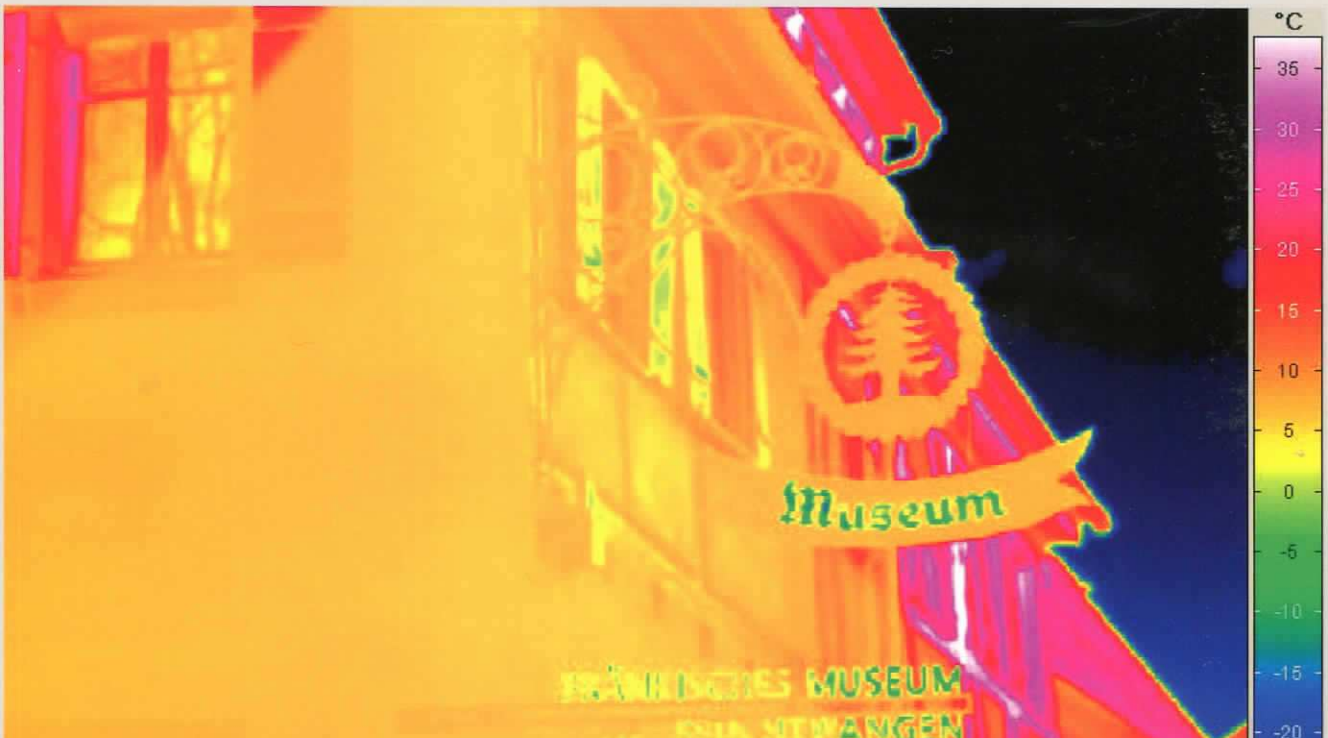
Inhalte – Projekte – Dokumentationen

Die Temperierung

Beiträge zum aktuellen Forschungsstand



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Inhalt

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The case of Italy: Energy efficiency and preservation – Two challenges for Temperierung

This paper presents some Italian experiences of Temperierung which has been implemented in selected case studies with the aim of warming an existing building and to obtain a proper architectural outcome. Temperierung may meet several needs within the building conservation process. It is suitable to favour the preservation of buildings and artwork in a museum and it may also supply a comfortable environment to people. The environmental behaviour of buildings has always been a topic in the history of architectural design. A strict connection can be found between the building construction and the technical devices, as it has been shown in several 19th century buildings. Additionally, building features such as envelope, construction materials or other arrangements can improve and remarkably increase the indoor environment and comfort.

Temperierung has been tested in Northern Italy since the early 1990s. In the following, the installation of this system in several historical palaces in 2002 (Palazzo Pallavicino in Cremona) and in 2006 (Palazzo Viani Dugnani in Pallanza, housing today the local Landscape Museum) will be discussed and compared. In 2007, a Temperierung was also installed in the small church Santo Stefano Oratory in Lentate sul Seveso where the indoor climate was monitored for one year.

Based on these experiences, the article presents the resulting measurements and further highlights the developments of the design assessment of the devices as well as the monitoring strategy.

