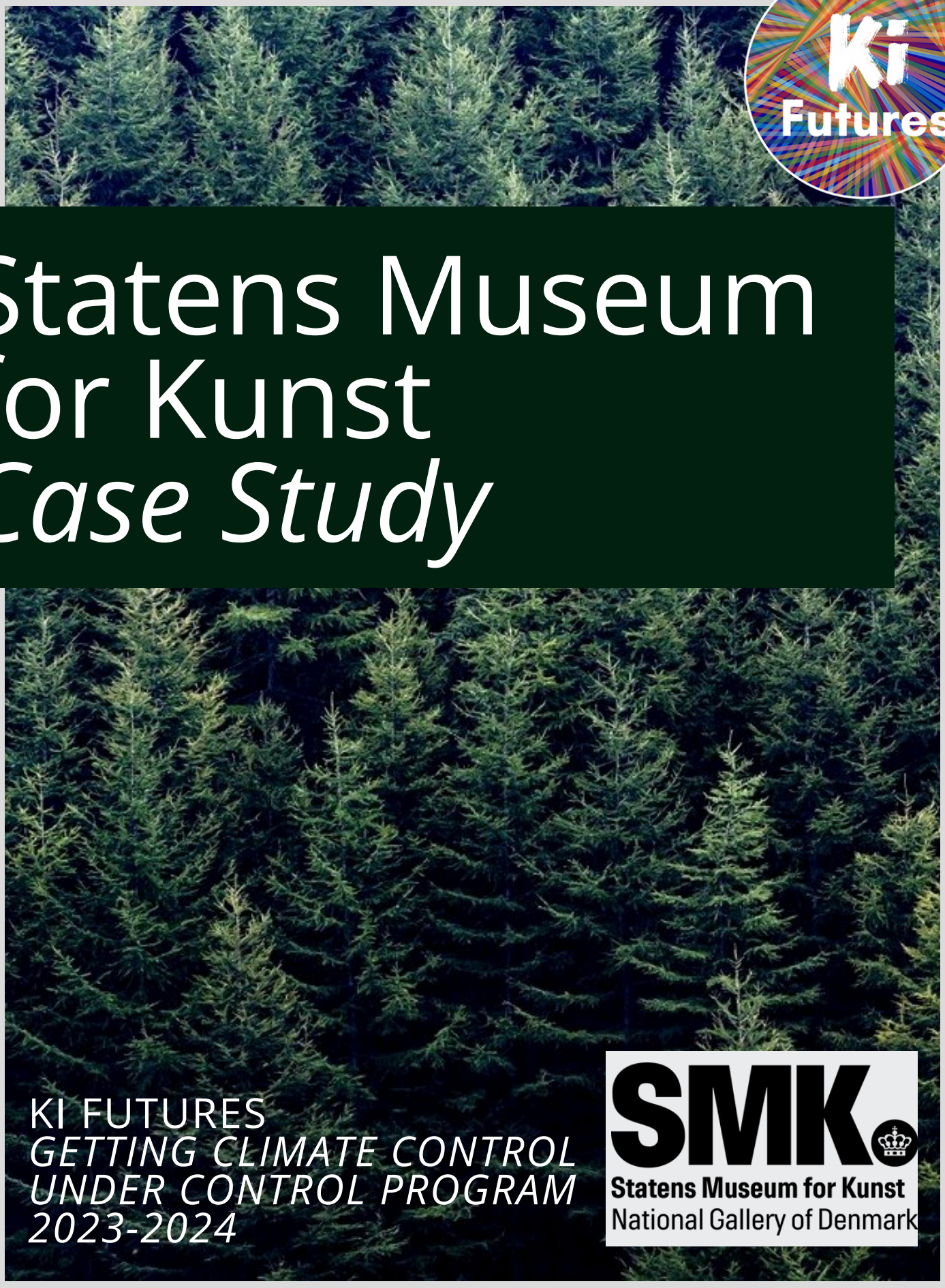

Statens Museum for Kunst *Case Study*

KI FUTURES
GETTING CLIMATE CONTROL UNDER CONTROL PROGRAM
2023-2024

SMK
Statens Museum for Kunst
National Gallery of Denmark

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Introduction & Background

SMK – National Gallery of Denmark is the largest art museum in Denmark and is also the so-called 'main museum' for visual art in the country. This gives SMK a special responsibility for helping to nurture and develop museum activities in Denmark and for cultivating and strengthening cooperation with museums in Denmark and abroad. The collection, comprising over 200,000 works of art, was originally founded as the royal collection, meaning that it was the private property of the Danish kings, but with the introduction of democracy in Denmark in the mid-1800s, the king's art collection was given to the people. That gift eventually became SMK.

