February/March 2013

Electrical Codes and Standards | Solar Leases

SOLARPRO

Optimal Design, Installation & Performance

solarprofessional.com

Array Wire Management

Code-Compliant Strategies

Battery-Backup PV Applications

System Configurations and Power Electronics

Ground-Mount Racking Systems

Product Lines from 34 Manufacturers

Interview

Alex Bradley

DuPont Photovoltaic Solutions



IRC Solar Roof Systems
Belmont Hill School
Belmont, MA

industry professionals
SUBSCRIBE FOR FREE
solarprofessional.com

CAB, EX2060
Case No. IPR2024-00139
1 of 84



SnapNrack™
PV Mounting System

Planning or bidding commercial projects?

Install Big Jobs Faster



Beyond equipment savings, SnapNrack 350 Series also saves valuable man-hours during installation.

Call SnapNrack for the most innovative, cost effective solar racking system.

(805) 540-6999
info@snapNrack.com
www.snapnrack.com

AEE Solar

I'm Plugged into AEE Solar

"AEE Solar is more than a supplier, they are a partner in business, having helped us launch our Solar division over 3 years ago. AEE Solar's quality products and outstanding service make them an indispensible asset to my business."

KURT GEWECKE
KG Solar and Renewable Energy



Proud Distributor of:

REC

REC 1st PLACE 2011

1

Photon

MODULE FIELD TEST

2011 PHOTON MODULE TEST WINNER

Get Tested Products from a Leading Distributor

When you buy from AEE Solar, you can be confident you are getting the best products the industry has to offer. With 30 years of solar experience, we know which products deliver the best value for your money.

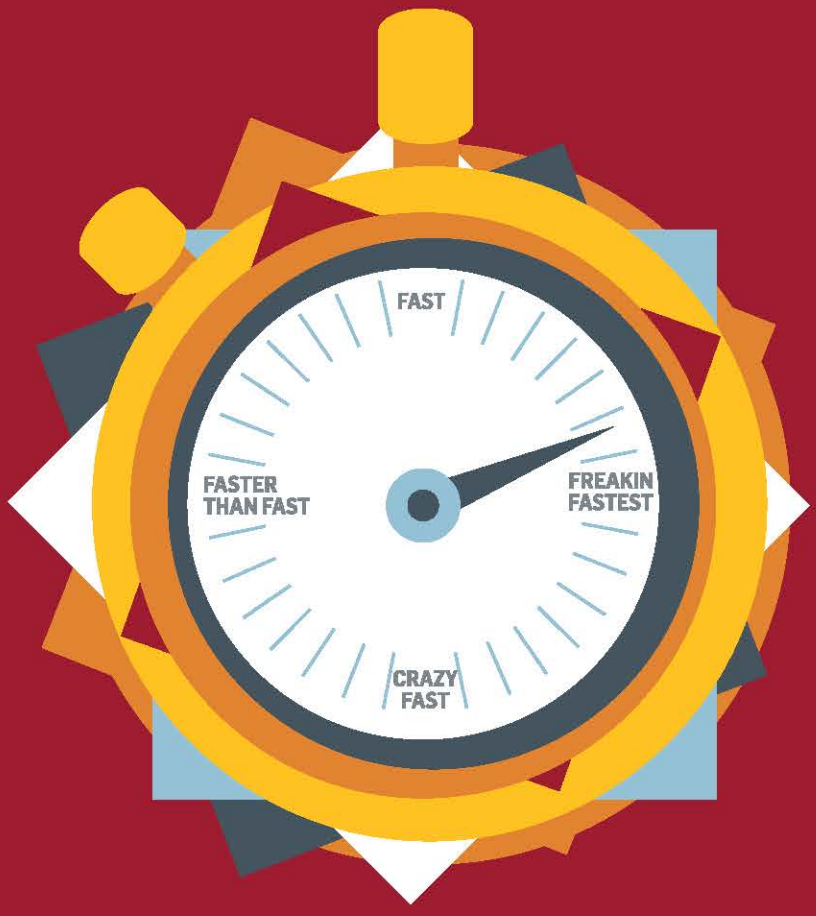
Plug *Your* Business into 30 Years of Solar Expertise

AEE Solar

The Only Wholesale Distributor You'll Ever Need

800-777-6609
www.aeesolar.com
sales@aeesolar.com

Zep Solar



Zep Solar offers a new way to install PV: **freakin' fast**

The Zep Compatible Platform unleashes a whole new level of installation efficiency.

Zep Solar installation systems combine Zep Compatible™ PV modules from leading PV module manufacturers with Zep Solar's revolutionary mounting and grounding hardware to offer the industry's first standard in PV installation technology. By eliminating long rails, grounding hardware, and separate fasteners, Zep Solar offers dramatic reductions in labor and logistics costs. ***And the stuff looks great too.***

Product Families Include:

- **ZS Comp™** for composition shingle roofs
- **ZS Tile™** for tile roofs
- **ZS Trap™** for trapezoidal metal roofs
- **ZS Wave™** for corrugated metal roofs
- **ZS Seam™** for standing seam metal roofs
- **ZS Aero™** for low-slope & flat roofs

Check out all six of our new product families on our all-new website at **www.zepsolar.com**



ZEP COMPATIBLE



WHY THE SMALLEST INVERTER WE'VE EVER MADE MAY BE THE BIGGEST.

The Aurora MICRO inverter is an introduction that has been years in the making.

We've put our decades of experience into engineering an incredibly simple-to-install, flexible microinverter that delivers the highest energy harvest on the market. Fast, easy installations that generate the most electricity? This could be big.

Get the specs at: **www.power-one.com/MICRO**

power-one®
Renewable Energy Solutions



Faster, safer, traceable solar PV testing. It's in the bag.

The PV150 Solarlink™ Test Kit contains more than simply the tools to meet all the commissioning test requirements of NABCEP and other international standards. It holds the secret to making it more efficient, easier and safer.

Solarlink™ connectivity between the PV150 tester and Solar Survey 200R irradiance meter, allows irradiance, module and ambient temperature results from the 200R to be transmitted over a wireless link and be recorded in real time in the PV150. This is the only PV installation tester with all of the PV electrical test functions in one hand-held unit. And now, you can improve speed and traceability by downloading all results via USB.

The solution to gaining the competitive edge? It's in the bag.

Available now, contact us for full details 813-886-2775
www.seawardsolar.com/solarpro or email enquiry@seawardsolar.com

FREE
PV Commissioning and Testing guidance book and posters
Visit seawardsolar.com/solarpro

SOLAR

Part of SEAWARD GROUP USA

Electrifying **ideas.**

We develop new ground-breaking products from brilliant **ideas.** With **knowledge, proven technology,** and engineering **creativity** we make today, what will lead the way tomorrow.



Ralph M., Photovoltaic Development Engineer

Electrifying Innovations

REFUsol

c UL us

With our innovative technology REFUsol inverters achieve a maximum efficiency of 98.2%.

REFUsol 012K, 016K, 020K and 024K three-phase string inverters are light, compact and easy to install.

As a leading technology company we supply first class products of the highest quality. Our promise: creating innovative products that are at the leading edge.

Making progress, made by REFUsol.

Made in USA

Phone: (866) 774-6643
info-usa@refusol.com
www.refusol.com

Contents

February/March 2013 Issue 6.2



58



46



30

Features

30 PV Array Wire Management

PV systems are expected to have a 25-year lifespan, and array wire management solutions should match this expectancy. However, designers and installers face persistent challenges to managing free-air conductors within the PV array. A compilation of feedback from PV industry experts—from *Code* gurus and inspectors to installers and O&M providers—provides a better understanding of the industry's current challenges, *Code* requirements and needs when it comes to managing and protecting exposed array conductors.

BY TOMMY JACOBY

46 Power-Conditioning Equipment for Residential Battery-Backup PV Systems

The owner of a grid-tied PV system with battery backup gets the best of both worlds: a reduced electric bill and the ability to live comfortably and safely without the grid when necessary. Installers of backup systems can access a market with fewer competitors, better margins and higher equipment and installation values. We introduce electricians and integrators who are new to battery-based grid-tied PV installations to basic system topologies and the power-conditioning equipment used to build these systems.

BY PAUL DAILEY AND JOE SCHWARTZ

58 Ground-Mount PV Racking Systems

Integrators who have set foot in the various industry trade shows over the last few years have likely noticed the proliferation of racking manufacturers offering products in the US and Canadian markets. These manufacturers, both old and new, continue to develop and refine their products. We provide an overview of ground-mount racking systems that are available in North America from 34 manufacturers and highlight features, differentiators and intended applications for each ground-mount racking product line.

BY DAVID BREARLEY, TOMMY JACOBY AND JOE SCHWARTZ

CAB, EX2060
Case No. IPR2024-00139
8 of 84

EXELTECH
SOLAR PRODUCTS
POWER THROUGH INNOVATION™



SIMPLIFY YOUR SOLAR INSTALLATION

Whether you're installing solar equipment for the first time or adding to an existing system, Exeltech Solar AC Module Inverters are the perfect solution. Exeltech Solar AC Module Inverters integrated with the PV panel during manufacturing are a fully self-contained UL-1741 certified PV combination that produces grid-ready, sine-wave solar electricity.



Main Features

- No DC Wiring
- No DC fusing, over current protection required
- No DC ground-fault detection, protection devices
- No DC combiner boxes
- No UL or inspection related DC cabling issues
- No PV series blocking or bypass diodes needed
- No series-connection problems where just one defective component can affect an entire system
- Incremental growth capability, start or add to the system for a fraction of the cost of a "string" inverter system
- Simplified system assembly, AC wiring connects directly to AC sub-panel with appropriate breaker
- Anti-islanding protection built into every AC module per UL1741 and IEE1547 safety standards

Exeltech's other products:
XLGT String Inverter
HelioSentry Monitoring System
To learn more, visit **www.exeltechsolar.com**

Scan QR Code
or go to exeltechsolar.com/acmodule

Contents²

February/March 2013 Issue 6.2

Departments

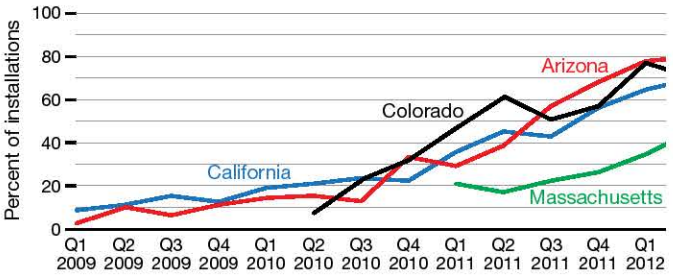


FRONT END

10 Contributors Experience + Expertise

14 QA Quality Assurance
Electrical Codes and Standards Applicable to PV Installations
The Evolution of Residential Solar Leasing

26 The Wire Industry Currents



14

BACK END

70 Interview An Experienced Perspective
Alex Bradley
DuPont Photovoltaic Solutions

74 Training Continuing Education for the Pro

76 Projects System Profiles
IRC Solar Roof Systems, Belmont Hill School
Aurora Energy, Talbot County Public Safety Center

79 Advertiser Index



76

ON THE COVER

IRC Solar Roof Systems, an affiliate of IRC Industrial Roofing Companies, was contracted to install this 186 kW PV array at the Belmont Hill School in Massachusetts. Roof-mounted Bentek Integrated Disconnect Combiners were utilized in conjunction with 14 Fronius IG Plus V 3-phase inverters.

Photo Courtesy IRC Solar Roof Systems

CAB, EX2060
Case No. IPR2024-00139
10 of 84

SOLON SOLquick™

The best lightweight commercial PV system



Perfect for Weight-Constrained Roofs

Expand Your Business. Win More Deals. Satisfy Your Customers.

- Lightweight, only 2.7psf load
- Low edge & point loads
- Minimum ballast, maximum power

Request a FREE layout at www.solquick.com

SOLON Corporation
6950 S. Country Club Road
Tucson, AZ · 85756-7151
Phone +1(520) 807-1300
Email solon.us@solon.com
www.solon.com

SOLON

SOLARPRO is a renewable resource

(...but don't forget to renew it.)

why?

To keep *SolarPro* free. While it may seem odd to renew a free subscription, your renewal ensures that we're not wasting money and paper by mailing copies to people who've moved on. What's more, a stringently qualified *and requalified* audience provides our advertisers with the good value they pay for. Both help us to keep your subscription free.

when?

Every two years. When you're eligible for your renewal, we begin a series of successive reminder messages to you via email. Your *SolarPro* subscription is on hold until we hear from you. Access to the website is limited and no further issues will be mailed at this point. Check your renewal date and eligibility anytime at solarprofessional.com/renew.

how?

Just update and click. Follow the link in any of the above-mentioned reminder messages or visit solarprofessional.com/renew. Review and update your subscription application information as needed and click "okay." Most renewals are approved instantly.

***SolarPro* represents a growing community of over 20,000 solar industry peers sharing their professional expertise.**

Renew your subscription and stay connected.

Contributors

Experience + Expertise



Paul Dailey, product and technical sales manager at AEE Solar, has worked in the distributed and renewable energy industry for more than 13 years, in capacities ranging from R&D and engineering to marketing and product management. Dailey holds a BS in mechanical engineering and an MBA from Washington State University.



Gabe Davis is a sales training manager at AEE Solar. After joining the solar industry in 2002, he worked in sales, marketing and new market development for REC Solar. Davis has sold more than 300 residential and commercial solar projects on both coasts and has been involved with system financing since 2007. He is an expert in sales strategies for residential systems using third-party financing, leases and power purchase agreements.



Tommy Jacoby is the principal at Jacoby Solar Consulting, based in Austin, Texas, where he provides PV design, consulting and installation services for a variety of clients and projects all over the world—from complex battery backup to large-scale grid-tied applications. Jacoby is a NABCEP Certified Solar PV Installer, an IREC ISPQ Certified PV Instructor, and a PV Systems Technical Editor for *SolarPro* magazine. He also provides third-party PV system inspection and commissioning services.



Ben Peters is the head of sales finance at AEE Solar. His responsibility is to grow dealer sales with innovative financing. Peters teaches classes on both residential and commercial solar finance, and is an expert on system economics. He previously worked as a senior finance analyst at REC Solar, growing its suite of financial offers, with an emphasis on solar leasing. Peters spent the first years of his solar career speaking to thousands of potential customers, an experience that showed him the need for more compelling financial offers.



Cari Williamette is the senior construction coordinator for the Solar Group at Westwood Professional Services, where she specializes in compliance with building codes and standards, construction permitting and performance testing of completed projects. Williamette's experience includes more than 30 years in the electrical industry, with 6 years in electrical contracting and 9 years in electrical and building trades inspections. She teaches classes on the *NEC* throughout the Midwest.

Learn Solar, Buy Solar, Accelerate Your Solar Business



Solar Training



Solar Products



Support Services

Now it's as easy as 1-2-3 to power up your solar business with ONTILITY.
With our solar training, products and services, accelerate your business today.

ONTILITY

To learn more, please contact us toll-free at 1.877.858.7479 or visit us at www.ontility.com

Solar Training · Solar Products · Solar Design · Solar Consulting · Solar Logistics · Solar Marketing

New from HEYCO® in 2013…

HEYClip™ MaxRunner® Cable Clip Array and SunScreener® for Solar Installers and Integrators

HEYClip™ MaxRunner® Cable Clip Array



- Patent Pending design
- Holds up to 12 cables with wire diameters ranging from .20″ (5,2 mm) to .28″ (7,2 mm)
- Constructed from PPE + PS flame retardant "Noryl®" material with a 301 Stainless Steel mounting clip
- Versatile Stainless Steel mounting clip is designed to secure the holder to a wide variety of aluminum extruded mounting frames up to .250″ (6,4 mm) thick
- **A Patent Pending Flush Mount design is also available to mount on flat panels or extrusions without mounting ledges**
- The injection molded wire holder has a VO flame rating and a UV (f1) rating for excellent resistance to outdoor exposure
- Molded internal locking tabs securely hold cables in place to prevent side-to-side movement or slippage of the cables
- Certified by UL for compliance with Canadian and US requirements under File E54523

Noryl® is a registered trademark of SABIC



Heyco® SunScreener®

- Does not violate panel integrity
- 304 Stainless Steel Washers firmly hold wire mesh screen to the module assembly-**preventing squirrels and rodents from damaging the interconnection wires, and birds from building nests under the solar panel**
- 303 Stainless Steel J-Hook easily attaches to the solar panel frames and can be trimmed or bent after assembly
- Installs quickly and easily with standard linesmen pliers
- Black color available for applications subject to HOA appearance restrictions

For FREE samples or product literature, call toll free 1-800-526-4182, or visit our website at www.heyco.com

HEYCO®

www.heyco.com

***"Stay Connected with Heyco"* Power Components**

Box 517 • Toms River, NJ 08754 • P: 732-286-4336 • F: 732-244-8843

SOLARPRO®

Publisher/Editor	Joe Schwartz
Managing Editor	Kathryn Houser
Senior Technical Editor/PV Systems	David Brearley
Technical Editor/PV Systems	Ryan Mayfield, Tommy Jacoby
Engineering Editor/PV Systems	Blake Gleason, PE
Technical Editor/Solar Heating Systems	Chuck Marken
Creative Services	Midnight Oil Design
Copy Editor	Kim Saccio-Kent
Proofreader	Gail Nelson-Bonebrake
Advertising Director	Kim Bowker
Advertising Manager	Connie Said
Operations Director	Scott Russell
Data Manager	Doug Puffer
Customer Service & Fulfillment	Jacie Gray, Shannon Ryan

Proud supporter of:

IREC Interstate Renewable Energy Council

NABCEP

SEIA Solar Energy Industries Association®

SEPA solar electric power association

CONTACT US

Subscriptions
To apply for a free subscription:
solarprofessional.com/subscribe

Send subscription questions to:
subscribe@solarprofessional.com

To change subscription information:
solarprofessional.com/myaccount

Letters to the Editor
Email your comments and suggestions to:
editor@solarprofessional.com

Industry PR
Send news and equipment releases to:
thewire@solarprofessional.com

Advertising
For advertising opportunities, visit:
solarprofessional.com/advertise

Western States Sales Office
Connie Said, Advertising Manager
connie.said@solarprofessional.com
Direct: 541.326.5773

Eastern States Sales Office
Kim Bowker, Advertising Director
kim.bowker@solarprofessional.com
Direct: 541.858.1791

Marketing
Promotional opportunities and offers:
marketing@solarprofessional.com

Copyright © 2013 Home Power, Inc. Contents may not be reprinted or otherwise reproduced without written permission. SolarPro is a registered trademark of Home Power, Inc.

While *SolarPro* magazine strives to publish only safe and accurate content, we assume no responsibility or liability for the use of this information.

Interior paper is made from 85%–100% recycled material, including 20%–30% postconsumer waste.

National Electrical Code®, NFPA 70® and NEC® are registered trademarks of the National Fire Protection Association, Quincy, Massachusetts.

SolarPro magazine | PO Box 68 | Ashland, OR 97520 | US

CAB, EX2060
Case No. IPR2024-00139
14 of 84



THE CLEAR CHOICE

PV + AC. That is our goal.

Most installations use the traditional string inverter to convert DC into AC.

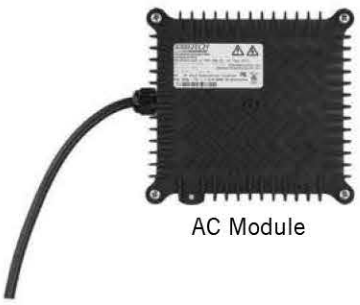
Solarbine is proud to introduce our 250W panel using the Exeltech Solar Products AC Module Inverter installed in place of the standard junction box. Each panel now becomes its own independent AC source, capable of quickly being installed in series with up to 9 others.

Imagine the savings, in material and time, from using Solarbine's all-in-one panel.

To purchase these and other solarbine products, please visit solarbine.net.



Scan this QR code or visit solarbine.net/**pvac** to learn more about Solarbine's PV+AC panel.



AC Module

www.solarbine.net

SOLARBINE

Electrical Codes and Standards Applicable to PV Installations

The codes and standards affecting PV equipment and system installations are almost as varied as the equipment itself. The Canadian Standards Association (CSA), California Energy Commission (CEC), Institute of Electrical and Electronics Engineers (IEEE), International Code Council (ICC), International Electrotechnical Commission (IEC), National Fire Protection Association (NFPA), Underwriters Laboratories (UL) and countless other agencies all have their own opinion as to how PV system components should be manufactured and how PV systems should be installed. As a result, there is no unanimity regarding what equipment is considered safe for use and what constitutes proper installation.

While the manufacturer's installation instructions generally take precedence over other requirements, many local or state jurisdictions have additional requirements beyond those found in the *National Electrical Code*. Furthermore, when a PV system is utility owned and operated, the installation is technically outside the scope of the *NEC*. But what exactly is a utility? This is a very important distinction because the *NEC* generally requires the use of equipment listed to UL standards. However, if a PV installation is not subject to the *NEC*, the use of equipment designed to meet other standards, such as those established by the IEC, may be permitted.

Since the standards to which PV equipment must conform vary by context, as do the applicable codes, it is incumbent on designers and installers to understand the regulatory context within which they are working. This regulatory context influences what equipment and installation practices are likely to be acceptable to the AHJ and the interconnected utility. Because there is no universal set of requirements, system designers and installers must be proactive about communicating with AHJs and utilities to streamline project permitting, inspection and commissioning.

Codes vs. Standards

According to the Merriam-Webster dictionary, a *code* can be either "a systematic statement of a body of law," in particular one that is "given statutory force," or "a system of principals or rules." By comparison, the dictionary defines a *standard* as "something established by authority, custom, or general consent as a model or example." While you may think of codes as mandatory, this is not always the case.

The NFPA has developed more than 300 codes and standards intended to "minimize the possibility and effects of fire and other risks." As explained on the NFPA website (nfpa.org): "A *code* is a model, a set of rules that knowledgeable people recommend for others to follow. It is not a law, but can be adopted into law." In other words, codes like the *NEC* become mandatory only after a governing body adopts them, making them enforceable by a legal jurisdiction in a particular area.

Most of the documents published by the NFPA are standards rather than codes. According to the NFPA: "A *standard* tends to be a more detailed elaboration, the nuts and bolts of meeting a code. One way of looking at the difference between codes and standards is that a code tells you *what* to do, and a standard tells you *how* to do it." This basic distinction holds true for equipment standards, like UL 1703 or UL 1741, which essentially tell manufacturers how to construct flat-plate PV modules or inverters, charge controllers, and combiner boxes, as well as how to test the equipment to ensure product safety.

Electrical Codes and Standards

The electrical codes and standards most likely to apply to PV installations are the *National Electrical Code,* the *National Electrical Safety Code (NESC)* and product standards. Most system designers and installers are quite familiar with the *NEC* and generally recognize applicable UL product safety standards. However, they may be less familiar with the *NESC* and equipment standards from organizations other than UL.

NFPA 70: NEC. The National Fire Protection Agency is the nonprofit fire prevention organization responsible for developing the *NEC* and other consensus codes and standards. Founded in 1896, the NFPA traces its origins to an 1895 movement in Boston that established standard pipe sizes for sprinkler systems—a standard that is now catalogued as NFPA 13.

The first edition of what is now known as the *NEC* or *NFPA 70* was published in 1897 under the cumbersome title *Rules and Requirements of the Underwriters' Association of the Middle Department for the Installation of Wiring and Apparatus for Light, Heat and Power.*

While *NEC 2011* is the most current edition, *NEC 2008* is still enforced in many jurisdictions, including California. Since the *NEC* is updated every 3 years, the process of developing *NEC 2014* is already far along. The first draft started circulating for public comment as early as June 2012, and the public comment period ended in mid-October. According to the schedule published in the *2012 NFPA* CONTINUED ON PAGE 16

CAB, EX2060
Case No. IPR2024-00139
16 of 84

Big solar is circling.

They don't smell blood...they smell money. It's yours.



Big changes are happening in solar. Companies are consolidating faster than ever, and soon there won't be business left for independent installers. Join the Solar Universe network before big solar closes in.

SOLARUNIVERSE™

Grow Your Solar Business Today

SolarUniverse.com/grow

This advertisement is not an offering. We will not offer you a franchise unless and until we have complied with applicable pre-sale registration and disclosure requirements in your jurisdiction. An offering can only be made by a prospectus filed first with the Department of Law of the State of New York. Such filing does not constitute approval by the Department of Law. © Solar Universe, Inc., 1152 Stealth St., Livermore, CA 94551.

Standards Directory, the final draft of *NEC 2014* will be presented to the NFPA general assembly in June 2013.

While the *NEC* per se is not legally binding, it has been adopted into law at state or local levels in all 50 US states. In those jurisdictions, local electrical inspectors enforce it as law. Just as you can be fined for exceeding the posted speed limit, you can receive a fine for noncompliance with the *NEC*. You might get a warning first, but if you refuse to come into compliance, you will be fined.



Courtesy Westwood Professional Services

Behind the fence? Installing a PV system behind a security fence does not mean that the facility is not covered by the *NEC*. Unless the PV system is utility owned and operated, you typically need special permission from the AHJ to use equipment that is not listed to UL standards.

National Electrical Safety Code. The *NESC* is published by the IEEE. It is revised every 5 years, and the most current edition is *NESC 2012*. Whereas the *NEC* is concerned with protecting people and property from electrical hazards involving wiring in buildings, structures and other premises, the *NESC* applies to electric supply stations, overhead and underground transmission and distribution networks, and cable TV and railroad signal systems.

