

# Welcome to the Dept. of Energy's "Building-Integrated Photovoltaics: Beyond the Shingle" Workshop!

Please help yourself to coffee and snacks. We will begin at 8:10am.



# Agenda Overview

8:00a – 8:15a	<b>Breakfast/Introductions</b>
8:15a – 8:45a	<b>SETO/BTO BIPV RFI Report</b> G. Stefopoulos (SETO), M. Lafrance (BTO)
8:45a – 9:15a	<b>Barriers &amp; Strategies for Integrating Architectural Solar – A U.S. Market Perspective</b> Chris Klinga, Stan Pipkin (ASA)
9:15a – 10:15a	<b>Industry Panel Discussion</b> GAF Energy, Mitrex, Next Energy Technologies, Toledo Solar
10:15a – 10:30a	<b>Break</b>
10:30a – 10:45a	<b>Boots on the Ground: Solar Roof Contracting Today</b> Amy Atchley (Starling RFS)
10:45a – 11:00a	<b>Let's Talk About BIPV Resilience</b> Dr. Mengjie Li (UCF)
11:00a – 11:50p	<b>R&amp;D Panel Discussion</b> EPRI, Penn State, NREL, LBL, Sandia
11:50a – 12:00p	<b>Concluding Remarks</b>

# Challenges and Opportunities for Building-Integrated Photovoltaics

## SETO/BTO Request for Information Report

Solar Energy Technologies Office / Building Technologies Office

RE+ BIPV Workshop – September 22, 2022



# Outline

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- **Background**
- **RFI overview**
- **Responses and learnings**
- **Workshops**
- **Further discussion**

# Background

- **Building-sited distributed PV was about 30% of new solar capacity installed in 2020**
- **Roof-mounted systems are currently the dominant design**
- **Other approaches and technologies could provide a competitive value proposition**
  - Providing better potential given the building aspect ratio
  - Combining redundant parts
  - Reducing overall system costs
  - Improving efficiencies

# Background

## Building-applied PV (BAPV)

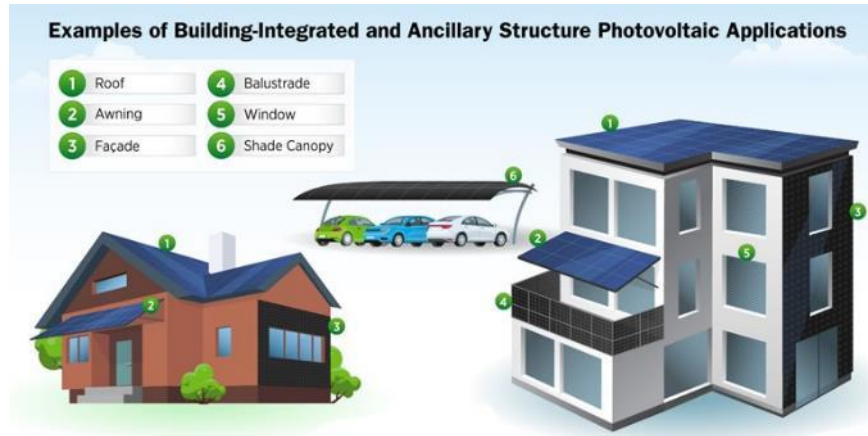


- ☐ Conventional PV modules
- ☐ Fully-functional building
- ☐ Electricity generation

## Building-integrated PV (BIPV)



- ☐ Specialized PV modules
- ☐ Integral part of building
- ☐ Electricity generation and building function



# RFI Details

- Collaborative DOE RFI between SETO and BTO
- March 7 to April 1, 2022
- 37 responses from a variety of stakeholders
- Focus on current state of the industry, challenges and barriers, gaps, and R&D needs
- Summary report at <https://www.energy.gov/eere/solar/summary-challenges-and-opportunities-building-integrated-photovoltaics-rfi>