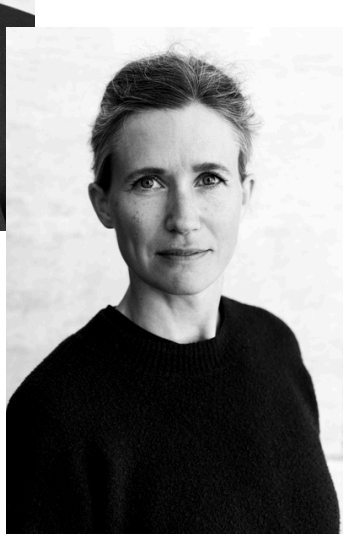
To preserve this collection for posterity is a great responsibility, and in light of the climate crisis it is also a problematic responsibility. With a sizeable collection and a building of more than 30,000 m2 in the centre of Copenhagen, SMK has a significant energy use. Adding to this is a very complex building mass consisting of two main parts, one from 1896 and one from 1998, with each of their challenges typical for their time. The old part of the building has drafts and leaks, the new building has an open space distribution, large window surfaces and high ceilings. The two buildings are connected by a 'sculpture street' which has a glass roof. All contributing to difficult indoor climate conditions and high energy use, especially when trying to maintain museum conditions.

It is clear that SMK, and art museums in general, has to find a way to solve the task of preserving art works for posterity in a more environmentally sustainable way. Therefore it was a very welcome opportunity to take part in KI Futures' Climate Control programme.

Stakeholder Involvement & Resources Utilized

To work with change, which working with Ki Futures Climate Control programme is, demands participation across the organisation. For the project SMK set up a working group, which includes four conservators from the preservation department, including the Head of Conservation as well as conservators in charge of outgoing loans, the green transition project manager and two staff members from The Agency for Culture and Palaces. Other key members of museum staff were included throughout the process, when necessary, and the entire staff has been regularly informed about the project.

Inger Smærup Sørensen, Green Transition Project Manager &
Pil Rasmussen, Head of Conservation



Project Team

- **Head of Conservation**
- **Head of Registration**
- **Conservators for outgoing loans**
- **Green Transition Project Manager**
- **Staff from The Agency for Culture and Palaces**

Objectives

For storage and exhibition of the collection, SMK has been adhering to ICOM-CC and IIC's Declaration on Environmental Guidelines as well as the Bizot Green Protocol for about 10 years, which is a series of evidence based guiding principles and new standards for energy efficient environmental control, shaped by the expertise and practice of museum professionals across the museum fields (ie. restoration, conservation science, facilities management, security, registrars, exhibitions, sustainability managers). When lending works of art to other museums SMK refers to these guidelines with a range of 40-60 % relative humidity and a temperature of 16-25 ˚C with fluctuations of no more than ± 10% RH per 24 hours within the range. However, loans often come with demands of a more strict climate control, which leads to a more tightly controlled environment with higher energy use in spaces used for temporary exhibitions. Continued use of the Bizot guidelines was maintained for the pilot program.

Because of an ongoing dispute/litigation regarding renovation of the HVAC system, it is currently not possible to adjust the basic control mechanisms, which would have been the desired approach to participation in this programme. The only experimental approach in the meantime was shutdowns of the HVAC units.

Due to the complexity of the building and the ongoing dispute/litigation, SMK decided to concentrate experimental efforts on shutdowns of the HVAC in two main types of area; an

Objectives

exhibition space with several adjacent rooms of different proportions, exterior walls and windows that is being used for different activities and outreach programmes; and a collections storage room with less human activity. These areas were chosen to test how far the limits for lowering the energy consumption of the HVAC system could be pushed against a “maximum pressure” area and an area with more stable conditions. Both areas are located in the old part of the building.

