Harbourfront Centre Theatre

IEA PVPS

Introduction

Harbourfront Centre Theatre is a popular attraction in Canada, a unique and creative cultural centre, drawing more than 17 million annual visitors and contributing millions of dollars to the local economy each year. Since 2005, Harbourfront Centre has been working on a series of projects that continue to transform Toronto's waterfront to Lake Ontario. The Theatre was originally constructed in 1926 as an icehouse, where large blocks of ice intended for freight and cold storage were stored. In 1986, the space was repurposed into a versatile 416-seat performance venue. The theatre's unique design features include a sleek, three-storey curtain wall that encloses the entire northern, eastern and western sides of the theatre, providing acoustic insulation and thermal buffering, additional lobby space, and an aesthetic external finish that preserves the integrity of this historical building. (Livio Nichilo, Internat Energy Solutions Canada Inc.)

The pre-feasibility study was performed by IESC. The fundraising was carried out by the Harbourfront Centre. The project design, specifications and management were delivered by IESC. IESC and Fitzpatrick Electric prepared and submitted documents for electrical permit. The artwork was incorporated by Sarah Hall, and Glasmalerei Peters Studio. The BIPV skylights were integrated on the near-West facing skylight curtain wall by Faber Solariums that was also the main contractor for this project. The electrical installation and commissioning was completed by Fitzpatrick Electric.

Source: Successful Building Integration of Photovoltaics – A Collection of International Projects

Aesthetic integration

Integrating technology with art, Sarah Hall, a local Canadian artist, along with Glasmalerei Peters Studio in Germany, was able to create within the glazing, a permanent art piece called Watermark that wraps around the Theatre. A series of artistic images and a collection of 360 photographs, compellingly documenting the history of Lake Ontario, were permanently embedded into the glass envelope that now generates electricity during daylight hours and is backlit with programmable, colour-changing LED lights at night. The artistic elements were created overseas with airbrushed, fired enamels sandblasted onto architectural glass. The photographic image gallery visible from within the building uses screen-printed photographs and dichroic glass. The transformation of the Harbourfront Centre Theatre provides a stunning example of how technology, a commitment to environmental sustainability and artistic creativity can be beautifully matched.

Energy integration

The BIPV system is grid-connected and most of the electricity generated is consumed instantaneously by the building. Besides the generation of 1,500 kWh per year of solar electricity, the BIPV contributes to the reduction of the theatre's energy consumption: the effective optical and thermal properties were carefully selected through Building Information Modelling (BIM) simulations to reduce heat gains during summer, reduce heat losses during the winter and allow sufficient daylight into the lobby space throughout the year. Hence, the BIPV curtain wall reduces the theatre heating, cooling and lighting loads in addition to improving thermal and acoustic comfort. IESC estimated that the BIPV retrofit results in annual savings of 28 MWh of electricity (due to space cooling reductions) and 10,600 m^3 of natural gas (due to space heating reductions). These energy savings translate to a greenhouse gas emission reductions of approximately 25 tons of CO_2 equivalent per year.

Technology integration

10 customized BIPV insulated glass units (156 Wp each) were installed on the near-West facing skylight curtain wall of the Centre. The BIPV system needs to meet the Canadian National Building Code as for all structures on buildings. Thus, all the necessary steps were taken (e.g. calculations for dead and environmental loads) to ensure that the retrofit meets or surpasses the Code. In addition, the installation was designed and installed to comply with the Electrical and Fire Code. The BIPV modules are wired in series and connected to a Kaco 1502xi inverter. The wires run inside the curtain wall mullions, to be both protected by the elements and invisible. All BIPV system components, including the skylight windows, are accessible for maintenance, if required. Snow guards are installed toward the bottom of the roof to ensure pedestrian safety in case of sliding snow. The inverter is located at level 3 of the theatre, approximately 3 m away from the BIPV installation. It is mounted on an aesthetically pleasing wooden board in order to be visually appealing for the visitors. Also, mounted on the board are the DC and AC disconnect devices required by the Electrical Safety Authority. For additional safety, an externally located AC disconnect was also installed as a requirement of Toronto Hydro. An optional Kaco watchdog card was also implemented, allowing the performance monitoring of the system through a web-based portal. Finally, a net metering system was applied, directly serving the building's load.

Decision making

In 2009, the curtain wall surrounding the theatre was reaching the end of its lifetime and required replacement. Bill Boyle, CEO of Toronto's Harbourfront Centre until 2014, was interested in incorporating new technologies into the Centre that reflected a sustainable outlook. The objectives of this project were to (i) replace the existing outdated curtain wall with an advanced performance one that will create a more comfortable and less energy-demanding indoor environment, (ii) mirror the sustainability commitments of the Centre and, (iii) create a narrative that links this historical building with the City of Toronto and its waterfront, through art.

Among possible technologies to reduce solar heat gains (reflective glass, electrochromic glass or BIPV windows), a high-performance BIPV façade was an evident solution. If designed properly, BIPV can offset cooling, heating and lighting loads of the building while generating solar electricity, a feature that no other window technology can provide. (Livio Nichilo, Internat Energy Solutions Canada Inc.)

A pre-feasibility study was assigned to IESC to evaluate the various façade technology options through Building Information Modelling (BIM). It indicated that a curtain wall system that integrates photovoltaic technologies and art could satisfy all objectives. However, as the proposed solution was a novel, custom-made technology demonstration, there was a price premium associated with it. In 2010, securing funding through private and public sectors as well as fundraising events made possible the realization of a retrofit project that seamlessly integrated BIPV and art on the façade of a historical building in Toronto.

