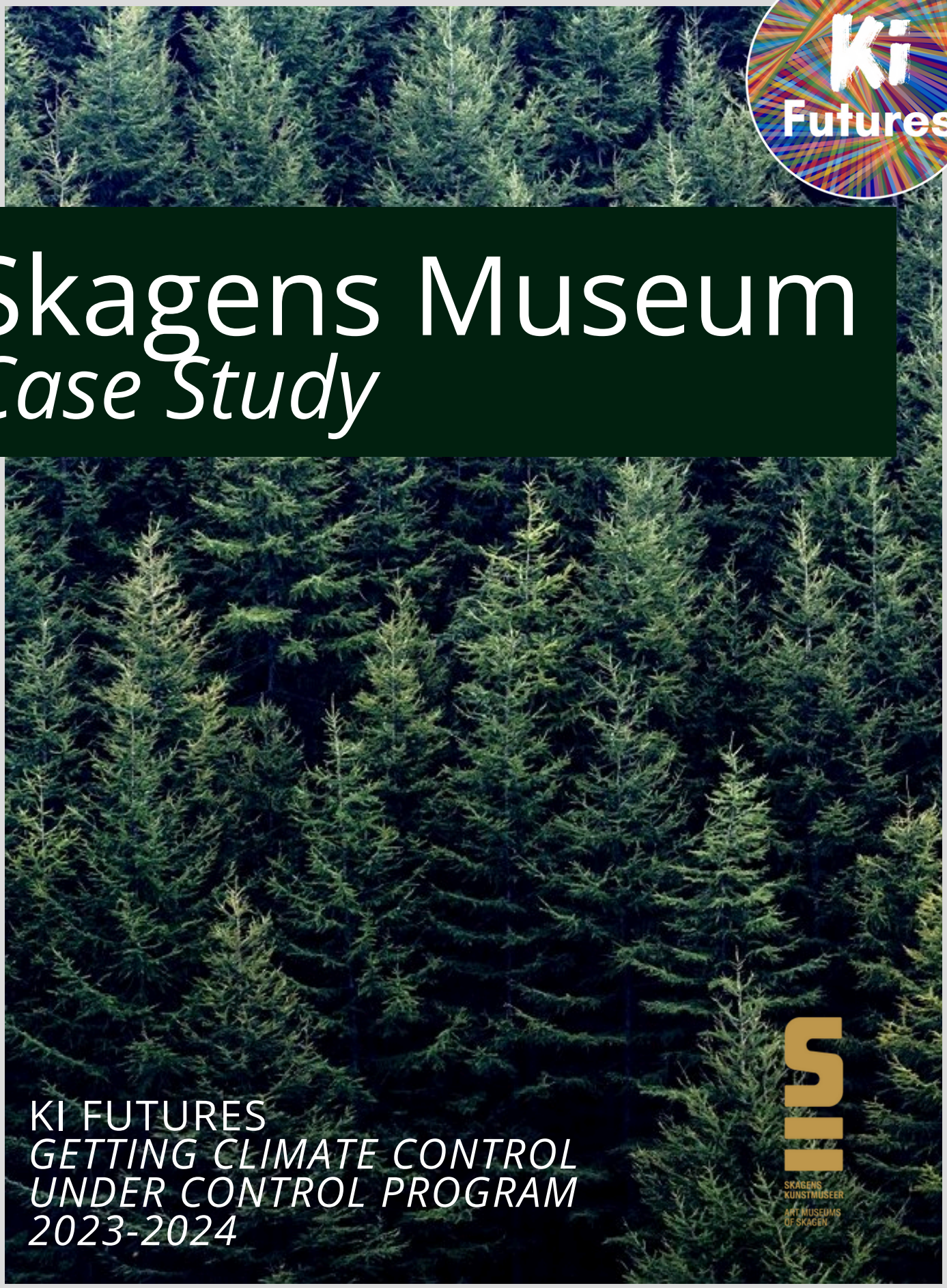

Skagens Museum
Case Study

KI FUTURES
GETTING CLIMATE CONTROL UNDER CONTROL PROGRAM
2023-2024

SKAGENS KUNSTMUSEER
ART MUSEUMS OF SKAGEN

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Introduction & Background

Introduction
Skagens Museum is an art museum located in the historic fishing village of Skagen at the most northern part of Jutland in Denmark. The collection is based on the artworks and legacy of Scandinavian artists who established an artist's colony in Skagen between the 1870's and 1930's.