In addition to the general objective of testing the building’s ability to keep a stable climate for a limited period of time without the help of the energy consuming HVAC system, it was also important to gain more knowledge about the building and the climate control system, to identify barriers and find new ways of cooperation across the organisation and with The Agency for Culture and Palaces, which is responsible for a large part of operations at SMK, including performance of the HVAC units.

- **Continued use of Bizot**
- **Test shutdowns of HVAC units**
- **Gain knowledge about building, systems, and behavior**
- **Identify barriers**
- **Inter-departmental and external partner cooperation**

Methodology & Process

The experimental programme for shutdowns began in early January 2024 and included four cycles in two test areas, initially planned as shutdowns of three hours, six hours, and finally 11 ½ hours overnight. The idea was to gradually assess any impact of the shutdowns when staff was at work and able to intervene, and if/when everything looked safe, to shut down overnight when conditions were expected to be best suited. However, the first shorter shutdowns in January proved to have little to no effect on the indoor climate in the test areas, and it was decided to focus solely on longer nightly experiments after this point. The timing of each test was planned according to the outside weather conditions to get typical data for all four seasons in Denmark.

As preparation for the experiments a number of art works were thoroughly documented photographically, so that conservators could observe the pieces throughout the project. Measuring points for climate data were set up with both horizontal and vertical distribution in the chosen test areas. Data loggers were used instead of the HVAC sensors that normally govern system regulations at SMK. T/RH has been logged in a band along the walls where the paintings are hung. The measuring points are at 1m, 2m and 3m (Tinytag view 2) to record any layering in the rooms and loggers were placed in the corners and at the middle of the walls. The HVAC system in SMK consists of 45 ventilation systems and 15 extraction systems. The ones that were chosen for the Ki Futures Climate Control Programme were VE21, which controls exhibition areas 221 to 226 and VE26, which controls collection storage room M14. VE21 is a Swegon Silver model M11, which can humidify and dehumidify and can regulate between 0 – 100% recirculation. The system is designed to deliver an air volume of up to 10,800 m3/h and regulates the air volume as needed. Blow-in nozzles have fixed settings and the system is controlled from the CTS system. VE26 is a Swegon Silver model M9, with roughly the same capabilities, except that it is designed to deliver an air volume of up to 6,730 m3/h.

Program Implementation & Monitoring Process

Temperature and humidity readings were evaluated after each cycle, and as they showed no alarming trends, no follow-up action was needed. On one occasion the wrong HVAC unit was turned off due to a human error, but fortunately weather conditions were similar the following week and we were able to repeat the trial.

