MARCH 2022
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CONSTRUCTION AND MAINTENANCE

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SPECIAL SECTION
EV Charging Infrastructure

SHOW ME THE MONEY

*The $1.2-trillion **Infrastructure Investment and Jobs Act** should drive significant business to just about every corner of the electrical industry. Read more on* ***pg. 22***

IN THIS ISSUE

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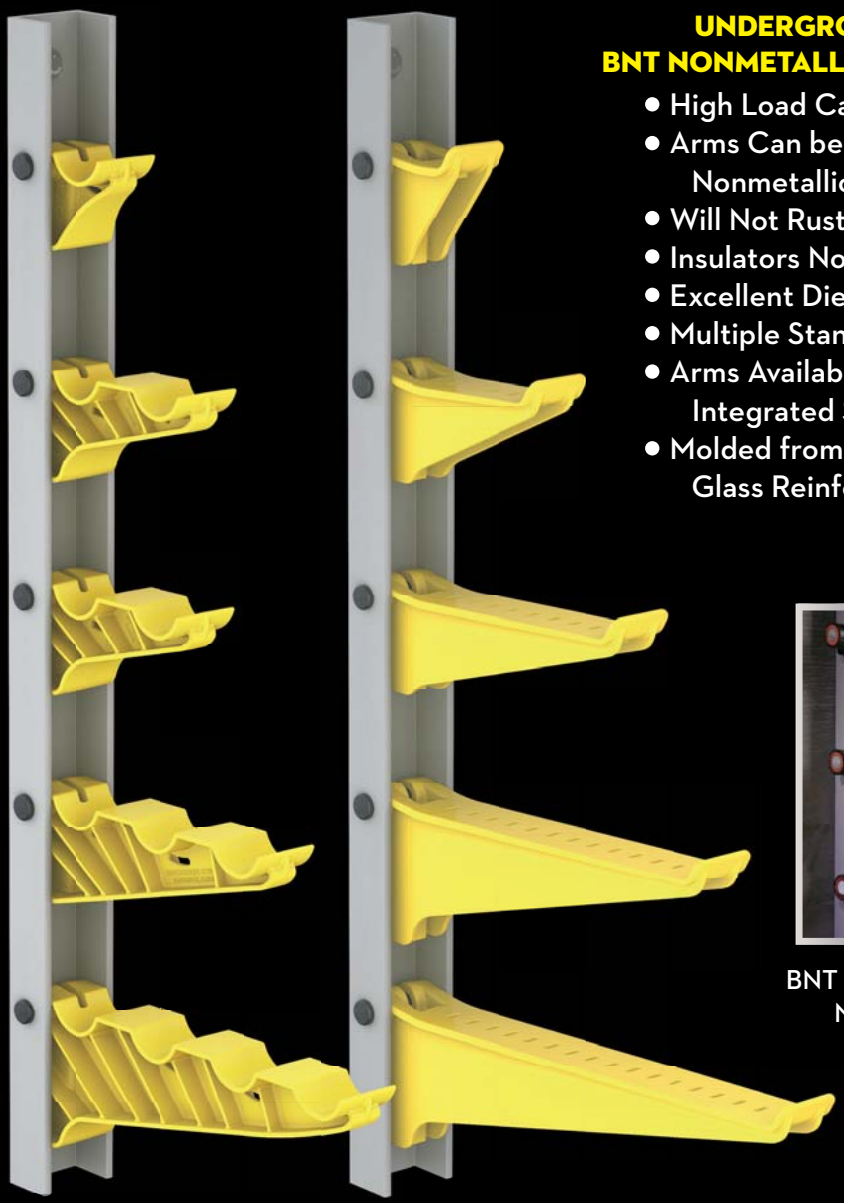
The BNT Nonmetallic Cable Support For Power Manholes And Vaults



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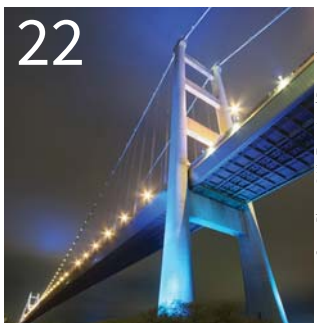

