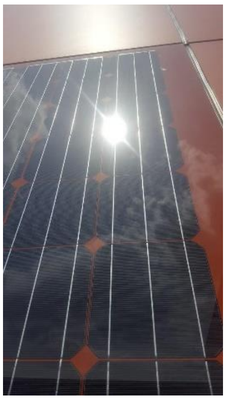


Q-Air – unique selling propositions in detail

Afraid of sitting at the window in winter?

Q-Air offers a U value so low that there can be no perceptible cold air movement at the panoramic window even in coldest winter. In the summer there will be no discomforting heat radiation from the glass despite not having any exterior sunshades.

With Q-Air, a nearly independent, nearly zero energy building not needing seasonal grid power reserve is possible. The building is equality self-sufficient in winter and summer.

Since there are no moving parts or openable enclosures, there is reduced need for maintenance. And all that with an additional benefit of the extra net-floor area.

REFLEX
Q-Air

Table of contents

Winter cold draught prevention

Have you ever experienced winter discomfort sitting at a tall window? The cold draught pouring from the inner glass surface enveloped your feet?

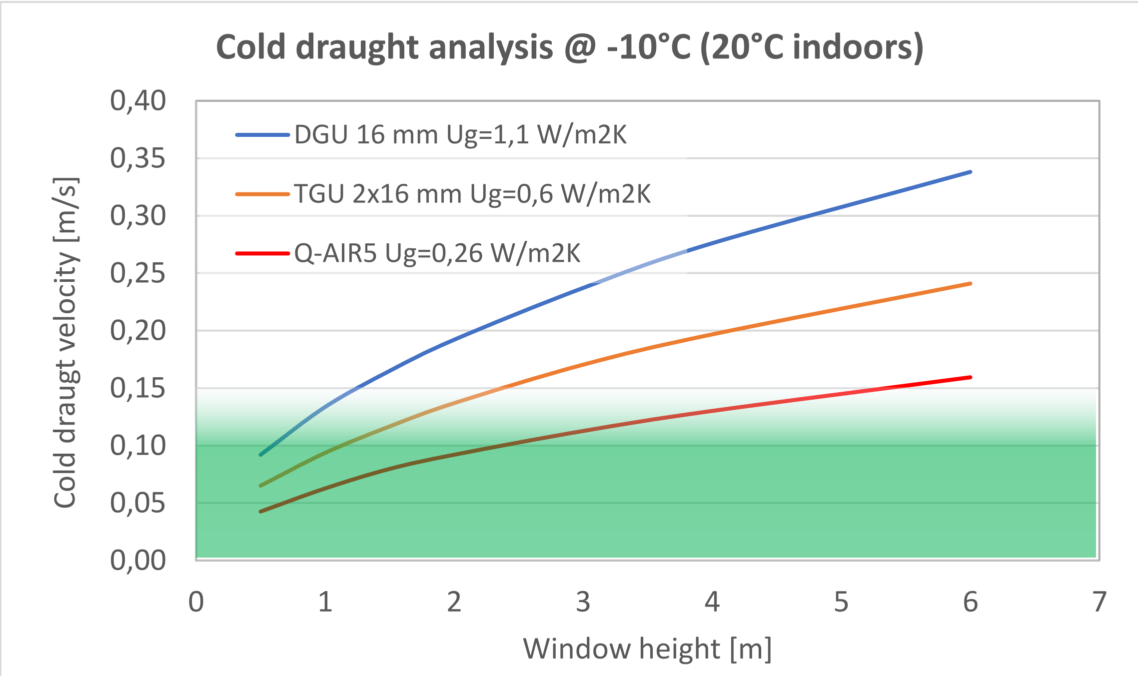
Cold draught becomes sensible when creeping air velocity reaches 0.15 m/s.

The taller the glass, the more the problem. The lower the U value, the better.

Q-Air can reach a low enough U value to remove the cloud draught sensation for up to 4 m tall glass units.