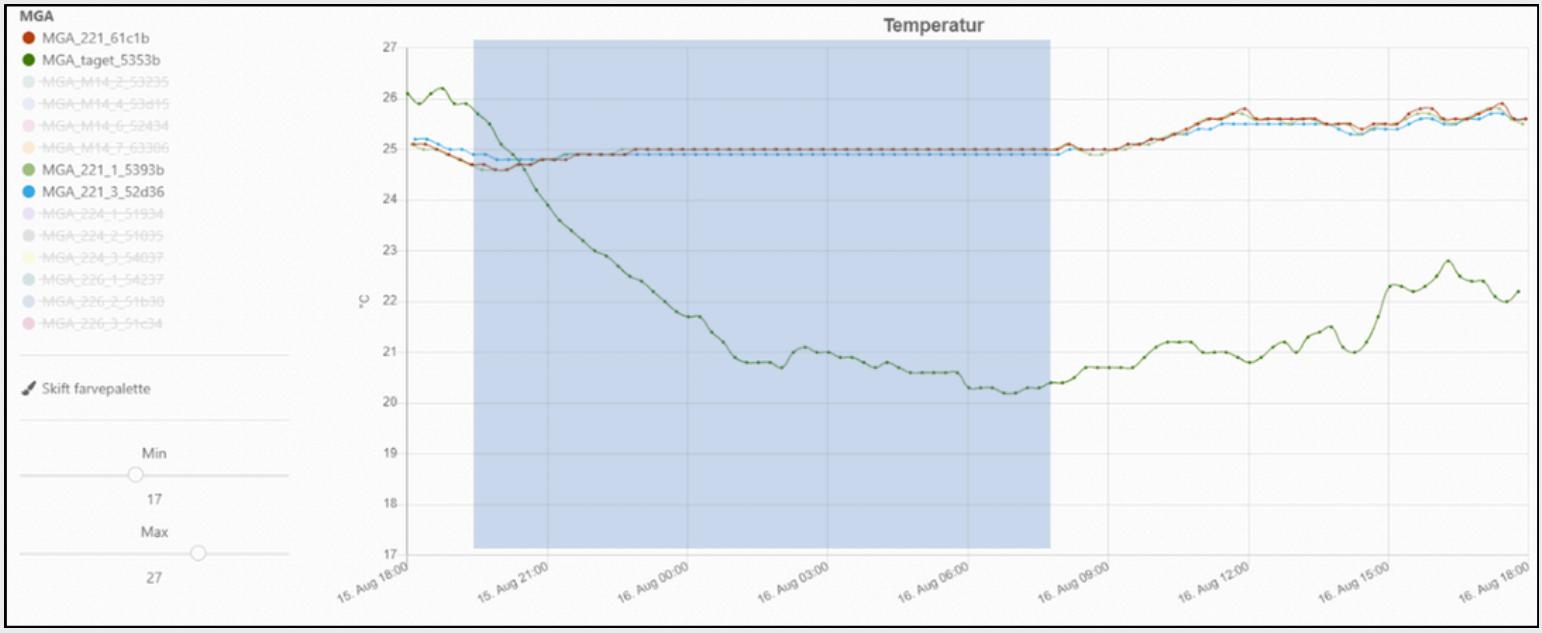
Since the sensors in the HVAC ducts were of no use without normal airflow, staff depended solely on the data loggers on the walls during shutdowns. The only staff members at work overnight are night guards, so alarms from the loggers were set up to send a text message to them in the control centre. This was set up for each shutdown and provided a prompt to contact the off-site service supplier for the HVAC system to turn the unit in question back on remotely, a service being paid for by the hour should the need arise. This was only activated once and turned out to work according to plan. In the long run, of course, this would not be a sustainable solution, as the many steps make it vulnerable and it requires too much coordination. Therefor it has been decided that logger data is sent directly to green transition project manager at SMK, who can decide when to involve the off-site service supplier.

The conservators chose a number of artworks to be monitored throughout the process, including works of art on parchment, wood, and canvas, as well as a wooden sculpture. As the shutdowns were in actual exhibition and storage areas the idea was to monitor the objects we expected to be most reactive, i.e. possibly showing any signs of change along the way and providing a sort of ‘canary in the mine’ for the rest of the artworks in those areas. Artworks were checked regularly and documented before and after the trial period, mainly photographically. Objects showed no signs of damage.

