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A brief overview of climatization strategies of historic houses in the Netherlands: From "one size fits all" to "a process of deliberation"

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A brief overview of climatization strategies of historic houses in the Netherlands:
From "one size fits all" to "a process of deliberation"

Bart Ankersmit and Marc Stappers

INTRODUCTION

The Netherlands has a rich collection of heritage. Throughout the country a collection of 61,809 state-listed buildings (as of 2022), 804 provincial-listed buildings (2021), 55,801 municipal-listed buildings (2015), 616 museums (2019), 1,459 protected archaeological sites, and 472 city views and landscapes (2021) provide citizens and tourists a view of our history and culture. Heritage management started to be decentralized in 1992, giving the local authorities a more important role working together with the Cultural Heritage Agency of the Netherlands (in Dutch: Rijksdienst voor het Cultureel Erfgoed; RCE), which implements policy, provides advice, and develops knowledge. RCE provides practical advice to owners and managers of various types of heritage so that together "we give our future a past."

In the early 1990s, the Dutch government provided substantial funding to address a backlog of preservation and conservation needs of collections in museums: the so-called Delta Plan for the Preservation of Cultural Heritage (Kirby Talley 1999). Many museums were refurbished, storage areas upgraded, climate control systems installed, collections and objects documented, and other preservation measures implemented. The focus was on preventive conservation, and it was in those days that one individual governmental consultant advised Dutch museums to maintain a very stable indoor climate. Energy consumption and carbon footprint were not taken into account in the process of improving the safety of collections. The main focus was on object preservation. The question was not if, but how climatization could be introduced into the historic houses.

Today we know that, as a result of this type of decision-making, the effects that humans have on the global climate—and on our cultural heritage—is permanent and significant (Sesana et al. 2021). The Intergovernmental Panel on Climate Change (IPCC) has developed scenarios that are becoming more real every day. For the Netherlands, these scenarios indicate that (KNMI 2021):

- Annual average temperatures will rise, resulting in more frequent heat waves;
- Moisture evaporation increases, resulting in a higher absolute humidity of the outside air;
- Periods of drought in spring and summer will increase in length and intensity;
- Inland water levels, such as those of rivers and groundwater, will rise during fall and winter; and
- Rain showers become much heavier, although less frequent;

These changes will have an impact on the indoor climate in our museums and historic sites.

In this paper, the authors would like to review a selection of historic houses that have been renovated in the past

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25 years and in which the climate has been optimized. The observations are intended as a general overview made from a governmental perspective. The paper provides general descriptions of a selection of projects in which the agency has been involved. With this paper the authors hope to inspire the reader by presenting the decision-making process and the lessons learned for these case studies against the backdrop of climate change. Are the solutions that were chosen sustainable, and are the museums now more resilient to climate change?

HOW DID IT START FOR US?

The authors were directly confronted with the relation between building physics and climate control when, in 2004, a medieval building that last used as a school was refunctioned into a city museum: Museum Martena in Franeker (Image 1).

The municipality, the architect, and the governmental climate consultant were primarily concerned with:

- What is the best location of the HVAC (heating, ventilation, and air conditioning) system?
- How can the climatized air be distributed to exhibition spaces?
- Is the floor of the selected location strong enough to carry the load of the HVAC units?

At that time it was thought that climate collection risks (Image 2) and human comfort could only be managed with an all-air HVAC system. So just such a system was placed in the attic of the building (Image 3). Already by 2008 the energy costs turned out to be unbearably high for this small organization, especially since the system was constantly trying to maintain an indoor climate of 18.5°C ±1.5°C / 51% ±1.5%, while the historical building fabric was evidently very leaky.

IMAGE 1. The exterior of Museum Martena in Franeker. BART ANKERSMIT

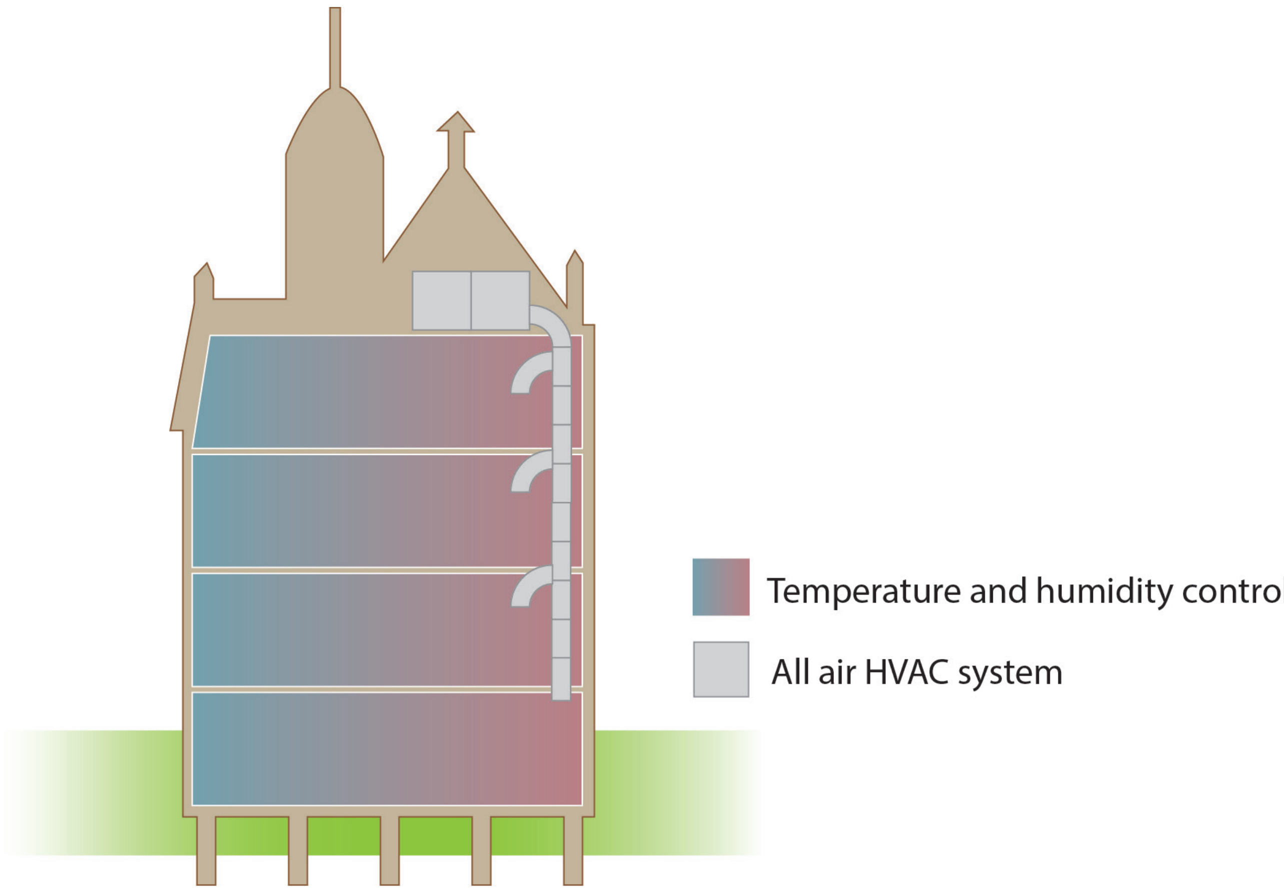


IMAGE 2 (top). One of the exhibition spaces with wooden panel paintings. **IMAGE 3** (bottom). Climate control strategy in Museum Martena. A single all-air HVAC system supplied air to all collection zones in the building. BART ANKERSMIT

