

Photovoltaic Railroad Power Installations Morningstar's Controllers Are Delivering Solar Success



ABSTRACT: *Photovoltaics* (PV) have been successfully powering tens of thousands of critical stand-alone **railroad power installations** since the early 1970s—across the roughest terrains and in the harshest environments—helping power critical train movement communication systems, signaling infrastructures and wayside applications with a 24/7/365 up-time. Stand-alone PV power systems are the perfect fit for the railroad industry—they are a proven source of DC power and they require very little maintenance, no ongoing fueling and have a 25+ year lifespan.

For almost 20 years **Morningstar's** controllers and accessories have been helping to provide continuous, reliable primary and standby power to these remote wayside site installations. From intermediate signals to highway crossings; from remote site power to track circuit control; from radio and microwave communications systems to equipment detection systems, Morningstar's controllers and accessories have proven themselves to be the industry's most reliable power electronic PV system components.

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Introduction

The rail industry has been a pioneer of the digital age and a leader in many technological advances, such as sensors that can detect when wheels and tracks are about to give out from stress. Railroads were an early adopter of technologies like RFID (radio frequency identification), which uses tags and radio waves to track the flow of trains and cargo. Today, the industry is embracing wireless sensors to provide better information on train movements, to improve efficiency and safety as well as to enable PTC (positive train control) in “dark territories”. Additionally, since many run through parks and residential areas, they are also increasingly more interested in reducing greenhouse emissions.¹

At the **forefront of technology innovation**, the **railroad industry was one of the first to adopt PV power**. A railroad operates with a simple focus—**profitability + safety**. Trains must run on time and critical wayside applications must work—**safety is paramount**. Inoperable gates, signals and communication systems simply are not an option. The industry demands a PV power system that provides high output, is reliable, has high system autonomy and is operationally cost-effective. Additionally, more and more railroads are beginning to ask for wayside PV power systems that support standards-based remote monitoring capabilities. They want these systems to provide system health and performance data.



The railroads adopted PV for one simple reason—the grid and rail line locations are not in sync. The grid is neither a convenient nor a cost-effective solution for a railroad. More times than not, the grid is distributed far from where a railroad needs power; and where it the grid may be present, a right-of-way negotiation may be required and could be costly. These logistical and operational challenges are something the railroads decided to forgo 40+ years ago. In the old days, the railroad ran “signaling pole lines” for their power and communication systems, but that proved extremely expensive and, at times, unreliable. The pole-lines were constructed using copper lines, which were expensive and also prone to storm damage and theft. Over time, they evolved their power infrastructure to the more reliable coded-signaling systems, which used pulse line technology. This evolution brought with it a need for remote power at every 1-2 mile interval. This new technology and power requirement made PV the ideal solution.

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Today, the railroad is the most cost-effective and energy-efficient way to move freight. Railroads are also greener and more sustainable than ever—delivering environmental and safety benefits.⁴

- Switching from truck to rail shipments means less fuel used and less greenhouse gas released.
- Every mile that a truck, or car for that matter, is not driven adds to the safety of everyone else on the road.

Furthermore, in recent years the railroad industry has adopted the use of LED Signal Lights, which along with the use of the digital, pulse technology, has greatly lowered power consumption and helped fuel the use of Solar by the railroad industry.



Case in Point - North America

North America's railroads move more goods across the continent than any other transport medium. Additionally, with fuel prices rising and shipping rates better than they have been in over a decade, railroad's freight industry is experiencing a resurgence². A train can move one ton 450-500 miles on one gallon of fuel—a train can carry the load of 280 trucks⁴—which makes it three to four times more fuel-efficient than trucks. In fact, in 2012 the U.S. freight railroads spent \$10.7B on new trains, tracks and other infrastructure, their highest amount ever. As a frame of reference, according to the Federal Railroad Association's National Rail Plan³:

- America's freight rail network spans 140,000 miles.
- The rail industry is reinvesting 40 cents of every dollar they earn back into infrastructure.
- The total freight shipments are expected to rise 61% in the next three decades to 16.9B tons in 2050. That's quite a leap from 2010 figures, when roughly 12.5B tons were moved.

Morningstar – The Controller of Choice for Railroading

Since 1995, Morningstar's controllers have been helping regulate railroad's off-grid PV power systems. Whether the wayside systems are PV-only or Hybrid (PV + secondary energy source) power installations, our controllers and accessories have been helping the railroad industry move trains reliably, safely and on schedule.

Morningstar's first and second generation [ProStar™](#) controllers were the first to be embraced by railroad's wayside PV power systems and to this day operate reliably in several thousand system installations worldwide. Additionally, Morningstar's [Relay Driver](#) has become the accessory of choice for railroad's low-voltage alarm applications and hybrid power installations.



In 2008, we introduced our innovative [TrakStar™](#) Maximum Power Point Tracking (MPPT) algorithm technology that maximizes the energy harvest from the PV array into the battery under all operating conditions. This technology innovation is used in Morningstar's [SunSaver MPPT™](#) and [TriStar MPPT™](#) controllers and has resulted in the TriStar MPPT controller becoming the world-leading MPPT solar controller. Morningstar's TrakStar MPPT algorithm provides more accurate and faster tracking, consistently operating at the PV array's real maximum power point. Leveraging TrakStar, Morningstar's MPPT controllers deliver high conversion efficiency at all power levels resulting in:

- * Significantly better in conversion efficiency at lower output levels.
- * Substantially better production at higher output levels.

