SIERRA COLLEGE

# PV System Mechanical Design

# Lesson Plan

- Electrical Design – Any Questions?

- NABCEP Learning Objectives:
  Mechanical Design

# NABCEP Learning Objectives

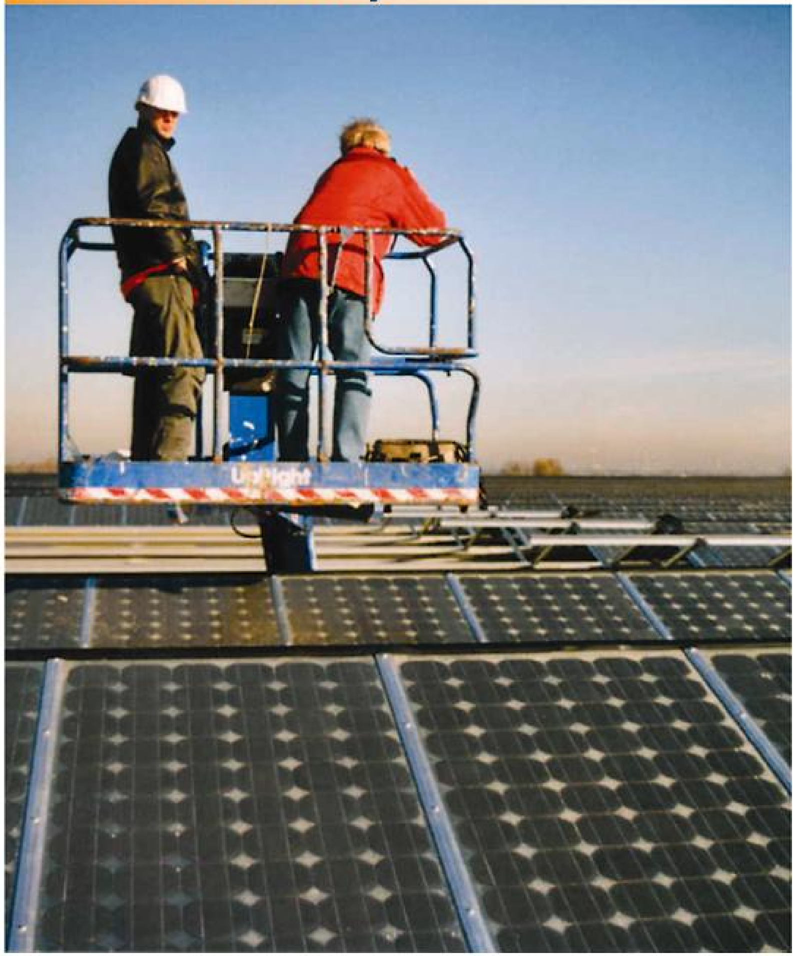
| Category | Course Time By % | Exam Items | Level of Testing | |
|---|---|---|---|---|
| 1. PV Markets & Applications | 5% | 3 | Comprehension | ✓ |
| 2. Safety Basics | 5% | 3 | Comprehension<br>Application | ✓ |
| 3. Electricity Basics | 10% | 6 | Comprehension<br>Problem Solving | ✓ |
| 4. Solar Energy Fundamentals | 10% | 6 | Comprehension<br>Application<br>Problem Solving | ✓ |
| 5. PV Module Fundamentals | 10% | 6 | Comprehension<br>Application<br>Problem Solving | ✓ |
| 6. System Components | 15% | 9 | Comprehension<br>Application<br>Problem Solving | ✓ |
| 7. PV System Sizing Principles | 10% | 6 | Application<br>Problem Solving<br>Design | ✓ |
| 8. PV System Electrical Design | 15% | 9 | Application<br>Problem Solving<br>Design | ✓ |
| 9. PV System Mechanical Design | 10% | 6 | Application<br>Problem Solving<br>Design | |
| 10. Performance Analysis, Maintenance and Troubleshooting | 10% | 6 | Analysis<br>Problem Solving | |
| Totals | 100% | 60 | | |

# NABCEP Learning Objectives

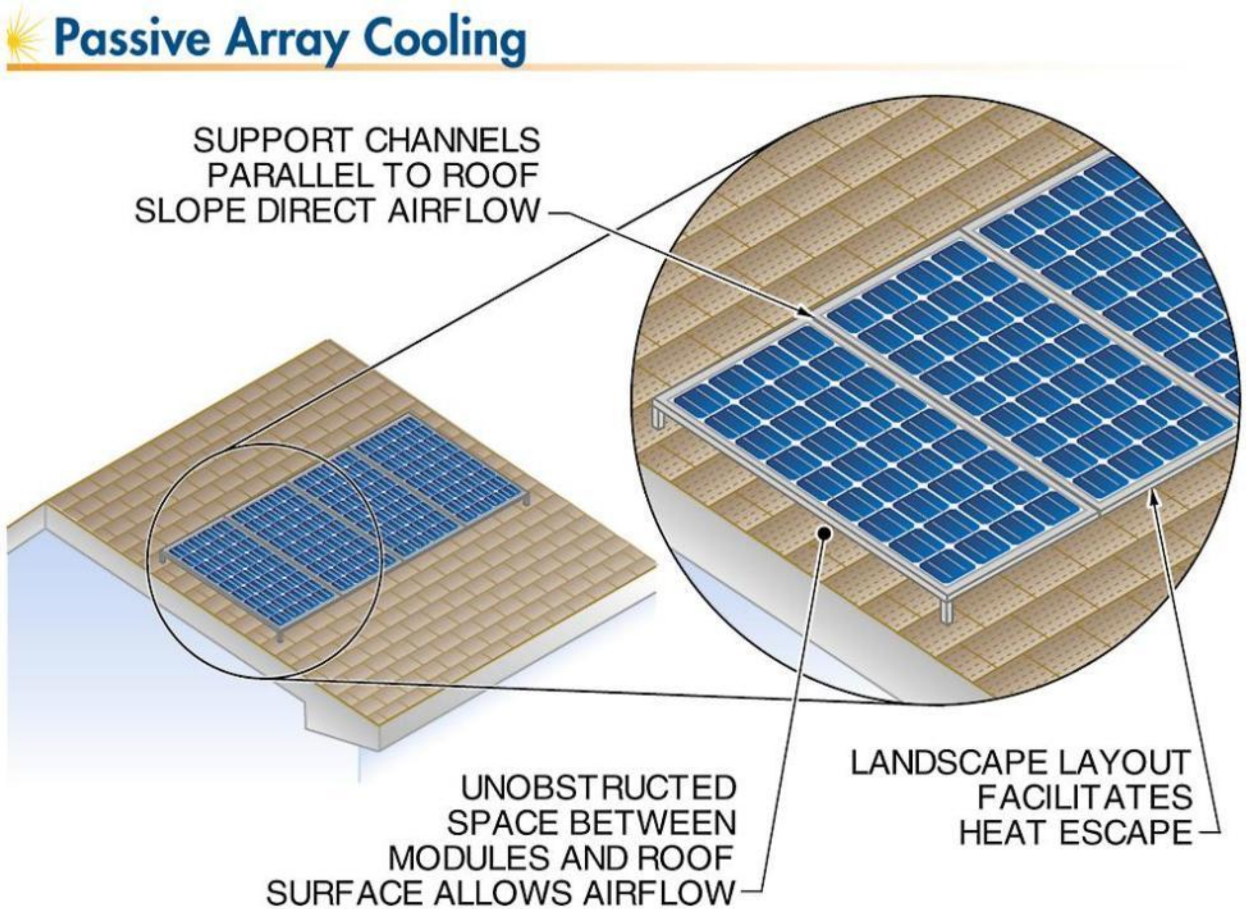
| 9. | PV System Mechanical Design<br>*Suggested Percentage Time Allotment: 10% or more* | Learning Priority |
|---|---|---|
| 9.1 | Identify the common ways PV arrays are mechanically secured and installed on the ground, to building rooftops or other structures, including rack mounts, ballasted systems, pole mounts, integral, direct and stand-off roof mounts, sun tracking mounts and for other building-integrated applications. | Important |
| 9.2 | Compare and contrast the features and benefits of different PV array mounting systems and practices, including their design and materials, standardization and appearance, applications and installation requirements, thermal and energy performance, safety and reliability, accessibility and maintenance, costs and other factors. | Important |
| 9.3 | Understand the effects on PV cell operating temperature of environmental conditions, including incident solar radiation levels, ambient temperature, wind speed and direction for various PV array mounting methods. | Important |
| 9.4 | List various building-integrated PV (BIPV) applications and compare and contrast their features and benefits with conventional PV array designs. | Useful |
| 9.5 | Identify desirable material properties for weathersealing materials, hardware and fasteners, electrical enclosures, wiring systems and other equipment, such as UV, sunlight and corrosion resistance, wet/outdoor approvals and other service ratings appropriate for the intended application, environment and conditions of use, and having longevity consistent with the operating life expectancies of PV systems. | Important |
| 9.6 | Understand the requirements for roofing systems expertise, and identify the preferred structural attachments and weathersealing methods for PV arrays affixed to different types of roof compositions and coverings. | Critical |
| 9.7 | Identify the types and magnitudes of mechanical loads experienced by PV modules, arrays and their support structures, including dead loads, live loads, wind loads, snow loads, seismic loads, in established combinations according to ASCE 7-05 Minimum Design Loads for Buildings and Other Structures. | Important |
| 9.8 | Identify PV system mechanical design attributes that affect the installation and maintenance of PV arrays, including hardware standardization, safety and accessibility, and other factors. | Important |
| 9.9 | Identify mechanical design features that affect the electrical and thermal performance of PV arrays, including array orientation, mounting methods and other factors. | Important |
| 9.10 | Review and recognize the importance of PV equipment manufacturers' instructions with regard to mounting and installation procedures, the skills and competencies required of installers, and the implications on product safety, performance, code-compliance and warranties. | Critical |