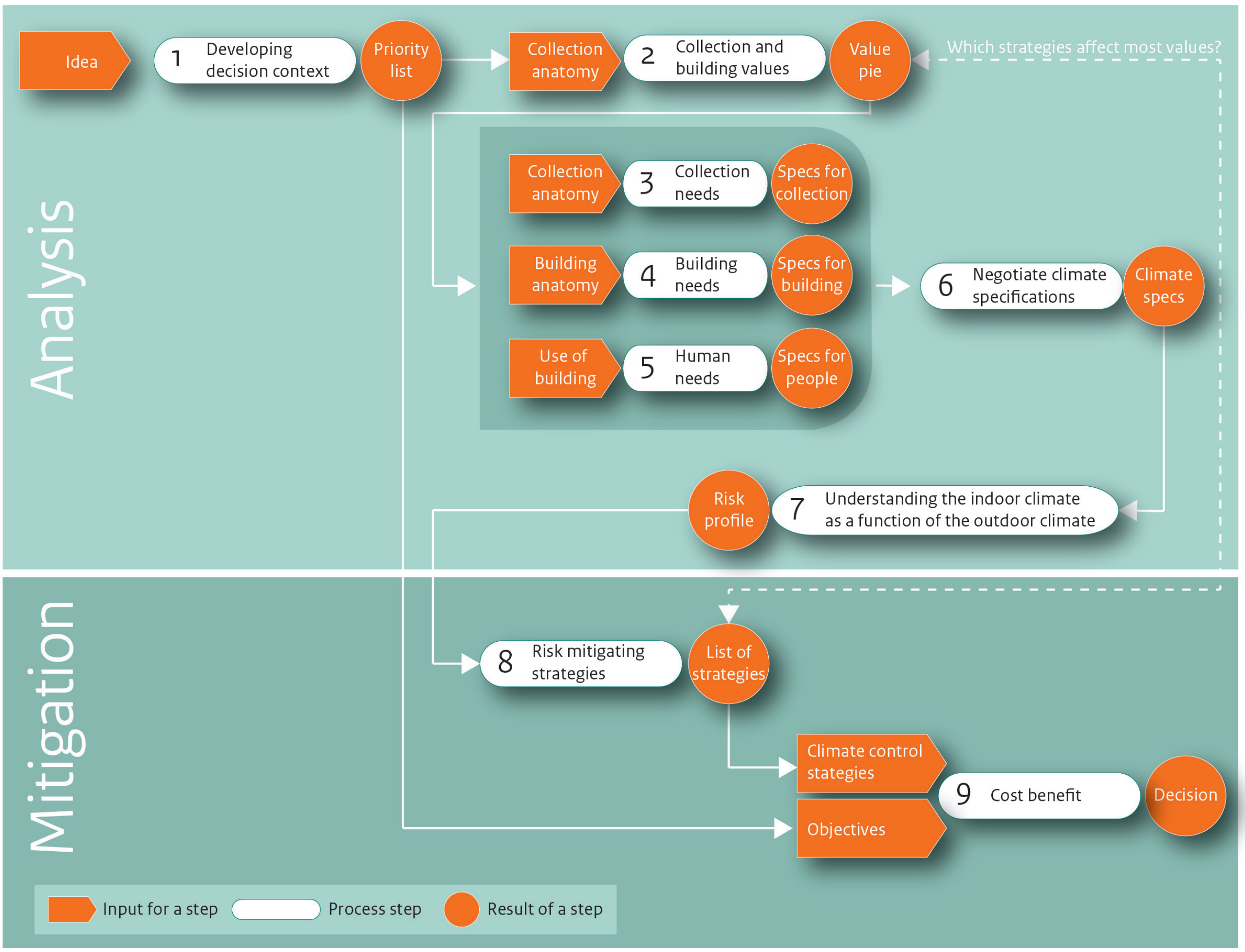
After careful analysis of the indoor climate and the functioning of the HVAC system (Ankersmit and Stappers 2011), it was decided by the museum and the municipality to switch off the system and rely on the thermal inertness of the heavyweight medieval building and accept certain climate risks. This example showed that the optimum specifications for the indoor climate should be based on many more objectives than only collection preservation or human comfort.

From standards to guidelines

In order to step away from prescribed fixed numbers, as found in certain standards such as the ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) handbook, and apply an integrative decision-making model, users should be able to critically review the most important factors that determine the outcome (Ankersmit and Stappers 2017). Nine consecutive steps were developed by RCE to assist heritage managers to find the optimum solution for their specific situation. The focus of this method is not only on the outcome, i.e. specifications and a mitigating strategy to reduce climate risks, but also on the equally important process that leads to that outcome. The nine steps are schematically presented in Image 4.

Obviously any outcome is only as good as the knowledge and experience that is used in the process. With limited budgets and the wish to develop sustainable solutions, it is important to focus on more than only the material aspects of moveable collections. One can ask how today's visitors and future generations can have optimum access to (the value or significance of) collections. Although following guidelines and standards might give a

IMAGE 4. The nine steps that can be followed to find the optimum mitigating strategy to control climate risks. BART ANKERSMIT & MARC STAPPERS



sense of security, thinking outside the box and considering the situation from several perspectives will give the best possible outcome for any situation—from low-tech to high-tech, and with every possible budget.

CASE STUDIES AND LESSONS LEARNED

In the last 25 years, RCE has been involved in many projects that had to deal with optimizing the indoor climate. A selection of case studies is presented below. This selection is made to present an overview of different types of challenges, approaches, and solutions. Note that the authors were not always involved, hence the process might be different from the aforementioned nine-step approach.

One size fits all: Heeswijk Castle, Heeswijk, 1996

In 1996, climate control was introduced in the museum of Heeswijk Castle in the town of Heeswijk because the collection and building with its interior finishes are both considered national treasures (Image 5).

Gas and electricity had been installed in the main building in the early 1990s. It was thought that climate control would greatly improve the overall preservation of the susceptible collections, so, as just mentioned, in 1996 a small climate control system was installed to control both the relative humidity and temperature in part of the castle. Since then the staff has been continually busy programming, reading, and calibrating data loggers (Ankersmit and Stappers 2019).

