

# Mechanical Integration of PV Systems

Ridha Hamidi, Ph.D.

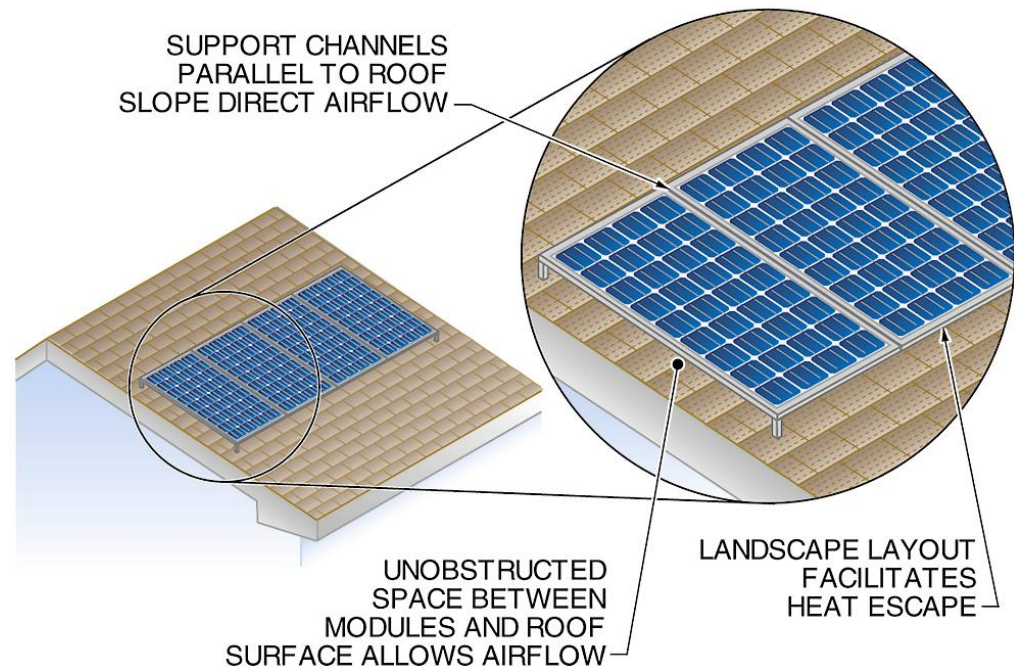


- **Aerial lifts are sometimes required to reach roofs or areas with poor accessibility.**



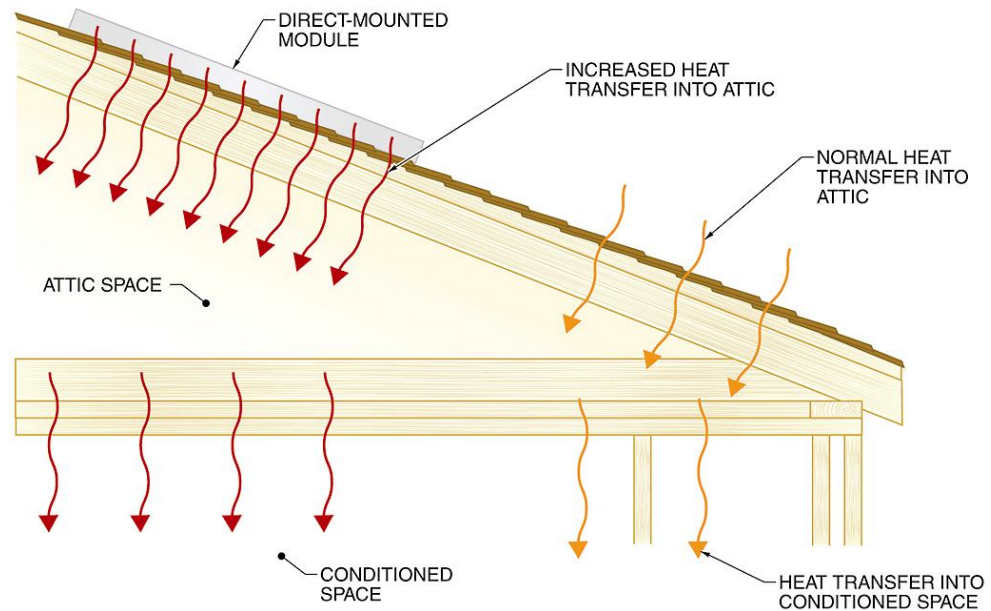
- **Several passive techniques can be used to keep arrays cool, which improves array performance.**

### **Passive Array Cooling**



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

#### Thermal Loads



- PV systems that match the shape, color, and/or alignment of the mounting surface produce aesthetically pleasing installations.



