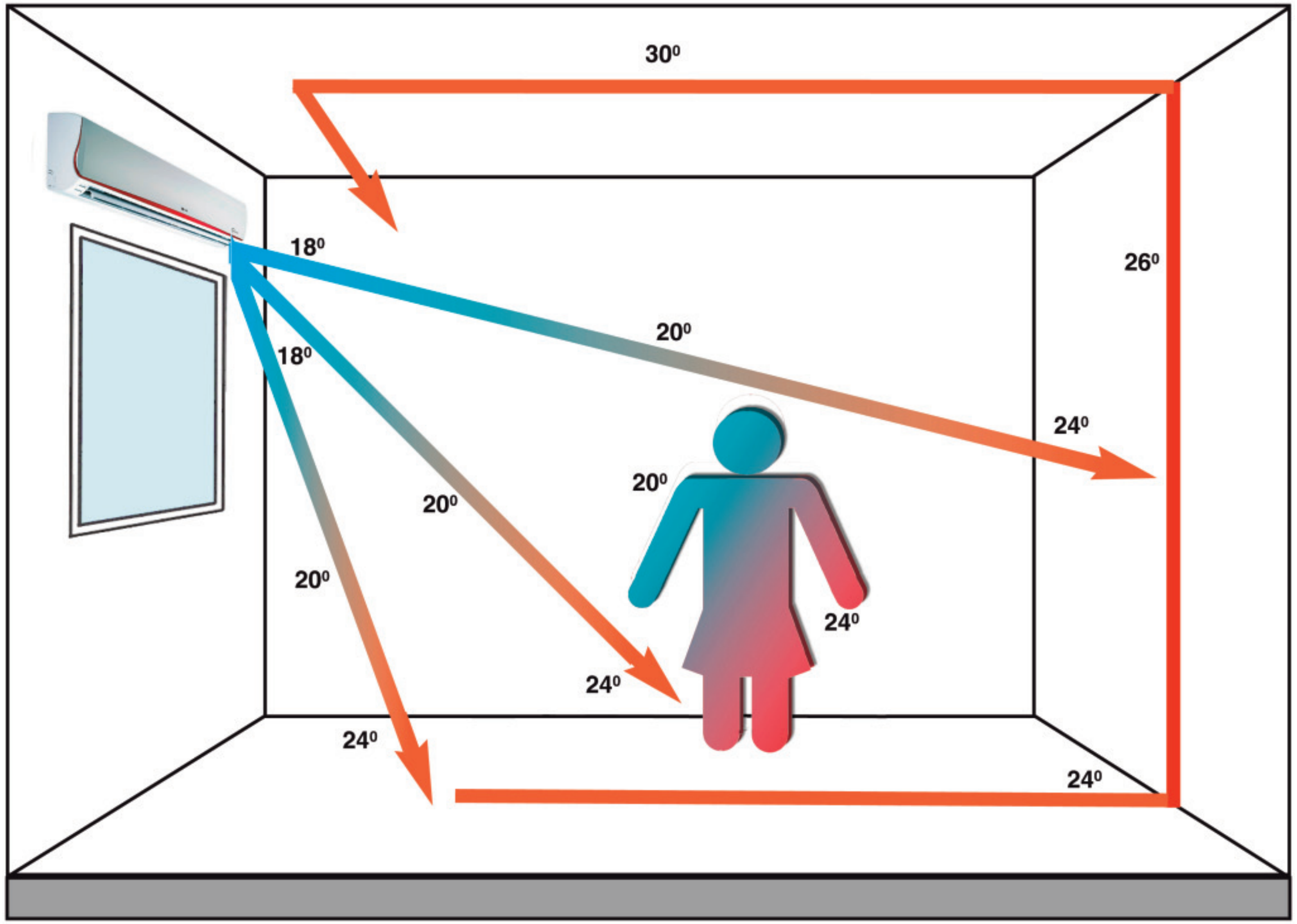
Air conditioning systems usually are convection cooling appliances which disperse cold air inside a room.

As with convection heating systems, the room temperature is layered and varies depending on the distance to the cold source.

