# Update on Toledo Solar Activities- Rooftops and PV-IGUs

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6th Annual Cadmium Telluride Workshop, October 20 & 21, 2022

# Who we are

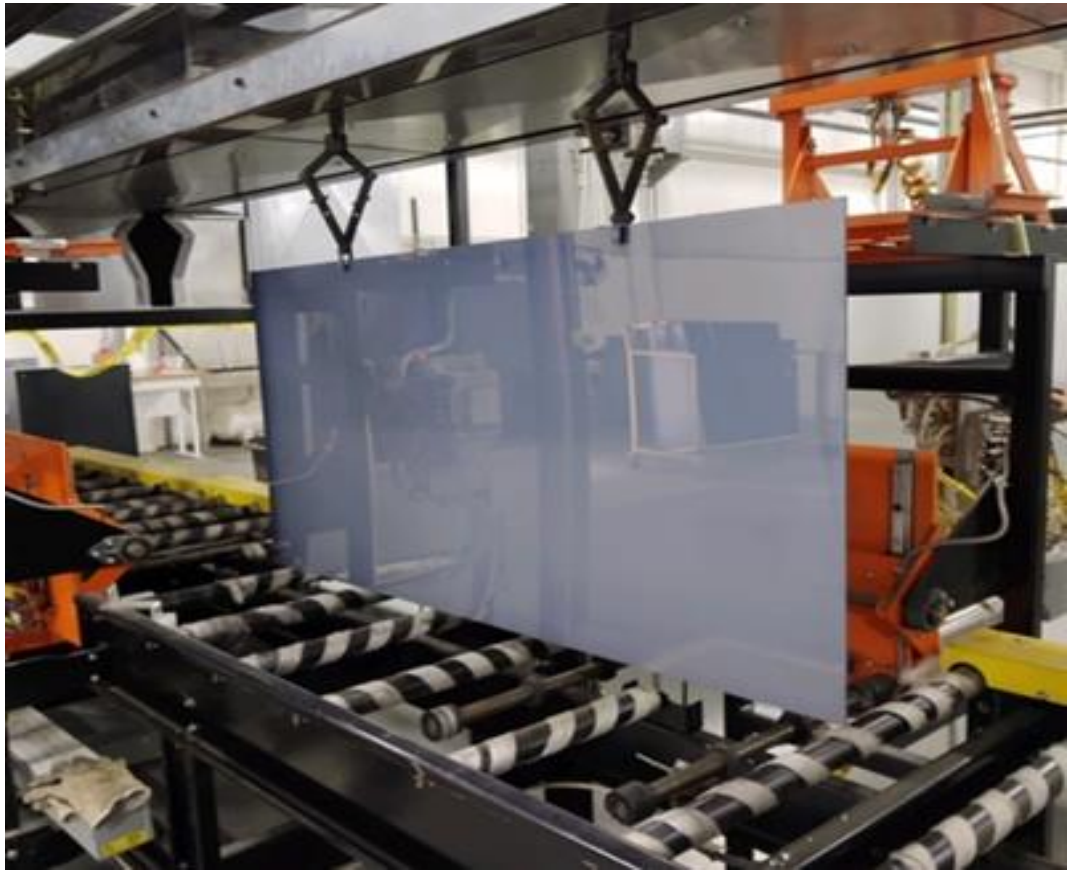

## Toledo Solar is a manufacturer and distributor of thin-film CdTe solar solutions

- focus on non-utility-scale applications
- typical product size of 2 ft x 4 ft
- deposition by vertical vapor transport (VVTD)