A historical architectural concept – between comfort and construction

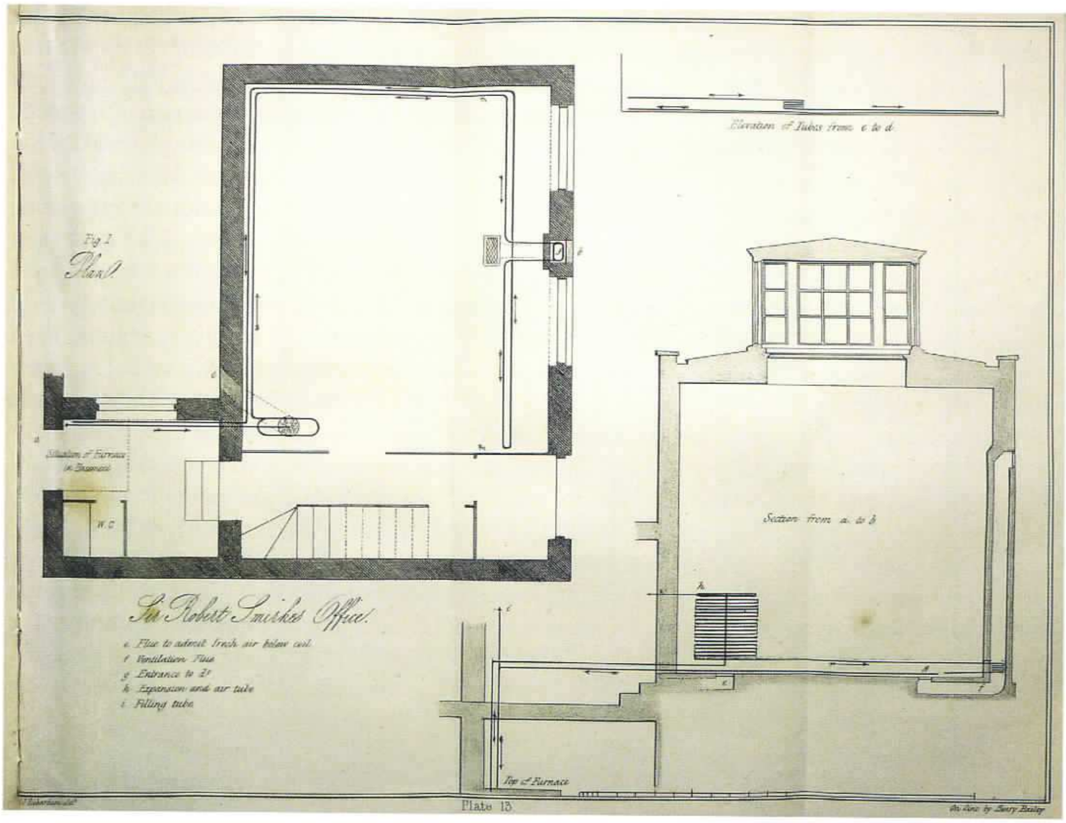
Buildings have always been built by taking into consideration environmental issues, including hard conditions like those in Northern climates or in very cold climate of the Little Ice Age (16th –17th century). Orientation, construction features, the use of materials, the connection to the surrounding built environment, the distribution of rooms and their use were taken into account in order to meet the requirements of comfort. With their sophisticated climate control systems, La Zisa in Palermo or the Trento Villas in Costozza are successful examples of how the outdoor environment was balanced with architectural features in history. Nevertheless, these buildings only represent the most studied, the well-known and therefore probably the most successful cases. But it is likely that similar solutions were also widespread in many other buildings.

Against this background, a historical analysis of buildings has always been carried out when understanding and analysing the environmental behaviour in the building. At the same time, it can help the design and installation of new plants by also taking into account the environmental behaviour recognized.

At the beginning of the 19th century, the rise of new needs in terms of comfort to be faced and the unexpected possibilities allowed by the use of new materials (glass, iron, even bricks) resulted in the development of new construction techniques. At the same time, the design of building services and central heating systems started. Most of the engineers and technicians involved are still unknown. However, there is now an increasing interest in studies on architects who led this innovation process. Among them are Charles Barry (1795–1860) and Robert Smirke (1780–1867) in England, Henri Labrouste (1801–1875) and Léon Vaudoyer (1803–1872) in France or Ludwig Förster (1797–1863) and Karl Ludwig Engel (1778–1840) in the German-speaking countries who designed buildings in which technical aspects played a key-role in the whole construction.[1]

According to the British architect and architecture historian Dean Hawkes, John Soane (1753–1837) was one of the earliest architects who paid attention to technical devices in building design: "But even more authoritative than these documents is the evidence of his practical application of new system of warming into designs for buildings from as early the steam heating installation at Tyringham House that was completed in 1797. [...] In the forty-five years that Soane lived in Lincoln's Inn Fields, he seems to have almost continuously experimented with all conceivable methods of heating encompassing stoves, fireplaces and three of central heating installation using, in turn, steam, warmed air and hot water as the heating medium".[2] Besides his most famous examples in London, the Dulwich Picture Gallery, the Bank of England, and Soane's own house (now a museum), further installations are described in a book by Charles James Richardson, a pupil of Soane.[3] In this, several installations of the Perkins' system, a hot water high-pressure system invented by a family of inventors and entrepreneurs which was patented in 1831, are presented. Piping circuits made of iron were usually placed around windows, doors or entrance halls in order to compensate heat losses. In some plants, pipes were fitted in a coil, placed in front of the fireplace or under a windows, shaping almost like a radiator or a kind of stove filled with warm water such as in the reading room of the British Library by Robert Smirke (fig. 1).

Perkins' patent was extremely successful when considering that it was even installed in the Houses of Parliament



1. Robert Smirke's Office with a Perkins system (Picture: Ch.J. Richardson „A popular Treatise on warming and ventilation", London, 1837)

in London. Since then hot water heating had spread throughout Europe and the United States. The Italian treatise on Perkins showed exactly the principles of the system.[4] It was meant to be used for agricultural applications, especially in greenhouses. In the mid-19th century in Italy, however, such a system was mainly installed in silk mills to create a warm environment that was needed for the growth of silkworms.