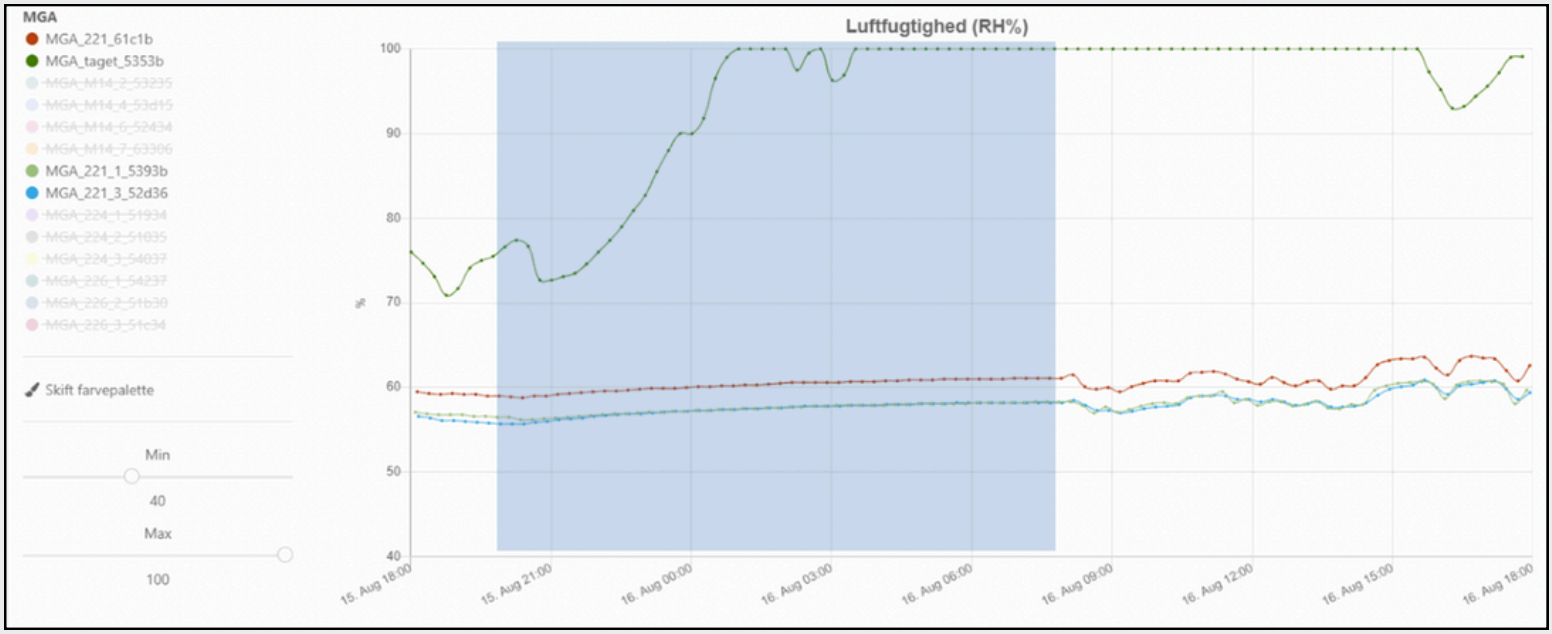
Outcome: Impact & Results

The main result of the experiments that SMK made as part of the Ki Futures Climate Control programme is that nightly shutdowns of the HVAC in the tested areas have had no significant influence on the indoor climate. An example is the controlled shutdown of the HVACs at SMK from 20.00 15 August to 7.30 16 August. The graph showing fluctuations is showing the outdoor climate (T/RH), the period for the closedown is marked in transparent blue.

Exhibition hall 221 (VE21)



Exhibition hall 221 (VE21)



The temperature for the three loggers positions (1m, 1,8m, 3m) show a high but steady temperature at approximately 25°C for the whole closedown period. The RH showed 55,7%-58,9%. RH rises slowly, approximately 1% for the whole closedown period. There is no doubt that for longer periods the climb in both T and RH would eventually exceed acceptable limits, but for around 12 hour periods overnight the rise is so slow that it seems possible to safely turn off controls. In conclusion the closedown of 11 ½ hours overnight does not seem to have much effect on the indoor climate. Possibly, on the contrary the climate seems to become more stable because the HVAC does not turn on and off, according to its setpoints.

This example was particularly important for decision making, since it was a very warm night with a humidity of 100 % outside, which is a great challenge to the building. At an early stage of the experiments it was concluded that very low temperatures were not a great problem in the old building, but the working group felt convinced that heat would be a greater problem. So as a result of these experiments it was decided to recommend the board of directors to introduce nighttime shutdowns of the HVAC system in the areas in question every night, which they decided to approve of. It is still too early to measure the exact results of closing down the system every night, but significant savings are expected and this approach can most probably be implemented in other areas of the old building as well.

Next Steps

It was clear from the beginning of the project that it would not be possible to get all the necessary knowledge within the time frame of the project. Therefore future experiments and shutdowns in other areas of the museum were planned early on with help from the coaches from Ki Futures Climate Control programme. SMK will continue doing controlled tests taking one area of the museum at a time, so that there will be enough human resources to monitor the process and time to analyze the results. These tests will begin in the autumn of 2024.

As part of the project a more comprehensive mapping of the HVAC systems at SMK was made, illustrating the unfortunate zoning of the systems. It will be a larger economic challenge to change this zoning, but documenting it is important for the process of systematization of knowledge and the mapping can also be used to discuss how to use the different spaces in the future. Learning to work *with* instead of *against* the building is essential in any case for an increasingly sustainable approach to facilities management.

Working with the coaches have made it clear that SMK, in addition to doing shutdown testing, should invest in more data loggers placed strategically in the rooms, instead of relying solely on the CTS sensors that are placed in the ventilation ducts, and which, as was expected, give a quite imprecise picture of the actual temperature and humidity in the spaces holding artworks. It was also recommended to consider working with AI, when the dispute/litigation is over and the HVAC system is fully adjusted. AI would be helpful in gaining more knowledge about the building and its reaction to different circumstances, and knowledge is key to reducing energy usage.