# RFI Details – Focus areas



State of the industry and key domestic markets



Product requirements



Key barriers and perceptions



RDD&C needs and opportunities



Stakeholder engagement processes



# Market Segments and Opportunities

## Products

- **Roofing**
- Covering/Shading Elements
- Glass products
- Vertical products

## Customer Segments

- **Commercial buildings**
- Residential buildings
- Government, education, healthcare
- Agriculture and greenhouses

## Domestic Manufacturing

- Proximity to market
- Building products typically produced close to consumption
- Cost/emission reductions

# Key Product Requirements

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Performance

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Cost

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Aesthetics

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Reliability, durability, and safety

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Process integration

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Supply chain integration

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# Key Barriers and Perceptions

## Technical Barriers

Costs

Performance

Aesthetic considerations

Technical complexity in installation, operation, and maintenance

Certification and permitting challenges

## Resource Shortages

Availability of products, product and supply chain reliability

Expertise shortage and lack of educational resources

Lack of sales, estimation, and other decision support tools

Lack of financial incentives specific to BIPV

## Awareness and collaborations

Technology awareness by designers and end-users

Existing silos in operating and business models of various affected groups

Disconnects between partnering groups and affected industries

## Research and Development

Lack of fundamental research

Lack of demonstration projects

# RDD&C Needs

## Product demonstration

Testing facilities and demonstration projects

Availability of data

## Models and tools

Production cost modeling

Energy yield modeling

Installed system cost modeling with consideration for O&M costs

Comprehensive assessment of benefits

## Performance improvements

Improved BIPV product designs – aesthetics, installation, O&M

Efficiency and energy yield improvements

Thermal management improvements

Installation and maintenance processes

Systems integration

# Stakeholder Engagement and Outreach

## Underrepresented groups

- Architectural community
- Construction industry
- Manufacturers and product implementation teams
- Power-electronics companies
- Trade associations and organizations
- Local/state regulators
- Investors

## Outreach mechanisms

- Publishing case studies
- Supporting and promoting demonstration projects
- Establishing dedicated BIPV conferences, trade shows, workshops, and other educational opportunities
- Creating a steering committee to make recommendations for specific certification standards for BIPV
- Providing funding opportunities for research and commercialization of BIPV solutions
- Instituting BIPV rebate programs or financial incentives
- Creating a coordinated national effort, like establishing a U.S.-based consortium
- Promoting early-stage innovation

# Purpose of Workshop

- Bring together various BIPV stakeholders from industry, academia, and research entities
- Create a forum for discussion and exchange of views and ideas
- Understand the current status and needs of the industry
- Receive input that would guide future DOE plans and activities

# DOE BIPV Workshops

- **RE+**
  - <https://www.re-plus.com/power/>
  - Thursday, September 22, 2022, 8:00 – 12:00p
- **Greenbuild International Conference and Expo**
  - <https://informaconnect.com/greenbuild/>
  - Tuesday, November 1, 2022, 9:00 – 12:00p
- **Buildings XV**
  - <https://www.ashrae.org/conferences/topical-conferences/2022-buildings-xv-conference>
  - Thursday, December 8, 2022, 1:00 – 5:00p



# Questions and Further Discussion



George Stefopoulos  
georgios.stefopoulos@ee.doe.gov

# US DOE BIPV Workshop - Building Technology Office

Marc LaFrance

US DOE

Advanced Technology and Energy Policy Manager

RE+ Conference, 22 September 2022



# Core functions of building envelopes

- Keep the rain out
- Keep the heat out in summer
- Keep the heat in the winter
- Maintain a view to the outdoors
- Provide safe and comfortable space
- Avoid mold, bugs and rot
- Reduce chances of condensation
- Ventilate indoor pollutants
- Avoid infiltration of outdoor pollutants and latent loads



# Building envelope infrastructure example – standards and ratings

## Fenestration:

- Simulation of U-factor, Solar Heat Gain Factor and Visible transmittance - ISO 15099
- U-factor testing - ASTM C 1363, C1199, NFRC 102
- Solar Heat Gain Testing – NFRC 201
- Spectral Optical Property – ISO 9050, ASTM E903, NFRC 300, 301
- Air Leakage – ASTM E283, NFRC 400

