Natural ventilation in the Nordics

Compiling case studies from history till modern time

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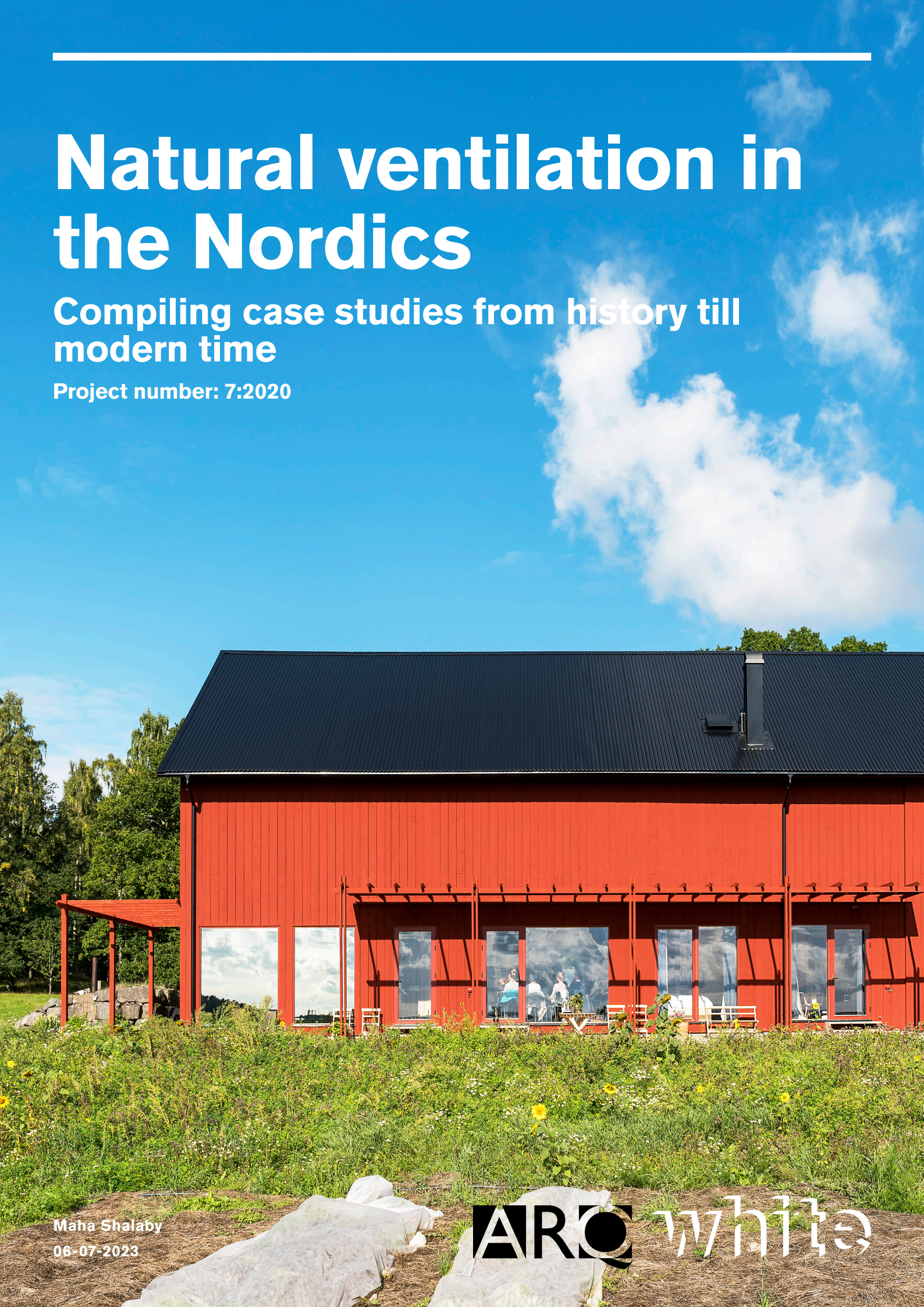

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Table of content

Introduction 3

Aim 4

Proposed research scope 4

Proposed scope 4

Case studies 4

- Gullhaug Torg 2A 5
- Powerhouse Brattørkaia 5
- Green lighthouse 5
- Harvard HouseZero 6
- 2226 Emmenweid 6
- Icelandic institute of Natiral History 6
- Ekolådan 7
- B&O Headquarters 7
- Villa Idun-Lee 7
- Ice House 8
- Mediå school 8
- 2226 Lustenau 8
- Active house 9

