Elin Dahlin (ed.)
NILU – Norwegian Institute for Air Research

Cultural Heritage Preservation

EWCHP–2012
Proceedings of the 2nd European Workshop on Cultural Heritage Preservation

Kjeller, Norway
24th – 26th September, 2012
Heating regimes in old Swedish churches, c. 1880-1980

Mattias Legnér1, Mia Geijer2

ABSTRACT
The paper will highlight the use of heating regimes throughout the twentieth century both in large cathedrals and rural churches of medieval origin in Sweden. How have norms of thermal comfort been balanced against conservation needs of the buildings, their interiors and valuable objects? The choice of heating regime in an old church can be seen as a negotiation between different stakeholders. Together these voices have been articulating a discourse on indoor climate since the late nineteenth century when churches in Sweden were first heated.

The historical indoor climate in churches is poorly known but often referred to in discussions on what kind of heating and climate is suitable for interiors and their artifacts. This is why it is important to collect empirically based knowledge on the features of the past climate. The historical indoor climate is shaped by several factors. Here we look at heating regimes, meaning how heating and ventilation systems have been selected, designed and used.

By studying decision making regarding the choice of regimes and also what experience was drawn from the application of technology we will better understand the priorities made between comfort and conservation aims and how scientific knowledge has been used (or not used) to reach these aims.

Keywords
Churches; conservation; heating regimes; ventilation; historical indoor climate; energy consumption

1. Introduction
Old stone churches in Sweden were, despite the cold winters of the region, evidently not built to be heated. Before the nineteenth century heat sources were generally confined to residential structures, whereas buildings that were used little were left cold. Heat for thermal comfort, as opposed to cooking or washing for which fire was necessary, was for a very long time considered a luxury since fuel was expensive. Also in the course of the twentieth century there have been shifting attitudes to the need of thermal comfort in churches [1]. As we shall see, the attitude of the church has historically been that some heat was necessary for the preservation of valuables in the church, and to protect the well being of the priest. In general it was considered sufficient to heat the vestry and not the whole building.

In Sweden, the idea of heating the nave was not widely accepted before the late 19th century. At this time a debate on the need for improved hygiene in public venues developed. Heating churches would decrease the risk for spreading illness when parishioners gathered for sermon. Cold churches, instead, were thought to make individuals more susceptible to diseases and would promote epidemics. In short, efforts to improve public hygiene developed alongside with technical devices for space heating.

2. Early regulation of heating
The need for technical installations had already in the late 19th century become so pressing that they could not be kept outside the churches. In his 1887 manual on church building, Helgo Zettervall, head of the Board of Public Works and Buildings, argued that heat should only be used in wintertime and be restricted to a minimum so that "the stay in church during sermon would not be uncomfortable" [2]. The idea was to use intermittent heating. Physicians, architects and engineers spoke for central heating because it promised improved hygiene, less maintenance and more comfort.

The views and advice on heating old churches do not describe a linear development from the nineteenth century and until today. There have been periods of discontinuity and hesitance on the suitability of permanent heating. Authorities encouraged churches to install central heating since it would improve the indoor climate. After WWII permanent heating became more common.

3. The articulation of views on heating in churches (1910–20s)
In the 1910s (1879–1966) Sigurd Curman and his disciples among them Erik Fant (1899–1955), articulated a restoration ideology that would dominate the Swedish conservation movement for the coming fifty years. While Curman gradually devoted himself to the administrative organization of the Swedish heritage director of the

1 Gotland University, Sweden, mattias.legner@hgo.se
2 Gotland University, Sweden, mia.geijer@faranstyrelsen.se
National Heritage Board Erik Fant became one of the dominant restoration architects of churches in Sweden. Between 1920 and 1955 he was involved in 150 projects concerning church buildings. He conducted his work mostly in the middle and northern parts, and on the island of Gotland in the Baltic Sea [3].

The restoration ideology of the period 1920-60 is commonly understood as a product of Curman’s mind. This reputation is built up on a few restorations generally regarded as groundbreaking. But it was actually his adepts who took on the complicated task of translating theory into a wider practice. Many of them took office in the administrative management of the built heritage, either in the Board of Public Works and Buildings, later transformed into The Board of Building and Planning or in the National Heritage Board. These offices were responsible of the official approval of restoration projects concerning churches and other buildings that were considered to be historically or culturally valuable. The Board of Building and Planning actually formed special departments of experts on modern installations such as heating and illumination.

