Automated Solar Shading and Lighting Control:
Montréal - Pierre Elliott Trudeau International Airport

Summary

The *NSERC Solar Buildings Research Network (SBRN),* in collaboration with the *Aéroports de Montréal (AdM)*, implemented an innovative combined solar shading and lighting control project at the Montréal International Airport. This installation allows for the automatic control of interior motorized shades to serve the following purposes:

- Maintain interior visual comfort for travelers and airport staff
- Reduction of cooling loads resulting from excessive solar gains
- Reduction of electric lighting energy use and the corresponding cooling load when natural daylight is sufficient for lighting the space

An initial research phase was conducted by Concordia University SBRN researchers, with financial support from Natural Resources Canada, in a single perimeter zone. The positive results from this study led the AdM to successfully implement the innovative control strategy throughout the airport in all perimeter zones.

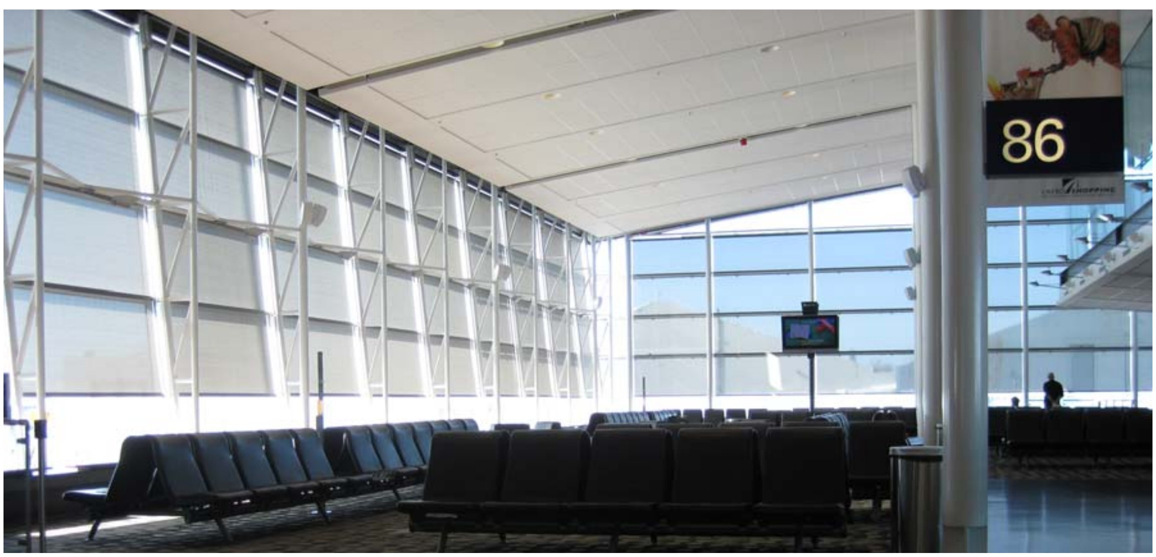

Figure 1: P.ET Airport Perimeter – Abundant Daylight with Automated Shades Closed

Project Highlights

- Seventeen (17) perimeter zones equipped with a single illuminance sensor to provide control signals for automated shade and light controls
    - Zones located in Departure / Arrival terminals
- Motorized *Somfy* shading devices connected to building automation system
    - Positional feedback from motors
- Electric lighting to be controlled when equipment installation permits
- Sensor and shade control completion: November, 2008.

Background

Highly-Glazed façades are architecturally desirable, in particular due to the daylight and views that they provide for building occupants. Commercial buildings often take advantage of glazing for its aesthetic and daylighting properties, but it is important that building designers consider the effects of building orientation and location. Heat loss through north-orientated glazed fenestration can be significant, as can the solar heat gain from the south. Commercial buildings, having high internal gains from people and equipment, have less to lose from a heat loss perspective than for example a house, but the increased cooling loads from solar gains can dramatically increase energy consumption[1].

From L to R: Complex Desjardins (1976) - Reflective; KPMG Tower (1987) - Tinted; 1250 René-Levesque (1992) - Transparent; Quebecor Building (2008) – Floor to Ceiling Transparent

Figure 2: Architectural Changes in Montreal: Tinted to Transparent (Photo Credit: imtl.org)

[1] Tzempelikos A. & Athienitis A.K. (2007). *The impact of shading design and control on building cooling & lighting demand*, Solar Energy, Vol. 81 (3), pp. 369-382.

Daylight and Glazing

In the past, commercial buildings were designed to have very spectrally selective glazing in order to reduce solar heat-gain and glare problems. This can be seen in the many office towers constructed with tinted or reflective glazing. This design premise placed the importance on electric interior lighting and a controlled HVAC system – the indoor environment was to be lit and air conditioned by unnatural means, since natural methods were often considered too variable or unpredictable.

