Building Integrated Photovoltaics & the path to Net Zero

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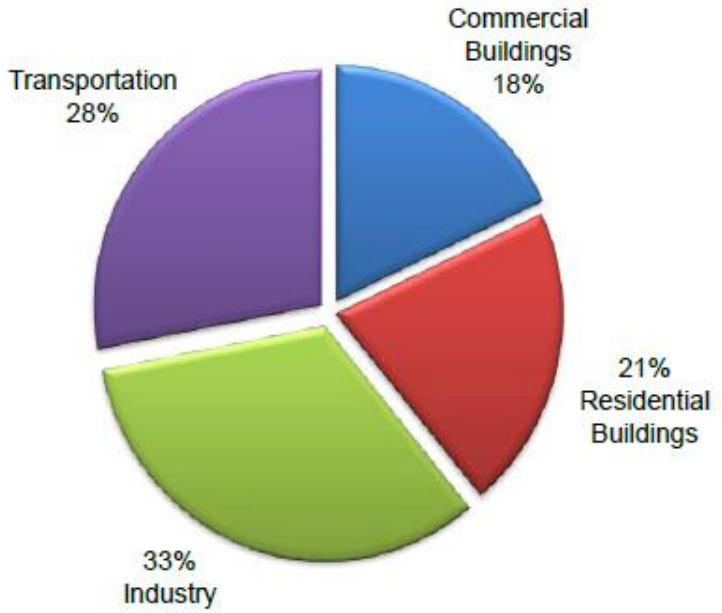
Agenda

- The Challenge
- Evolution of Building Integrated Photovoltaics (BIPV)
- BIPV & “Net Zero”
- Looking Forward

The Challenge

Buildings account for almost 40% of US energy consumption – and 72% of electricity use …



… yet the amount of solar energy that hits the earth in an hour could meet the world's energy need for a year.

How do we reconcile this?

Conclusion: The power is there, we just need to perfect the technology that will make it accessible.

Evolution of BIPV

History of BIPV

- **Photovoltaic modules started appearing on buildings in the late 1970's.**
- **First PV products specifically designed to be *integrated* into the building envelope appeared in the 1990's.**
- **Building Integrated Photovoltaics (BIPV) was born.**

Why BIPV?

Most buildings lack sufficient roof space to generate more than a small portion of their energy requirements

BIPV Product Applications –

generating energy at the point of consumption

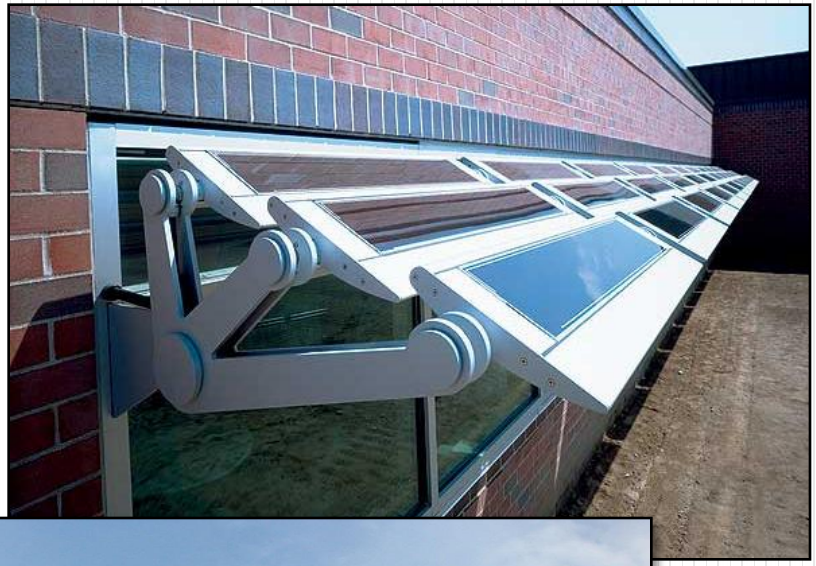
- **Curtain Walls**
- **Window Walls**
- **Sloped Glazing**
- **Sunscreens**
- **Skylights**

Curtain Walls

Window Walls

Sloped Glazing

Sunscreens



Skylights

BIPV & “Net Zero”

Strategy for Net Zero

Significant energy reduction

- Early Planning
- High Efficiency HVAC
- Extra Insulation
- Increased Day-lighting
- Energy efficient lighting and controls

+

Energy Production & Storage

Work in Progress

Office Building Renovation

- Oslo, Norway
- Built 1980
- 2 buildings @ 2600m2
- Energy consumption: ~250 kWh/m2/year