Officially recognized by the American National Standards Institute (ANSI) as ANSI Standard IEEE C2, the *NESC* provides guidelines for the installation of utility electrical systems and provisions for ensuring the safety of both employees and the general

PROJECT PORTFOLIO FINANCING

Commercial Financing REALLY.

• Get your project from concept to completion.
• Maintain control.
• Protect your bottom line.

US solar distributing

North America's Exclusive Distributor of ET Solar.

(916) 679-4044 • www.ussolardistributing.com/commfinance

CAB, EX2060
Case No. IPR2024-00139
18 of 84

public. In many states, but not all, a regulatory body like the public service commission or public utility commission has adopted some edition of the *NESC* or a portion of it. While it is not always adopted as law, the *NESC* is generally used as a reference for utility requirements. Depending on your location, these requirements are variously referred to as *General Order 95,* the *Green Book,* the *Blue Book* and so forth. Like the *NEC,* the *NESC* is not intended as a design specification or instruction manual.

Product standards. One of the biggest differences between the *NEC* and the *NESC* centers around product listing. The *NEC* repeatedly stresses that all equipment must be listed. For example, Section 690.4(D) requires the use of inverters, modules, combiners and charge controllers that are "identified and listed for the application." As clarified by definitions found in *NEC* Article 100, *listed* equipment is commonly *identified* and *labeled* by an organization that is acceptable to the AHJ—typically a Nationally Recognized Testing Laboratory (NRTL), like UL.

Since UL is responsible for developing product safety standards for the US, many inspectors generically refer to listed equipment as "UL listed." However, the Occupational Safety and Health Administration (OSHA) currently recognizes 15 different NRTLs that list electrical products to UL standards. At least five of these organizations—CSA, Intertek (ETL), MET Laboratories, TÜV Rheinland and UL—test PV modules or inverters to the applicable product safety standard (UL 1703 or UL 1741) for use in the US.

Unlike the *NEC,* the *NESC* does not necessarily require the use of equipment listed to UL standards by an NRTL. Instead, the *NESC* defers more broadly to recognized organizations, like ANSI or the American Society for Testing and Materials (ASTM). Whereas UL 1741 is the safety standard for inverters in installations covered by the *NEC,* inverters used in PV systems that are utility owned and operated may conform instead with IEC or IEEE equipment standards and be acceptable under the *NESC.*

Note that some jurisdictions have additional PV equipment testing requirements. For example, the CEC and California Public Utilities Commission require independent performance verification testing for PV modules and inverters receiving rebates under California Solar Electric Incentive Programs. These tests are required in addition to product listing to UL standards. A list of rebate-eligible equipment is maintained at the Go Solar California website (gosolarcalifornia.com).



CAB, EX2060
Case No. IPR2024-00139
19 of 84

QA

Utility Owned and Operated?

Most utility-scale PV systems in the US are designed and deployed using 1,000 Vdc–rated PV modules and inverters. Since manufacturers have only recently started UL-listing PV equipment at 1,000 Vdc, many distributed PV generation facilities in the US have been constructed using equipment built to international equipment standards. While this is allowed under the scope of the *NESC,* many of these PV power plants are not technically utility owned and operated, but are instead classified as *non-utility generators,* also known as *independent power producers.*

The *NESC* uses a rather generic definition of a *utility:* "an organization responsible for the installation, operation, or maintenance of electric supply or communications systems." By comparison, the federal government's definition of a utility is narrower. According to the US Energy Information Administration (EIA), an *electric utility* is: "a corporation, person, agency, authority, or other legal entity or instrumentality aligned with distribution facilities for delivery of electric energy for use primarily by the public. Included are investor-owned electric utilities, municipal and state utilities, federal electric utilities, and rural electric cooperatives. A few entities that are tariff based and corporately aligned with companies that own distribution facilities are also included." The deciding factor appears to be who is buying the power. If the purchaser is the public, then the company is a utility. If the electricity is sold to a utility, then the generating company is a non-utility generator.

According to "Grid 2030," a report published by the Federal Energy Regulatory Commission, in 2003 there were more than 3,100 electric utilities in the US: 213 investor-owned utilities; 2,000 public utilities, including municipal utilities; and 930 electric cooperatives. In addition, there were approximately 2,100 non-utility generators at that time. However, in the decade since, the number of non-utility generators has increased dramatically. A March 2012 report from the American Public Power Association (publicpower.org) indicates that non-utility generators are responsible for more than 50% of the new power generation capacity under construction today and more than 80% of the capacity "at the earlier stages of development."

As clarified in *NEC* Section 90.2(B)(5), a PV generation facility that is utility owned and operated is not covered by the *NEC,* which generally allows the utility to use equipment that is not listed to UL standards—provided that it meets other recognized standards. These utility-owned projects must typically adhere to some version of the *NESC* as amended by the local utility. Since the utility acts as its own AHJ for these projects, it can waive listing requirements for equipment and it can regulate installation practices, depending on its grid system.

Occasionally a utility asks the local electrical inspector to review a project, in which case *NEC* compliance may be required. Further, if a non-utility generator constructs an identical PV power plant and this PV plant is operated as an independent power provider, then the AHJ will likely require the use of listed equipment in accordance with the *NEC.* When a developer or private entity is building a system, most jurisdictions require that local or state inspectors verify installation compliance with the locally adopted edition of the *NEC.* The applicable *Code* edition and enforcement process varies by state, county or city, according to the legal wording in local statutes.

The distinction between a utility and a non-utility generator is important. Just last year, a product listing issue halted construction for 2 months at a high-profile 230 MW PV project in Antelope Valley, California. Reportedly, the AHJ, a county safety inspector, took issue with the fact that there was no UL mark on the module connectors on the IEC-listed modules delivered to the site. As a result, half of the project workforce—approximately 120 people—was temporarily furloughed until the EPC was able to come up with a solution that the AHJ found acceptable. (See "First Solar Installs First PV Module at 230 MW Antelope Valley Solar Ranch One," Greentech Media, June 29, 2012.)

The Antelope Valley project is an important reminder of what can happen when project designers and installers are not on the same page as the AHJ. A PV power plant is not considered to be "behind the fence" simply because there is a security fence around the facility. "Behind the fence" is shorthand for a facility that is under the exclusive control of an electric utility, because security fencing is often required to ensure public safety.

It is important that system designers and installers—especially those working for non-utility generators or independent power providers—be proactive about discussing applicable codes and standards with utilities and AHJs. While IEC and UL both develop safety standards for electrical equipment, the respective standards themselves can be different. A piece of equipment that is tested to IEC standards does not necessarily comply with UL standards and vice versa. Similarly, a product that complies with ANSI standards may not be listed to UL standards. If the utility requires ANSI compliance and the electrical inspector requires compliance with a UL standard, there may be a problem—most equipment will not have both labels. Early discussions with the utility and the local inspector can help eliminate costly delays in energizing the system.

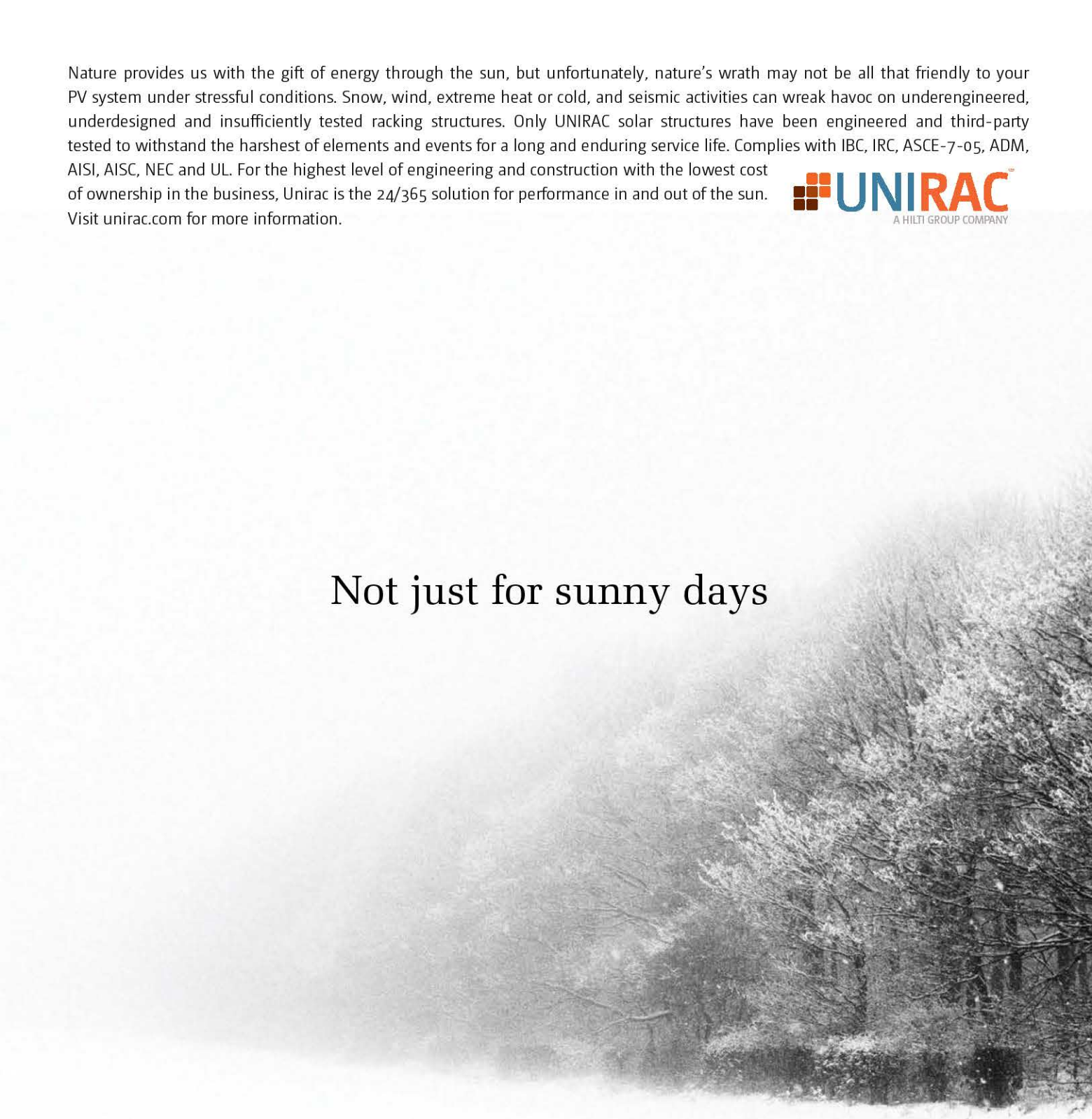
—Cari Williamette / Westwood Professional Services / Eden Prairie, MN / westwoodps.com

CAB, EX2060
Case No. IPR2024-00139
20 of 84

Nature provides us with the gift of energy through the sun, but unfortunately, nature's wrath may not be all that friendly to your PV system under stressful conditions. Snow, wind, extreme heat or cold, and seismic activities can wreak havoc on underengineered, underdesigned and insufficiently tested racking structures. Only UNIRAC solar structures have been engineered and third-party tested to withstand the harshest of elements and events for a long and enduring service life. Complies with IBC, IRC, ASCE-7-05, ADM, AISI, AISC, NEC and UL. For the highest level of engineering and construction with the lowest cost of ownership in the business, Unirac is the 24/365 solution for performance in and out of the sun. Visit unirac.com for more information.

UNIRAC
A HILTI GROUP COMPANY

Not just for sunny days



www.unirac.com

QA

The Evolution of Residential Solar Leasing

The introduction of the solar lease financing model and third-party system ownership has rapidly and fundamentally transformed the residential solar market in the US. One could argue that the advent of high-voltage string inverters in the US market in 2001 was the last transformative event of this magnitude. The solar lease is a once-in-a-decade industry-changing product that has created vast opportunities for some integration firms, and competitive challenges and disadvantages for others. Examining the evolution of the residential solar lease, its current status, and likely future developments can assist integrators in navigating these often complex and quickly evolving system-financing mechanisms.

Solar Lease History

Many people contend that the residential solar lease was born in 2007 when Sunrun, a start-up finance company led by two Stanford business graduates, introduced its residential lease product. Lynn Jurich and Ed Fenster believed that the number one, two and three obstacles to the propagation of residential solar were—no surprise—money, money and money. Sunrun's financial model was simple: Leverage investor resources and tax equity to purchase PV systems on behalf of residential homeowners, providing a financed solution with no or low up-front costs. The solar lease effectively simplifies a homeowner's path to investing in solar. Under this model, the lease provider—not the residential homeowner—receives all rebates, tax credits and depreciation. The lease provider in turn offers a warranty on all aspects of the system and provides some degree of system monitoring and O&M over the typical 20-year lease term. At the end of the term, homeowners have three options: renew the lease, purchase the system at fair market value or have the system removed at no cost.

Residential solar lease providers typically offer two plan options.

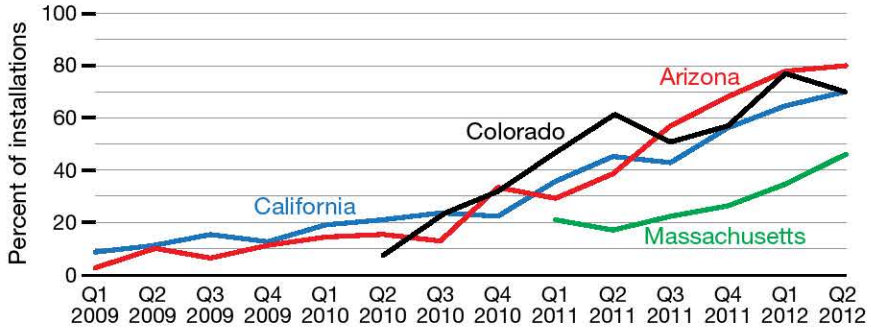
Monthly payment plan. A monthly payment plan allows for zero money down or a low up-front investment, usually in the $1,000–$4,000 range. The homeowner agrees to purchase all the electricity produced by the PV system for the next 20 years at a rate lower than or equal to the local rate of conventional power per kilowatt hour. Depending on the specifics of the financing, the new rate may include an escalator that can be more beneficial to the lease provider than to the customer. The general lease approach provides the homeowner an opportunity to switch to solar power without having to come up with the system's total cost out of pocket. It also streamlines the homeowner's transaction by eliminating the need to claim the 30% federal tax credit.

Prepaid plan. Under this plan, the homeowner makes a large payment (typically about 65% of the total system cost) at the initiation of the lease term, but does not need to make another payment over the lease's 20-year term. This approach enables the customer to have a PV system installed without shouldering the tax liability necessary to take full advantage of available tax credits. A prepaid plan may be ideal for a homeowner such as a retiree living on a fixed income, who is prepared to make a large investment in solar but does not have the tax appetite required to take advantage of the 30% federal tax credit. The system owner also typically benefits from an extended warranty, O&M services and system monitoring provided over the 20-year term.

Both of these options have proven to be very appealing to a large number of consumers who want to make the switch to solar. According the *2012 U.S. Solar Market Insight* report published by GTM Research and SEIA, as of Q2 2012 solar leases finance approximately 70% of residential installations in the major markets of California and Colorado, 80% of the installations in Arizona and more than 45% in Massachusetts. The increase in third-party–owned residential systems is expected to continue across all mature solar markets.

Early on, solar lease providers faced challenges from a regulatory standpoint. Existing rebate and interconnection processes were based CONTINUED ON PAGE 22

Percentage Third-Party–Owned Residential Installations: Q1 2009–Q2 2012



Courtesy GTM Research/SEIA

Figure 1 Since their introduction in 2007, solar lease products have fundamentally changed the residential PV market in the US. In several major solar markets, leased systems accounted for 45%–80% of installed residential systems in Q2 2012.

CAB, EX2060
Case No. IPR2024-00139
22 of 84



Let us help you grow your business.

http://goo.gl/UCvwe

Become a wholesale partner.
Apply now and get an iPad Mini on your first order.*

- Credit terms and financing available
- Competitive pricing
- Same day shipping!
- We answer our phone!

affordable solar

1.866.365.5115
affordable-solar.com

4840 Pan American Frontage Rd N | Albuquerque, NM 87109 | USA

7am - 6pm MST

*When you spend $10,000 or more. You must mention this ad or fill out the form from our QR code.

CanadianSolar · SOLECTRIA RENEWABLES · HYUNDAI HEAVY INDUSTRIES CO.,LTD. · SMA · UNIRAC · enphase

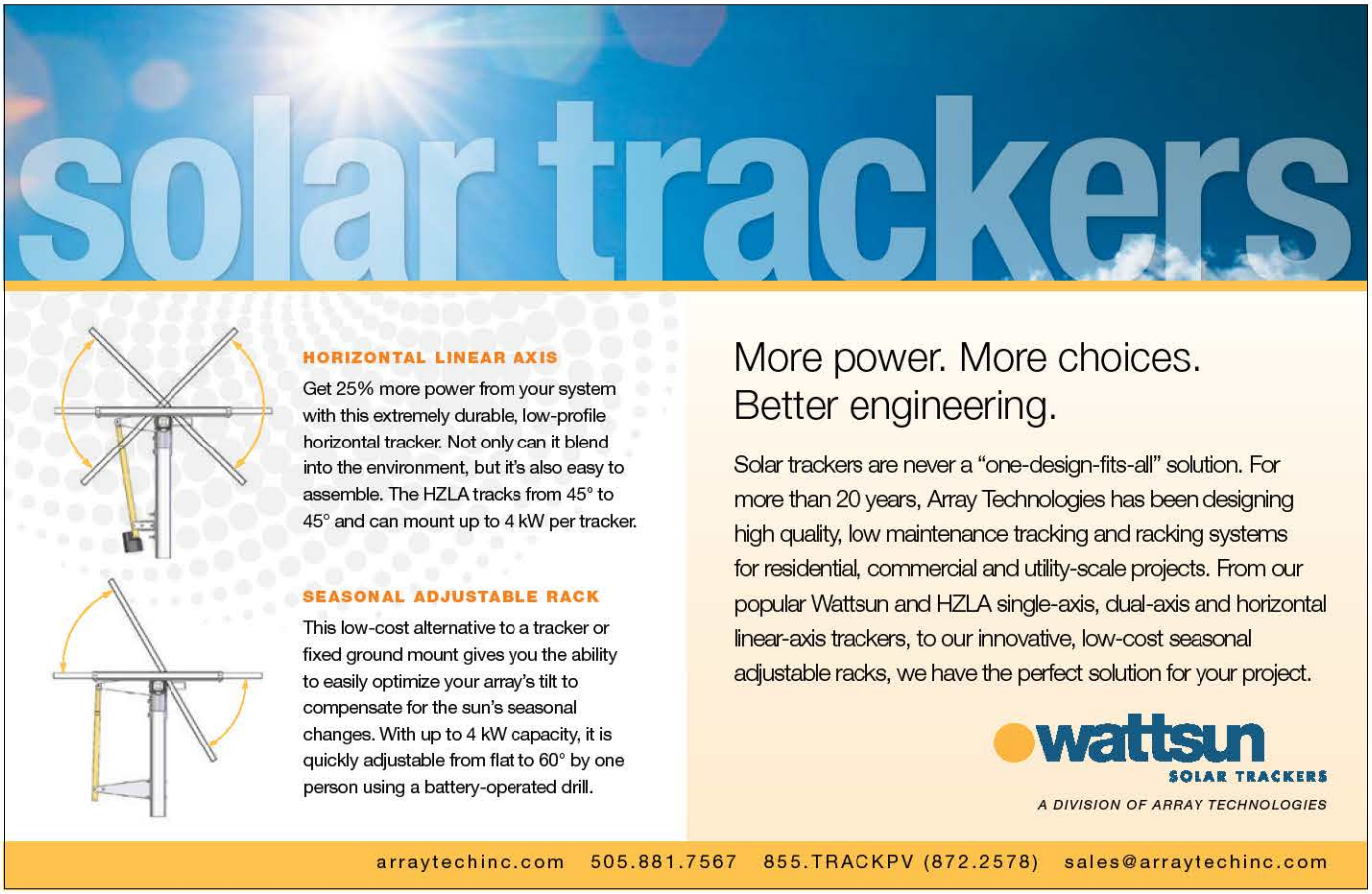
on the concept of sole ownership. However, Sunrun and other solar finance companies have worked diligently to resolve these issues. Residential solar lease financing is now available in at least 12 states. The primary limiter on these products is generally not regulatory issues, but regional financial viability based on available financial incentives, electricity costs and the region's solar resources. Currently only a few states explicitly prohibit third-party residential financing.

Current Lease Models

As residential lease products continue to evolve, providers are developing and refining a range of business models. There are currently three solar leasing models.

In-house model. In the in-house model, one company operates all segments of the solar leasing value chain. It creates the investment funds, sells the lease contracts and installs the systems. SolarCity is one of the biggest providers of residential third-party solar financing and has successfully pioneered this approach. This model requires a tremendous amount of capital and, in the case of SolarCity, is still not profitable. Other players are entering this market, however. Vivint, a large national provider of home automation, alarm and energy management products and services, has recently announced aggressive plans to expand its business into the residential solar lease market.

Dealer network model. Most residential solar finance providers utilize the dealer network model. In this approach, the solar lease companies raise the funds and develop tools that allow smaller solar integration companies to generate proposals. These dealers originate lease contracts that the lease provider funds and owns through its investment fund. In some instances, the dealers originating the sales do not install the system themselves, but have the lease provider subcontract out the installation. Some examples of companies that operate under the dealer network model include NRG SunLease, OneRoof Energy, SunPower and Sunrun. NRG SunLease—formerly SunCap—is an example of a company that offers its lease product to qualified dealer partners only. OneRoof Energy has plans to open its dealer network to not only solar companies, but also roofing contractors as a way to expand its presence in the residential lease space. SunPower provides a lease product to its dealer base, allowing it to sell modules and provide its authorized dealers with competitive offers. Sunrun focuses on selecting well-established solar companies to source its deals and complete its installations.



CAB, EX2060
Case No. IPR2024-00139
24 of 84

Open-source model. In the open-source model, the finance companies focus on only a few aspects of the value chain and rely on the industry to fulfill the remaining job aspects. An example is Sungevity, a company that sets up its own fund, sells its lease to residential customers using an innovative virtual sales model, and utilizes a network of installation subcontractors to provide installation and O&M services. Another company that employs the open-source model is Clean Power Finance (CPF). CPF provides the tools that allow solar installers to quote lease financing, while it secures the funds to finance the project. Given the increasing competition in the residential lease market and the changing industry dynamics, the open-source model benefits from leveraging individual companies' core competencies in areas where the lease providers may be less experienced. This model will continue to evolve as more companies launch that provide specialized services such as system design, installation and O&M.

Lease Provider Overview

Several companies have helped pioneer residential solar leasing. The following overviews are not meant to be all inclusive, but rather to provide background information on some of the major players currently operating. Examining these companies' backgrounds and offerings can help integrators evaluate the lease market, explore avenues to enter it and assess strategies to optimize their business plans and capitalize on the opportunities presented by the various solar lease models and offerings.

Clean Power Finance. Match.com founder Gary Kremen started up CPF (cleanpowerfinance.com) in 2007. As well as offering other services, the company provides a web-based solar proposal tool and a residential lease or power purchase agreement product that it launched in 2011. CPF's focus is to create a bridge between solar integrators and the financial industry. CPF does not market itself directly to the residential consumer, but rather provides white-label financing products that allow solar installation companies to offer financing under their own brand name.

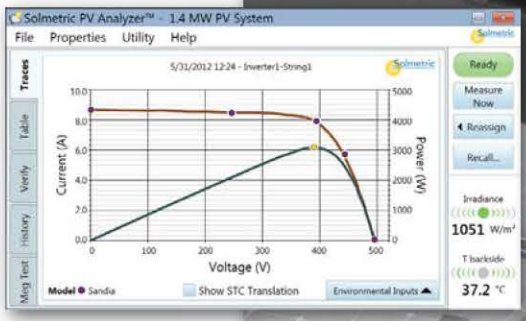
NRG SunLease. NRG SunLease (nrgsunlease.com) provides residential solar financing through a dealer network. The firm is a subsidiary of Fortune 500 company NRG Energy. NRG SunLease has been active in many major US solar markets, with a dealer network of more than 40 companies. It is active in multiple states including Arizona, California, Colorado, Massachusetts, New Jersey, New York and

What's your Return on Irradiance™?

Will your array deliver the ROI you expect?

Find out quickly and conclusively with the Solmetric® PV Analyzer. I-V curve tracing and built-in PV models equip the PVA to measure performance with more detail and in less time during commissioning and O&M.

*Now shipping with v2.0 Software!





Safety

Find pinched wires and leakage problems before they become dangerous with the Megger® MIT430 Insulation Resistance Tester, available from Solmetric. PVA 2.0 software manages your meg-test data.

Free live webinars:
www.solmetric.com

Solmetric
Expert tools.
Better Solar.

CAB, EX2060
Case No. IPR2024-00139
25 of 84

Texas. NRG SunLease will be releasing a new product for 2013.

OneRoof Energy. Founded in 2009, OneRoof Energy (oneroofenergy.com) employs the dealer network model. OneRoof Energy supports system installation during new construction or building reroofing, and the company has recently announced partnerships with several large roofing contractors and solar equipment manufacturers. It offers in-house resources to support its network, allowing partners to focus on system design and installation.