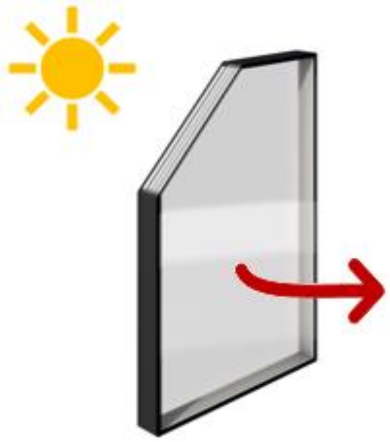
Cold draught calculation[1] (0.4 m from the window):

(DGU stands for double glass unit, TGU for triple glass unit)



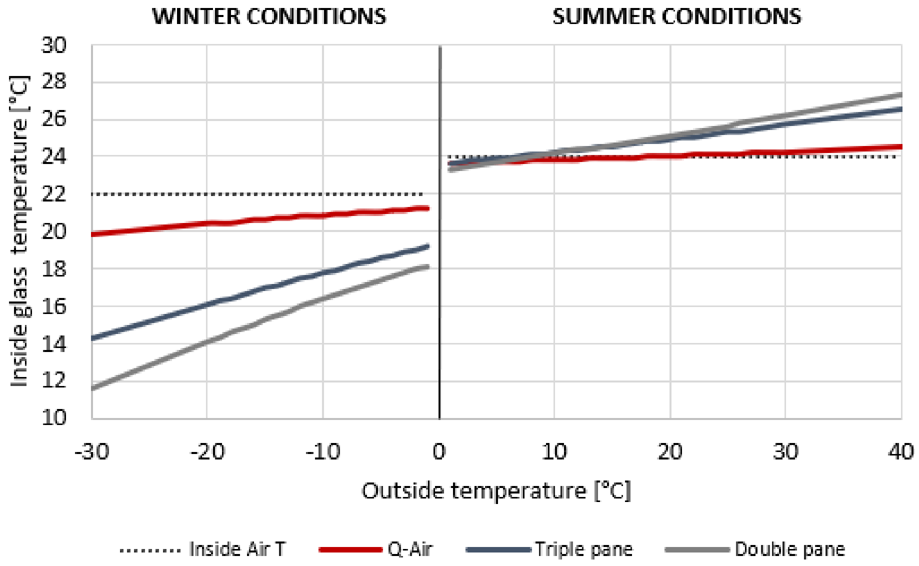
[1] Heiselberg P. Draught Risk from Cold Vertical Surfaces. *Building and Environment*, 29 (1994): 297-301.

Summer heat radiation from the glass



Experience teaches us that sitting behind the glass in the sunny summer day might bring discomfort from radiating heat. This phenomenon becomes apparent when the glass solar gain (g) exceeds 0.3. Basic glass units might pour heat inward through pure conduction.

Inner glass surface temperature is given for Q-Air 5 and several reference glazing.



With Q-Air 5:

- **Long wave radiant heat transfer in summer is reduced**
- **Reduced convection in winter**

	Winter (-30 °C)	Summer (40 °C)
Q-AIR5	19.8	23.6
TGU	14.3	25.1
DGU	11.6	26.0

Inner glass temperatures were calculated with Barkley Lab Window7.4 according to ISO 15099: https://windows.lbl.gov/software/window/window.html

Environmental conditions	**Winter conditions**		**Summer conditions** Direct Solar radiation 783 W/m²	
	Inside	Outside	Inside	Outside
Air T	22°C	From -30 to 0 °C	24°C	From 0 to 40 °C
Convection coefficient	Fixed combined 7.5 W/m²K	Fixed combined 25.0 W/m²K	Fixed 7.5 W/m²K	Fixed 7.0 W/m²K
Radiation	/	/	ASHRAE/NFRC 24°C, Room ε=0.85	Sky T from 0 to 40 °C Sky ε=0.74

By maintaining radiant asymmetry and reducing convective air movement the inhabitants feel more comfortable at a lower room temperature thereby saving energy!