- Aerial lifts are sometimes required to reach roofs or areas with poor accessibility.

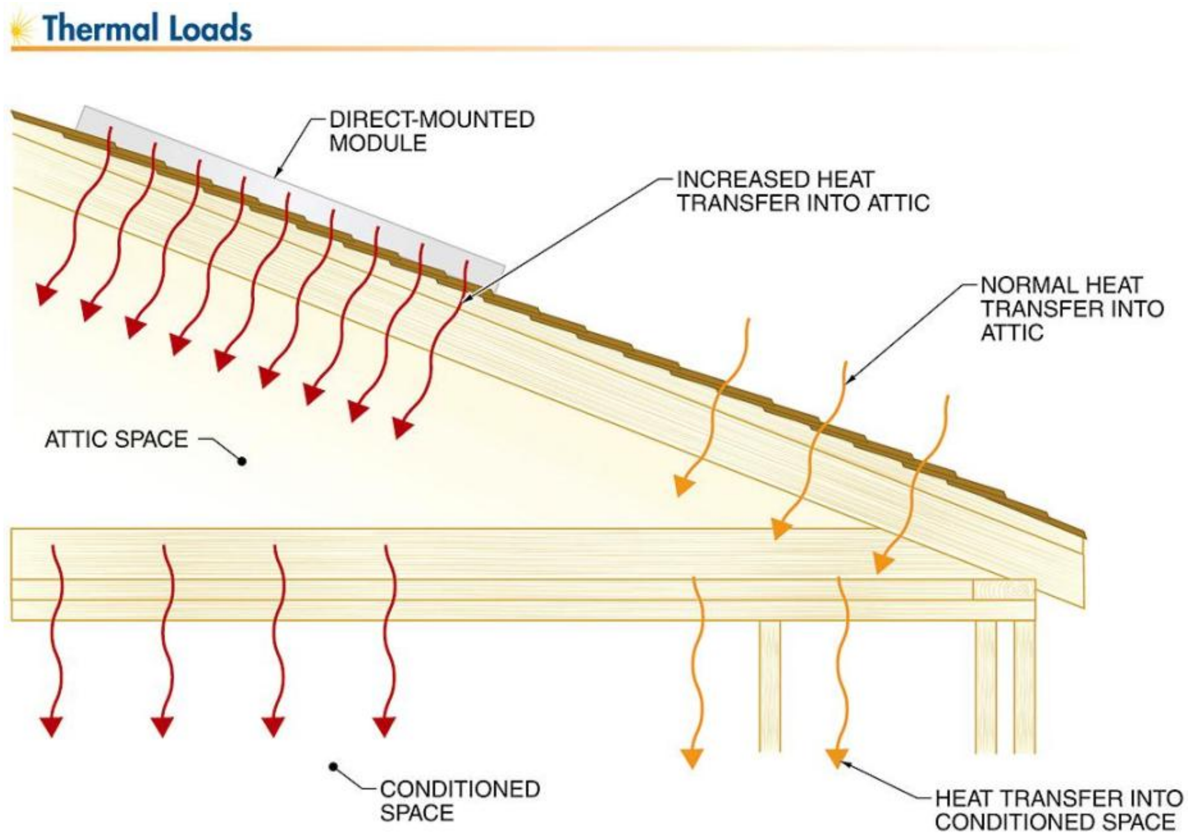
## Roof Accessibility



SolarWorld Industries America



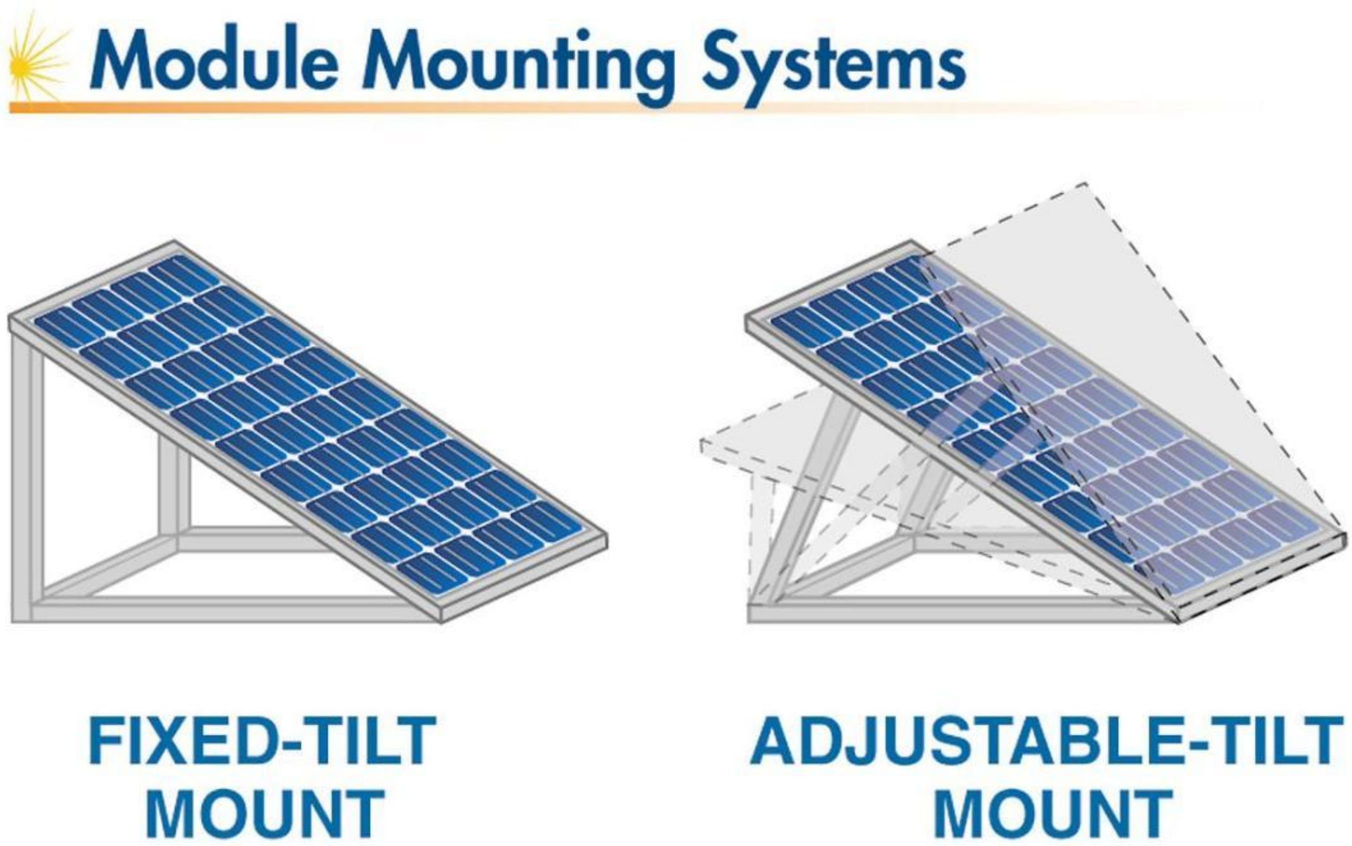

- Several passive techniques can be used to keep arrays cool, which improves array performance.




- Modules mounted directly on the roof surface increase the heat transfer into a building.

- Assembling PV subsystems such as panels before lifting them to the roof is easier and reduces installation time.