References 10

Introduction

The construction industry is reponsible for 39% of the global energy related carbon emissions, with 28% from operational emissions, which is energy needed for heating, cooling and for powering the system [(1),] and 11% from materials. With this into account, and considering that some UN reports already show that it is already hard to meet the 1.5 °C threshold set by the paris agreement in 2015 [(2)], there is a direct need to transition to zero carbon houses and even positive energy buildings and districts.

Since the majority of the carbon emissions in the construction industry is from operational energy, integrating natural ventilation in buildings is more important now in comparison to before. In addition to that, with the general need to reduce the carbon footprint of buildings, reducing the size and need of mechanical systems would accordingly reduce the building's carbon foot print (do we have references for that?). Natural ventilation in some cases has even shown to be more energy efficient in comparison to using mechanical systems, depending on the building's heat source [(3)]. In addition, research has shown that total energy consumption of buildings designed with natural ventilation is less than those with mechanical ventilation also because of people's living habits which has a big influence on the total buildings' energy [(4)]. In addition to that, the European environment agency has shown the prediction in temperature increase that can reach more than 6 °C in some areas in the Nordics, which supports the need to integrate natural or hybrid ventilation in new buildings tocope with the future weather changes.

Despite that, ventilation consultants in the Nordics are less eager towards implementing natural ventilation solutions in new buildings. This was illustrated through a recent survey (April 2022) that was carried out by the federation of European heating, ventilation and air conditioning associations with an aim to map input from different Swedish stakeholdershas focusing on the Swedish ventilation sector for residential buildings. The survey was answered by a total of 215 people, where 55% of them were professionals within ventilation inspection, 16% were different types of consultants, an 29% had other occupations [(5)]. The survey showed the following:

- The majority of the answers disagreed that natural ventilation would be a suitable ventilation strategy, and were more supportive of mechanical systems. This is because natural ventilation was asserted to perform worse in comparison to mechanical ventilation as the supply opening areas are not enough.
- Several people indicated a need to increase comptence in the building sector, not only to have sufficient knowledge in their own focus area, but to have a more holsitic approach towards other areas that affect indoor quality.

As a conclusion, while natural might be hard to apply in the Nordics due to extreme weather conditions, and the difficulties associated with controlling humidity, hybrid ventilation can still be an adequate solution, especially in mitigating future weather conditions. Nevertheless there has been some case studies in scandinavia where natural ventilation has been successfully applied, where this report will highlight some of them.

Aim

The aim of the study is to identify examples of buildings in the Nordics that have been designed with natural ventilation in focus. This report summarizes some references from Scandinavia but also from Europe. The report also outlines a proposal for a bigger application in the topic of natural ventilation, that would aim to provide scientific arguments regarding the succesful integration of natural ventilation in the Nordic countries.

Proposed research scope

This section describes the proposed research scopes that would be possibly implemented in an expanded research application to ARQ in addition to other research grants.

First Proposal:
A) Background part, discussing the importance of natural ventilation, especially with the global ambitions in the AEC (Architecture, engineering & construction) industry to reduce buildings' carbon footprint.
B) 2-3 featured projects with interviews of the main architects involved and the HVAC consultant.
C) Preparation, execution and documentation of a panel discussion with a reference group of natural ventilation specialists in Scandinavia and abroad.
D) Discuss the extent where hybrid ventilation be a way to cut carbon emissions from reducing the use of materials, operational energy and from changing or maintaining the HVAC system.

Second Proposal:
A) Background part, discussing the importance of natural ventilation, especially with the global ambitions in the AEC industry to reduce buildings' carbon footprint.
B) 5-6 projects (mainly from those presented in this document). The projects to be organized from most recent to older, the focus would be on Scandinavian projects, both from a research and practical perspectives.

Case studies

The following section summarizes 13 case studies, 10 of which are located in scandinavia. The case studies would be further evaluated in the expanded research application to identify the conducted research so that more scientific arguments can be presented.