SolarCity. SolarCity (solarcity.com) was founded in 2006, launched its lease product in 2008 and is currently one of the largest solar finance and integration companies in the US in terms of market share. SolarCity utilizes an in-house solar lease model and has been very successful in securing external financing including investments from Credit Suisse, First Solar, Google, PG&E and US Bancorp. The company has a significant presence in all major residential markets that allow third-party residential lease products and have favorable market conditions. At the time of publication, SolarCity was in the process of launching its IPO.

Sungevity. Founded in 2007, Sungevity (sungevity.com) helped pioneer the open-source finance model. It was also one of the first companies to conduct preliminary PV system survey, design and sales activities over the phone and via the Internet. Sungevity launched its residential lease product in 2010 and is active in major solar markets across the US. The company has a centrally located phone and web-based sales team and a regional network of solar installation subcontractors.

SunPower. SunPower (sunpowercorp.com) is a global manufacturer of solar modules that was founded in 1985 as a subsidiary of Cypress Semiconductors. The company distributes its equipment and solar lease products through an authorized dealer network. SunPower has a national presence and offers residential financing options in most major US solar markets. French oil conglomerate Total acquired a majority share in SunPower in 2011.

Sunrun. Founded in 2007, Sunrun (sunrunhome.com) is currently one of the largest solar finance companies in the US in terms of market share. Its dealer network model has allowed it to expand into most major US markets with a distributed team of subcontracted installation companies. Sunrun has made substantial investments in its financial and service infrastructure and markets directly to residential consumers using mass media strategies.

Opportunities to Consider

Residential solar leasing will continue to evolve as new sources of investment are introduced, and market and policy developments take effect. How can traditional solar integration companies participate in the rapidly expanding solar lease market now and in the future?

An obvious initial step for integrators who do not currently offer solar lease products is to open a dialogue with one of the many companies operating dealer network or open-source solar financing business models. Depending on the market your business is serving, these discussions may create opportunities to add solar lease financing offerings and provide online tools to administer them. Subcontracted installation opportunities may also be available. In addition, several equipment wholesalers offer lease products or other financing options to dealers operating in specific geographical markets.

Other opportunities are also worth considering. One such option is to provide O&M services to owners of leased systems. Some companies that have installed systems for third-party providers may be unable to offer O&M services at competitive rates, which may allow companies to compete for such contracts or to bid on individual opportunities. In some cases, the original installation company may no longer be in business, requiring the finance company to rely on new partners to provide system service and maintenance. For example, Akeena Solar installed hundreds of systems in partnership with Sunrun in California before it rebranded as Westinghouse Solar and switched its core focus to ac module systems. Sunrun now works with local installation companies to provide O&M services for these installed systems.

In another new financing business model, *cloud solar,* individual companies upload project profiles onto online platforms where investors finance projects that meet certain economic requirements. CPF received a US Department of Energy grant to create an online O&M marketplace and is building the foundations of the cloud solar concept for the residential sector. Providers like Distributed Sun (distributedsun.com), SCS Renewables (scsrenewables.com) and Sol Market (solmarket.com) are already financing large commercial and utility-scale projects based on the cloud model. Integrators may want to evaluate these networks to gain an understanding of the types of large-scale projects that financial investors are currently appraising. As this model evolves and becomes more common, it may be deployed in the residential sector.

While third-party financing has seen unprecedented growth in the major solar markets, it is unclear how the model will compare to more traditional financing after 2016 when the 30% federal tax credit is set to expire. The solar lease model relies on tax equity investments. In their absence, solar companies and their customers may revert to more familiar ways to invest in solar. Some companies are already offering government-sponsored loan products like the Federal Housing Administration (FHA) PowerSaver and US Department of Housing and Urban Development (HUD) Title I loan programs. One of the largest Title I lenders in the US, Admirals Bank, is

CAB, EX2060
Case No. IPR2024-00139
26 of 84

already seeing an increase in solar loan customers, since the required monthly payments can be comparable to or lower than some solar lease offers.

Another residential financing innovation to watch is the combination of lease financing with more traditional forms of lending. One example is using the FHA PowerSaver loan to finance a lease prepayment. This allows a homeowner to take advantage of the tax equity money the lessor is providing, while continuing to benefit from having a monthly payment rather than making a large one-time payment. Unsecured loans are also a potential source of financing these prepayments. With the credit crunch, banks and other lenders stopped offering unsecured loans as they had a reduced appetite for risk, but as the economy improves, encouraging banks to offer more credit to homeowners, unsecured loans will become available to a greater number of people.

Finally, Property Assessed Clean Energy (PACE) financing may be another source of solar lease payment financing. Again, the solar lease provider takes the federal tax credit and then uses this source of funds to finance the prepayment amount. It should be noted that there are currently federal restrictions against PACE financing for residential installations, and most open programs are limited to the commercial sector. However, this may change in the future. The PACENow website (pacenow.org) offers regular updates on PACE program status throughout the US.

If the interest rate and term of financing offers from FHA, HUD or PACE programs result in a lower monthly payment than a monthly solar lease, the homeowner would benefit from these financing approaches. Integrators should watch developments related to these financing sources closely, since any changes could represent an opportunity to stay one step ahead of competition in the residential solar marketplace.

Members of the solar community will continue to see new solar lease and financing opportunities. A good strategy to stay ahead of the curve is to explore traditional financing options, reach out to third-party residential solar lease providers to evaluate offerings currently available in your market, and research how your company can take advantage of new business opportunities created by innovative solar financing.

—Gabe Davis / AEE Solar / San Luis Obispo, CA / aeesolar.com

—Ben Peters / AEE Solar / San Luis Obispo, CA / aeesolar.com



CAB, EX2060
Case No. IPR2024-00139
27 of 84



DPW Solar Announces Updated Ballasted Racking System

[Albuquerque, NM] The POWER-FAB CRS-G2 low-slope roof-mount racking system from DPW Solar offers several advancements over the company's first-generation CRS product. The CRS-G2 features a simplified design, 50% fewer components and faster assembly rates. The fully ballasted, nonpenetrating racking solution accepts standard concrete blocks, assembles with a single tool and permits field adjustments for roof-contour variations. The product's integrated grounding system meets the UL 467 standard, and wire management attachments are provided. The CRS-G2 system includes thicker roof-membrane protection pads than the first-generation CRS product, and it has an interconnected module support system. The product is packaged on pallets to facilitate transport to the roof.

DPW Solar / 505.889.3585 / dpwsolar.com

DECK Releases Performance Benchmarking Tool

[Portland, OR] A recently released product from DECK Monitoring provides PV plant owners and operators with the ability to establish high-quality array performance baselines. The SolarAnywhere SystemCheck integrates DECK's existing software platform with site-specific satellite irradiance and predictive modeling data supplied by Clean Power Research. Users input system parameters such as modules, inverters and array azimuth values. The software utilizes NOAA GOES satellite imagery, with hourly granularity and resolution up to 1 kilometer, to calculate simulated performance estimations. The results are reported via the DECK software administration panel, providing plant operators the ability to chart predicted versus actual performance. In turn, this baseline data can be used to effectively manage O&M requirements for the system.



DECK Monitoring / 503.224.5546 / deckmonitoring.com

Motech Introduces Certified 1,000 Vdc Modules



[Newark, DE] Motech Americas announced the availability of new module lines listed by Intertek to the UL 1703 standard for 1,000 Vdc applications in North America. The polycrystalline IM Plus Series has power outputs of up to 260 W and 310 W. The monocrystalline XS Plus Series has power outputs of up to 265 W and 320 W. The modules are manufactured in Motech's Delaware facility and meet ARRA Buy American Act compliance guidelines. Both the IM Plus and XS Plus series module lines feature positive power tolerances of up to 4.99 W and include a 25-year progressive power warranty and a 10-year materials and workmanship warranty.

Motech Americas / 302.451.7500 / motechsolar.com

CAB, EX2060
Case No. IPR2024-00139
28 of 84



INDUSTRY LEADING 98% EFFICIENCY UTILITY-SCALE INVERTERS

NEW
SMARTGRID 500XT

FEATURES
- 98% CEC efficiency
- External transformer
- Built-in redundancy
- Subcombiner options
- 600 VDC
- 208 VAC
- MODBUS communications
- User-interactive LCD

OPTIONS
- Uptime guarantee
- Stainless steel enclosure
- Web-based monitoring

OPTIONS FOR UTILITIES
- Real power curtailment
- Reactive power control
- Voltage ride-through
- Frequency ride-through

SOLECTRIA RENEWABLES

Solectria Renewables, LLC is the leading U.S. based grid-tied photovoltaic inverter manufacturer for residential, commercial and utility-scale solar installations. Our versatile line of high efficiency products provides power solutions ranging from 1kW residential systems to multi-megawatt solar farms. Solectria Renewables' products are backed by more than 20 years of experience in the power electronic and inverter industries and are supported by world class warranties. All of our commercial and utility-scale PV inverters are manufactured in the USA, ARRA compliant, Ontario FIT Content Compliant, and listed to UL 1741/IEEE 1547.



www.solren.com | inverters@solren.com | 978.683.9700



Danfoss Offers Utility-Scale Inverters

[Loves Park, IL] Danfoss has introduced a US-designed and -manufactured 1,000 Vdc utility-scale inverter line with power ratings of 1,000, 1,250 and 1,500 kW. Designed for medium-voltage applications, the units' 3-phase output voltages are 300, 350 and 400 Vac, respectively. The SLX Series inverters are housed in an outdoor-rated NEMA 4 enclosure and employ a liquid-cooled power train that provides full power output at temperatures up to 50°C. Danfoss offers external isolation transformers that are matched to the inverter operating parameters and utility requirements. The SLX Series inverters have a maximum efficiency of 98% and a CEC-weighted efficiency of 97.5%. All models include a built-in datalogger that allows irradiance, wind speed and temperature sensors to work in parallel with logged production and performance data measurements.

Danfoss / 855.335.2912 / danfoss.us/solar

Lochinvar Introduces New Solar Heating Tank Models

[Lebanon, TN] Lochinvar, a manufacturer of high-efficiency water heating products, has expanded its equipment line with the introduction of its Thermal-Stor storage tank, which is designed primarily for systems that incorporate hydronic space heating. Heat generated from solar collectors or ground-source heat pumps is transferred to the storage tank via a spherical heat exchanger affixed to the side of the tank. The product maximizes tank stratification and system efficiency by minimizing the mixing of hot and cold water. When coupled with a backup boiler, the unit acts as a hydraulic separator that decouples the system loads from the boiler output, eliminating boiler short cycling. Nine Thermal-Stor models are available, with capacities ranging from 125 to 900 gallons.



Lochinvar / 615.889.8900 / lochinvar.com

Tamura Releases DC-to-DC Converter for PV Applications



[Escondido, CA] Designed to replace low-voltage wiring to the PV array to power data acquisition system electronics, the TCDC-7001 Smarty DC-to-DC converter has a rated dc input of 200–600 volts and a 24 Vdc dual output with a rated load current of 1 amp. The DIN rail–mountable product is TUV certified to UL 1741 and UL 1012 standards. Electrical specifications include a typical operating efficiency of 80% and a standby power rating of 2 W at 600 Vdc. The TCDC-7001 is available direct to combiner and monitoring equipment OEMs. It is available to integrators through distributors such as CED Greentech, Digi-Key and Mouser Electronics.

Tamura Corporation of America / 800.472.6624 / tamuracorp.com

CAB, EX2060
Case No. IPR2024-00139
30 of 84



Rich represents a growing team of solar entrepreneurs who have discovered the AllSun Tracker complete system advantage for installations large and small. “We now spend less time on system design and more time on sales and installation, which has truly transformed the way we do business.”

We are now inviting selected partners to offer our dual-axis tracker systems to their residential and commercial customers. Contact us now to learn more about one-day lead time, one-pallet shipment, one-day installation, free ground shipping and free on-line monitoring. Track us down at allsuntrackers.com.

AllSun Tracker ENTIRE SYSTEM 10 YEAR WARRANTY







AllSun TRACKERS™

Made by AllEarth Renewables in the U.S.A.

For more info CALL 802-872-9600 or visit www.allsuntrackers.com

PV Array V Management

By Tommy Jacoby



Securing, Supporting and Protecting Conductors within the PV Array

CAB, EX2060
Case No. IPR2024-00139
32 of 84

Vire



Courtesy IRC Solar Roof Systems

PV systems are expected to have a 25-year lifespan, and array wire management solutions should match this expectancy. However, designers and installers face persistent challenges to managing free-air conductors within the PV array.

Implementing a safe, reliable and *Code*-compliant wire management system for exposed PV conductors is not an easy task. PV module leads can be too long or sometimes too short, requiring site-specific solutions for supporting and interconnecting the cables. Equipment grounding, PV source-circuit and inverter-output conductors from microinverters and ac modules must also be managed to ensure protection from potential damage. Within the PV array, these various conductors are often secured to module frames, support rails and other racking system components. While securing array wiring seems like it should be a straightforward exercise, the reality is that integrators continue to face numerous challenges.

UV-rated plastic wire ties provide a flexible, convenient and low-cost solution for bundling and fastening array conductors, but they are not a permanent answer and require regular inspection and replacement. Stainless steel cable clips work well for attaching conductors to the module frame, but this solution is often limited to supporting only one or two conductors at a time, and not all modules have frames. Structural channels or integrated cable management solutions within the module support rails assist with protecting and routing conductors, yet precautions must be taken where conductors enter and exit the channels to protect them from sharp edges that may compromise their insulation. In addition, module rails tend to run either east-west or north-south, so they may not provide support where conductors run perpendicular to the rail alignment.

Unfortunately, the PV industry lacks consistent, standardized wire management solutions for free-air conductors within the array. Coupled with the harsh environmental conditions that PV array conductors are exposed to—UV radiation, high winds and extreme ambient temperatures, and ice, snow and other debris—wire management continues to be the Achilles heel of the majority of PV installations. In this article, I check in with several PV industry experts—from *Code* gurus and inspectors to installers and O&M providers—to better understand the industry's current challenges, considerations, *Code* requirements and needs when it comes to managing and protecting exposed conductors within the PV array.

CAB, EX2060
Case No. IPR2024-00139
33 of 84

The Importance of Wire Management

The majority of PV systems have integrated leads, or wires, used for making electrical connections between modules. The module leads and the associated homerun conductors are often installed in free air within the PV array—meaning they are not in conduit. These exposed circuits contain potentially lethal voltages and currents that could electrocute someone, or cause a fire, in a faulted condition. As a result, we need wire management solutions that can endure the extreme environments in which PV arrays are installed while ensuring the systems are safe and reliable.

The harsh environment. John Wiles, senior research engineer at the Institute for Energy and the Environment (IEE) at New Mexico State University, provides an important background perspective on the fundamental challenges of PV array wire management in terms of the environmental conditions the materials are exposed to. He notes, "Before we even start with *NEC* requirements of array wire management, we must address the fact that the outdoor environment that exposed PV conductors must survive is one of the most difficult environments that any electrical system will face outside of utility transmission systems.

"The temperatures may range from -60°C (-76°F) to +90°C (+194°F). UV irradiance may exceed 2,000 hours per year. Winds and gusts of 90–130 mph are not uncommon. And then there is the physical abuse of wind-driven sleet, snow, rain, hail and sand. The environment also includes Mother Nature's living creatures, such as squirrels, rats, rabbits and birds, who all like the warm, secure areas behind PV modules and may even enjoy a meal of conductor insulation from time to time.

"PV modules will be producing dangerous levels of voltage and current—30 volts and greater is a shock hazard, and 30–50 milliamps can stop a heart—for at least 40–50 years, and probably longer. The exposed PV conductors, and even those in raceways, must survive the severe environment for that length of time without posing a safety risk, while retaining the initial levels of performance.

"I have witnessed USE-2 conductors that are still in good condition after 33 years in the sun, yet poorly secured loose USE-2 module interconnection cables rubbing against racks and abrading halfway through the insulation due to wind motion in only 3 months."

The risk of ground faults. Exposed conductors within the PV array are particularly vulnerable to coming in contact with module frames and support rails. Conductors should be installed and dressed so that they are protected from physical damage to avoid compromising the insulation, because damaged insulation can result in a ground fault. Ground faults may not be detected until too late, as we have recently learned from two widely publicized PV system fires CONTINUED ON PAGE 34

Unfortunately, the PV industry lacks consistent, standardized wire management solutions for free-air conductors within the array. Coupled with the harsh environmental conditions that PV array conductors are exposed to—UV radiation, high winds and extreme ambient temperatures, and ice, snow and other debris—wire management continues to be the Achilles heel of the majority of PV installations.

The Consequences of Poor Wire Management

I have done quite a few fire investigations. While the specifics of many of these investigations are confidential, there are several types of problems where poor wire management contributed to failures. All of the following practices have caused fires in the field:

- Putting USE-2 string conductors in contact with sharp edges, creating undetected ground faults that end up short-circuiting the array
- Not properly identifying conductors and incorrectly polarizing combiner boxes, creating array short circuits and combiner box fires
- Improperly installing thermal expansion fittings, especially in runs that require multiple fittings
- Not properly accounting for thermal expansion and conductor weight, causing damage at roof edge fittings and boxes
- Not properly addressing thermal expansion of conductors inside raceways, causing damage at box fittings
- Improperly using stainless steel wire ties, putting too much stress on conductor insulation
- Not fully seating plug connectors
- Putting stress on junction box and plug connectors, causing them to fail and separate (which can cause an arc if under load)
- Using improper torque procedures on combiner box terminals (It is common for combiner box terminals to loosen over time due to improper torquing or thermal cycling and vibration on rooftops.)

New mistakes are invented every day.

—Bill Brooks, president, Brooks Engineering

CAB, EX2060
Case No. IPR2024-00139
34 of 84

Stand apart from the crowd.

Earn NABCEP Accreditation for Your PV Installation Company



Accreditation sets your company apart. It sends a powerful message to customers that you care deeply about quality and accountability. It demonstrates a commitment to your employees that you are devoted to on-the-job safety. As an accredited company you'll gain a clear competitive advantage and be included in NABCEP's promotional efforts.

LEAD THE WAY

NABCEP's widespread respect carries through to our new PV Installation Company Accreditation program. Companies that choose to earn our accreditation are advancing the standards for performance in our entire industry and stand to become industry leaders themselves.

NABCEP ACCREDITED
PV Installation Company

GET ACCREDITED TODAY

Accreditation is within reach of any conscientious PV installation company. Inquire today how you can demonstrate your commitment to safety and customer satisfaction. Your investment will help advance the standard of excellence for the entire photovoltaic installation industry while earning you deeper trust in the marketplace.

www.nabcep.org/company-accreditation
(800) 654-0021

NABCEP Accreditation
The New Standard of Excellence

NABCEP™
Raising Standards. Promoting Confidence.

in Bakersfield, California, and Mount Holly, North Carolina. (See "The Bakersfield Fire," *SolarPro* magazine, February/March 2011, and *The Ground-Fault Protection Blind Spot: A Safety Concern for Larger Photovoltaic Systems in the United States,* Solar America Board for Codes and Standards, January 2012.)

Undetected ground faults due to blind spots in the ground-fault protection system can result in arcing and fires when a second ground fault occurs. Alternatively, when a ground fault is detected, Paul Mync and John Berdner point out: "A ground fault not only causes PV system shutdown and energy loss, but also presents a safety concern that all designers, electricians, installers and service technicians need to be aware of. ... Proper wire management is essential to avoiding ground faults, especially at the array where conductors are installed in free air and more easily damaged." (See "PV System Ground Faults," *SolarPro* magazine, August/September 2009.)

Industry Input and Best Practices

In an effort to communicate best practices in array wire management and related challenges that PV integrators may face, I asked several industry colleagues to share their experience and expertise in PV wire management.



C'mon, man! We all like to finish the job early, but laying source-circuit conductors on the roof is not a form of wire management—even if they are bundled together with wire ties. When laid directly on flat roofs, conductors are not protected and will likely be stepped on, tripped over and so on by maintenance personnel and other individuals who access the roof.

What are common wire management mistakes?

"The most common issue we see with wire management involves pinched wires leading to ground faults in the PV array. Often, when a

Snake Tray® Cable Management for Solar Installations

Revolutionary hand bendable cable pathway saves on time and installation costs!



- Hand bendable design snakes around any obstacle
- Trays connect together with a single connector bolt
- Built-in mounting rings
- "Lobster trap" design eliminates the need for wire ties
- Protects and secures cables from rain, snow and hurricane force winds



Snake Tray products are manufactured with 100% solar power!

Snake Tray® products are covered by one or more of the following patents: #6637704, #6637165, #6463704, #6460812, #6449912, #6361000, #6347493, #6019323, #6347493, #6460812, #5953870, #5839702, #6926236, #7168212, #7959019. Other Patents Pending.

800.308.6788 ♦ www.snaketray.com ♦ Made in the USA

CAB, EX2060
Case No. IPR2024-00139
36 of 84

PV module is mounted, the module output wire gets pinched between the module frame and the metal mounting system, giving the current an easy path to ground.

"Another issue we have seen involved the use of metal wire ties to bundle array conductors. The goal was to increase the life of the wire management system, assuming that UV-rated plastic wire ties would degrade over time and need to be replaced. However, the metal wire ties ended up cutting into the conductor insulation, causing multiple faults throughout the array. This problem was exacerbated when [the ties were] installed on a tracker, on which the conductors were moving throughout the day. In fact, the ground faults were intermittent and occurred only when the tracker was in certain positions, making them very difficult to locate and repair."

—Adam Burstein, president, Next Phase Solar

"Common mistakes with regard to wire management include installing conductors in contact with sharp edges, allowing conductors to touch abrasive roofing materials, laying homerun source-circuit conductors on membrane roofs, not observing the specified bending radius for conductors per *NEC* Article 338.24, insufficient support of conductors and stress on junction box and plug connections."

—Bill Brooks, president, Brooks Engineering

"As a third-party inspector, Cadmus typically sees more than 100 PV installations in the Northeast each year consisting of the good, the bad and the ugly. One of the most common issues we observe is the lack of protection and wire management beneath pitched-rooftop arrays. Although conductors may not necessarily be readily accessible or easy to see, they are still in danger of damage from ice, debris and animals."

—Matt Piantedosi, associate engineer and master electrician, The Cadmus Group

What wire management challenges has your company encountered?

"Besides squirrels, the biggest issue we face is a 'recreate the wheel' approach at every site as we strive to meet *NEC* requirements while installing systems that will last 25 years. With racking and modules evolving almost monthly, it is hard to stick to any one approach. Different techniques and materials are needed. Some good wire management materials, like stainless steel cable clips and coated steel cable ties, are readily available, though expensive. We need new approaches to this problem, and we need module manufacturers to work with racking manufacturers to come up with easy-to-implement solutions. I do not believe it should be up to installers to solve the problem.

"*NEC* Article 392.3(B)(1)(a) says single-conductor cable must be 1/0 or larger and marked for use in cable tray. Obviously source-circuit



CAB, EX2060
Case No. IPR2024-00139
37 of 84

conductors, whether PV Wire or USE-2, are much smaller than 1/0 and do not meet this requirement. So it is up to the AHJ whether it supports a cable tray wire management solution. This can lead to some uncertainty in design and possible inspection issues.

"Another issue is the length of module leads. Depending on the orientation of the module—two in portrait versus four in landscape being the most common options on large ground-mount systems—the module leads may or may not easily reach the cable tray, and cable clips or wire ties may be needed to secure these conductors to the module frame or support rails. Note that if the module leads can be secured in the cable tray, fill calculations must be done to figure out what width of cable tray is necessary."

—Rebekah Hren, director of implementation, O2 Energies

"The largest issue for us is interrow wiring on ballasted flat-roof systems. Most racking manufacturers do not provide an integrated solution, but a few are starting to come onboard. Installing rigid or intermediate metal conduit is time-consuming, and PVC does not age well in the rooftop environment. Strut is not UL listed for the application, and other industry raceways can be cost prohibitive or are not UL listed for the application.

"Another problem with using conduit for interrow wire management is roof clearance. Once properly installed and supported, the installed height of the raceway may be as high as 6 inches above the roof deck. At this height, there may not be adequate clearance to route the conduit underneath the southern edge of the module or racking system."

—Geoff Greenfield, president, Third Sun Solar



Interrow wire management challenges Very few manufacturers of flat-roof racking systems include a wire management solution for the gaps between rows. Installers are often left to develop their own solution—if any.

"Wire management can be one of the most labor-intensive tasks on an installation. It can also be tedious and CONTINUED ON PAGE 38

TEALSOLAR™ COMBINER BOX

TEAL
We Power Technology™



Featuring StraightShot™ for Large Conductors

Now Listed to 1000VDC UL-1741

RELIABLE & CONFIGURABLE

Configurable Options:
- 1000VDC or 600VDC
- # Input Strings
- Fuse Rating (or Isc)
- Enclosure Style
- Disconnect & TVSS
- PVobserver™ String Current Monitoring
- Condensation Vent
- StraightShot™ for Large Conductors

UL 1741 1000VDC listed configurable product family
Reliable combiner designs for your PV plant
Focused on commercial and utility scale PV BOS
Industry leading customer service, quality & flexibilty

CONTACT TEAL TODAY FOR YOUR BOS NEEDS !