*SolarWorld Industries America*




- Mounting systems may hold modules at a fixed tilt, or may allow adjustments to be made to the tilt for greater solar energy gain.

- Roof rack mounts secure modules on a triangular trusslike structure that mounts to flat or low-tilt roofs.

Roof Rack Mounts

## Standoff Mounts

Sharp Electronics Corp.

- Standoff mounts allow several inches of space between the modules and the mounting surface.

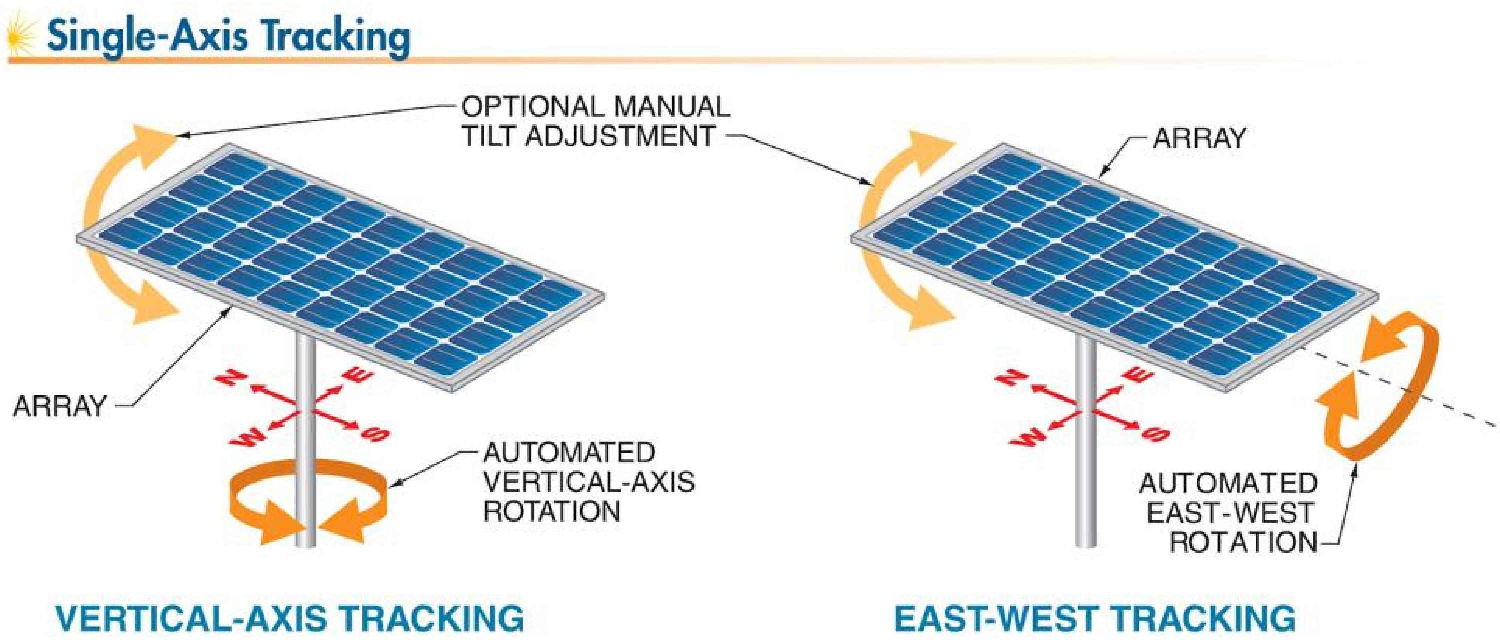
## Ground Rack Mounts

SPG Solar, Inc.