New research and experience have however shifted the design methodology: daylight is beneficial to human health and productivity. *Humans spend the majority of their lives inside the built indoor environment, and they should thus not be deprived of the conditions under which they naturally evolved.*

The design trend we are currently witnessing places the emphasis on a highly transparent building envelope that allows a vast amount of natural light to enter the interior. The importance of increased fresh-air delivery to curtail what has become known as the *sick building syndrome* is also being acknowledged. Harnessing the natural elements can assure that these new design criteria are met - with daylight and natural ventilation - without increasing the use of non-renewable energy sources.

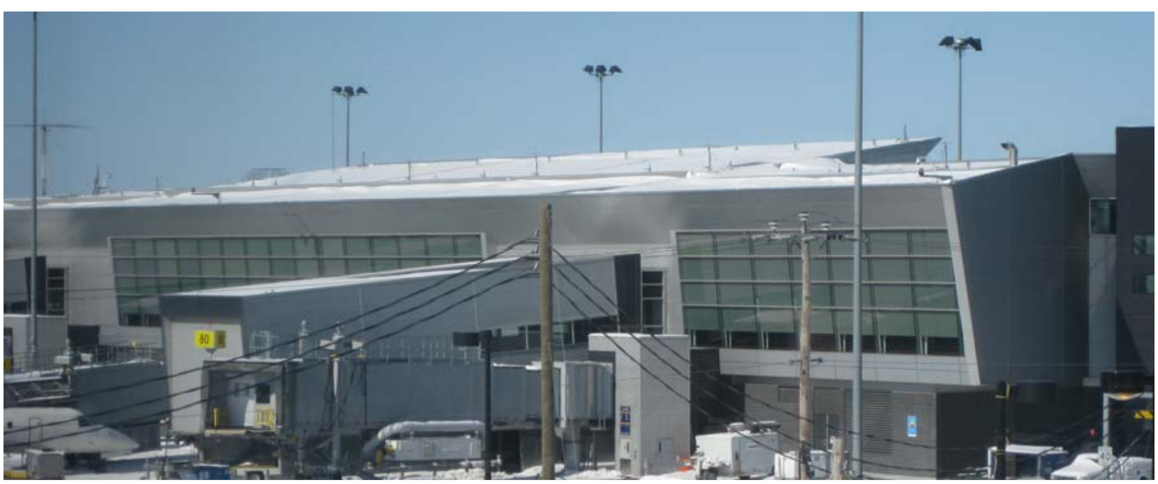

Figure 3: P.E.T Airport and Highly Glazed Façade - Blinds closed on sunny day

Advances in glazing technology have allowed for only the visible portion of the solar energy spectrum to be transmitted, with the non-visible reflected, however about 50% of the total energy from the sun is still in this range. The challenges of the past regarding fenestration still exist, though to a lesser extent due these technological advances. Still the same, excessive solar heat-gain and glare still are challenges that must be addressed.

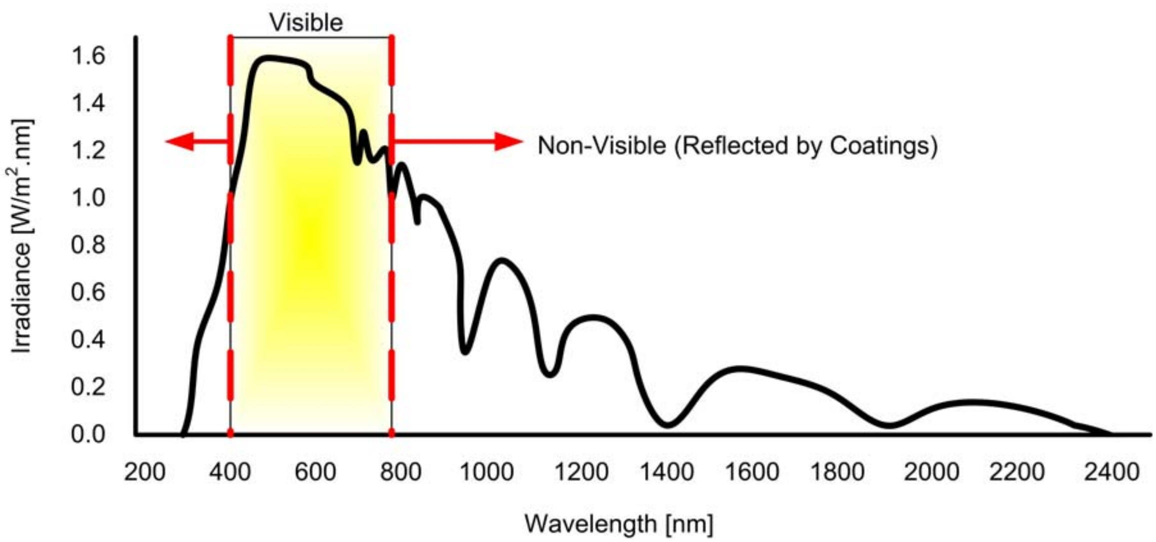

Figure 4: Spectrally Selective Coatings may allow the transmittance of only visible portion of the energy in the solar spectrum which still needs to be controlled

Apart from the health and productivity benefits from daylight that researchers are now quantifying, there is a secondary benefit of using daylight to illuminate a space: natural light puts off less heat for every lumen of light compared to the most efficient electric alternative. Table 1 demonstrates the high lumens of light per Watt of energy from skylight and direct beam sunlight, compared to other electric sources.