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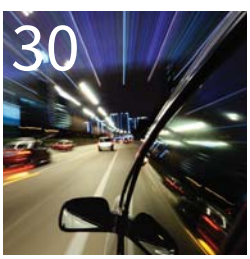
EV SPECIAL SECTION



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DEPARTMENTS

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IP1

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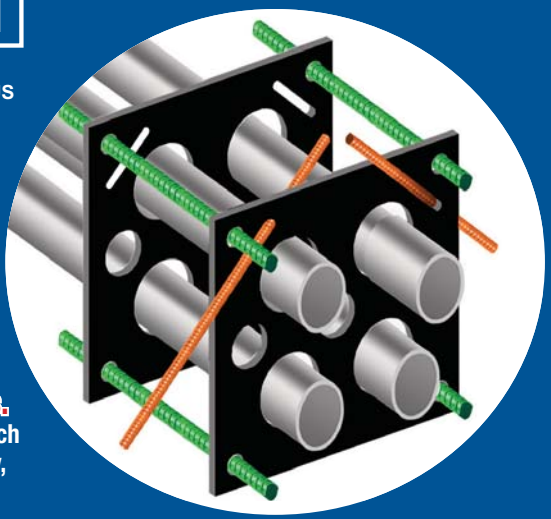

Assemble Conduit Above Trench-

No Workers Below - Prevents Injuries and Deaths.

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IP3b

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Meets Flexible Mandrel Test Requirements

Bore Spacers **IP2**

Sizes 1/2" thru 6"

Roll assembled conduit into caissons and under obstructions

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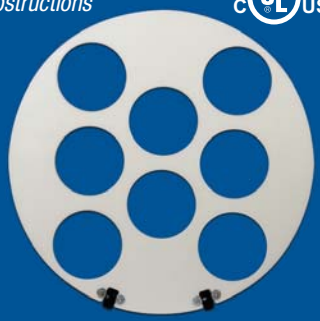

IP13A-F

Conduit Transition Couplings

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PVC Schedule 40 & 80

Transitions in Less Than

5 Minutes

PATENT PENDING

IP15

End Bell Adapter

Schedule 40/80 PVC

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Save Cost on the Rigid Nipple, Tape & Labor

Use for Entire Job - Not Just for Repair

IP15

1 Piece Reaming Bit

1/2" thru 6"

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EDITOR'S CHOICE: TOP PRODUCT PICKS FOR MARCH 2022 – PART 1

Photo Gallery ▶ Check out five recent product innovations from around the industry.
https://bit.ly/3MshXng

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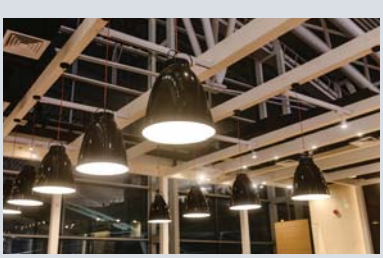
PREVENTING ELECTRICAL SHOCKS ON THE JOB

Safety ▶ Electrical Consultant Mark Lamendola shares advice on avoiding electrical hazards on the job.
https://bit.ly/3hXUFrm



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INTRODUCTION TO COMMERCIAL SERVICE CALCULATIONS

Training ▶ This real-world example illustrates the process of sizing branch-circuit conductors.
https://bit.ly/3tLvdLo

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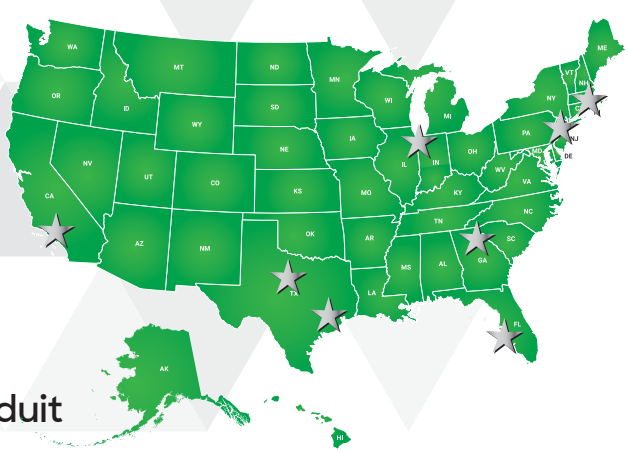