Lessons learnt

This was the first time we were attempting to design and install a BIPV system (and one of the first installations in Canada) so there were some technical challenges along the way. At the early stages of the design, we realized that there were no specific BIPV standards in place. In fact, even though the electrical performance of insulated glass units (IGUs) was warranted for 90% and 80% of the rated performance after 10 and 20 years, respectively, these were not certified by the Canadian Standard Association (CSA) since no standards existed at the time. In addition, CSA approved inverters are

generally larger than the inverter we needed. Finding and evaluating a reasonably priced, locally sourced, 1.5 kW inverter with monitoring capabilities, good technical support, and short delivery time was time consuming. Major delays occurred regarding manufacturing and shipping the IGU overseas. Delays also occurred because Toronto Hydro was unfamiliar with BIPV technologies, which caused confusion regarding system impacts and required assessments. This is why it is important to set the proper standards, codes and regulations to accommodate for a complex technology such as BIPV. It is the only way to reduce risk and accelerate the implementation of BIPV technologies in the built environment. (Livio Nichilo, Internat Energy Solutions Canada Inc.)

Designing and implementing a high performance BIPV curtain wall system that integrates artwork is challenging. It requires the use of BIM tools to assess the impact of the BIPV system and the artwork on the building heating, cooling and lighting loads. It also requires strong coordination between the project manager, the structural engineer, the artist, the installer and the electrician. The conventional linear design process does not work. It requires concurrent engineering, an integrated design process where all parties comprehend the installation functions and project objectives and work in parallel. Finally, when the proper standards, codes and regulations are in place, the project timelines can be reduced by half.

No incentives from utilities were made available for the BIPV installation. However, funding was received from both the private and public sectors through the Toronto Atmospheric Fund, Toronto Sustainable Energies Fund, Canadian Heritage Fund and Enwave. In addition, Harbourfront Centre held fundraising events to help finance this building retrofit project. As the BIPV installation demonstrates the integration of sustainable technology and artwork, payback was not a core objective for this project.

PROJECT DATA

Project type	renovation
Building use	cultural
Building address	231 Queens Quay W, Toronto (Ontario), Canada

BIPV systems

BIPV SYSTEM DATA

Architectural system	skylight
Integration year	2010
Active material	monocrystalline silicon
Module transparency	semi-transparent
Module technology	glass-glass, recognizable PV, customized modules
System power [kWp]	2.96
System area [m²]	21.5
Module dimensions [mm]	1,549 x 1,260
Modules orientation	South-West
Modules tilt [°]	45
Annual FV production [kWh]	1500

BIPV SYSTEM COSTS

Stakeholders

Main building designer

Internat Energy Solutions Canada Inc.

BIPV system designer

Internat Energy Solutions Canada Inc., Fitzpatrick Electrical Contractor Inc.

BIPV system installer

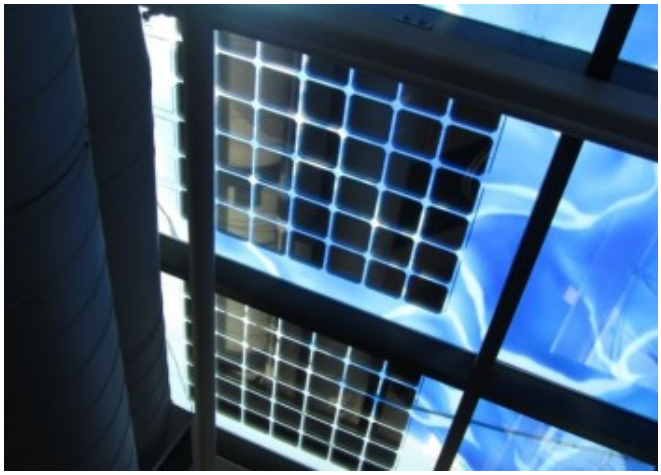
Fitzpatrick Electrical Contractor Inc.
41 Maple Street Uxbridge, Ontario, Canada
info@fitze.ca 905 686 1661
https://www.fitze.ca/

Collaborators

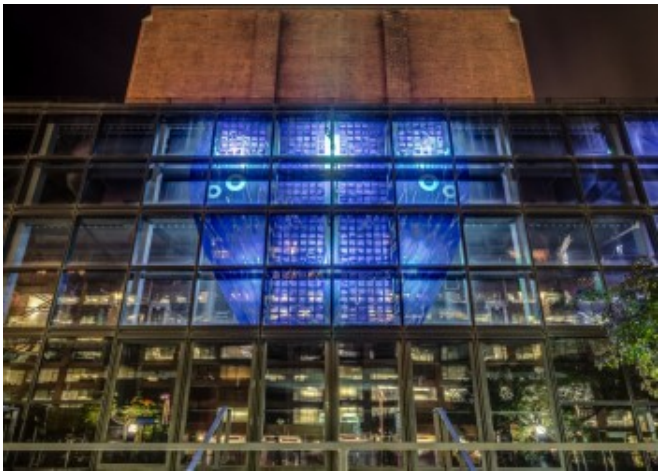
Sarah Hall, Glasmalerei Peters Studio, Faber Solariums

Harbourfront Centre, on the waterfront of Toronto, Ontario © Mark Bradshaw (Harbourfront Centre)

Inside view. The pictures document the history of Lake Ontario © Sarah Hall



Interior view of the West-facing BIPV skylight incorporating the permanent art installation © Veronique Delisle (NRCan)



Watermark art installation as part of the west-facing façade of the theatre, backlit with LED lights at night © Sarah Hall

Case study author:

Sarah Hall