TEAL Electronics - We Power Technology™

For more information, please contact us at 1-800.888.8325 - marketing@teal.com - www.tealsolar.com

Copyright 2011 TEAL Electronics Corporation. All rights reserved

CAB, EX2060
Case No. IPR2024-00139
38 of 84

Who is watching your bottom line?

We are!



STOP at
Booth 421
PV America
East

The logical choice.

The Solar Power Experts

energiebau

Value Added Reseller

Energiebau North America Inc. | 732.302.3015 | info@energiebau.com | www.energiebau.com

frustrating, especially if you do not have a clear, sensible wire management plan heading into the installation, and subsequently lack the appropriate materials or tools to securely and safely manage conductors within the array. In such cases, it can be tempting for installers to take shortcuts, especially with a flush-mount array on a 105˚F roof in June. It takes a vigilant and experienced lead installer to properly train new installers and ensure wire management details are not overlooked.

"Modules installed in the landscape orientation can present a beast of a wire management situation, especially if you intend to adhere to the securing and supporting requirements specified in *NEC* Article 334.30. In particular, I am referring to the requirement that conductors be secured within 12 inches of each box, cabinet, conduit body or other termination, which in this application is the module junction box. If modules within the same row are installed in the landscape orientation with the junction boxes facing the same direction, it is usually impossible to connect the module leads and adhere to this requirement without creating some sort of series jumper because the module leads are too short. This can add significant time and material costs to an installation."

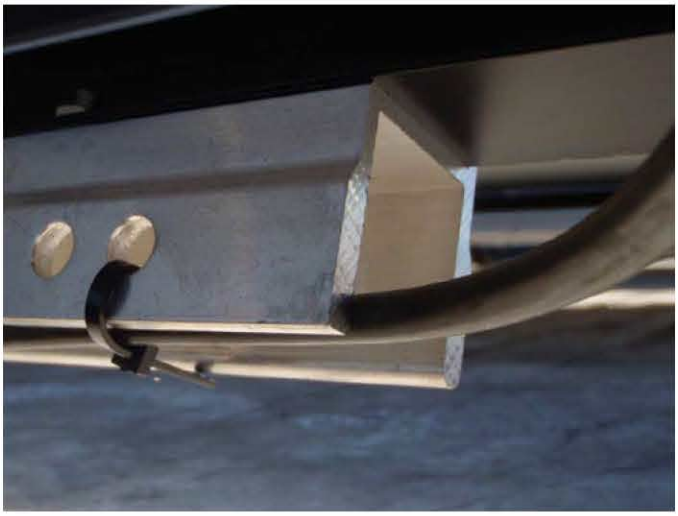
—Conor Black, field manager, Positive Energy, Las Cruces Branch

What factors do you consider when selecting a wire management solution?

"Key factors include code compliance, ease of installation and cost—both upfront and labor. For large ground-mount arrays, the selection gets folded into the racking system selection, and any additional costs for wire management solution add-ons are factored in accordingly."

—Rebekah Hren, O2 Energies

Sharp edges and objects When installing and dressing conductors within a PV array, extra care should be taken to protect conductor insulation from coming into contact with any sharp objects, such as cut ends of module support rails and metal straps. Keep in mind that the conductors and array components may move relative to one another in high-wind conditions and from thermal expansion.





Minimum bending radius *NEC* Article 338.24 specifies a minimum bending radius of five times the conductor diameter. The average 12 AWG PV Wire conductor has an outer diameter of 0.219 inches, which would require a bending radius of approximately 1 inch. When module leads are too short to make the necessary connections, conductors may be pulled too tight, violating the specified bending radius and applying unnecessary strain to the point of connection with the module.

"We consider the application, location, *NEC* requirements relative to the AHJ's interpretation and cost, labor usually more so than material."

—Geoff Greenfield, Third Sun Solar

"In no particular order, we consider the following factors: code compliance; acceptance by the specific AHJ; effectiveness of the method for actually protecting the wires, as determined by our engineers and experience; long-term durability; ease of installation; and cost."

—Blake Gleason, director of engineering, Sun Light & Power

"We consider the expected lifetime of the wire management products and whether they offer a 25-year solution. This includes their UV rating and if they might become brittle or breakable when exposed to sunlight or high ambient temperatures. We also assess if the solution will protect wires from sharp edges within the mounting structure and keep conductors off the roof surface. We want a solution that can be installed in a manner that does not create future problems, such as ground faults."

—Conor Black, Positive Energy

Do you consider wire management features when selecting racking systems and modules? If so, what factors do you consider?

"Yes, but I believe the industry currently has a problem with the serious disconnect between installation methods and module manufacturers. In general, module leads are too long for portrait installations

CAB, EX2060
Case No. IPR2024-00139
40 of 84

and too short for landscape installations. In portrait orientation, many inches of copper conductor are wasted for each module installed, creating a cost burden for the manufacturer and an installation headache for the installer who has to manage extra wire. In landscape orientation, very few modules have leads long enough to meet *NEC* requirements. Good wire management means that the bending radius requirements of at least five times the wire diameter are met; there is not a lot of stress or tension at the module junction box when the module leads are pulled to clipping points on the frame or racking system; and the securing requirements of within 12 inches of a box or enclosure are met. It can be physically impossible to meet these three requirements with module leads that are too short."

—Rebekah Hren, O2 Energies



Courtesy Positive Energy

Looking good With a plan, patience and proper materials, an installer can adequately protect conductors beneath flush-mount arrays.

"Absolutely. Many racking systems have evolved to be very fast to install, and many have addressed automatic module grounding, but very few have sufficiently addressed wire management. For now, when evaluating new racking systems, we usually have to imagine what kind of wire management solution we would use and determine the amount of cost and complexity it adds to the base racking cost. Module manufacturers are usually similar with respect to wire management, but occasionally leads are too short to adequately provide strain relief for module-to-module landscape connections without adding a jumper. Modules with built-in lead management, such as durable clips built into the frame, are fantastic."

—Blake Gleason, Sun Light & Power

What are some of the wire management solutions your company employs?

"I have worked only on ground-mounted arrays for the last 3 years. Currently, we employ several different techniques, depending on which manufacturer's racking product we use. For example, Schletter's racking system (schletter.us) has an integrated tray and thus does not require a cable tray system. Some racking systems do not have an integrated raceway, in which case we use a Legrand Cablofil cable tray (legrand.us) attached to the back of the racking system."

—Rebekah Hren, O2 Energies

"On pitched roofs, we use SnapNrack's Pitched Roof PV Mounting System (snapnrack.com) because we can place the array conductors inside the rail channels. For flat-roof applications, conduit is installed wherever possible, using conduit blocks to keep it elevated above the roof. This decreases the required ambient temperature adjustment per *NEC* Table 310.15(B)(2)(c) and provides adequate clearance for general roof maintenance.

"On pole- and ground-mount systems, we secure the conductors to the module frames with cable clips. Sometimes we wrap the exposed conductors in split, flexible corrugated-plastic conduit to provide additional protection."

—Ken Gardner, owner, Gardner Engineering

"For many years we used UV-rated wire ties to manage conductors on pitched-roof systems, but we have seen a lot of failures with this approach, even on those ties shaded from direct sunlight by the modules. Now we use stainless steel cable clips and Heyco's (heyco.com) SunBundler product to secure conductors within the PV array. We typically use this approach on pole- and ground-mount systems as well.

"On flat roofs, we like the PanelClaw (panelclaw.com) Grizzly Bear ballasted mounting solution because it has integrated conduit pipes cast into the ballast blocks that protect the conductors as they are routed between rows. For similar reasons, we also like Ecolibrium Solar's (ecolibriumsolar.com) Ecofoot2 product, which offers integrated wire management clips both within and between the rows."

—Geoff Greenfield, Third Sun Solar

"On pitched roofs, we use Wiley Electronics' (we-llc.com) Acme Cable Clip ACC—which is compatible with PV Wire and USE-2 wire types—to secure conductors to module frames. PV source-circuit conductors are routed in Professional Solar Products' (prosolar.com) module support rails within the array and in EMT between and beyond it. We utilize the same approach on flat roofs, but we switch to a cable tray system when managing a large number of conductors. We do not have a specific wire management solution for ground-mount applications—it really depends on the racking system being used."

—Blake Gleason, Sun Light & Power

CAB, EX2060
Case No. IPR2024-00139
41 of 84



Cable trays Before specifying and using cable trays to protect and manage conductors within the PV array, check with your local AHJ. Currently, the *NEC* does not allow cable trays in applications like the one shown above, even though the conductors are well secured, supported and protected.

"In general, we never use wire ties to secure PV array conductors—conductors are either fastened to modules using cable clips or run alongside the module support rails and secured at approximately 3-foot intervals with EPDM collar clamps. For a while, we allocated a couple of staff members to auditing old systems, and we found that some of the EPDM collar clamps were slowly deteriorating, but it always seemed to be the clamps that were overfilled."

—Conor Black, Positive Energy

Wire Management and the *NEC*

NEC Section 690.31(B) allows the use of single-conductor types USE-2 and PV Wire "in exposed outdoor locations in photovoltaic source circuits for photovoltaic module interconnections within the photovoltaic array." In addition, Section 690.31(D) permits the use of 16 AWG and 18 AWG conductors for module interconnections, although the majority of installations these days use a 10 AWG or 12 AWG conductor.

Since Article 690.31 does not address how to install and manage these exposed conductors, you must turn to Article 338, "Service-Entrance Cable: Types SE and USE," for installation requirements, such as supporting and securing. Article

eGauge
the smarter meter
Affordable, reliable and robust energy monitoring
Data logging
Built-in web server
12 Circuits
Second by second view
DC battery voltage
Alerts
No fees

eGauge Systems LLC
capture your footprint [tread lightly]
www.egauge.net (877) 342-8431

CAB, EX2060
Case No. IPR2024-00139
42 of 84

338.10(B)(4)(b) directs you to Article 334.30 for securing and supporting requirements in outdoor environments, and Article 338.24 specifies the allowable bending radius for type USE conductors.

Per *NEC* 334.30, type USE conductors "shall be supported and secured by staples, cable ties, straps, hangers, or similar fittings designed and installed so as not to damage the cable, at intervals not exceeding 1.4 m (4.6 feet) and within 300 mm (12 inches) of every outlet box, junction box, cabinet, or fitting." The IEE's Wiles points out that "in windy areas, supports this far apart for exposed USE-2 or PV Wire would be inadequate to prevent conductor motions that would abrade the insulations over time." In addition, conductors may need to be secured more frequently than the minimum requirement to comply with Article 300.4, which requires that conductors be protected against physical damage, and Article 110.12, which requires that they be installed in a neat and workmanlike manner.

Unfortunately, Table 392.3(A) does not include single-conductor cable type USE-2 or listed and labeled PV Wire in the list of wiring types permitted to be installed in cable tray.

> "PV modules will be producing dangerous levels of voltage and current—30 volts and greater is a shock hazard, and 30–50 milliamps can stop a heart—for at least 40–50 years, and probably longer. The exposed PV conductors, and even those in raceways, must survive the severe environment for that length of time without posing a safety risk, while retaining the initial levels of performance."
> —John Wiles, senior research engineer, IEE

In addition, in industrial establishments "where conditions of maintenance and supervision ensure that only qualified persons service the installed cable tray system," Section 392.3(B)(1)(a) does not allow single-conductor cables smaller than 1/0 AWG in cable trays. In other words, per the *NEC*, cable tray can be used as a wire management solution in very few PV applications. According to Wiles, "nothing is certain at this time, but there is a proposal to the 2014 *NEC* to allow the use of small conductor cables in cable trays on the roof."

Table 1: *NEC* Requirements for Wire Management—2008 versus 2011

2008 *NEC*	2011 *NEC*
Article 110 Requirements for Electrical Installations	
110.12 Mechanical Execution of Work	110.12 Mechanical Execution of Work
Article 300 Wiring Methods and Materials	
300.4 Protection against Physical Damage	300.4 Protection against Physical Damage
Article 334 Nonmetallic-Sheathed Cable: Types NM, NMC and NMS	
334.30 Securing and Supporting	334.30 Securing and Supporting
Article 338 Service-Entrance Cable: Types SE and USE	
338.10(B)(4)(b) Installation Methods for Branch Circuits and Feeders	338.10(B)(4)(b) Installation Methods for Branch Circuits and Feeders
338.24 Bending Radius	338.24 Bending Radius
Article 392 Cable Trays	
392.3(B)(1)(a) Single Conductors	392.10(B)(1)(a) Single-Conductor Cables
Article 690 Solar Photovoltaic Systems	
690.4(B) Conductors of Different Systems	690.4(B) Identification and Grouping
690.31(A)–(E) Methods Permitted	690.4(B)(1) Photovoltaic Source Circuits
	690.4(B)(2) Photovoltaic Output and Inverter Circuits
	690.4(B)(3) Conductors of Multiple Systems
	690.4(B)(4) Grouping
	690.4(E) Wiring and Connections
	690.4(F) Circuit Routing
	690.4(G) Bipolar Photovoltaic Systems
	690.31(A)–(E) Methods Permitted

The 2011 version of the *NEC* added wire management requirements in Articles 690.4 and 690.31. Brooks of Brooks Engineering points out, "There are several specific changes related to identification of conductors and raceways and routing of circuit conductors to reduce the likelihood of firefighters coming in contact with energized PV circuits while fighting fires." Some of the changes in Article 690.4 include circuit identification and grouping; requiring qualified persons to install PV system equipment and conductors; routing circuits, both in and out of conduit, when inside a building or structure; and isolating electrical circuits from each monopole of a bipolar PV array. Article 690.31 expanded upon Part (E), elaborating on the requirements and guidelines for installing PV source circuits indoors.

Going beyond the *NEC*

Complying with the *NEC* provides a good baseline for wire management, but you must consider additional steps CONTINUED ON PAGE 43

CAB, EX2060
Case No. IPR2024-00139
43 of 84

Protecting PV Array Conductors from Pests

At SPI 2012 in Orlando, O&M emerged as one of the more-discussed topics. Though much of the focus is on medium- to large-scale PV system O&M, we must keep an eye on the multitude of smaller residential systems. The majority of these systems are installed on shingle or tile pitched roofs and utilize a mounting system that follows the roofline, providing a few inches of clearance between the roof and PV modules. The word on the roof is that squirrels and other small animals like to nest beneath the modules, perhaps for warmth or protection from larger predators. Regardless, *squirrel damage* is becoming an all-too-common term in our industry, as the animals continue to wreak havoc on the insulation of array conductors, and correspondingly on our PV systems. Animal mitigation is paramount for long-term system performance, return on investment and safety, especially since pitched-roof residential installations, where this damage seems to be most prevalent, are probably the least monitored systems once installed and commissioned.



Topher Donahue

Squirrels, birds, mice, raccoons—you name it, we have seen them trying to nest under rooftop arrays. The latticework of rails and modules makes a very attractive habitat for wildlife, especially in the spring. Few critters do as much damage as squirrels. They love to chew free-air wires, USE-2 and PV Wire alike. The result of this damage can be extensive. Failing to prevent animal access during the original installation can lead to thousands of dollars in repair costs only a few months or years later. It can mean a complete deinstallation and reinstallation of an array in addition to module lead wire repairs. This can quickly wipe out any financial payback for a customer. We have seen cases where every module in a residential system has had module lead wires completely chewed to the junction box. Losing production due to a chewed wire is one thing, but the biggest risk is to structure and life. A fault within the array can lead to arcing. If there is indeed a nest near the arc, the debris from the nest adds to the list of materials that could easily catch on fire.



Courtesy Heyco

Heyco SunScreener Heyco's SunScreener mounts a screen (not included) or other protective guard to the frame of most PV modules, forming a barrier of protection against rodents and birds around the array.

There are a lot of challenges to installing animal guards. Many EPC contractors deploy different materials and methods. Some best practices to consider while addressing this issue are:

- Use materials properly rated for the installation environment.
- Attach screening barriers to rails and structural members—drilling a module frame may void the manufacturer's warranty.
- Do not block airflow beneath the array.
- Keep in mind that the UL equipment listing and manufacturer warranty may be jeopardized if the module leads are repaired or modified in the field.
- Where metal screening products are used and may become energized, make sure they are properly grounded.
- Anticipate leaf and other material debris buildup to occur over time. Install screens and guards so they can be removed easily for repairs and general maintenance.

I am encouraged to see two recently introduced animal guard products. Heyco's (heyco.com) SunScreener hook helps facilitate attaching screen mesh to framed modules, creating a guard or skirt around the array. Additionally, Spiffy Solar (spiffysolar.com) recently launched its Spiffy Clip squirrel- and bird-guard system, which includes both clips and black screening at a cost of $1.65 per linear foot. I encourage more manufacturers to develop similar solutions. Until then, it is our duty as PV system designers and installers to provide protection against squirrels and other small critters that may frequent our arrays.

—Stephen Kane, president, Kane Solar

CAB, EX2060
Case No. IPR2024-00139
44 of 84

to provide a safe and reliable installation. Some best practices that may not be directly specified by *Code* include: using drip loops where conductors enter enclosures from free air, protecting and shading conductors from direct sunlight whenever possible, securing exposed conductors more frequently than every 4.5 feet and conducting ongoing inspection and maintenance of the PV array conductors.

Wire management system maintenance should include inspecting and replacing conductor labeling when needed, and verifying the condition and effectiveness of the conductor support and protection systems. Where conductors may be subject to physical damage, conductors should be checked for damaged or discolored insulation. Regular inspections also provide an opportunity to look for signs of pests that may be living within or frequenting the array. Evidence of nests, fur and droppings are telltale signs of unwanted guests.

Since *best practices* with regard to wire management are constantly evolving, I asked Brooks and Wiles what they suggest. Although their opinions on the use of plastic wire ties differ, they each point out the importance of material selection and addressing the high levels of sunlight and thus damaging UV radiation that can occur in and around the PV array.

What are important considerations and best practices beyond minimum *Code* requirements?

"Best practices are to keep sunlight-resistant materials out of direct sunlight as much as possible. Most of the materials used in PV systems that are exposed to sunlight experience some degradation over time. Using the available shade of modules and other obstructions simply makes things last longer. Good-quality UV-rated plastic wire ties and stainless steel cable clips are probably best around modules. Plastic wire ties do deteriorate over time, but ongoing operation and maintenance is necessary in all exterior wiring systems—regardless of materials used."

—Bill Brooks, Brooks Engineering

"Both USE-2 and PV Wire are available with colored insulations such as white, red and green, but care should be exercised when considering them. While these colored cables are marked 'Sunlight Resistant' and have passed the 720-hour accelerated UV test, they do not have as much carbon black in them as the black insulated cables. Carbon black is one of the main insulation components that provides a conductor with UV-radiation resistance. Cables with less carbon black may not fare as well over 40–50 years in the extreme PV environment as cables with high levels of carbon black.



CAB, EX2060
Case No. IPR2024-00139
45 of 84

"Similarly, PVC- or thermoplastic-insulated cables have passed the 720-hour accelerated UV tests, but PVC-insulated electrical components like jacketed UF cables and liquid-tight nonmetallic conduit (LFNC) have not survived well in the hot, sunny Southwest outdoor environment. As a result, exposed conductors in PV systems should have black thermoset insulations that contain cross-linked polyethylene. These insulations are sometimes marked XLPE or XLP. Remember, PV systems can receive more than 2,000 hours of UV exposure each year for 40–50 years, and the accelerated 720-hour UV tests are equivalent to approximately 1,500–2,000 hours—once.

"Plastic wire ties, even the best ones, should be avoided. The conductors should be secured to module frames and racks with metal cable clips with no sharp edges or pipe clamps with EPDM rubber inserts. The conductors should be fastened at a minimum of every 12 inches to prevent any movement. Lastly, some protection from birds, rodents and other small animals should be considered where these animals are prevalent, but the protection scheme should not inhibit the cooling of the array. A galvanized wire mesh hardware cloth with ½-inch holes has been used successfully in areas where animals present a problem."

—John Wiles, IEE

Final Thoughts

While the challenges related to *Code*-compliant wire management methods, materials and products are numerous, equipment manufacturers have slowly been developing solutions for these issues. Listening to feedback from the field allows some manufacturers to differentiate their products, capture market share and provide the industry with products that will drive down installation costs and increase the safety of PV systems over their 25-year–plus operational lifespans.

When asked about how they would like to see wire management solutions improve, experienced designers and installers from across the country are looking to module, racking and wire management product manufacturers for help. With continued communication and coordination between the various entities involved, we can certainly develop wire management solutions that ensure safe and reliable PV systems.

How would you like to see wire management solutions improve?

"One possible solution to the problems associated with the module leads being too short or too long is junction boxes that come with connectors but no leads, or just one lead and one connector. Another possible solution is modules that can be ordered specifically for portrait or landscape installation, with leads of according lengths.

"I believe that module manufacturers need to get out in the field to see the problems that occur on-site. For the most part, installations are similar enough that these should be easy problems to solve if we can get the module manufacturers working in harmony with the racking manufacturers."

—Rebekah Hren, O2 Energies

"It would be great to have a flat-roof, open-top tray system that is UL listed for the application, is easy to install, is inexpensive and complies with *NEC*."

—Geoff Greenfield, Third Sun Solar

"We need a more cost-effective solution for properly managing conductors when modules are configured in landscape orientation. There are several situations in which the design or racking system may call for installing modules in this orientation, but doing so creates a wire management headache."

—Conor Black, Positive Energy

"First of all, we should clear up confusion in the Code regarding wire trays versus cable trays versus auxiliary gutters. We need a long-lasting, practical lay-in wire management solution for handling a lot of small conductors in a rooftop environment.

"Also, I have recently seen way too many commercial rooftop systems with PV source-circuit wiring 'installed' by pulling out a couple hundred feet of it and laying it on the roof—no strain relief, no mechanical protection and no attempt to get it away from the hot roof. Presumably, if we had readily available practical wire management solutions, we would see fewer installations with bad practices and resulting fires."

—Blake Gleason, Sun Light & Power

CONTACT

Tommy Jacoby / Jacoby Solar Consulting / Austin, TX / tommy@jacobysolar.com

Contributors

Conor Black / Positive Energy / Santa Fe, NM / positiveenergysolar.com

Bill Brooks / Brooks Engineering / Vacaville, CA / brooksolar.com

Adam Burstein / Next Phase Solar / Berkeley, CA / nextphasesolar.com

Ken Gardner / Gardner Engineering / Ogden, UT / gardnerengineering.net

Blake Gleason / Sun Light & Power / Berkeley, CA / sunlightandpower.com

Geoff Greenfield / Third Sun Solar / Athens, OH / thirdsunsolar.com

Rebekah Hren / O2 Energies / Cornelius, NC / o2energies.com

Stephen Kane / Kane Solar / Lyons, CO / kanesolar.com

Matt Piantedosi / The Cadmus Group / Waltham, MA / cadmusgroup.com

John Wiles / Institute for Energy and the Environment, New Mexico State University / Las Cruces, NM / ieenmsu.edu

Resources

The Ground-Fault Protection Blind Spot: A Safety Concern for Larger Photovoltaic Systems in the United States, Solar America Board for Codes and Standards, January 2012, solarabcs.org/about/publications/reports/blindspot/pdfs/BlindSpot.pdf

CAB, EX2060
Case No. IPR2024-00139
46 of 84

BECOME ANOTHER SUCCESS STORY TODAY



Snow Dragon Renewable Energy is making it do-able, are you?

Installer Al Ducharme (left) and Ed Person (right), owner of Ledgewood Farm in NH, stand with a new array made up of 96 Kyocera 245W modules used in a 23.5Kw PV system which will cover 100% of the farm's electricity needs. This is one of many systems that altE Direct customer Snow Dragon Renewable Energy has installed. Al Ducharme and his wife Donna of Snow Dragon in New Hampshire have been happily working with altE since 2007.

Call us today at **888.218.1023** or visit us online at **www.altEdirect.com**

altE direct

making renewable do-able™ for over 14 years!

altE DIRECT IS THE PERFECT PARTNER FOR YOUR SUCCESSFUL SOLAR BUSINESS:

- Get the top name brands at the most competitive prices
- Receive friendly service and support from the best trained, passionate wholesale representatives in the industry
- Get residential install leads

Friendly, Technically Savvy Staff & Competitive Prices

Some of the quality brands we proudly represent:

KYOCERA · Schneider Electric · SolarWorld · IronRidge · Fronius · Solectria Renewables · SolaDeck PV Roof Mount Enclosure · SMA · Suntech · MidNite Solar, Inc · enphase Energy · Quick Mount PV



Power-Condition
for Residential Battery

Storms, wildfires, and overloaded or faulty electrical grid transmission and distribution networks result in power outages that impact tens of millions of US residences each year.

Hurricane Sandy, the nation's most recent large-scale storm, resulted in utility outages that affected 8.5 million customers across 21 states at its peak, according to the US Department of Energy.

Large-scale grid failures inevitably lead to surges in demand for PV systems with battery-backup capabilities. However, many solar design and installation firms have determined that battery-based systems are too expensive to sell effectively or too complex to design, install and service. As a result, many firms have little, if any, experience with these systems. Offering battery-backup options to residential customers is profitable for integrators who invest the time, resources and training to come up to speed with, and stay current on, battery-based system equipment selection, design and installation. The falling costs of PV modules, and ongoing advancements in battery-based inverter and BOS technologies, can make PV with battery backup an attractive offering for integrators who serve the residential market.