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A Front Row Seat to the Future

By Ellen Parson, Editor-in-Chief

Now almost four months after the Infrastructure Investment and Jobs Act (IIJA) was signed into law by President Joe Biden (on Nov. 15, 2021), a lot of knowns and unknowns remain. One thing we do know is, at roughly $1.2 trillion ($550 billion of which will be earmarked for infrastructure projects over the next five years), this piece of legislation marks the single largest infrastructure revitalization investment since construction of the interstate highway system in the 1950s. A few things we don't know are the exact time frame in which "plans" will turn into "actions" or the specifics surrounding how, where, and when individual projects will play out across the country. As of press time in mid March, Congress has yet to approve the full funding. However, once that step occurs, it will be up to the individual agencies (such as the U.S. Departments of Transportation and Energy, the EPA, and FEMA) to start doling out money. Geared toward modernizing almost every type of U.S. infrastructure imaginable, according to the White House, the $550 billion in new spending will target the following areas (plus more):

- $110 billion for roads, bridges, and major projects
- $66 billion for passenger and freight rail
- $11 billion for transportation safety
- $39 billion for public transit
- $17 billion for ports and waterways
- $25 billion for airports
- $7.5 billion for clean school buses and ferries
- $7.5 billion for electric vehicle charging
- $1 billion to reconnect communities, including funds for projects that remove barriers to opportunity caused by legacy infrastructure.

Turn to page 22 for a special report by Freelance Writer Tim Kridel on the significant amount of business the IIJA stands to bring to just about every corner of the electrical industry. Not only does he provide an inside look at what industry experts foresee in terms of type and scope of projects, but he also does a phenomenal job of breaking down a vast topic into easy-to-understand pieces. As can be expected with this type of monumental, multi-year initiative run by the government, progress won't happen over night. But the good news is, it will eventually happen — and, when it does, the electrical industry will have a front row seat.

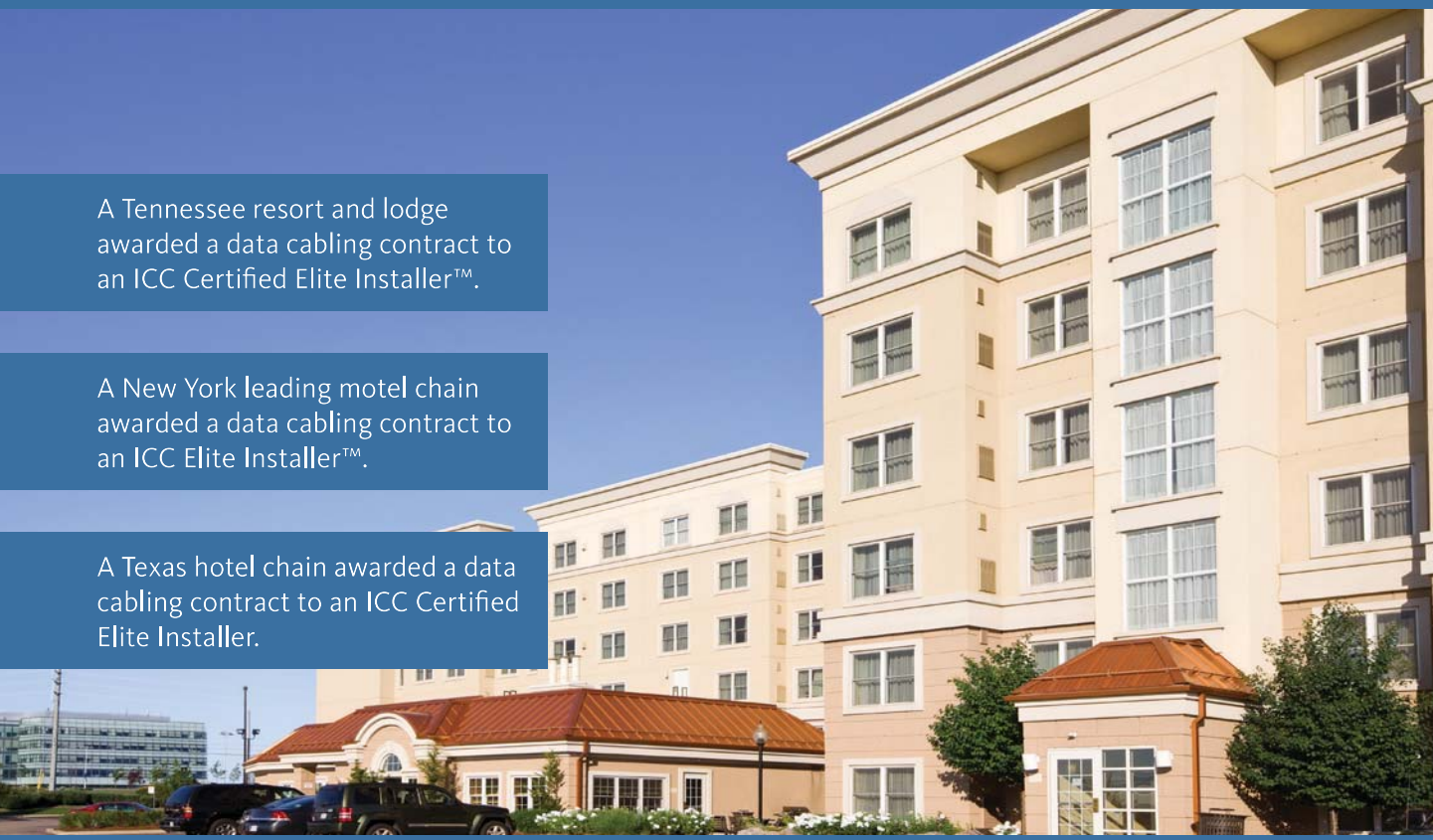
"It will take electrical engineers and contractors, as well as their clients, a while to navigate the IIJA's myriad programs, funding formulas, timelines, and other nuances," writes Kridel. "That's not necessarily a bad thing because it's also going to take a lot of time — probably the better part of this year — to line up everything necessary to start work on IIJA projects."