Background
The collection at Skagens Museum is mostly artworks on canvas, wood or paper. Some artworks are also sculptures and arts-and-crafts stoneware as well as some furniture and artist's materials which were owned by members of the artist's colony.

The museum was founded in 1908 by key members of the artist's colony and supporting patrons. The museum exhibited on various sites in the town until the current museum building opened to the public in 1928. The original red brick building had smaller extensions built in 1982 and in 1989 as well as a larger modern slate tiled extension in 2015, with a dedicated space for temporary exhibitions, new museum storage, offices and a conservation studio.

The museum is heated with district heating by underfloor heating and some water-borne radiators in office spaces and corridors, museum shop and conservation studio. In the modern extension where museum objects and artworks are kept in the gallery and storage, the heating is done by air-conditioned ventilation.

The whole building complex has six different HVAC-zones controlling the indoor climate in the museum, needing substantial amounts of energy. Especially two oversized cooling units demand large amounts of energy.

Before the climate control project started, the parameters in-house and stated in the museum's loan conditions were: 50% RH +/- 5% per 24h, which specifically should be understood as in the range between 47,5 and 52,5% RH. Temperature should be between 18 and 23 Celsius with a maximum fluctuation of 2 degrees per 24 hours. Humidity and heating control systems had to run 24 hours a day.

Stakeholder Involvement & Resources Utilized

Skagens Museum's main project team has been the manager of facilities and security and a paintings conservator. The team also included the museum's registrar during parts of the project. In addition to this, the loans committee as well as the museum's managers were involved in approving the new parameters for internal climate control as well as for loan conditions.

With an increasing interest amongst some staff members about the importance of sustainability, the invitation to take part in the project came at the right time to start tackling some of the challenges involved with energy efficient climate control. The project team was formed based on a mutual understanding of the need for more sustainable practices at the museum. At the same time, the museum was also undergoing some changes in organization and a generational change of manager of facilities and security, which made it possible to adapt a more pragmatic approach to climate control as well as making it easier to prioritize participation in the program.

Michael Karred Jensen and Tor Erik Skaaland

Project Team

- Manager of Facilities & Security
- Paintings Conservator
- Registrar
- Loans Committee
- Museum's Managers

Objectives

The main objective was to bring down the energy consumption used by the HVAC-systems in the building, as well as getting a more systematic approach to understanding the building and its indoor climate.

From a conservation perspective, there was also an opportunity to address parts of the old building with problematic and rapid fluctuations, due to sun and heat during the summer and condensation in the colder winter months. It was necessary to look at efficient ways of stabilizing the indoor climate in certain areas of the original building, as the HVAC and ventilation in these areas did not work as intended in delivering a stable indoor climate.

- **Lower energy consumption**
- **Systematic approach to understanding the building and its indoor climate**
- **Address problematic climate areas of the museum**
- **Stabilizing indoor spaces**

Methodology & Process

Dataloggers called RoomAlyzers from IoT-fabrikken were placed at strategic places throughout the building. Firstly, they were used to collect data at the level of paintings in the exhibition galleries, but also to compare measurements and performance of the climate control and CTS-system. One RoomAlyzer sensor were also available for CO2 monitoring in the temporary exhibition space.

The CTS-system, which is also collecting and storing data, although less accessible to download or use for statistical purposes, has been used to get daily insight into the climate control, HVAC-systems and its performance as well as energy consumption. It has been especially useful to assess situations and effects before and after implementation of changes to the climate control.

More “official” numbers from various bills and the meter readings from the energy provider were also provided from the museum’s administration.