The owner of a grid-tied PV system with battery backup gets the best of both worlds: a reduced electric bill and the ability to live comfortably and safely without the grid when necessary. Installers of backup systems can access a market with fewer competitors, better margins and higher equipment and

By Paul Dailey and Joe Schwartz

CAB, EX2060
Case No. IPR2024-00139
48 of 84



Courtesy Skywire Electrical Systems

installation values than installers who offer grid-direct systems only. In this article, we introduce electricians and integrators who are new to battery-based grid-tied PV installations to basic system topologies and the power-conditioning equipment used to build these systems. While the learning curve may seem steep, experienced installers will need very few additional skills or tools to design and install battery-backup PV systems, particularly if they employ a preconfigured and prewired power-conditioning system.

Primary System Configurations

Integrators can configure a battery-backup PV system as either dc coupled or ac coupled. Each of these primary system configurations has benefits and drawbacks to consider, and each influences equipment selection as well.

DC coupling. Traditionally, the majority of battery-backup PV systems have been dc coupled. In dc-coupled systems, PV array source circuits are typically configured at relatively low dc voltages of less than 150 Vdc maximum. Individual source circuits are routed to a combiner box that provides overcurrent protection for each string and combines the individual dc inputs, allowing a single pair of larger transmission conductors to be run from the combiner box to the system's dc charge controller. Because the charge controller is usually installed in close proximity to the system's inverter/charger and battery bank, the wire run distance between the array combiner and the system's charge controller can be significant, especially if the array is ground mounted rather than on the roof. With a ground-mount system, the conductor cost may be significant due to the transmission distance and the dc-coupled array's relatively low-voltage and high-current characteristics.

In dc-coupled systems, the output of the charge controller is connected to the system's main low-voltage (typically 48 Vdc nominal) dc bus via overcurrent protection and disconnect equipment. When the utility grid is functional, the system's utility-interactive battery-based inverter converts the dc energy generated by the PV array to alternating current, synchronizes the ac waveform with the utility grid and exports

ning Equipment
y-Backup PV Systems

CAB, EX2060
Case No. IPR2024-00139
49 of 84



Courtesy Fire Mountain Solar

Typical residential backup This project, installed by Fire Mountain Solar, represents a standard residential battery-backup system. An 8 kW utility-interactive Radian GS8048 inverter and a load center, manufactured by OutBack Power Technologies, are integrated with OutBack's new EnergyCell AGM batteries and Integrated Battery Rack. The battery rack includes overcurrent protection and a disconnecting means for each 48 Vdc string of batteries.

any surplus energy to the utility. During power outages, the battery-based inverter disconnects from the utility grid and energizes select household electrical circuits using energy stored in the batteries or provided by the PV array. To prevent battery overcharging, the charge controller regulates the dc current that the PV array generates during daylight hours.

AC coupling. In ac-coupled systems, a grid-direct string inverter effectively replaces the PV charge controller that is used in dc-coupled systems, and typically the source-circuit combiner box as well. In these systems, the PV array is configured at relatively high voltages of up to 600 Vdc, and the string inverter converts the array output to 240 Vac. In ac-coupled systems, the string inverter's ac output is connected to the battery-based system's ac bus. When the utility grid is functional, ac electricity provided by the string inverter supplies energy to household loads, and excess energy is exported to the utility grid. In the event of a grid failure, the battery-based inverter disconnects from the utility grid and energizes select household electrical circuits using energy stored in the batteries or provided by the PV array via the string inverter.

Because ac-coupled systems do not use charge controllers to regulate battery charging during a utility outage, alternate means of array charge control are required. In ac-coupled systems that utilize battery-based inverters and string inverters from the same manufacturer, battery charge regulation can be seamless. When components from multiple manufacturers are used, battery charge regulation can become considerably more complicated in these systems. (See "AC Coupling in Utility-Interactive and Stand-Alone Applications," *SolarPro* magazine, August/September 2012.) In addition, while most battery-based inverters are capable of ac coupling, some string inverter manufacturers do not permit, support or offer a warranty on the use of their string inverters in ac-coupled systems.

Compared to dc-coupled systems, ac-coupled platforms have the advantages of higher array voltages, streamlined array wiring and lower transmission conductor size and cost. While the string inverter used in ac-coupled systems is more expensive than the charge controller it replaces, the elimination of the source-circuit combiner box and lower array wiring labor and equipment costs can make the overall installed outlay for these systems roughly equivalent. In retrofit installations that are adding battery backup to an existing grid-direct system, ac coupling is often the preferred approach because the array wiring does not need reworking to operate at the lower voltages that most dc charge controllers require.

Power-Conditioning Equipment

Four companies manufacture the majority of the power-conditioning and system-integration equipment employed in battery-backup PV systems in North America. Magnum Energy and OutBack Power Technologies offer power electronics and integration equipment that is primarily intended for use in dc-coupled systems but that can be utilized in ac-coupled systems as well. Schneider Electric manufactures utility-interactive battery-based inverters and string inverters, dc charge controllers and system integration hardware for both ac- and dc-coupled systems. SMA America offers utility-interactive battery-based inverters, string inverters and additional components that can be used to develop highly integrated ac-coupled systems. A fifth company, MidNite Solar, offers charge controllers, system integration hardware and battery enclosures that can be utilized in battery-backup systems.

OUTBACK POWER TECHNOLOGIES

OutBack Power released its current generation of utility-interactive battery-based inverter/chargers in 2012 with the goal of simplifying the design and installation of battery-backup systems. The Radian Series GS8048 has a rated ac power output of 8,000 W at 25°C, a nominal input voltage of 48 Vdc and an ac output voltage of 120/240 Vac. The product has a dual power module design that provides a degree of redundancy and improves overall conversion efficiency during both low-power and high-power operation. Up to 10 Radian GS8048 inverter/chargers can be configured in parallel for a 120/240 Vac system with a rated power output of 80 kW. A second Radian model, the GS7048E, is offered for international and developing world markets. This product has a 7,000 W rated output at 230 Vac/50 Hz and a nominal input voltage of 48 Vdc. CONTINUED ON PAGE 50

CAB, EX2060
Case No. IPR2024-00139
50 of 84

IT'S TIME FOR THE 500kW INVERTER THAT FINALLY HAS IT ALL

Here you go. All you expect from PV Powered now comes from Advanced Energy.

Introducing the AE 500TX, the latest innovation from Advanced Energy. This 500 kW inverter gives you industry-leading reliability, performance, and technology – combined into one fully-integrated system that delivers financial gains at every turn.



We're not just another solar energy company.
We're empowering the industry.

advanced-energy.com/AE500

AE ADVANCED ENERGY®

CAB, EX2060
Case No. IPR2024-00139
51 of 84



Courtesy Skywire Electrical Systems

DC coupled This large residential battery-backup system, installed by Skywire Electrical Systems, utilizes three utility-interactive OutBack Radian GS8048 inverters to provide a total power output of 24 kW at 120/240 Vac. Six FLEXmax controllers regulate battery charging from a 24 kW PV array during grid outages. A 2,700 Ah, 48 Vdc nominal bank of NorthStar AGM batteries provides energy storage.

OutBack's Radian GS8048 inverter can be factory integrated with one of the manufacturer's five GS Load Center models to reduce installation time in the field. For example, the GSLC175-PV-120/240-GS Load Center can be factory prepared with dual 175 Adc inverter/battery circuit breakers, dual ac inputs to integrate grid and generator charging, a 120/240 Vac maintenance bypass assembly, a PV ground-fault–detector interrupter (GFDI), two PV array inputs, OutBack's FLEXnet dc battery monitor and three shunts for system charge and discharge monitoring. This particular assembly is intended for systems using a single Radian inverter and two OutBack FLEXmax dc charge controllers.

OutBack Power is continuing to manufacture its previous generation of utility-interactive inverter models. Two environmentally sealed units are available: the GTFX2524 and GTFX3048, with output ratings at 25°C of 2,500 W and 3,000 W and input voltages of 24 Vdc and 48 Vdc nominal, respectively. Two vented models are also available. The GVFX3524 has a rated output of 3,500 W at 25°C and an input voltage of 24 Vdc nominal, and the GVFX3648 has a rated output of 3,600 W at 25°C and an input voltage of 48 Vdc nominal. OutBack Power also manufactures an international series of six GTFX and GVFX inverters with 230 Vac/50 Hz output. The company offers a wide range of integration enclosures and hardware for its GTFX and GVFX inverter products, including complete preassembled power-conditioning systems.

OutBack Power currently manufactures two PV charge controllers that can be fully networked with either the Radian or the GTFX and GVFX inverter/charger systems. The FLEXmax series includes the FM80-150VDC, which has a maximum output current rating of 80 A at 40°C and an absolute maximum PV open-circuit voltage of 150 Vdc. The FM60-150VDC has a maximum output-current rating of 60 A at 40°C and an absolute maximum PV open-circuit voltage of 150 Vdc. The controllers are designed with the functionality to step down a higher array voltage to a lower nominal battery-charging voltage. For example, a 72 Vdc nominal array voltage can be stepped down to charge a 48 Vdc nominal battery. While 48 Vdc nominal battery banks are recommended for most battery-backup systems, the FM80 and FM60 controllers are field programmable for integration with 12, 24, 36, 48 or 60 Vdc nominal battery banks. An environmentally sealed version of the FM-80 controller—the FLEXmax Extreme—is scheduled for release in Q1 2013.

OutBack Power released two additional product lines for battery-backup applications in 2012. The company is currently offering two valve-regulated lead-acid (VRLA) absorbed glass mat (AGM) battery models, as well as an integrated battery rack. The EnergyCell batteries are 12 Vdc nominal and available with capacity ratings of 153.8 Ah or 178 Ah at the 20-hour discharge rate. OutBack's Integrated Battery Rack (model IBR-3-48-175) is designed to house three 48 V strings of batteries for up to 28.8 kWh of total energy storage in a single enclosure. The product also includes integrated high-current dc breakers that provide battery string overcurrent protection and disconnecting means for system maintenance.

SCHNEIDER ELECTRIC

Schneider Electric manufactures power-conditioning equipment for both dc- and ac-coupled battery-backup systems. The company is the only North American manufacturer that offers utility-interactive battery-based inverters, string inverters and high-voltage dc-array charge controllers. Schneider's Conext XW utility-interactive battery-based inverter line includes three models, each with 120/240 Vac output. The inverter with the highest power rating is the XW6048-120/240-60. This inverter has a 6,000 W continuous power rating at 120 Vac output, a 5,752 W continuous power rating at 240 Vac output and a nominal dc input voltage of 48 Vdc. Schneider offers a second 48 Vdc nominal battery-based inverter, the XW4548-120/240-60, with a continuous output power rating of 4,500 Vac at both 120 and 240 Vac. The third model in the Conext XW inverter line is the XW4024-120/240-60, with a 4,000 W continuous output rating at 120 and 240 Vac, and a nominal dc input voltage of 24 V.

Up to four XW inverters can be configured in parallel for a total system power capacity of 24 kW at 120/240 Vac. In addition, up to six XW inverters can be used in a 3-phase configuration for a 36 kW system with an output voltage of 120/208 Vac. Three XW models are available with CONTINUED ON PAGE 52

CAB, EX2060
Case No. IPR2024-00139
52 of 84



Bank on it. SunSeeker® Tracker.

The All Weather SunSeeker tracker from SPG Solar is now available for your next solar project. Requiring 30% fewer posts. Producing up to 25% more power. Saving tens of thousands of dollars for each megawatt installed, the SunSeeker is the most proven and profitable single-axis tracker on the market. It's so good we couldn't keep it to ourselves anymore.

Call SPG Solar at (800) 815-5562 or visit spgsolar.com for savings — and solutions — you can take to the bank.

SPGSOLAR®

230 Vac/50 Hz outputs for international and developing world projects. Dual ac inputs allow for backup generator input and grid interaction. An optional automatic generator-start unit is also available. The Conext XW Power Distribution Panel includes a conduit box and all ac and dc disconnects and integration wiring to support a single inverter.

For ac-coupled systems, Schneider Electric offers four Conext TX string inverter models with field-selectable output voltage options of 240 and 208 Vac. The Conext TX 2800, TX 3300, TX 3800 and TX 5000 are rated for 2,800, 3,300, 3,800 and 5,000 W, respectively, when configured for 240 Vac output. When TX string inverters are deployed in ac-coupled systems in conjunction with the Conext XW battery-based inverter, battery charging is regulated during utility grid failures by frequency phase–shift functionality that is integrated into the battery-based inverter. This degree of product integration provides installers with a fail-safe string/battery-based inverter configuration for ac-coupled systems.

Schneider Electric also offers two dc array charge-controller models that can be used to build fully networked dc-coupled systems. The XW-MPPT60-150 has a power rating of 60 A with a PV array maximum open-circuit voltage rating of 150 Vdc. The unit has voltage step-down functionality and can be configured to charge 12, 24, 36, 48 and 60 Vdc nominal battery banks from a higher-voltage PV array. Schneider has also released the only 600 V charge controller currently available in the North American market. The XW-MPPT80-600 allows integrators to configure arrays at open-circuit voltages that are similar to those utilized by string inverters to drive down costs of array wiring and BOS equipment requirements.



Courtesy Schneider Electric

AC or dc coupled Schneider Electric manufactures utility-interactive battery-based inverters, string inverters and dc charge controllers. The battery-based Conext XW series inverter, shown here with optional ac and dc distribution panels, can be ac coupled with Schneider's TX series string inverters or dc coupled with the company's XW-MPPT 150 or 600 Vdc charge controllers.

Training Opportunities

Advancements in inverter and integration hardware for battery-based systems are making them more straightforward to design and install, but they are still relatively complex compared to residential grid-direct systems. Working with batteries presents additional design, installation, *Code* and safety requirements. Programming battery-based inverters correctly can present a relatively difficult learning curve. Several training resources are available to integrators.

Product-specific training. Battery-backup equipment configuration, installation and programming vary greatly from manufacturer to manufacturer. If battery-backup PV systems represent a new application for your business, we recommend participating in product-specific training from the manufacturer of the equipment you are considering. Battery-based inverter and charge controller manufacturers frequently offer classroom training in conjunction with industry conferences or training events hosted by equipment distributors such as AEE Solar, as well as online via live or archived webinars. Additionally, all of the manufacturers discussed in this article have extensive product installation manuals available online.

Third-party training. Training in battery-backup PV systems is also available from several third-party training providers. Notably, Solar Energy International (solarenergy.org) offers extensive training in ac- and dc-coupled battery-based systems via online courses, as well as a 5-day hands-on workshop at the company's PV Lab training facility in Paonia, Colorado. ●

SMA AMERICA

SMA pioneered the development of ac-coupled system platforms in the 1990s, using its battery-based and string inverters. Today, the company offers a range of products for utility-interactive battery-backup systems. While SMA's battery-based Sunny Island inverter models can be deployed in dc-coupled systems that incorporate PV charge controllers from other manufacturers, this approach limits the overall level of component networking integration that can be achieved.

SMA has developed an extremely high level of integration between its Sunny Island inverters and Sunny Boy string inverters in ac-coupled systems. This functionality includes frequency-shift battery charge regulation that is sophisticated enough to ramp up and down PV array charge current produced by the system's string inverter

CAB, EX2060
Case No. IPR2024-00139
54 of 84

based on battery state of charge, a feature that is not available in ac-coupled systems using components from other manufacturers.

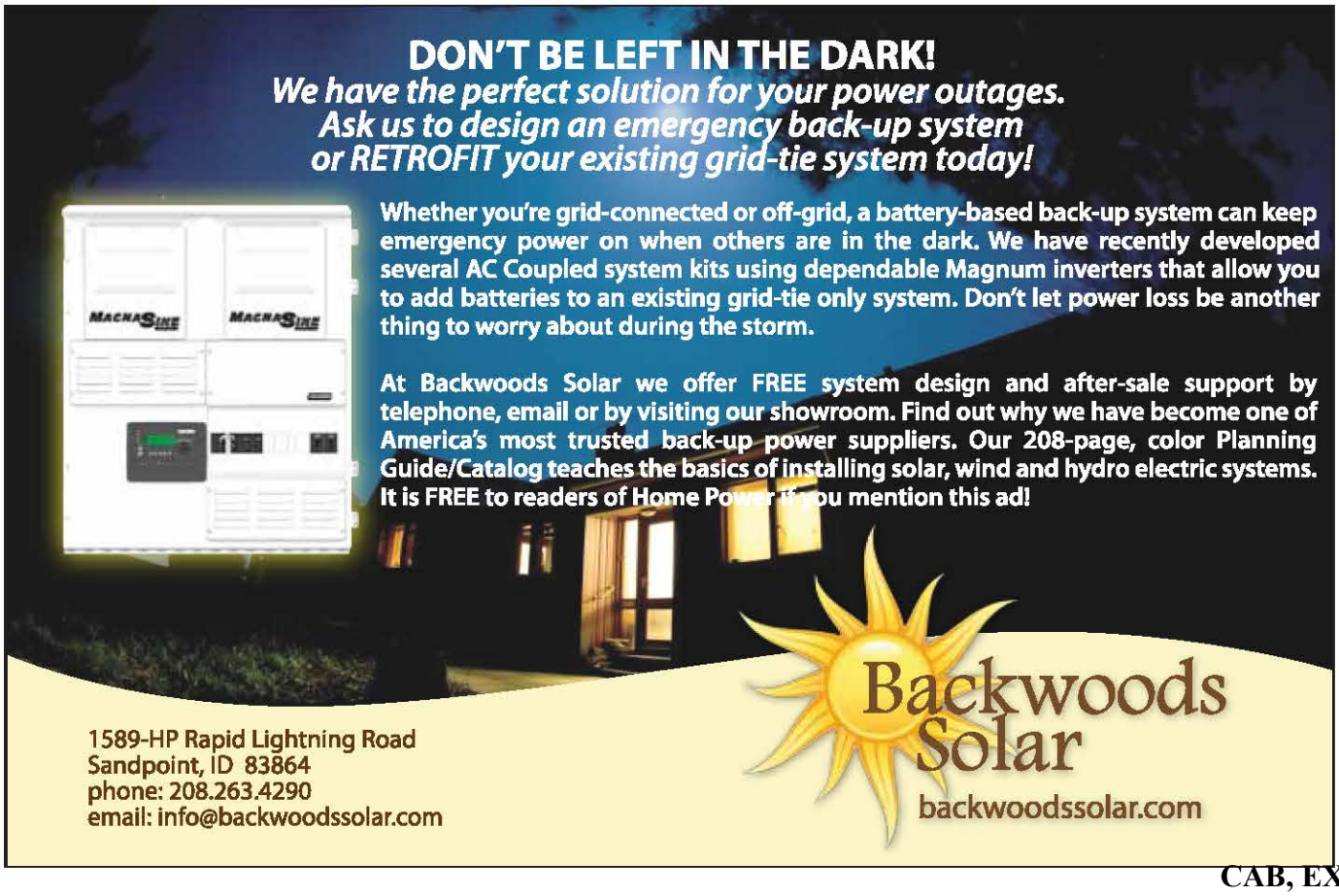
SMA manufactures a wide range of string inverters that can be used in ac-coupled applications. With rated power outputs of 700 W to 10 kW, these inverters can be fully integrated with and controlled by SMA Sunny Island inverters. The company revised its battery-based Sunny Island product line in 2012 with the addition of two new inverter models—the Sunny Island 4548-US and 6048-US—and plans to phase out its existing Sunny Island 5048-US model. The two new products have rated power outputs of 4,500 W and 6,000 W at 25°C, respectively, a nominal dc input voltage of 48 Vdc and an ac output voltage of 120 Vac. Up to nine Sunny Island inverters can be combined for a 72 kW, 120/208 Vac 3-phase system.

One previous limitation with SMA's component offerings for ac-coupled systems related to inverter ac-voltage compatibility. Sunny Island inverters have a 120 Vac input/output voltage. However, Sunny Boy inverters have a 240 Vac output voltage. To ac-couple the battery-based and string inverters, systems required two Sunny Island inverters configured to provide 120/240 Vac output. To solve this technical limitation, in 2012 SMA released its UL-listed Smartformer. The product is a 120/240 Vac autoformer designed for systems that ac-couple a single Sunny Island battery-based inverter with a single Sunny Boy string inverter. The Smartformer provides step-up and step-down options to supply backed-up





AC coupled This high-capacity system provides backup power to multiple buildings on a large Texas ranch. Two independent systems utilize a total of 10 SMA Sunny Boy 6000-US string inverters ac-coupled with a total of 24 SMA Sunny Island 5048-US inverters. Deka Unigy II AGM batteries provide 14,202 Ah of total energy storage at 48 Vdc nominal. The systems are charged by arrays with a combined capacity of 65.8 kW.



CAB, EX2060
Case No. IPR2024-00139
55 of 84

loads with 120 Vac and 240 Vac, and it allows the ac coupling of a Sunny Boy inverter with a single Sunny Island inverter.

MAGNUM ENERGY

Magnum Energy's MS-PAE series of inverter/chargers are not designed for utility-interactive operation, meaning the units cannot export power to the grid. However, Magnum's products can be used in ac-coupled systems where a string inverter provides ac power to household loads and to the utility grid. In this configuration, string inverters from manufacturers that permit the use of their products in ac-coupled systems are utilized to export PV-generated energy to the grid when utility power is present, and also to maintain the batteries at a full state of charge. During a grid failure, the string CONTINUED ON PAGE 56

Battery-Backup System Considerations

If your company is new to battery-backup PV systems, we recommend sourcing preconfigured and prewired inverter and integration products from an equipment wholesaler who is experienced in the design and installation of these systems. You should be aware of the following high-level system design considerations and specific details that relate to battery-backup systems.

Determining critical loads. In residential applications, it is not practical to design backup systems that will support every electrical load found in a typical residence, and managing customer expectations up front is important. The salesperson and the customer should agree on the specific loads and circuits that require backup during utility failures. In small systems, these loads typically include communications equipment such as televisions, phone chargers, computers and Internet routers, as well as select lighting circuits. Larger systems may be designed to support critical loads including refrigerators, freezers, well pumps, and blowers and controls for natural gas– or propane-fueled heating systems. Installers often use colored outlets and switches to identify backed-up circuits.

Establishing a load profile. The total capacity of the backup system is based on the power, energy and surge requirements of the backed-up loads in relation to the duration of the grid failure for which the system is designed. These values serve as a baseline to specify inverter and battery-capacity requirements.

Single manufacturer. In most cases, it is advantageous to specify power-conditioning equipment that includes inverters, PV charge controllers (if used) and integration hardware from a single manufacturer. This strategy enables full networking integration between components and streamlines system design and installation. If a specific project requires equipment from multiple manufacturers, be sure to consult one of your distributor's system engineering or technical support specialists before finalizing the design. Some products work together better than others.

Battery selection. Batteries and related selection and system design criteria are covered in detail in "High-Capacity Battery Banks," *SolarPro* magazine, February/March 2012. In utility-interactive battery-backup systems, valve-regulated lead-acid (VRLA) absorbed glass mat (AGM) batteries are recommended for most applications. This type of battery functions well in battery-backup PV applications—and, unlike flooded-battery types, VRLA AGM batteries do not need to have distilled water added periodically.

Battery enclosures. For small systems, integrators often fabricate an enclosure for battery containment. Manufactured enclosures are readily available that protect homeowners from live electrical battery interconnections and present a professional-looking finished system. In either case, it is important to verify that the enclosure is designed to support the combined weight of the batteries and provides adequate ventilation for the battery type used.

Battery temperature sensing. All battery-based inverter and charge controller manufacturers offer battery temperature sensors and enable these sensors to communicate with the system's power-conditioning equipment over a network. This functionality should always be employed to ensure optimal battery charging and to prevent damage to the batteries due to overcharging.

AC bypass switch. Power-conditioning integration hardware should include an ac bypass switch. This makes it possible to manually bypass the inverters and connect the critical-loads panel to grid power during any required system maintenance.

Dual ac inputs. If the backup system design includes an engine generator, the design needs to specify inverters that have provisions for dual ac inputs (grid and generator).

Financing. Battery-based systems can be more difficult to finance than grid-direct systems. Battery-backup systems are eligible for federal tax incentives, but they may not be eligible for specific state or utility financial incentive programs. Currently, most third-party lease programs specifically exclude battery-backup systems. The Admirals Bank Title I and Title I Plus I home improvement loan programs can finance up to $40,000 for a PV system with battery backup. Traditional home improvement loans may also be a good option, provided the homeowner has sufficient equity. You should conduct up-front research regarding incentive and financing programs in your service region to determine eligibility. ●

CAB, EX2060
Case No. IPR2024-00139
56 of 84

ALL SOLAR ENERGY IS NOT CREATED EQUAL

At SolarWorld we believe our energy is different because we're different. And it's not just because we've been powering American homes and businesses for over 35 years.

We have a true commitment to making solar work in America. In fact, we're leading the charge to keep solar manufacturing strong here. Last October, we decided to take a stand against illegal trade practices that resulted in many American manufacturers closing their doors. And even though we had some strong opposition, we stood up to a foreign government creating unfair advantages in the global marketplace. Today, we continue to fight the battle, and we're winning. Solar energy started here. Let's work together to keep it here. You can learn how to join or support us at AmericanSolarManufacturing.org .

We're SolarWorld – America's Authority on Solar™

SOLARWORLD



inverter synchronizes its output with the ac waveform generated by the MS-PAE inverter to provide power to critical loads and to charge the battery bank. Magnum Energy has integrated frequency-shift functionality into its MS-PAE inverter/charger models to provide battery charge regulation in ac-coupled systems during power outages. This feature is typically used in conjunction with an additional diversion load to ensure optimal battery charge regulation.