As the article points out, there are at least three major hurdles that stand in the way of real momentum. First, President Biden signed a bill, not a check, notes Kridel. So, disbursement of the money could take months (or years, in some cases). Even if all funds were available today, supply chain delays present a formidable obstacle that will inevitably hinder the industry's ability to keep up with demand. And then there's always the chronic skilled labor shortage, which isn't going away any time soon. Despite these challenges, there's no doubt that resilient electrical professionals will be poised to profit. For more information on how to stay updated on infrastructure revitalization from a state and local government perspective, peruse the White House's 465-page guidebook for "Building a Better America" at https://bit.ly/3vTynz9.

Diving into one of the specific areas called out by the IIJA as a top priority, *EC&M* has also dedicated more than 30 pages in this issue to a special section on the evolution of electrical vehicle charging infrastructure. Starting on page 29, read the compilation of feature articles covering all of the key considerations electrical professionals should keep in mind as the national buildout of electric vehicle (EV) charging infrastructure takes shape.

Ellen Parson

Are You Profitable Installing Hotel Cabling Projects?



A Tennessee resort and lodge awarded a data cabling contract to an ICC Certified Elite Installer™.

A New York leading motel chain awarded a data cabling contract to an ICC Elite Installer™.

A Texas hotel chain awarded a data cabling contract to an ICC Certified Elite Installer.

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50 Counties to Watch in 2022

Check out *EC&M*'s picks for the 50 counties with the most growth potential this year.

By Jim Lucy, Editor-in-Chief, *Electrical Wholesaling*

Need to map out which counties in your market area may offer the best growth opportunities this year? The U.S. government offers a surprising amount of free market data that can point you in the right direction. The U.S. Census Bureau; Bureau of Labor Statistics; and Bureau of Economic Analysis offer free data on employment, building permits, housing starts, and general business activity that can help you discover pockets of potential construction activity before projects actually start breaking ground.

Two good economic indicators from the U.S. Census Bureau track population growth and building permits on a county, metropolitan statistical area (MSA), state, and national level. *EC&M*'s editors used this data to identify and rank the fastest-growing counties in the United States (see **Table** on page 10). Let's look at these two leading economic indicators in more detail.

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POPULATION DATA

Population growth (or decline) directly impacts the electrical construction industry because new residents need places to live, shop, go to school, worship, work, and play. When folks move into or leave a local market area, it immediately affects the potential demand for the construction and renovation of homes and apartments, schools and colleges, churches, synagogues and other houses of worship, hospitals and medical offices, strip malls, government offices, sporting facilities, and other retail, commercial, and institutional construction.