Fant never held an administrative position of any of the offices but he was closely linked to the Board of Building and Planning as an expert on restoration. Furthermore he was the first to officially articulate the restoration ideology of the early decades of the 20th century. His article “On the modern principles of church restoration” from 1922 was often quoted [4]. During his nearly forty years of work Fant would be put to the test on many difficult issues concerning church restoration. One of the more difficult challenges during the second quarter of the twentieth century was how to reconcile the spiritual and aesthetic experience of a medieval church with the new demands of modern society. Between the 1920s and the 1950s artificial illumination, central heating, thermal insulation and running water were installed for the first time in many medieval stone churches.

The basic characteristic of the restoration ideology of the first half of the 20th century was the conception that every restoration was a balancing act between tradition and modern functional thinking. [6] The architect should adapt the church to contemporary needs and meet the demands on comfort of today’s generation [4]. Without modern technical installations the buildings risked becoming obsolete and abandoned. It was the architect’s task to find a way to enhance the aesthetic and historic values of the building while also making it more useful. The changes made to a building in different periods should remain visible, but together they should form an artistic completeness [7].

Common interior changes of the time connected to the introduction or modernization of heating regimes were that windows which had been enlarged in the eighteenth or nineteenth centuries were reduced to their former size in order to let less daylight into the church. Often a second pane of glass was put into the windows for insulation, or the glass was replaced altogether. Wooden doors were insulated and some were also provided with interior doors for improved thermal comfort.

Wall paintings were only to be exposed if ovens had been exchanged for central heating, since ovens contributed so highly to particle deposition and the darkening of the walls. Antiquities such as pulpits, retables and wooden sculptures were often returned to the church after having been kept at a museum for some time as the climate in the churches were regarded as safe after the installation of central heating. That meant that the cultural value of interior of the church was upgraded, but also more sensitive, as heating was installed [8].

The most difficult challenge for the architect regarding modern requirements on comfort was the heating. Much like other architects Erik Fant thought that ovens were deplorable since they dirtied floors with fuel and walls with soot. A view deeply rooted in the heritage management beginning with Zettervall. In the 1920s Gurney’s ovens were still very common in smaller churches. The will to get rid of the ovens seems to have inspired architects to design central heating systems for churches: "Therefore, in modern restoration work the issue of suitable heating devices has been approached with great interest" (p. 158) [4].

In his article Fant promotes the use of electricity for heating. As the industries were not working on Sundays refund rates could be offered to churches and cultural institutions. Fant found electric heating to be the method that most easily could meet the demand of aesthetic solutions as it was considered to be clean. He even suggested portable electric ovens which could heat the church before the sermon and be taken out before the congregation arrived. But his positive attitude towards electricity turned out to be too optimistic. The distribution net was only slowly expanded into remote parts of the country. The risk of fire was great and the price of electricity was high. The practical experience eventually worked in favor of other solutions such as water based heating fuelled with oil. The demand of electricity should not be allowed to influence when the churches could be used [9].

4. Views on heating in the 1960-70s

Beginning in the 1960s there was a growing concern among antiquarians and architects that medieval stone churches were suffering badly from overheating. It was said to contribute strongly to particle deposition on walls and vaults, and to a climate that was too dry for the wooden interiors and objects [9]. In some cases with oil burners, temperature in the church may have been increased in order to heat the chimney more.

There were conflicting views on the need for heating in the 1960s and 70s [10]. In 1967 a conclusion drawn by the National Institute of Building Research was that stone churches that had not been intended to be heated, should remain unheated. This particular piece of advice
does not seem to have had a noticeable influence on the management of churches. Instead, the 1960s became the culmination of permanent heating for comfort.