Gullhaug Torg 2A

Architect: Snøhetta
HVAC consultant: Skanska
Building type: Housing, offices and restaurants
Area: 11,200 m2
Year: 2023
Country: Oslo
Environmental certification: ambition for BREEAM-NOR excellent for the office, and BREEAM_NOR very good for the homes.

The building was designed with three innovations in mind, building is operated without the need for purchased energy for heating, ventilation or cooling. It will also not have any mechanical ventilation system. The building will be ventilated by natural ventilation through openings in the facade that is controlled by an advanced system that operates based on the temperature and wind conditions. It will also adopt future technologies and products to reduce greenhouse emissions by 50% in comparison to a similar building [6].

Powerhouse Brattørkaia

Architect: Snøhetta
Building type: Office
Area: 17 800 m2
Year: 2019
Country: Trondheim, Norway
Environmental certification: BREEAM Outstanding certification
Awards: Fast Company Innovation by Design Awards 2020, Sustainability Category

This building is going to be the world's northmost energy-positive building. It produces more energy than what it consumed over its life span, including constriction, demolition, and the embodied energy in the construction materials. This includes increasing the envelope efficiency by insulation, intelligent solutions for airflow to reduce the need for eating, heat recovery solutions for ventilating air, using seawater for heating and cooling, and using energy efficient appliances. The building was designed so that it receives maximum sun exposure throughout the day and seasons. The roof and upper part of the facade are covered by 3000 m² solar panels approximately. The building's thermal mass also absorbs heat an cold which regulates the interior temperature [7] [8].

Green lighthouse

Architect: Christensen and Co Architects A/S
HVAC consultant: COWL
Building type: University building
Area: 950 m²
Year: 2009
Country: Denmark

Denmark's first Co2-neutral building has integrated daylight, renewable energy, intelligent materials as well as hybrid ventilation to meet its climate goals. The design uses 70% less energy consumption, minimizing its carbon footprint. Also, with hybrid ventilation, it was possible to maintain indoor comfort levels, as a backup system in winter brings in fesh air from outside. The system also allows heat recovery when it is not possible to solely rely on natural ventilation due to the weather conditions. This building is a succesful example of how natural and hybrid ventilation can be implemented in the Nordic countries [9].

Harvard HouseZero

Architect: Snøhetta
Building type:Office
Area: 4600 ft2
Year: 2018
Country: USA

Refurbishment of an exiting building, 100% naturally ventilated, and alsmot zero energ for heating and cooling (no HVAC system). The building adjusts automatically, 285 sensors collecting 17 million data points each day. Natural ventilation controlled by a window actuation system, sophisticated software and sensors that open and close the windows automatically to maintain the internal thermal comfort throughout the year [10].

2226 Emmenweid

Architect: Baumschlager eberle architekten
Building type: Office & administration
Area: 2196 m2
Year: 2018
Country: Switzerland
Award: 2022 Brick award, 1st prize, category 'working together'.

Refurbishment of an exiting building, historical significance, into a cost-effective building. With a ground-breaking energy concept for an office building, 2226 Emmenweid provides high levels of indoor comfort without heating, cooling or mechanical ventilation. Its name refers to the interior temperature: a constant 22 to 26°C. Temperature stability is achieved through double-skinned walls almost 80cm thick and the restrained use of glass. Achieve indoor temperature from internal gains by people, equipment and lighting. Sensor-controlled ventilation panels control temperature and CO2 levels and ensure a comfortable environment whatever the season [11].

Icelandic institute of natural history

Architect: Arkis
Building type: Offices, laboratories and specimen collections
Area: 3515 m2
Year: 2010
Country: Iceland

The building is part of the Urridaholt master plan that has emphasis on sustainable development. fritted glass, reducing heat gains, and therefore also assisting with natural ventilation. double facade for natural ventilation. each office has at least two operable windows, one upper and one lower, to improve the airflow from in-between the double facade [12].

Ekolådan

Architect: White Arkitekter
HVAC consultant: By Demand
Building type: Hotel
Year: 2017
Country: Sweden

Sustainable eco barn, 100 year old barn transformed into a climate positive ecological hotel and retreat with its own farm and vegetable production. Is also equipped with solar energy and a biological purification system, built with wood making it climate positive. Collaboration with Bydemand, specialized in natural ventilation systems [13].