With the U.S. Census Bureau's population data (released annually), you can quickly identify where the most residents are moving into or leaving a geographic area. The **Map** on page 12 uses this data to show you which counties have added or lost population over the past 10 years and clearly illustrates the massive population shift the United States is experiencing — with tens of thousands of people moving from areas in the Midwest and Northeast to Sunbelt locations in the Carolinas, Georgia, Florida, Texas, and Arizona as well as Intermountain states like Colorado, Idaho, and Utah.

The population growth in the fastest-growing counties in these states is staggering. For instance, from 2015 to 2020, the Phoenix metropolitan area in Maricopa County, Ariz., added 404,658 new residents (+9.7%), and Texas had five counties with population increases of over 100,000 in this period: Travis County (+120,500) and Williamson County (+110,127) in the Austin metropolitan area; Harris County (+181,694) in the Houston area; and Collin County (+157,055); and Bexar County (+132.012) in the San Antonio metropolitan area.

BUILDING PERMITS

Construction economists consider building permits available each month from the U.S. Census Bureau to be a

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EC&M's Picks for the 50 Fastest-Growing Counties in the United States in 2022

County	Metropolitan Area (MSA)	Size of County	2020 Population Estimate	2015-2020 Population Change	2015-2020 % Population Change	1-Unit Permits per 1,000 Residents	1-Unit Building Permits (Nov. 2021)	1-Unit Building Permits (Change YOY)	1-Unit Building Permits (% Change YOY)
Williamson County	Austin-Round Rock, TX	Medium	617,855	110,127	21.7	13.84	8,549	3,546	70.9
Collin County	Dallas-Fort Worth-Arlington, TX	Large	1,072,069	157,055	17.2	11.83	12,679	2,890	29.5
Osceola County	Orlando-Kissimmee-Sanford, FL	Medium	385,315	61,455	19.0	17.11	6,591	2,246	51.7
St. Johns County	Jacksonville, FL	Medium	278,715	52,133	23.0	20.87	5,817	1,802	44.9
Wake County	Raleigh, NC	Large	1,132,271	109,400	10.7	7.90	8,950	2,005	28.9
Manatee County	North Port-Sarasota-Bradenton, FL	Medium	411,219	48,398	13.3	14.25	5,860	2,405	69.6
Maricopa County	Phoenix-Mesa-Scottsdale, AZ	Large	4,579,081	404,658	9.7	5.46	25,000	4,262	20.6
Sarasota County	North Port-Sarasota-Bradenton, FL	Medium	443,465	38,366	9.5	11.96	5,302	1,837	53.0
Douglas County	Denver-Aurora-Lakewood, CO	Medium	360,750	38,417	11.9	9.42	3,397	1,169	52.5
Mecklenburg County	Charlotte-Concord-Gastonia, NC-SC	Large	1,128,945	94,896	9.2	5.81	6,557	863	15.2
Clark County	Las Vegas-Henderson-Paradise, NV	Large	2,315,963	218,131	10.4	4.76	11,025	3,021	37.7
Harris County	Houston-The Woodlands-Sugar Land, TX	Large	4,738,253	181,694	4.0	4.12	19,533	2,167	12.5
Ada County	Boise City, ID	Medium	494,399	61,145	14.1	9.12	4,509	374	9.0
Montgomery County	Houston-The Woodlands-Sugar Land, TX	Medium	626,351	90,438	16.9	17.65	11,055	3,757	51.5
Bexar County	San Antonio-New Braunfels, TX	Large	2,026,823	132,012	7.0	3.62	7,327	3,107	73.6
Pasco County	Tampa-St. Petersburg-Clearwater, FL	Medium	570,412	75,282	15.2	14.20	8,098	3,959	95.7
Duval County	Jacksonville, FL	Medium	966,728	55,622	6.1	5.84	5,645	929	19.7
