Fraunhofer USA

FRAUNHOFER CENTER FOR SUSTAINABLE ENERGY SYSTEMS CSE

BUILDING INTEGRATED PHOTOVOLTAICS (BIPV)

1 *Our outdoor testing huts test adhesively mounted and conventionally racked modules for durability*

Building Integrated Photovoltaics (BIPV)

CSE's Building Integrated Photovoltaics (BIPV) research leverages the Center's deep expertise in both PV and building technologies, and allows researchers to analyze and develop building enclosure designs and incorporate PV components.

In-house R&D expertise includes module optical and thermal design, process development for novel materials, energy modeling, and durability assessment. CSE supports the development of innovative PV module designs, materials, and applications through proof of concept, pilot production, and lifetime testing.

Characterization is performed in lab and field conditions - both for new construction and existing historical building retrofits. Examples of team collaboration include:

- Designing and testing a variety of building integration approaches;
- Developing and testing unconventional mounting approaches for residential PV; and
- Assessing the influence of building integration on module performance and on building energy dynamics.

BIPV Skills and Capabilities

The BIPV interdisciplinary team leverages the combined skills and capabilities of the Photovoltaic Technologies Group and the Building Enclosures and Materials Group to provide unparalleled expertise in:

- Development and testing of novel building-integrated solar systems
- Design of novel energy-efficient materials and systems
- Module prototyping
- Advanced laboratory thermal testing
- CFD Modeling
- Module and system performance assessment, based on outdoor exposure testing and characterization
- Module reliability, including accelerated stress tests
- Failure analysis and materials characterization
- Assessment of new materials for conventional and lightweight modules
- PV system integration
- Novel PV mounting approaches

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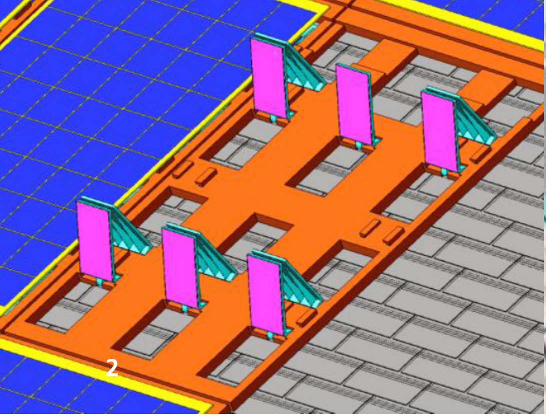


2 *Implementation of an adhesive mounting approach for glass-glass and glassless modules*
3 *Fraunhofer CSE mock-roofdeck outdoor PV testing facilities*
4 *Irradiance corrected power (ICP) vs ambient temperature for three mounting configurations*

- Demonstrations and pilots
- In situ performance, monitoring and long-term evaluations

BIPV Lab Areas of Research

The BIPV lab at Fraunhofer CSE specifically focuses its research on:

- **Module Design, Fabrication & Prototyping:** Fabrication facilities with support for novel materials, new form factors and innovative applications.
- **Module & Material Characterization:** EL and IR imaging, precision flash testing, angle of incidence performance, energy yield testing, failure analysis, and polymer science and engineering.
- **Accelerated Aging and Testing:** Development of new test methods to simulate rigorous operating conditions including effects of humidity, temperature and mechanical stress.
- **Outdoor Exposure and Performance Testing:** Long-term, grid-connected and off-grid outdoor exposure testing in northeast and southwest climates.
- **Numerical Analysis**: Allowing detailed analysis of building materials, building envelope systems, and whole buildings.

Case Study: How different mounting configurations affect module temperature and power

Fraunhofer CSE investigated the possibility of adhesive mounting as an alternative which could have a great potential in BIPV applications. Flush mounting of PV modules, like it is often required for BIPV applications, is known to increase module temperature and to reduce module output, however.

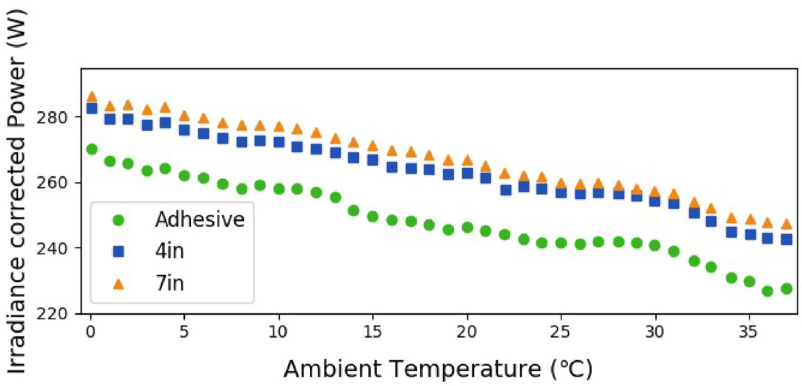
CSE investigated the magnitude of the temperature increase and corresponding power loss for three gap spacings: no gap (adhesive mounting), 4-inch gap and 7-inch gap (see **Image 4** below) for the same glass-glass module in Albuquerque, New Mexico. The effective cell temperature (ECT) was estimated from the open circuit voltage. The adhered module was found to be 10.0-15.6°C higher in temperature than the racked modules. The adhesively mounted module showed a power loss of 5% of nameplate power compared with the racked modules.

A strategy to reduce this negative effect would be a gap of 1.5 inches (or more), which would enable ventilation to substantially reduce module temperature compared to the directly adhered (no gap) case.

Case Study: Assessment of moisture build-up risk with adhesively applied rooftop PV

For the U.S. Department of Energy SunShot Initiative, Fraunhofer CSE developed Plug and Play PV Systems that used adhesively-mounted rooftop PV modules. Adhesive mounting creates a narrow gap of <5 mm between the PV back-panel and roof surface, which causes concerns about the moisture build-up under the module. To assess this moisture build-up risk, lightweight PV modules were adhesively attached on half of the roof of a test hut located in Boston, MA, while the remaining half served as the reference. Moisture pin sensors were used to determine the moisture content (MC) of the wood in the roof assembly.

MC measurements during the winter and summer seasons showed a seasonal pattern in the MC: lower values (7-11%) during the summer and higher values (11-15%) during the winter. Over the one-year measurement period, CSE observed no adverse impact of the adhesive-mounted PV on the hygrothermal behavior of the underlying roof deck element.



4