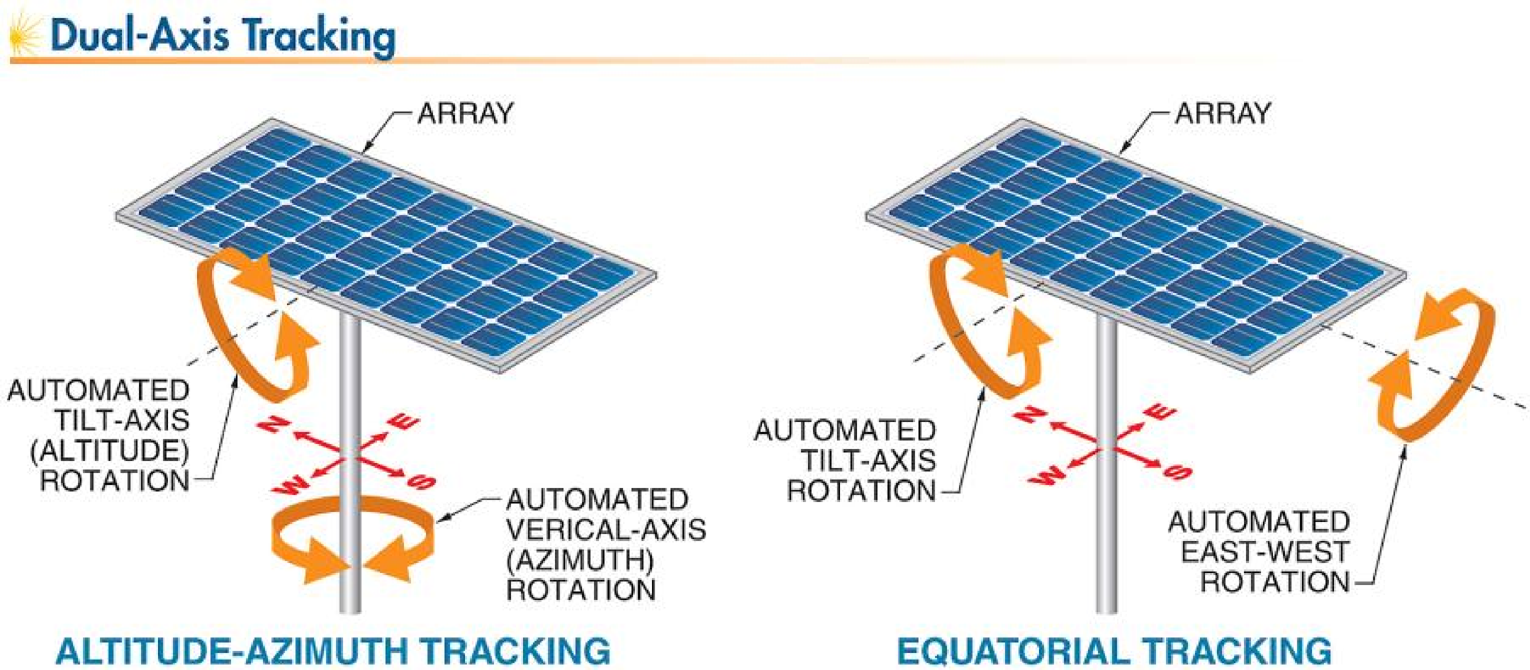
SunWize Technologies

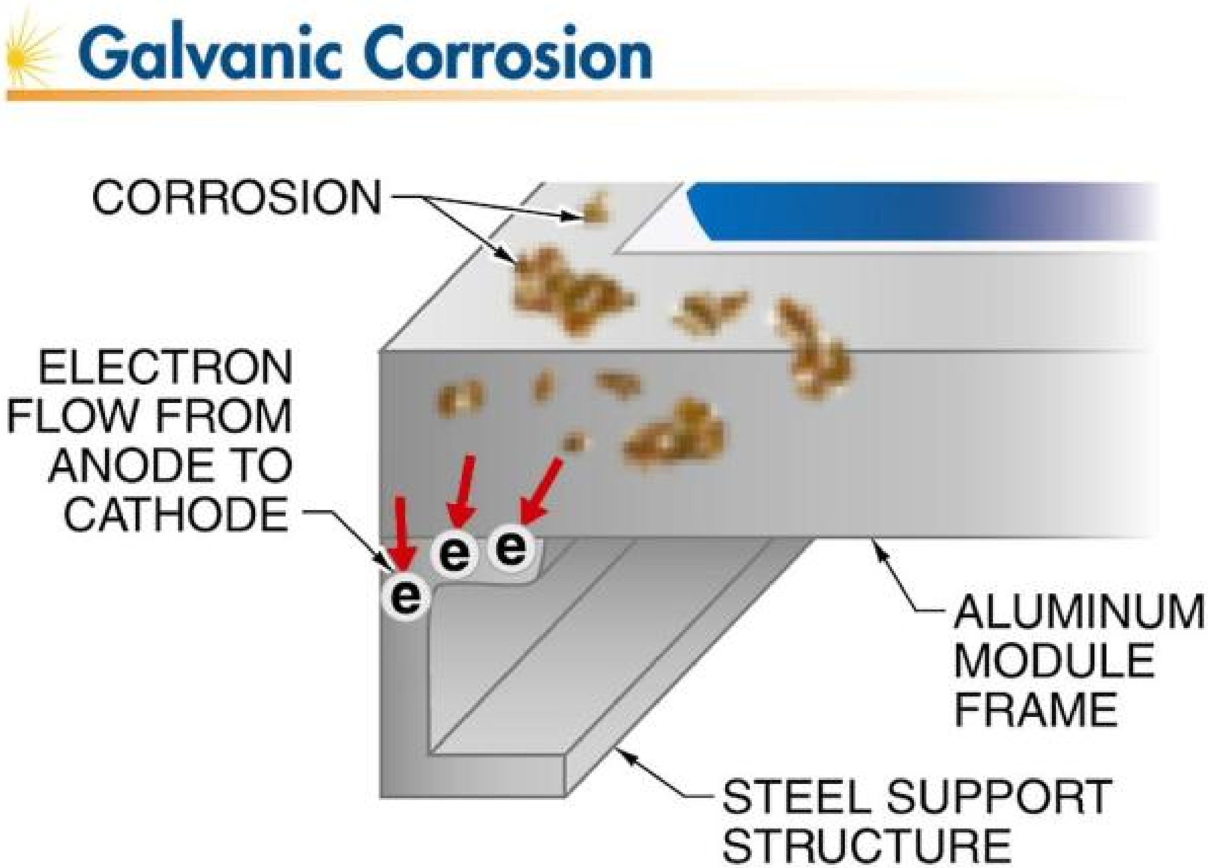
- Ground rack mounts are versatile designs that can accommodate both large- and small-scale installations.

- Single-axis tracking mounts rotate one axis to approximately follow the sun as it moves across the sky.



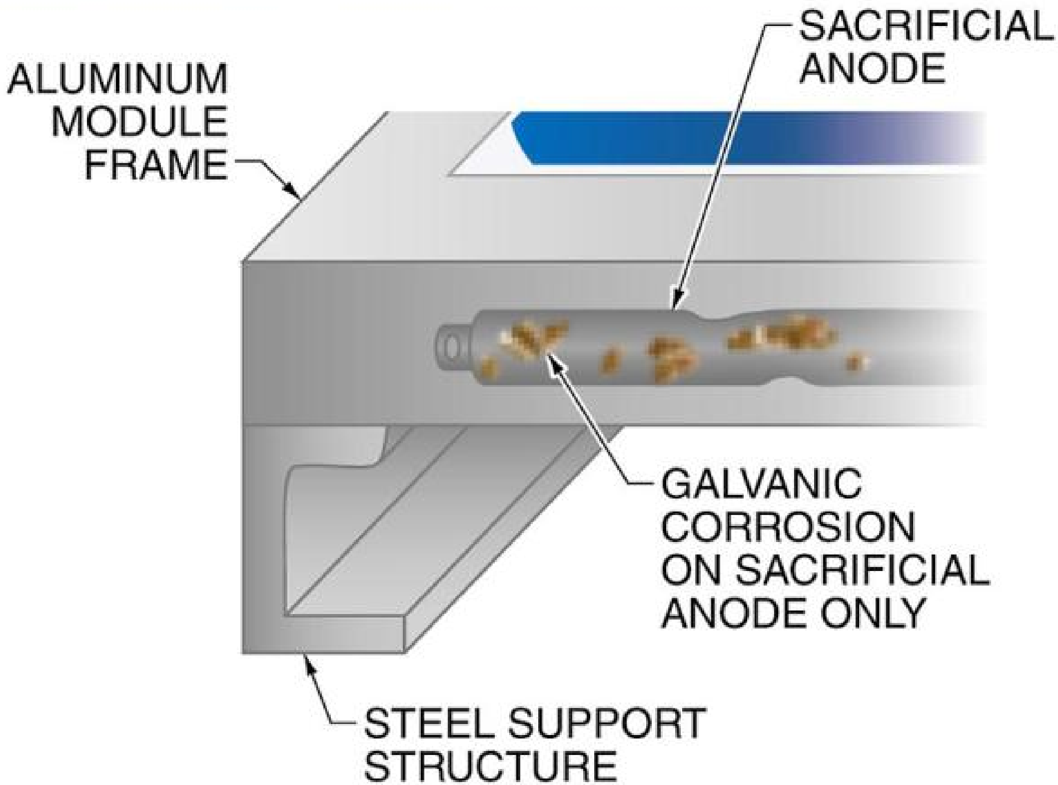
- Dual-axis tracking mounts rotate two axes to exactly follow the sun as it moves across the sky.