- **Assembling PV subsystems such as panels before lifting them to the roof is called panelizing**

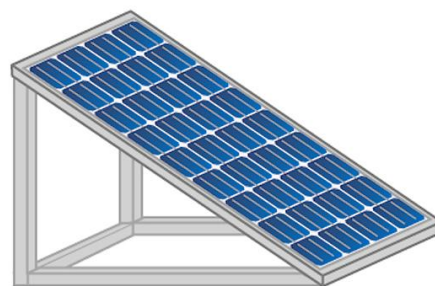
### Preassembly



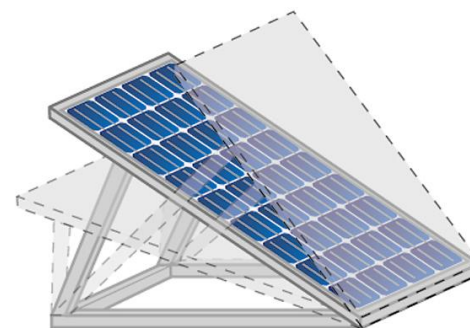
*SolarWorld Industries America*

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

## Module Mounting Systems



**FIXED-TILT  
MOUNT**



**ADJUSTABLE-TILT  
MOUNT**

- Direct mounts have little or no space between the modules and the mounting surface.

## Direct Mounts



*DOE/NREL, Jim Yost*



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





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

- PV modules can be integrated into building exteriors as roof shingles, windows, skylights, awnings, and many other structures.

Building-Integrated PV Systems



Sharp Electronics Corp.  
SHINGLES



WINDOWS



DOE/NREL, Lawrence Berkeley Lab  
SKYLIGHTS



DOE/NREL, University of Texas Health Science Center at Houston  
AWNINGS



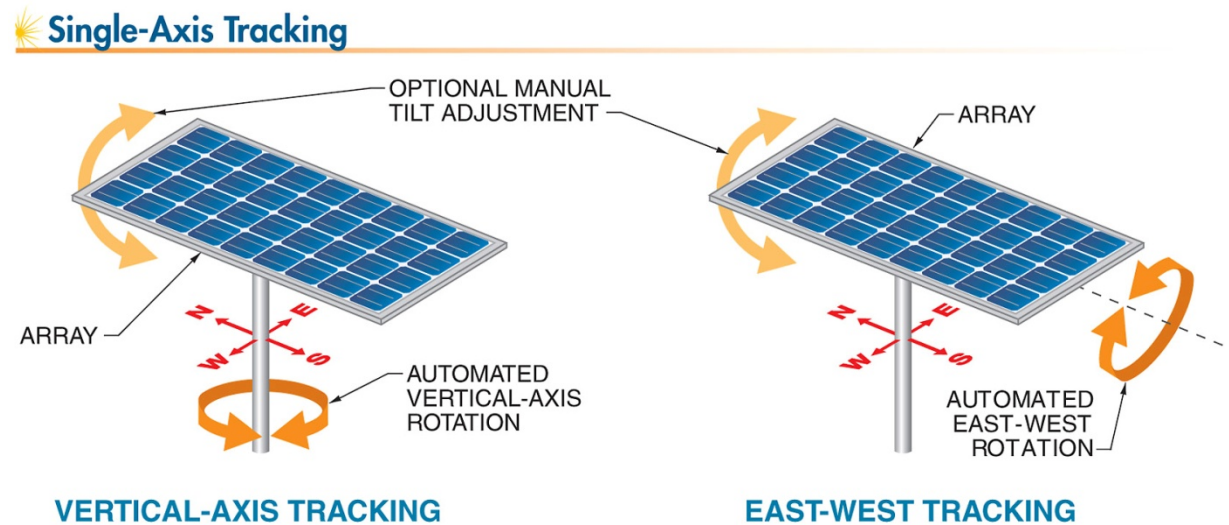


- **Ground rack mounts are versatile designs that can accommodate both large- and small-scale installations.**

- Pole-mounted arrays can be used in a variety of applications, such as lighting, communications, water pumping, and signage.



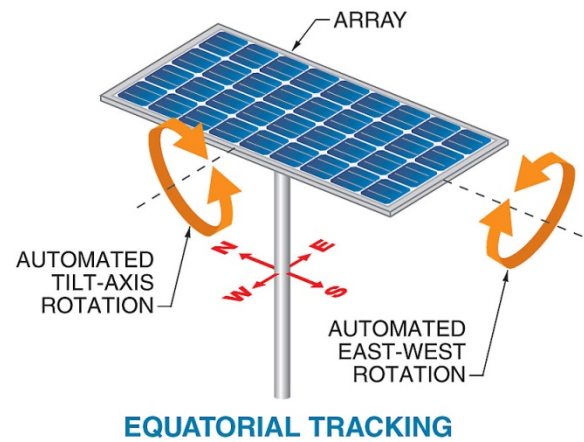
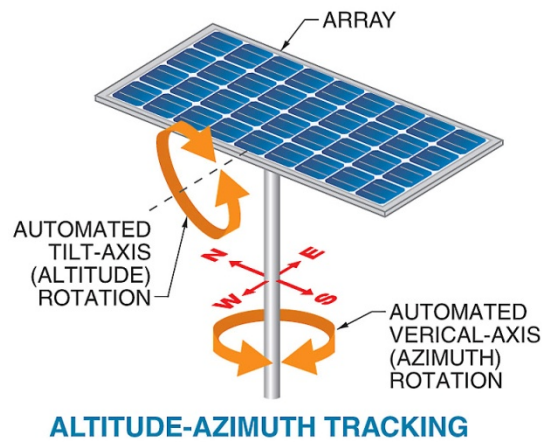
- **Single-axis tracking mounts rotate one axis to approximately follow the sun as it moves across the sky.**