B&O Headquarters

Architect: KHR Architecture
HVAC consultant: Birch & Krogboe AS
Client: Bang & Olufsen
Building type: Showroom & offices
Area: 5500m²
Year: 1998
Country: Denmark
Award: Nominated for the Mies van der Rohe Award, 1999
Red Dot Award, 2002
Dupont Benedictus Award Honorable Mentions, 2003

Bang & Olufsen's headquarters, well integrated in the surrounding overlooking sheep fields. Most distinctive with hybrid ventilation. The building is ventilated with the help of natural airflow when possible, and supplemented mechanically with helping fans when needed. Three floors with large open office. Designed with displacement ventilation, light cool air enters, pushing the heat upwards, where air is sucked out or expelled into the attic. The air exists the building via two vents through the large fans. The fans are stationary if there is enough pressure, and can operate when it is needed such as in cases of low air quality as a result of higher Co2 concentrations. Fans can also cool the building during the night, as the building accumaltes the heat during the day, and radiates it during the night, which in turn minimizes the need for mechanical cooling[14] [15] [16] [17].

Villa Idun-Lee

Architect: Per Nadén & Anton Kolbe in collaboration with Axel von Friesen & Marika Vaccino.
HVAC consultant: ByDemand
Building type: Villa
Year: 2016
Country: Stockholm
Award: Nominated to Träpriset 2020

Constructed using the 12M module. The facade consists mostly of prefabricated wall elements. Brick wall in the middle of the building to stabilize the building. Designed with natural ventilation using the stack effect [18].

Ice House

Architect: Minarc
Building type: Residential
Area: 1,500 sq ft
Year: 2011
Country: Iceland

Minimalist design, energy efficient technologies and eco friendly materials. It was designed to maximize passive solar energy and cross ventilation which would reduce the need for electricity. To improve the air quality, no forced air systems were used [19].

Mediå School

Architect: Letnes Architects AS
HVAC consultant: VVS Planconsult AS
Building type: School
Year: 1998
Country: Norway

The school has an exhaust chimney with a combined sunspace/extract chamber on the roo. The sunspace provides more daylight to the classrooms, improves the air ventilation, and enhances the efficiency of the recovered heat from the exhaust air. Fresh air is provided through an inlet tower with a connected embedded duct [20] [14].

2226 Lustenau

Architect: Baumschlager Eberle Architekten
Building type: Office & administration
Area: 2421 m²
Year: 2013
Country: Austria

Baumschlager Eberle Architekten headquarter building in Lustenau's Millennium park. Constant indoor temperature between 22°C and 26°C. Dependant on internal heat gains as a heat source, such as from people, lights and equipment. Health and wellbeing, sun and wind inside the building. Low construction and energy costs and a natural climate creating a nice and comfortable working environment. Interior sensor-controlled ventilation panels in the windows automatically opens when the Co^2 or the temperature exceeds the acceptable thresholds. During the summer, the panels open at night to cool the building. The sensors can also be overriden enabling the panels to be manually controlled. High thermal mass of the building also contributes. High quality materials and sustainability concept estimating a 200 year life span [21].

Awards:
Wienerberger Brick Award: Grand Prize "Special Solution" | Wienerberger, Vienna, AT
Antonio Petrini Prize (Office Building Novum, Würzburg, D) | City of Würzburg, D
Shortlist: The European Union Prize for Contemporary Architecture – Mies van der Rohe Award | Foundation Mies van der Rohe, Barcelona, E
Energy Globe Austria - Award for Sustainability | Energy Globe Foundation, Neukirchen / Altmünster, AT
German Design Award - Gold | Rat der Formgebung

Active house

Architect: AART A/S
HVAC consultant:
Developer: VELFAC & VELUX
Building type: Residential
Year: 2009
Country: Denmark

The active house is a label developed by the Velux group to outline the important points that needs to be considered in order to design more sustainable and energy efficient building. One example is a prototype of a house in Denmark that was designed so that it produces more energy than what it consumes. The building was designed using hybrid ventilation ensuring a comfortable indoor environment [22] [23].

References

(1) https://worldgbc.org/advancing-net-zero/embodied-carbon/#:~:text=Buildings%20are%20currently%20responsible%20for,11%25%20from%20materials%20and%20construction.