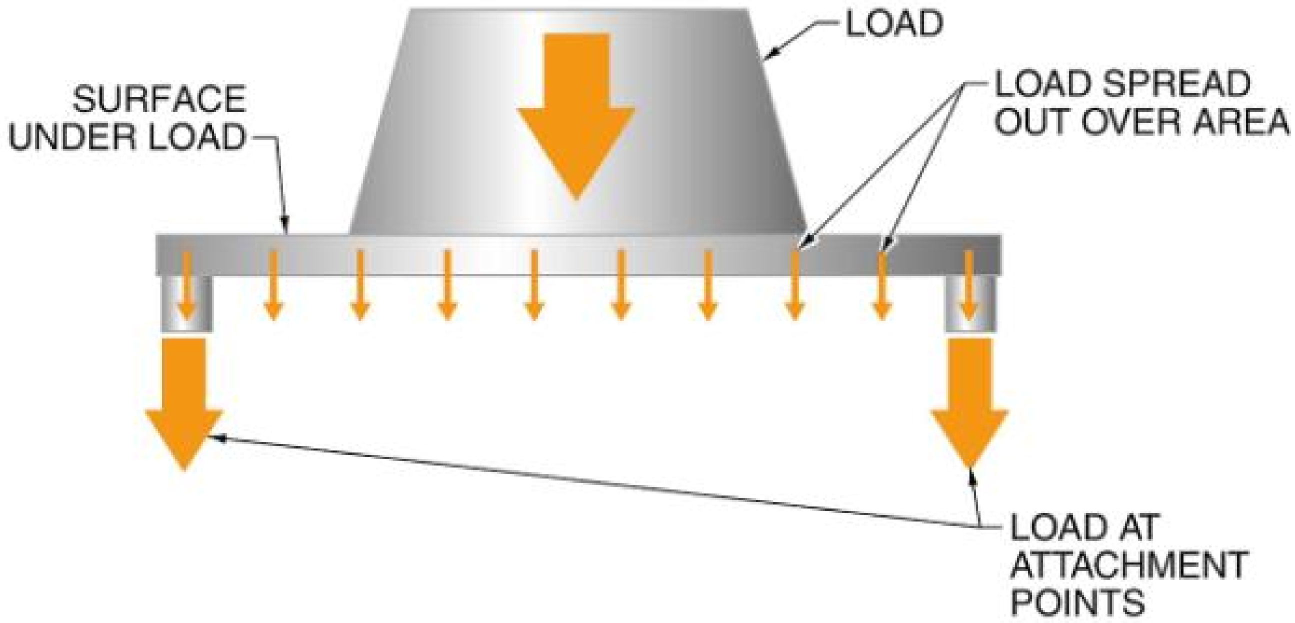

- Galvanic corrosion can occur when two dissimilar metals are in contact with each other.

## Sacrificial Anodes



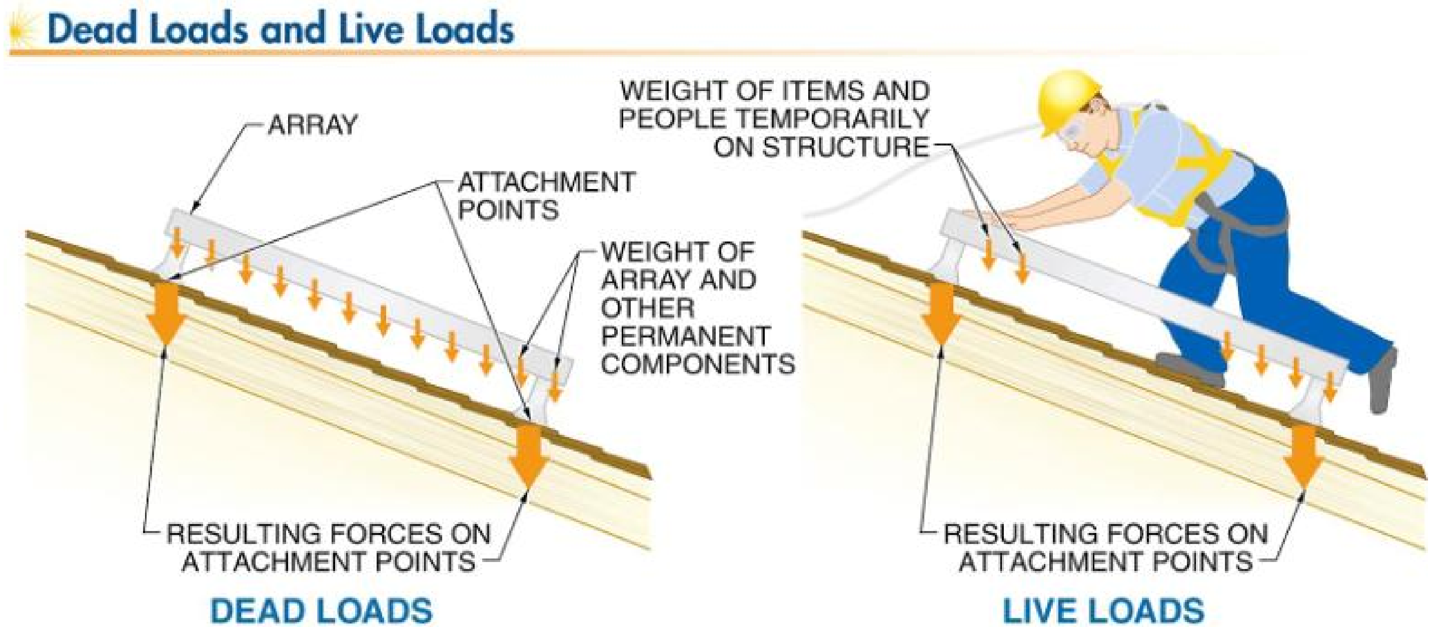

- Sacrificial anodes are more prone to galvanic corrosion than the metal they protect, so they corrode first.

