To Track... or Not to Track

Richard Perez

A 1,360 watt PV array on a Wattsun dual-axis tracker follows the sun all day, like a big silicon flower, maximizing solar output.

Trackers are PV mounting racks that follow the sun. PVs generate more electricity when they are directly facing the sun, but the sun is constantly moving across our sky. In the morning, it's low on the eastern horizon, and at sunset, it's low on the western horizon. At noon, the sun stands high in the sky. This apparent solar motion is due to the earth's rotation. Trackers maximize energy production by keeping the PV modules perpendicular to the incoming sunlight. How much more energy do you get? Well, this depends on the site and the type of tracker—from 25 to 40 percent more energy annually over a static mounted array.

Location, Location, Location...

For a tracker to be effective, it must be placed in a suitable location. A good tracker site is one that receives dawn-to-dusk sun—seeing the sun very early in the morning and receiving sunlight until sunset. There is no point in buying a tracker if your site doesn't begin receiving sunlight until 10 in the morning, or if it loses sunlight at 2 in the afternoon.

A good tracker site is free of solar obstructions, such as trees and buildings. A good tracker site needs access to sunlight all during the day, during all seasons. It's always best to evaluate the solar site with a device such as the Solar Pathfinder before even considering a tracker.

Trackers are usually ground-mounted, using a heavy steel pole sunk into a concrete foundation. While I've known of a few that were mounted on roofs, this is not recommended—it creates structural problems on the roof and tends to be noisy during windy weather. When siting your array, keep in mind that pole mounts might be considered unaesthetic by your neighbors, and they take up physical and visual space in your yard.

Trackers come in two basic types—electrically operated and thermally operated (sometimes called "active" and "passive"). Each type has its advantages and disadvantages. Each has sites to which it is more suitable. And each is different in cost, effectiveness, and reliability.

Thermally Operated Trackers

Thermally operated trackers use the transfer of mass (weight) from one side of the tracker to the other to track the sun. This mass transfer causes the tracker to pivot from east to west to follow the sun. These units are basically "balancing acts." Two tubes with strategically placed shading are mounted on the east and west sides of the tracker. These tubes are filled with a material—usually Freon—that vaporizes (becomes a gas) at relatively low temperatures. As the sun warms up the Freon on one side of the tracker, the

Freon vaporizes. This vapor takes up more space than the liquid Freon, pushing some of the liquid Freon to the other side, where it stays in the heavier, liquid form on the cooler, shaded side of the tracker.

This process transfers weight from the one side of the tracker to the other side. This weight transfer causes the balance of the tracker to change, and it rotates to the west. Since the vaporization of the Freon is caused by solar heat, the tracker follows the sun's motion across the sky. The most common thermally operated tracker is made by Zomeworks. UniRac also manufactures a small passive tracker that accommodates up to two, 120 watt modules.

The big advantage of the thermal tracker is simplicity and thereby reliability. There are no electrical parts to fail. The Freon is inside a sealed system, requiring no maintenance or energy to operate other than solar heat. A second advantage of thermal trackers is cost—they are generally less expensive than electrically operated trackers.

Thermal trackers have several disadvantages. First is that, being powered by solar heat, they are slow to react to solar motion. At night, they remain facing west and rely on early morning sunlight to return to the east—this process may take an hour or more depending on ambient temperature and wind. In winter weather, thermal trackers are somewhat sluggish and imprecise in performance because they are dependent on building up enough heat to vaporize the Freon.

A second disadvantage is that thermal trackers only track the daily east-west motion of the sun; they do not track the daily and seasonal north-south motion of the sun. Thermal trackers need to be manually adjusted about four times per year to compensate for the sun's seasonal north-south motion. I figure I increase annual output by 4 to 7 percent by doing this.

The third potential disadvantage of thermal trackers is that some models are shipped completely assembled. This makes shipping and installing the tracker more difficult and expensive, because of its size and weight. Zomeworks currently manufactures a line of thermal trackers (F-Series Track Rack) that come partially assembled, and easily fit in the bed of a pickup truck. Some smaller passive trackers can be shipped UPS.