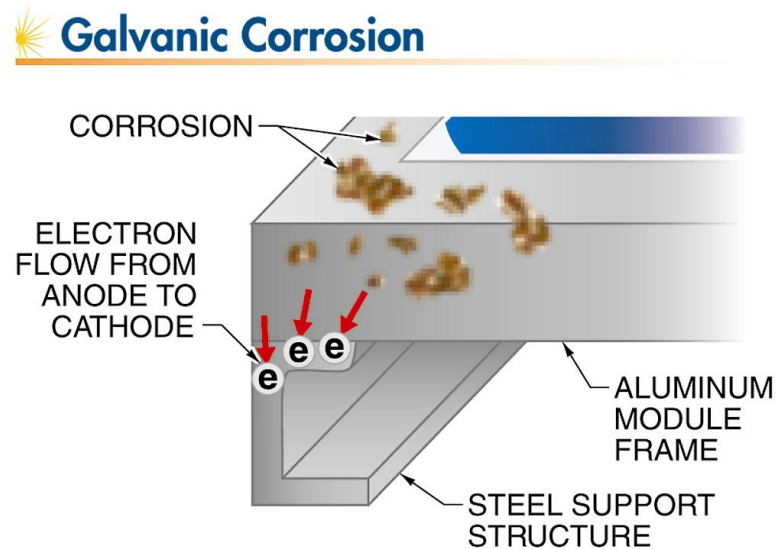
- Dual-axis tracking mounts rotate two axes to exactly follow the sun as it moves across the sky.



### Dual-Axis Tracking

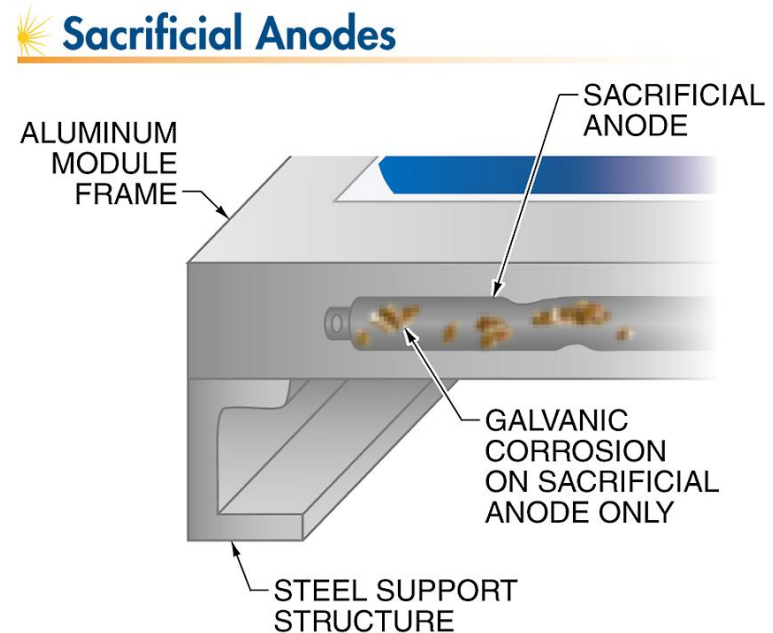


- Galvanic corrosion can occur when two dissimilar metals are in contact with each other.