In 1999 the other so-called museum rooms in the older part of the main building became air conditioned (Image 6). In 2009 the first malfunctioning of the climate control system occurred, when the cooling unit completely failed. This situation lasted until 2013, when one of the two original units was replaced. Since then, the new

IMAGE 5. The exterior of Heeswijk Castle in Heeswijk. BART ANKERSMIT

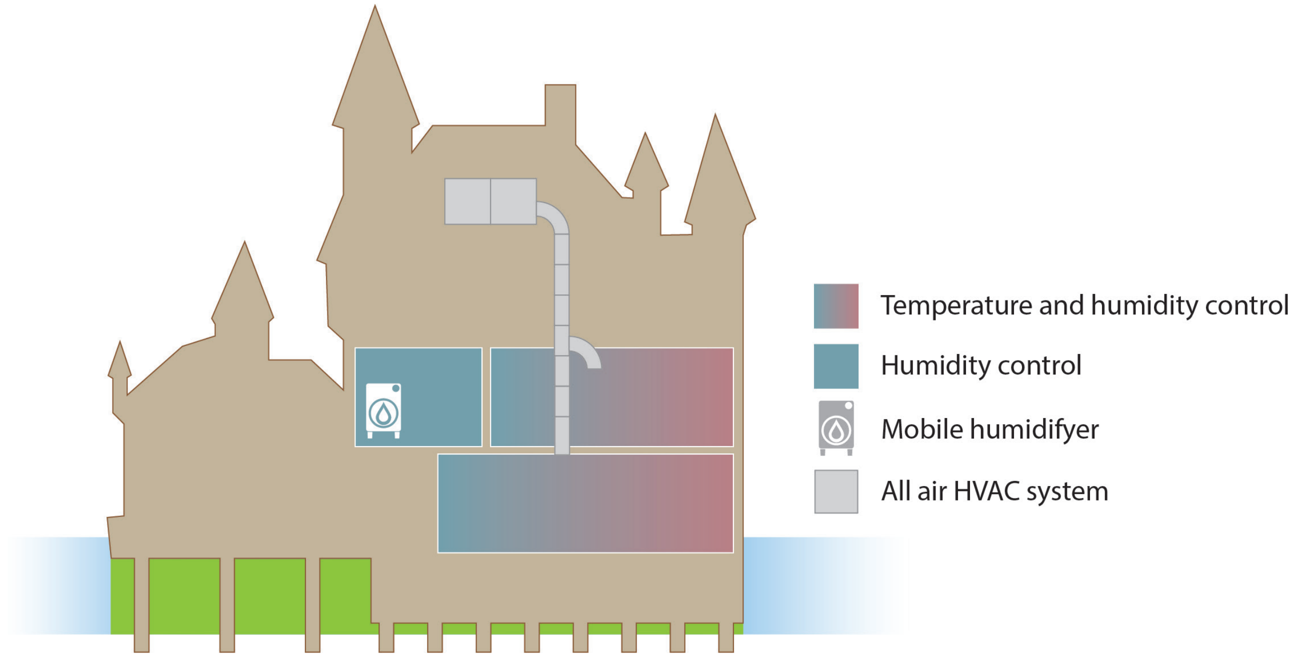


IMAGE 6. Climate control strategy in Heeswijk Castle with a mixture of techniques. BART ANKERSMIT

cooling unit (and, because of that, dehumidification) has functioned, but at only 50% of its original capacity. In 2011, the control software was updated. The second malfunction of the climate control system occurred in 2014. The humidification became highly unreliable. This situation lasted for two years. In response two steam humidifiers were installed. To further stabilize the relative humidity, mobile (de)humidifiers were placed in different rooms throughout the castle. One of the rooms, the Chinese room (Image 7), was climatically separated from the rest by a glass pane in the door frame because of its more valuable and vulnerable collection. It is assumed to be the room with the lowest infiltration rate.

Although several wooden objects show cracks and other deformations, the climate risk assessment and object survey indicated that the collection is currently not at risk for biological nor mechanical degradation. The risk of chemical degradation varies over the year: while in winter the lifetime of chemically unstable materials is doubled, this benefit is reduced by higher temperatures in summer.

The analysis of collection, climate, building, and systems showed that in the past few years the climate in the castle has never been the (strict) museum climate that was originally intended, yet the collections did not suffer climate related-damages. New, more realistic specifications can be developed by applying the proofed relative humidity concept (Michalski 1993). If a lower relative humidity (and temperature) is accepted in winter, it would greatly reduce the risk of condensation on and/or in the building envelope.

Since the climate control system seems to have a limited effect on the indoor climate there appears to be a high potential to reduce energy consumption and improve control temporarily shutting down (parts of) the system, optimizing the use of mobile (de)humidifiers, and rethinking the open-door policy.

Adjusting setpoints in winter: Our Lord in the Attic, Amsterdam, 2006

In the city center of Amsterdam is "Our Lord in the Attic," a museum featuring a private Catholic church dating from 1663. The church, which occupies the top three floors, was built secretly by a wealthy merchant during a time when the Protestant city government forbade Catholic worship. The four-story-high listed building receives approximately 100,000 visitors annually (Image 8). In the mid-1990s humidification and dehumidification was implemented using 12 mobile humidifiers and three dehumidifiers to control environmental conditions in the building.

IMAGE 7. The Chinese room in Heeswijk Castle in Heeswijk. PHOTO COURTESY OF THE AUTHORS

In 2006, the museum faced different climate-related challenges, such as condensation on windows and exterior walls during winter, uncomfortably high temperatures in summer, and a fluctuating relative humidity that was considered unacceptable for collection preservation. In collaboration with the Technical University of Eindhoven, the indoor climate and building physics were evaluated.[1]

Results indicated that the outdoor climate has an almost immediate effect on the indoor climate and that all climate-related damages observed in the collection were formed during the years that the building was fitted with central heating but lacked humidity control (Maekawa et al. 2007). This observation was substantiated by research performed on the collection of the Rijksmuseum (Ekelund et al. 2019). Dry winters caused wood to crack and panel paintings to deform. The proofed humidity fluctuation for this collection was large. The implementation of an all-air HVAC system was seriously considered, but would not have been able to stabilize the indoor climate without serious draftproofing, which would have enormous impact on the architectural values of this precious 17th-century monument. It was decided to remove most of the humidifiers and allow a lower

IMAGE 8. The exterior of Our Lord in the Attic on the left, with the entrance on the other side of the alley. MARC STAPPERS

winter temperature of 17–18°C (62.6–64.4 °F) and expand the museum volume with an extra adjacent building (Images 9 and 10).

The two buildings, separated by a small alley, are connected by an underground passage. The renovated building became the new entrance and presented the valuable and susceptible objects in display cases.

Risk assessment helped the staff of the museum to realize that the building was their most precious object in the collection (Brokerhof et al. 2005). From that moment on it was decided to seriously look at how the building was used to accommodate events like weddings.

Obviously now that the (summer) temperatures are increasing as the global climate changes, human comfort levels will decrease. The museum actively informs visitors on warm days that comfort levels are not optimal, especially since they have to walk steep stairs to reach the hidden church. It might be expected that in the future mobile cooling units will be placed for short periods of time to reduce the heat load during the spring and summer temperature extremes.

Slow heating: Amerongen Castle, Amerongen, 2010

Amerongen Castle is a historically grown ensemble, i.e., the house and collection are equally important, that dates back to the 13th century. The 17th-century house was continuously inhabited by one family until 1976, when it became a historic house museum visited by approximately 50,000 people annually (Image 11).