## Wall Insulation

- ASTM C 518, C 177

## Wall System

- ASTM C1363, ASTM C1155



Air Leakage




Hot Box



Solar Calorimeter

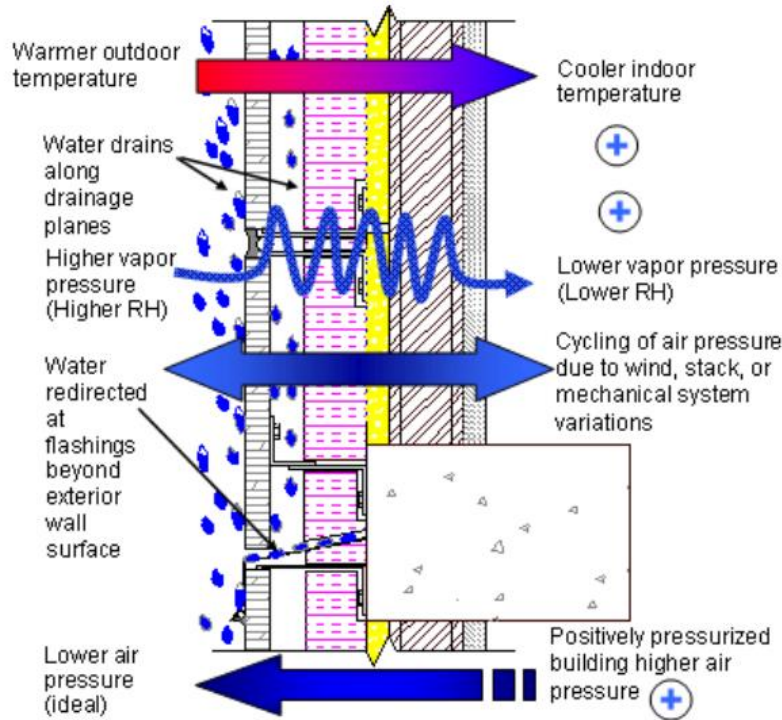


Spectrophotometer

 COOL ROOF RATING COUNCIL®	<b>Initial</b>	<b>Weathered</b>
	<b>Solar Reflectance</b>	<b>0.00 Pending</b>
	<b>Thermal Emittance</b>	<b>0.00 Pending</b>
	Rated Product ID	_____
	Licensed Seller ID Number	_____
	Classification	Production Line
Cool Roof Rating Council ratings are determined for a fixed set of conditions, and may not be appropriate for determining seasonal energy performance. The actual effect of solar reflectance and thermal emittance on building performance may vary.		
Manufacturer of product stipulates that these ratings were determined in accordance with the applicable Cool Roof Rating Council procedures.		

 National Fenestration Rating Council® <b>CERTIFIED</b>	<b>World's Best Window Co.</b> Millennium 2000+ Vinyl-Clad Wood Frame Double Glazing • Argon Fill • Low E Product Type: <b>Vertical Slider</b>	
<b>ENERGY PERFORMANCE RATINGS</b>		
U-Factor (U.S./I-P)		Solar Heat Gain Coefficient
<b>0.35</b>		<b>0.32</b>
<b>ADDITIONAL PERFORMANCE RATINGS</b>		
Visible Transmittance		Air Leakage (U.S./I-P)
<b>0.51</b>		<b>0.2</b>
Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. <a href="http://www.nfrc.org">www.nfrc.org</a>		