Major strategies

- Geothermal heating & cooling
- Low U triple glazing, fixed & operable; exterior sunshades
- PV on rooftop & adjacent garage

Expected result:

- Energy consumption: from 250 kWh/m2/year to 49, including user equipment and server installation
- Energy generation: 41kWh/m2/year

Components in a Net Zero solution

Vertical wall performance equals

up to 72% of rooftop array

- The rooftop option is the first area to harvest,
- Given that most office buildings have limited rooftop area, the next logical solution for Net Zero is to utilize the vertical walls.
- Vertical effectiveness is greater from late fall to spring, when rooftop installations are least effective

MONO & POLY CRYSTALLINE PANELS

Mono-Crystalline

- Original Solar Technology
- Black with White Diamonds
- Multiple Standard sizes
- Highest Performing (~20%)
- Silicone wafers mounted onto 1/8” glass with aluminum frames.

Poly-Crystalline

- Blue square pattern
- Multiple Standard sizes
- Second generation technology.
- Medium Performance (~17%)
- Silicone wafers mounted onto 1/8” glass with aluminum frames.

THIN FILM FLAT PANELS

- Latest solar technology
- Black to dark bronze
- Standard size – 24” x 48”
- Medium performing (10 - 12%)
- Vacuum deposited ionic metal onto glass. (Similar to Guardian SunGuard sputter coat process)

BIPV Curtain Wall

RETROFIT

- Install onto any existing curtain wall system
- Produces 72% of rooftop arrays
- Improves Solar Heat Gain Coefficient (SHGC)
- Potential payback in 24-36 months

BIPV Sunscreens

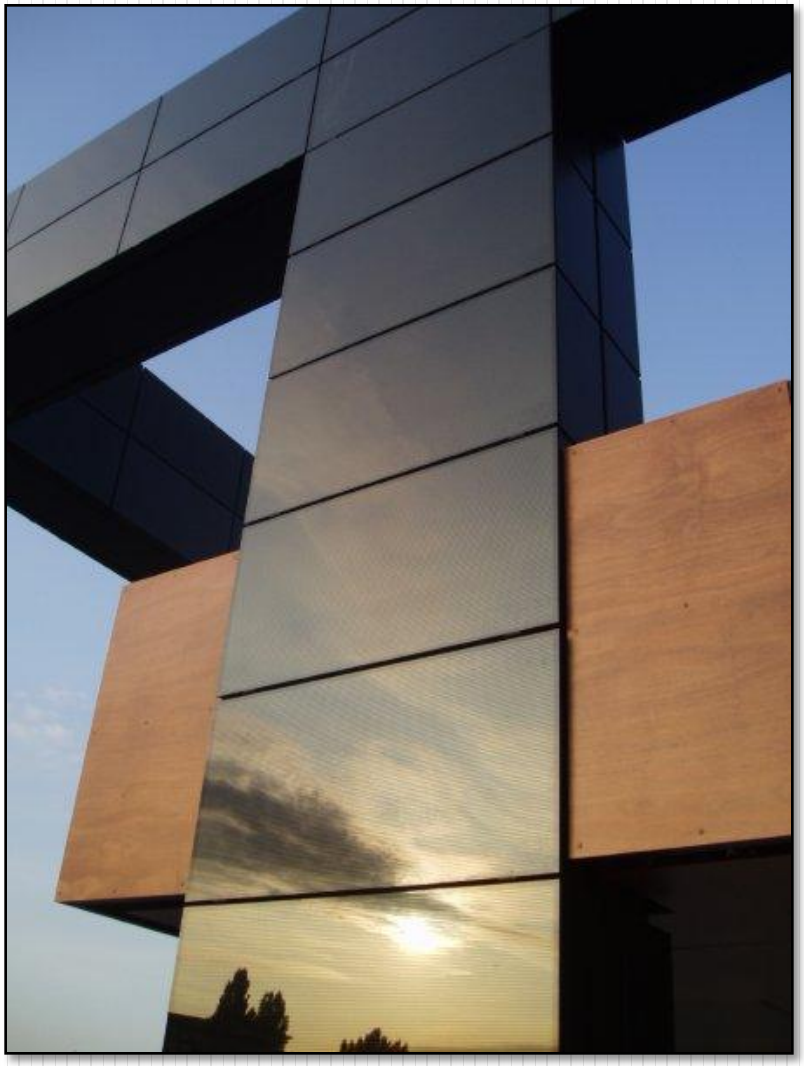
- Produce 100% of rooftop arrays
- Improve Solar Heat Gain Coefficient (SHGC)
- Install on new or existing buildings
- Potential payback in 24-36 months