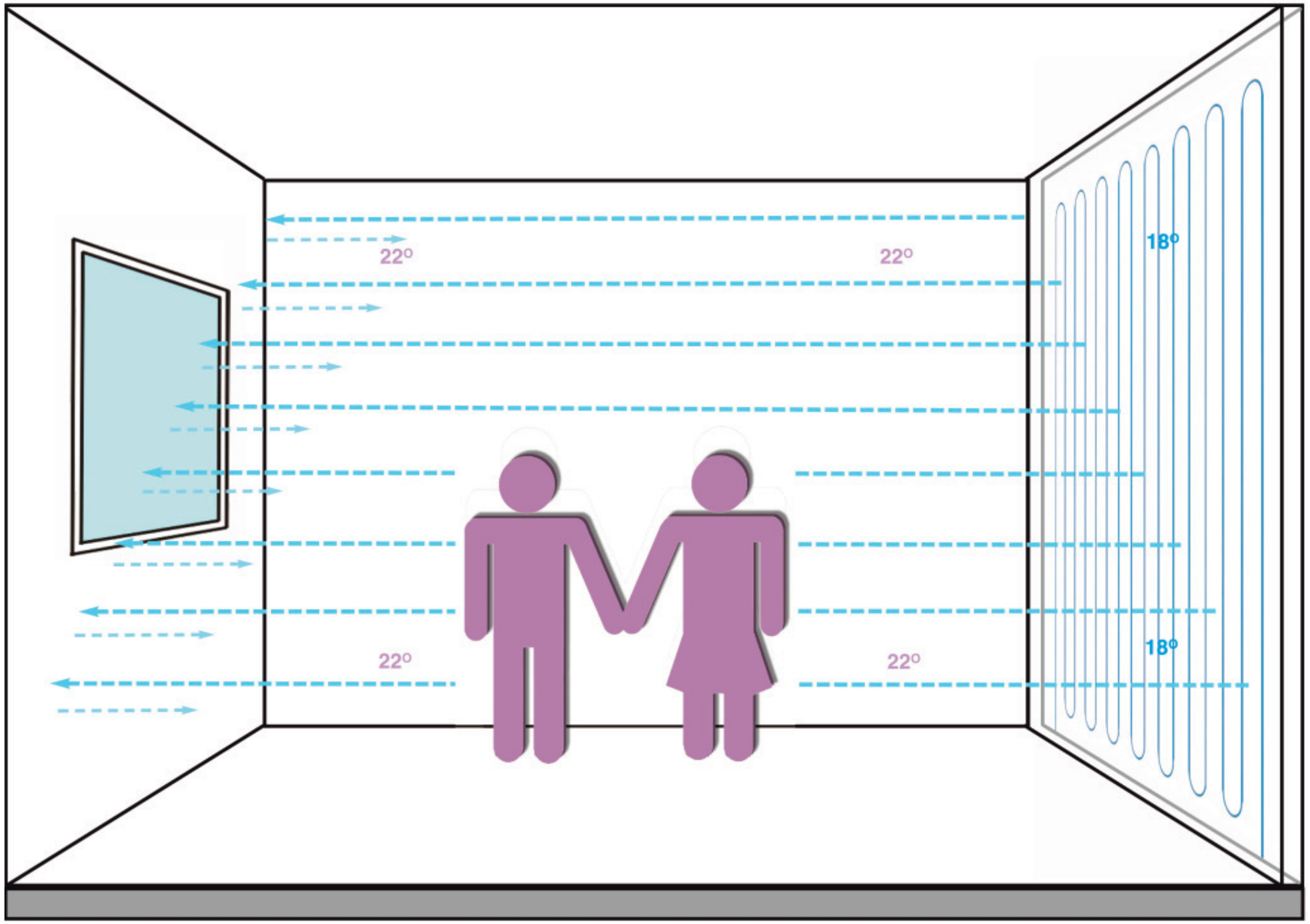
More than with heating installations, a cold air stream is being experienced as **uncomfortable**, and the goal of a uniform room temperature regulation is difficult to achieve.

The usual energy source is electricity.

Room occupants often complain about draught, chilliness and dry mucous membranes.



… or with a wall cooling system



Wall cooling systems basically are **wall heating installations with very low flow temperature.**

A human body perceives radiation that lies below skin temperature as **comfortably cooling**.

Wall cooling systems are cooling uniformly and consume less energy than electricity-powered air conditioning.

