1. New Construction is the Best Time for PV
2. Design Considerations to Maximize Solar Potential
3. Installation Failures
4. Architectural Integration of PV
5. What is "Solar Ready"?
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 designed for optimal sun exposure
- Efficient conduit runs that have been predetermined
Design Considerations to Maximize Solar Potential
First design for energy efficiency

- Efficient building construction
- Efficient systems and appliances
- Operations and maintenance
- Change in user behavior
Energy Efficiency First

“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
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** 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
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 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
Solar PV design considerations

Building orientation – run long axis east/west to give large southern exposure
Solar PV design considerations

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.

Photo credit: EERE

Powered by SunShot
U.S. Department of Energy
Solar PV design considerations

Maximum solar production can be achieved when the PV panels are *tilted* towards the sun

Photo credit: EERE
## Tilt Angle Calculation

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Angle / Tilt Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 25°</td>
<td>Latitude x 0.87</td>
</tr>
<tr>
<td>Between 25° and 50°</td>
<td>(Latitude x 0.76) + 3.1°</td>
</tr>
<tr>
<td>Above 50°</td>
<td>Use calculator</td>
</tr>
</tbody>
</table>

*Source: www.solarpaneltilt.com*
Solar PV design considerations

Tracking can maximize solar production by tracking the sun’s position

Photo credit: One Fridge Off the Grid
Solar PV design considerations

Solar PV output depends on orientation, tilt and tracking

![Simulated energy production graph](image_url)
Site layout can determine the feasibility of solar PV
Solar PV design considerations

System location will be dictated by the **available area** for the desired system size.

Photo credit: NREL
Solar PV design considerations

Shading will play a major role in the available area for the desired system size

Photo credit: NREL
Solar PV design considerations

Shading greatly affects solar PV production

Photo credit: CSE

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Solar PV design considerations

Strategies to prevent self-shading

Photo credit: NREL
Design to Minimize Shading

Lose the shaded cell’s production (left) instead of the entire module’s production (right)
Solar PV design considerations

Strategies to prevent self-shading

Photo credit: CSE
Calculation for inter-row spacing

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

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

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

$$d = \frac{h}{\tan a}$$
Example calculation for inter-row spacing:

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

61.86 in = 24 in ÷ tan 21°
Solar Installation Failures

Shading on the panels

Shading from a neighboring building
Source: Aurora solar

Shading from improper row spacing
Source: Pveducation.com
Solar Installation Failures

Damaged roofing

Potential snow dam

Poor design/installation

Damaged roof shingle
Ways to integrate solar PV into buildings:

• Rooftop solar
• Carports and shade structures
• Awnings and shade structures
• BIPV roofs, shingles, and panels
• BIPV window glazing and architectural features
Solar PV Carports

Photo credit: CSE
Solar PV Carports

Photo credit: Lumos Solar, Boulder, CO
Solar PV Carports
Solar PV Carports

Photo credit: NREL
Solar PV shade structures

Photo credit: NREL
Awnings and shade structures

Photo credit: NREL
Awnings and shade structures

Photo credit: NREL
BIPV roofs, shingles and panels

Photo credit: NREL

Powered by SunShot
U.S. Department of Energy
BIPV roofs, shingles and panels

Photo credits: NREL, Solarcentury
BIPV window glazing and architectural features
BIPV window glazing and architectural features
BIPV window glazing and architectural features

Photo credit: NREL
What is Solar Ready?

Planning for the eventual installation of a solar system when designing a building can significantly improve the economics of the investment.

Computer-generated rendering of the University of Buffalo SUNY Solar Decathlon 2015 House
Credit: US DOE Solar Decathlon
What is Solar Ready?

Installation efficiency can be maximized and costs minimized by understanding these systems’ requirements and accounting for them during the design and construction of the building.
Solar Ready Building Planning Guide

• By the National Renewable Energy Laboratory

Source: www.nrel.gov/docs/fy10osti/46078.pdf
Avoid shading from trees, buildings, etc.
Solar Ready Checklist

✓ Check the zoning laws for the proposed site to ensure that future neighboring construction will not cast shadow on the array
Solar Ready Checklist

- Determine where a future solar array might be placed
If the roof is sloped, the south-facing section will optimize the system performance.
Minimize area dedicated to rooftop equipment to maximize available open area for solar panel placement
Solar Ready Checklist

✔ The type of roof installed can greatly affect the cost of later solar PV installation.
The roof must be capable of carrying the load of the solar equipment
The wind loads on rooftop solar must be analyzed to ensure that the roof structure is sufficient.
Solar Ready Checklist

✓ Add additional safety equipment for solar equipment access and installation

Photo credit: ASI Hastings
Solar Ready Checklist

- Decide whether the solar panels will be mounted, and consider the different mounting strategies available.

Photo credit: Baker Electric
If the panels will be placed on the roof, consider how installation might affect the roofing warranty.
Solar Ready Checklist

✔ Make sure all equipment is in compliance with the current version of the National Electrical Code
Solar Ready Checklist

✔ Provide conduit or duct for access to electrical service
Quiz and Discussion
Site orientation needs to account for:
a) Tree growth on the north side
b) Neighboring buildings on the south side
c) Future potential development
d) Geological conditions
e) Both (b) and (c)
What is meant by Net zero?

a) The building uses less than it produces on an annual basis

b) The building sells back electricity to the utility grid

c) The building has a zero energy bill at least six months per year

d) The building has a photovoltaic system installed on the roof
What does solar-ready imply?

a) Roof space, free of obstructions, is reserved for a solar array

b) The electrical service is sized to add solar PV

c) The roof is capable of carrying the load of the solar equipment

d) Roof-mounted equipment is located to allow for solar

e) All of the above
Which of the following is a common rule for determining the optimal tilt for solar panels?

a) Use the location’s latitude
b) Use the location’s longitude
c) Always use 30 degrees
d) None of the above
What are the peak hours of solar production?

a) 7:00am – 6:00pm
b) 8:00am – 4:00pm
c) 9:00am – 3:00pm
d) 10:00am – 2:00pm