No exterior sun shading

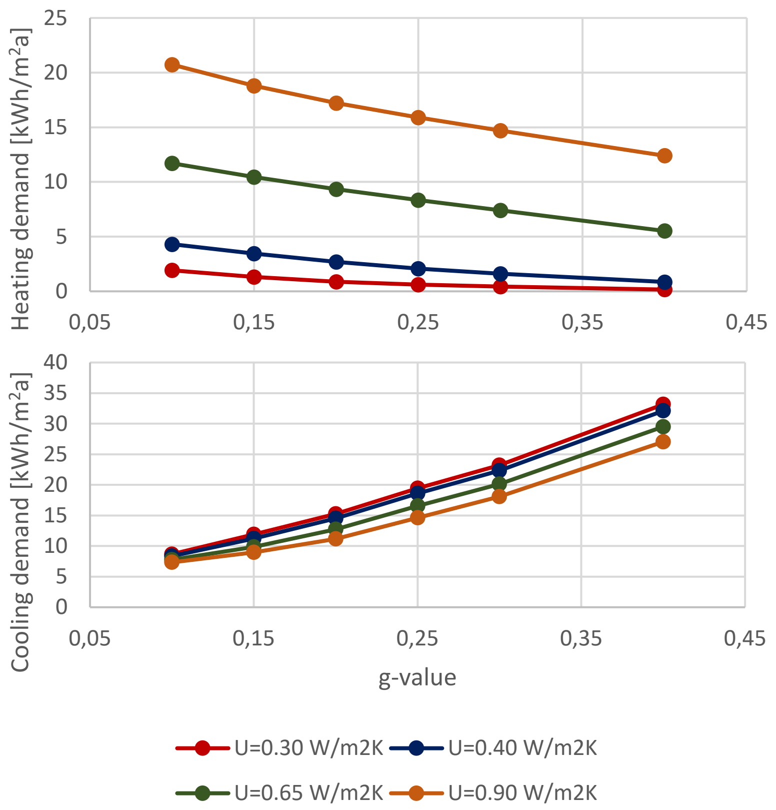
Heat-trapping capacity of modern, low U-value glazing causes a substantial increase in closed time for the dynamic exterior sun shading devices. In many cases, this means that a building’s occupants cannot see outside if that part of the building is insolated. Recent improvements in glazing U value have caused shading device to be closed most of the sunny daytime.

On the other hand, it was shown[2] that solar gain modulation no longer benefits energy requirements of a building if the glazing U value falls below 0.4 W/m^2K. This means dynamic exterior shading could be harmlessly discarded in exchange for a low U-value glazing with a modest solar gain.

[2] Vanhoutteghem, Lies, Gunnlaug Cecilie Jensen Skarning, Christian Anker Hviid, and Svend Svendsen. "Impact of façade window design on energy, daylighting and thermal comfort in nearly zero-energy houses." *Energy and Buildings* 102 (2015): 149-156.

Nearly independent nearly-zero energy building

To reach as low as possible CO_2 emissions in a heating dominated region, it is essential that the heating demand of a building be reduced to as close to zero as possible. PV and wind power supply are concentrated around summertime. It seems natural to take advantage of that concentration by trading winter heating for summer cooling. Diagrams below show simulated building in Oslo, Norway, with 70% glass to wall ratio. Remaining 30% is sufficient to provide needed PV power for self-need of the building for summer cooling should investors pursue building integrated PV option. Otherwise, most grid systems incorporating PV power have difficulties with finding demand for excess power in the summer and are sometimes willing to pay consumers for electricity uptake.