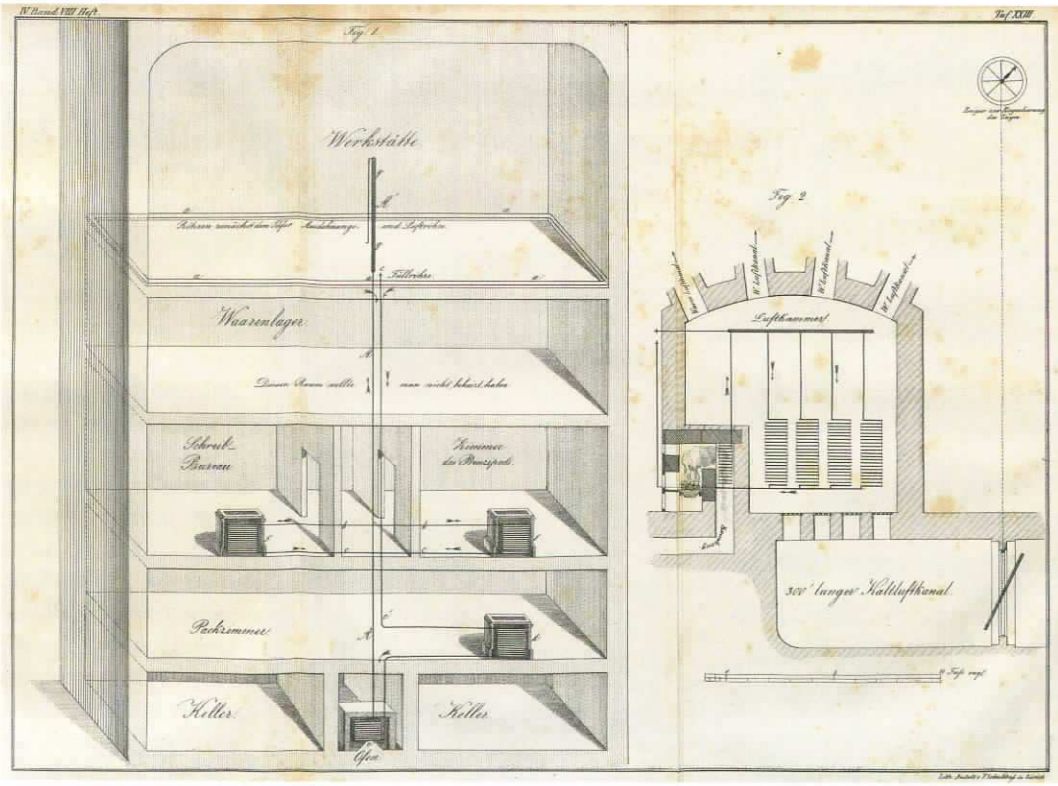
Perkins' heating system has become well-known thanks to the literature starting to disseminate and popularise scientific matters in order to answer practical issues. To give an example, the German publication *Zeitschrift für das gesamte Bauwesen* outlined the system with flattering words: „[...] das neueste Heißwasser-System, wie es Herr A.M. Perkins eingeführt hat, das taugliche, das tauglichste und das am besten geeignete, und das bisher gefühlte Mangelhafte zu beseitigen, da dasselbe die größten Erfordernisse, wie Solidität, Nutzen, Einfachheit, Dauer und Wohlfeilheit, in sich vereinigt und mit Sicherheit und Leichtigkeit allen neuen und älteren Lokalitäten angepasst werden kann"[5] (fig. 2). Further, Louis Audot, a celebrated author and publisher also working on conservatories, stated in the *Pratique de l'art de chauffer par le thermosiphon* in 1844: „Nous dirons donc aux personnes [...] qu'indépendamment des ingénieurs, auxquels on doit l'application de la science à l'art de chauffer les habitations, il existe aussi des constructeurs qui ont su mettre en pratique les leçons des savant."[6]

Hot water heating systems were not something absolutely new, at least since Jean Simon Bonnemain in France had carried on experiments on a chicken farming around 1777. In England, Jean Baptiste Chabannes established a company installing heating and ventilation systems in the House of Commons and the Covent Garden Theatre, among others. However, a deeper connection between architectural structure and devices can be recognized in this period. Half a century later, Henri Labrouste designed and built the Sainte Geneviève Library (opened 1851) and the new reading room of the National Library in Paris (achieved following Labrouste's design after his death). Both of them were well studied with respect to indoor climate control: the building shells were composed with overlapping layers of thick materials: stones, wooden bookcases and even books which limit the heat loss towards the outside. Furthermore, it has to be remarked that heating systems were designed to supply only a little amount of power (the required temperature was only 15 °C).

Looking at the past, looking for energy efficiency

Many building restorations were carried out in Italy since the beginning of the 1990s by taking into consideration the preservation of historical building features. This approach also involved the installation of new building devices to guarantee the usability of an old building in regard to modern standards and comfort requirements.

The problem of supplying water, artificial heat and light and of removing waste and sewage, in other words, the problem which can now be solved by connecting a building to the grid, was once solved by specific building features (masonry thickness, windows dimension, material choice, and most of all, a different use of spaces) rather than by specific technical plants. The same should



2. Perkins' Heating System (as shown in Zeitschrift für das gesamte Bauwesen, 1840)

be achieved today with a building restoration. In fact, to arrange new needs also implies to install new devices, grids and plants at the expense of the historical built fabric. These new technical plants may be seen as controversial to the conservative aim of the most advanced building restoration practice. Some attempts can be made to minimize the impact of new technical plants on the ancient structure. In general, the plants should be considered as a new layer of the multi-stratified structure of each historic building and, therefore, they should be installed in order to maintain the layers below. Heating systems, water supply, and fire fighting may be designed consequently. This approach described is widely acknowledged in building conservation and has already been challenged in designing technical systems. Moreover, the new technical plants may be designed with the purpose to exploit and empower the original building features and materials, such as the thermal inertia of the traditional masonry.

The Temperierung system that was installed in the Palazzo Cattaneo in Cremona in 1996 was probably the first in Italy. Palazzo Cattaneo is a precious and very well preserved 18th century palace with well-preserved historic surfaces, floors, stucco and fresco decorations as well as with a historical hot air heating system. During refurbishment this historic device was maintained and coupled with a new Temperierung system consisting of copper pipes which circulate hot water into the still unheated rooms such as corridors, hallways, gangways, passages and lobbies. Similarly to the 19th century warming systems, the palace was equipped with pipes circuits for hot water run alongside the walls, trying to establish a constructive relationship between building components (including building envelope), construction materials and building services.

Another example for a Temperierung system being installed is the Palazzo Pallavicino. This large building, which originally consisted of a group of little gothic houses being changed between the 14th and 18th century, is now a wide two-storey building surrounded by two courtyards. It was abandoned for decades and consequently decayed when it was chosen at the end of the 1990s to house a music school, a small museum and a school for the conservation of old musical instruments, particularly strings.[7] Wood preservation and didactic purposes thus require to be strictly connected with an intensive use and with a stable and constant indoor climate. During restoration the Palazzo was equipped with a Temperierung system in 2006. Unlike to the Palazzo Cattaneo, the internal plasters and mural paintings were in a poor state of conservation. For this reason, it was not necessary that Temperierung was used to preserve the original wall surface. On the contrary, it was possible to increase the thermal efficiency of the system by considering the results in terms of heating which were experimented a few years ago. The layout of the system consists of four lines of copper pipes circulating hot water. The pipes run into the thickness of a plaster over-layer on the existing walls. At the base of the walls an empty duct carved out from the plaster houses electric wiring and devices. Double windows and thermal insulation in the attic were added to limit heat losses and reduce the heating loads.