Problems with the desiccation of organic materials inside the church, and paint flaking on wooden objects, were observed [11]. A manual stressing the importance of heating with care and only intermittently was issued in 1976 [12]. In 1977, following the first energy crisis, the Swedish government issued a grant for measures to conserve energy in houses. Churches were included in this policy, but with the restriction that all measures had to be approved by the National Heritage Board. In its directives on how to conserve energy in churches, co-authored by I. Holmström, the risk of desiccation of wooden materials was emphasized. Even conservation heating was said to cause desiccation. This led the Board to recommend that a church containing valuable wooden objects should not be heated more than absolutely necessary. During sermons a maximum temperature of 16 to 18 °C was recommended. The church would not be harmed by being unheated, except that water pipes ran the risk of freezing [13]. In a memorandum from the National Heritage Board these directives were repeated, with the amendment that when the outside temperature fell the indoor temperature should also be allowed to decrease [14]. This recommendation had to do with an increased awareness of desiccation occurring due to the heating of churches wintertime.

5. Heat installations in Gotland churches, c. 1900 – 1960

The survey of rural churches is based on twenty-four restoration programs proposed by Erik Fant between 1927 and 1954 in which heating installations were included in the program [15]. They cover twenty-two different churches, all of them on Gotland, and represent a quarter of the stock of functioning churches with medieval origins. The installations were carried out in connection with interior restorations of churches.

5.1 Steam heat, 1920 – 1940s

In the period from 1920 to 1960 almost all churches on Gotland went through interior and exterior restorations which completely changed how the churches appeared and were perceived. Still in the 1920s most churches on Gotland were heated with ovens or had no heating at all [5]. Only a few of the ninety two churches had some sort of central heating. Fant was often faced with the challenge of installing central heating in an aesthetically pleasing way. Central heating was installed in many of these churches for the comfort of the parishioners, often before electricity was installed. Not until in the late 1950s was there an electric grid covering all parts of the rural island of Gotland.

By the 1920s calorifiers were considered obsolete. The heating chamber required space and the circulation of air would dirty the walls. Instead low pressure steam, and somewhat later low pressure hot water, had become the most common system for central heating. To make heating more efficient additional insulation of windows, doors, floors and ceilings was necessary. Walls could rarely, if ever, be insulated in stone churches, but the top of vaults were after WWII.

In the 1920s low pressure steam heat had become a popular technology for central heating. It was thought that this system would provide enough comfort, and after the stoves had been abolished there would no longer be a problem with the dirtying of walls and vaults. Some of the pipes and radiators of these systems from the 1920s and 30s are still in use today. This is the case in Dalhem, Klinte, Hejde, Roma, Bunge and Hörnse. Boilers, however, have been replaced long ago and the boiler rooms have been renovated.

Heat distributed through low pressure steam was a common choice in intermittently heated churches of the 1920s and 30s. Steam heat would raise the temperature very quickly and did not demand an electric pump to distribute the heat. A drawback was that a steam boiler had to be located lower than radiators and piping. On Gotland with its small churches this meant that it would have to be dug into the ground below the building.

The boiler room should not make a mark on the exterior since it was seen as a profane element. The only realistic option (except for electric heating which was available in just a few Gotland churches before the 1950s) to digging a basement for the boiler was to place it in a separate building. In Eke a separate boiler room was built in 1964. At that time the digging of basements below or adjacent to the church had stopped long ago [16].

Östergarn and Hejde churches are clear examples of boiler rooms having been dug below the vestry in order to make room for a steam boiler and coke storage. This was a difficult operation since it could mean that the vestry and the wall of the choir were destabilized. The work had to be organized in many stages performed with caution. The space was divided with a partition wall: on one side there was the boiler, and on the other coke or firewood was stored and easily accessible for the stoker.

Östergarn church still looks pretty much the way it did after Fant’s restoration of 1935. The boiler room was concealed below the vestry, and all piping and radiators inside the church were placed behind the pulpit and the altar, below the pews, and up on the gallery. Fant worked purposely to conceal sources of heat so that only the heat, not its sources, would be perceived. These efforts probably decreased the efficiency of the installation somewhat. The church should look like it did not belong to the modern time of Fant’s, when it actually was making use of contemporary comfort technology. Comfort heating was desired, but not the aesthetics of the installations.