## Wall systems – complex moisture and air management



# BIPV needs to ensure core functions are maintained

Courtesy: Whole Building Design Guideline



# Roofing conventional PV vs BIPV

## Conventional

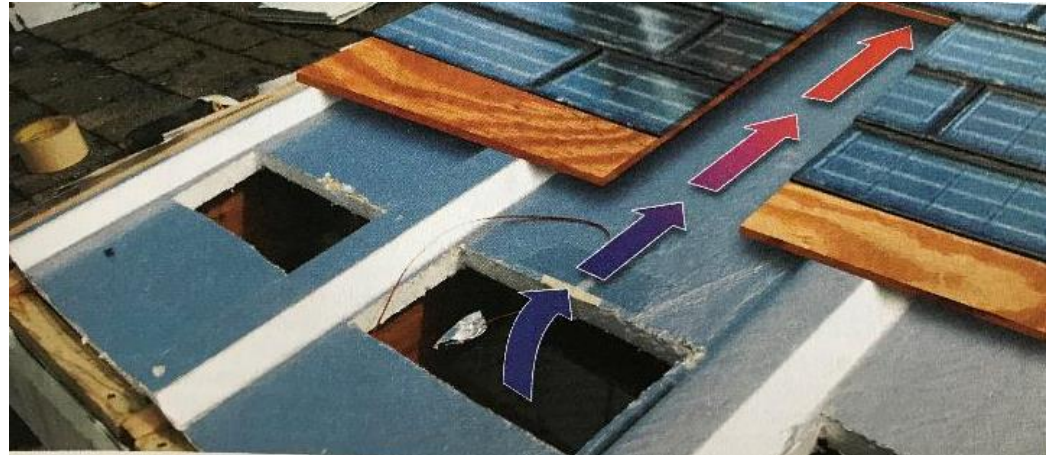
- Shades roof from heat gain
- Allows panels to cool to produce higher output
- Not always aesthetically pleasing to some



## BIPV

- Higher cell temperatures, lower output
- Increase in heat flux to attic/plenum compared to cool roofs
- Generally greater aesthetics

## Above Deck Ventilation – lower peak cooling



# Example of BIPV with high efficiency



## Key Benefits

- Highest output PV
- Cells allowed to cool
- Optimized sun angle
- Shades windows from sun

## Concerns

- Aesthetically less appealing
- Window cleaning is more difficult/costly

Source: “Transition to Sustainable Buildings, Strategies and Opportunities to 2050”, IEA 2013



# Thermal Performance of Spandrels in Glazing Systems

## Issues:

- Thermal-bridging of aluminum framing
- Differing construction of opaque wall areas vs. transparent areas
- Lack of consensus in thermal modeling

## Needs:

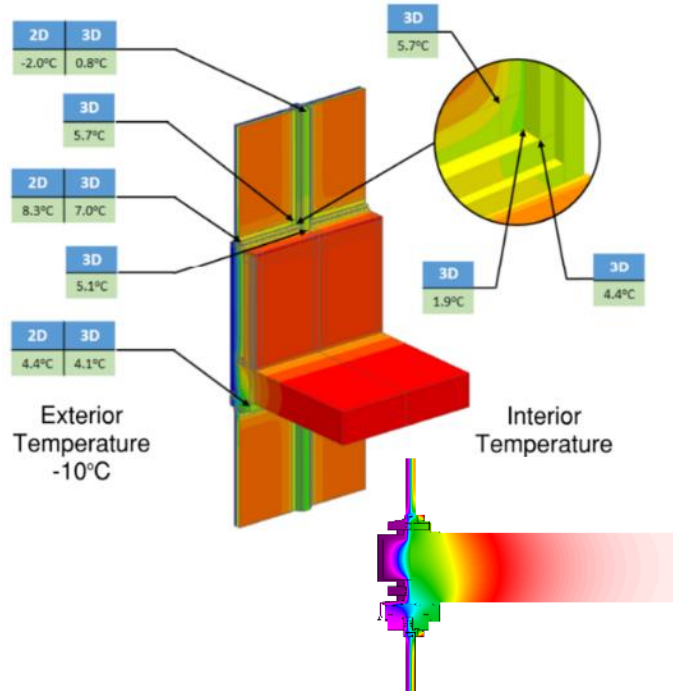
- Higher performing spandrel systems to meet more stringent codes
- Thermal modeling consensus based on validation and experimentation

## Outcome:

- *Design Guidance* document with best practices and recommended modeling procedures



**CHARLES PANKOW  
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To learn more, contact Anne Ellis

[aellis@pankowfoundation.org](mailto:aellis@pankowfoundation.org)