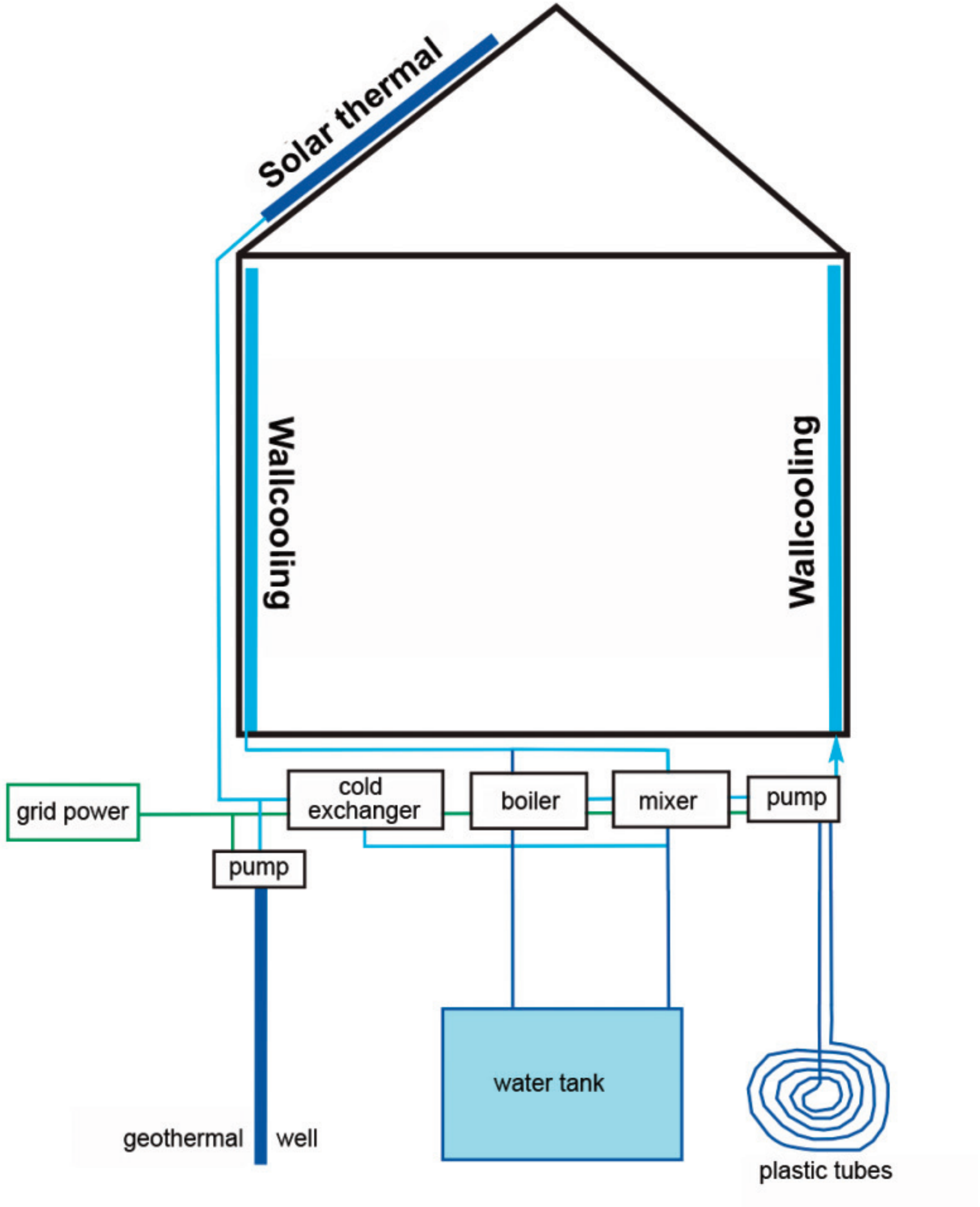
The flow temperature of the circulating water is the parameter which defines whether the wall tempering system has a heating or cooling function.

Suitable for generating the water temperatures necessary for the **wall cooling circuit** are

- **Ground heat pumps**
- **Solar thermal installations** equipped with a cold exchanger
- **Underground cold water tanks**

The supplied water has to be mixed with colder or warmer water in order to reach application temperature.

