Biophilic adaptive façades for healthy and energy-efficient buildings
in Quebec's northern territories

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Introduction

This research aims at developing biophilic adaptive façades as a promising nature-friendly strategy to design healthy and energy efficient buildings in the extreme cold climate of Quebec's norther territories.

Biophilic Adaptive Façade

An adaptive intermediate system designed based on biophilic recommendations that could moderate the extreme Nordic climate to provide building occupants with a healthy indoor lighting environment and sufficient connectivity to outdoor nature.

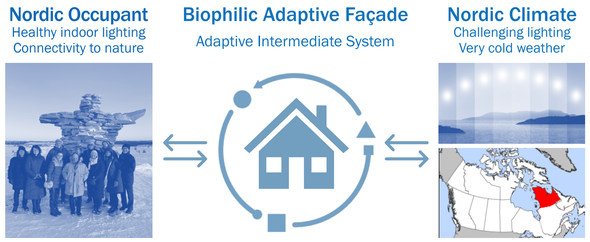

Figure 1. The idea of biophilic adaptive façades

Building Façade[1]

The enclosure of buildings consisting of several components such as wall, windows, shadings, curtains and blinds, located between outdoor and indoor environments.

Adaptive Façade[1]

A façade system with abilities to make changes to its' components.

Biophilic design[2]

A nature-friendly approach to building design proposing several recommendations for daylighting strategies, view to nature, material and form of the façade.

Light-related health[3]

Biological responses to light and day/night cycles enabling vision and affecting body clocks, alertness, performance and mood.

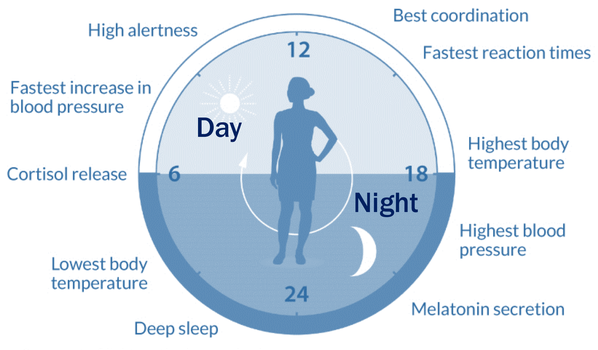

Figure 2. Impact of light on the human body

Building occupants' needs[4]

- A right amount and quality of light at the right time of the day
- Sufficient accessibility to nature and natural patterns.

Extreme Nordic climate[1]

-Challenging lighting & day/night cycles and very cold weather
-Non-adapted & climate-disconnected buildings causing light-related health issues such as tiredness, sleep problems and depression.

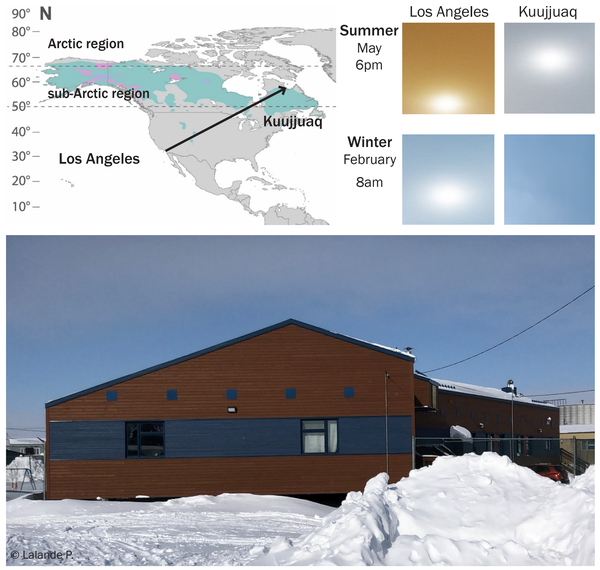

Figure 3. Challenging lighting conditions and an example of buildings in the North

Methodology[5]

Experimental set-up to capture light in architectural models
Computational analysis of lighting parameters related to health through using high dynamic range imagery & post-processing techniques