At the same time as the work on Östergarn proceeded, Erik Fant also worked with restoring Hejde church. This church had a stove in the northeastern corner of the nave. [17] It would be replaced with steam heating but the old
chimney would be reused. A more spacious and deeper boiler room than the one in Östergarn was excavated. After having considered mounting the piping in the floor of the choir and the nave, it was instead cut into the wall. Around 1940, however, low pressure steam was clearly re-evaluated by the authorities. Now it was discredited on much the same ground as stoves had been rejected by architects previously. Steam heat emitted too intense heat and caused soiling, it was said. The last church that Fant had steam heating installed in on Gotland was Anga church (1946-47). Before WWII he had produced numerous restoration programs in which steam heating systems had been installed in Gotland churches, such as in Anga, Bunge, Buttle and Dalhem. By 1938, however, he seems to have reconsidered the pros and cons of steam heating. When putting together a program for the restoration of Eเตelhem he wrote that for the sake of the developed murals a low pressure water system should be installed. The church was not restored until after WWII, and then electric heating was chosen. Eเตelhem church underwent a similar process, having electric heating installed in 1952.

5.2 The triumph of electrical heating
At Vreta monastery church Curman and Fant had chosen electric heating. Already in 1922 had Fant become a protagonist for the use of electricity in churches as shown above, but he saw it as a future technology. In the early 1920s electricity was not yet available in large parts of the country, and it was also too expensive to use for heating. The electrical grid was growing around this time, reaching places where it had not been available before. It had become an option for some churches to use surplus electricity produced by recently built hydroplants at night or at weekends, when demand reached its minimum. This meant that a church could be heated in the night before a sermon. For small churches with access to electricity Fant recommended portable electric ovens for intermittent use. They could be removed when not in use: "Then one gets rid of every visible heat source and one only needs a minimum of wiring" (p. 149) [4]. Portable ovens would be put in the aisle and be removed at the beginning of the sermon. One drawback was of course that the temperature would drop quickly right after the removal of the heat sources, causing a cold draught in the nave. Another drawback was safety, since portable ovens could easily start a fire than permanent installations. In larger churches pew heaters placed at feet level would give the most comfortable heat, Fant argued. In short, electrification represented "a number of substantial advantages compared to other systems" (p. 150) [4].

After WWII prices on electricity decreased gradually. This is one reason why electric space heating became a very popular choice in Swedish churches. The number of applications from parishes to the authorities on installing electric heating seems to have culminated in the years 1950–51. In 1946 a total of 452 applications on electric heating had been granted in Sweden. Seven years later the sum had tripled to 1,238, or more than a third of all existing churches in the country.

In the 1950s electric heating was installed in a number of Gotland churches, such as Alfa, Alva, Eksta, Eเตelhem, Gerum, Gröttingbo, Levide, Linde, Lojsta, Näs, Rone and Sundre. This had become an attractive option for churches which had not had central heating installed before WWII. The electrical grid had developed considerably, the costs for installation were lower than for central heating and there seems to have been a widespread belief that running costs would be low, at least if heating intermittently. Electrical heating was best suited for intermittent use since it gave off heat immediately when turned on. If a church was to be heated permanently electrical heating was not an attractive choice since it would prove very expensive.

6. Cathedrals
This survey is based on documents concerning the restorations of four medieval cathedrals. Cathedrals were among the first public buildings to be equipped with central heating. The documents offer a close understanding of the discussions prior to the installation of central heating. The cathedrals worked as role models for the technical development within the dioceses. As they were in more varied and frequent use than the ordinary parish churches there were a larger number of stakeholders who took interest in the application of heating regimes. The dioceses were the driving force of the restorations. But there were also congregations connected to the cathedrals. Normally these congregations were obliged to pay the costs of heating and lighting. It was their comfort, as well as the priests, that were in focus when central heating was installed. In some cases fundraising and donations by the parishioners contributed to the financial possibility to install heating and artificial illumination.

The cathedrals were not only buildings of adoration. They were also shrines of national history, filled with objects illustrating the development of art and architecture. The Board of Public Works Buildings and later the Board of Building and Planning were closely involved as its approval of technical and aesthetical transformations was necessary to conduct any work on the public buildings. Architects linked to the board were often in charge of the building works. As the cathedrals were considered to be culturally valuable the National Heritage Board took an early and relatively close interest in the restoration processes, especially when it came to questions concerning archaeology and medieval artifacts.

6.1 Early heating regimes of the cathedrals
The records of the early heating regimes of the cathedrals are scarce. The vestries may have been equipped with fireplaces. From the late 18th century brick stoves were installed and later on, as the foundries were becoming industrialized, iron ovens were installed
in the vestries. By the 1870s the Gurney's ovens made their conquest of the cathedrals. At first they were not met with objection from the central authorities, if they were informed at all. Visby, Uppsala and Strängnäs were all equipped with Gurney's ovens, as were the post reformatory cathedrals such as Karlstad and Kalmar.