For a **low-budget solution**, it's possible to bury long plastic tubes at 3-4 m depth below ground and connect them to the circulation pump of the wall heating system. A crude temperature regulation can be achieved by switching the pump on and off.



Water-based wall heating and wall cooling systems are, from a technological viewpoint, **simple to install**.

All work processes, such as the fitting of pipes, the plastering of walls, the mounting of dry construction elements, and the installation of temperature control devices **are well-known techniques**.

In view of increasing energy costs, heating/cooling systems which are energy-saving and suitable for the use of renewable energies have **good market chances**.

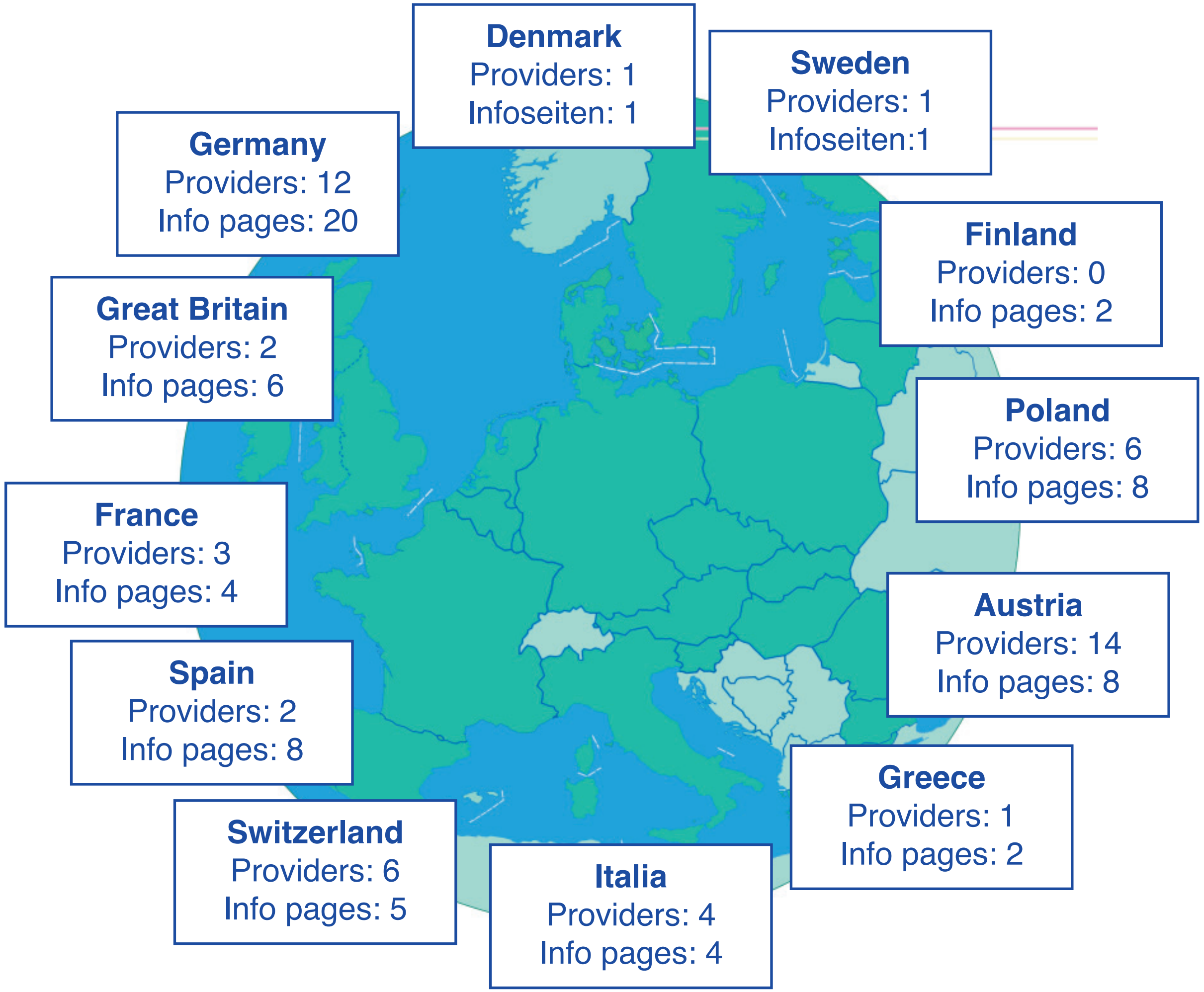
The installation of surface tempering in new buildings and especially the existing buildings stock presents **chances** in structurally weak regions for **strengthening of regional economic activities**.