Electrically Operated Trackers

Electrically operated trackers use photoelectric sensors to determine the location of the sun. The sensors and an electronic control box activate electric motors to position the tracker so that the PV array is perpendicular to the sun. The most common electrically operated tracker is made by Array Technologies under the brand name Wattsun. SolarTrax and Small Power Systems also manufacture active trackers in various sizes.

The big advantage of electrical trackers is that they are super precise. The PV array mounted on them is always perpendicular to the sun (assuming that the weather is clear and not cloudy). Most of these trackers can be purchased with a dual-axis option so they track not only the east-west motion of the sun, but also the daily and seasonal north-south motion. In addition, electrically operated trackers can be wired to return to the east at sunset so that the array will already be facing the sun at daybreak.

A second advantage of electrically operated trackers is that they ignore temperature, since they are powered by electricity, not the sun's heat. This makes this type of tracker more accurate in climates with cold winters.

Freon in the two side tubes allows this Zomeworks thermal tracker to follow the sun. The braced pole supports were custom-made to aid installation in rocky ground.

Precision—this large Wattsun tracker moves east to west with a top-of-pole gear; north-south adjustment is powered by a screw-drive actuator arm.

A third potential advantage of this type of tracker is shipping and installation. Since the tracker doesn't have to be assembled at the factory, it can be shipped in a number of boxes, reducing shipping expense and handling difficulties. The tracker can be assembled piece by piece on its mount; this is far easier than trying to hoist a heavy preassembled tracker onto its mounting pole.

It might at first glance seem that electrically operated trackers are the only way to go. But unfortunately, these trackers are not without their weak points. Their main problem is reliability. Electrically operated trackers are complicated and employ electronics and electric motors. Their reliability is much lower than thermally operated trackers. Being electrically operated devices, these trackers are sensitive to damage from lightning. The manufacturers of these trackers have made great strides in making their products resistant to lightning damage, but in the event of a close or direct strike, damage still may occur.

A second disadvantage of electrically operated trackers is expense. The initial cost is somewhat higher than thermally operated trackers, and since reliability is lower, there will likely be maintenance costs over the years.

Another minor disadvantage is that these trackers use some electricity to operate. The whole idea of tracking is to maximize energy production, and using electricity to accomplish this reduces maximization. How much? Well, actually, not very much at all. Wattsun trackers consume an average of 5 watt-hours per day. This energy use is insignificant in terms of total array production.

Tracker Economics

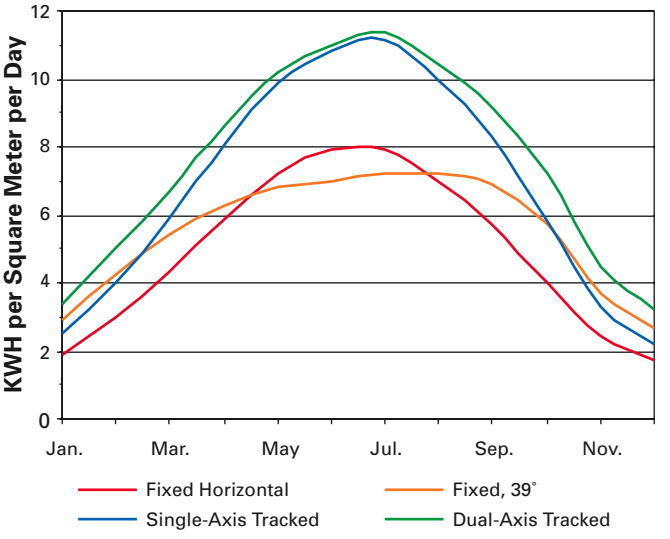
PV modules cost money, as do trackers. Where is the break-even point? At what point does the tracker become more cost effective than simply buying more PV modules and using a fixed mount? Currently, this break-even point is at about 500 to 600 watts, depending on location (solar window) and type of tracker.