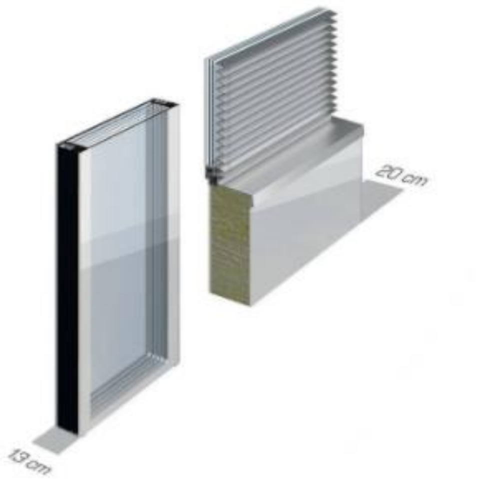
Building dimensions: 30 x 17 m^2, Building ventilated volume: 7529 m^3; Infiltration @ 50Pa: 0.50 ACH; U-value (Groundfloor, Roof): 0.15 W/m^{2}K; Occupancy count: 14 m^2 per capita; Lightning: LED light 0.50 W/m^2; Equipment: 6.00 W/m^2; Internal temperature occupied days: 22 – 24 °C; Internal temperature non-occupied hours: 20 – 26 °C; Variable air volume ventilation by heat recovery VAV; Zero temperature unmet hours.

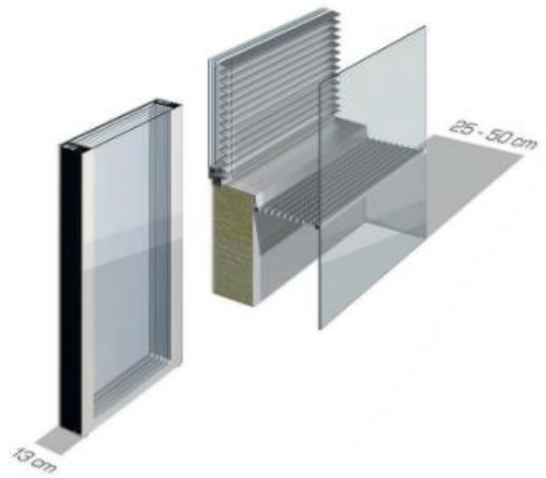
In this way, the building does not need any winter power reserve. It obviously does not need any seasonal energy storage, and it can also be demonstrated by hourly simulations that nocturnal energy storage is also not essential. These are substantial improvements for the nearly zero energy buildings in the northern climates.

Costs, reduced maintenance and extra floor space

From a return on investment (ROI) perspective reduced maintenance, and extra floor space are the most significant direct value contributors of the Q-Air on top of savings made by omitting exterior sun shading.

The investment cost of the Q-Air is typically located in between that of systems such as a Closed cavity, Double skin glass facades and standard Triple-pane glazing, though special requirements for fire safety or panel dimensions can push the cost up significantly.





Q-Air facades are usually less than 15 cm thick. Conventional solutions with comparable performance such as triple-pane glazing with parapets could easily reach 40 cm thickness of mineral wool insulation. In such cases, Q-Air façade saves 20-25 cm space. In some cases, this is sufficient to pay-back the extra investment cost into the Q-Air.

Exterior shading devices require maintenance. Mechanical louvres are maintenance heavy. All too often, dynamic shading systems require building occupants to receive training on how to operate them or else users will use shades as glare control, which seems to be the only intuitive use of such devices.

Modern electrochromic devices lose their capability to develop full shading contrast over time. “Calendar ageing” as it is called causes the annual loss of about 2-3%. Electrochromic devices of solid-state type (best to date) function on the same principle as Li-ion battery. Though manufacturers of electrochromic shading devices are more than willing to share information on tens thousands of cycles their devices can experience with no degradation, they are concealing calendar ageing data. Luckily, there is now ample literature on calendar ageing with batteries[3]. Today, no electrochromic glass manufacturer gives any warranty on the optical properties. Although electrochromic glass requires no maintenance, it requires maintenance of electronics.

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[3] Keil, Peter, Simon F. Schuster, Jörn Wilhelm, Julian Travi, Andreas Hauser, Ralph C. Karl, and Andreas Jossen. "Calendar Aging of Lithium-Ion Batteries I. Impact of the Graphite Anode on Capacity Fade." *Journal of The Electrochemical Society* 163, no. 9 (2016): A1872-A1880.