## Structural Loads

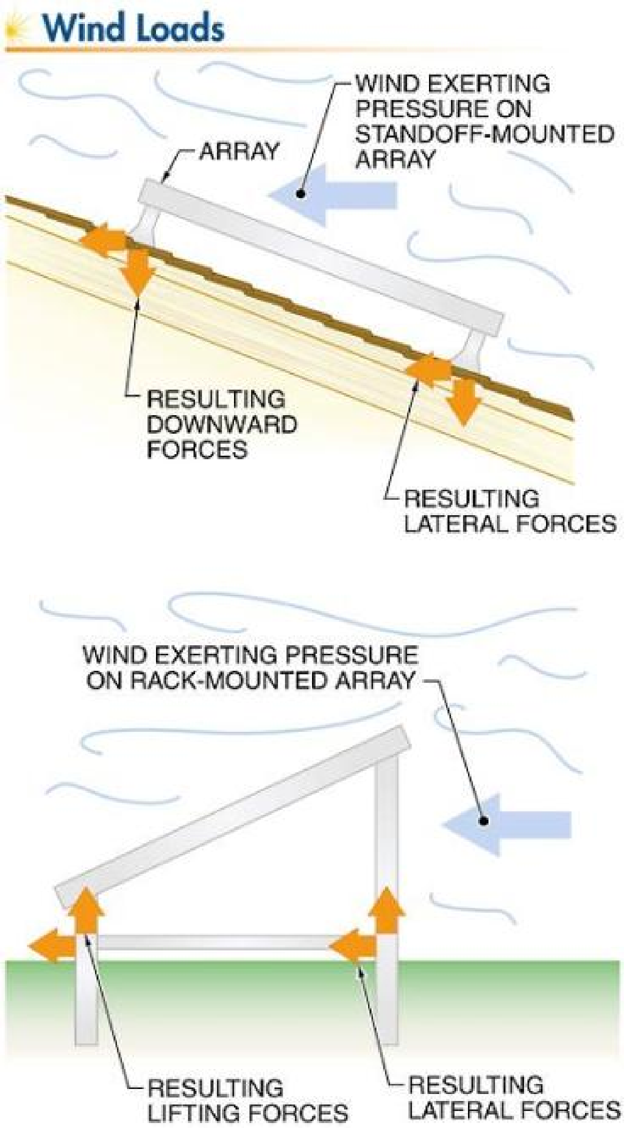


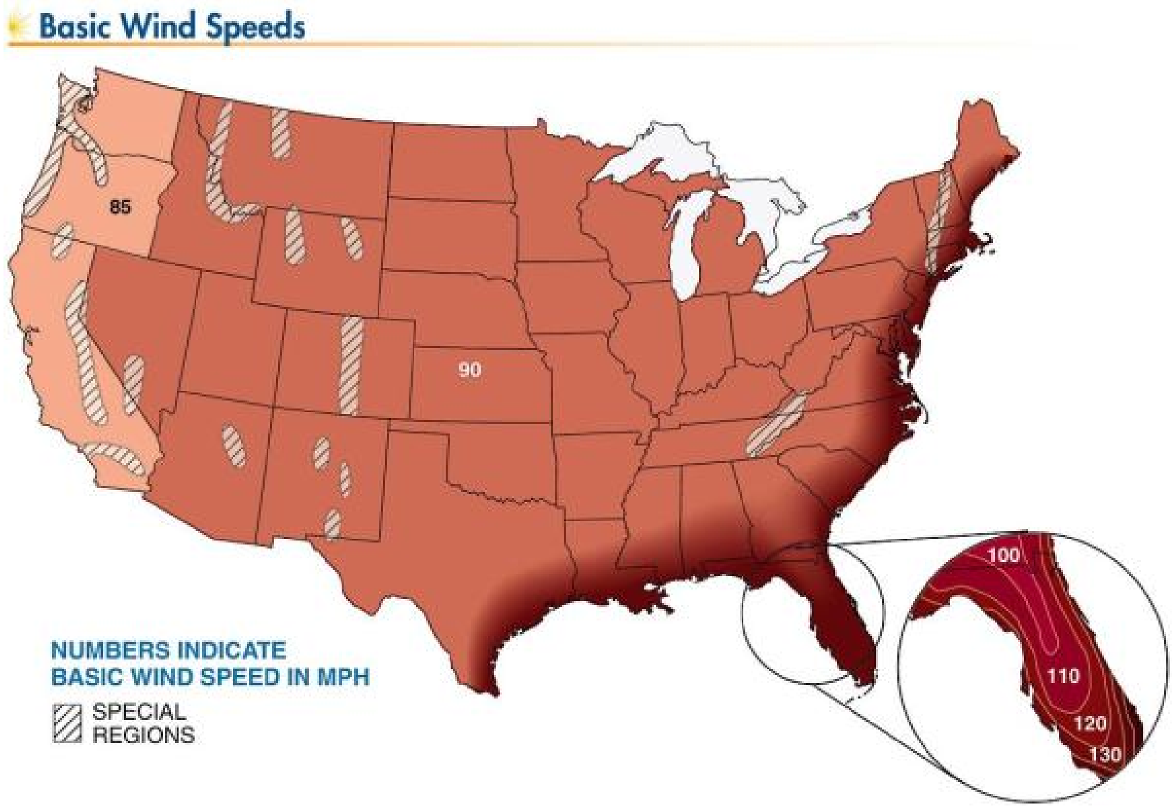

- Most structural loads are specified as a force per area. When the area attaches to other structures at certain points, the load is divided between the points.

- Dead loads result from the weight of arrays and permanent components. Live loads are caused by the weight of people and/or items that are temporarily on the structure.

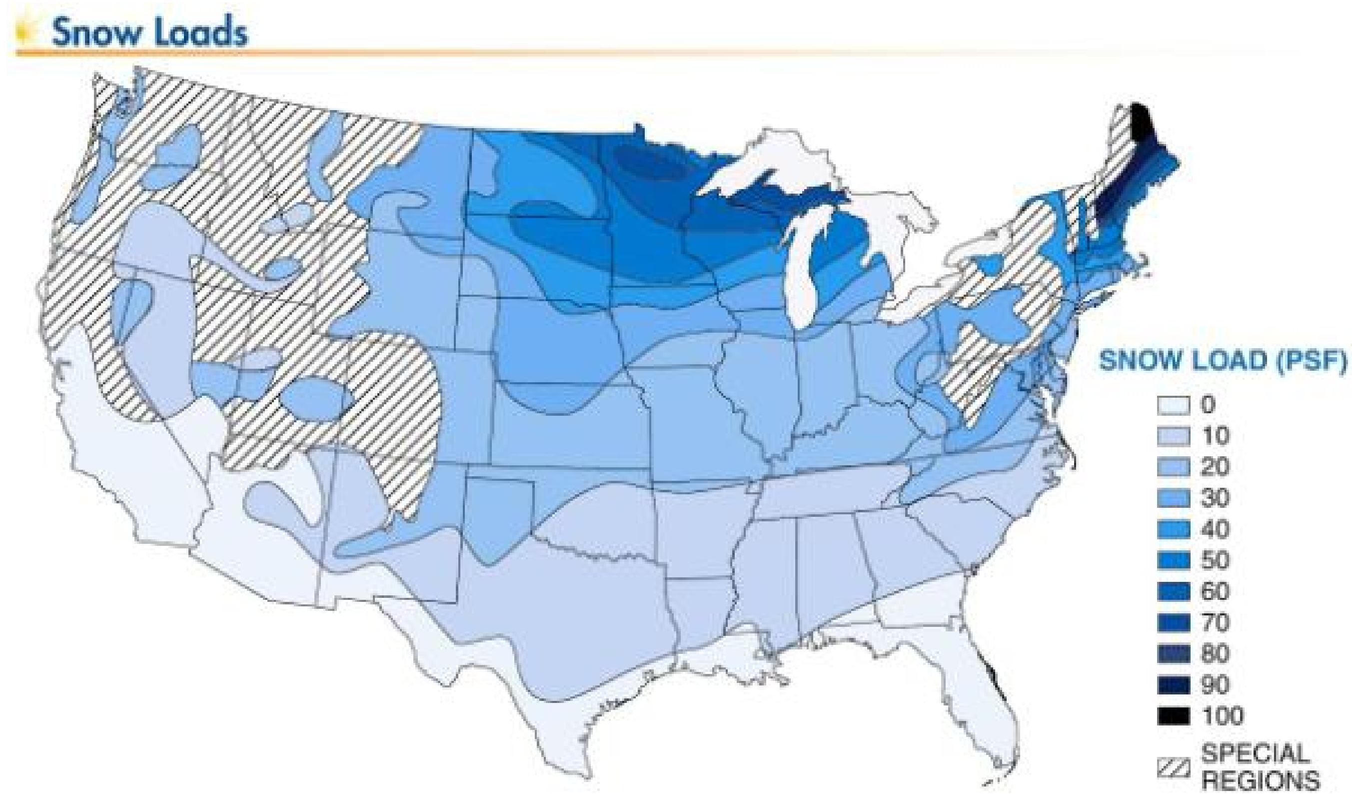


- The wind-load forces at attachment points can be downward, lifting, or lateral forces, depending on wind direction and the orientation of the array.