# Vertical Vapor Transport Deposition (VVTD)

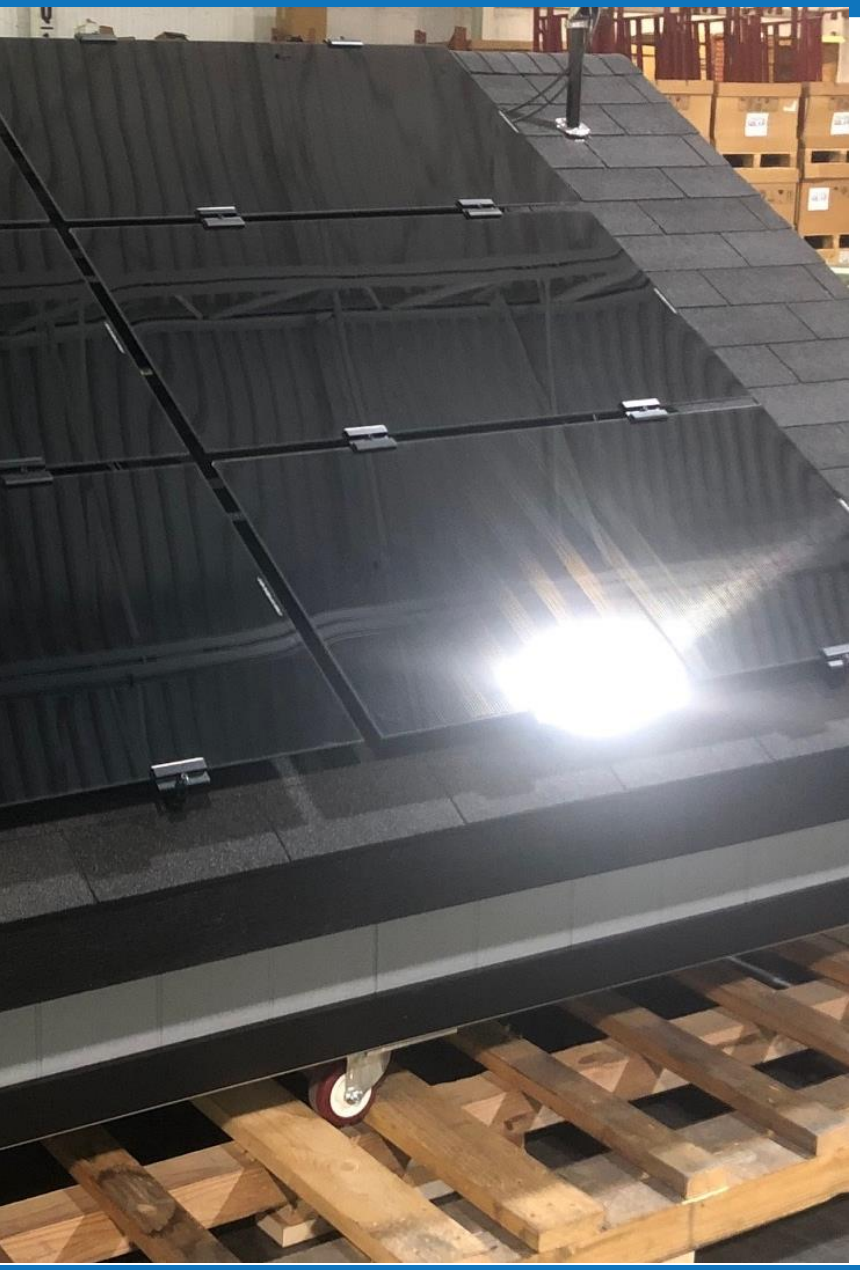
VVTD advantages include:

- Heating done from both sides with no interference from horizontal transport rollers
- Horizontal vapor streams designed to deposit films from both sides so that two plates can be transported side-by-side through the coater to double the throughput
- Vertical configuration facilitates excellent thermal ramps and temperature control and permits high temperature depositions exceeding the strain temperature of the glass



*Thin-film coated plate exiting the coater*

# Residential/Commercial Rooftops



## Modules for rooftops and groundmounts

- Frameless, cadmium telluride (CdTe), glass-to-glass modules
- Rooftop mounts and ground mounts certified to IEC & UL 61730 & 61215; CEC listed and CE declared.
- Modules are 115 W, low voltage 79 V for 1500/1000 V systems, 15 yr. warranty on workmanship and material, 30 yrs. on power output with 90% of minimum rated power for the first 10 yrs. & 80% for 30 yrs.

