BUILDING INTEGRATED PHOTOVOLTAICS

Design & Technology Series #04

Fig. 1: Red Deer Polytechnic Student Residence with black BIPV wall panels (used with permission by Clark Builders, photographed by Crystal Puim Photography)

What are BIPVs?

Photovoltaic (PV) technology is a form of renewable energy that converts sunlight into electricity through solar cells that are connected to form modules. The modules can then be arranged in a grid-like system to form an array, as seen in conventional solar panels. When the modules or arrays are integrated into building envelope components, they are known as building integrated photovoltaics (BIPV).[1]

One of the primary benefits to BIPV systems is that since they can replace exterior cladding components, the need for separate cladding material is eliminated, as the photovoltaic panels serve as both rainscreen and power source. When integrated into building components, they can also provide functions like thermal insulation[2], noise reduction, daylight illumination, and/or weather protection. Removing redundant materials reduces material waste and capital costs. BIPV panels are available in a variety of colours and patterns, allowing more freedom in building envelope design, including panels that seamlessly integrate with Alberta Infrastructure's recommended PERSIST approach to exterior walls.

As of 2023, there were over 50 commercial, institutional and residential BIPV projects in Canada, several of which are in Alberta. This demonstrates an increase in the incorporation of BIPVs into the construction of new public buildings and retrofits as a principal or ancillary source of electrical power, which supports the Government of Alberta's (GOA) commitment to responsible environmental stewardship through its built infrastructure.[3]

Making the Most Out of BIPV Systems

PV technology dates to the 1950s when the first practical solar cells were developed, however the technology has long surpassed those early solar cells. As the technology has evolved, efficiency has risen while cost premiums in adopting solar technology have significantly decreased. The efficiency of the PV modules was only about 6% in the 1950s, but has increased so that the average of commercially available panels ranges between 20-22% in 2024.[4] The cost of solar PV modules has decreased from about $100 per watt (1970s) to an average of $0.20 to $0.30 per watt (2024), and the cost of other system components, such as inverters, batteries, and racking systems, has also decreased along with the price of installation. Unused energy from a PV system can be sent to the grid for power or cash credits, while battery storage can provide base or emergency power for a facility - highlighting the long-term value of BIPV systems.[5]

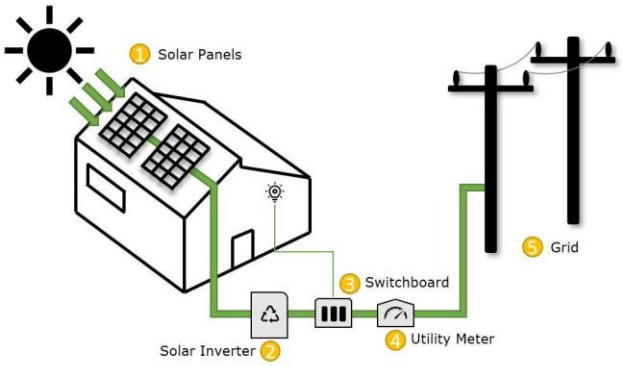

Fig. 2: How solar panels work (used with permissions by Solar Choice)

To maximize the benefits of a BIPV system, consideration must be given to **design** and **education**.

Design: While BIPV systems may be retrofitted to existing buildings, the greatest benefits are achieved when energy efficiency has been designed into the building right from the start. Choose lighting, equipment, and other fixtures to meet user requirements while minimizing energy consumption. Situate the building for best solar exposure and identify

[1] *Solar Energy for Public Buildings in Alberta,* TSB, May 4, 2016. https://www.alberta.ca/system/files/custom_downloaded_images/tr-solar-energy-for-alberta-final.pdf

[2] "Building-Integrated PV Insulation: The Smart Way to Power and Protect Your Building, Mose Solar, Feb 9, 2025. https://www.moserbaersolar.com/building-integrated-pv-solutions/building-integrated-pv-insulation-the-smart-way-to-power-and-protect-your-building/#:~:text=for%20building%20operations.-,Thermal%20Insulation%20Properties,low%20as%200.5%20W/m%C2%B2K.

[3] "Building-integrated Photovoltaics," Government of Canada, Dec 15, 2023. https://natural-resources.canada.ca/energy-efficiency/building-integrated-photovoltaics (Government of Canada)

[4] Daniel, Ifeoluwa, "The Price and Efficiency Journey of Solar Panels Over Time," Jul 9, 2024, IntegrateSun. https://www.integratesun.com/post/the-price-and-efficiency-journey-of-solar-panels-over-time (IntegrateSun)

[5] "Micro-Generation in Alberta," UCA Alberta Government. https://ucahelps.alberta.ca/Micro-Generation-in-Alberta.aspx

possible locations for PVs/BIPVs. Take advantage of natural light and solar heat gain to reduce power and gas consumption. Design the structure to support future PVs, including sufficient space for supporting equipment.