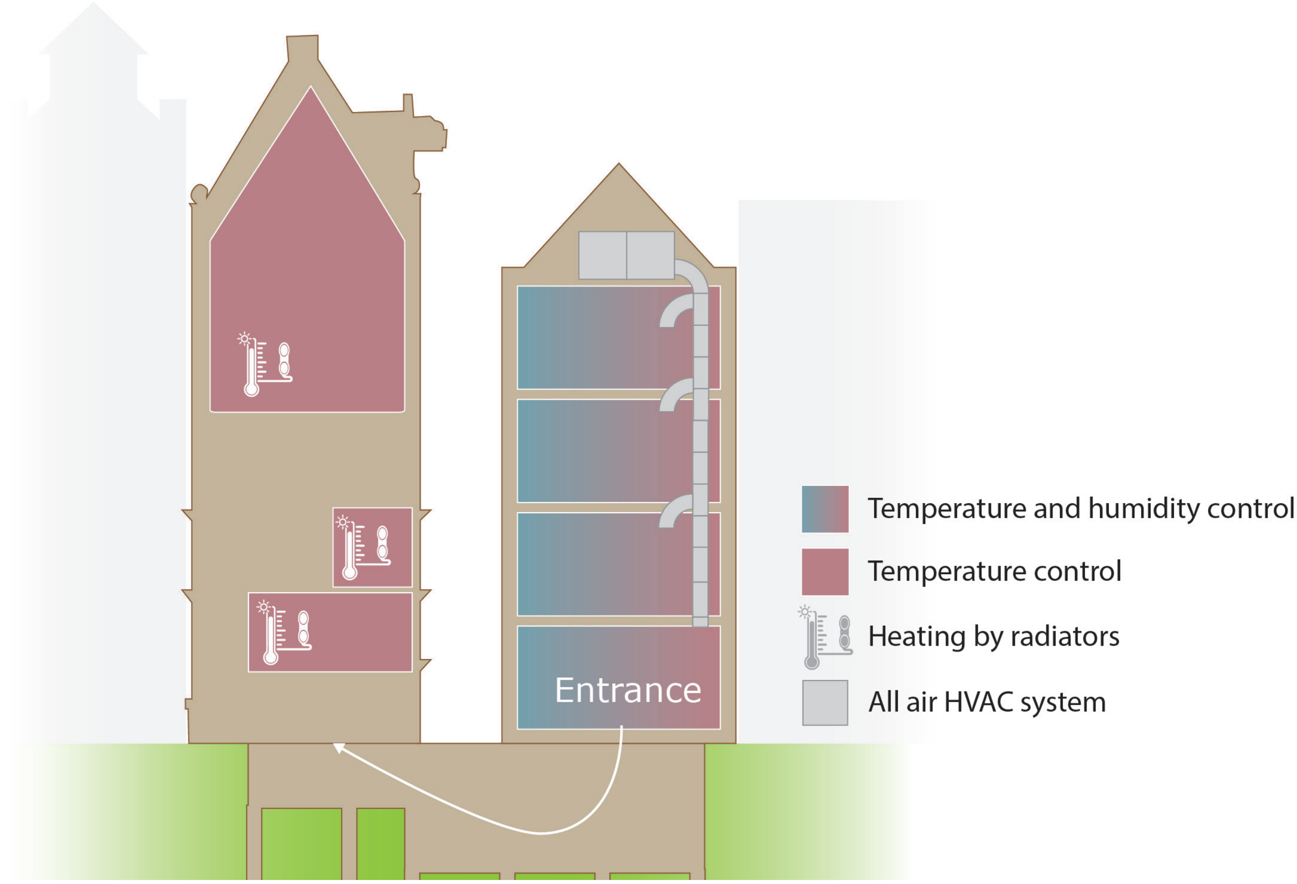


IMAGE 9 (top)**.** Climate control in the historic building is by a small number of radiators and an occasional humidifier in some of the rooms, while the entrance building is fully climatized using HVAC systems. MARC STAPPERS **IMAGE 10** (bottom)**.** Climate control in the historic building is by a small number of radiators in only a few rooms, while the entrance building is fully climatized using HVAC systems. BART ANKERSMIT

IMAGE 11. The exterior of Amerongen Castle in Amerongen. BART ANKERSMIT

When Amerongen Castle was restored between 2006 and 2010, the question of how to control the indoor climate to an acceptable level became urgent—especially since the house was experienced as being very moist and damp. Several climate control strategies were discussed and evaluated with stakeholders in expert meetings. After careful consideration, control over the indoor temperature was seen as a key aspect in controlling the indoor humidity levels. Floor heating was thought to have two advantages over radiators and convectors: (1) it would be invisible to visitors and therefore would not impact the experience quality, and (2) a uniform, low temperature could be maintained in the building.

It was decided to install a low temperature floor heating system in the hallways of the souterrain (underground area), with a maximum temperature setpoint of 10°C, and the belle etage (main floor), with a maximum temperature of 8°C (Image 13).

The floor heating in the souterrain resulted in an increase of the annual minimum temperature from 3–5°C to around 10°C. On the belle etage, one of the most important rooms in the house is located: the Grand Salon (Image 12). It contains very valuable moveable collections and is not heated directly, instead receiving warmth from the floor-heated hallway. The annual average temperature in the salon slightly increased. Although the yearly average relative humidity remained around 60–65%, the house was experienced as being less moist and damp. Careful inspection of a selection of susceptible objects showed that no new mechanical damage due to relative humidity fluctuations occurred between 2009 and 2018.