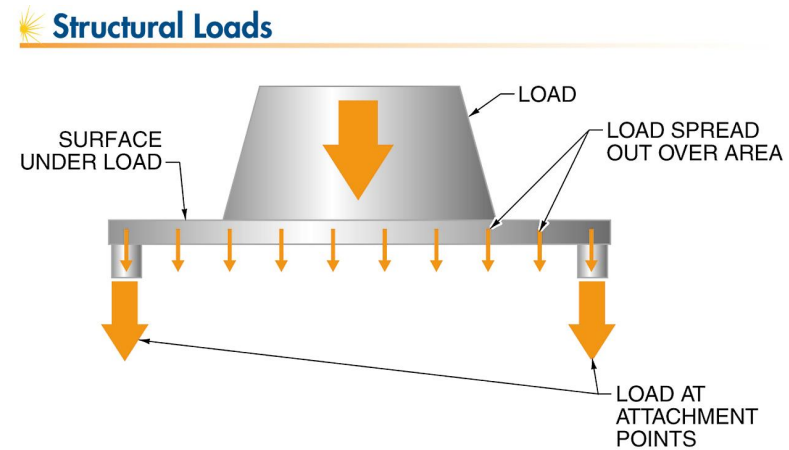




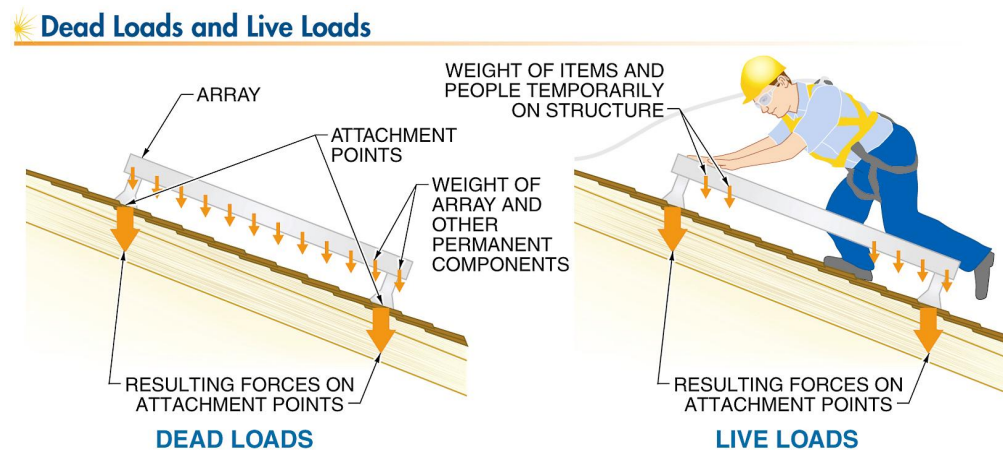
- **Sacrificial anodes are more prone to galvanic corrosion than the metal they protect, so they corrode first.**



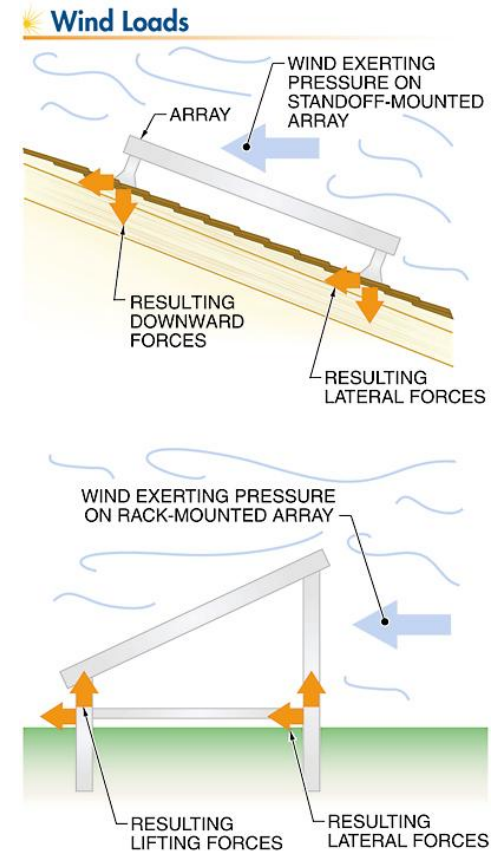
- Most structural loads are specified as a force per area. When the area attaches to other structures at certain points, the load is divided between the points.



