Natural Resources Canada | Ressources naturelles Canada

Canada

Factsheet: Building-Integrated Photovoltaics (BIPV)

BIPV are solar power generating building products or systems that are seamlessly integrated into the building envelope, replacing conventional building materials.

Serving a dual purpose, a BIPV system is an integral component of the building skin that converts solar energy into electricity and simultaneously provides building envelope functions such as:

- weather protection (water proofing, sun protection);
- thermal insulation;
- noise protection;
- daylight illumination; and/or
- safety.

BIPV systems can be installed during the construction phase of a building or deployed in the course of a retrofit of an existing building when one of the envelope components needs to be replaced. The built environment allows for many ways to integrate BIPV. In general, there are three main application areas for BIPV:

- roofs (e.g. shingles, tiles, skylights);
- façades (e.g. cladding, curtain walls, windows); and
- externally integrated systems (e.g. balcony railings, shading systems).

The photos below illustrate the range of possibilities BIPV has to offer.

BIPV products currently available on the market use either crystalline silicon-based (c-Si) solar cells or thin film technologies such as amorphous-based silicon (a-Si), cadmium telluride (CdTe) and copper indium gallium selenide (CIGS). Semi-transparency can be achieved with most technologies by either spacing the opaque solar cells or making the thin film layer transparent. However, module efficiency decreases with the increase of transparency.

BIPV = Displaces building material + generates solar power

Benefits of BIPV

The benefits of BIPV are manifold: BIPV not only produces on-site clean electricity without requiring additional land area, but can also impact the energy consumption of a building through daylight utilization and reduction of cooling loads. BIPV can therefore contribute to achieving net-zero energy buildings. Turning roofs and façades into energy generating assets, BIPV is the only building material that has a return on investment (ROI). Furthermore, the diverse use of BIPV systems opens many opportunities for architects and building designers to enhance the visual appearance of buildings. Finally, yet importantly, building owners benefit from reduced electricity bills and the positive image of being recognized as “green” and “innovative”.

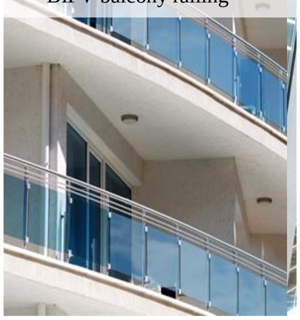
BIPVT – A Subset of BIPV

A subset of BIPV is BIPV with thermal energy recovery – so-called BIPVT. Such systems produce heat and electricity simultaneously from the same building surface area. When air is used as the heat recovery medium (BIPVT/a), the extracted thermal energy is available either for direct use for low temperature applications (e.g. fresh air preheating), or through the mediation of a heat pump, for higher temperatures (e.g. space heating, domestic water heating). The main benefit of BIPVT is that it produces more energy per surface area than a stand-alone BIPV system. A side benefit is that, under heat recovery conditions, the PV cells will be cooler than in a BIPV roof without thermal energy recovery, thus improving the module efficiency.

BIPV roof

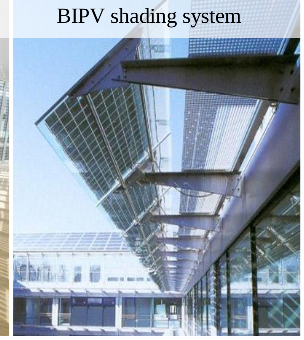
BIPV façade

BIPV balcony railing



BIPV curtain wall

BIPV shading system



BIPV skylight

BIPV in Canada

A study conducted by Natural Resources Canada in 2006 revealed a huge market potential for BIPV in Canada, indicating that about 71.34 TWh could be generated by installing this emerging technology in residential and commercial/institutional buildings [1]. The construction trend towards highly-glazed multi-storey buildings in the past decade has further increased the area suitable for BIPV. In addition, technological advancements in regard to energy-efficient, flexible, coloured and transparent solar materials allow for wider applications of BIPV.