El Paso County	Colorado Springs, CO	Medium	728,310	54,216	8.0	6.34	4,616	546	13.4
Ellis County	Dallas-Fort Worth-Arlington, TX	Small	191,760	28,429	17.4	13.56	2,601	463	21.7
Canyon County	Boise City, ID	Small	237,053	30,097	14.5	11.71	2,776	514	22.7
Rutherford County	Nashville-Davidson-Murfreesboro-Franklin, TN	Medium	339,261	40,860	13.7	9.66	3,278	537	19.6
York County	Charlotte-Concord-Gastonia, NC-SC	Medium	289,105	38,320	15.3	8.58	2,481	532	27.3
Madison County	Huntsville, AL	Medium	379,453	26,259	7.4	9.19	3,487	253	7.8
Comal County	San Antonio-New Braunfels, TX	Small	164,812	35,942	27.9	21.79	3,592	734	25.7
Clark County	Portland-Vancouver-Hillsboro, OR-WA	Medium	496,865	39,545	8.6	5.97	2,967	300	11.2
Pierce County	Seattle-Tacoma-Bellevue, WA	Medium	913,890	69,573	8.2	3.26	2,975	737	32.9
Pima County	Tucson, AZ	Large	1,061,175	51,685	5.1	4.46	4,734	1,218	34.6
Travis County	Austin-Round Rock, TX	Large	1,300,503	120,500	10.2	6.43	8,361	68	0.8
Rockwall County	Dallas-Fort Worth-Arlington, TX	Small	109,888	19,630	21.7	23.32	2,563	636	33.0
Cherokee County	Atlanta-Sandy Springs-Roswell, GA	Medium	265,274	29,850	12.7	8.84	2,345	443	23.3
Union County	Charlotte-Concord-Gastonia, NC-SC	Small	244,562	22,511	10.1	10.13	2,478	781	46.0
Henry County	Atlanta-Sandy Springs-Roswell, GA	Small	239,139	22,591	10.4	9.14	2,186	723	49.4
Salt Lake County	Salt Lake City, UT	Large	1,165,517	62,827	5.7	3.40	3,965	350	9.7
Fulton County	Atlanta-Sandy Springs-Roswell, GA	Large	1,077,402	71,650	7.1	2.98	3,207	851	36.1
Chesterfield County	Richmond, VA	Medium	358,245	23,152	6.9	6.23	2,232	523	30.6
Washoe County	Reno, NV	Medium	477,082	34,465	7.8	5.24	2,500	364	17.0
Deschutes County	Bend-Redmond, OR	Small	201,769	27,377	15.7	8.34	1,682	270	19.1
Kaufman County	Dallas-Fort Worth-Arlington, TX	Small	143,198	29,115	25.5	10.43	1,493	787	111.5
Johnston County	Raleigh, NC	Small	216,246	31,116	16.8	14.93	3,228	350	12.2
Gwinnett County	Atlanta-Sandy Springs-Roswell, GA	Medium	942,627	54,030	6.1	4.21	3,972	733	22.6
Davis County	Ogden-Clearfield, UT	Medium	359,232	24,418	7.3	5.20	1,868	318	20.5
Adams County	Denver-Aurora-Lakewood, CO	Medium	519,883	29,435	6.0	5.16	2,681	324	13.7
Polk County	Des Moines-West Des Moines, IA	Medium	494,281	26,764	5.7	5.98	2,954	261	9.7
Oklahoma County	Oklahoma City, OK	Medium	804,041	26,635	3.4	6.20	4,985	953	23.6
Lexington County	Columbia, SC	Medium	303,946	22,091	7.8	7.81	2,375	497	26.5
Denver County	Denver-Aurora-Lakewood, CO	Medium	735,538	52,210	7.6	1.94	1,427	455	46.8
Davidson County	Nashville-Davidson-Murfreesboro-Franklin, TN	Medium	694,176	13,779	2.0	5.56	3,857	766	24.8
San Bernardino County	Riverside-San Bernardino-Ontario, CA	Large	2,189,183	74,831	3.5	1.78	3,901	550	16.4
Durham County	Durham-Chapel Hill, NC	Medium	327,306	26,292	8.7	6.20	2,028	314	18.3
Walton County	Crestview-Fort Walton Beach-Destin, FL	Small	76,648	13,503	21.4	26.00	1,993	745	59.7

Notes: Counties ranked by 10-year, 5-year and 1-year population growth through 2020; year-over-year (YOY) increase in single-family and 5-unit building permits through Nov. 2021 and building permits/1,000 residents. Large counties — 1 million or more residents; medium counties — 250,000 to 999,000 residents; small counties — 250,000 residents or less. All data pulled from the U.S. Census Bureau.