A similar layout was designed for the Temperierung in the Museo del Paesaggio (Landscape Museum), which has been housed in the Palazzo Viani Dugnani in Pallanza since 1914 (fig. 3, 4, 5). Built in the 18th century this former summer dwelling of a wealthy Milanese family now hosts a rich collection of archaeological findings of ancient local civilizations as well as of regional 19th century paintings. The main requirement was to install a heating system that allows the museum to be visited in wintertime while at the same time mitigates risks for the artworks through the change of indoor climate. This is because the paintings were not affected by the cold climate in winter and were used to these conditions for years. In this case, Temperierung was chosen for the following reasons: Radiant heating does not relevantly influence the water content of the indoor air and does not even affect RH gradients, since the air is not troubled by convection.[8] Furthermore, Temperierung has often been thought as a good solution to avoid paintings from being affected by thermal gradients between the indoor environment and the external walls.

Therefore, a new chalk plaster baseboard was designed in 2009 to cover the three lines of copper pipes. Cables and electrical wiring run into a cavity below the plaster skirting. The lack of thermal insulation has shown to be critical in the case of Palazzo Pallavicino due to relevant heat loss. To eliminate this kind of problem in Palazzo Viani Dugnani, wood fibre panels were added behind the pipes under the windows where the walls are thinner.[9]

Temperierung to prevent

The Oratorio di Santo Stefano in Lentate is a well-monitored case study of a building equipped with Temperierung. This chapel was built near Milan in the 14th century as a mausoleum of the noble Porro family. The structure is an example of a one-room gentilitial oratory which is widespread over Northern Italy such as the best-known Cappella degli Scrovegni in Padua with frescos by Giotto.[10] The masonry is made of bricks and stones of various sizes and the wall sections are not homogeneous. Some parts probably consist of a multi-leaf masonry, built with a more regular external layer (more bricks than stones), and an internal layer made of mortar and aggregate stones. These different loading conditions, typologies of the mortar joints and stone types must be considered both from the structural and thermal point of view.

The indoor climate of the building was analysed by three measuring campaigns before, during and after the restoration. The first campaign (1986–1992) monitored air T and RH and also included the surface temperatures of the northern and southern inner walls. Indoor temperature presented minor variations, and fell rarely lower than 0 °C while RH was over 65 % only in summertime. Mixing Ratio never differed much from external values. The gravimetric method was employed to determine the moisture content of the masonry. Measures were performed at different levels on the floor, and up to 10 cm in depth. Moisture content values were up to 7,5 % in the northern and southern wall, being particularly high at a height of 4 meters from the floor. Thus, water was driven into the walls because of rising damp and percolation from the leaking roof.

Another campaign analysed the climatic behaviour of the building in 2003 just before the most recent restoration.[11] Thermal imaging was employed to detect the surface temperatures and to analyse water leakages, infiltrations and rising damp. The indoor temperature and humidity gradients were also mapped using a digital psychrometer composed of two coupled thermometers (measuring dry-bulb and wet-bulb temperature). Thermographic surveys showed cold areas both on the northern and southern walls. On the southern wall they occured because of the solar radiation and the cold floor, with low values of rising damp. On the northern wall, high rising damp appeared because of gravimetric samples of moisture content (up to 10 %). RH values remained above 60 % average, rising over 75 % between April and May. Surface temperature was not homogeneous. The main damages of frescoes were noticed corresponding



3, 4, 5. Pallanza, Palazzo Viani Dugnani. Building sites (left, middle), Plaster base, pipes running alongside walls (right)
(Pictures: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)

to the coldest areas. The restoration project took these items seriously into account: first, the roof was repaired; second, an obstructed ventilation duct running under the floor was reactivated.[12] Following the path of restoration works, a Temperierung system was installed in 2007 (fig. 6) in order to control the indoor climate and to reduce the risk of condensation.[13] Since the fresco decorated plaster was lost at the bottom part of the internal walls (approx. up to 10 cm above the floor) due to rising damp and condensation, it was possible to install a single copper pipe (18 mm in diameter) at the base of the walls under the surface where the historic plaster was lost. Hot water is provided by two electric boilers placed in a service room which adjust the water temperature following climate variations.

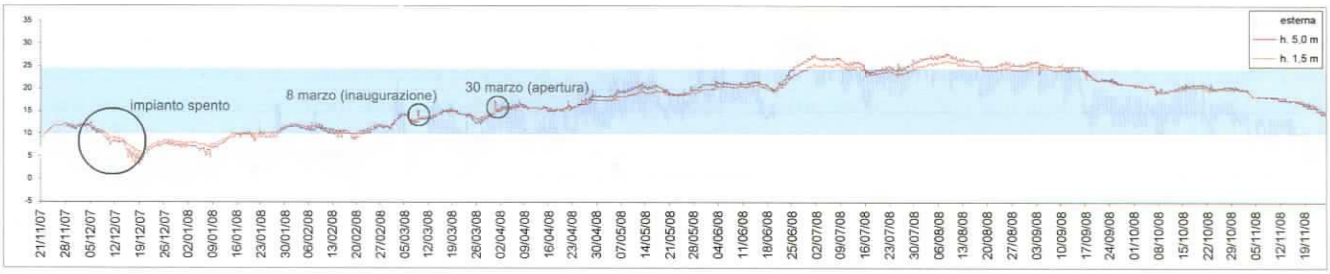
In this case, the implementation of Temperierung was mainly intended to be a device for preventive conservation as it is implemented to reduce the risk of condensation on the colder part of the wall surface. Its function as a heating system, which may slightly improve the indoor comfort during wintertime, is secondary.