Five years after taking office as the head of the National Building Board, Helgo Zettervall wrote his manual for church building (mentioned above). Zettervall was heavily influenced by a similar manual issued in Denmark but foremost by the theories of Viollet-le-Duc. As an architect Zettervall had an immense influence on the restoration of gothic cathedrals in Sweden during the second half of the 19th century, beginning in Västerås as leader of the buildings works in the 1860s and ending in Uppsala in the 1890s.

6.2 The introduction of central heating
In Västerås cathedral the question of heating was raised already in 1859 by the architect of the ongoing restoration, Per Ekman. He suggested that, since the floor was going to be replaced, it would be wise to add channels for floor heating. The idea was probably to use some sort of hot air heating, though it was never clearly outspoken in this early phase. Two years later the question was raised again and this time it was handed over to the parish. Other matters concerning the finances made the question of heating less important at this time. Finally in 1877 a calorifier was installed. It was mainly funded through private donations and a special fund raised by letting the church for concerts.

The final choice of a calorifier was preceded by the evaluation of several alternatives. Gurney's ovens were offered by the Swedish agent but also by one of the largest foundries in Sweden, Kockums. Two different calorifier solutions were also considered. The final choice was the calorifier suggested by Kockums. It was estimated to produce an average temperature of 6–10 °C in the winter and was said to have a high efficiency. Even though the Gurney's oven was cheaper to install, the heating cost would be higher in the long run due to their large fuel consumption. The calorifier was of a construction that allowed hot air to be mixed with steam. Kockums recommended that the calorifier should be used at least 4 days a week to produce optimal comfort at minimal fuel consumption as well as the best durability of the stoves.

Parallel to the discussions on heating of Västerås cathedral runs a discussion of the damp interior of the church. The problems of leaking roofs and poor drainage seemed to be constant. The installation of a central heating system was soon connected to the appearance of condensation on the windows. The thermal comfort was also affected and complaints of draft were raised. Ten years after the installation the question of the damaging effect of the heating on the interior was connected to the existing heating system. The nature of the problems was never specified. The Kockums calorifier was switched off and another leading producer of heating devices, Ebbes bruk, was chosen for the new system. The new calorifier demanded reconstruction of the channels in the vestibule, but in large there were no other changes made to the interior. Only a few years later the need for cleaning the walls from soiling was obvious. Cleaning of the walls and vaults was also connected to the urge of decorating the plain surfaces in correspondence with the current aesthetical ideals of how a gothic cathedral should appear.

As in several of the cathedrals Gurney's ovens had been put to use in Visby, Uppsala and Strängnäs in the 1870s. In Visby four Gurney's ovens were delivered by Graham Brothers foundry in 1877. An oven had been installed previously in the vestry. The ovens were placed in central positions and their flue tubes were wrapped around pillars in the aisle, gathered in one of the central vaults and led through a chimney on the roof through the attic. Soot leaking from the flue tubes soon caused complaints. In the 1890s a large exterior restoration was carried out and just after the turn of the century interest turned instead to the interior. A new heating regime was by now integral to the restoration program. The architect in charge of the planning of the restoration recommended that an engineer specialized in heating should make an investigation of what kind of heating system would be the most efficient. To economize, one long-lasting idea was to keep the Gurney's ovens, but move them into the rear end of the church. An alternative solution was to put a calorifier in a heating chamber. The engineer Wilhelm Dahlgren made the necessary technical calculations based on these alternatives. He promoted a calorifier of his own construction as the most efficient and economically beneficial of the two alternatives. Furthermore he argued that the best solution to achieve an even temperature within the church would be a steam system with steam boilers and radiators in strategic positions. He managed to persuade the building committee and got the commission to develop this suggestion further.