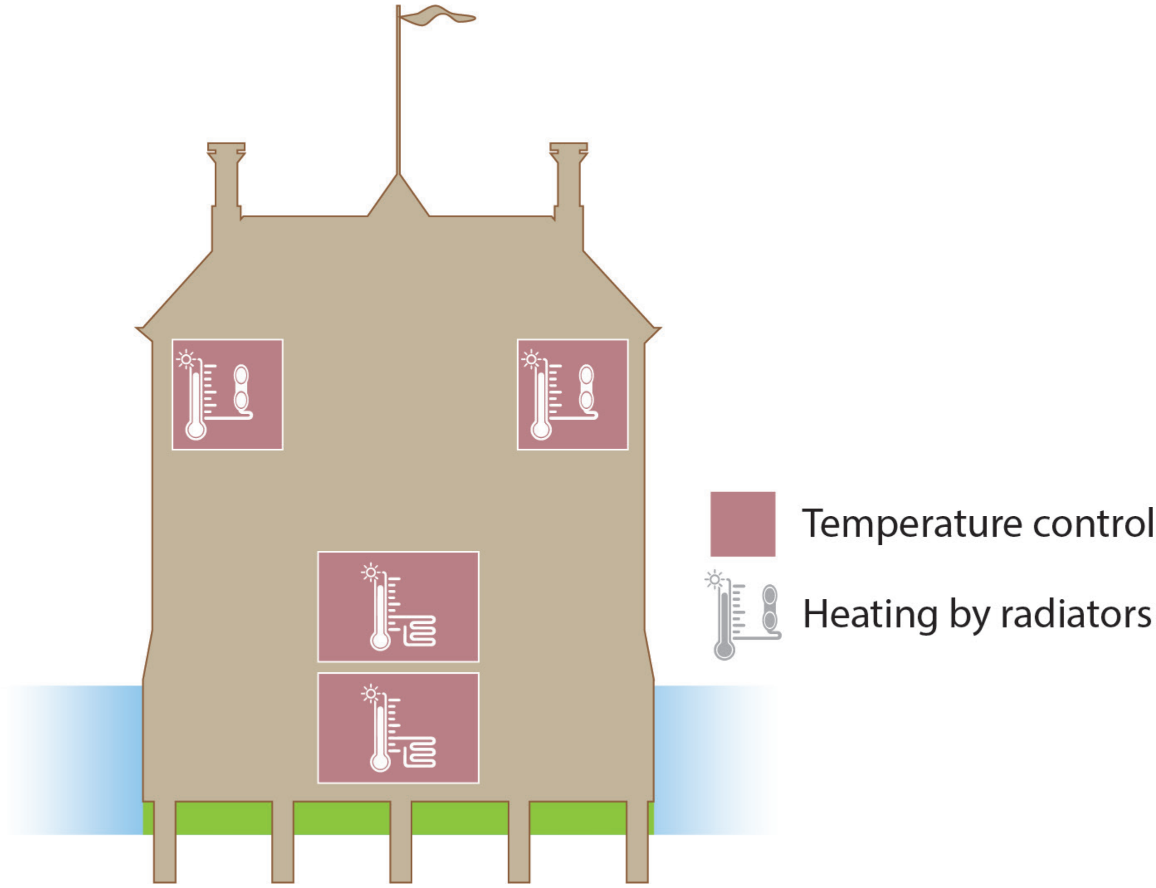


IMAGE 12 (top). Che Grand Salon on the belle etage (main floor). MARC STAPPERS **IMAGE 13** (bottom). Amerongen Castle with the floor heating on two levels, the basement and the hallways on the ground floor. The former living apartments, now office spaces, are heated by radiators. The unheated historic rooms will be minimally heated by the adjacent heated spaces. BART ANKERSMIT

Under climate change, it can be expected that due to increasing risks of river floods the castle will be flooded more often. The floor heating will be beneficial since it will reduce the drying time of the walls and floors after such an event. Since floor heating is relatively slow, no extra damage is to be expected due to reduced drying times.

Separating collection comfort and human comfort: Museum Oud Amelisweerd, Bunnik, 2011

Museum Oud Amelisweerd is located just outside the city of Utrecht in a park setting (Image 14). The building was built in 1770 as a summer house. In 2011, after a period of 30 years in which the house was not used and only partially lived in, it was renovated and refunctioned as a museum.

The layout, floors, doors, and ceilings have remained unchanged since 1770. These characteristics, together with the 18th- and 19th-century Chinese (Image 15) and Dutch wallpapers that are still present on the ground floor level, makes this house unique and highly valuable. On the first floor,[2] many wallpaper fragments were found related to the many inhabitants of the house over the years. In these rooms up to 20 layers of wallpaper were found, indicating a rich history of interior design.

When plans were made for the renovation and refunctioning, several scenarios were investigated and evaluated:

- Preservation of the wallpaper on the first floor being the most important objective, limit visitation and sunlight there to an absolute minimum.
- Optimum preservation of the wallpaper on the ground floor. On the second floor a daylit museum provides

IMAGE 14. The exterior of Museum Oud Amelisweerd in Bunnik. MARC STAPPERS

IMAGE 15a/b. The Chinese wallpaper in Museum Oud Amelisweerd in Bunnik. MARC STAPPERS

access to wallpaper fragments and temporary exhibitions; visitation is limited.

- Preservation of the wallpaper and exhibits for museum collections with unlimited visitation.

To achieve optimum climate conditions on the ground floor, a conservation heating system was installed. Within bandwidths the relative humidity is created by controlling the temperature. A low-capacity climate control system with heating, cooling, and dehumidification function was placed in the attic (Image 16). Air ducts and nozzles are hidden in the fireplaces. No ducts that affected the historic structure had to be installed. This system results in low temperatures in winter that are uncomfortable to visitors. On the first floor a slightly higher temperature is maintained, while in the attic a visitor center allows comfort temperatures to be maintained. This way, the house is split into three different climate zones: a ground floor in which optimum conditions to preserve the wallpapers is maintained, on the first floor a mixed zone with a slightly higher temperatures and controlled relative humidity, while on the third floor (attic) visitor comfort is key. Preservation of the wallpapers requires low temperatures, a more or less stable relative humidity, and preferably a relative humidity somewhat lower than 50%. This means that in rooms with important wallpapers the indoor climate is preferably not or only slightly heated and maybe slightly dehumidified.

This project was complex. Different stakeholders had very different objectives. Opinions varied from "rather use all the cultural value in the next 50 years by providing open access now, than have 100 years of preservation without access." Bringing the opinions and expectations together to create a shared decision proved very challenging. This required time and careful discussions, which are often lacking in many projects that are managed based on time and budget.

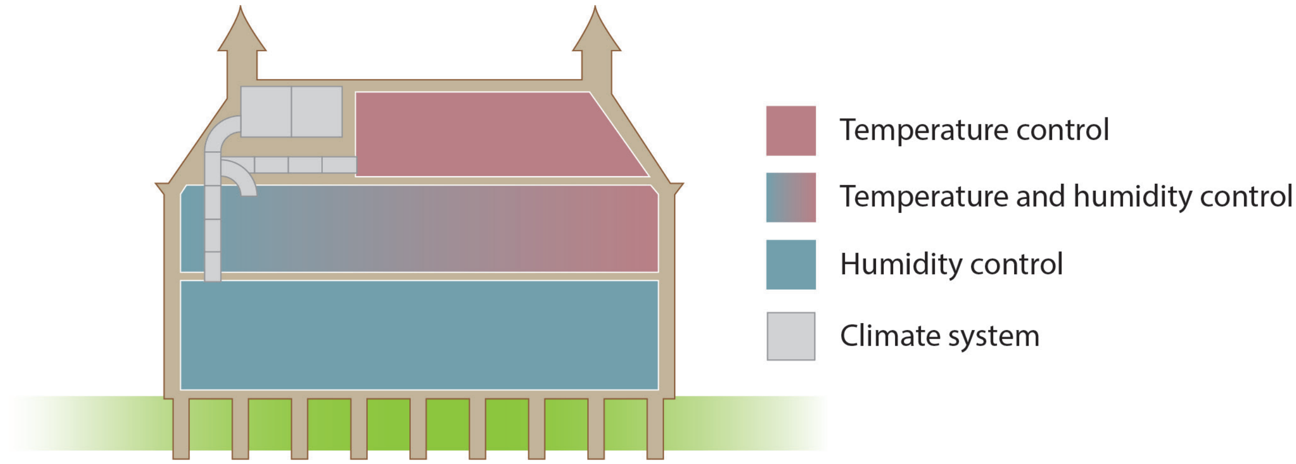
Obviously, in such a historic building installing full air conditioning for human comfort only will become unsustainable. Separating human comfort and collection comfort, and providing adequate comfort levels for both at the same time, can only be achieved by zoning the museum. When human comfort levels are required in collection zones, local heating can be installed during cold seasons and ventilation during warm periods.