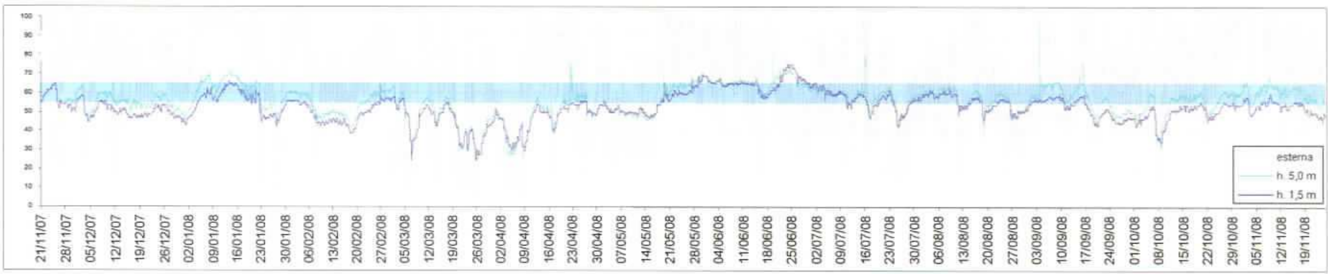
After the intervention, a continuous monitoring was running for two-years including thermographic and psychrometric surveys (fig. 7, 8, 9, 10, 11, 12). This monitoring campaign, which was carried out with the same instruments used in 2003 for better comparability, aimed at finding out the effectiveness of Temperierung to reduce the risk of local condensation and its influence on the indoor hygrothermal parameters. The latter was particularly important because the building had been suffering from rising damp and water infiltration for a long time, leading to the presumption of still having damp walls even after restoration. An improper warming of the indoor air would have favoured the sudden drying of the walls and consequently a massive salt migration. Considering the completion of the restoration of the mural paintings, this had to be carefully avoided.

The monitoring campaign started in November 2007, 24 hours before the Temperierung system was switched on. T and RH hourly measurements were compared with the psychrometric and thermographic maps. Psychrometric surveys were managed both in plan and cross sections alongside walls to analyse the T, RH and MR distribution inside the building. Measurements were carried out daily during the first week, then monthly, and were then regularly repeated every two months. The results clearly show that the effects of the warming from Temperierung only affect the lower parts of the walls near the floor (fig. 10). The temperature on the plaster surface ranges up to 33 °C next to the path of the pipe (35–50 cm above the floor), whereas the temperature of the upper part of the walls is not directly influenced by the system. This finding confirms the positive consequences of such a system in terms of preventing condensation, since the lower masonry may easily be affected by the risks of water condensing.

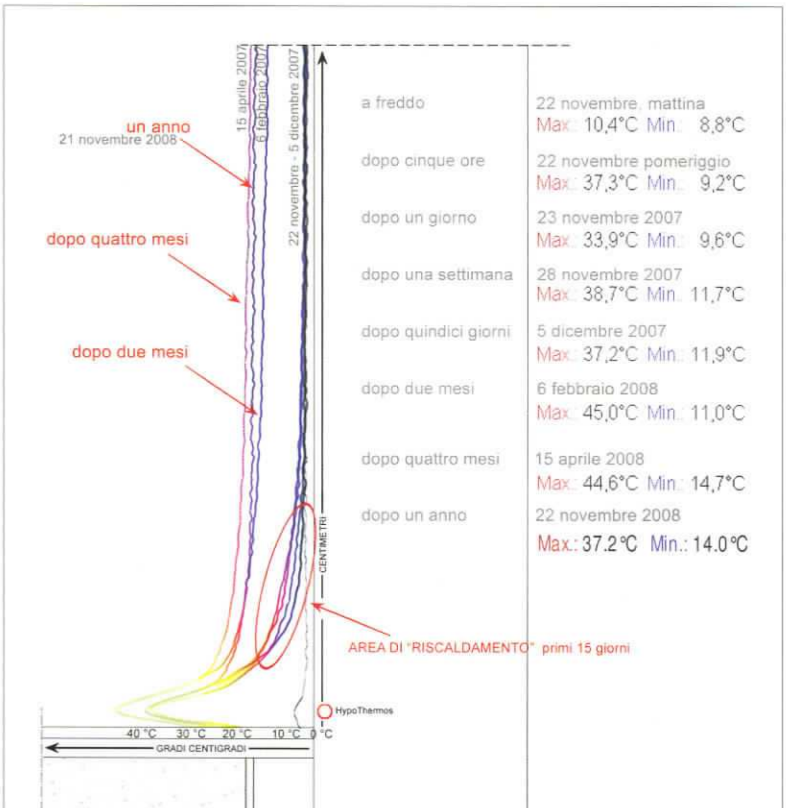
On the other hand, data has shown that the indoor climate is less modified. T and RH values do not show sudden

6. Lentate sul Seveso, Oratorio di Santo Stefano. Interior with the pipe circuit highlighted in red (Picture: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)



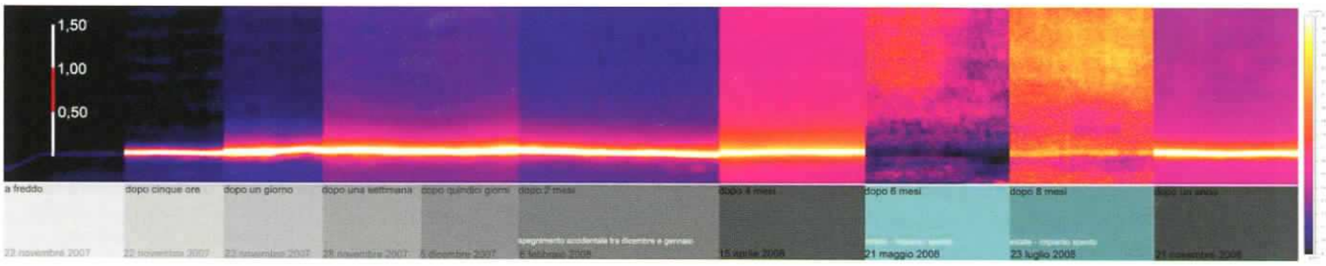


7, 8. Lentate sul Seveso, Oratorio di Santo Stefano. Yearly trend of T, Yearly trend of RH (Pictures: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)



9. Lentate sul Seveso, Oratorio di Santo Stefano. Comparison of surface temperatures on a vertical section throughout a year (Picture: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)

10. Lentate sul Seveso, Oratorio di Santo Stefano. Comparison of thermographic analyses throughout a year (Picture: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)



changes in the moment when the plant is switched on, nor do they differ very much when the system has been working for a long time or during the coldest months of wintertime. It should be noted that only one ring of pipes provides heat (approx. 200 W of power supplied to a room of more than 1000 m^3). Regarding the indoor climate, it was found that the T and RH distribute uniformly in the room, irrespective of whether the system is switched off or on. When switched on, isotherms surveyed at 1,50 m above the floor did not show the air to be heated noticeably nearby the wall surfaces. On the contrary, when the same values (T and RH) are measured alongside the wall surfaces on vertical sections, a thermal gradient is highlighted, ranging from the highest values in the lower part (nearby the pipe), progressively decreasing until the height of one meter, after which the temperature is constant. In any case, thermal gradient is so limited that convection alongside the wall surfaces is avoided.