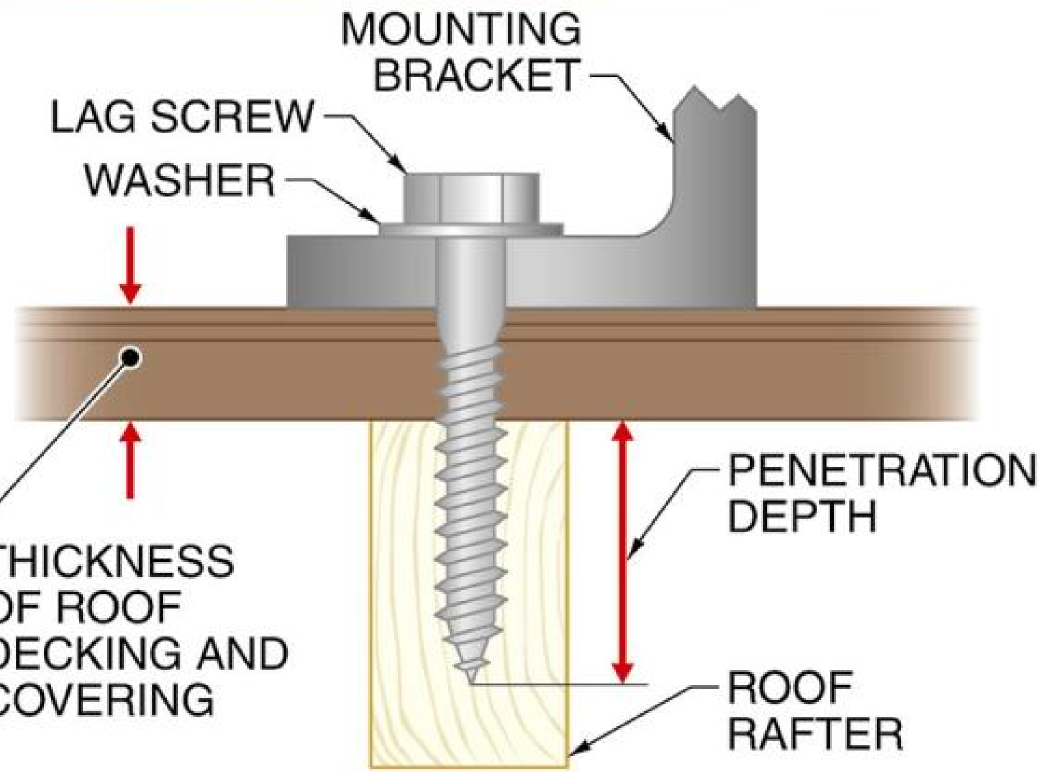



- Basic wind speeds are region-specific and are highest in coastal areas prone to hurricanes.




- Snow loads cause forces similar to dead loads, but the potential magnitude of a snow load varies greatly among geographic regions.

## Lag Screws




- Lag screws are the most common type of fastener used to attach array mounting systems to wood structures, usually residential roofs.

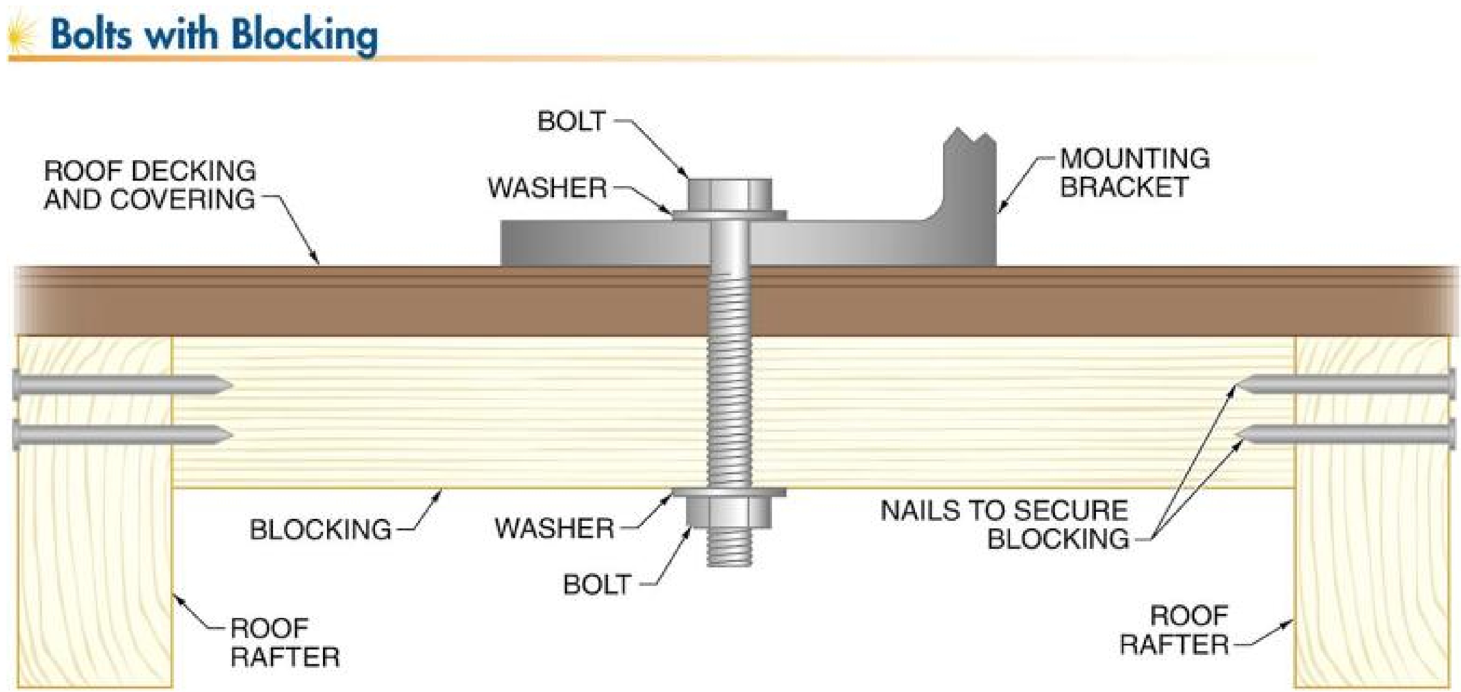
- Allowable withdrawal loads for lag screws are greater with larger screw diameter, deeper thread penetration, and higher-density lumber.

## Allowable Withdrawal Loads*

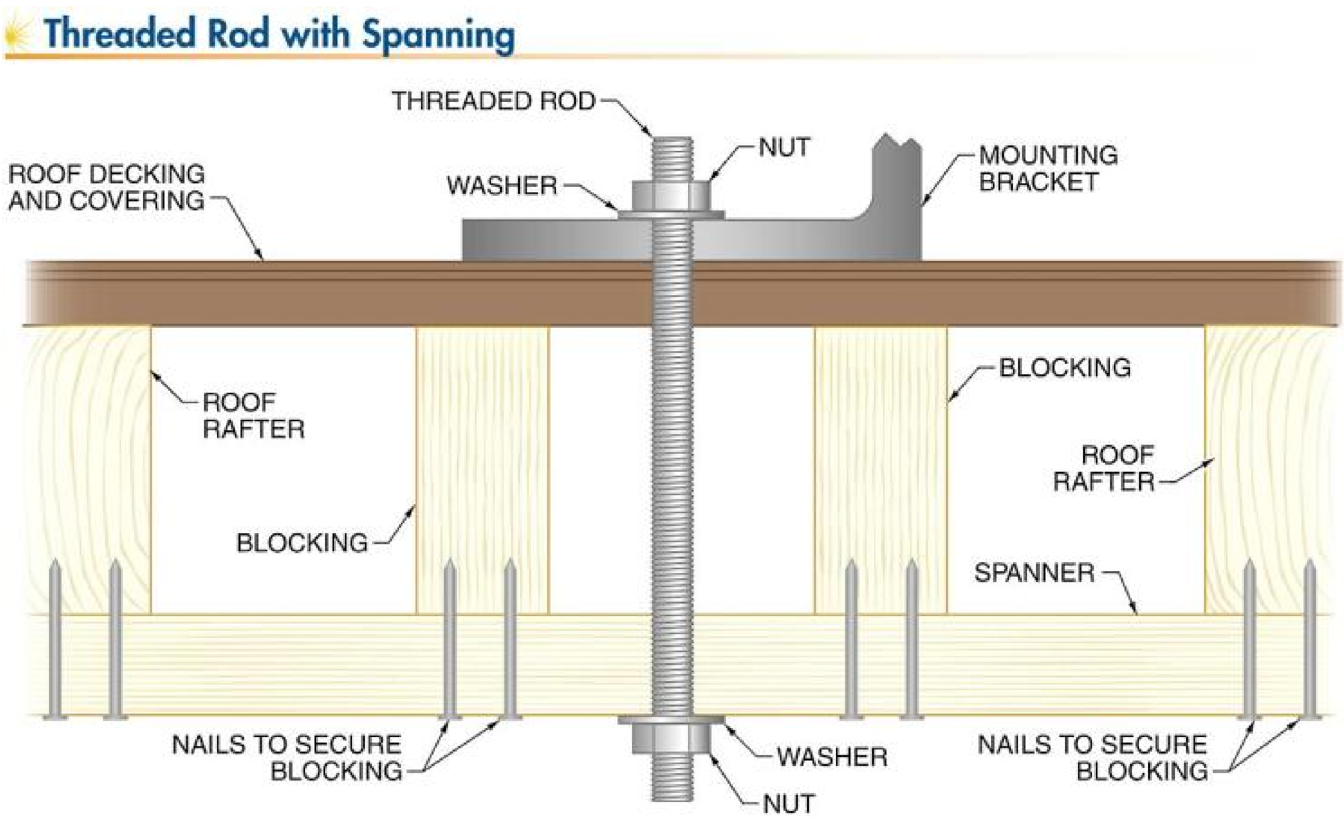
| LAG SCREW DIAMETER† | WOOD TYPE | | |
|---|---|---|---|
| | Southern Yellow Pine | White Spruce | Douglas Fir |
| 1/4 | 281 | 192 | 167 |
| 5/16 | 332 | 227 | 198 |
| 3/8 | 381 | 260 | 226 |
| 7/16 | 428 | 292 | 254 |
| 1/2 | 473 | 323 | 281 |