- **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.**

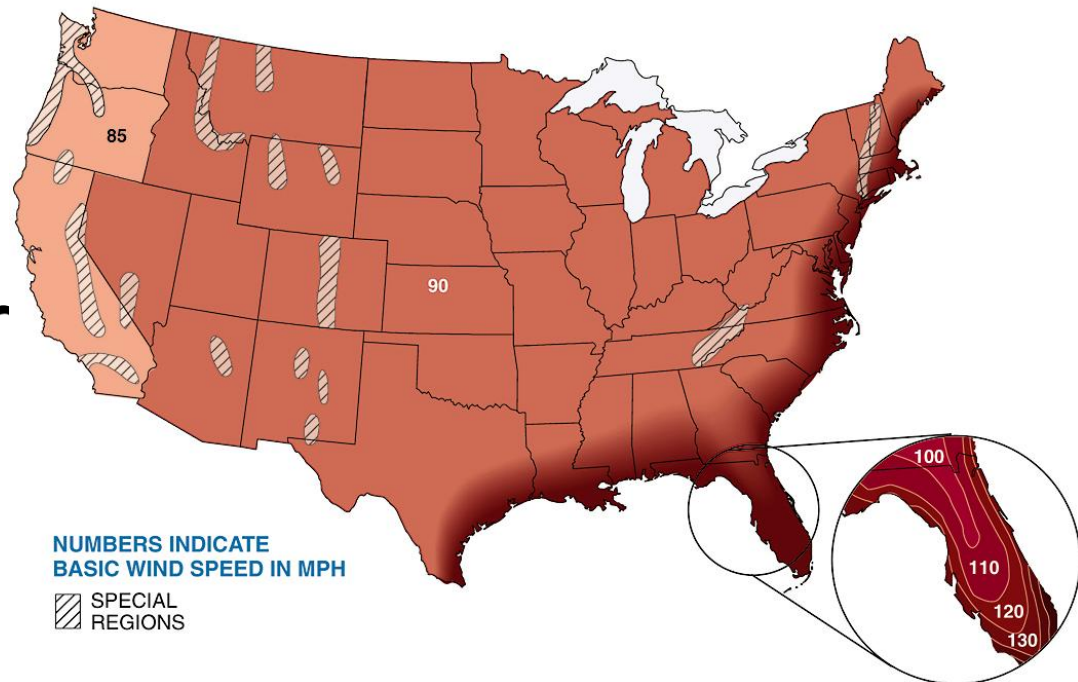


- The wind-load forces at attachment points can be downward, lifting, or lateral forces, depending on wind direction and the orientation of the array.



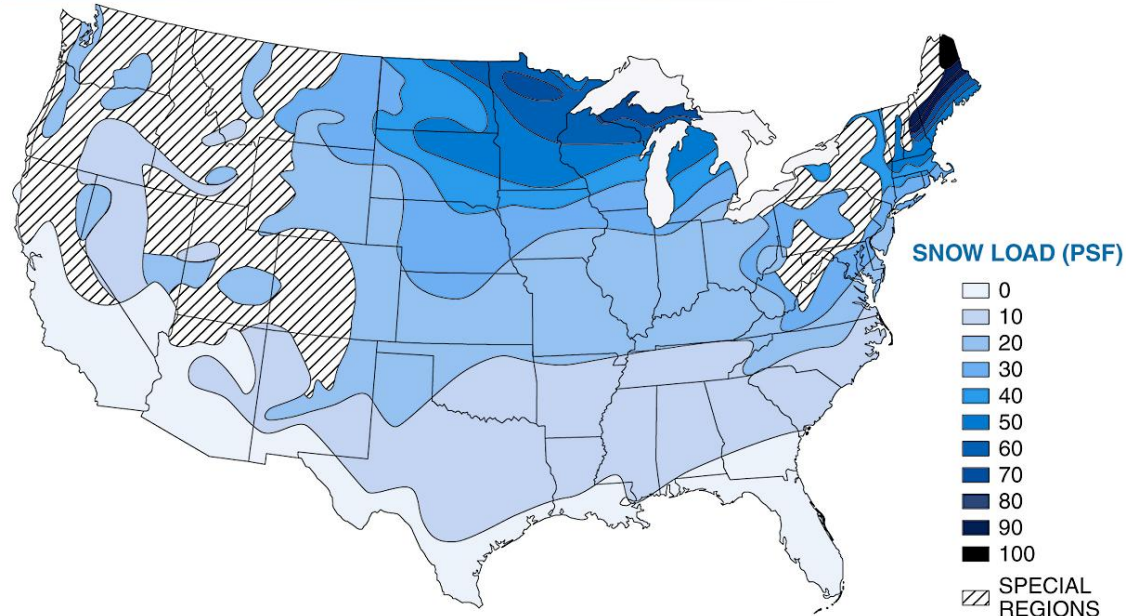
- Basic wind speeds are region-specific and are highest in coastal areas prone to hurricanes.

### Basic Wind Speeds



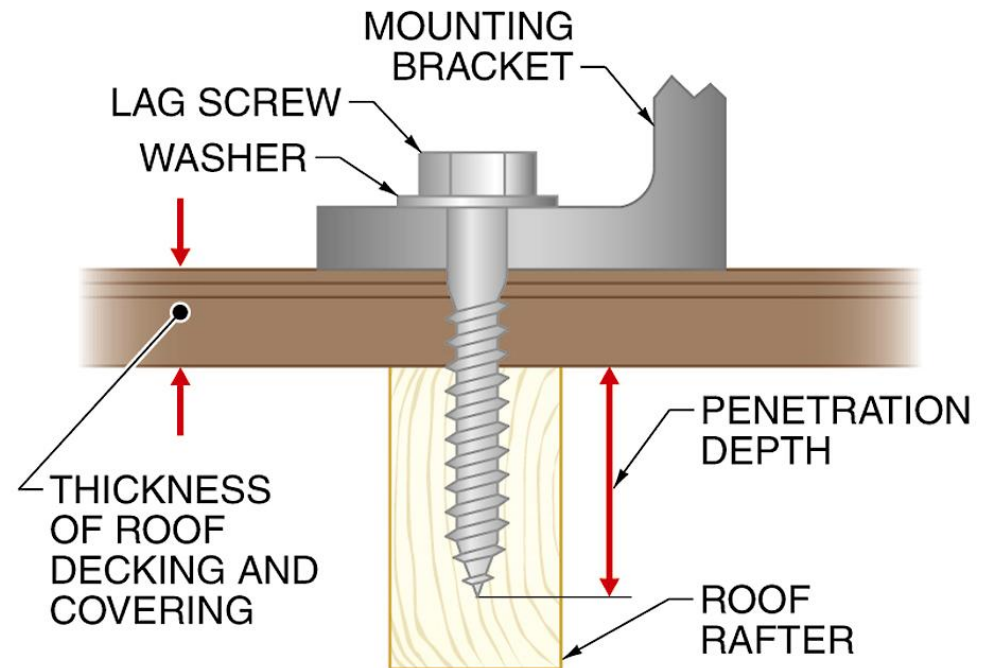
- Snow loads cause forces similar to dead loads, but the potential magnitude of a snow load varies greatly among geographic regions.