Magnum Energy offers two MS-PAE inverter/charger models. The MS4024PAE has a rated power output of 4,000 W at 25°C and an input voltage of 24 Vdc nominal. The MS4448PAE product has a rated power output of 4,400 W at 25°C and an input voltage of 48 Vdc nominal. Both models feature 120/240 Vac output, and up to four inverters can be configured in parallel for a system power rating of up to 17.6 kWac. Magnum Energy integration panels and router are required for parallel stacking of the MS-PAE series inverter chargers.



Courtesy Namasté Solar

Smartformer SMA America's new Smartformer product allows integration of a single SMA Sunny Boy string inverter (240 Vac output) with a single SMA Sunny Island battery-based inverter (120 Vac output) in battery-based grid-tied and off-grid applications.

MIDNITE SOLAR

MidNite Solar does not manufacture inverters for battery-based systems, but the company does offer a number of products for battery-backup projects that integrators should be aware of. MidNite manufactures a line of PV charge controllers: the Classic 150 (150 Vdc maximum input voltage rated for 96 A), the Classic 200 (200 Vdc maximum input voltage rated for 79 A) and the Classic 250 (250 Vdc maximum input voltage rated for 63 A). New, lower-cost "light" versions of these controllers that do not include the programmable display are also available. Additionally, MidNite offers eight battery enclosure models designed to house a range of battery numbers, models and sizes that are typically used in battery-backup systems. Inverter integration enclosures (E-panels) and hardware, as well as dc-rated circuit breakers, are available as individual components or as part of complete preassembled systems that incorporate inverters from Magnum Energy, OutBack Power, Schneider Electric or SMA America.

Battery-Backup Opportunities

Battery-backup systems present a great opportunity for integrators to develop a new, high-margin market for their products and services. They also offer ongoing O&M opportunities since batteries have a limited operational life expectancy. Considering the recent and ongoing advances in battery-backup inverter technologies and system integration equipment, the technical and cost barriers are lower than ever. As these technologies continue to mature, battery-based backup may become a common feature in many residential PV systems that are designed to provide a host of smart-grid tasks such as load shifting and EV charging to best manage time-of-use rates. Installers and integrators who understand the components, design and installation of utility-interactive battery systems will have a leg up as these new products and applications hit the market.



Courtesy Magnum Energy

Integration options Magnum Energy's MS-PAE series inverters are not designed to export power to the grid, but can be used in utility-interactive ac-coupled battery-backup systems. Magnum offers inverter integration enclosures and hardware that can be prewired to reduce installation time and complexity.

CONTACT

Paul Dailey / AEE Solar / San Luis Obispo, CA / pdailey@aeesolar.com / aeesolar.com

Joe Schwartz / *SolarPro* magazine / Ashland, OR / joe.schwartz@solarprofessional.com / solarprofessional.com

Manufacturers

Magnum Energy / 425.353.8833 / magnumenergy.com

MidNite Solar / 360.403.7207 / midnitesolar.com

OutBack Power Technologies / 360.435.6030 / outbackpower.com

Schneider Electric / 847.397.2600 / schneider-electric.com

SMA America / 916.625.0870 / sma-america.com

CAB, EX2060
Case No. IPR2024-00139
58 of 84



Thermalito Water & Sewer District
Oroville, CA, USA

CreoTecc
SOLAR MOUNTING SYSTEMS

With no clamps to fasten, modules are inserted easily into rails for 50% faster panelization. With over 600MW installed globally, Creotecc has clampless mounting solutions for residential, commercial and utility applications.

CALL OR VISIT US ONLINE TODAY FOR A QUOTE: 831.438.9000 | CREOTECC.US



SunEarth INC.
Quality Solar Energy Products

**THINK THERMAL–
THINK SUNEARTH**



The Empire Series Liquid Flat Plate Collector

www.sunearthinc.com

SunEarth, Inc.
8425 Almeria Avenue, Fontana, CA 92335
(909) 434-3100, FAX (909) 434-3101
Distributor inquiries welcome.

CAB, EX2060
Case No. IPR2024-00139
59 of 84



Courtesy Michael Crawley/Cupertino Electric

Ground-Mount PV

Rack Your Brain No More

In commercial and residential applications, ground-mount PV systems provide the flexibility to install arrays in open spaces when available roof area is limited, obstructed or nonexistent. Ground-mount PV systems can range in size from a few kilowatts to multimegawatts and can be adapted to a variety of site conditions. They often allow for optimized designs, such as specifying the array's optimal pitch and orientation to maximize kilowatt-hour production. Over the years, racking systems have evolved from off-the-shelf metal framing channels adapted and assembled in the field to engineered solutions, many of which do not require field modifications such as cutting, drilling and welding.

Pre-engineered ground-mount racking systems are typically made of anodized aluminum, steel or a combination of aluminum and steel components, generally assembled with hot-dipped galvanized or stainless steel hardware. Some racking systems are certified as conforming to the integrated grounding and bonding requirements of UL 2703, which approves ground-mount racking system components to serve as a grounding means for module frames—meaning there is no bare copper equipment-grounding conductor to purchase, install and manage. Several manufacturers are awaiting UL 2703 certification for their products, while others have not addressed the listing yet.

Given that ground-mount arrays often consist of long east-west rows of modules—and thus multiple support rails coupled together—certain manufacturers are beginning to provide provisions in rail splices for thermal expansion. Likewise, ground-mount racking systems are beginning to incorporate wire management features to help protect conductors while reducing the amount of time that installers spend securing and supporting the array wiring.

In addition, ground-mount racking systems can offer different foundations and installation approaches for addressing uneven terrain and various soil types and conditions. Where excavation is limited due to land use—such as installations

CAB, EX2060
Case No. IPR2024-00139
60 of 84

on landfills, or areas where subterranean obstacles like underground utilities or shallow bedrock exist—foundations that do not require penetration, such as precast or cast-in-place concrete ballast blocks, may be necessary. Where excavation and digging are possible, installers can use concrete footings, driven piles, micropiles and helical screws to secure and support arrays. Depending on the racking system design and soil type, the plan may require either a single row or double rows of vertical support posts and associated anchorage points. Likewise, installation tolerances for the vertical support members differ among product offerings and are important to consider for complex or uneven sites where it may not be possible to install every post perfectly.

Given the number of ground-mount racking products available, module clamping and securing methods vary greatly. Some manufacturers have introduced clamping methods that do not require hardware, whereas others continue to rely upon the traditional top-down clamping style. It is always important to ensure that the products are compatible by reviewing the racking system's method for securing modules and the installation requirements for the particular module used. Many ground-mount racking manufacturers have solutions for securing both framed modules and frameless laminates, but these methods may not be in compliance with a specific module manufacturer's installation requirements.

Racking Systems

By David Brearley, Tommy Jacoby and Joe Schwartz

In this article, we provide an overview of ground-mount racking systems that are available in North America from 34 manufacturers. As project size continues to increase along with the necessity to drive down installation costs, racking manufacturers, both old and new, continue to develop and refine their solutions for the industry. Integrators who have set foot in the various industry trade shows over the last few years have likely noticed the proliferation of racking manufacturers offering products in the US and Canadian markets. Our intent is to provide an objective overview of information related to key features, differentiators and intended applications for each manufacturer's ground-mount racking product lines.

ADVANCED SOLAR PHOTONICS

Advanced Solar Photonics manufactures PV modules and racking systems for large commercial and utility-scale projects. Its SunRail ground-mount racking product is designed to American Society of Civil Engineers (ASCE) 7-10 and International Building Code (IBC) 2006 or 2009 standards. The racking system's substructure is a single line of galvanized steel helical anchors. An east-west row of helical anchors can be installed on uneven terrain and in areas with limited access, and easily adjusted or removed. Several of the racking system's upper components are preassembled at the factory to reduce in-field installation time. In addition to providing multiple UL-listed grounding options, the system incorporates cable channels and ducts for wire management. The company's support team offers code-compliant designs for any locality. Geotechnical soil investigation and analysis services are also available.

Advanced Solar Photonics / 407.804.1000 / Lake Mary, FL / advancedsolarphotonics.com

ADVANCED SOLAR PRODUCTS

Advanced Solar Products offers a compact ground-mount racking solution that does not require excavated foundations or piers. The Solstice ballasted racking system, which can also be deployed on flat rooftops, is available with standard tilt angles of 5°–25° or in custom tilt angles. Due to its ballasted design, the racking system can accommodate flexible array layout configurations that avoid site obstacles and can conform to irregular site boundaries or uneven terrain. The system is ideal for areas with soft or rocky soils or where underground obstacles such as utilities are present. The Solstice racking system is compatible with most major-brand modules and Burndy WEEB electrical bonding hardware.

Advanced Solar Products / 908.751.5818 / Flemington, NJ / advancedsolarproducts.com

AP ALTERNATIVES

AP Alternatives operates two automated prepanelization production lines located in Napoleon, Ohio, and Fresno, California, to deliver preassembled racking and module subsystems. Modules can be preracked, prewired and pregrounded prior to delivery to the jobsite. Options for framed crystalline modules include three- or four-module cartridges, and smaller thin-film modules can be prepanelized in three-, six- or 10-module configurations. The cartridges are designed for easy transport and installation, and they mount directly onto the racking system's foundation posts. Foundation options include helical piles that can be driven by AP Alternatives' anchor vehicle, or a ballast block with post. Once installed,

CAB, EX2060
Case No. IPR2024-00139
61 of 84

the northern structural members of each cartridge provide a trough for wire management.

AP Alternatives / 419.267.5280 / Ridgeville Corners, OH / apalternatives.com

APPLIED ENERGY TECHNOLOGIES (AET)

Applied Energy Technologies provides ground-mount racking systems for commercial and utility-scale PV applications. The Rayport G utility-scale system is an all-steel product that features seven preassembled components, has minimal attachment points and offers one row of vertical support posts. The racking system allows ±2 inches of adjustment to address misalignment of the vertical support posts, accepts most PV module types, including thin-film laminates, and is preset to the project-specific module layout, which eliminates the need for drilling or cutting in the field. At the time of publication, UL 2703 certification was pending. AET also manufactures the T6 Ground Mount system, which utilizes aluminum purlins and rails supported by a single line of 4-inch galvanized Schedule 40 steel posts. The company offers layout and loading analyses, and it also provides online and on-site installation training.

Applied Energy Technologies / 586.466.5073 / Clinton Township, MI / aetenergy.com

CLENERGY

Clenergy's PV-ezRack mounting system is compatible with most framed and frameless modules. The company offers two product lines for commercial and utility-scale ground-mount applications: SolarTerrace II and SolarTerrace III. The SolarTerrace II is suitable for installation on uneven ground, arrives partially preassembled and consists of anodized aluminum and hot-dipped galvanized steel components. The racking system is supported by a single row of vertical piles. Modules are installed in portrait orientation. The SolarTerrace III, which is designed for use in environments with high wind and snow loads, allows module mounting in landscape or portrait orientation and can be pitched to 45°. The racking system is constructed of anodized aluminum components and can be installed on concrete or ground-screw foundations. Clenergy's ground-mount products include the PV-ezGrounding system, which offers integrated electrical bonding of all aluminum and galvanized steel components.

Clenergy / 760.346.4240 / Palm Desert, CA / clenergy.us

COOPER B-LINE

Cooper B-Line is a division of Cooper Industries, which Eaton Corporation recently acquired. The company's ground-mount system utilizes a unique module clip that is compatible with most framed modules. The clips clamp the module frame to the support rail without the use of nuts and bolts, reducing installation time and eliminating the need to verify torque values. In addition, the clips ground the module frame to the module support rails. Cooper expects to have ETL certification to UL 2703 for the racking system soon. The all-steel racking system can be customized for a variety of site conditions and subarray configurations, does not require drilling or cutting in the field and includes integrated wire management. The company provides racking system design and layout assistance to help address project limitations and goals.

Cooper B-Line / 877.586.8607 / Houston, TX / cooperindustries.com



Courtesy Creotecc

Clampless mounting Creotecc's Creoterra ground-mount racking system utilizes an insertion rail design that eliminates the materials and labor associated with more traditional clamp-and-bolt top-down module mounting. However, module electrical bonding clips are not compatible with this design.

CRC SOLAR

With more than 50 years of experience in roll-forming structural steel products, CRC Solar entered the PV industry in 2011. The all-steel CRC Solar Fixed Tilt ground-mount racking system utilizes a single row of posts (driven or bolted to concrete) and accepts thin-film and crystalline modules. The product's design accommodates up to a 5% grade variation. The installed posts have a maximum horizontal tolerance of ±2 inches in all directions and must be installed within 2° of the desired vertical orientation.

CRC Solar / 800.457.8837 / Moundridge, KS / crcsolar.com

CREOTECC SOLAR MOUNTING SYSTEMS

Creotecc Solar Mounting Systems, which has been providing PV mounting solutions in Europe for more than 25 years, introduced its clampless

CAB, EX2060
Case No. IPR2024-00139
62 of 84

mounting system to the US market in 2009. The company's Creoterra ground-mount racking system is suitable for residential, commercial and utility applications. The product line features an insertion rail design that eliminates the need for individual module clamps. In addition, the interface between the pile bracket and the driven piles allows for minor adjustments in the field. Due to the clampless design, module frames must be individually grounded. Modules are installed in portrait orientation, and the array tilt angle can adjust 10°–50°. To account for pile positioning variations, the slot along the Creoterra system's base rail enables positioning of piles anywhere along the rail length. The module support rails and the associated support structure are pending UL 2703 approval. For projects over 500 kW in capacity, Creotecc provides professional engineering services and on-site installation support.

Creotecc / 831.438.9000 / Scotts Valley, CA / creotecc.us



Courtesy DPW Solar

Multipole mount DPW Solar manufactures a range of ground-mount racking systems for residential through utility-scale arrays. Developed for residential and small commercial projects, the G2 Multi-Pole mount uses a single row of concrete-encased steel pipes to support the system's strongback, rails and modules.

DAETWYLER CLEAN ENERGY

Daetwyler Clean Energy designs, engineers and manufactures commercial and utility-scale PV mounting systems. The Uni-Mount ground-mount commercial product line is constructed of aluminum structural members and uses a single-post foundation that is compatible with ground screws, driven piles, concrete-encased poles or ballast mounts. The racking system accommodates all module types in portrait or landscape orientation. Designed for projects larger than 500 kW, Daetwyler's Modu-Rack series offers preassembled module panels consisting of several individual modules that are prepanelized in a controlled environment where they can be electrically configured and tested prior to arriving at the jobsite. With ballast, nonballast and driven beam foundation options, the racking system can also be secured using a single-point soil anchor that functions like an underground toggle bolt, resulting in minimal soil disturbance below grade.

Daetwyler Clean Energy / 704.659.7474 / Huntersville, NC / daetwylerce.com

DPW SOLAR

DPW Solar manufactures three POWER-FAB product lines for ground-mount PV systems. Common features include integrated wire management, compatibility with the company's lock-in-place RAD fastening hardware and approved equipment grounding using Burndy's WEEB electrical bonding products. For residential and small commercial projects, DPW Solar offers several pole-mount products that include side-of-pole, top-of-pole and multipole models. The G2 Multi-Pole mounts utilize a single row of concrete-encased 3-, 4- or 6-inch Schedule 40 or 80 steel pipe to support a 5-by-4-inch horizontal strongback structural member. Rails are secured to the strongback. Adjustable elevation brackets allow for 0°–55° array tilt angles. For higher-capacity arrays, DPW Solar manufacturers the Large Ground Mount product line. This system can be specified to any tilt angle and utilizes a double row of 2- or 2.5-inch Schedule 40 or 80 steel pipe to support the aluminum upper array structure and rails. Several models are available that allow configuration of arrays in columns of two to six modules in landscape orientation. The company designed its Power Peak ground-mount product line for large commercial and utility-scale applications. The system utilizes a single-line driven galvanized steel pile foundation, and its design allows for module prepanelization. DPW Solar provides a number of technical services, including permit-ready drawings, foundation designs, and pile driving and rack assembly capabilities.

DPW Solar / 505.889.3585 / Albuquerque, NM / dpwsolar.com

CAB, EX2060
Case No. IPR2024-00139
63 of 84

HATICON SOLAR

HatiCon Solar's ground-mount system features preassembled components and does not require on-site cutting or welding. Depending on the site-specific soil conditions, the system's galvanized steel micropiles can be driven directly into the earth or cast in concrete footings. The product line is also compatible with helical ground screws. The post system allows 12 inches of vertical adjustment, and the proprietary bearing block provides 0°–8° of east-west adjustment to address misalignment of the posts. The aluminum racking system can be tilted 0°–35°, utilizes preassembled mounting clamps that are compatible with framed or frameless modules and is approved for use with the Burndy WEEB electrical grounding system. Modules can be installed in either portrait or landscape orientation. HatiCon Solar provides on-site foundation-load analysis, engineered drawings, wet stamps and installation services.

HatiCon Solar / 866.489.4472 / Ontario, CA / haticonsolar.com



Courtesy HatiCon Solar

Micropiles HatiCon Solar's ground-mount racking system is compatible with driven micropiles, helical ground screws, or cast-in-concrete footings. Micropile anchorage systems, as shown here, require lighter and less expensive driving equipment compared to systems that utilize a single row of larger and heavier piles.

IDEEMATEC

IdeemaTec provides two ground-mount racking systems for the North American market. The safeFix Alu racking system utilizes a hybrid fastening design with an aluminum insertion rail between adjacent rows of modules. The shared insertion rail aligns framed modules prior to the installation of traditional-style clamps. A single row of I-beams or U-shaped posts, rammed into the earth or set in concrete, can be specified to support the structure. The standard tilt angle options are 20°, 25° and 30°. The safeFix Steel racking system offers an all-steel substructure that reduces overall material costs. Its patented clamp-and-rivet module fastening system is compatible with all types of modules, including frameless, and provides theft prevention. Supported by a single row of I- or Z-beams either set in concrete or directly rammed into the earth, the racking system has standard tilt angles of 25° and 30°, yet can be customized to any tilt angle.

IdeemaTec / 415.248.7806 / San Francisco, CA / ideematec.de

IRONRIDGE

The ground-mount system manufactured by IronRidge combines installer-supplied 2- or 3-inch Schedule 40 or 80 steel pipe with the company's Standard XRS Rail system and associated attachment components. No drilling is required to attach the aluminum rails to the horizontal pipe members. The racking system is compatible with a variety of footings, including helical piles, precast ballasts and concrete piers. An optional north-south brace that provides additional structural rigidity is available for sites with high snow or wind load conditions. A variety of accessories are available, including wire management clips, and the system is compatible with Burndy electrical bonding WEEB clips and grounding lugs. In addition, IronRidge offers product documentation, CAD drawings and PE-stamped engineering certification letters for most states. An online Ground-Mount Design Assistant provides integrators with racking system layout, engineering and quotation services. The company also manufactures a line of top-of-pole and side-of-pole racking products.

IronRidge / 800.227.9523 / Willits, CA / ironridge.com

KB RACKING

KB Racking partnered with German EPC Solea AG to manufacture and distribute the utility-scale GROUNDFIX ground-mount racking system to the North American market. The steel and aluminum system is compatible with all standard framed modules and includes fully integrated grounding.

CAB, EX2060
Case No. IPR2024-00139
64 of 84

Customizable array configurations range from two to three modules per column in portrait orientation. The racking system's tilt angle can be set in a 10°–35° range.

KB Racking / 888.661.3204 / San Francisco, CA / kbracking.com

LEVELONE

CantSink galvanized steel helical piles support LevelOne's ground-mount racking system. The company offers a variety of fittings to provide attachment options between the piles, the racking system's pipe framework and the module support rails. Five extruded aluminum rail profiles are available in a variety of lengths to accommodate various span distances. All rail models include integrated channels and an associated clip for wire management. For framed modules, Burndy WEEB grounding clips provide an ETL-approved grounded connection between the rails and the module frame. LevelOne is introducing a lower-cost racking system that incorporates aluminum and steel materials, a single row of piles and the option to prepanelize module sections. The company offers design and engineering services for commercial and utility-scale projects.

LevelOne / 248.322.8444 / Madison Heights, MI / levelonesolar.com

MOUNTING SYSTEMS

Mounting Systems developed the Sigma Series ground-mount products for large commercial and utility-scale open-terrain PV array fields. Sigma I, a single-row driven-pile system, is compatible with all module types and features a rail connection approach that follows the terrain to reduce or eliminate the need for site excavation or grading. Modules can be installed in portrait or landscape orientation and configured in single or multiple rows at inclinations of 25° or 30°. Sigma II is a two-row racking system that can be anchored using micropiles or helical piles, or with footplates secured to concrete ballast. Modules can be laid out in single or multiple rows in portrait or landscape orientation. The Sigma I and Sigma II products are designed to several standards including IBC 2009, California Building Code (CBC) 2010 and ASCE 7-10. Mounting Systems also manufactures the Omega ballasted ground-mount product line for open-terrain PV installations.

Mounting Systems / 855.731.9996 / West Sacramento, CA / mounting-systems.us

ORION SOLAR RACKING

Orion Solar Racking has designed different model variations of its Jupiter Ground Mount System to be compatible with concrete-encased pipe, driven pile, helical pile and concrete ballast anchorage systems. The Jupiter I ground-ballasted racking system is constructed of all-aluminum structural members and can be used with both framed modules and frameless laminates. The Jupiter II pile ground mount is supported by a single row of driven piles, and the system can be adjusted to compensate for pile-angle deviations of up to 2°. The Jupiter III system uses helical piles from PierTech systems. Orion Solar Racking also offers 2-, 4- and 8-module top-of-pole mounts that allow for tilt angles of 10°–60°.

Orion Solar Racking / 310.409.4616 / Commerce, CA / orionsolarracking.com

PATRIOT SOLAR GROUP

Patriot Solar Group offers three ground-mount–racking product lines. The High-Wind Fixed Horizontal System is

Row length Long rows of modules are subject to increased mechanical stress from thermal expansion and contraction, and racking manufacturers have different approaches for addressing this issue. The simplest solution is to segment the array, as Independent Power Systems did with this 110 kW array utilizing the Sigma II product from Mounting Systems.



Courtesy Independent Power Systems/Mounting Systems

CAB, EX2060
Case No. IPR2024-00139
65 of 84

available in 2.5, 5, 7.5 and 10 kW configurations. The racks utilize a galvanized steel substructure and aluminum rails that support two rows of modules in portrait orientation. The array tilt angle adjusts in a range of 0°–45°. The 2500 Series Ground Mount System supports a single row of modules in portrait orientation and has an adjustable tilt angle of 10°–45°. Patriot Solar Group also offers a line of 2, 3 and 4 kW top-of-pole mounts.

Patriot Solar Group / 517.629.9292 / Albion, MI / patriotsolargroup.com



Courtesy RBI Solar

UL 2703 listing Several manufacturers, including RBI Solar, have had their racking systems tested and listed to the UL 2703 standard that addresses PV-mounting system equipment grounding and bonding. More manufacturers are expected to follow suit in 2013.

POLAR RACKING

The PR series of ground-mount products from Polar Racking includes a two-module side-of-pole mount and an extensive line of top-of-pole mounts that support two- to 24-module arrays. Top-of-pole models are available for both portrait and landscape orientations. The mounts' galvanized steel substructure integrates with Polar Racking's PolaRail aluminum rails. The rails' extrusion includes two channels that secure and protect 10–12 AWG PV source-circuit conductors. PolaRail rails are compatible with Burndy WEEB module and array grounding clips, lugs and bonding jumpers. Rail splice bars and module mid clamps and end clamps are provided based on array requirements. Polar Racking also offers a Drop'N'Go ballasting system for its larger pole mounts. The pre-engineered and precast ballasts eliminate the need for excavation and include a set-in-place conduit for homerun wiring.

Polar Racking / 519.915.7600 / Windsor, Ontario / polarracking.com

PROFESSIONAL SOLAR PRODUCTS

Professional Solar Products manufactures one product line for ground-mount applications that is designed to minimize the number of required footings. The low-profile GroundTrac racking system utilizes readily available and locally sourced 1.5-inch Schedule 40 galvanized pipe for the vertical post and horizontal purlin structural members. The posts are typically set in concrete footings, and 1.5-inch Hollaender slip-on T fittings secure the purlins to the posts. The manufacturer recommends a maximum rear post height of 5 feet and a maximum front post height of 30 inches. Three GroundTrac rail sizes are available: 124 by 2.5 inches, 136 by 2.5 inches and 164 by 3 inches. The 124- and 136-inch rails can be installed at tilt angles of 0°–30°. The 164-inch rails can be installed at tilt angles of 0°–20°. Preslotted and unslotted rails are available. For the latter, Professional Solar Products provides a GroundTrac drill-guide base and bit that are used to locate and drill rail-hole positions for securing the rails to the purlins. Both rail profiles utilize a proprietary Drop-N-Lock U-bolt assembly. Modules are installed in landscape orientation using provided top-down mounting hardware.