* in lb/in.
† in in.

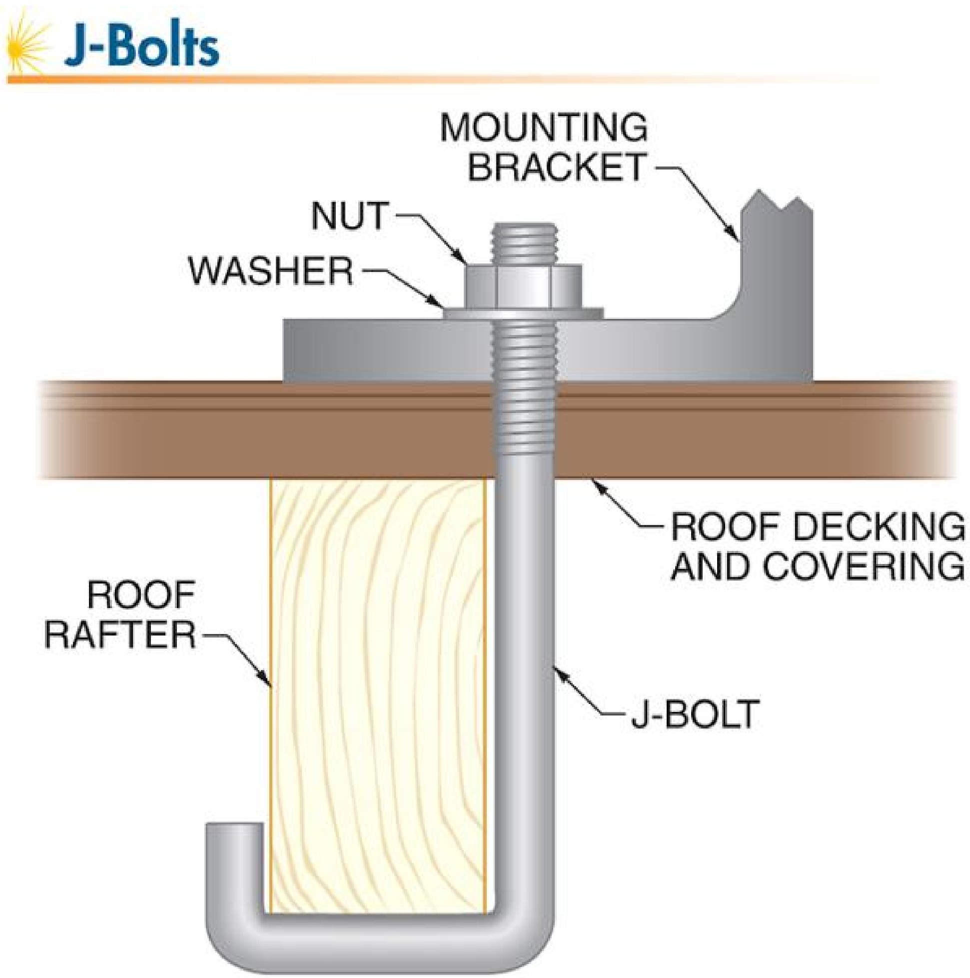
- Blocking is used to provide a structural member between roof rafters.



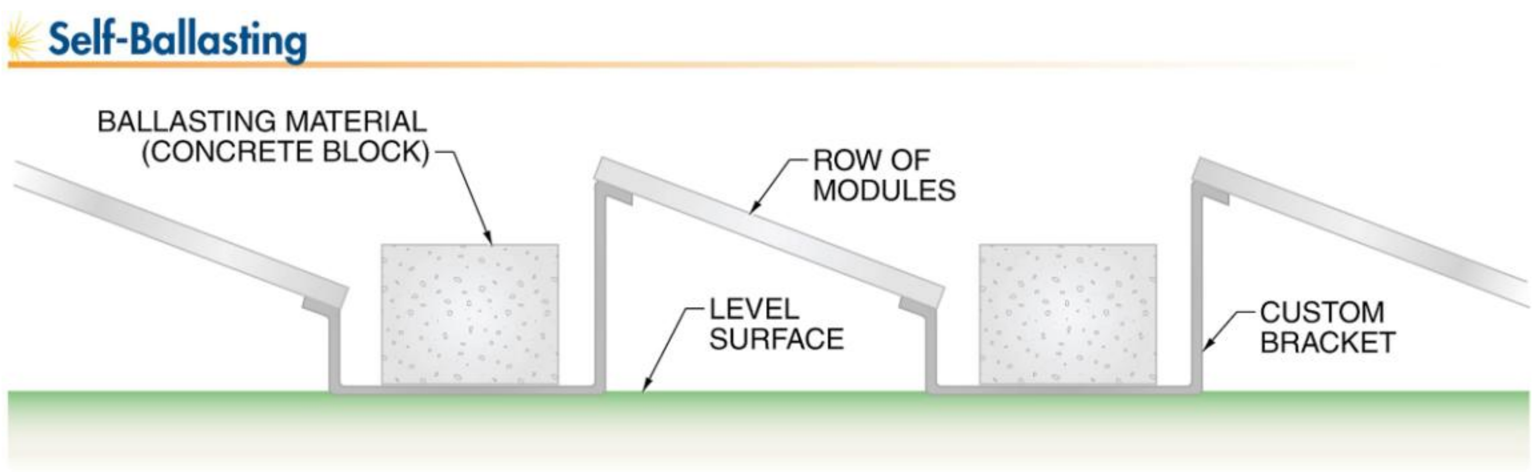
- Spanning is used to provide a structural member across roof rafters. Blocking boards are required to support the spanner.



- J-bolts secure attachment points by hooking around structural members.



- Self-ballasting systems rely on the weight of the array, support structure, and ballasting material to secure the array without making roof penetrations.



## Rack Mount Ground Foundations

*DOE/NREL, Utah Office of Energy Services*

- Ground foundations for rack mounts typically include concrete footers and may use wood as part of the aboveground rack structure.

## Weather Sealing with Caulking

- To weather-seal roof penetrations, caulking material is applied between the bracket and the roof surface, around the fastener, and in the pilot hole.

# Weather Sealing with Flashing

- Flashings and rubber boots provide the highest-quality weather seal for attachment penetrations.