# Toledo Solar booth at the RE+ Show

Anaheim,
Sept 19-22



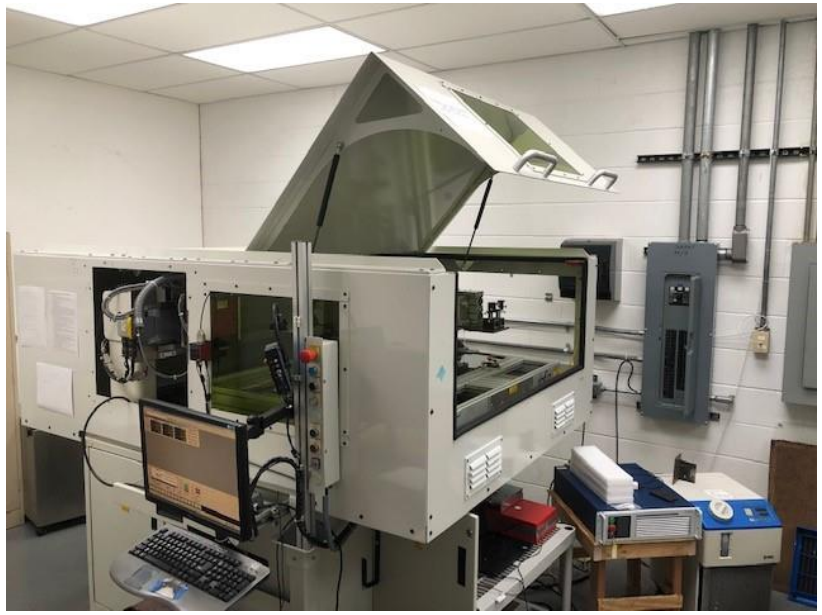

# Semitransparent Building-Integrated PV

*TSI PV window prototype with 20% VLT. Left: sky reflected from outside surface; Right: scene from building interior with panel propped against window.*

## BIPV:

- IGU or laminated glass
- Different ablation patterns: dot, linear, checkerboard
- Module performance 115 V / 60 W (for 20% transparency) and custom designs with 20-70% transparency dependent on customer aesthetic preferences
- Easily installed and scalable from 1 ft. x 1 ft. small fixtures to 4 ft. x 10 ft. units for curtain walls and glazing constructs

# Lamination & Laser Ablation



*TSI's R&D laser ablation facility accommodates full size 2'x4' PV panels on glass.*

*TSI's R&D laminator handles glass up to 4'x6' or three 2'x4' PV modules simultaneously.*

Modify standard CdTe panels with two additional steps, ablation, modified lamination:

- Laser ablation deletes a desired amount of film for semitransparency in a variety of patterns that are appealing to the eye
- Vacuum lamination provides a hermetic seal glass-to-glass protecting the thin-film semiconductor from the elements, while providing safety to installers and robustness to the module structure

# Ablation pattern examples

Laminated coupons with six different ablation patterns used for customer evaluation

- 20% VLT (visible light transmission)
- 11” x 11” coupons
- 3 linear patterns
- 1 linear w/ no visible interconnects
- Two checkerboard

Full-size laminated modules available at TSI for customer viewing of all patterns.