Table 1: Comparison of Light Sources (Murdoch, 2003[2]; *Rosenfeld et al., 1977[3])

	Lamp	Type	Colour Temp. (K)	Initial lm/W	Life (hr)
1	Incandescent	60 W Standard	2770	14.8	1000
2	Tungsten-Halogen (TH)	100 W T3	2800 - 3400	16	2000
3	Fluorescent	40-W T8	3500 - 5000	94	20,000
4	Fluorescent	35-W T5	3500 - 5000	104	16,000
5	Direct Beam Sunlight	---	5800	100*	---
6	Skylight on Vertical	---	5800	120*	---

Considering this, replacing electric light with natural daylight actually reduces the internal heat gain of the building – and hence the cooling load. Add to that a third benefit: the sun's energy is free! However, as mentioned above, excessive solar energy – especially that from direct beam sunlight – can be detrimental to comfort and energy consumption. As a result, some form of solar shading *must* be considered.

Shading Control

The Trudeau airport is a high internal-gain application: cooling of the building occurs even when the exterior temperature is below 0°C. As a result, heat gain is not desirable for a good portion of the year.

It is well known that light coloured objects are actually highly reflective in the visible range of the solar spectrum – this is opposed to dark coloured objects which are highly absorptive. A white coloured shade can reflect 70-80% of the energy in the visible spectrum. As earlier seen in Figure 4, visible light is the portion of the spectrum that contains most of the energy that is transmitted through the fenestration.

The light-coloured blinds of the Trudeau airport are programmed to progressively close as the interior lighting levels are increasing above a certain value. Excess solar energy is

[2] Murdoch, J.B. (2003). *Illuminating engineering: From Edison's lamp to the LED.* New York, NY: Visions Communication.
[3] Rosenfeld, A.H. & Selkowitz, S.E. (1977). Beam daylighting: An alternative illumination technique. *Energy and Buildings, 1* (1), 43-50.

reflected to the exterior. Likewise, the electric lighting can be controlled to also turn off when the natural light level exceeds a prescribed set-point. Energy and dollar savings from turning off the lights – especially in a large airport – can be significant.

Figure 5: Panoramic View of Montreal's Trudeau Airport Departures Area, showing different lighting and shading zones

Lighting Study and Implementation

The study conducted by the SBRN allowed for a relation to be developed between the lighting intensity (lux) measured at ceiling mounted sensors, the daylight entering the airport, and the electric lighting. The result was that with a single sensor, set-points could be assigned to trigger certain actions - close blinds progressively, and turn off the lights.

Since implementation of the shading control system, the biggest success has been the acceptance of the new system by the airport employees. Before the automated control, repeated requests were made to the building operations to close the shades because people were uncomfortable. These complaints are now a thing of the past.

The SBRN will continue to work with it's partners on this innovative application, especially for quantifying the energy saving benefits that result from this application.

Figure 6: Installation of a ceiling mounted light sensor

Project Partners

NSERC Solar Buildings Research Network

The NSERC Solar Buildings Research Network (SBRN) receives over $5,000,000 in funding from the Natural Sciences and Engineering Research Council. The SBRN is currently the major Canadian research program focused on solar energy utilization in buildings. It brings together 24 Canadian researchers from eleven universities to develop the solar-optimized homes and commercial buildings of the future. The Network also includes researchers and experts from Natural Resources Canada (NRCan), the Canada Housing and Mortgage Corporation (CMHC) and Hydro-Québec. Industrial partners from the energy and construction sectors are involved in most projects, developing the know-how that will help them compete in the global market.

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Aéroports de Montréal

Aéroports de Montréal (ADM) is a not-for-profit corporation without share capital and is responsible for the management, operation, and development of Montréal–Pierre Elliott Trudeau International Airport (formerly Montréal–Dorval International Airport) and Montréal–Mirabel International Airport under the terms of a 60-year lease signed with Transport Canada in 1992.

Aéroports de Montréal's mission is threefold:

- Provide quality airport services that are safe, secure, efficient and consistent with the specific needs of the community.
- Foster economic development in the Greater Montréal Area, especially through the development of facilities for which it is responsible.
- Coexist in harmony with the surrounding environment, particularly in matters of environmental protection.

www.admtl.com

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