If you are installing an array with six to eight, 75 watt, PV modules and you have a dawn-to-dusk sunlight tracker site, it may be cost effective to place them on a tracker rather than buying more PVs. Cost effectiveness will also depend on when you need more electricity. Obviously, trackers give you more gain in the summer when the days are longer, and less in the winter. For grid-tied systems with annual net metering, this can be a bonus because the tracker's excess summer production will help offset your winter utility bill. Trackers with as few as two PV modules can be cost effective in PV direct (batteryless) water pumping systems. See http://rredc.nrel.gov/solar/calculators/PVWATTS to compare the difference between fixed mount and single-axis or dual-axis tracking for your own site.

Tracker Tips

Plan on spending some bucks on the tracker's foundation—this is not the place to save money. A tracker, regardless of type, is a huge wind sail, and you don't want it blown over in high winds. The mounting pole for a home-sized array will be a 6 to 8 inch (15–20 cm) diameter steel pipe (or larger, depending on tracker size). This pipe needs to be secured into the ground with a substantial

Fixed & Tracked Arrays in Sacramento, California



Graph and data courtesy of NREL and Array Technologies

No motors or sensitive electronics on the back of the Zomeworks trackers—simplicity is reliability.

concrete base—don't skimp on the concrete! Follow the manufacturer's recommendations for mounting, and then add a bit more concrete to make sure that your tracker stays in the ground.

If you are installing a large, preassembled tracker, get some help. Assuming that your tracker holds eight or more modules, it may not fit into the back of most pickup trucks if it comes assembled. Have at least four friends (or a crane) assist you in placing the tracker on top of its mounting pole—this beast is heavy. It's also best not to mount the modules on the tracker until it is resting atop its pole.

Electrically operated trackers can be configured to run either directly off of the PV array, or from the system's main battery. In my experience, the model powered by the system's battery is far more reliable and precise in its tracking because it has a steady, 24/7 power source. For grid-tied applications, the Wattsun tracker can be run from an AC circuit instead of a battery. It uses a converter to provide 24 VDC.

These trackers are available with an external, manual switch kit (an additional cost option) that allows you to manually position the tracker. Buy this manual control! It allows you to manually position the tracker for easy snow removal during the winter, and for installation and maintenance. It also allows you to face the tracker south in the event of failure in the tracker's control electronics.

Tracker Experiences

I operate both thermally and electrically operated trackers here at our off-grid site in southwestern Oregon. I have found our thermally operated Zomeworks tracker to be supremely reliable, although somewhat imprecise at following the sun, especially during our cold and windy winters. Our electrically operated Wattsun trackers are super precise, but have not been without their failures during the thirteen years we've used them—twice from lightning, and six times from just plain old electronics failures. Since we have a dawn-to-dusk-sun tracker site and use lots of energy in the summer, using trackers here is a real energy booster for us.

Access

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Tracker economics and comparisons • www.wattsun.com/faq/cost_comparison.html • http://rredc.nrel.gov/solar/calculators/PVWATTS

Zomeworks Corporation, 1011A Sawmill Rd., Albuquerque, NM 87125 • 800-279-6342 or 505-242-5354 • Fax: 505-243-5187 • zomework@zomeworks.com • www.zomeworks.com • Thermally operated trackers

UniRac, Inc., 3201 University Blvd. SE, Suite 110, Albuquerque, NM 87106 • 505-242-6411 • 505-242-6412 • info@unirac.com • www.unirac.com • Small thermally operated trackers

Array Technologies, Inc, 3312 Stanford NE, Albuquerque, NM 87107 • 505-881-7567 • Fax: 505-881-7572 • sales@wattsun.com • www.wattsun.com • Wattsun electrically operated trackers

SolarTrax Power Stations, 619 Commercial Ave., Covina, CA 91723 • 626-331-9570 • Fax: 626-331-8584 • info@solartrax.com • www.solartrax.com • 1.4 KW to 5.1 KW electrically operated trackers

Small Power Systems, 74550 Dobie Ln., Covelo, CA 95428 • 707-983-8498 • Fax: 707-983-6525 • george@smallpowersystems.com • www.smallpowersystems.com • Electrically operated trackers