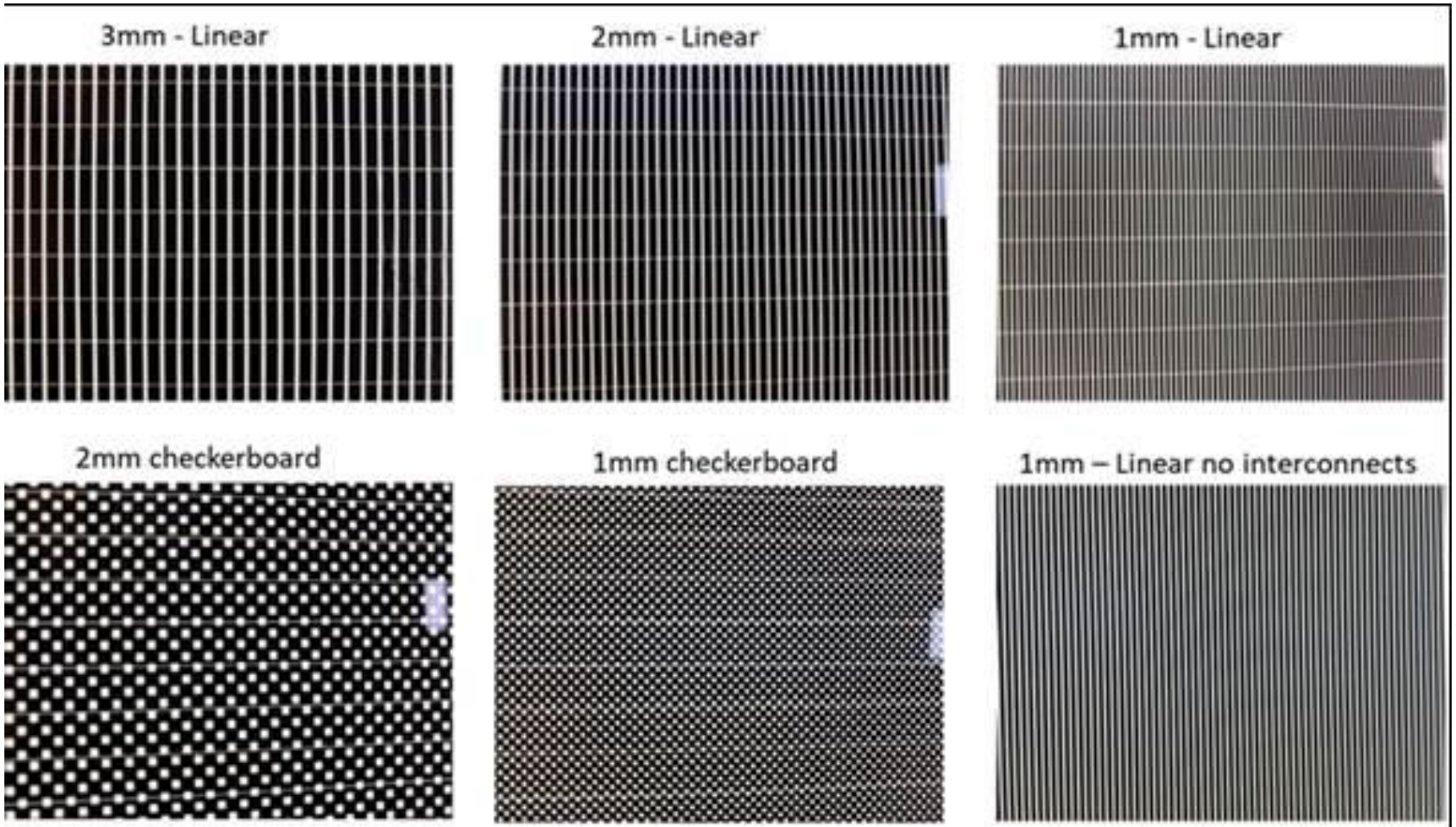



Fig. 1 Images of six different ablation patterns with 20% visible light transmission (VLT). A ~2” x ~3” region of the full 24” x 48” panel is shown with daylight illumination from behind.

