Architectural Integration of Solar PV into Building Design
1. New Construction is the Best Time for PV
2. Design Considerations to Maximize Solar Potential
3. Lousy Design Decisions
4. Architectural Integration of PV
5. What is "Solar Ready"?
New Construction is the Best Opportunity to Consider PV
Benefit of incorporating PV into new construction

- Lower upfront cost of installation
- Service panel design to incorporate 100% electric load

Photo credit: ASI Hastings
Benefit of incorporating PV into new construction

Design can include other sustainable technologies
Benefit of incorporating PV into new construction

- Roof tilt and azimuth can be designed for optimal sun exposure
- Efficient conduit runs that have been predetermined
Figure 3. About half of all commercial buildings were constructed before 1980

Existing Structures - Design Considerations

- Age of roof (roof replacement = ideal time)
- Shading by adjacent buildings/trees
- Design for energy efficiency FIRST to reduce cost of solar
Design Considerations to Maximize Solar Potential
FIRST – Design for Energy Efficiency (EE)

- Efficient building construction
- Efficient systems and appliances
- Operations and maintenance
- Change in user behavior
- Natural daylighting
- Natural ventilation
“Designing energy efficiency into projects during construction is much more cost-effective than retrofitting later. And energy efficiency saves owners across the U.S. billions of dollars in utility bills over the lifetime of their buildings.”

— Maureen Guttman, AIA
All EE things you should do first

• FOCUS on energy efficiency – it’s CORE to modern architecture
• Drive down demand as low as possible – extremely important; you’ll need fewer panels and drive down the cost of solar
• Consider orientation! Face south!
• Use daylighting so you need fewer light bulbs
Designing a Zero Energy Building

**STEP 1** Increase energy efficiency
- Efficient building construction
- Efficient systems and appliances
- Operations and maintenance
- Change in user behavior

**STEP 2** Address remaining needs with on-site renewable energy generation
- Wind
- Solar
- Hydro Energy

Photo credit: EERE
A **Zero Energy Building (ZEB)** is an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

— U.S. DOE
Solar PV and Zero Energy Buildings

According to the National Renewable Energy Laboratory (NREL), rooftop PV and solar water heating are the most applicable supply-side technologies for widespread application of ZNE buildings.
Solar PV and Zero Energy Buildings

Profiting from the Sun
How Building Developers Can Unlock the Country’s Largest Potential for Renewable Energy - Quickly and Profitably

A Point Energy Innovations White Paper

Powered by SunShot
U.S. Department of Energy
Solar PV gives points for rating systems
Solar PV design considerations

- Building orientation
- Tilt of system
- Site layout
- Shading from other structures and landscape

Photo credit: Green Passive Solar Magazine
Building orientation – run long axis east/west to give large southern exposure
In the last few hours of daylight, west-facing PV panels have an advantage over south-facing panels as they're tilted towards the setting sun.
Maximum solar production can be achieved when the PV panels are *tilted* towards the sun.

Photo credit: EERE
Design considerations: TILT for ground mounted Tracking can maximize solar production by tracking the sun’s position
Solar PV design considerations: TILT

Solar PV output depends on orientation, tilt and tracking
Site layout can determine the feasibility of solar PV
Shading will play a major role in the **available area** for the desired system size.
Shading greatly affects solar PV production
Strategies to prevent self-shading
Design to Minimize Shading

Interconnect ribbons

Lose the **shaded** cell’s production
Design to Minimize Shading

Interconnect ribbons

Lose the entire module’s production
Solar PV design considerations - SHADING

Strategies to prevent self-shading

Photo credit: CSE
Calculation for inter-row spacing:

\[ d = \frac{h}{\tan a} \]

- \( d \) = minimum distance between rows
- \( h \) = height differential between the top of the panel and the ground
- \( a \) = solar altitude angle
Design to Minimize Shading

\[ d = h \div \tan \alpha \]
Design to Minimize Shading

Solar altitude angle (angle “a”)

NOAA Solar Calculator

Source: https://www.esrl.noaa.gov/gmd/grad/solcalc/
Design to Minimize Shading

Assume $h = 24''$ and $a = 21^\circ$, find $d$

$$d = h \div \tan a$$
Example calculation for inter-row spacing:

\[ d = h \div \tan \alpha \]

\[ 61.86 \text{ in} = 24 \text{ in} \div \tan 21^\circ \]
Solar PV design considerations – ENERGY USE

How much energy will this building use?

Photo credit: Autodesk
Solar PV design considerations – ROOF AREA

How much roof area do I need for PV panels?

Rule of Thumb
1kW = approx. 100 sf

Photo credit: CSE
How can I approximate the system size?

Use calculator
• PV Watts
• System Advisor Model (SAM)
Solar PV design considerations – STRUCTURAL LOAD

Racking only
2-4 lbs./ft²

Ballasted mounted
5-9 lbs./ft²