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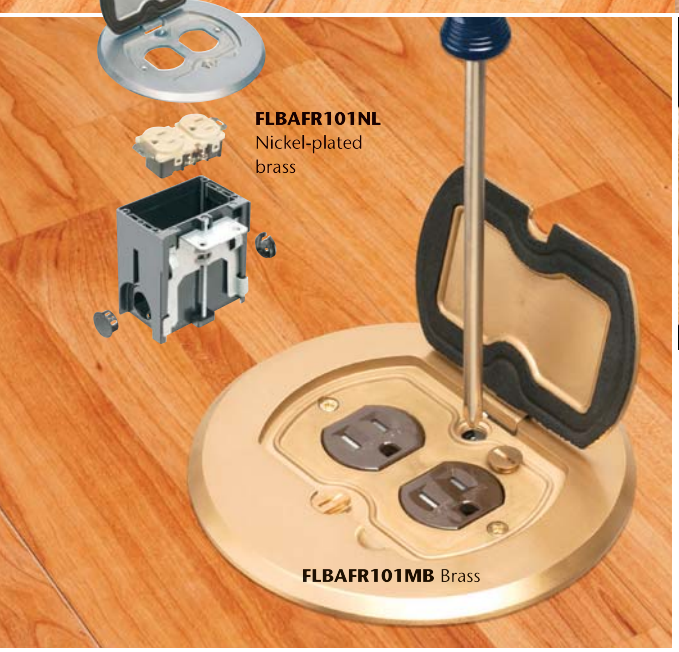

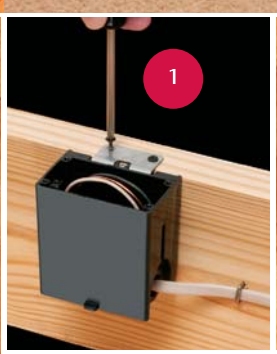

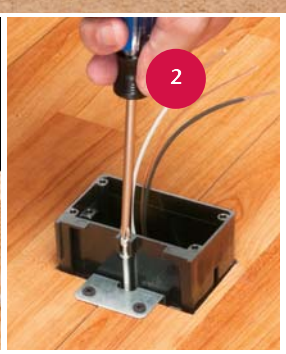

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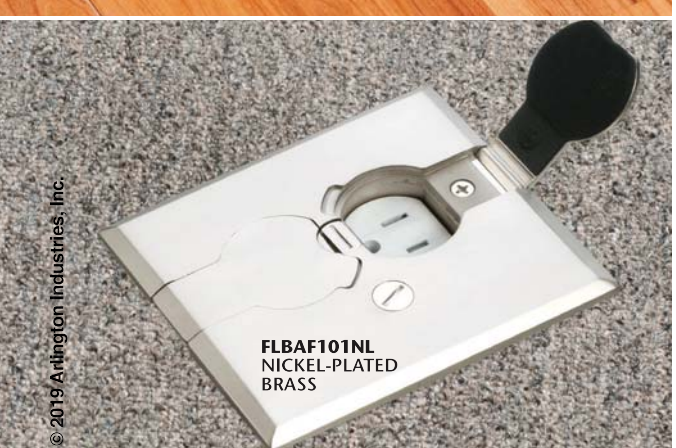