Thin Film

Crystalline

BIPV Dry-Screen

- Alternative to composite panels, GFRC, stucco, or EIFS.
- Install onto new or existing buildings
- Vertical wall will produce 72% of rooftop array
- Potential payback with federal tax incentives 24-36 months



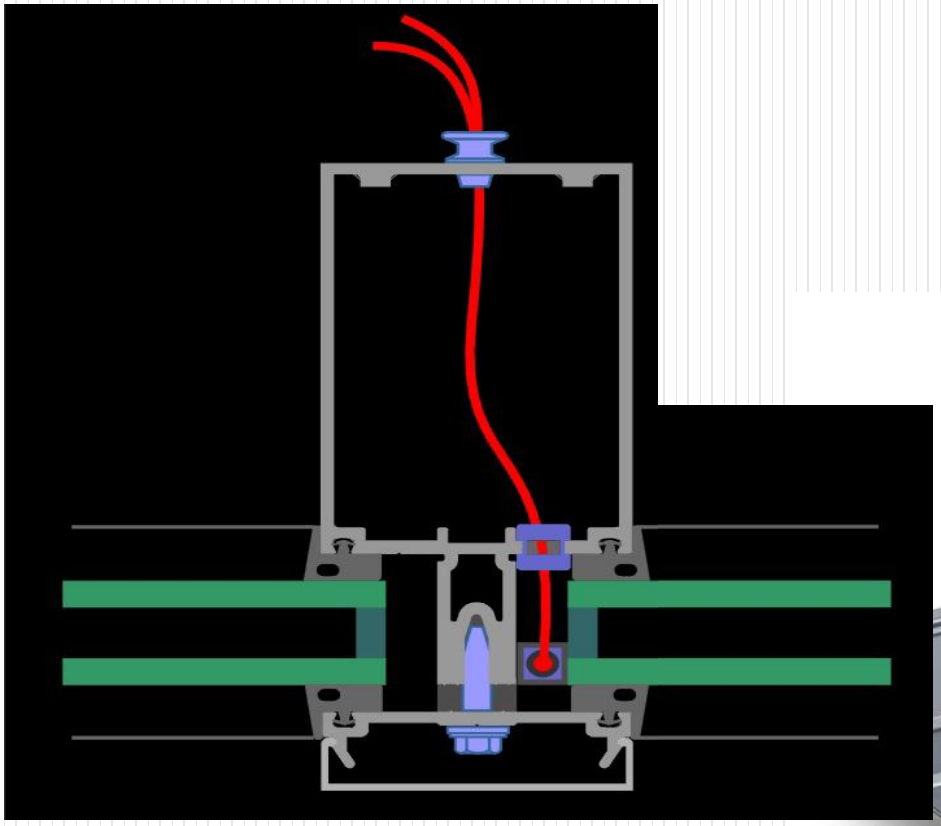
BIPV "Practicalities"

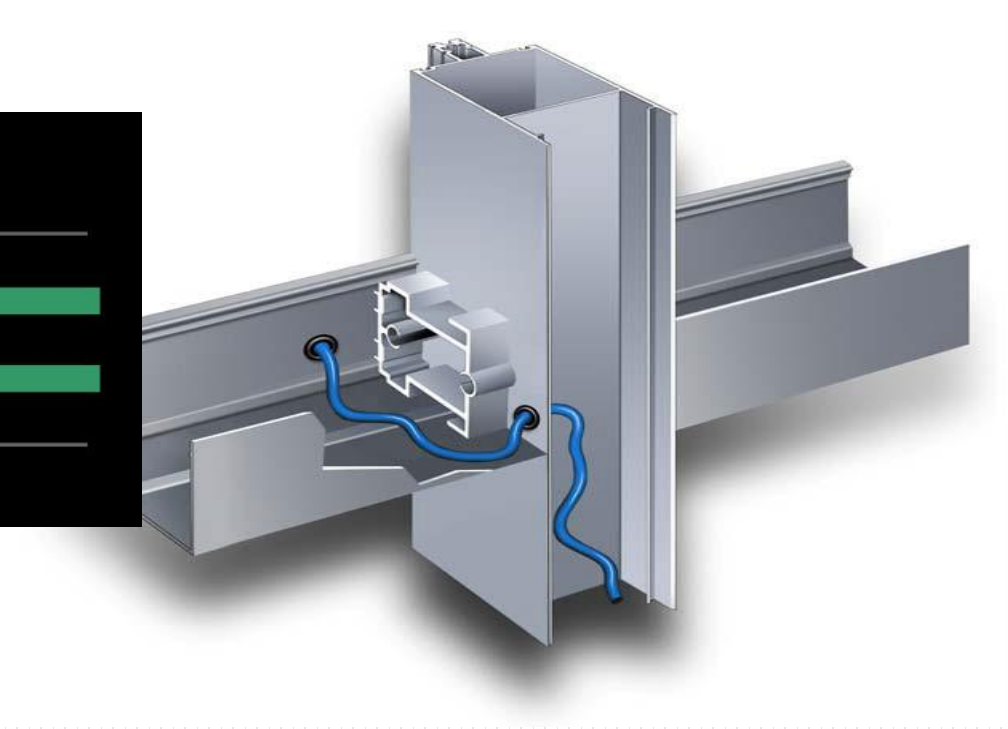
- **The addition of BIPV modules does add cost, but is still less costly than other building materials such as granite, due to the double function of generating electrical power.**
- **Any conventional glass application can be replaced with BIPV modules having the same structural and thermal characteristics.**