At this stage a number of competing proposals appeared representing different technical solutions, with each contestant promoting his own products. To carry out an installation in a cathedral was a prestigious task for the competing engineers as well as for the foundries. An interesting discussion can be followed in the documents concerning the choice of a heating regime. Other aspects than the actual solution of the heating system was lamented on, such as permanent or intermittent heating, the thermal effects of different systems and of open or closed benches, the maintenance and economy in long and short term and of course the aesthetical effects. In the end a low pressure steam system was chosen. The boilers were put in a separate building, close to the church, and a culvert was led into the church. To lead the steam to the radiators the old stone floor was replaced and pipes were placed beneath the new one. This made the National Heritage Board react as archeological
values would be damaged. The diocese answered the protests by pointing out that the floor was quite recent and that only a small number of tombs had to be moved. From the winter of 1891 the steam boilers were put to work producing an average heat of 16 °C.

Uppsala cathedral was the central cathedral of the Swedish church. It was also the last major restoration achievement of Helgo Zettervall, though the architect Emil Langlet was in charge as the local leader of the restoration project. In order to replace the existing ovens the building committee turned to an experienced engineer, Edvard Westin, who had won a medal for his heating devices in the Paris expedition of 1878 and held a position at the Royal School of Technology. As his suggestion was about to be accepted by the committee, competition turned up. Ernst August Wiman submitted two suggestions. The building committee of the diocese turned to the board of the Royal School of Technology for guidance. Surprisingly the board did not support its own employee but favored the hot air solution suggested by Wiman. His system was thought to be easier to maintain and to produce heat at a lower cost. An advantage was that the steam furnaces were put outside of the cathedral; hence the risk of fire and stains from the smoke was lowered. The basement of an 18th century building facing the cathedral was put to use and a culvert was dug between the buildings. As the hot air was to be let out through grids in the floor, archaeological examinations of tombs affected by the piping were necessary in order to secure archaeological values. But there was never a question of finding other solutions to avoid damage on potential finds.

In the case of Strängnäs no less than six ovens, manufactured by Bolinders, were installed in 1876. They seem to have worked satisfactorily, producing an average temperature of about 9 °C. In the 1890s, the question of a more updated heating system was raised by the architect Fredric Lillevkist. Two suggestions for central heating were submitted by two experts on heating devices; Wilhelm Dahlgren offering a hot air solution with warm chambers and Hugo Theorell suggesting an automatically regulated low pressure steam system. According to Theorell the overall architectonic values would not be disturbed as the size and the location of the radiators was adjustable.

In the case of Strängnäs an interesting discussion concerning how the demands for a modern use of the church, and the call for a heating system would risk the patina and the historic and architectural values of the church was introduced by the architect. Favoured the caliphron solution Lillevkist feared that the introduction of piping that was necessary for steam heating would put both archaeological and aesthetic values at risk. He was concerned that only economical issues had guided the choice of technical solution. According to the engineer Hugo Theorell the decision to use steam was guided by the fact that it would be difficult to achieve an even temperature if a hot air system was used in a building of the size of Strängnäs cathedral. Furthermore heating chambers were space consuming. An alternative solution suggested that the piping should be drawn over the attic, the tombs under the floor were spared. The heating system was ready to be put to use in 1910. Three boilers and a storage room for coke were fitted into the basement of the vestry. To minimize the aesthetical damage the radiators in the church were covered with a simple but decorative metal grid. A brick wall was built behind the main altarpiece in order to protect the sensitive wooden object from radiating heat from a large radiator behind it. The wall was integrated into the overall decorative solution for the new altar arrangement.

The first records of damages on wooden objects related to the changed climate in the church appeared already in 1915 when the main altarpiece was reported to be in need of repair. In 1918 several of the medieval altarpieces were in need of conservation. To survey the climate hygrometers were installed and suction filters were placed on the radiators in the chancel. In the following decades several interventions were made by conservators on the wooden artefacts of the interior. The same tendency can be noted in Västerås, where several of the valuable altarpieces repeatedly were in need of conservation, beginning in the 1920s.

### 6.3 New generations of heating regimes

The price of coke was rapidly increasing during the early decades of the 20th century. Subsequently the costs for heating the church soon proved to be a burden for the congregations. Technical problems were commonplace and the calculations of the efficiency were often proven to be too optimistic as they were based on buildings with better insulation. The large single pane windows, often poorly caulked, and many doorways caused draft and thermal discomfort in these old and spacious buildings.