Building historical research provides opportunities: Hof van Heeckeren, Zutphen, 2017

Since 2017, the 17th-century Hof van Heeckeren has been the new museum building for housing three cultural organizations: the Municipal Museum Zutphen, Museum Henriette Polak, and the Municipal Archeology Department (Image 17).

This building originated from the amalgamation of several medieval buildings. The indoor climate was an important subject, and especially the loan requirements for objects proved to be very challenging. Loaned objects generally come with tight specifications, which weigh heavily in the discission-making process. If not considered carefully, this might result in a desire to maintain a very strict indoor climate throughout the museum. But in the case of Hof van Heeckeren there wasn't a strong desire to exhibit loans throughout the whole museum. Historical research showed that one part of the building already was modified several decades ago. In this earlier

IMAGE 16. **The climate strategy of Museum Oud Amelisweerd is carried out by separating three layers—collection comfort, collection and human comfort, and human comfort—to accommodate the differing functions.** BART ANKERSMIT



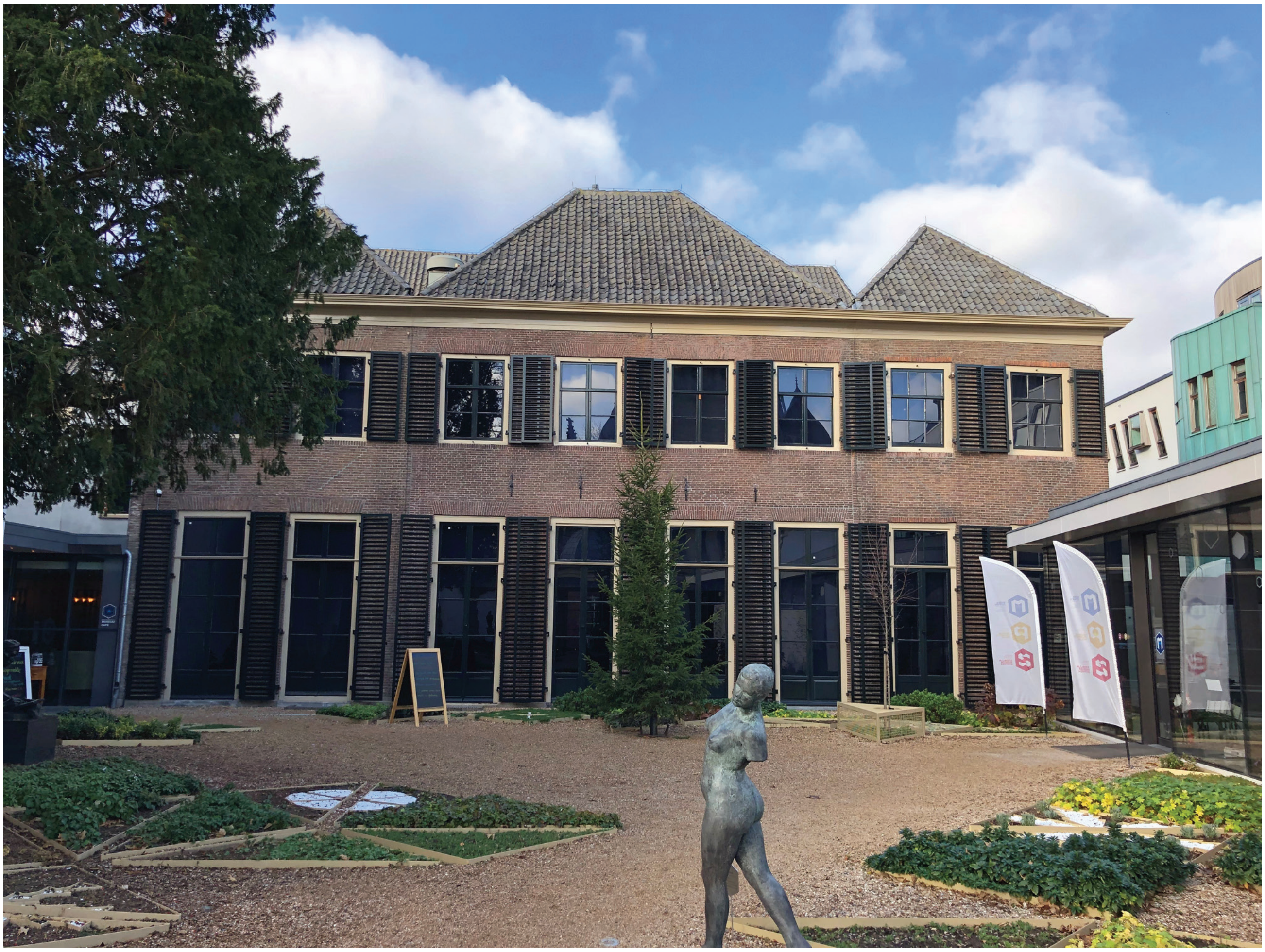


IMAGE 17. The exterior of Hof van Heeckeren in Zutphen with the new entrance on the right. Originally this side was the backside of the building. MARC STAPPERS

renovation the outer walls were already insulated. This gave the museum the opportunity to locally optimize the hygrothermal properties and allow higher heat and moisture loads. This means that a very wide range for relative humidity can be maintained in the major part of the building and that for a smaller zone, i.e., the temporary exhibition gallery, a more strict indoor climate can be realized (Image 18). And since the system works with an overpressure, the extra air tightening of this part of the building could easily be executed.

Local dehumidification: Het Witsenhuis, Amsterdam, 2022

Het Witsenhuis (Image 19) was built in 1884-1885 by the architect Eduard Cuypers and immediately used as an artist's studio. The first tenants were the painters George Breitner and Isaac Israels.

The soberly furnished artists' studios had bare plank floors on which paint could be spilled. After Breitner's departure in 1891, Willem Witsen moved in. When in 1943 Witsen's widow died, she left the entire house to the State of the Netherlands, with the stipulation that the furnishing of the first floor should be preserved as a tribute to Willem Witsen, and that the rest of the house should provide living space for two or three writers who were allowed to live there free of rent. She left behind a large sum of money to make all this possible.