Professional Solar Products / 805.486.4700 / Oxnard, CA / prosolar.com

PV RACKING

PV Racking's ground-mount system features slide-in module mounting, rather than bolts and clips, to secure the modules to the racking structure. Although the company's system is compatible with concrete and driven-pile anchoring approaches, PV Racking promotes the use of PierTech helical piers with its ground-mount racking product. Using this approach, the galvanized steel piers are mechanically screwed into the soil and serve as the main posts for the racking structure. While the racking product appears to require a fair amount of minor field fabrication, the concept of slide-in module mounting is innovative. PV Racking offers five rail profiles to accommodate module frame thicknesses of 1.16–2 inches. One downside to the slide-in approach is that module-grounding clips cannot be used for electrically bonding the modules to the rails. However, the system's rails provide T slots that accept WEEB grounding lugs for bonding the rails to the substructure.

PV Racking / 610.990.7199 / Southampton, PA / pvracking.net

RBI SOLAR

Each ground-mount racking system from RBI Solar is custom engineered to IBC and ASCE standards based on specific site

CAB, EX2060
Case No. IPR2024-00139
66 of 84

and array configuration requirements. The company offers a range of all-steel ground mounts that it developed for large commercial and utility-scale projects and that require no field welding, drilling or other on-site fabrication. Foundation options include concrete piers, precast or cast-in-place concrete ballast, driven post, and screw or helical piles. In 2012, Intertek tested two of RBI Solar's ground-mount products (models GM-I and GM-T) and listed them to the UL 2703 standard.

RBI Solar / 513.242.2051 / Cincinnati, OH / rbisolar.com

SCHLETTER

Schletter manufactures several ground-mount racking solutions intended for residential, commercial or utility-scale arrays. Suitable for commercial and utility-scale systems, the company's FS Generation 6 product is ETL listed to UL 2703 as an electrically bonded unit, and is designed to meet IBC and ASCE standards for structural loading. The single-line support post system can be installed on uneven terrain and utilizes U-shaped, galvanized steel piles that are driven mechanically. Several of the racking systems' upper components are shipped preassembled to reduce installation time. Clamps are available for any module type, including frameless PV laminates. Schletter also offers the 2.5 kW FS kit, which supports 10 modules and uses concrete foundations rather than driven piles for residential applications. The company also offers the PVMax3 system and the recently released FS ECO product. The concrete-ballasted PVMax3 was developed for sites where the soil is too soft or too rocky to utilize driven-pile anchoring. Several versions of this product accommodate different module column or row configurations for portrait or landscape layouts. The FS ECO racking system features all-steel structural components and has a lower price point than Schletter's aluminum racking systems. Schletter offers a range of support services that include geotechnical soil analysis and reports, as well as third-party PE-stamped drawings.

Schletter / 520.289.8700 / Tucson, AZ / schletter.us

S:FLEX

Developed for large commercial and utility-scale projects, S:FLEX's ground-mount racking line is designed to meet the wind-, snow- and seismic-loading requirements of the 2006 IBC. The product line supports both portrait and landscape module layouts, as well as framed (frame thickness of 1.1–2.05 inches) or frameless modules, and an array tilt angle of 15°–35°. S:FLEX's galvanized steel Sigma foundation

FS UNO — No on-site welding, cutting, or heavy-duty cranes needed.



- 100% galvanized steel mounting superstructure, up to G165 specifications
- Cold-rolled, hot-dip galvanized steel posts for extended product longevity
- 100% IBC code compliant system, with PE stamps available in most states
- In-house geological testing • Installation training available

made in USA

SCHLETTER

Schletter US (520) 289-8700 | Schletter Canada (519) 946-3800

CAB, EX2060
Case No. IPR2024-00139
67 of 84

post can be rammed into soil or cast in concrete footings depending on the site's soil conditions. Slotted 6063-T6 aluminum posts are designed to slide into position alongside the foundation piles, creating an adjustable post assembly that can accommodate a maximum terrain slope of 6° in the east-west direction. Purlins are secured to adjustable bearing blocks atop the post assembly and include internal splices between structural members. Top-down mounting rails can be positioned anywhere along the purlins. Cross braces between the front and rear posts provide additional rigidity to the overall racking structure. S:FLEX offers structural design services to determine the load-bearing capacities of specific applications.

S:FLEX / 303.522.3974 / Sheridan, CO / sflex.com



Courtesy Schletter

Single-row piles In an effort to drive down costs from large commercial and utility-scale array fields, many manufacturers have introduced racking systems that utilize a single row of driven piles. Schletter's FS Generation 6 system follows this design approach and also includes provisions for conductor management.

SNAPNRACK

SnapNrack offers two product lines for deploying ground-mount PV systems. The Series 200 Ground Mount System is intended for residential and light commercial projects. This mounting solution integrates with a standard 1.5-inch galvanized pipe substructure. Pipe clamps are used to attach aluminum SnapNrack ground rails to Schedule 40 or Schedule 80 pipe. These rails accept proprietary snap-in channel nuts that anchor the module clamps. WEEB hardware can be used to electrically bond the modules to the rails. Concrete-encased piers are typical with the Series 200 system, but other foundation options are available. SnapNrack's Series 350 Ground Mount System is intended for large commercial and utility-scale PV projects. While multiple foundation options are available, the Series 350 Ground Mount System typically uses a driven-pile foundation capped with a roll-formed Z purlin. To further reduce mounting structure costs, the Series 350 system can be specified with a steel version of the SnapNrack ground rail.

SnapNrack / 877.732.2860 / San Luis Obispo, CA / snapnrack.com

SOLAR FLEXRACK

The innovative ground-mount product from Solar FlexRack is preassembled in the factory, folds down for shipping and unfolds in the field. This approach reduces construction time and installation costs. The preassembled components are custom designed for each project, based on module selection and mounting configuration. The typical Solar FlexRack system uses extruded aluminum vertical rails and horizontal galvanized steel Z purlins. Two tilt-bracket options are available, as well as several post profiles. The Solar FlexRack Smart Post is a C-shaped, roll-formed driven pile with slots that will accommodate a bolted connection to a tilt bracket. Cable clips can be snapped anywhere along the vertical rails, and several different wire management systems can be integrated along the horizontal Z purlin. The Solar FlexRack assembly is electrically bonded and tested to UL 2703, and module bonding clips are available.

Solar FlexRack / 888.380.8138 / Youngstown, OH / solarflexrack.com

SOLARWORLD

The Sunfix ground-mount system is optimized for use with SolarWorld Sunmodules, but it is compatible with other PV modules with frame thicknesses of 40, 42, 45, 46 and 50 mm. Modules are installed in portrait mode using three horizontal aluminum rails, with two modules per column and a shared center rail. The horizontal rails are attached to an aluminum substructure that ships partially preassembled to reduce installation times. This substructure consists of north and south posts, each attached to its own foundation, with a lateral brace and a top chord between the posts. SolarWorld's racking system fits a variety of foundations, including earth screws, driven pile, ballast block and concrete pier. The Sunfix ground mount accommodates tilt angles of 5°–40°. Optional WEEB hardware is available to electrically bond the modules to the rails. Cable tray and other hardware can be used with the system for wire management.

SolarWorld / 805.388.6590 / Camarillo, CA / solarworld-usa.com

CAB, EX2060
Case No. IPR2024-00139
68 of 84

SUNLINK

SunLink offers two solutions for ground-mount PV systems. The SunLink Large-Scale GMS is a galvanized steel support system intended for large commercial and utility-scale PV applications. Landscape-oriented modules are intended to be prepanelized on vertical rails with three or four modules per column. Construction machines can then place the panels on top of a pair of horizontal Z purlins. A driven-pile galvanized post bolted to an angled post frame is used to carry the Z purlins. For smaller systems where ground penetration is not possible or desirable, SunLink offers the Ballasted GMS. Precast concrete ballasts are used to carry galvanized steel A-frames, which support horizontal galvanized steel tubes. Modules are attached to these mounting tubes using cast aluminum panel clamps. Both systems accommodate 15°, 20°, 25°, 30° and 35° tilt angles. Wire management solutions are available, as well as integrated module-grounding hardware tested to UL 2703.

SunLink / 415.925.9650 / San Rafael, CA / sunlink.com

SUNMODO

SunModo's ground-mount systems all use the company's EZ Helio Standard Rail, a heavy-duty aluminum rail extrusion. The system accommodates both landscape and portrait module orientations. Landscape-oriented modules can be installed in columns of two to four; portrait-oriented modules can be installed in columns of two or three. In both cases, the aluminum rail is oriented vertically over a double-row steel pipe substructure that is braced front to rear. Depending upon the number of modules per column, the substructure is composed of 2-inch pipe or a combination of 2-inch and 2.5-inch pipe. Standard foundation options are concrete-encased post, ballast block and earth screw. While top clamps are used to mount landscape-oriented modules to pairs of rails, a middle mount-plate kit allows installers to bottom-mount columns of portrait-oriented modules using a shared middle rail. Compatible WEEB hardware is available as an option.

SunModo / 360.844.0048 / Vancouver, WA / sunmodo.com

TERRAFIX SOLARPARK

Terrafix Solarpark specializes in providing the US market with ground-mount racking systems that use earth-screw foundations. With more than 40 different earth-screw models, the company can accommodate a wide variety of geologies and terrains, including marsh, sand, bedrock and slopes up to 38°. Each machine can install as many as 100 earth screws per day. No grading is required, as the racking system can follow terrain contours. Because they do not require concrete, earth-screw foundations can be structurally loaded immediately. The company's ground-mount system uses a hot-dipped galvanized steel substructure that bolts directly to the ground screws. The modules are installed on heavy-duty aluminum rails. With modules in portrait orientation, two-module columns are typical, with 14 or 16 modules per rack; in landscape orientation, four-module columns are typical, with 20 modules total. Terrafix Solarpark provides project-specific designs for its fixed-tilt ground-mount racking systems.

Terrafix Solarpark / 510.483.7200 / San Leandro, CA / terrafixsolarpark.com

TERRASMART

TerraSmart specifically designed its TerraFarm ground-mount racking to be installed on a Krinner ground-screw foundation. Front and rear leg assemblies bolt directly to the top flange of the ground screws. A lateral steel brace is installed front-to-rear between these legs. Internally spliced 2.5-inch steel pipes are installed horizontally, across the front and back, to support the module mounting rails at the desired tilt angle (10°–45°). The module rails are galvanized steel Z purlins, slotted on the bottom to accommodate pipe clamps, with holes in the top as needed to bottom-mount the modules using through bolts. Additional cross bracing is provided using



Courtesy SnapNrack

Steel versus aluminum One of the ways that manufacturers are driving structural costs down is by reducing or eliminating aluminum components in their mounting systems in favor of less expensive steel components. This is evident across manufacturers and product lines. For example, SnapNrack's Series 350 Ground Mount System, shown above, utilizes a steel superstructure and can be ordered with steel or aluminum rails.

CAB, EX2060
Case No. IPR2024-00139
69 of 84



Courtesy Terrafix Solarpark

Screws and helical piles Earth screws and helical piles offer an alternative to rammed piles for an array foundation. Terrafix Solarpark manufactures more than 40 earth-screw models with various profiles suitable for geologies ranging from sandy soils to bedrock. Compared to concrete footings, which take time to set, one advantage of these products is that they can be structurally loaded immediately.

tensioned galvanized steel cable. No field welding, drilling or cutting is required. Compatible WEEB hardware is available. TerraSmart also sells ground-screw installation equipment.

TerraSmart / 239.362.0211 / Fort Myers, FL / terrasmart.com

UNIRAC

Unirac offers residential, light commercial and utility-scale ground-mount products. Designed for the smallest ground-mount applications, the company's universal SOLARMOUNT aluminum rail system can be configured for high- or low-profile tilt mounting. The Unirac Large Array (U-LA) system is available for arrays 3 kW and larger. The U-LA system uses a steel pipe–based substructure to support SOLARMOUNT rails. Both racking systems work with standard top-mounting hardware, and universal grounding clips are available. The ISYS Ground 2.0 is Unirac's ground-mount solution for larger commercial and utility-scale projects. The system uses large galvanized steel components that allow for 16- to 24-foot spans between foundation points. A driven-pile foundation is typical, but poured concrete, ballast block and earth screws are also options. A heavy-duty top chord assembly is installed on each pile. A pair of horizontal C-beams are installed on either end of the top chord and used to support a hat-channel beam that carries the modules. For optimal installation efficiency, workers can prepanelize columns of modules and lift these panels into position using construction machines.

Unirac / 505.242.6411 / Albuquerque, NM / unirac.com

U.S. SOLAR MOUNTS

The Adjustable Ground-Mount (AGM) System from U.S. Solar Mounts is scalable from just three modules to systems large enough for commercial applications. A concrete-encased galvanized steel pipe foundation is typical. Preassembled torque cradles are installed on each pipe and used to carry a pair of 4-inch galvanized steel torque tubes. Anodized aluminum module-mounting rails are installed over the torque tubes. Landscape-oriented modules can be top- or bottom-mounted to these rails. The assembled racking system is balanced over the pipe foundations, and the tilt angle can be manually adjusted in a range of 0°–50°. An optional linear actuator can be added to the AGM System, along with optical or GPS controls, to enable automatic east-west or solar azimuth tracking.

U.S. Solar Mounts / 608.272.3999 / Sparta, WI / ussolarmounts.com

ZILLA

Zilla designs and manufactures a complete line of solar-mounting components that are configurable for a wide variety of applications, including ground mounts. Zilla ground-mount systems can be used with poured concrete, ballast block and helical earth-anchor foundations. The Zilla Helical System is recommended for soft soils, as it allows for immediate leveling and attachment. A helical drive shank, compatible with most engine-driven power takeoffs, is used to drive the helical anchors. After an adapter plate is installed at each anchor, a prefabricated truss system is bolted to the foundation and used to carry extruded aluminum Zilla Rac rails. Modules can be bottom- or top-mounted to the rails. Portrait orientation is typical, with two modules per column. Both proprietary grounding hardware and compatible WEEB hardware are available.

Zilla / 855.670.1212 / Lafayette, CO / zillarac.com

CONTACT

David Brearley / *SolarPro* magazine / Ashland, OR / david.brearley@solarprofessional.com / solarprofessional.com

Tommy Jacoby / Jacoby Solar Consulting / Austin, TX / tommy@jacobysolar.com / jacobysolar.com

Joe Schwartz / *SolarPro* magazine / Ashland, OR / joe.schwartz@solarprofessional.com / solarprofessional.com

CAB, EX2060
Case No. IPR2024-00139
70 of 84

MidNite Solar's Prewired Radian AC Coupled System

Do you have a grid tied system and want to add battery backup? If so, this is for you!

A single 120/240 volt inverter system comes pre-wired with an 8,000 watt inverter, MidNite E-Panel and 2 MidNite surge arrestors. Systems are available for single or dual Radian inverters. Dual AC inputs allow for generator back up as well. An optional MNBE-D battery enclosure and cabling is also available.



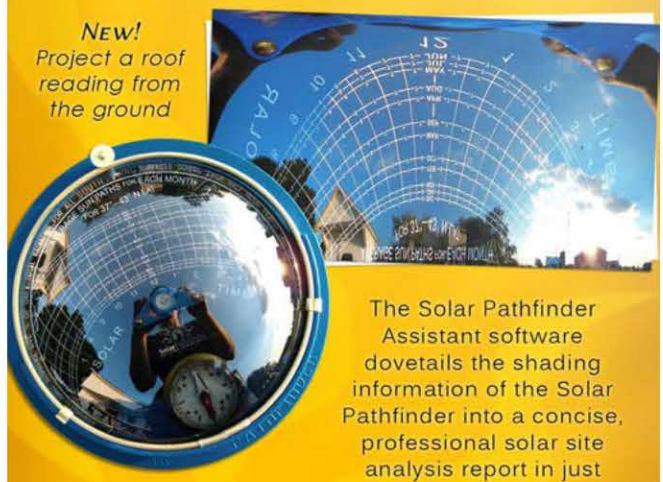
www.midnitesolar.com

17722 67th Ave NE Arlington, WA 98223 PH. 360-403-7207 Fax 360-691-6862

Raising the Standard of Solar Site Analysis

To New Heights

New! Project a roof reading from the ground



The Solar Pathfinder Assistant software dovetails the shading information of the Solar Pathfinder into a concise, professional solar site analysis report in just seconds.

Solar Pathfinder™ ASSISTANT

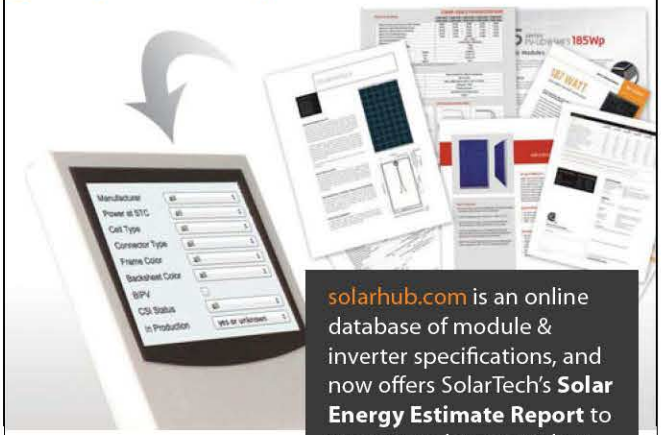
Phone: (317) 501-2529

info@solarpathfinder.com

WWW.SOLARPATHFINDER.COM

SOLAR HUB

Need product data?
Wish you had a simple summary report for your solar quote?



solarhub.com is an online database of module & inverter specifications, and now offers SolarTech's **Solar Energy Estimate Report** to present and compare key data from competing solar proposals. All for FREE!!

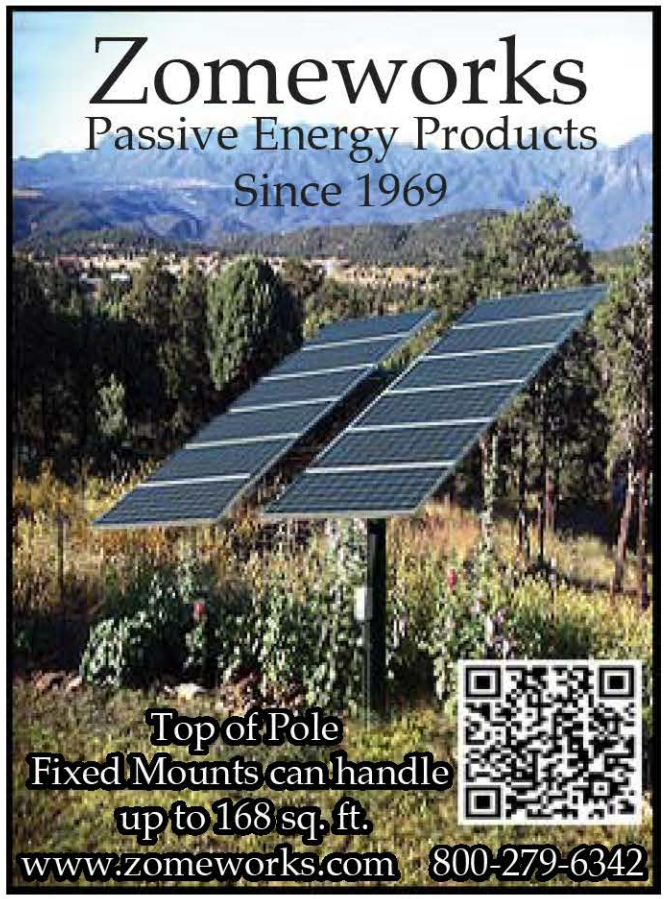
- Manufacturer-Verified Data
- Advanced Filtering
- Over 500 Manufacturers' Products
- Continually Updated
- New SEE Report Generation Functionality

SolarHub is a free service brought to you by:

solarnexus · Solar Tech · SOLARPRO · NABCEP

Zomeworks

Passive Energy Products Since 1969



Top of Pole Fixed Mounts can handle up to 168 sq. ft.

www.zomeworks.com 800-279-6342

Interview

An Experienced Perspective

Alex Bradley, DuPont Photovoltaic Solutions

Investigating Module Performance in the Service Environment

Alex Bradley is a principal investigator for DuPont Photovoltaic Solutions, studying material reliability in service environments over time. He obtained a PhD in chemistry from the University of New Hampshire in 1997 and was a postdoctoral fellow with the Council on Science and Technology at Princeton University before joining DuPont in 2001. Dr. Bradley is an industry representative on the Standards Technical Panel for UL 1703, the equipment safety standard for flat-plate PV modules and panels, and serves as the American Chemistry Council's alternate representative on the *National Electrical Code*–Making Panel No. 4 regarding PV installation, the panel responsible for *NEC* Articles 690 and 705.



Courtesy DuPont Photovoltaic Solutions

Alex Bradley, DuPont Photovoltaic Solutions A principal investigator for DuPont, Dr. Bradley runs the company's Fielded Module program, which studies how modules and materials perform over time in the service environment.

At Solar Power International 2012, Bradley moderated a panel called "Standardization of Codes for Solar Project Development." SolarPro *staff met with him afterward at the DuPont booth on the floor of the Orlando Convention Center.*

SP: While DuPont is a household name, some people may not be familiar with its role in the solar industry. Where does DuPont fit into the value chain?
AB: DuPont has a historic place in the solar industry. The company was an original supplier to the Jet Propulsion Laboratory research program sponsored by the US Department of Energy, which developed many of the original specifications for PV modules. We donated our Tedlar polyvinyl fluoride [PVF] film for PV backsheet and EVA encapsulant materials. The goals of the study were to develop a 30-year module—one that met the functional, safety and reliability requirements for large-scale terrestrial deployment of PV—and to derive the appropriate balance between system cost and system life and reliability.

Now, more than 30 years later, DuPont products are used to manufacture both crystalline silicon and thin-film PV cells and modules. We provide films, resins, encapsulation sheets, flexible substrates, conductive pastes and silicon inks, as well as high-performance seals for solar cell manufacturing equipment and wet-etch additives for semiconductor texturing.

SP: What kind of work do you do as a principal investigator?
AB: I'm heading up our Fielded Module program, in which we're going out into the service environment and looking at how our materials and our competitors' materials have performed over time. In our minds, that's the true test of performance.

This is a unique initiative, one that provides us and system owners with a significant amount of information. By virtue of being a 200-year-old company, our material science capability is well established, and we can leverage our experience from other industries. DuPont PV materials have been out in the service environment for well over 30 years. Since we haven't changed the recipes for some of our materials very much, we can learn a lot by understanding how these materials perform over an extended period of time and throughout the module lifetime.

SP: How does this approach differ from other methods of performance testing?
AB: For the most part, the industry uses accelerated aging tests to try to predict

CAB, EX2060
Case No. IPR2024-00139
72 of 84

the quality and reliability of PV modules. These tests can include thermal cycling, damp heat exposure, humidity-freeze cycling, hail impact analysis, static and dynamic mechanical loading, and so forth. I have colleagues at DuPont who perform accelerated aging tests on a mini mockup structure, and they beat the heck out of the test modules to establish relative durability.

The limitation to this approach is that we can generate failure modes that aren't seen in the service environment. What we want to understand is how modules perform in the real world. If accelerated aging tests generate other types of failures, this isn't really helping us or helping the industry. We still lack a fundamental understanding of how these results relate to module performance in the service environment. We can test for anything, but what do the results truly mean?

SP: What is the process used for the Fielded Module program?
AB: Basically, I'm always looking for modules that have been deployed in different environments and in different applications—for example, roof mounted versus ground mounted—and have been in service for different periods of time. All of these things have an effect on the rate of degradation.

It's an interesting dynamic. When I first started the program, no one would let me in the door. They'd say, "You can't come inside the fence," and "No, you can't do that." So, we now have ten PV systems installed at DuPont locations worldwide. Some of these installations function as living labs, where we're using a systems approach for our own learning, so that we can understand module degradation and material performance in detail. At the same time, we're gaining access to other facilities that will provide additional learning opportunities.

SP: So when you're testing these modules, are you bench-testing them? Are you doing laboratory testing or field testing?
AB: I have a whole analysis and characterization plan that we benchmarked against Sandia National Labs. They published a lot of good work to establish the process we go through. We do flash testing to get the I-V curve and understand the power degradation. Then we start trying to identify the root cause of the degradation. For example, we have thermal imaging and electroluminescence imaging to see if there are cracked cells or hot spots. We test for electrical insulation and material properties as well.

We go through an in-depth, nondestructive analysis in our North America Applied PV Lab. Then, if need be—I'm a chemist by training—I actually destroy the module. We have a destructive analysis protocol so that we can look at the chemical degradation as well. Sometimes degradation is not on the outside; it's on the inside. So there's no other way to characterize it other than to crack that egg open and see what's inside.

SP: How do you go about doing that?
AB: What we do is actually quite interesting, and I'm not taking any credit for that. Here again our process is benchmarked against Sandia. The process is called *coring,* like taking an ice core out of Antarctica. We pull out that core. We polish it. We perform a cross-section analysis using a scanning electron microscope. That gives us the thicknesses of each individual layer. Then we do a point chemical analysis of each layer, and we look for degradation problems. It's intense, and some people think I'm a little crazy for doing it. But I love to learn and I'm very interested in it.

SP: Are the older modules displayed here at your booth all products that you have tested for performance?
AB: Yes. These modules are all about the same age—somewhere between 10 and 12 years old—but they have different material sets, and you can clearly see that the protective materials have performed differently.

SP: What is the story with the module with a whiter backsheet than the others? It shows no visible signs of delamination.
AB: That is an AstroPower module made with a Tedlar PVF film-based backsheet. The company worked right down the street from us and was a long-standing customer of ours. This module came out of a 1.5 kW roof-mounted system in Delaware. The whole system was donated to us. We analyzed all of the modules in our laboratory, and they all got a clean bill of health. The modules all passed the wet leakage test, indicating that the system was still safe. The performance degradation was about 0.8% per year.