Education: Provision of energy conservation training for building users should be applied to every building, regardless of whether it is outfitted with PVs. Publicly visible displays or software can be used to provide information on how much energy the building is consuming, with the goal of further reducing the energy and the carbon footprint of the facility. Public areas can be outfitted with "dashboard" interfaces that display metered energy performance information in a clear, attractive, and accessible manner.

Where to Incorporate

The technology for BIPV systems allows them to be combined with numerous building components for seamless integration. The main application areas include:

- **Roofs:** From residential to commercial, there are a variety of products that allow for BIPV to be included in roof designs for most buildings. These products include solar shingles, tiles, and skylights.
- **Facades:** BIPV panels can be found in the form of exterior cladding tiles, curtain walls and window systems. With facades as an option, showcasing these panels at the main entrance of a building may provide an engaging visual statement and a useful teaching tool.

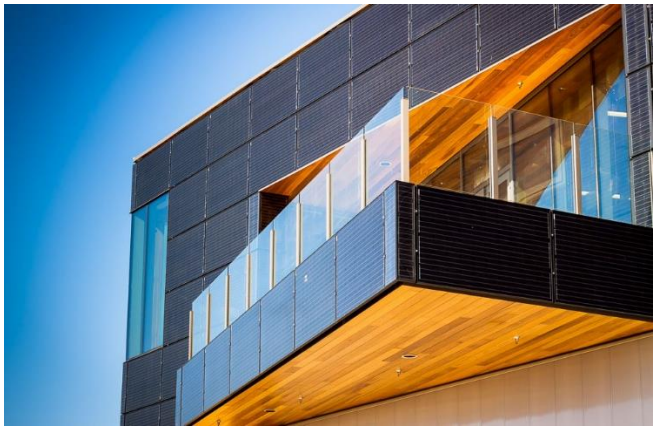

Fig. 3: Mosaic Centre featuring BIPV exterior cladding (used with permission from Jacob Komar, Revolve Engineering Inc).

- **Externally Integrated Systems:** These systems include balcony railings and window shading systems, both of which can be integrated with PV cells to complement an entrance facade while generating solar power.[6]

What to Keep in Mind

Several factors contribute to a successful design with BIPV systems. Consider the location and types of BIPV technology to avoid accidental damage or willful vandalism, while optimizing solar exposure and maintainability.

Pitched Roofs: Pitched roof systems allow snow to fall off more easily, meaning less obstruction to the PV cells for generating of solar power, and less chance of load damage.

Facade Systems: Technologies allow panels to be "pre-tuned" for specific sites/climates. This permits efficient vertical application onto a structure or facade, as well as a more integrated appearance for the overall facade. Vertical BIPVs are also subject to reduced snow and dirt accumulation and may be more accessible than roof-mounted systems for cleaning and inspection.

Glazing: Semi-transparent modules can be used to replace architectural elements commonly made with glass or similar materials, such as window glazing. Available technologies use spaced solar cells and/or thin film technologies (varying levels of transparency). As transparency increases, module efficiency decreases due to reduced sunlight capture, requiring a balance between aesthetics and energy goals.

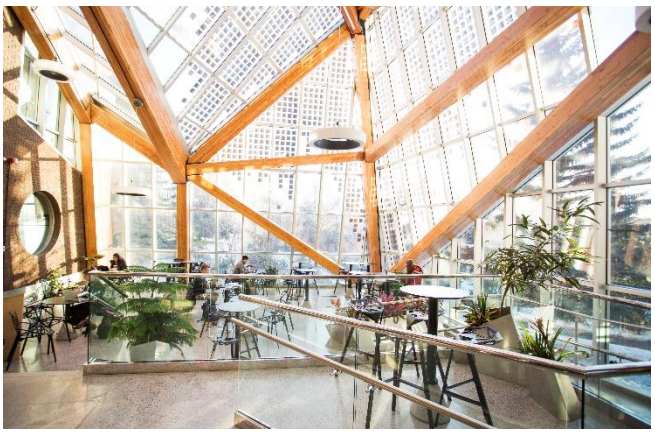

Fig. 4: Agriculture and Forestry Building Atrium of the University of Alberta (U of A) using translucent PV panels (used with permission from U of A)

Shading Devices: Wall-mounted BIPVs may be installed over openings or designed into building features, like entrance canopies or parking shelters, to provide protection from the elements, unwanted solar heat gain, and glare.

Emerging Tech: BIPVT is a subset of BIPV where there is also thermal energy recovery (heat and electricity are produced simultaneously from the same surface, producing more energy per surface area than a standalone BIPV).[6] Perovskite solar cells use a material that may offer higher efficiency at lower costs (lab tested efficiency reached 25%).[7]

[6] Government of Canada

[7] IntegrateSun

For further information contact: Building Design & Spatial Technology <infras-tsbarchitectural@gov.ab.ca>
Technical Services and Procurement Branch, Alberta Infrastructure

Alberta