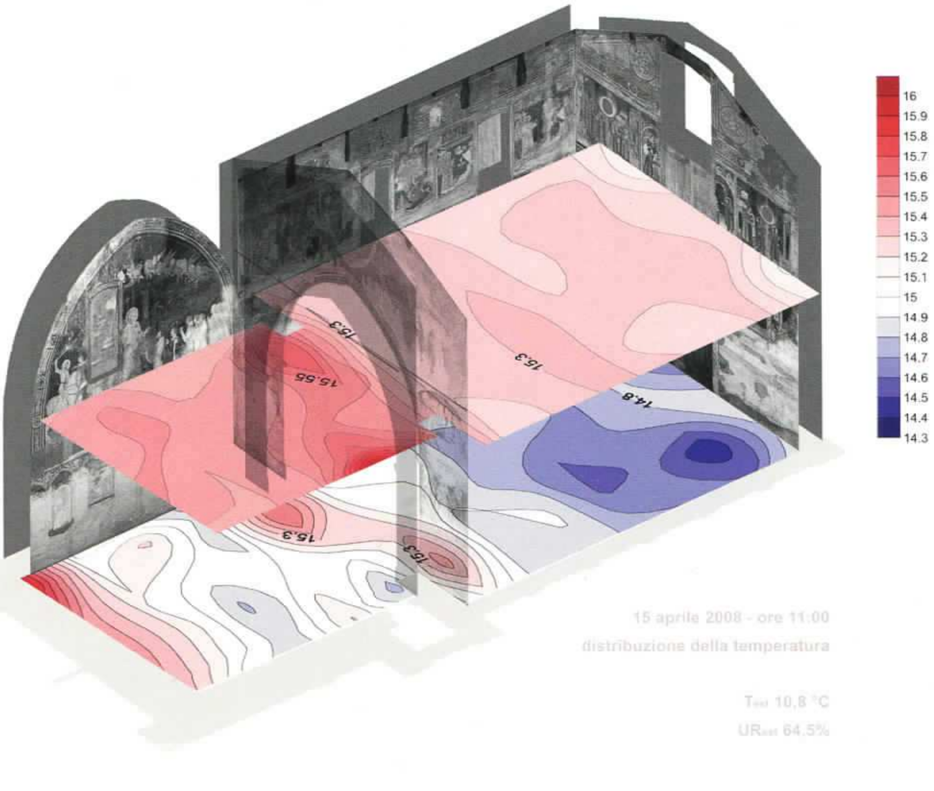
Further results could be obtained through data collection within a one-year period after the Temperierung system was switched on. Indoor RH values were constantly and progressively decreasing (before the installation they were constantly around 65 %). This is probably due to the general drying of the building (effective roof, ventilation channel below the floor.) than to the thermal effect of the Temperierung. Moreover, indoor temperature remained constant within a small range of fluctuations. Thus, lower values of RH would imply lower values of MR, allowing walls working as a kind of "buffering devices" balancing the variation of the indoor climate.

Last but not least, a slow and constant increase in the difference between outdoor and indoor values of T and RH may be read as a consequence of the joint effects of tempering and buffering. More regular and smoothed trends of the indoor parameters may suggest a cushion effect of Temperierung, softening the consequences of the outdoor variation on the indoor climate and, therefore, increasing the thermal inertia of the building shell. Positive effect may therefore be even on humidity: when the temperature is lowering outside, the counteracting action of heat provided by Temperierung may control the rising RH. When the outdoor temperature still stands low, dry walls may slowly soak up increasing moisture due to the slightly indoors lowering temperature. A specific campaign of measurements could be oriented to detect this particular aspect.