(2) https://www.unep.org/resources/emissions-gap-report-2022

(3) https://www.ark.fi/en/2023/02/natural-ventilation-is-more-energy-efficient-than-its-reputation/

(4) https://www.eea.europa.eu/data-and-maps/figures/observed-annual-mean-temperature-trend-2

(5) https://www.rehva.eu/rehva-journal/chapter/status-of-ventilation-in-sweden

(6) Skanska. (2023). Skanska- see our projects. Hämtat från Gullhaug Torg 2A: https://www.skanska.no/hva-vi-gjor/prosjekter/249739/Gullhaug-Torg-2A

(7) Snøhetta. (2023). Retrieved from Powerhouse Brattørkaia, The northernmost energy-positive building: https://www.snohetta.com/projects/powerhouse-brattorkaia https://www.snohetta.com/projects/powerhouse-brattorkaia

(8) Sørensen, Å., Andresen, n., Walnum, H., Alonso, M., Fufa, S., Jenssen, B., . . . Fjeldheim, H. (2017). SINTEF. Retrieved from Pilot Building Powerhouse Kjørbo. As Built Report: http://hdl.handle.net/11250/2488993

(9) VELUX. (2023). VELUX. Retrieved from Green Lighthouse, Denmark's first CO2-neutral building: https://www.velux.com/what-we-do/healthy-buildings-focus/demonstration-buildings/green-lighthouse

(10) Snøhetta. (2018). Snøhetta. Retrieved from Harvard HouseZero, An energy-positive prototype for ultra-efficiency: https://www.snohetta.com/projects/harvard-housezero

(11) Baumschlag-ereberle. (2022). baumschlager eberle Arkitekten. Hämtat från 2226 Emmenweid Emmenbrücke, Switzerland Office and Administration: https://www.baumschlager-eberle.com/en/work/projects/projekte-details/2226-emmenweid/

(12) Rose , E. (2011). Dezeen. Retrieved from Icelandic Institute of Natural History by Arkís: https://www.dezeen.com/2011/01/05/icelandic-institute-of-natural-history-by-arkis/

(13) White. (2017). White Arkitekter. Retrieved from Ekoladan, Lindeborgs Eco Retreat: https://whitearkitekter.com/se/projekt/ekoladan-lindeborgs-eco-retreat/

(14) Tommy, K. (2003). NTNU. Retrieved from Natural ventilation in buildings : architectural concepts, consequences and possibilities: https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/231090

(15) Bang & Olufsen. (2007). BEOWORLD. Retrieved from Bang & Olufsen Headquarters: https://www.beoworld.org/article_view.asp?id=27

(16) KHR. (2003). KHR architecture. Retrieved from B&O headquarters: https://khr.dk/en/projects/

bo-headed/

(17) Aimée , M. (2017). Design week. Retrieved from Bang & Olufsen: the “proud Danish brand” with a global design outlook: https://www.designweek.co.uk/issues/20-26-february-2017/bang-olufsen-proud-danish-brand-global-design-outlook/

(18) Thisispaper. (2020). Architecture. Retrieved from Villa Idun-Lee by Per Nadén and Anton Kolbe: https://www.thisispaper.com/mag/villa-idun-lee-by-per-naden-and-anton-kolbe

(19) Archdaily. (2012). Archdaily. Retrieved from Ice House / Minarc: https://www.archdaily.com/258160/ice-house-minarc

(20) SINTEFF. (1997). Design of Fan-Assisted Natural ventilation, Generell Guidelines and Suggested Design for Energy-Efficient Climatization-System for School Building in Grong, Norway. Norway. Retrieved from https://www.aivc.org/sites/default/files/airbase_11185.pdf

(21) Baumschlager-eberle. (2016). baumschlager eberle architekten. Retrieved from 2226 Lustenau Lustenau, Austria, Office and Administration: https://www.baumschlager-eberle.com/en/work/projects/projekte-details/2226-lustenau/

(22) Hansen, E. K., & Olesen, G. G. H. (2011). The Window: a Poetic Device and Technical Tool to Improve Life in Energy Positive Homes . World Sustainable Building Conference - SB11Helsinki, Helsinki, Finland.

(23) Foldbjerg, Peter & j, Gitte & Feifer, Lone & Hansen, Ellen. (2011). Indoor Environmental Quality of the first European Model Home 2020 Building: Home for Life.

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