To date, more than 50 commercial, institutional as well as several smaller residential BIPV projects have been realized in Canada, providing new market opportunities for solar manufacturers and the building envelope industry. The photos below present some successful Canadian BIPV installations.

What Can We Expect in the Future?

Presently, BIPV is still a niche market but in many countries, it has become an economically viable building envelope material due to falling prices for PV modules. As a result, BIPV is currently one of the fastest growing segments in the global solar PV industry [2]. The main drivers are rising climate change concerns which have resulted in increasingly stringent energy efficiency requirements for buildings, and subsequently in growing interest from architects, building designers and developers. Further technological improvements in regard to efficiency and flexibility as well as decreasing costs are expected.

In Canada, green building activity is expected to continue growing at a fast pace [3] and new Canadian labels and standards such as the recently established Canadian Home Builders' Association (CHBA) Net Zero Home Labelling Program and the Zero Carbon Building Standard of the Canada Green Building Council (CaGBC) will further encourage on-site renewable energy generation in buildings.

BIPV Activities at CanmetENERGY

Natural Resources Canada's CanmetENERGY research centre in Varennes, QC, has been building awareness and establishing domestic capacity in the integration of PV into buildings as distributed energy generation resources since 2000.

Setting the Foundation for BIPV in Canada

For over 15 years, CanmetENERGY has been involved in BIPV research, development and demonstration to remove technical barriers and promote the integration of PV in Canadian buildings.

Following a lengthy consultation process with industry associations and municipal, provincial and federal governments, the report "Photovoltaics for Buildings: Opportunities for Canada" (2001) set the vision for PV in Canadian buildings and provided recommendations to encourage the wider use and market acceptance of PV products for buildings in Canada [4].

In order to further promote the integration of PV in buildings to Canadian architects, Natural Resources Canada collaborated with the Royal Architectural Institute of Canada (RAIC), in 2003, by co-hosting a workshop on BIPV together with the University of British Columbia (UBC) School of Architecture. Derived from the workshop was a booklet that later served as material for a training course on BIPV provided by the RAIC to Canadian architects [5].

Since 2003, Natural Resources Canada has furthermore contributed to building awareness towards the potential of BIPV under Canadian climatic conditions and established a domestic capacity by funding several demonstration projects, for example, through the Technology Early Action Measures (TEAM) program.

In subsequent years, NRCan also contributed to promoting the integration of PV in buildings by supporting Canadian student engineers and architects who successfully competed in the U.S. Department of Energy Solar Decathlon. The collegiate contest challenges student teams to design and build full-size, solar-powered houses that blend design excellence and smart energy production with innovation, market potential, and energy and water efficiency. The aim was to help build a future Canadian workforce that is adapted to the demands of a technology-driven economy.

From 2008 to 2013, CanmetENERGY led a joint collaboration between 86 national experts from 19 countries of the International Energy Agency (IEA), under the framework of the IEA Solar Heating and Cooling (SHC) and Energy in Buildings and Communities (EBC) Technology Collaboration Programs. The objective of the joint SHC Task 40/EBC Annex 52 "Towards Net-Zero

Varennes Library, QC
© Maxime Gagné BIPV façade

Residence in Calgary, AB
© One House Green

Jeanne & Peter Lougheed Performing Arts Centre, Camrose, AB © University of Alberta

Enwave Theatre, Toronto, ON
© Sarah Hall Studio Inc.

Energy Solar Buildings" [6] was to develop a common understanding of net-zero buildings as well as tools, guidelines and innovative solutions including on-site renewable energy technologies such as BIPV. One of the highlights of this international collaboration is the publication of three books [7] [8] [9].

In 2013, CanmetENERGY completed the construction and commissioning of its outdoor testing facility, able to characterize the electrical and thermal performance of PV and BIPV products with thermal energy recovery using air as the heat recovery fluid (see figure 1). This testing facility contributed to building the Canadian government's capacity for product testing and standard development. It also led to a three-year international collaboration between CanmetENERGY and Kongju National University (KNU) in South Korea, from 2014 to 2017. In the context of this project, Canadian scientists developed a model to predict the thermal and electrical performance of a Korean-designed BIPVT collector prototype and performed testing to characterize the collector's performance and validate the model.