# Visual appearance of ablated patterns

3mm linear

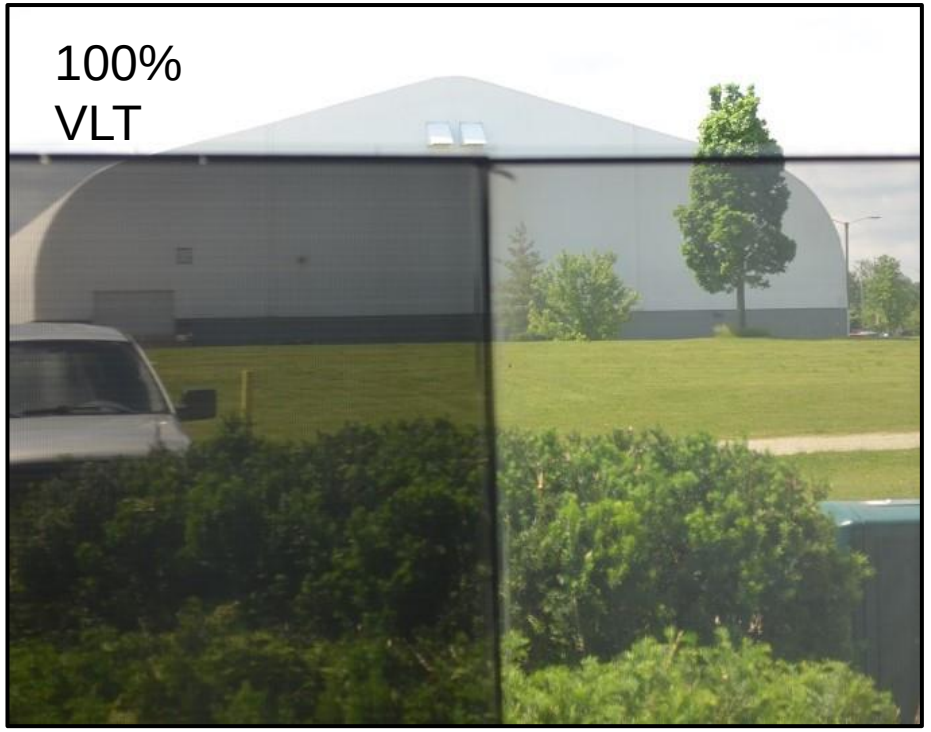
2mm checkerboard

View through ablated, laminated modules with 20% VLT. Relatively coarse ablation patterns of 3 mm linear and 2 mm checkerboard using camera at 6 feet focused on ablation patterns.

View through TSI lunchroom window showing:

upper: clear window,

lower: left/right = 8% / 50% transparent PV panels




8% VLT 50% VLT

# Components of the PV-IGU

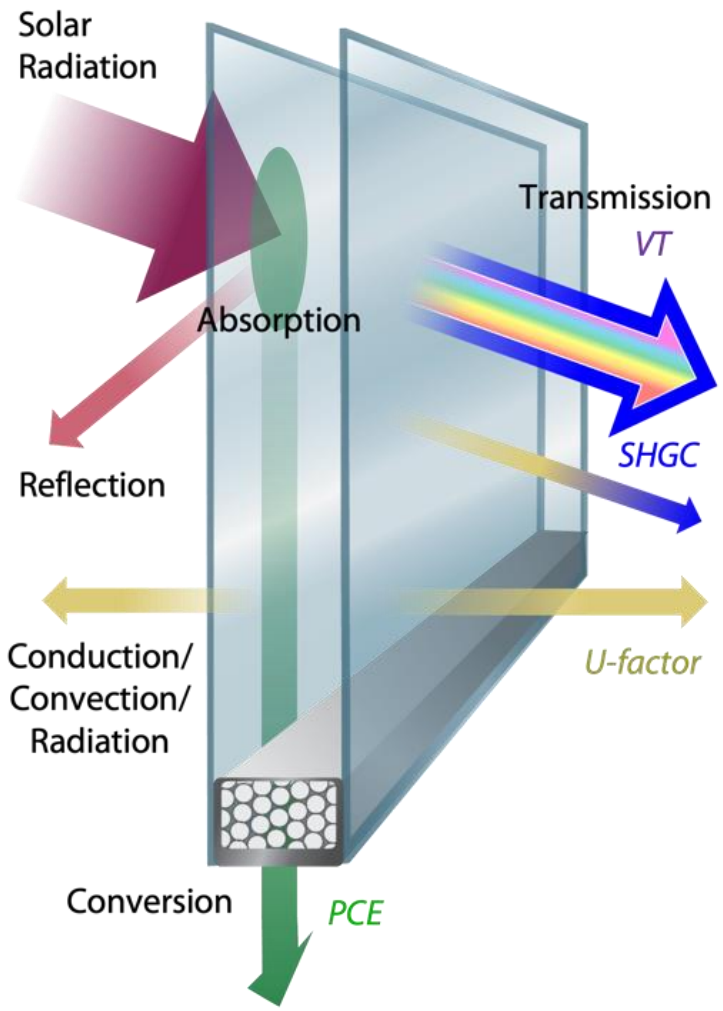
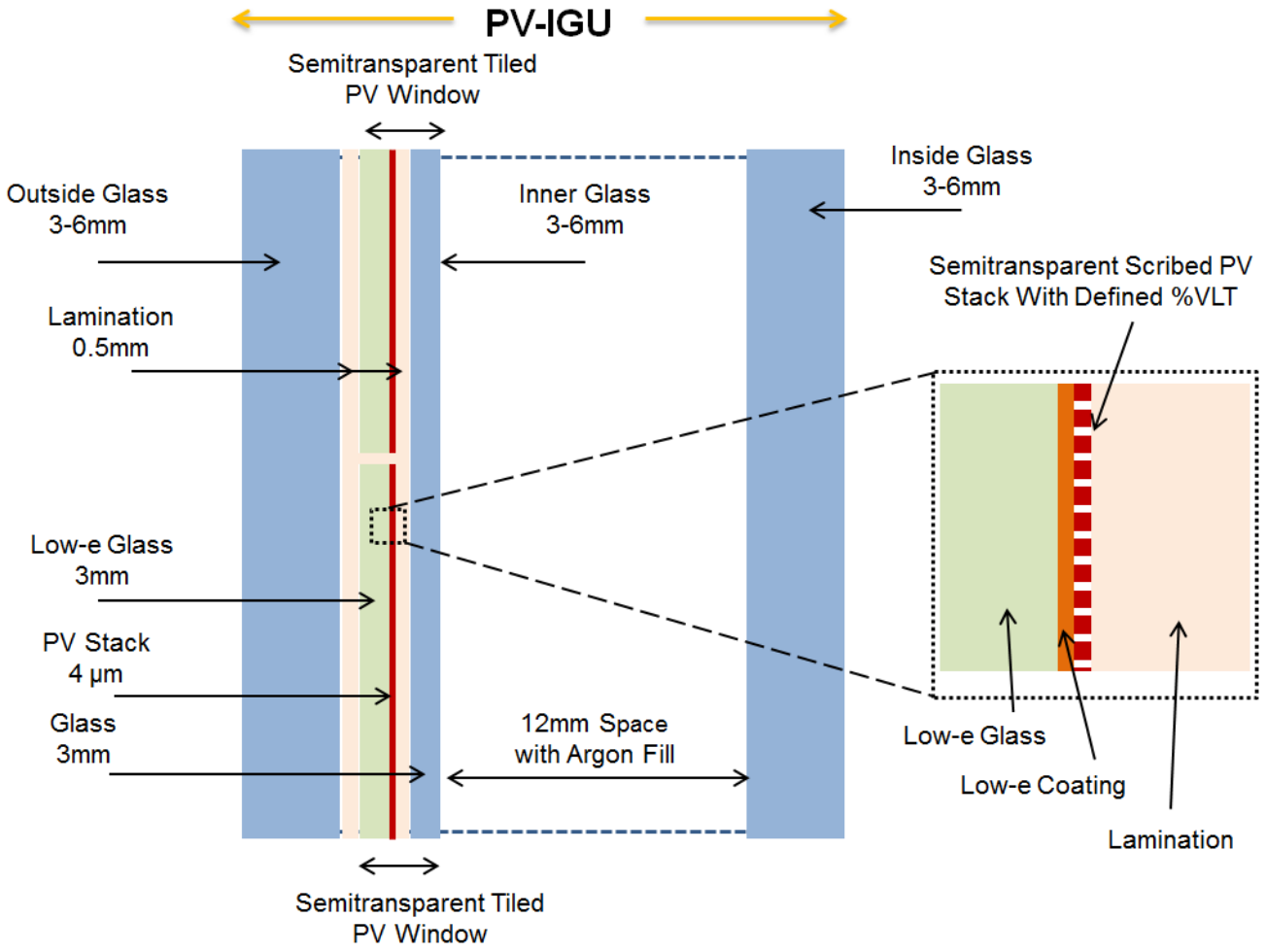