#### Snow Loads



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

## Lag Screws



- 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.

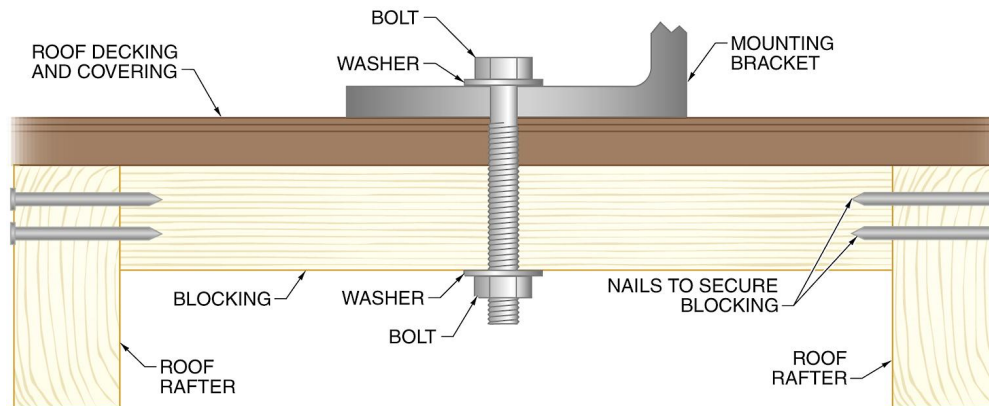
† in in.





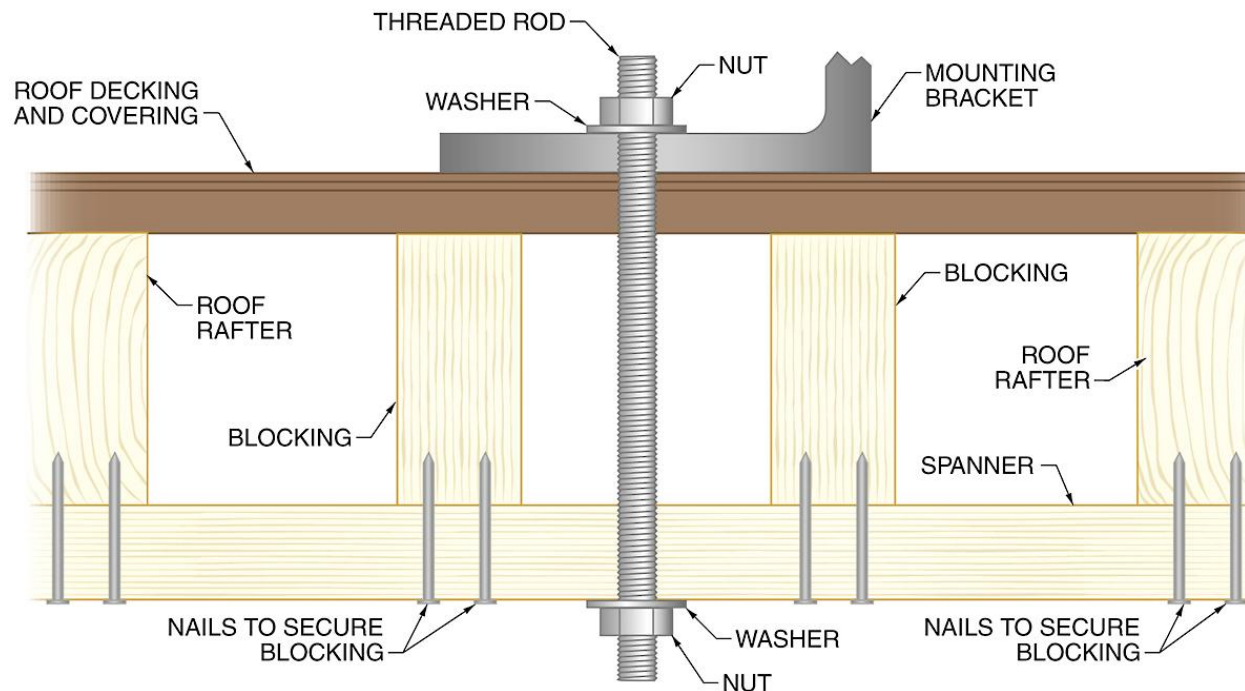
- **Blocking can be used to provide a structural member between roof rafters. (VERY RARE)**