Wall heating and wall cooling is **not yet known well enough at European scale**.

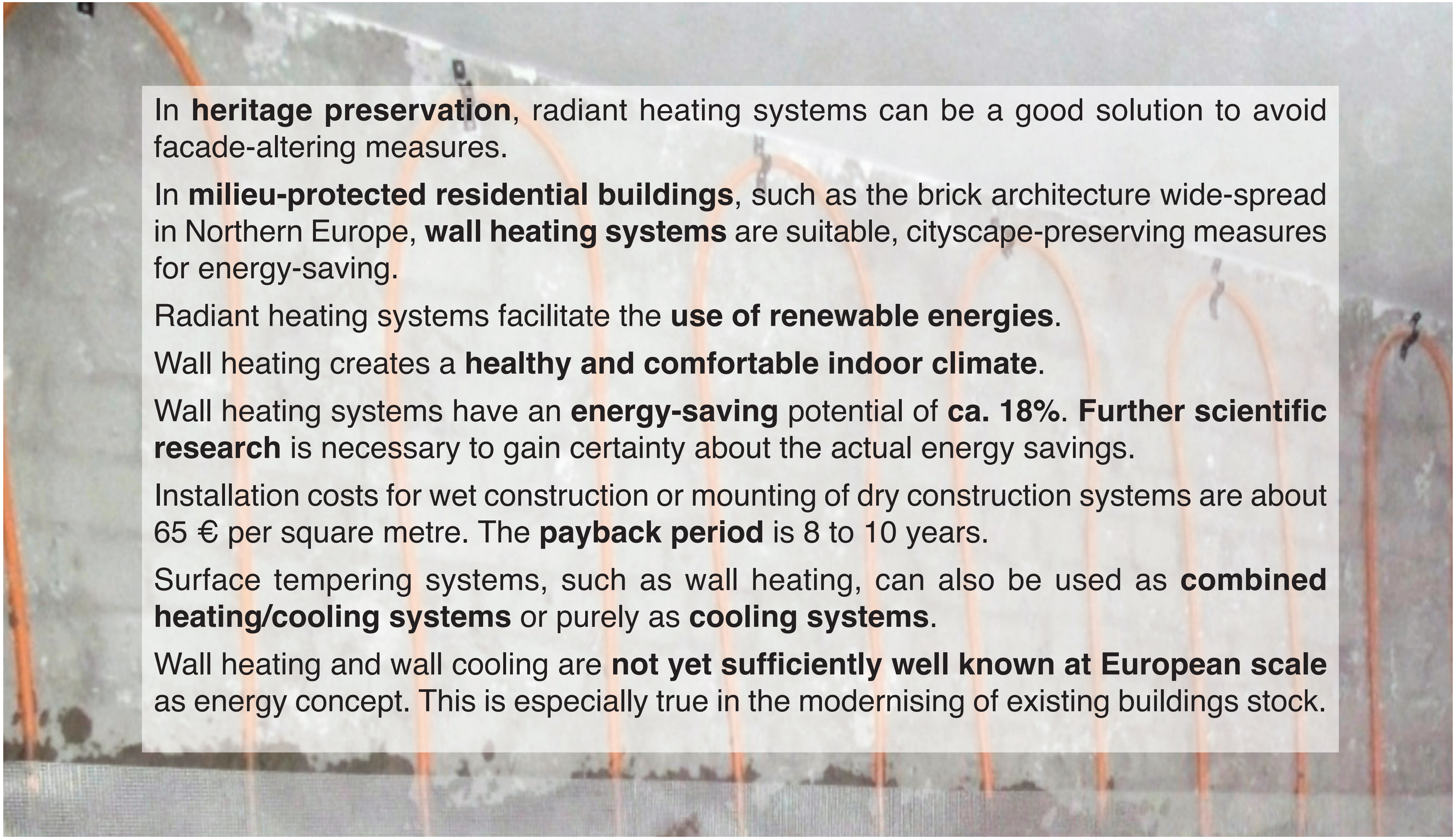
Only in **Austria** and **Switzerland** the discussion seems to be more advanced than in other European countries, but even there is focused rather on newly constructed buildings.