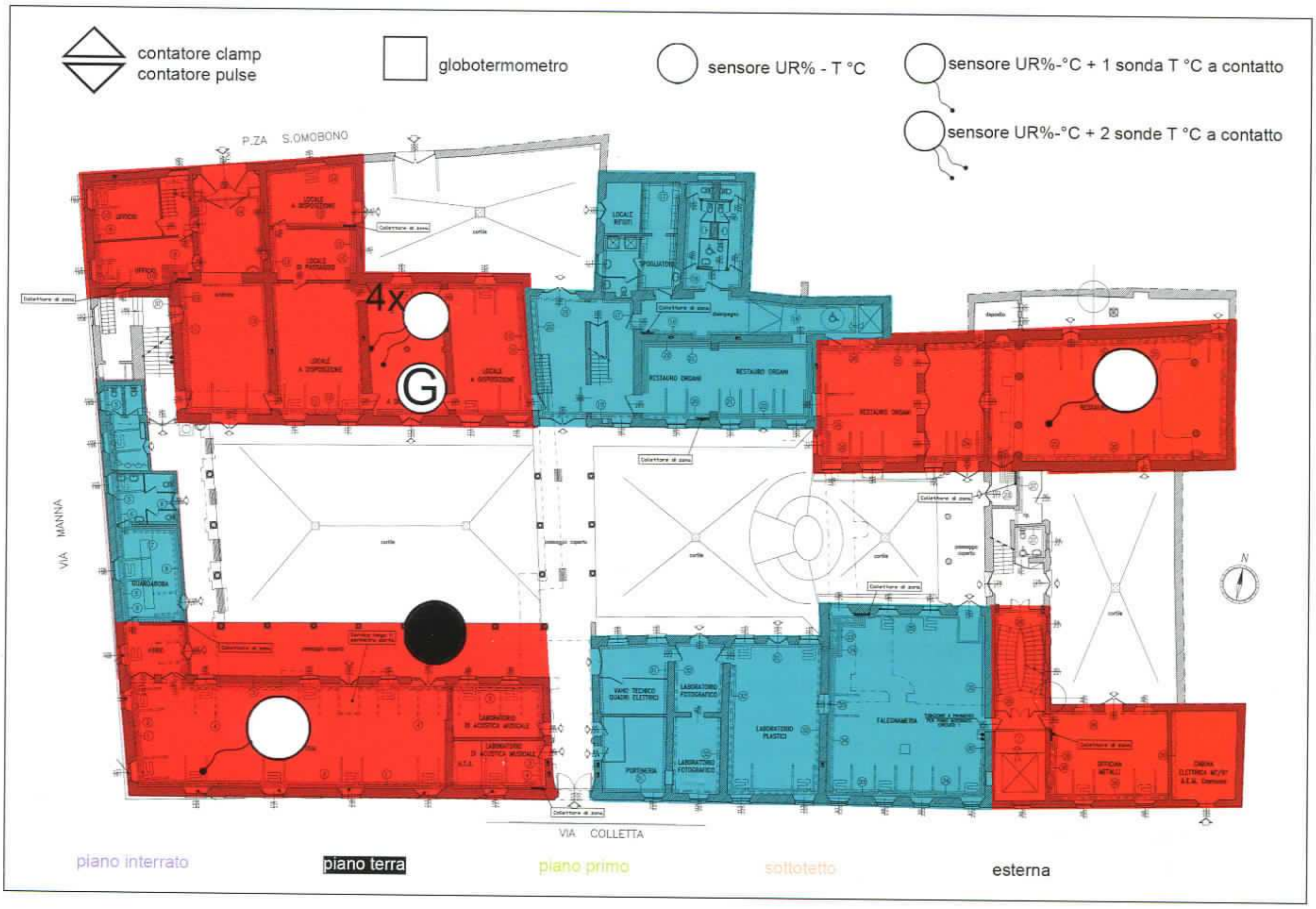
Monitoring to understand

In the effort to clarify open questions about the range of usefulness of Temperierung and to better understanding the issues above mentioned, the system will be assessed more in detail in Palazzo Pallavicino. The following measurement program (fig. 12, 13) aims at looking at the strict interactions between the Temperierung system and the technical features of the envelope and the whole building construction.

Considering the large number of heterogeneous rooms, the Palazzo Pallavicino is a very significant case study in order to understand different behaviour of the system facing various working conditions. Moreover, problems with uncomfortable conditions for users and with regulating the system require an analysis of different recorded climate values. The various construction phases of the building, each one with different construction features, interact with the system



11. Lentate sul Seveso, Oratorio di Santo Stefano. Psycrometric mapping of T at floor-level and about 4 mt above (Picture: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)



12. Cremona, Palazzo Pallavicino. Plan of the proposed monitoring scheme
(Picture: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)

in different ways, thus showing different indoor environments and providing several inputs for the analysis. Aspects of the indoor environment which result in differentiated behaviours are: orientation, thickness and quality of the brick masonry, position compared with other rooms, and width of heat loss areas (including windows and other openings).

The monitoring program is targeted on obtaining a complete description of the rooms laying on a cross-section (from north to south) of the building by continuous measuring T and RH. The rooms in which the monitoring is planned provide enough non-homogeneous features to get a general overlook on the interactions between building and the Temperierung system. Besides environmental sensors for T and RH measurement, probes for measuring surface temperatures (PT100) will be installed on heated walls at different heights: generally one over the plaster on the heating pipe and one above. This configuration will be repeated both on inner and outer walls. It is also planned to measure surface temperatures in correspondence of the pipes on the outdoor surface of the wall so that a rough quantification of the heat loss can be obtained. Additionally, a globe-thermometer will be placed in one room to measure the radiating component of the system and to simultaneously analyse the relation between comfort perceived by users and the operation of the system.

The aspect of energy efficiency will also be taken into account. Therefore, the monitoring system will be equipped with sensors which will measure the power consumptions of the Temperierung in real-time. Furthermore, the monitoring campaign will also include psychrometric mapping and thermographic analysis performed in specific moments and conditions to be coupled and compared with other results. This way it will be possible to describe gradients and discontinuities and to define the influence of the system on the indoor climate and on the comfort of the users.

Discussion and conclusions: Temperierung between building construction and building conservation

After a few preliminary remarks on case studies, some much-debated issues about Temperierung are discussed in the following in order to show its „controversial" usefulness.[14]

Temperierung is not (always) a heating system. It can be installed to work as a heating system, but it has not necessarily been designed for this purpose. For applying and implementing Temperierung it can be said: „Der Ein-

13. Cremona, Palazzo Pallavicino. Section of the proposed monitoring scheme
(Picture: Laboratorio di Analisi e Diagnostica del Costruito, Politecnico di Milano)

satz der Temperierung wird vor allem begrenzt durch die thermische Speicherfähigkeit eines Gebäudes (Raumtemperierung) und die Größe eines lokalen Schadbildes (Bauteiltemperierung). Die Arbeit sieht als Hauptziel der Bauteiltemperierung den lokalen Bautenschutz, der Grundtemperierung den Bautenschutz gesamter Räume/Gebäude und der Raumtemperierung die Raumnutzung.“[15] Based on this, a scale of different types and degrees of Temperierung can be outlined, from a simple, easy circuit running throughout the external masonry (as in the case of Lentate) up to sophisticated installations integrating different purposes such as artwork preservation and comfort requirements. If *Grundtemperierung* may be considered a basic intervention and the least invasive on existing buildings, a complete heating system represents the highest and most complicated level. Additionally, it should be noticed that good results can be obtained by using Temperierung as a radiant heating and that, if thermal insulation is properly designed and thermal bridges are avoided, considerable energy savings can be achieved.