In Strängnäs the congregation complained that they had not been allowed to influence the choice of system but none the less had to fund it themselves. The discontent was certain to add to the perceived discomfort. New methods of heating were introduced and electric heating was often considered as an alternative. But the application of electric heating in the lofty cathedrals proved to be too costly. In Västerås the piping for the steam heat could, with some alteration, easily be reused for a water based system. In 1928 the steam boilers were replaced with oil boilers. New radiators were installed and concealed by iron grids designed by Erik Fant. Bench heating was also introduced. Shortly after their installation complaints of draft were raised. The closed benches had been replaced with open benches in the 1890s to help the circulation of the warm air when central heating was introduced. In 1945 they were replaced by a new generation of closed benches to improve the effect of the bench heating as well as to satisfy the aesthetic views of the time. The open, neo-gothic benches of the 1890s were considered to be ugly.
In Strängnäs the old heating system was judged to be irreplaceable by the 1940s. It was hard to keep the temperature above the desired minimum of 5 °C during the cold season, especially on windy days. The National Board of Building and Planning declared that it was urgent to install a new heating system as valuable objects in the cathedral were at risk to be severely damaged. The Board pointed out the importance that all arrangements that required aesthetic considerations should be handled by an experienced architect and the National Heritage Board should be able to consider: all works that affected the walls, the substructures, tombs or floors. The potential damage to medieval murals by staining and the risk of causing cracks in valuable wooden objects due to unsuitable placement of some of the radiators were pointed out. The new heating system, still based on coke boilers, was installed in 1951. It was meant for intermittent use. The intention was to keep the temperature at an average level of 5–10 °C. To avoid the inconvenience of draft from the entrances hot air devices were installed in the wind catchers. In addition to the new heating system, double glazing and insulation of the vaults was carried out. To hide the radiators in the chancel, stone benches were designed by Ragnar Hjorth. The same manner of hiding low radiators was applied elsewhere in the church. In other parts the aesthetically disturbing effect of the radiators were modified by shelves and other arrangements such as bent metal sheets. These would also lessen the tendency of black stains above the radiators. A few years later the question of an oil furnace was raised once more. This allowed for constant and even heating, but also temperature regulation through thermostats. The oil furnace was installed in 1954.

There are relatively few comments on the effect of the heating in Uppsala. The late 19th century use of cement in the exterior caused severe conservation problems which greatly overshadowed the issues of the interior. Only in the middle of the 20th century was a connection made between the heating regime and the poor state of the exterior. As the vaults were poorly insulated, the heating made water condensate and caused continuous cracking of the cornice where the roof, vaults and walls met. Improved isolation and a shift of heating system thus became part of the extensive restoration program that was under development and debate throughout several decades.

In Västerås hot air heating was outdated in the 1950s. By then the community was planning for a district heating system to which the cathedral was connected. This offered a clean and neat solution at a low cost. Interestingly Västerås was the first cathedral in which floor heating by hot water pipes was introduced as a part of a major aesthetic transformation of the church, led by Erik Lundberg. Lundberg was one of the youngest disciples of Sigurd Curman, and the one that redeveloped and transformed the restoration theory of the early 1920s to a modern version. His ideals enhanced the handicraft and the materials of traditional building techniques and favoured contemporary design in dialogue with historic artifacts. Lundberg was influential as a teacher and just like Erik Fant, he formulated his views on restoration in influential articles [19, 20]. To Lundberg the aesthetics and the history of the building were essential. The new technique of floor heating made it possible to conceal the disturbance of visual technical devices for heating. But the installation of floor heating called for a complete renewal of the floor and extensive excavation to secure archaeological finds.

In the 1980s, Visby cathedral was connected to a district heating system. During the extensive restoration, led by architect Jerk Alton, the chapel in the southwest part of the church was closed off from the main church hall in order to allow sermons for the few attendants on an ordinary Sunday. In this way more expensive heating was saved for the large religious feasts, concerts and other public events.

6.4 The effects of heating on the medieval cathedrals

The intermittent heating of the early period when Gurney’s ovens and other cast iron ovens were dominating was soon connected to the discomfort of radiating and uneven heat, dirty handling of coke and soiling of interiors. But no effect on wooden fittings and artefacts were recorded.