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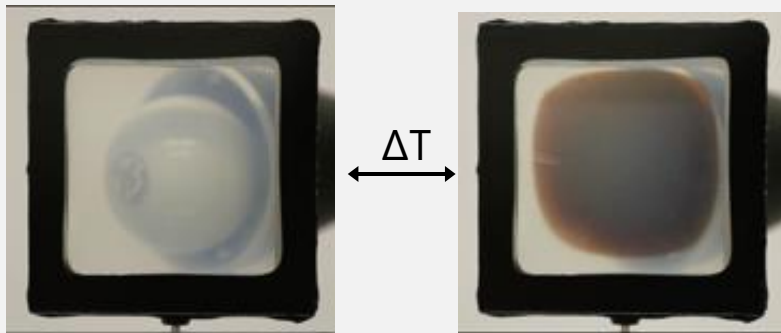
RDH Building  
Science

Simpson Gumpertz  
& Heger Inc.

# Perovskite materials for photovoltaic windows project

## Thermochromic PV

*Dynamic solar heat gain control + PV generation*



Transparent

Colored + PV

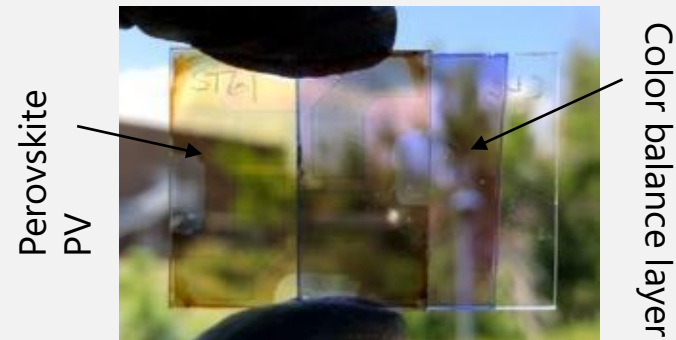
- Generates electricity and modulates solar heat gain for significant building energy savings
- Proof of concept demonstrated.
- NREL holds >10 patents on the technology
- Durability improved
- Significant investment makes them market viable in ~5 years



Lance Wheeler, PhD  
NREL

## Neutral color semitransparent PV

*High efficiency without sacrificing aesthetics*



- >6% geometric efficiency with >30 visible light transmittance and neutral gray color
- Compatible with current glazing and lamination processes
- Investment makes technology market viable in ~3 years.

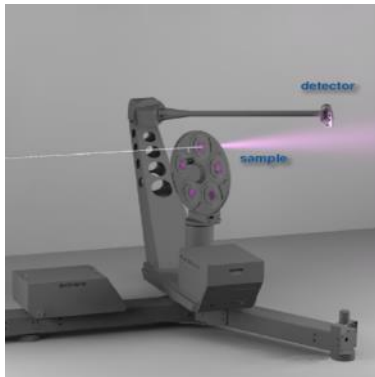
# National Laboratory expertise and advanced facilities



LBNL Flexlab



ORNL Guarded Hot Box



LBNL Goniophotometer



NREL Differential Thermal Cycling Unit



PNNL Lab Homes

# Resources and contact info

US DOE – Pathway to Zero Energy Windows – Advancing Technology and Market Adoption - [Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption \(nrel.gov\)](#)

US DOE - Opaque Envelopes: Pathway to Building Energy Efficiency and Demand Flexibility Key to a Low-Carbon, Sustainable Future

[Opaque Envelopes: Pathway to Building Energy Efficiency and Demand Flexibility](#)

Grid-interactive Efficient Buildings Technical Report Series Windows and Opaque Envelope

[Grid-interactive Efficient Buildings Technical Report Series: Windows and Opaque Envelope \(energy.gov\)](#)

LBNL Core Window Lab – Primer videos and resources

[Outreach | Windows and Daylighting \(lbl.gov\)](#)

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Cell 240-474-2177

# Barriers & Strategies for Integrating Architectural Solar – A U.S. Market Perspective



**Christopher Klinga**

Architectural Solar  
Association

- Technical Director of the Architectural Solar Association
- Principal at SolMotiv Design.
- Past experience with Lighthouse Solar and Lumos Solar
- B.S. in Mechanical Engineering from the University of Colorado in Boulder, CO.
- NABCEP PV Installer certification
- Licensed professional engineer in Colorado and Texas.