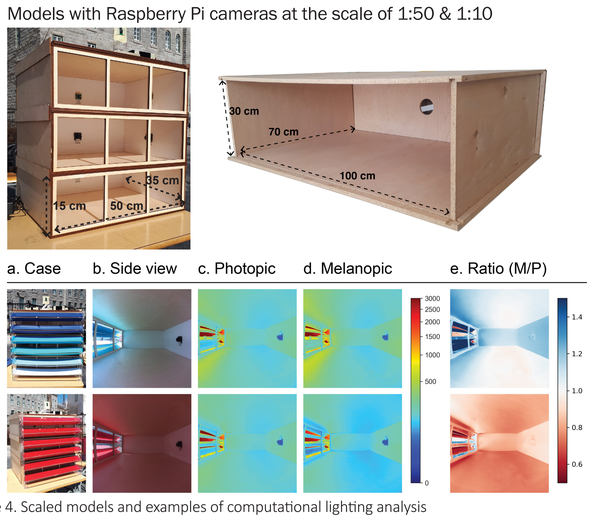

Figure 4. Scaled models and examples of computational lighting analysis

Benchmarking Results

Health responses to daylighting have been calculated in the field of view of a potential user in the space having different exterior shading panels. The results show the remarkable impact of panels on health responses, i.e. image forming (photopic lux) and non-image forming (melanopic lux). It is noticeable that only shading panels could manipulate the intensity, color temperature and distribution of lighting resulting in different responses. The panels could change the color temperature of perceived light to blue, white, yellow and red hues which have different image-forming and non-image forming effects. The color and orientation of panels play key roles in manipulating lighting and occupants' health responses.

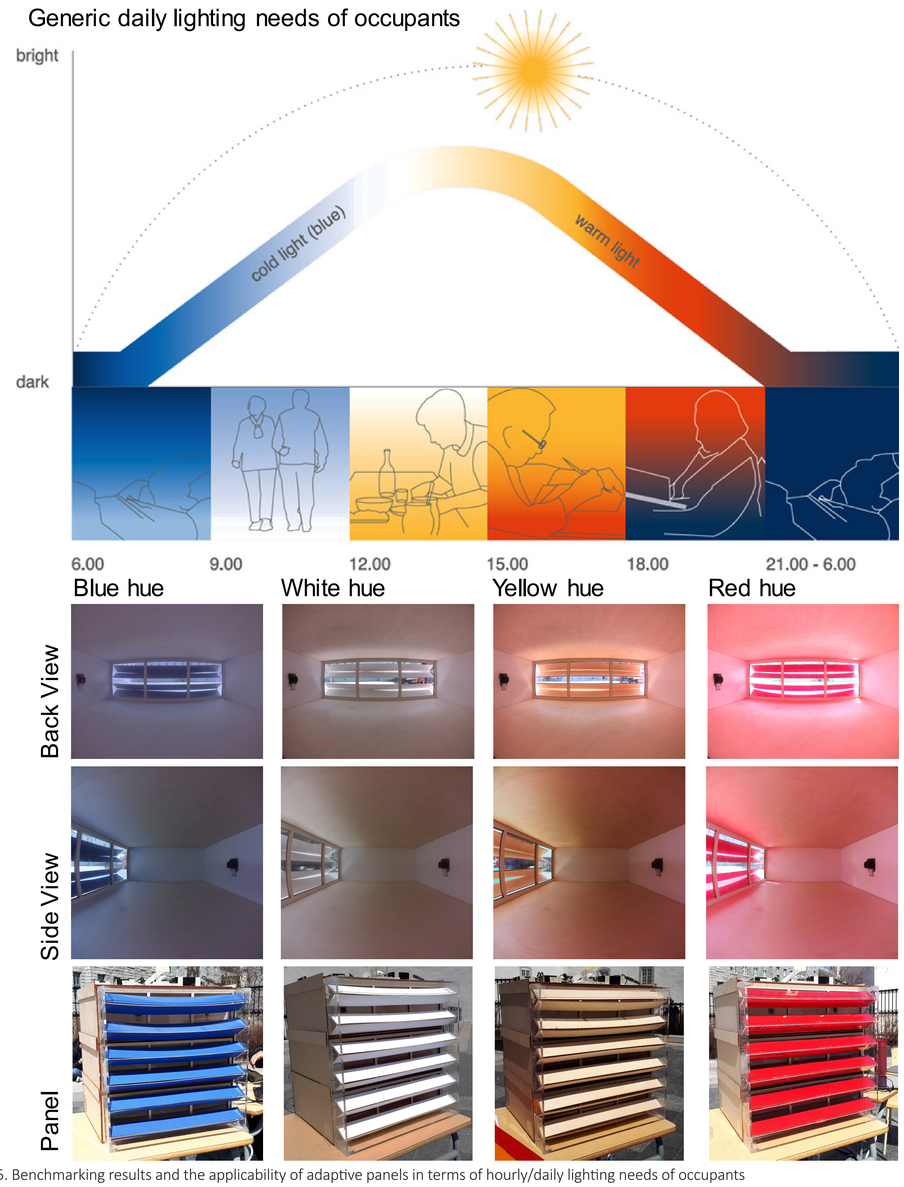

Figure 5. Benchmarking results and the applicability of adaptive panels in terms of hourly/daily lighting needs of occupants

Main Conclusions & Future Studies

The biophilic development of adaptive façades could satisfy hourly/daily/seasonally needs of Nordic occupants to a healthy indoor lighting and sufficient accessibility to natural cycles. Future studies must optimize the design variables of such systems in terms of health responses and energy efficiency. Lighting adaptation scenarios should also be developed in future research.

Acknowledgment

The authors are grateful to the Sentinel North of Université Laval for the financial support.

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