*Diagram of energy flow and important performance metrics in IGU design.*

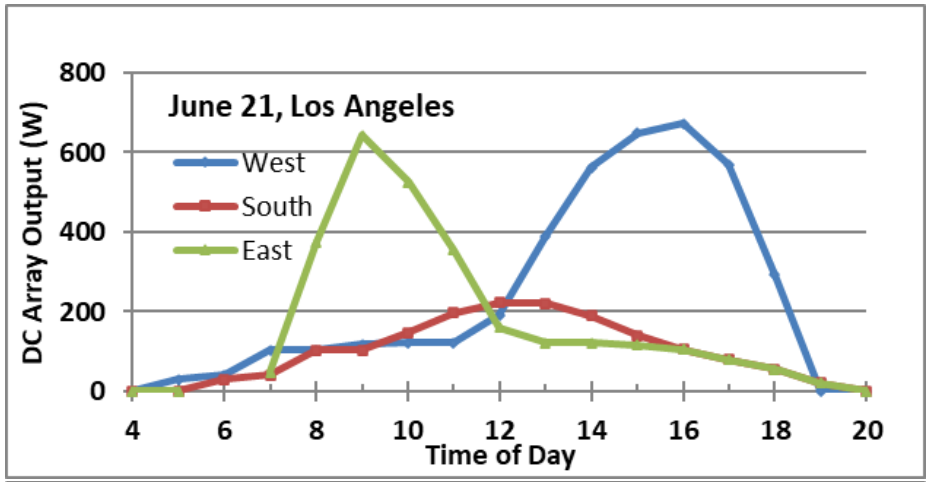


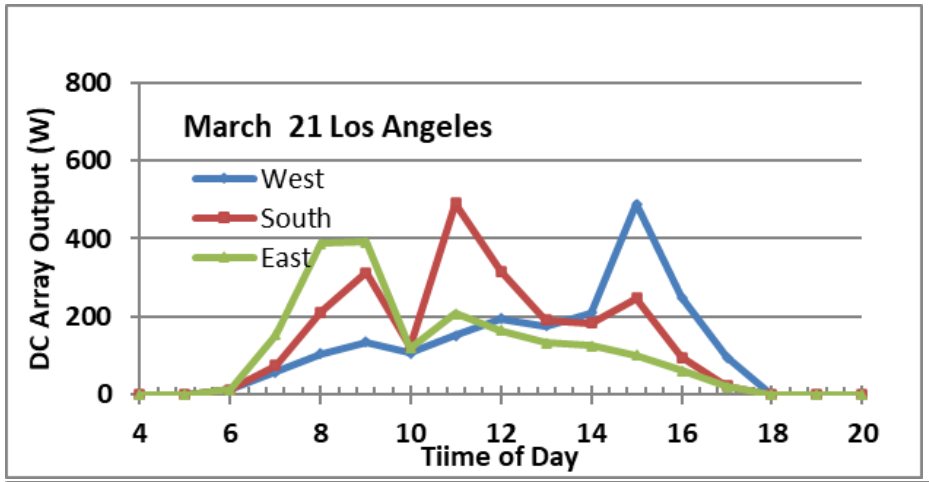

*IGU construction design detail with semitransparent solar submodule.*

# PV-IGU Power Generation vs. time of day

Value of solar windows includes total energy production, but also valuable time-of-day production.
See example below for Los Angeles, CA, with high electricity costs late in the day. (from PVWatts)