**Stan Pipkin**

Architectural Solar  
Association

- US Regional Manager of the Architectural Solar Association
- Owner of Lighthouse Solar and Pipkinc.
- Master of Architecture from the University of Texas.

[1\\_Klinga\\_Pipkin\\_ASA - RE+ BIPV Workshop.pdf](#)

# BIPV Industry Panel Discussion



**Moderator: Jennifer  
DiStefano**

Contractor to the  
U.S. Dept. of Energy



**Danial Hadizadeh**  
Mitrex



**Mark Hartel**  
Toledo Solar



**Corey Hoven**  
Next Energy Tech



**Scott Lowry**  
GAF



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
ENERGY EFFICIENCY &  
RENEWABLE ENERGY

# BREAK 10:15 - 10:30am





# Boots on the Ground: Solar Roof Contracting Today

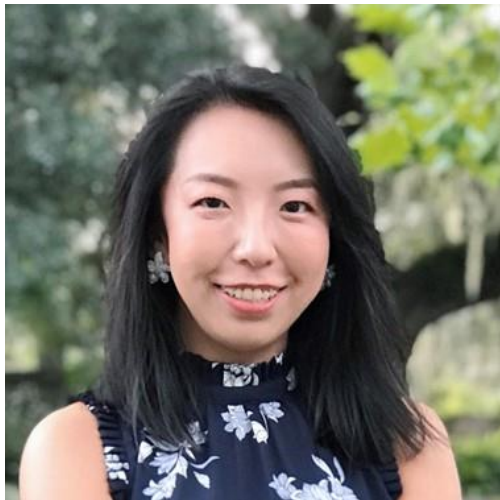


**Amy Atchley**  
Starling RFS

Amy Atchley is a solar roofing contractor in Sonoma County, CA. Amy is also the cofounder and COO of "Starling Roofing for Solar". Starling makes an award winning solar-roofing-system, giving solar roofers a product advantage to go with their business model advantages.

[2 Atchley Starling - RE+ BIPV Workshop.pdf](#)

# Let's Talk About BIPV Resilience



**Dr. Mengjie Li**  
University of Central Florida

Dr. Li is a research scientist at Florida Solar Energy Center and University of Central Florida. She has a background of high efficiency solar cell fabrication, and is currently focused on degradation pathway analysis of PV modules and improving energy and community resilience with renewable energy solutions. She will discuss the role of BIPV in improving energy resilience and the current state-of-art in BIPV durability and reliability characterization research.

[3 Li UCF - RE+ BIPV Workshop.pdf](#)

# BIPV R&D Panel Discussion



*Moderator:*  
**Jeff Cook**, NREL



**Laurie Burnham**  
Sandia Nat. Lab



**Nadav Enbar**  
EPRI



**Jacob Jonsson**  
Lawrence Berkley Nat. Lab



**Simon Miller**  
Penn State Univ.



**Lance Wheeler**  
NREL

# Thank you! Join us at upcoming DOE BIPV events

## 1. Greenbuild Conference – November 1-3, 2022 – San Francisco, CA

- DOE BIPV Workshop on Tuesday, 11/1, 9am-12pm



## 2. Buildings XV Conference – December 5-8, 2022 – Clearwater Beach, FL

- DOE BIPV Workshop on Thursday, 12/8, 1-5pm



For questions about our BIPV workshop series, please reach out to George at [georgios.stefopoulos@ee.doe.gov](mailto:georgios.stefopoulos@ee.doe.gov).

# Learn About Upcoming Funding Opportunities

## EERE Funding Opportunity Updates

Promotes the Office of Energy Efficiency and Renewable Energy's funding programs.



SIGN UP NOW:

[energy.gov/eere/funding/  
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## SETO Newsletter

Highlights the key activities, events, funding opportunities, and publications that the solar program has funded.



SIGN UP  
NOW:

[energy.gov/solar-newsletter](https://energy.gov/solar-newsletter)

Thank you!

# Thank you!

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**Marc Lafrance**

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