Five canvas paintings were selected to be condition checked and documented. They were picked because of challenges due to structural conservation history as well as they all were displayed in the old building where fluctuations were expected to be most extreme. All the paintings have gilded frames. Condition reports were made based on the museum’s pdf-form, but Atricheck’s app was also tested as a report format, photography and on visual examination of the objects in the galleries before, during and after changes to the climate control. Two paintings were later removed from the galleries due to a curatorial change.

Program Implementation & Monitoring Process

Initial monitoring by the dataloggers showed that the temporary exhibition gallery and storage in the modern extension could achieve a very stable environment in the above-mentioned range of 47,5 to 52,5% RH and a stable temperature, while the old galleries had fluctuations between 44 and 65% and 16 to 26 Celsius.

The museum's new parameters for climate control were agreed to be in the interval between 40–60% RH with fluctuations of maximum +/- 10% within a 24h period. The temperature must be stable between 16°C and 25°C, and frequent fluctuations must be avoided. The agreed new climate control does not require 24-hour operation, which enabled experiments with nightly shutdowns.

The first changes were introduced in September 2023 after coach Jacob's site visit, with reduction of overnight intake of air from the outside and less air flow. But more major changes to the climate control were first implemented from January 2024.

From September 2023, adjustments were made to the air-conditioning and ventilation in non-collection areas, like offices, hallways and the museum shop. It was started to observe and monitor how the modern building and HVAC-system responded to nightly shutdown. The indoor climate in these areas responded well, making us confident that some form of night mode or shutdowns could be possible in collections areas.

The temporary exhibition gallery in the modern extension, is where first tests of new settings and night mode at the ventilation, by recycling the air during the night were started from November 2023. This had promising results, at least for the kWh as well as maintaining a stable climate. Later, in January 2024 we felt confident the modern gallery could be without ventilation, and we introduced a full nightly shut down of 13 hours of the HVAC-system in the area.

During February 2024, there was an incident with the HVAC system, where new air-conditioned air was not introduced to the gallery, as a fire damper had been kept shut after an automatic test. This went on for nearly two weeks without anyone noticing it, because of the stable RH and T, all within the agreed new parameters. It went on undetected because the CTS-system did not activate any alarms as the RH and T were stable in range of 40 and 60% RH range and temperature range. The incident was thought provoking but made us confident that the gallery could maintain a good indoor climate in terms of RH and T, even with 13 hours shutdown of the HVAC-system going forward. The massive concrete walls and thick timber floors in the modern extension might make the temporary exhibition space able to buffer some of the more extreme fluctuation of the outdoor environments.

The incident with the shut fire damper (shutters), led us to investigate the CO2 levels in the gallery. At peak time for two days, it went above the recommended limit, but on most days, the room was able to maintain a good indoor climate. Going forward, we are planning to introduce CO2 censors in the HVAC system and introduce a new parameter in which we adjust the ventilation.

Parallel to the changes in the temporary exhibition gallery, the old part of the building was also tested. From September 2023, it was evaluated if the HVAC-zone including the museum galleries in the old part of the building could manage a reduction of airflow at night to 30% as well as having the air recycled, instead of using fresh air from the outside.

From January 2024, the automatic fire doors (non-security doors which closes automatically in a case of fire) separating the side galleries from the main galleries in the old building were left open during night. It was discovered that the reason for the unstable environment and condensation partly was that the automatic fire doors negatively interfered the intended air flow from the smaller side galleries to the main galleries. Adjusting air flow in the building, both reducing the volume of air allowed into the building by the HVAC-system (ventilation speed at 30% during night as well as 0% fresh air) as well as looking at letting some automatic fire doors being left open, have resulted in a more stable environment for the paintings.

The climate control and setpoints in the CTS-system have been adjusted gradually throughout the project period to adapt to changes in season and after evaluation of precious implemented settings.

New windows and doors in some parts of the old building were already planned, but installed during the project period, which we hope to have had a beneficial effect on stabilizing the indoor climate in the old part of the building.

During the project, we looked at opening and closing procedures, as well as a policy for curtains and lighting policies in parts of the old building, because of the large windows which influence the indoor climate.