**Bolts with Blocking**



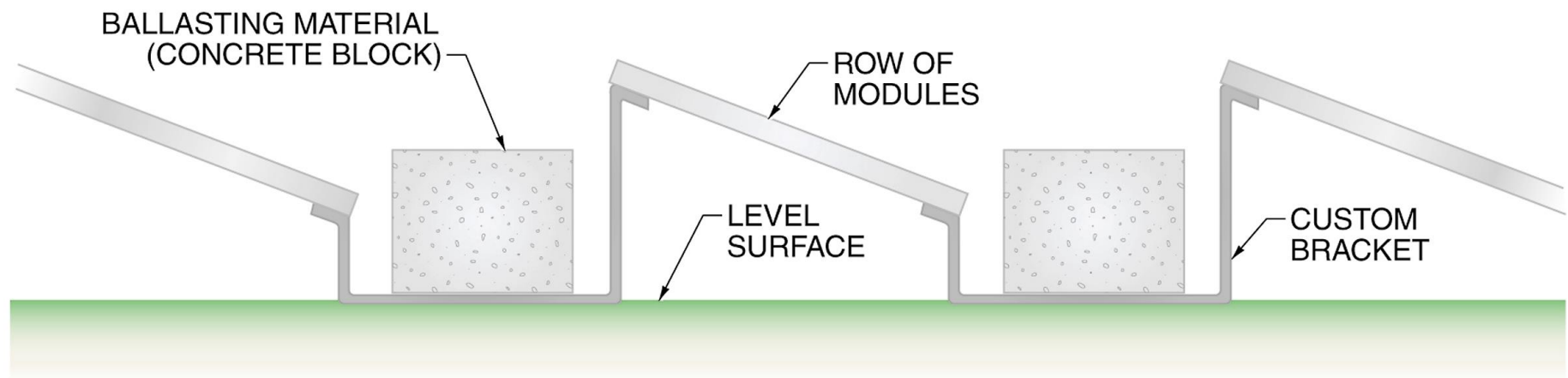
- Spanning is used to provide a structural member across roof rafters. Blocking boards are required to support the spanner. (VERY RARE)