A comparison of the results of a google research with native-language search terms confirms this fact (December 2012).

The search was limited to water-based wall heating systems, and excluded electrical wall heating.



Summary



In **heritage preservation**, radiant heating systems can be a good solution to avoid facade-altering measures.

In **milieu-protected residential buildings**, such as the brick architecture wide-spread in Northern Europe, **wall heating systems** are suitable, cityscape-preserving measures for energy-saving.

Radiant heating systems facilitate the **use of renewable energies**.

Wall heating creates a **healthy and comfortable indoor climate**.

Wall heating systems have an **energy-saving** potential of **ca. 18%**. **Further scientific research** is necessary to gain certainty about the actual energy savings.

Installation costs for wet construction or mounting of dry construction systems are about 65 € per square metre. The **payback period** is 8 to 10 years.

Surface tempering systems, such as wall heating, can also be used as **combined heating/cooling systems** or purely as **cooling systems**.

Wall heating and wall cooling are **not yet sufficiently well known at European scale** as energy concept. This is especially true in the modernising of existing buildings stock.

Articles and studies on energy efficiency in buildings

Bundesministerium für Wirtschaft und Technologie (BMWi) (2010) **Zahlen und Fakten: Energiedaten: Nationale und Internationale Entwicklung** Referat III C 3, BMWi, Berlin (www.bmwi.de/BMWi/Navigation/Energie/Statistik- und-Prognosen/energiedaten.html)

Gerth,M.,Kämpke, T., Radermacher, F.J. und Solte,D. (2011): **Die soziale Dimension des Klimaschutzes und der Energieeffizienz im Kontext von Bau-und Wohnungswirtschaft.** Forschungsinstitut für anwendungsorientierte Wissensverarbeitung, Ulm (www.faw-neu-ulm.de/artikel)

GdW Bundesband deutscher Wohnungs- und Immobilienunternehmen e.V (2011) **DENA-Sanierungsstudie zur Wirtschaftlichkeit von Modernisierungsmaßnahmen ist unrealistisch**, Medien- Information Nr. 05/11 vom 10.02.2011, GdW, Berlin (http://web.gdw.de/pressecenter/pressemeldun-gen/177-energieeffizienz/134-dena-sanierungsstudie-zur-wirtschaftlichkeit-von-modernisierungsmassnahmenist-unrealistisch?tmpl=component&format=pdf)

Michelsen, C. und Müller-Michelsen, S. (2010): **Energieeffizienz im Altbau: Werden die Sanierungspotenziale überschätzt? Ergebnisse auf Grundlage des ista-IWH-Energieeffizienzindex.** Wirtschaft im Wandel, 9, 447–455 (www.iwh-halle.de/d/publik/wiwa/9-10-5.pdf)

Schröder, F., Engler, H.J., Boegelein, T. und Ohlwärter, C.(2010): **Spezifischer Heizenergieverbrauch und Temperaturverteilungen in Mehrfamilienhäusern – Rückwirkung des Sanierungsstandes auf den Heizenergieverbrauch.** HLH: Lüftung/Klima Heizung/Sanitär, 61(11), 22-25 (www.brunata-metrona.de/fileadmin/Downloads/Muenchen/HLH_11 2010.pdf)

Stadt Zürich, Umwelt- und Gesundheitsschutz (2012): **Untersuchung der Stadt Zürich zur Wirksamkeit unterschiedlicher Dämmstärken.** (www.stadt-zuerich.ch/content/gud/de/index/umwelt/bauen/energieeffizient_bauen_sanieren/energie-coaching/Praxisbeispiele.html)

Studie der Universität Cambridge zu vermuteten und tatsächlichen Verbräuchen deutscher Bestandsgebäude und Niedrigenergiehäuser (2012): Minna Sunikka-Blank/Ray Galvin: **Introducing the prebound effect: the gap between performance and actual energy consumption.** Aus: Building Research & Information, Volume 40, Issue 3, 2012 (www.tandfonline.com/doi/abs/10.1080/09613218.2012.690952)