SP: What about this module with the yellow backsheet? The backsheet material actually looks jaundiced. Also, the membrane has delaminated in many places and is starting to crack.
AB: The backsheet polyethylene terephthalate, or PET, material on this module is completely discolored, and the material is embrittled. As you might suspect by looking at it, this module failed the wet leakage test, which means it's no longer electrically insulated.

This manufacturer decided to replace the traditional weatherable outer surface with a different weathering material, and you can see that was a poor design decision. The PET backsheet material didn't last quite as long. Clearly the design of the polymeric material wasn't a good choice. Although it was done to lower cost on the front end, this design isn't paying off on the back end. The primary function of a backsheet is to insulate the module for safety, but it also has to protect the module and ensure weatherability. This module is still supposed to last another 15 years, and, in my opinion, it's not going to make it to the finish line.

Interestingly, this particular manufacturer used the same PET backsheet material through three product

CAB, EX2060
Case No. IPR2024-00139
73 of 84

generations—from a 70 W module to a 125 W module and eventually to a 143 W module. We've tested some of these sister products and found other degradation modes resulting in a loss of electrical insulation. So they carried that bad design and the problems associated with it through three different product iterations.

We look at that and conclude that materials clearly do matter. The challenge is that it takes so long to prove it out, and a lot of the accelerated aging tests may not be predicting it. Industry stakeholders sometimes have to grin and bear it for 10 years and wait to see how things eventually degrade. Unfortunately, that means a PV system owner, whether a small rooftop or large MW utility system, is unknowingly running a beta-test facility for unproven design iterations.

SP: A lot has changed in the decade since these modules were manufactured. The industry is more mainstream. Manufacturing capacity is much larger. Module construction has changed. How do you think today's products will hold up?
AB: The fundamentals of module degradation are still the same.Resistive losses will occur. These changes in short-circuit current, open-circuit voltage and fill factor have a deleterious effect on module performance. Solder bonds and interconnects are still going to fail; we see that in modules that are 4 years old and ones that are 30 years old. Cells are still going to crack—even more so now. The cells on these 10-year-old modules are 750 microns thick. They are like a hockey puck compared to cells nowadays, which are about 150–180 microns thick. What happens when a cell breaks? It starts to get hot. That is going to accelerate the degradation of the polymer.

So a lot of the fundamentals are still true, whether the technology is 20 years old or 2 years old. And unfortunately we're still going through these same issues. We're not learning that materials matter.

I was at an installation in Arizona about a year ago, and modules were still turning yellow on the front side. We thought we'd worked that out 20 years ago, but the same problems are occurring over and over again. That's what happens when you have new suppliers coming to the market that don't know how to formulate and choose the proper additives for their films.

The more things change, the more they stay the same. Take frameless modules, for example. One of the ways that companies tried to cut costs 10 or 12 years ago was to take the frame off. What happened? The modules delaminated. The adhesive doesn't stay on. So I'm walking around the floor of the expo hall here at SPI 2012, looking at all these new frameless PV laminates and thinking, "It's a shame, but 10 years from now they are going to be delaminating from the edge."

I also saw manufacturers turning the glass inside out again. This is textured glass, right? I saw a couple modules on display where the texture is on the outside, and the manufacturer is saying that the modules are going to capture more light. Well, once the things get dirty and grimy, it's harder to clean the dirt out of the pinholes in the surface of the glass.

It's like fashion: What's old is new again. That's part of the justification for our program, and for my participation in codes and standards committees. As an industry, we don't want to keep repeating the same mistakes.

SP: There is so much downward price pressure in the industry right now that it makes you wonder about the compromises that manufacturers are forced to make to remain competitive. There must be a tradeoff in quality, reliability and longevity. Do you think we will eventually see PV turn into a 10-year product?
AB: I hear people suggesting this. They say, "Oh, the modules are so cheap that we'll just get rid of them after 10 years and put new ones up." But they don't consider the rework and scrap involved with that. You have to take those costs into account on the front end if you want to sell me that story.

SP: In the October/November 2012 issue of *SolarPro* magazine, we published module specifications for UL-listed and CEC-eligible PV modules. Even after we filtered the table to include only modules rated 200 W or larger, there were more than 900 modules. What is your advice to the people who have to make purchasing decisions?
AB: I read that article and was also struck by the number of modules. I believe there were more than 60 manufacturers included in that table. Every one of those companies is probably saying: "My product is the best. It performs the best. This is the product you should be buying."

Obfuscation is here! People don't know what to choose. They are coming to our booth and saying, "You have to help me understand what I should buy." We're helping them understand that materials matter.

You have to dig deeper into the module. You have to ask more questions about what it's made of and how it's consistently manufactured. What are the cells? What are the edge seals? What is in the backsheet? What are the protective materials? There are a lot of different EVAs—the vinyl acetate content varies. There are different types of backsheet materials and different backsheet constructions. But you can specify any of these if you know what you want.

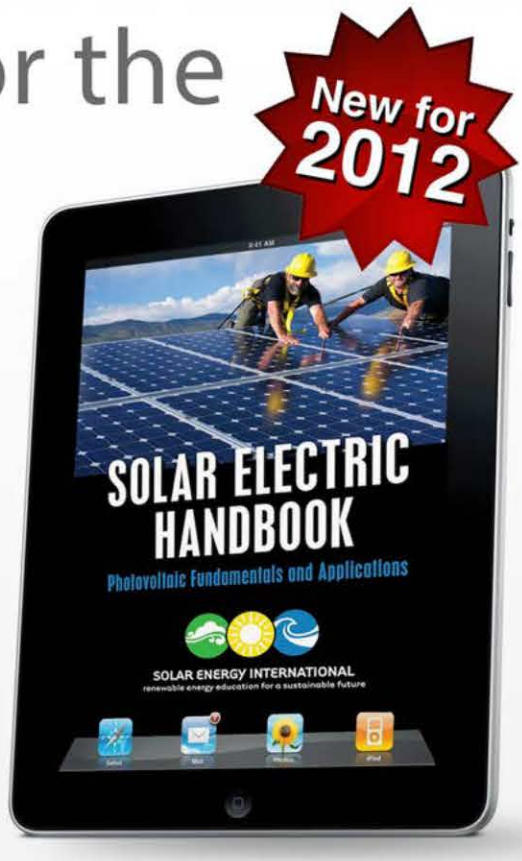
A move to transparency would really help the industry. Right now modules are black boxes with a watt number. But people are hungry for more information. One of the reasons we're here at SPI 2012 is to provide education and awareness, to help people become sophisticated buyers and installers of modules and systems.

CAB, EX2060
Case No. IPR2024-00139
74 of 84

Are you ready for the next generation solar textbook?

It's here!

New for 2012



www.solarenergy.org

Introducing...

PVSelect.com

Your One-Stop Design Tool for Pairing and Comparing Modules and Inverters... Fast, Simple & *FREE*!

- Streamlined module and inverter selection on one Web site
- Over sixty inverters from nine manufacturers
- Over two hundred PV modules from twenty manufacturers



Visit **pvselect.com** today, a free solar design resource provided by

BLUE OAK ENERGY SOLARPRO

DH Solar

The Solar Tracker Company



Fully Adjustable Commercial Trackers

Dual-Axis Tracker

- *40% More Efficient*
- *Pole-mounted/More Efficient/Runs Cooler*
- *Up To 288 sq. ft.~ 4--5 KW Systems*
- *Uses Any Module*
- *Quick & Easy Installation*
- *HD Base Stands Available*

Call For More Information & Pricing

DH SOLAR

(A Division of DH Satellite)

600 N Marquette Rd, Prairie du Chien WI 53821

608-326-8406 ~ 608-326-4233 (fax)

www.dhsolar.net ~ 800-627-9443

TRAINING

Continuing Education for the Pro

For additional training opportunities and course details, visit solarprofessional.com/training.

Arizona

PV Installation Lab
eRenewable Resource Institute
Feb 1 – Feb 3
Mar 1 – Mar 3
Phoenix
erenewableresource.com

PV Installation & Design
eRenewable Resource Institute
Feb 18 – Feb 22
Mar 18 – Mar 22
Phoenix
erenewableresource.com

Grid-Direct PV Design & Installation
Solar Energy International
Mar 4 – Mar 8
Tucson
solarenergy.org

PV Technical Sales
eRenewable Resource Institute
Mar 12 – Mar 16
Phoenix
erenewableresource.com

Advanced PV Design & Compliance
eRenewable Resource Institute
Mar 25 – Mar 29
Phoenix
erenewableresource.com

California

Sunny PRO Club Regional Forum
SMA America
Feb 12
Riverside
smaregionalforums.com

REC Solar Professional Training
REC Group
Feb 13
San Diego
recgroup.com

PV Design & Installation Intensive
Solar Living Institute
Feb 25 – Mar 1
Hopland
solarliving.org

Advanced PV Topics and the 2011 *NEC*
Sean White Solar
Mar 2
Mar 15
San Francisco
maximumpowerpointtraining.com

Advanced PV Systems
Solar Living Institute
Mar 4 – Mar 8
Hopland
solarliving.org

Advanced PV Systems for College Credit
Diablo Valley College
Mar 30 – May 11
Pleasant Hill
dvc.edu

Colorado

NABCEP PV Installer Seminar
Thames Solar Electric
Mar 18 – Mar 22
Denver
thamessolar.com

Florida

Installing PV Systems
Florida Solar Energy Center
Mar 4 – Mar 8
Cocoa
fsec.ucf.edu

Hawaii

Sunny PRO Club Regional Forum
SMA America
Feb 28
Honolulu
smaregionalforums.com

Louisiana

PV Training
ONTILITY
Feb 11 – Feb 15
New Orleans
ontility.com

Maine

Solar Heating Design & Installation
Kennebec Valley Community College
Mar 2 – Mar 6
Fairfield
kvcc.me.edu

Maryland

PV Technical Sales
IEC Chesapeake
Mar 8
Laurel
iecchesapeake.com

New York

PV Refresher Course
SUNY Orange
Feb 11 – Feb 18
Middletown
sunyorange.edu

Wisconsin

PV & Solar Thermal Structural Considerations
Midwest Renewable Energy Association
Feb 23
Milwaukee
midwestrenew.org

Solar Domestic Hot Water
Midwest Renewable Energy Association
Mar 2
Madison
midwestrenew.org

Residential Solar Water Heating Site-Assessor Training
Midwest Renewable Energy Association
Mar 3
Madison
midwestrenew.org

PV Math
Midwest Renewable Energy Association
Mar 15
Madison
midwestrenew.org

Canada

Sunny PRO Club Regional Forum
SMA America
Mar 19
Ottawa, ON
smaregionalforums.com

Online

Allied American University
allied.edu

Allied Schools
training4green.com

Imagine Solar
imaginesolar.com

HeatSpring Learning Institute
heatspring.com

Midwest Renewable Enegy Association
midwestrenew.org

ONTILITY
ontility.com

Solar Energy International
solarenergy.org

Solar Living Institute
solarliving.org

Solar Training School
solartrainingschool.com

Step Up Education
stepupeducation.com

Sun Pirate
sunpirate.com

Zep Solar
training.zepsolar.com

Post or view professional trainings online at: solarprofessional.com/training

CAB, EX2060
Case No. IPR2024-00139
76 of 84

NABCEP Continuing Education CONFERENCE

March 8, 9 & 10, 2013 – Sacramento, CA



Second Annual Continuing Education Conference for NABCEP Certified Installers and Technical Sales Professionals.

This conference offers NABCEP Certified Installers and Technical Sales Professionals an opportunity to fulfill their entire 18 hours of continuing education requirements at one event. Registrants will be able to attend workshops on the NEC, financial analysis, safety, emerging fire codes and manufacturers' training sessions.

California State University, Sacramento is home to the California Smart Grid Center and the Engineering Department is acting as the on campus host to this event.

This conference builds upon the highly successful Continuing Education Conference held in March 2012. "As a trainer, I have to say that was hands down the best audience I've had the opportunity to present to. I think it is a reflection of the NABCEP certifications," said Ryan Mayfield of Renewable Energy Associates, LLC who will be providing his popular session on NEC Updates again in Sacramento.

- Registration to the event will be limited to NABCEP Certified Installers and Technical Sales Professionals.
- Industry-leading manufacturers and organizations taking part include: Ameresco; Burndy LLC; Enphase Energy; Magnum Energy; Mitsubishi Electric; Morningstar Corporation; Power-One; Quick Mount PV; Schletter; Schneider Electric; SMA; Solar Edge; SolarWorld; Solectria Renewables; Tigo Energy; Rolls Battery Engineering; and Zep Solar.
- Educational sessions from: Ryan Mayfield on NEC updates; Andy Black on Economics of PV; and Tony Diaz on Roofing for Non-roofers. Safety training by SolarCity.
- Conference attendance will be capped at 300.
- Meet and exchange information on best practices with other NABCEP certified professionals.
- More opportunities to meet one-on-one with manufacturers' representatives.

To register or for more information, go to
www.nabcep.org/ce-conference-2013

Sponsored by

SMA

inter solar connecting solar business | NORTH AMERICA

Schneider Electric

SolarWorld

Rolls BATTERY ENGINEERING

SOLARPRO

exclusive conference media partner

IRC Solar Roof Systems
Belmont Hill School



Courtesy IRC Solar Roof Systems (4)

Overview

DESIGNER: Steven J. Strong, president, Solar Design Associates, solardesign.com

LEAD INSTALLER: Michael Donnelly, director of electrical operations, IRC Solar Roof Systems, ircmaine.com

DATE COMMISSIONED: January 16, 2012

INSTALLATION TIME FRAME: 45 days

LOCATION: Belmont, MA, 42.5°N

SOLAR RESOURCE: 4.3 kWh/m²/day

HIGH/LOW DESIGN TEMPERATURES: per Solar ABCs solar reference map: 90°F/1°F

ARRAY CAPACITY: 186.7 kW

ANNUAL AC PRODUCTION: 232 MWh

IRC Solar Roof Systems, an affiliate of IRC Industrial Roofing Companies, was contracted to develop a 186 kW PV installation at Belmont Hill School, a private school located in Belmont, Massachusetts. The 14,000-square-foot array is installed on the roof of the school's Jordan Athletic Center and generates enough electricity to offset approximately 20% of the facility's electrical demand.

The 778-module system is one of the largest school-based projects in eastern Massachusetts and the first commercial PV interconnection for the municipal-owned local utility, Belmont Municipal Light Department (BMLD). An initial challenge was working with BMLD's existing regulations for commercial solar production. While Massachusetts requires investor-owned utilities to support distributed generation and system net metering, municipal-owned utilities need participate only voluntarily. This required IRC to work with the BMLD board to gain approval of the project's net metering program.

In the design phase, a single central inverter was considered. However, the only available location was not ideal because the inverter would have been located in a high-traffic area near the school's delivery entrance. Multiple string inverters were the preferred solution based on an available exterior wall surface at the second-floor level. An adjacent low-slope roof provided the installation crew and future maintenance crews a safe and convenient working surface. School administrators also favored the location since the inverters are not visible from ground level.

The structure supporting the main standing-seam metal roof over the Jordan Athletic Center's ice rink is composed of light-gauge purlins with 4.5-foot on-center spacing. Utilizing an attachment method such as the railless S-5! PV Kit would have streamlined

CAB, EX2060
Case No. IPR2024-00139
78 of 84





the attachment to the metal roofing seams but would have resulted in excessive point loading between the structural purlin members. The engineered solution uses IronRidge XRS extruded aluminum rails in conjunction with S-5! mounting clamps to span the structural members while transferring the collateral loads created by the PV array directly to the purlins.



The PV source circuits are combined at the array to minimize the number of conductors from the roof to the inverter location. This design approach required 14 disconnecting combiners that are mounted on the roof surfaces in close proximity to the array. The location of the combiners assisted with PV source-circuit wire management by allowing an easy transition to conduit for the output circuits. The inverters' 277 Vac circuits are combined in a panelboard at the inverter location to simplify the conductor run to the facility's main distribution panel.

IRC worked with the school's faculty and staff to integrate an educational component that allows students, teachers and parents to view real-time and historical performance and environmental data. A 40-inch flat-screen monitor installed in the athletic building displays continuously updated system information that highlights the environmental benefits of Belmont Hill School's solar project. An online classroom supplements the on-site learning opportunities.

> "Engineering a solution at Belmont Hill School was made easier by the partnership of the school, the local energy committee and the support of the Belmont Municipal Light Department. IRC Solar Roof Systems is contracted to provide ongoing O&M for both the PV and the metal roofing systems."
>
> *—Kurt Penney, business development, IRC Solar Roof Systems*

Equipment Specifications

MODULES: 778 Sharp ND-240QCJ, 240 W STC, +5/-0%, 8.19 Imp, 29.3 Vmp, 8.75 Isc, 37.5 Voc

INVERTERS: 3-phase, 277/480 Vac service; 14 Fronius IG Plus V 12.0-3WYE277, 12 kW, 600 Vdc maximum input, 230–500 Vdc MPPT range

ARRAY: 14 modules per source circuit (3,360 W, 8.19 Imp, 410.2 Vmp, 8.75 Isc, 525 Voc); four source circuits per inverter typical (13.4 kW, 32.8 Imp, 410.2 Vmp, 35 Isc, 525 Voc); 186.7 array capacity total

ARRAY INSTALLATION: Roof-mount, steel standing-seam roofing panels, IronRidge XRS racking, S-5! mounting clamps, 210° azimuth, 18.4° tilt

ARRAY STRING COMBINERS: 14 Bentek six-pole Integrated Disconnect Combiners, 15 A fuses

SYSTEM MONITORING: DECK Monitoring production and environmental monitoring; Obvius AcquiSuite server, dashboard and Modbus communication

CAB, EX2060
Case No. IPR2024-00139
79 of 84

BE CONNECTED.
BE CURRENT.
BE COMPETITIVE.



PV America® EAST

Surge forward with connections, solutions and professional development designed to help your business grow as fast as the PV industry itself. **PV America 2013 East** keeps you on top of rising demand for PV with: technology from **150** exhibitors, **30+** expert-led conference sessions and ample networking with **4,000+** professionals.

PV Solar Technology Solutions
February 5 – 7, 2013
Pennsylvania Convention Center
Philadelphia, Pennsylvania

Register today at www.pvamericaexpo.com/east

Presented By:

SEIA Solar Energy Industries Association®

SEPA solar electric power association

Advertiser *Index*

Company	Page
Advanced Energy	49
AEE Solar	1
Affordable Solar	21
AllEarth Renewables	29
Allied Moulded Products	35
altE direct	45
Antaris Solar	25
Array Technologies	22
Backwoods Solar Electric Systems	53
Creotecc	57
DH Solar	73
eGauge Systems	40
EKO Instruments	57
Eltek	43
Energiebau	37
Exeltech Solar Products	7
Helios Solar Works	17
HEYCO	12
HomePower.com Contractors Directory	79
MidNite Solar	69
NABCEP	33
NABCEP Continuing Ed. Conference	75
ONTILITY	11
Power-One	3
PV America 2013 East	78

Company	Page
PVSelect.com	73
Quick Mount PV	IBC
REFUsol	5
Schletter	65
Seaward Solar	4
SMA America	BC
Snake Tray	34
SnapNrack	IFC
Solar Energy International	73
Solar Pathfinder	69
Solar Universe	15
Solarbine	13
SolarHub	69
SolarPro Subscription Renewal	10
SolarWorld	55
Solectria Renewables	27
Solmetric	23
Solon	9
SPG Solar	51
SunEarth	57
TEAL Electronics	36
Unirac	19
US Solar Distributing	16
Zep Solar	2
Zomeworks	69

The homepower.com
CONTRACTORS DIRECTORY

From the publisher's of *SolarPro*, *Home Power* magazine has been educating the residential renewable energy market since 1987. Homeowners everywhere look to us when it comes time to choose a contractor for their project. Will they find your business listed in our ***FREE*** online directory?

- **Highly Qualified, Highly Educated Customer Prospects**
- **Over 1,000 Installation Businesses Are Already Listed**
- **Adding Your Listing Is Fast, Effective and *FREE***

Add your business today! Login or register at
homepower.com/contractors



CAB, EX2060
Case No. IPR2024-00139
81 of 84

Aurora Energy
Talbot County Public Safety Center

Overview

DESIGNER: Fariborz Mahjouri, PE, CEO, Aurora Energy, aurora-energy.com

LEAD INSTALLER: Mike Kabler, project manager, Aurora Energy

DATE COMMISSIONED: June 2012

INSTALLATION TIME FRAME: 23 days

LOCATION: Easton, MD, 39.2°N

SOLAR RESOURCE: 4.6 kWh/m²/day

ANNUAL HEATING DEGREE-DAYS: 4,707

RECORD LOW TEMPERATURE: -21.7°F

COLLECTOR ARRAY AREA: 1,686 sq. ft.

AVERAGE ANNUAL PRODUCTION: 153 MWh

Equipment Specifications

COLLECTORS: 32 Solar Panels Plus SPP-30A evacuated tube, 52.7 sq. ft. each

HEAT EXCHANGERS: Advanced Industrial Components L-Line LA 14-50

PUMPS: 4 Grundfos UPS 26-99 FC

STORAGE: Existing 1,500-gallon tank

CONTROL & MONITORING: Thermo Technologies USDT 2005

FREEZE CONTROL: Closed-loop antifreeze, DOWFROST HD heat transfer fluid

COLLECTOR INSTALLATION: Nonpenetrating ballast mount on TPO roofing, 180° azimuth, 38° tilt

Do you have a recent PV or solar heating project we should consider for publication in *SolarPro?*

Email details and photos to: projects@solarprofessional.com



Courtesy Aurora Energy (2)

Fluctuating hot water demand presents an interesting challenge for commercial water heating system design. In the Talbot County Public Safety Center, the average inmate population is approximately 100, but the maximum population can reach as high as 157. To solve the design challenge posed by this wide swing in demand, Aurora Energy developed a rooftop heat dissipation system to prevent system overheating during periods of low usage.



The array consists of 32 evacuated-tube collectors, with 30 tubes each, plumbed in two parallel banks of 16 collectors. A ballasted, nonpenetrating mounting system secures the collectors to the roof surface. Each of the two collector loops is coupled with an equivalent number of fin-tube heat dissipaters that are controlled by thermostatic diverting valves.

The system's pump station was built at the site and consists of two pumps and one micro-bubble separator for each loop. Each pump has a dedicated controller. The first pump runs at a lower temperature gradient between collector inlet and outlet. The second pump starts at a higher temperature gradient and serves as a backup if the first pump fails. In addition, the second pump increases flow rate during periods of high solar insolation. The system's heat exchangers and pumps are located close to the collector arrays to keep the glycol-circuit piping as short as possible.

> "Manipulating tube numbers to manually increase and decrease the active capacity of the collector field to match inmate population would have placed an undue burden on the facility staff. The solution was a heat dissipation system that automatically matches solar hot water production with consumption, thereby eliminating the potential for system overheating."
> *—Mike Kabler, Aurora Energy*

CAB, EX2060
Case No. IPR2024-00139
82 of 84



With our severe Rocky Mountain winters, only Quick Mount PV delivers the installation speed and absolute confidence we need.

Will Serene, Independent Power Systems

Extreme Conditions Demand Quick Mount PV

Will Serene designs rooftop solar systems in Colorado, where Rocky Mountain winters deliver enough wind-driven rain, ice and snow to push marginal components to their breaking point.

That's why Will trusts Quick Mount PV – the strongest, longest lasting rooftop PV mounts on the market today – to keep his installations secure and watertight. "Quick Mounts install fast and keep our crews moving efficiently from job to job," Will said. "And there's a Quick Mount for just about any kind of roof we see."

Quick Mounts are flashed with heavy-gauge aluminum and manufactured entirely without welds or seams. The patented QBlock waterproofing seal is elevated 7/10" above the surface of the flashing where rainwater flows. All exposed fasteners are stainless steel. And Quick Mount's pullout and shear strength are the best in the industry.

Designing the perfect PV array for harsh environments can be a real challenge. Choosing the best mount is easy:

It's Quick Mount PV.

QUICK MOUNT PV ADVANTAGES:

- 100% IBC compliant
- Patented elevated water seal
- All aluminum flashing
- All hardware included
- Works with all leading racks
- 10-year warranty; 50-year expected life
- Live tech support, year-round training

INDUSTRY LEADING TECHNOLOGY



QBase: Where the Roof Meets the Load

Our **QBase Low Slope**, **QBase Comp** & **QBase Universal Tile Mounts** use the world's strongest off-the-shelf base.



QBlock: Patented Elevated Water Seal

Our **Classic Comp** & **Shake Mounts** install watertight, code-compliant attachments with a single bolt.



CLASSIC COMPOSITION



CLASSIC SHAKE



QBASE COMPOSITION



QBASE LOW SLOPE



QBASE UNIVERSAL TILE

MADE IN THE USA

925-478-8269

products@quickmountpv.com

www.quickmountpv.com

Quick Mount PV®

RESPECT THE ROOF®

Even grids have an off day



Backup power when it's needed most

When the power goes out, who will you trust to keep the lights on? A grid-connected solar array is a great way to save money on utility bills, but only a system with battery backup can deliver true security and independence. Take the sound investment of grid-tied PV to the next level with the SMA Sunny Island.

Because preparation is only as good as the equipment that stands behind it.



www.SMA-America.com