With the introduction of central heating it soon became obvious that the heating regimes had damaging effects on the decorative elements and the wooden artefacts in the churches. When the temperature was raised as central heating was installed, the frequency of conservation of wooden artefacts increased. The most common damages reported were cracking of paint and desiccation-cracks. The connection between heating and need of conservation was made in 1918 in Strängnäs when the altarpiece was in a poor state. In the 1920s several altarpieces were in need of conservation in Västerås as well. But the actions taken to prevent further damage were normally local intervention such as suction filters, hydrosopes and air humidifiers rather than an overall attempt to survey the entire situation of the building. The tendency of black patches appearing on walls above radiators was noted and was countered by attempts to change the direction of the radiating heat by specially designed benches and shelves concealing the radiators. These also had the function of concealing the radiators and were combined with more or less artful grids.

By the end of the studied period, the oil crisis caused a debate considering energy rates. In Visby this had a major influence on the use of the cathedral as well as the aesthetics as a chapel was separated for the weekly use of the congregation while the church hall became a room for special events.
7. Heating for comfort, not for conservation

Heating was introduced in old churches in Sweden in the late nineteenth century. The primary aim was then, as now, to achieve thermal comfort. The preservation of the building, its interiors and objects always seems to have come in second place. In order to achieve thermal comfort, different heating regimes have been developed. A first generation of heating regimes was the Gurney’s ovens made of iron and most commonly fuelled with coke. These ovens proved to be very popular in parishes as the costs for installation and running were low. But they were abhorred by architects and engineers for several reasons. Architects argued for central heating for reasons of hygiene, thermal comfort, and less maintenance. The central heating systems constituted a second generation of heating regimes. According to leading architects of the time such as Fant and Lundberg, pipes and radiators of central heating systems should be concealed in order not to disturb the archaic sense of place in an old church.

A variety of systems were applied in the cathedrals from calorifier to steam systems by the end of the 19th century. On Gotland low pressure steam heating was installed in many churches in the 1920s and 30s. The war put a moratorium on all restoration, which entered a much more intense phase after 1946. At this time electric heating became the most promising (and the third generation) of available heating regimes. Churches which had central heating systems generally had them converted from steam to hot water in the 1940s and 50s.

The practical choice of positions of radiators and piping came in conflict with aesthetic views. When they could not be concealed under floors or over attics, great care was taken to hide the radiators behind benches, grids and shelves or at least make them less visible by covering them with a coat of paint.

Issues under debate today – such as mould growth, air pollution, dehydration of wood, the flaking of paint layers – were recognized already a century ago, but damages caused by indoor climate were not allowed to affect the choice of heating solutions. It is illustrating that while the indoor temperature was measured, the RH fluctuations or the outdoor temperature was never or rarely documented. The absence of documented RH measurements in churches is difficult to explain since conservators and engineers have been aware for a long time that variations in RH influence most materials much more than T does. All three generations of heating regimes used before the 1980s have proved to cause similar unwished alterations such as soiling, paint cracking and flaking, and dehydration. These effects have been by shorter and shorter intervals of conservation and by attempts to increase RH. An exception was Strängnäs cathedral in which hygrometers were used around 1920.

Efforts to understand the climate of a building in a more holistic and complete manner have largely been lacking. In hindsight it can be said that especially central and electric heating from the beginning were associated with a strong sense of technological optimism, and that this uncritical optimism led architects and engineers to underestimate the drawbacks of these heating regimes when applied in stone churches with sensitive interiors and objects. In time, however, the unwished consequences of heating were gradually recognized by authorities, but these authorities had very little to say about the heating regime. In Sweden preservation authorities approve new installations, but have no influence on how they are actually used. In the first half of the twentieth century, many installations were made without the approval or knowledge of authorities.

The cost of installing and running a heating system was a main issue in the choice of heating regime. Low investment costs were favoured but there was an awareness of the long term economy regarding as well the cost of fuel as for maintenance. Rates of different fuels have however fluctuated. Coke was imported and the war periods in the early 20th century made supply uncertain. Even if Sweden was a country of rich water supplies, electricity was considered expensive in the first half of the 20th century and the distribution net was poorly extended. After WW2 oil became cheap and the optimism of the period did not foresee any lack of organic fuel in the future. The oil crisis of the 1970s put a harsh point to this optimism.

8. Acknowledgements

Our thanks to the Swedish Research Council for project funding.

9. References

Diakonistyrelsens Bokförlag, Stockholm.


[16] The restoration programs are unpublished but are available at Antikvarisk-Topografiskt Arkiv in Stockholm.