The apartment can be visited by appointment (Image 20). The apartment has very limited climate control: a little heating but no moisture control. In 2020, the small organization of volunteers who check the condition of the collection regularly and give tours to visitors noticed signs of mold on the book collection. It was decided not to

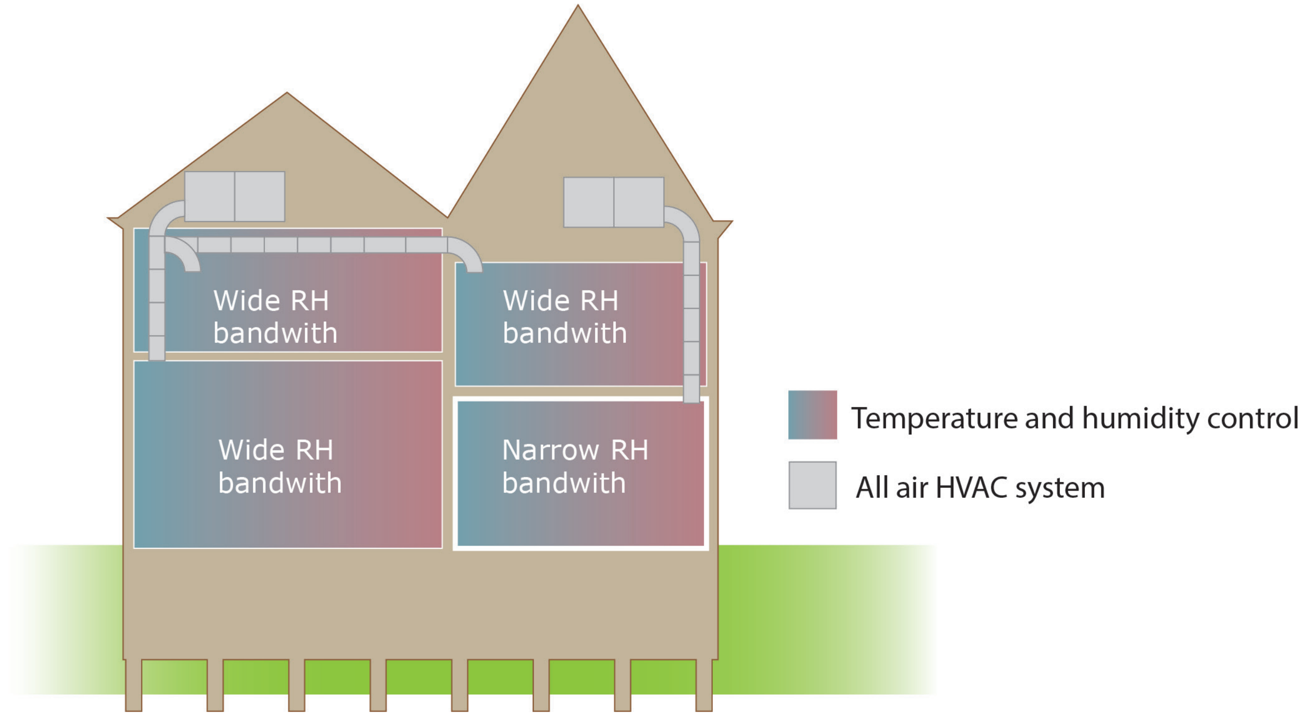


IMAGE 18 (top). The climate strategy of Hof van Heeckeren. Most museum galleries have wide relative humidity bandwidths, while in the gallery for temporary exhibitions, which will accommodate most loans, both temperature and relative humidity are maintained within tight boundaries. BART ANKERSMIT **IMAGE 19** (bottom). The exterior of Het Witsenhuis in Amsterdam. MARC STAPPERS

IMAGE 20. The interior of the Witsenchamber with a datalogger on the table and the furnace for a small amount of heat on the right. BART ANKERSMIT

take immediate action but to start continuous monitoring of relative humidity and temperature to get a better idea of the indoor climate and the risk it poses to the collection—especially since implementation of preventive measures is limited due to the authenticity of the space.

After several months of data collection, it was decided to move the bookcase a few centimeters from the floor and the relatively cold outside wall. It was hoped that the local relative humidity would drop below levels that accommodate mold growth. When it became clear that passive measures would not be able to reduce the risk of mold to an acceptable low level, a mobile dehumidifier was borrowed from the Amsterdam Museum and installed in a utility closet space. This unit was connected to an external hygrostat to have better control over the relative humidity. Since then, the relative humidity slowly dropped to levels around 55% in the room and below 60% in the bookcase, which reduced the mold risks sufficiently (Image 21).

DECISION-MAKING

The process of making decisions today is quite different than the way they were made in the past. Nowadays mitigating strategies have to meet more needs than the preservation of moveable objects only. Obviously the (architectural) values of the historic house have become more important in weighing alternatives, but also sustainability aspects like energy consumption, available long-term budget, and knowledge within the organization have become more and more relevant. All of this must now account for global climate change, not only in terms of its effects on indoor climate control strategies but the threats increasingly extreme weather poses for buildings and collections. This requires the organization to design a project that allows addressing

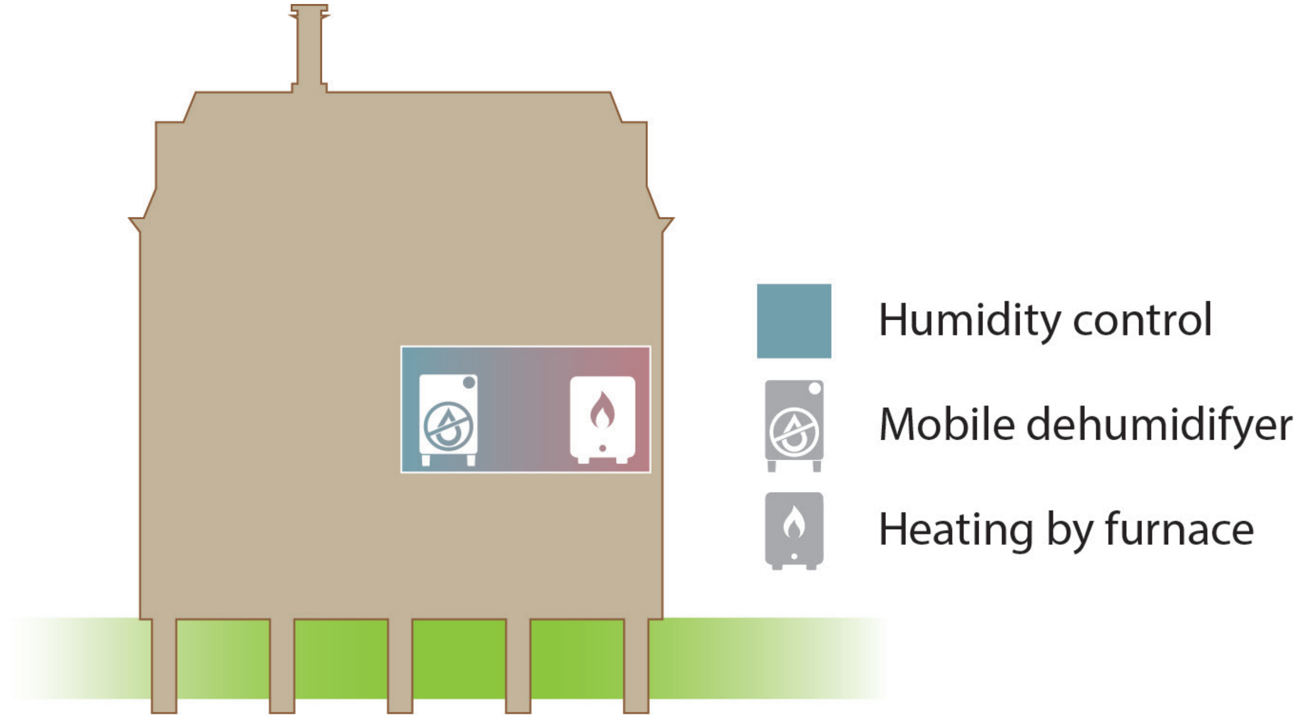


IMAGE 21. The climate control strategy of the Witsenhuis. After careful study of the effect of different passive measures to reduce the risk of mold, a mobile dehumidifier was installed. Bart Ankersmit

these considerations in an inclusive way to ascertain the optimum solution that best fits the organization, the building, and the collection.