In the *note from the editors,* published in one of the standard references about Temperierung, it is discusses that, among many ambiguities caused by the different characteristics of the Italian case studies, Temperierung can counterbalance heat losses throughout the building envelope.[16] The authors claim that it “does not heat spaces but rather isolates them thermally from the outside.”[17] Here a misunderstanding about energy saving is apparent since compensation of heat losses does not mean a better insulation from outside. Based on the experiences that have been gained over time, the pros and cons of the system are emphasized in German literature, especially by Großeschmidt and Künzel, which is summarised in the following:

1. Wärmestrom versus Wärmestau

Großeschmidt, when comparing the effects of Temperierung with those of an air heating systems, hints at the “U-value in the formula for transmission heat loss, which is actually a function of the wall's humidity”.[18] Regarding the supposed increase of thermal resistance which was confirmed by simulations[19] it is clear, that the heat released to the wall thickness generates thermal flows and consequently, if not blocked by insulation, causes heat losses towards outside. However, this calculation has failed to consider two important variables: time and thermal storage in the walls, which is function of the mass. After being heated, the wall remains warm for a certain period of time, still releasing heat mainly to the inner part and to the indoor environment. Such a mechanism should be measured by *in situ* monitoring campaigns.

2. Formation of water alongside the lower parts of walls
Rising damp can hardly be avoided by a Temperierung system: a drier wall will draw more humidity from the ground. Rising dump must be somehow blocked at the origin and it cannot be avoided if there is an active moisture source in the lower part of the walls. On the contrary, a warmer surface can avoid temperature from falling close to the dew point ensuring a safer behaviour as regards to condensation.

3. Coanda effect
Großeschmidt describes a boundary layer convection enhancing the wall heating, and, potentially, the insulation of the indoor environment. Künzel points out that, being the walls vertical, a slightly convection upwards is obviously originated along the surface. It must be explicitly mentioned that monitoring instruments can hardly detect such an effect due to the very slow movement of the air.

4. Radiant effect
Großeschmidt claims that with Temperierung it is better exploited than in any other system. Künzel disagrees, arguing that radiation generates always the same results, either from the floor, from the ceiling or from the walls: „dies ist keine Besonderheit der hier vorgestellten Temperierung“.[20] Of course, heat radiation works always in the same way. Nevertheless, the radiant effect that can be felt depends on the distance of the body receiving the radiation from the surface that releases the heat. In other words, bodies feel a higher or lower radiant effect, depending from the room width, and from their loss of heat towards cold surfaces.

Finally, the economic side has to be taken into account. The buildings, which were considered as case studies, were not heated at all or were only slightly heated before being equipped with a Temperierung system. It is clear that in these conditions it is impossible to have a comparison based on real data. Also differences in consumptions and efficiency with other systems (hot air, radiators, floor heating, etc.) can only be supposed. The Swedish Salsta Castle, demonstrating low consumption values in a building heated by Temperierung in comparison with another equipped with radiators, is still the only reference and is not yet repeated with other measurement campaigns.[21]

Further considerations can be made on building features and on our knowledge of these features. Describing today the behaviour of an historic building using contemporary calculation tools is a difficult task. First of all we need to understand how the building was meant to work in the past, being it built with pre-industrial materials and under different requirements and standards. A series of typical environmental mechanisms of historic buildings can be considered: thermal inertia of masonry, capability of heat accumulation, shape and positioning of openings, distribution, and orientation. It must be said that a lower level of light, heat and comfort was generally requested to buildings in the past: the traditional know-how of historic builders could provide them without technical services.

In conclusion we can state that Temperierung can be an effective tool within the building conservation process. Several different issues should be taken into account when deciding how to change the environmental conditions within a heritage building: first of all, the preservation of the architectural substance and materials (which could be affected both by the physical impact of building services, and by changes in the indoor climate) must be considered, but also the comfort requirements, and in case of museums, the environmental conditions for artwork preservation. From the point of view of recent theories of conservation, the installation of a Temperierung system within a heritage building could be controversial as well, when considering principles like the minimum intervention or the reversibility of the intervention.

Nevertheless, almost any kind of installation of climate control systems in a historic building implies invasive interventions: even the simple addition of thermal insulation to improve the passive performance and avoid thermal bridges could be unacceptable. On the other hand it must be underlined that a Temperierung system should enhance the general environmental mechanisms of historic buildings without modifying too much their behaviour. Even if the hygrothermal conditions can become different after installing the system, the interaction between the building envelope and the indoor environment remains unchanged and the mechanism by which the building will continue to influence the environmental conditions will be more or less the same.

The experience made with Temperierung over the recent years has revealed that it is not a “miracle solution” to any possible problem. But compared with other systems it has shown to be suitable for exploiting some peculiar features of historic buildings, such as the thermal inertia of the walls and their humidity buffering capacities. Nevertheless, more data and more analyses are required.

Most of all, referring to some considerations from the first part of this article, Temperierung represents a strong architectural concept which can provide very good results when applied in building conservation interventions. Once again the case of Palazzo Pallavicino is a good example: the addition of a new plaster layer for the copper pipes to the old decayed walls can be seen as a choice of design and renovation which exemplifies the idea of building conservation being understood as an re-interpretation of the historic building for contemporary use. Rather than being the reason for irreparable losses of historic substance, the installation of a new heating system is a good way to add a strong, recognisable and at the same time harmonious sign of a contemporary intervention to a historic building: „not only the artistic and art-historical display value of historical buildings but, also, the original structure and substance of these buildings must be retained [...] on the other hand, the electrical and hydraulic utilities installed in buildings demonstrate the most important cultural representations of our times compared to the past; thus contemporary users of a building must take visible responsibility for the consequences“.[22]

Endnotes

1 Hawkes 2012.
2 Hawkes 2009, pp. 5–6.
3 Richardson 1837.
4 Saint Martin 1839.
5 Strickler 1840, p. 285.
6 Audot 1844, pp. VI–VII.
7 Grimoldi 2013.
8 Holmberg 2004, p. 100–101.
9 Grimoldi/Manfredi 2010.
10 Galli Michero 2007.
11 Rosina 2007.
12 Pracchi 2007.
13 Ibid.
14 Kilian 2011, p. 72.
15 Löther 2005, p. 101. Löther considerations were confirmed by Künzel 2009 and by Löther and Freytag 2007.
16 Kippes 2004.
17 Ibid., p. 8.
18 Grosseschmidt 2004, p. 25.
19 Krus/Kilian 2011.
20 Künzel 2009, pp. 82–83.
21 Holmberg 2004.
22 Becker 2004, p. 424.