More “Practicalities”: Plug & Play Wiring

- Relatively Simple Process
- Preserve Thermal, Water and Air Performance
- Stress Relief Bushings Protect Wiring
- Installation Team
  - Glass & Glazing Subcontractor
  - Electrical Subcontractor

“Plug and Play” Wiring Curtain Wall

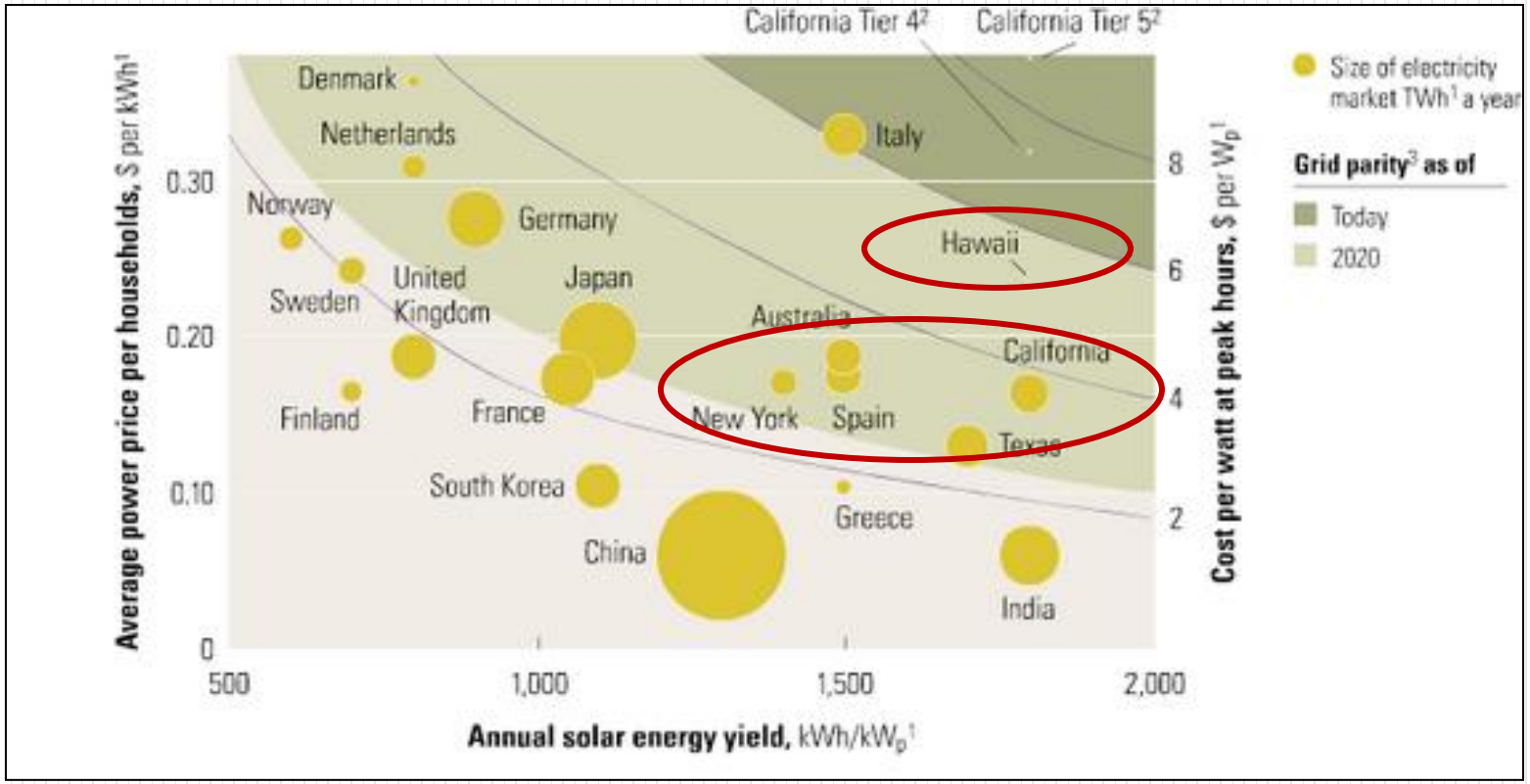




Looking Forward

PV market momentum

- US Market grew 109% in 2011; non-residential grew 127% - now largest market segment
- Much of US is approaching unsubsidized grid parity



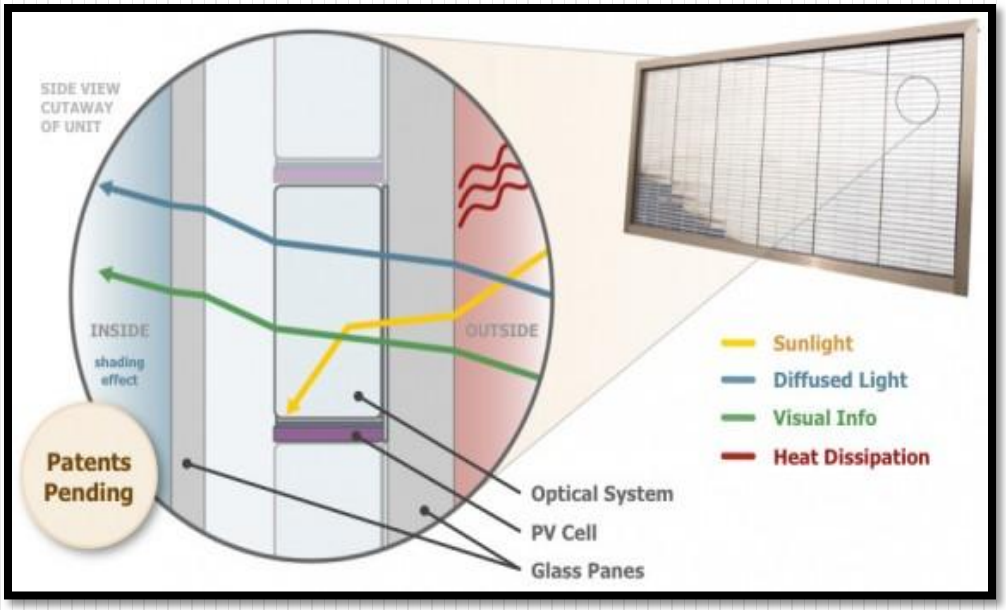
Source: CIA country files; European Photovoltaic Policy Group: Eurostat; PG&E; Public Policy Institute of New York: McKinsey Global Institute analysis

Government “encouragement” for Net Zero Buildings

- The DOE has set a goal that 100% of new commercial buildings by 2025 will be net zero energy buildings.
- California has a goal that all new residential buildings will be net zero by 2025; all commercial buildings by 2030
- Federal, state & local tax credits and other incentives
- The DOE estimates that BIPV fenestration (window) products have the potential to generate up to half the electricity needed in the country.

Rapidly evolving glazing technology …

Guardian SunGuard PVGU



- PV cells (Pythagoras) adhered to interior surface of IGU
- ~120 w/m2
- ROI as low as 3 years

Tropiglas (Australia)

- Spectrally-selective glass coating converts UV to longer wavelengths, deflects IR to periphery where PV cells are located
- Blocks UV and suppresses heat while producing electricity
- 35 w/m2 currently, 50+ w/m2 potential

More evolving glazing technology

Sharp

- Semi-transparent thin film PV laminated to glass
- For balconies, curtain wall
- Act as heat shield as well, reducing AC load
- ~75 w/m2

Resulting BIPV Forecasts

- **Worldwide Market for BIPV will grow 4-6 times over the coming 5 years**
  - **Increasing from $606 Million in 2012 to $2.4 – 3.7 Billion in 2017**
- **“Smart” glass will grow 30X, from ~100,000 m2 in 2012 to over 3 million m2 in 2020**

Pike Research Forecasts

Final Thought

- **The power is there, we just need to perfect the technology that will make it accessible.**

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