Conclusion

Even though we as a museum know our building well and monitor temperature and humidity every day, there are still surprises. It is important to seek knowledge, t0 discuss findings across subject boundaries and departments in the museum and make the building and the climate within the building a topic of priority. Creating awareness about energy consumption throughout the organisation, is also a way to create awareness about the conservation task, which is so essential to sustainable museum operations and even more so with the huge weather challenges that we now see due to climate change.

Statens Museum for Kunst

OVERVIEW

Geographic Location: Copenhagen, DK
Number of Staff: 120
Number of Annual Visitors: 600.000

BUILDING

Description: Original building 1986, with a modern addition built in 1998, neither of which are airtight building envelopes.
Size: 39.174 m2

COLLECTIONS

Description: SMK owns the nation's largest art collection, comprising over 200,000 works of art.

ENERGY SAVINGS

N/A

During the project SMK has only been able to test and is therefore not able to show concrete results. However it has been decided to have nightly shutdowns of 2 of 45 ventilation systems, and as soon as possible begin testing on an additional 4 ventilation systems, in the hope that these tests can lead to a larger number of systems being shut down every night.
It was clear from the beginning of the project that it would not be possible to get all the necessary knowledge within the time frame of the project. Therefore future experiments and shutdowns in other areas of the museum were planned early on with help from the coaches from Ki Futures Climate Control program.

It has been fantastic for SMK to take part in the KI Futures Climate Control program. Even though we as a museum know our building well and monitor temperature and humidity every day, there are still surprises. It is important to seek knowledge, to discuss findings across subject boundaries and departments in the museum and make the building and the climate within the building a topic of priority. Creating awareness about energy consumption throughout the organisation, is also a way to create awareness about the conservation task, which is so essential to sustainable museum operations and even more so with the huge weather challenges that we now see due to climate change.

PILOT ACTIONS

Nightly HVAC system shutdowns tested

- **12 hour shutdowns most effective**
- **3 galleries + 1 storage space tested**

TARGET AREA	BEFORE PILOT	AFTER PILOT
Climate Control Parameters	Bizot	Bizot
Loan Agreements	Bizot "SMK follows the BIZOT-guidelines and the ICOM-CC and IIC Declaration on Environmental Guidelines (2014) to ensure the safety of the art works, while seeking to reduce the environmental impact. Relative humidity in exhibition and storage spaces is to be maintained between 40% and 60%. It must not vary by more than 10% in any 24 hour period. More sensitive objects will require specific and tighter RH control, depending on the materials, condition, and history of the work of art. A SMK conservator's evaluation is essential in establishing the appropriate environmental conditions for the works of art requested for loan."	Bizot SMK's loan agreement highlights what their own practices are, rather than stating requirements and includes environmental considerations. Additionally, a bespoke approach clearly states that a conservator is required to determine the appropriate environmental conditions for an object.
Energy Consumption	Energy usage 2023 for Sølvgade: Electricity: 2.246 MWh District heating: 3.641 MWh District cooling: 2.087 MWh Water: 8.035 m3 Energy usage 2023 for warehouse building: Electricity: 38,1 MWh District heating: 300,4 MWh Water: 31,6 m3	Unchanged
Facilities	HVAC ranges cannot be adjusted Running HVAC systems 24/7	Nightly shutdowns in gallery spaces

SMK plans to implement the proven HVAC system shutdown protocols in other parts of the building.The team has a clearer understanding of how the building is behaving and the facilities, registration, and conservation teams are working together for future collections care strategies and advocating with international communities.
Head of Registration, Thor Nørmark-Larsen, has created a declaration for registrars which will be presented at the 2024 ERC in Rome, Italy.

Declaration for Registrars

HVAC Nightly Shutdowns

Ki Futures

SMK
Statens Museum for Kunst
National Gallery of Denmark

Getting Climate Control Under Control

Danish Cohort

May 2023 - December 2024

articheck

DANSKE MUSEER ORGANISATIONEN

AUGUSTINUS FONDEN

SMK Statens Museum for Kunst National Gallery of Denmark