Since their introduction in 2009, Morningstar's TriStar MPPT controllers became the controller of choice for railroad's wayside PV power system installations. Per the industry's requirement for highly reliable, efficient power systems, the TriStar MPPT controller allows the solar array to be configured at voltages higher than the system battery. This enables a more effective use of all the solar energy reaching the modules, while also reducing voltage and power losses in the connections between the arrays and the controller.

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The TriStar MPPT Controller has helped make pole line maintenance safer. As pictured in the triple tower PV system installation below, the solar modules are now mounted using a retractable tower system. As such, the maintenance crew no longer has to risk a high climb –they can simply service



the modules at ground level. To facilitate this safety innovation, these new retractable towers can no longer use the large and bulky copper wire bundles of 'yester-year'. Instead, they require small gauge wire loops, which expand and contract as the PV array is raised and lowered. Morningstar's TriStar MPPT Controllers help to efficiently enable these systems' to work without voltage losses, using a more cost-effective lower gauge wiring solution.

Traditionally, the railroad has built its track following river bed bottoms, as geographically that creates a track path that is easier follow and more cost-effective to install. But these installations can traverse many cliffs and bluffs and thusly require the PV array to not always be co-located with the wayside power system's battery bank. Morningstar's TriStar MPPT Controllers are also perfectly suited for this installation scenario. Using our innovative TrakStar MPPT technology, the TriStar MPPT Controller makes greater distance (long wire run) installations possible—no longer does the solar array need to be located near the battery storage (system bungalows). In fact, in Montana, our controllers are helping to regulate a PV system, where the array is installed 600ft from the wayside installation's battery system.

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The TriStar MPPT controller is also the PV industry's only controller to use industry-standard communication protocols and interfaces—a perfect fit for railroad's new requirement to have their PV systems support standards-based remote monitoring capabilities. The TriStar MPPT controller enables system monitoring and up to 200 days of data logging and uses the open MODBUS™ protocol. It is also equipped with an on-board RS-232 serial communications port. Furthermore, the 60 Amp TriStar MPPT controller (model TS-MPPT-60A) is EIA-485 and Ethernet-equipped to enable open and flexible serial communications and TCP/IP networking, respectively.



The TriStar MPPT controller is manufactured in an ISO 9001 certified facility and meets several key [certification standards](#), including:

- AREMA Compliant
- EMC Compliant (Immunity, Emissions and Safety)
- UL 1741 and CSA C22.2 No. 107.1-01 Listed
- FCC Class B Part 15 Compliant
- NEC Compliant
- CE, REACH and RoHS Certified

Sample Typical Power System Scenarios

- Railroad wayside power installations typically need to run fairly heavy loads using a 12V battery system. E.g., a Defect Equipment Detection system could use 5 PV modules in Series to charge a 12V battery. This application is easily enabled by Morningstar's TS-MPPT-60A controller.
- Furthermore, if that system is located in a valley, where the PV array is only exposed to sun light for a limited time (e.g., fewer than three hours per day) then the TS-MPPT-60A is the best choice. The higher input voltage capacity of the TS-MPPT-60A enables the system installer to “wire up” the power system to almost 100V input and to mount the PV array far up a hill—away from the valley location—to a higher solar irradiance location. The TS-MPPT-60A offers the industry's best conversion efficiency (99%), which is especially useful in this lower output level scenario.

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Summary

For more than 20 years, Morningstar's products have been helping provide stand-alone, solar electric power to many industrial system installations around the world—telecommunications, oil and gas, security and instrumentation. Further, since 1995, Morningstar's products have been helping regulate railroad's off-grid PV power systems. Whether the wayside systems are PV-only or Hybrid (PV + secondary energy source) power installations, our controllers and accessories are helping the railroad industry move trains reliably, safely and on schedule.

Morningstar's products are renowned for their robust thermal, mechanical and electronic circuitry design, high quality and outstanding reliability, and long operating life and dependable performance. Our products are integral power electronic components in more than two million off-grid photovoltaic power systems in 112 countries, across all seven continents. They get the job done when utility power is unavailable, unreliable or cost-prohibitive.

To learn more: www.morningstarcorp.com

Better Efficiency across a Broad Operating Range

Better Efficiency at Lower Power Levels

Morningstar's TriStar MPPT Controllers have significantly better efficiency at lower power levels. Unlike other products, which must operate at close to their nominal power rating to reach their peak operating efficiency, the TriStar reaches its ideal operating efficiency at as little as 20% of rated power and maintains this level throughout most of its operating range.

Significantly Better Efficiency at Higher Power Levels

Morningstar's TriStar MPPT Controllers have significantly better efficiency at higher output levels. Other brands peak at 1/3 of the maximum current and taper off at higher currents, but the TriStar MPPT will provide extra power when it is needed most.

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Higher State of Charge

- Morningstar's TriStar MPPT controllers keep the batteries at a higher State of Charge (SoC), given the same PV array compared to an identical system using a competitor's controller. A higher average SoC means better battery health and longer battery bank life. It also means better and longer system autonomy.

Highest Efficiency and Reliability

- Morningstar's TriStar MPPT controllers deliver better production at higher ambient temperatures for all operating conditions. Delivering the industry's highest reliability and operating life, the TriStar MPPT controllers feature a robust thermal and mechanical design. Their electronic circuitry is engineered to optimize efficiency, performance quality and reliability. They are also the industry's lowest in self-consumption, using a mere 1.7W of power.

Sources:

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5. logisticsviewpoints.com/2013/04/01/the-resurgence-of-rail

Railroad installation pictures courtesy of Ameresco Solar and RedHawk Energy Systems, LLC / Arthur N. Ulrich Company.

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