Figure 1: BIPVT collector prototype designed by KNU on CanmetENERGY's PVT Testing Facility

Current BIPV R&D Activities (2016-2020)

Currently, CanmetENERGY is working on two R&D projects focusing on BIPV funded by NRCan's Office of Energy Research and Development (OERD):

- "Systems Solutions and Tools for Combined Building-Integrated Solar Electric and Thermal Technologies" (STBIST) funded through the Energy Innovation Program (EIP) [1]; and
- "High Performance Building Envelope Systems" funded through the Program of Energy Research and Development (PERD) [2].

These projects are addressing three key challenges of the BIPV industry by focusing on the following activities:

- Regulations: Support the development of building codes and product standards for BIPV;
- First-cost disadvantage: Demonstrate the added value and cost-benefit of BIPV; and
- Lack of integration: Disseminate how BIPV can be integrated into the building envelope.

Regulations

BIPV products must conform separately to both PV and building product standards (e.g. fire codes, water tightness, wind resistance), which vary from one country to another. Scientists at CanmetENERGY are representing Canada as national experts in the International Energy Agency (IEA) Photovoltaic Power Systems (PVPS) program Task 15 "Enabling Framework for the Acceleration of BIPV" [10]. CanmetENERGY is particularly involved in subtask C, which focuses on regulatory issues and aims at establishing an international framework for BIPV standardization.

To further advance the development of international standards for BIPV, CanmetENERGY is also a member of the Project Team (PT) 63092. PT 63092 is a joint effort of the International Electrotechnical Commission's (IEC) Technical Committee (TC) 82 Working Group (WG) 2[3] and the International Organization for Standardization (ISO) TC 160[4] to develop technical specifications for photovoltaic modules and systems used in building construction.

[1] Project number EIP-EU-BE-06 - P-002599.001
[2] Project number BE1-02 - P-002519.001
[3] IEC/TC 82 WG2 focuses on the development of international standards for non-concentrating terrestrial photovoltaic modules.
[4] ISO/TC 160 focuses on the development of international standards in the field of glass in buildings.

First-Cost Disadvantage

Currently, there is an incomplete understanding of the value of BIPV. To demonstrate the cost-benefit potential of BIPV, CanmetENERGY is developing case studies of Canadian BIPV installations to highlight the benefits of BIPV not only as an electricity generation technology, but also as a building envelope component that generates a return-on-investment.

In addition, CanmetENERGY conducts research and development (R&D) to evaluate the cost-benefit of recovering the heat from BIPV to produce both thermal and electrical energy using the same building surface area. The impact of implementing heat transfer enhancement strategies to increase the value of the recovered thermal energy is also being assessed. Moreover, simulation and field testing activities are also being undertaken to develop optimized engineering concepts to integrate BIPVT/a with HVAC systems.

Lack of Integration

BIPV systems not only generate energy, but are also an integral component of the building envelope. To help building designers understand the performance of BIPV and BIPVT systems regarding both of these functions, CanmetENERGY is developing detailed as well as simplified models to predict the performance of BIPV and BIPVT installations under different configurations.

In addition, CanmetENERGY is evaluating existing BIPV software tools available on the market to better inform architects, consultants, engineers and researchers on their capabilities and limitations. In a next step, CanmetENERGY will develop design guidelines to inform engineers and architects on how to integrate BIPV in a building to ensure performance and safety.

Furthermore, CanmetENERGY conducted a consultation survey among BIPV specialists in 2017 to better understand the current constraints inhibiting the market development of BIPV in Canada [11]. The results from this survey will contribute to orient future BIPV research and development efforts in Canada. They will also be used to launch a discussion among relevant BIPV stakeholders on how to overcome the barriers to the market uptake of BIPV in Canada.

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