DISCUSSIONS AND CONCLUSIONS

For each of the cases described above the challenges and solutions are summarized in Table 1. Based on the rough general evaluation of these case studies some observations can be made:

- **Balanced values.** While in the past a building was seen as a container to show and preserve objects, today it is recognized as a valuable asset. When the staff realizes that their building should be approached like their most precious painting, they are much more willing to stop drilling holes, hammering in nails, or install ducts—especially since most of these actions involve major and often irreversible changes that impact the cultural value enormously and often includes invasive measures to the historic fabric to withstand climate extremes. For historic house museums this is not recommended.
- **Integrated teamwork.** A "national individual consultant" is risky as a best practice—a "one size fits all" approach is most likely to be developed. One person is hardly ever able to bring in all the knowledge needed, add new knowledge, and encourage a collaborative approach that enables bridging the gaps between knowledge fields. Acting in networks, and sharing ideas and exploring alternatives together, will greatly help finding new solutions for old problems.
- **Sufficient time.** Time is required to find the optimum. If projects are pressed for time, this is most likely the highest risk factor in terms of falling short. Finding the optimum solution in complex projects like those involving a historic house takes time and a high quality of expertise and knowledge.
- **Meticulous monitoring.** It used to be normal to rely on climate control systems to preserve moveable collections. Nowadays we know that in historic house museums the formulated climate specifications seldom are met. Monitoring is key in knowing the current indoor climate and thus knowing if the defined specifications are being achieved.
- **Convincing evidence.** Although the indoor climate might feel improved, this does not mean that it actually is. But sometimes also the reverse takes place when systems malfunction. Martena and Heeswijk showed

Year	Case study	Challenge	Solution
1996	Heeswijk Castle, Heeswijk	Presenting a mixed collection	Full HVAC for one room and some control (HVAC) in others
	Museum Martena	Reducing energy consumption	Shut down HVAC, lower winter temperature, and stand by humidifier
2006	Our Lord in the Attic, Amsterdam	Too warm in summer and too dry in winter; condensation on windows	Adjust temperature and relative humidity setpoints in winter; allow low winter temperatures; exhibit susceptible objects in annex.
2010	Amerongen Castle, Amerongen	Due to flooding, relative humidity is high and house feels damp.	Low-temperature floor heating in cellar and ground floor.
2011	Museum Oud Amelsiweerd, Bunnik	Susceptible wallpaper in authentic historic house that will become museum	Separate house into three different climate zones: ground floor: low temperature + humidity control, first floor: temperature + relative humidity control, second floor: temperature control
2017	Hof van Heeckeren, Zutphen	Creating museum and meeting strict loan requirements	Seasonal adaptations for climate in museum, temporary exhibits in a room with separate HVAC system
2022	Witsenhuis, Amsterdam	High relative humidity causing mold	Long-term monitoring resulting in dehumidification

TABLE 1. The case studies with their challenges and solutions.

that the indoor climate does not become significantly more risky when (part of) a system is not in operation. Monitoring of the state of the (moveable) collections is the ultimate proof if preservation objectives are being achieved.

This paper only describes a very limited number of climatized historic houses in the Netherlands. This overview shows that each historic house deserves a careful process of decision-making before intrusive solutions are implemented. Changing the hygrothermal balance in a historic building is not without risk. Although an HVAC might initially reduce the occurrence of short fluctuations, seasonal variations often cannot be completely prevented. The overall effect of an expensive all-air system is often rather limited.

When aiming to implement sustainable solutions to reduce energy consumption, one of the options is to reconsider the specifications for relative humidity and temperature and seek alternative approaches to what is commonly used in museums. Passive control by thermal capacity, shading devices, and hygric buffering, or active means like smart ventilation, can significantly reduce energy consumption.

The most general conclusion that can be drawn is that many moveable objects in our historic houses have survived remarkably well in conditions that were far from the classical ideal, which shows us that strict climate specifications for objects are not required per se. It is essential to realize that a single universally safe relative humidity value does not exist for the preservation of this valuable heritage, and that sacrificing the building to preserve an “ideal” that is proving to be highly questionable is not sensible.

Summing up, defining indoor climate specifications takes time; the numbers should be critically evaluated and (re)considered. Different stakeholders will have different ideas, and only by working together can the optimum specifications can be found. This means that attention will have to be paid to the process that will lead to the specifications.

Solutions for indoor climate challenges in historic house museums are similar to solutions for global climate change.

Provide a safe environment where it is most needed: close to the objects. Display cases and microclimate boxes should be (re)considered more seriously. Careful design of climate zones is needed, as is realizing a strict museum climate might not be required 24/7, every day of the year, in all spaces. Often one room/zone can accommodate loans, and managing the climate in this room should be flexible enough to achieve the highly varying loan conditions. Nowadays more museums study the effect of temporary shutdowns of HVACs (Linden 2012). The results show that depending on the building physics a nightly shutdown often does not create excessive relative humidity fluctuations, but does significantly reduce energy consumption.

In Museum Martena the organization depended on a large all-air system. Because of that linear thinking the museum almost went bankrupt after only five years. It can be assumed that many museums and historic houses in the world face the same challenges if the primary focus is on maintaining strict specifications without realizing that objects are more resilient, and budgets can be spent far more wisely. Given that temperatures will rise due to climate change, it is expected that a low relative humidity, always occurring in winter, can be managed more easily because the need for heating will reduce. High temperatures in summer will be a challenge. Museums should not maintain the same temperature throughout the year and allow a seasonal temperature fluctuation, even considering an indoor temperature higher than allowed in most museums today—especially since cooling for human comfort will become even more expensive when energy prices increase. Perhaps alternative energy sources, such as solar panels, can in some cases provide the required energy.

Finally, the shift that we observe in indoor climate control in the Netherlands is that designs become more problem oriented, and evidence based, with a focus on climate data and hygrothermal modeling. Solutions for indoor climate challenges in historic house museums are similar to solutions for global climate change: integrated teamwork, sufficient time, meticulous monitoring, and convincing evidence to make sure what is designed and implemented is sustainable. Unfortunately, an assessment of how resilient the historic house museum is to climate change, following implementation of climate control strategies, is not part of the decision-making thus far. Today we have a focus on sustainable solutions with a strong focus on energy consumption. It would be very beneficial to broaden this scope to include climate change resilience.

ENDNOTES

1. A detailed description of this research can be found on the Getty website: https://www.getty.edu/conservation/publications_resources/teaching/case/olita/index.html.
2. The authors employ the European usage of the term, in which “first floor” means the floor above the “ground floor” (as opposed to US usage, where the terms are interchangeable), and so on.

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