Outcome: Impact & Results

The climate in the modern extension has broader ranges of T and RH after implementing the new parameters, but it is possible to keep a relatively stable environment with less energy usage, amongst other things because of the large volume of air in the gallery space and the building materials, which might have a positive buffering effect on the climate during nightly shutdowns.

Ensuring better flow of air by passive means by keeping fire-doors open in the galleries overnight has resulted in a more stable indoor climate with less rapid fluctuations in the old part of the museum. The energy usage here is less than before, as the HVAC-systems does not have to compensate just as much for changes in weather and the day and night cycle.

The impact on the collection is not immediately apparent, as visual inspections of the paintings and the condition reports reveal no detectable damage that can be linked directly to the project. One wax-resin-lined painting was reported with slightly bulging during the summer, but at the time of the last condition reporting, it was back to a normal state. One minor crack was added to the condition report for the mentioned painting, but again, the evidence is not sufficient to conclude anything. Some changes to the ventilation have even resulted in a more stable environment in the areas where the selected paintings are exhibited.

Broader ranges

Better airflow

More stable environment with less energy

Next Steps

We did have ambitions to make changes to the cooling units during the project. The two cooling units seems to be over-dimensioned for the HVAC-systems and currently have the biggest demand for energy, especially during the summer. During the project we have tested if we could rely just on one at a time, instead of the two currently installed, but have not been able to make major or permanent changes to the cooling units yet. Even having one on stand-by uses energy. Going forward we want to investigate how we best can reduce the energy consumption of the cooling units, as this is one of the biggest energy consumers at the site.

Because of reduced air flow in some zones during the day as well as during the night, which have resulted in a more stable RH and T in the old parts of the building, CO2 sensors and measurements must be included in the setpoints and programmed into the CTS.

COOLING UNIT UPDATES

CONTINUED ENERGY REDUCTION

CO2 MONITORING & PROGRAMMING IN THE CTS

CONTINUED INTER-DEPARTMENTAL COOPERATION

Conclusion

The museum has updated the in-house climate control parameters as well as the terms and conditions for loans, resulting in a situation where saving energy has been possible.

Passive control of air flow between gallery spaces at night by opening some previously shut automatic fire doors ensured better air circulation, as well as nightly shutdowns or addressing air flow with reduction of ventilation speed and recycled air, have both stabilized indoor climate in parts of the building and reduced the museum's total energy consumption.

Energy consumption was reduced by 22%, which equals to a financial saving of 13% compared to the year before implementation of the first changes. The numbers of energy usage from the district heating are not included in the calculation, but this is also expected to be slightly less than from the time before the project started, because of a slight reduction of indoor temperature.

Regarding the condition assessments of the selected paintings on display, it was not found any damage or significant change in condition which could be directly related to the project or implementation of new climate setpoints at the museum.

By approaching the issues as a team, the collections staff and facilities staff have been brought closer to a collective understanding as well as better cooperation.

Key Achievements

Significant reduction of energy consumption and financial savings, which does not necessarily mean a harmful environment for the collection.

The project coincided with organizational changes at the museum, which made it easier to prioritize attending the program activities but also enable better cooperation between the various roles and adapt the new parameters for the climate control. Participating in the project has given a better collective understanding and cooperation across roles to solve the museum's challenges and the various needs for collection, staff and visitors.

13%

Saved 13% on their energy bill!

83.694,00 kWh

Energy Savings

22%

Energy Reduction

Lessons Learned

Getting to know the building and the various systems for controlling the indoor climate was a huge and ongoing process. It takes time to understand how everything works and functions, as well as how it all affects across systems, zones and throughout the seasons.

Better staff collaboration and cooperation (conservation and facilities alignment). The synergy effect of participating with other daily tasks has been very important. Focus on the dynamic and adapt.

The building and the environment are like a fine equilibrium. Climate control and modern buildings are complex, and it takes time and resources to fully understand changes, and for us, it has been difficult at times to separate the activities for the program and the daily maintenance.

Do not always trust the CTS-system and look at the bigger picture: compare with dataloggers and trust your instincts.