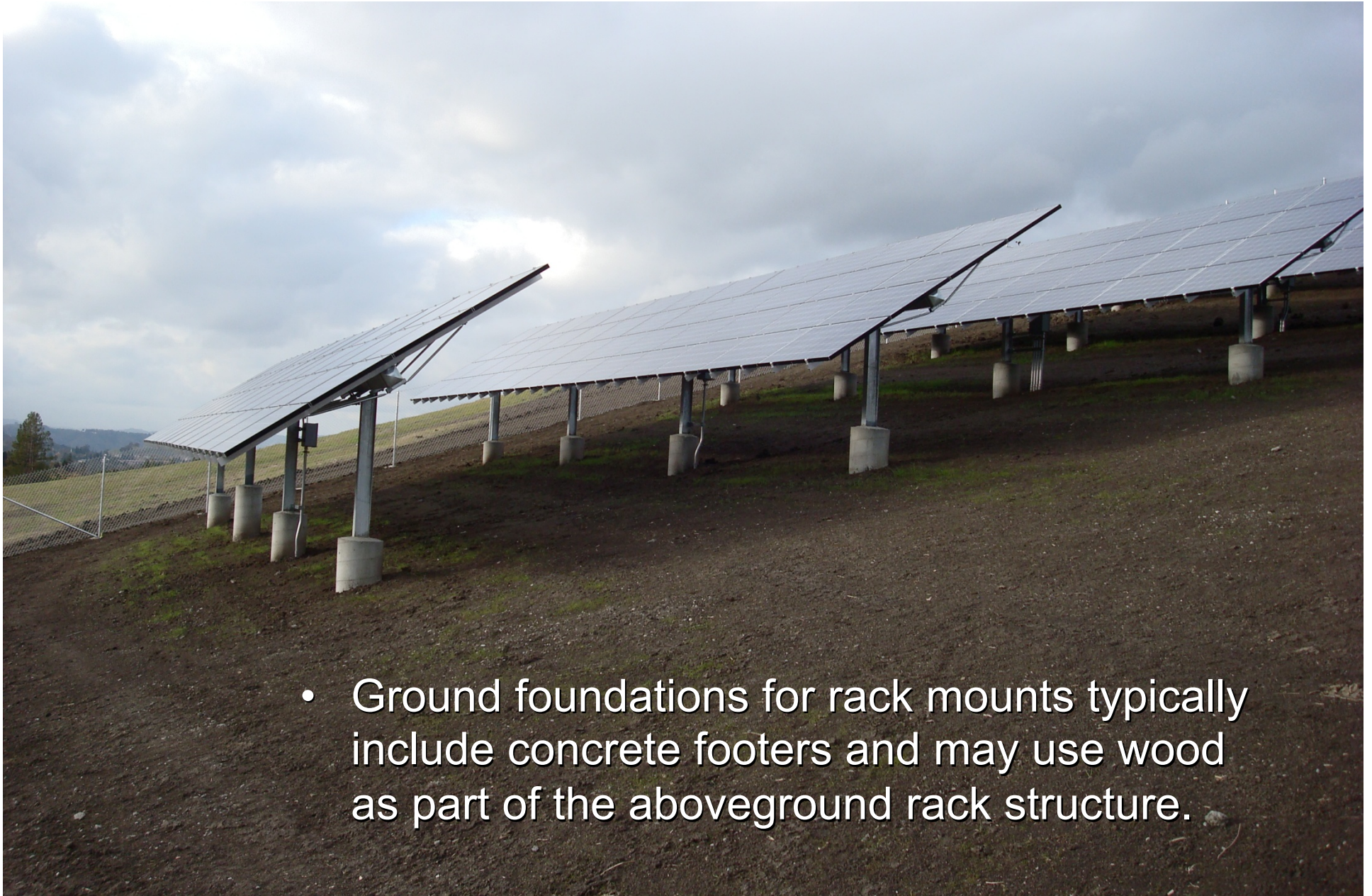
### Threaded Rod with Spanning



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

## Self-Ballasting



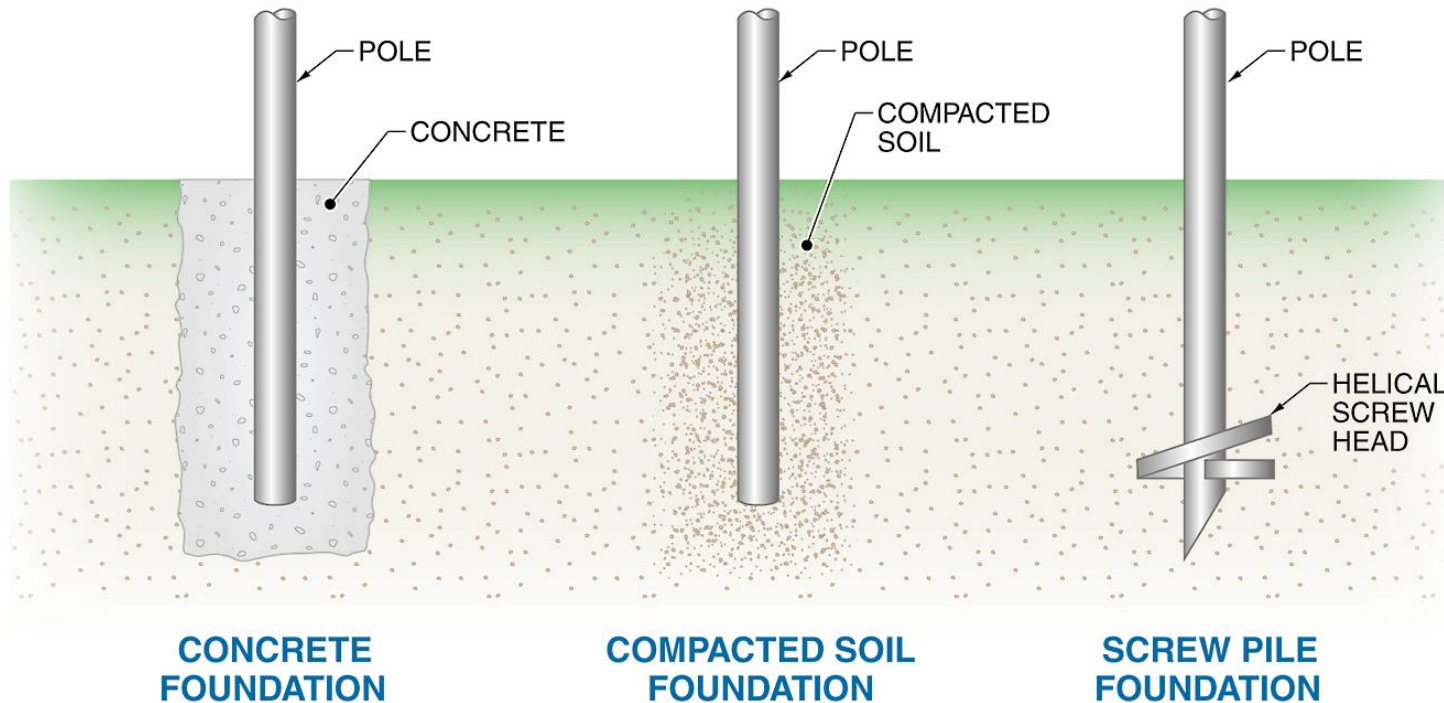


- Ground foundations for rack mounts typically include concrete footers and may use wood as part of the aboveground rack structure.



- Pole foundations may be encased in concrete or compacted soil, depending on local building requirements and the type of soil.

### Pole Foundations



## 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.

- There's no reason for every roof penetration not to get a metal flashing





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