Walberg, D.: **Energieeffiziente Highend-Gebäude: Wirklichkeit und Grenznutzen**, Proceeding of the 33rd International Uponor Kongress 2011, S. 73-78. (www.uponor.de/~/media/Files/Uponor/Germany/ Arlberg/Beitrag_6_Walberg.ashx)

Articles on wall heating

Berneth, Claus-Peter: **Wandstrahlungsheizung - für Sanierung und Neubau.** Aus: DBZ Deutsche Bauzeitschrift 52(2004)Nr.1, S.72-74 (http://six4.bauverlag.de)

Buchner, Peter: **Wandheizung erwärmt Mittelschule.** Aus: Moderne Gebäudetechnik 63(2009) Nr.4, S.14-15 (www.tga-praxis.de)

Bund deutscher Zimmermeister: **Lehmplatten wärmen angenehm. Wandheizung.** aus: Mikado (2011) Nr.3., S. 54 ff. (www.mikado-online.de)

FAQs zur Wandheizung. Aus: IKZ-Haustechnik · Heft 9 /2008, S. 30-34 (http://www.ikz.de/uploads/media/IKZH_200809_1529_Heizungstechnik.pdf)

Fraunhofer-Institut für Bauphysik IBP. IBP-Bericht HTB-19/2010: **Bewertung der hygrothermischen Verhältnisse in verschiedenen Wandkonstruktionen nach der Sanierung mit einem diffusionsoffenen Wandheizungssystem.** (www.energiewerkstatt-rn.de/ download/Fraunhofer_Bewertung-zur-ClimateWall.pdf)

Freytag, Michaela: **Wandheizung im Lehmputz. Wandflächenheizung in Lehm auf Fachwerk.** Aus: Bauhandwerk 34(2012)Nr.6, (www.bauhandwerk.de)

Hartmann, Frank: **Hohe Energieeffizienz und thermische Behaglichkeit. Maßnahmen und Auswirkungen zur Integration einer Trockenbau-Wandflächenheizung in ein bestehendes Heizkörpersystem.** Aus: IKZ Haustechnik, Magazin für Gebäude- und Energietechnik 63(2010)Nr.5, S.106-108 (www.ikz.de)

IBN, **Institut für Baubiologie und Ökologie, Lehrheft 8** (Heizungsinstallation), 2013, S. 50 f. (http://www.baubiologie.de/site/fernlehrgang/lehrhefte.php)

Lukas, Bruno: **Erneuerung der zentralen OP-Abteilung im Marien-Hospital Marl.** Aus: Moderne Gebäudetechnik, Jg.: 66, Nr.7/8, 2012 (www.tga-praxis.de)

Lukas, Bruno: **Eine Kindertageskrippe mit ÖKO-Modellcharakter. Mit Holzbauweise, Wärmepumpe und Wandheizung mit Lehmputz.** Aus: RE Regenerative Energien (2010)Nr.2, S.25-27 (www.tab.de)

Meier, Claus: **Richtig heizen - 14 Fragen und Antworten.** Aus: Deutsche Burgenvereinigung, Praxis Ratgeber Nr. 11 – September 2009 (www.deutsche-burgen.org/pdf/nr11.pdf)

Menzinger, Wolfgang; Dick, Georg: **391 qm warme Wände. Bausubstanz schützen und Nutzerkomfort erhöhen.** Aus: sbz Sanitär-, Heizungs-, Klima- und Klempnertechnik 64(2009)Nr.15/16, S.32-35 (www.sbz-online.de)

Meurer, Gerd: **Wandheizung im Denkmal - bauwerkserhaltend und angenehm.** Aus: Restaurator im Handwerk (2011)Nr.3, S.39-41 (www.restaurator-im-handwerk.de)

Plate, Joachim: **Mit Flächenheizungen sanieren. Verband versorgt Handwerk mit Informationen.** SBZ Sanitär. Heizung. Klima. Aus: Nr.9, 2012 (www.sbz-online.de)

Schwan, Christoph, **Die Temperierung**, (www.termosfassade.info, dort unter „Forum“)

Stahl, Ulrich; Frieling, Werner; Falk, Manfred; Plate, Joachim: **Mit neuem Schwung in Richtung Altbau. Flächenheizungen und Flächenkühlungen.** Aus: IKZ Fachplaner 3(2008)Nr.2, S.22-24 (www.ikz.de)