Recommendations

Access to data can be overwhelming and tricky (depending on the organization) and the potential amount of collected data will be huge, and without the right set of skills or tools to analyse and interpret the data, it can be a challenge to assess the progress systematically. We therefore recommend a more holistic approach which does not necessarily focus so much on numbers and statistics.

We were lucky and could test new parameters and HVAC-system changes during the project period because we did not have any exhibitions with loans at the time, which meant it was only our own collection at potential risk.

Before eventually doing changes to the air flow, for example by reducing the air flow or fresh air, it is wise to install CO2-sensors, preferably also with CO2-alarms in the CTS-system, as the reduction of air flow and/or bigger range of T and RH can impact the CO2 levels in some exhibition spaces at peak times. Before, we would have alarms telling us something was wrong because of RH or T was outside the narrow setpoints, which is not always the case anymore, and for us CO2 has been introduced as a third parameter which should be monitored. Which for us now, requires more regular checks of graphs and the CTS, as the alarms only let you know when the climate is outside the 40 and 60 range or if the temperature is off.

Be prepared for it to be a dynamic process and be willing to adapt to challenges/new situations. It will be an ongoing process, even after the project has ended, but hopefully new relations and understandings have been formed during the project in addition to energy savings.

Skagens Kunstmuseer Impact Report

OVERVIEW

Geographic Location: Skagens, DK
Number of Staff: 46
Number of Annual Visitors: 160.000 annual

BUILDING

Description: Original building from 1928. Extended in 2015 to include a temporary exhibition space, storage, offices and a conservation studio. Six HVAC-ventilation zones throughout the building.
Size: 917 m2

COLLECTIONS

Description: Paintings on canvas, wood and paper, drawings and letters, plaster casts as well as some cultural history objects from 1870s-1930s.

ENERGY SAVINGS

83.694,00kWh / 22%

The numbers are electricity consumption only, and district heating is not included.

CARBON REDUCTION

8,284 tCO2e

FINANCIAL SAVINGS

13%

By approaching the issues as a team, the collections staff and facilities staff have been brought closer to a common understanding as well as better cooperation. Changes have included addressing air flow and night mode with reduced ventilation for HVAC-systems, both stabilizing indoor climate in parts of the building and reducing the museum's total energy consumption.

PILOT ACTIONS

- **Agreeing on new climate parameters and setpoints.**
- **Nightly HVAC system shutdowns in office spaces.**
- **Experimentation with overnight shutdowns in exhibition space in modern extension.**
- **Experimentation with reduction to air flow and fresh air intake by the HVAC in original parts of the building**
- **Passive control of air flow by letting some previously locked automatic fire doors (non-security) previously shut between gallery spaces at night left open to ensure better air circulation.**

TARGET AREA	BEFORE PILOT	AFTER PILOT
Climate Control Parameters	50% RH +/- 5% per 24h, in the range of 47,5 and 52,5 RH. Temperature between 18 and 23 Celsius with a maximum fluctuation of 2 degrees per 24 hours. Humidity and heating control systems must run 24 hours a day. Temporary exhibition gallery in the modern extension could achieve this, while the old galleries had fluctuations approximately raging between 45 and 65% and 16 to 26 Celsius.	Refer to Bizot
Loan Agreements	- Air humidity shall be 50% RH +/- 5% within 24 hours. - The temperature shall remain stable at 20°C +/- 2°C within 24 hours. - All humidity and heat control are functioning 24 hours.	Refer to Bizot
Energy	378.078,00 kWh	294.384,00kWh
Facilities	HVAC systems ran 24 hours based on CTS measurements in ventilation system.	HVAC systems and CTS control adjusted to dataloggers in gallery spaces. HVAC systems adjusted to accommodate seasonal changes.

Capacity for more holistic approach.
Better understanding of HVAC and ventilation systems and building.
Better staff collaboration and cooperation (conservation and facilities alignment).

22%

Savings on Energy Consumption

8,284 tons CO2e

Carbon emissions savings

Getting Climate Control Under Control

Danish Cohort

May 2023 - December 2024