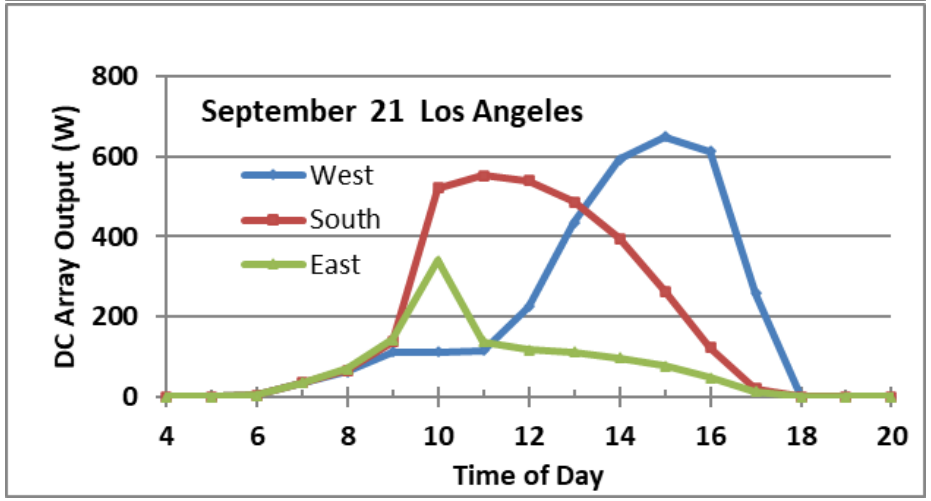
summer

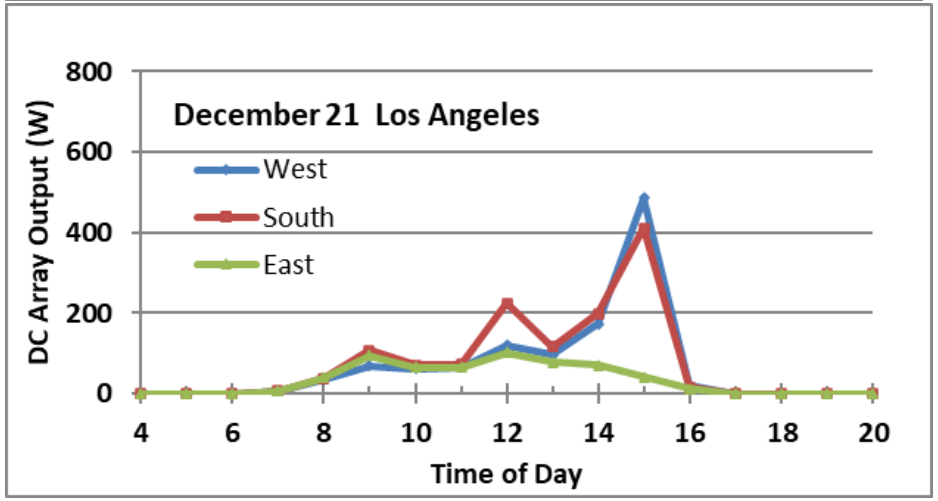



spring

fall




winter

# CdTe Accelerator Consortium

- Cadmium Telluride Photovoltaics Accelerator Consortium (CTAC) of The University of Toledo, Colorado State University, NREL, First Solar, Toledo Solar, and Sivananthan Labs with Toledo Solar's emphasis on expanding markets for non-utility scale CdTe PV

- Building-applied rooftop PV systems

- Building-integrated atriums, canopies,

- Semitransparent laminated PV windows & PV-Insulating Glass Units (IGUs) for use in residential and commercial buildings, curtain walls, & other glazing structures

- Toledo Solar has demonstrated fully-functional, stand-alone, 2 ft. x 4 ft. semitransparent modules in a variety of ablation patterns and transparencies: checkerboard, linear, & dot patterns with 20%, 30%, 50%, and 70% optical transmission with competitive power output.

Thank you!