Teders, Klaus: **Schutz der Bausubstanz mit Wandheizungen.** Aus: Deutsches Ingenieurblatt 17(2010)Nr.3, S.58-59 (http://dib.schiele-schoen.de)

Supplier list based on internet research

(no claim for completeness)

www.climate-wall.de
www.harreither.com
www.joco.de
www.kaelberer-heizsysteme.de
www.kermi.de
www.lenz.ch
www.mair-heiztechnik.de
www.naturbo-lehmputz-lehmbauplatten.de
www.rossatogroup.com
www.schnauer.at
www.simplex-armaturen.de
www.thermoglobe.de
www.uponor.de
www.variotherm.at
www.viega.com (Viega)
http://vikersonn.de/wandheizung
www.wandheizung.de (WEM)
www.wandheizungsmodul.de (Sanha)
www.wieland-cuprotherm.de

Building-biological Assessment of Heating Methods

source: IBN, Institute of Building Biology + Ecology Neubeuern, 2013

Nr.	Bewertungskriterien	Offener Kamin [2] 4.2 a [3]	Kaminofen (Strahlung) 4.2 c	Kachel-/ Grundofen [4] 4.2 d	Elektrohzg. (Speicher) 4.3	Fußboden-heizung 4.4.4 a	Radiator 4.4.3 a	Platten-heizkörper 4.4.3 b	Fußleisten-heizung 4.4.5	Wand-heizung 4.4.4 c	Warmluft-heizung 4.4.6
1	Strahlung*	3	2	3	1-2	1-2	1	2	2	3	0
2	Konvektion/Luftzirkulation	1	2	2	0-2	1	1	2	1-2	3	0
3	Lufttemperatur-Unterschiede*	0-2	2	3	0-2	1-2	1	2	2-3	3	1
4	Wandtemperatur	2	2	2	1-2	1	1	1	3	3	1
5	Heizkörper-Temperatur	1-2	1-2	3	1-2	2	2	2	2	3	1
6	Luftqualität/Geruch	1-2	1-3	2-3	0-2	1-2	1-2	1-2	1-2	3	0
7	Luftfeuchte	2	1-2	2-3	0-2	3	1	2	2	3	0
8	Ionisation	3	2	2	0	2	1	2	2	2	0
9	Elektrische/magnetische Felder	3	2	2-3	0	2	1	1-2	2	2	2
10	Lärm/Hellhörigkeit	3	3	3	1-3	3	2	2	2	2	1
11	Reinigung/Entstaubung	0-2	2	2	1	3	2	1-3	1	3	0
12	Trägheit/Aufheizzeit	2	2-3	1-3	1-2	1	2	2	2	1-2	3
13	Bedienung/Komfort	1	2	2	3	3	3	3	3	3	3
14	Regelbarkeit	1	1	1	1-2	1	2	2	2	2	3
15	Kosten/Nutzen	2	3	2	1	2	1	2	2	2	1
16	Umweltbelastung*	0	1-2	2	0-2	2	2	2	2	2	2
17	Ökobilanz der Materialien	2-3	1	2-3	1	0-2	1	1	1	0-2	1
	Punkte-Bewertung**	**30-39**	**35-42**	**44-50**	**14-33**	**33-37**	**29-30**	**36-40**	**38-42**	**48-51**	**22**
	Gesamtnote	**2**	**2**	**3**	**1**	**2**	**2**	**2**	**2**	**3**	**1**

* *Doppelte Bewertung*
** *max. mögliche Punktzahl: 60*

0 = erhebliche Mängel
1 = bedenklich
2 = befriedigend
3 = gut/empfehlenswert

1) *Verschiedene Punktzahlen (z.B. 1-2) sind durch unterschiedliche Konstruktionen/Bauweisen/Materialien/Brennstoffe bzw. Rahmenbedingungen (Vorlauftemperatur, Aufstellungsort, Wärmebedarf u.a.) begründet*
2) *Nur als Zusatzheizung geeignet*
3) *Kapitelnummer*
4) *echter Kachel-/Grundofen (ohne Warmluftauslässe)*

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Baltic Sea Region
Programme 2007-2013

Part-financed by the
European Union
(European Region
Development Fund)

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