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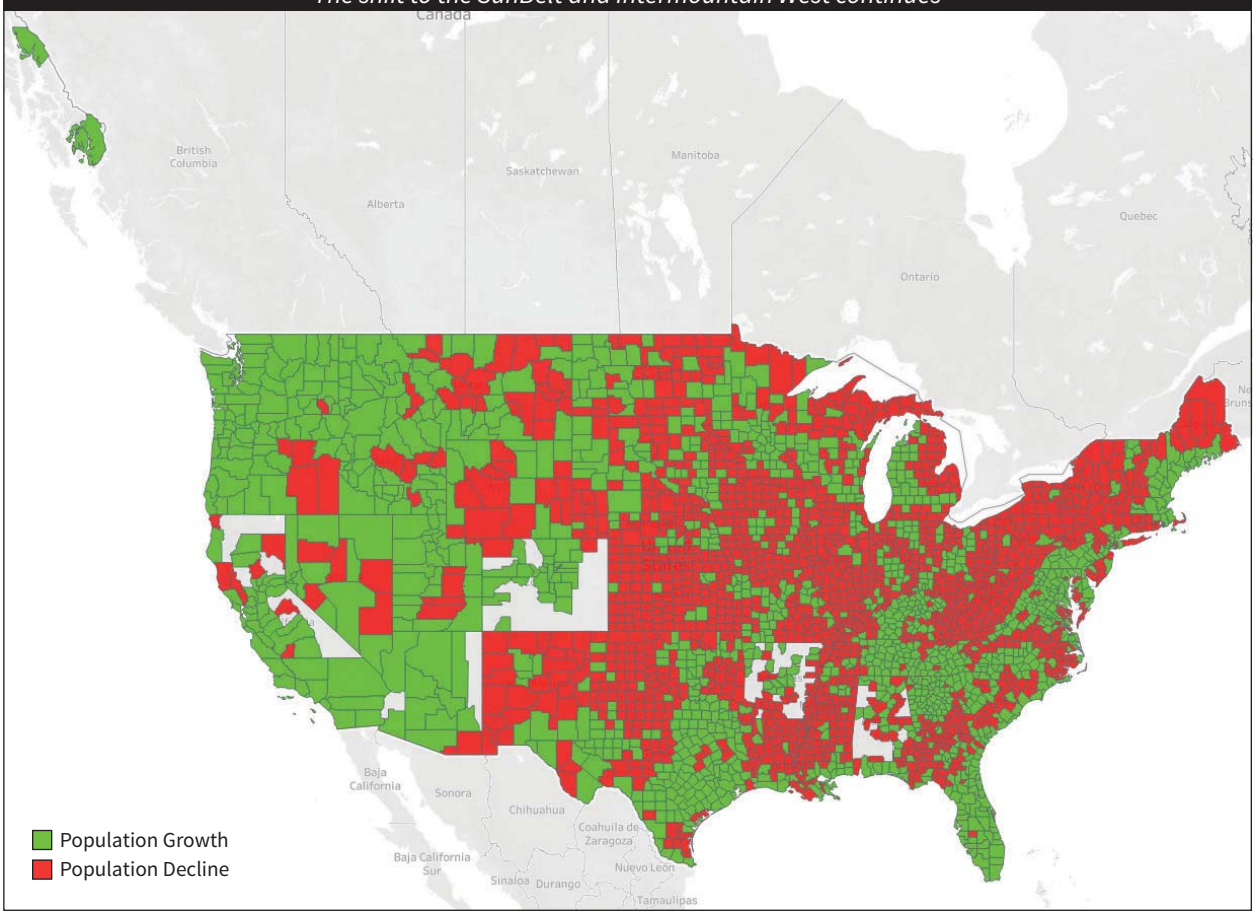
U.S. County Population Change: 2010-2020

The shift to the SunBelt and Intermountain West continues



In this map, the counties outlined in green had population increases over the past 10 years, while the counties in red lost population. It illustrates how a "green wave" of population growth is sweeping over the Sunbelt and Intermountain states. (Map created in Tableau.com)

reliable indicator of future construction activity because home builders generally won't purchase a permit until they are serious about building on a lot. Even if you don't do much in the residential construction or renovation market, you should still watch building permits because once new homes get built, retail, commercial, and other types of construction tend to follow.

As we mentioned earlier, building permits are closely tied to population growth, and most of the market areas in the table ranked high in both population growth and increases in single-family building permits from November 2020 to November 2021. Arizona's Maricopa County was a statistical monster in this category, adding 4,262 single-family permits for a +20.6% year-over-year (YOY) increase. Other housing hot spots are Tampa-St. Petersburg's Pasco County (+3,959 permits); Houston's Montgomery County (+3,757 permits); Austin's Williamson County (+3,456 permits); San Antonio's Bexar County (+3,107 permits); and Las Vegas' Clark County (+3,201 permits).

Construction economists also like to look at how many building permits were pulled in a market area for every 1,000 residents so they can take size out of the equation and evaluate large, medium, and small areas at the same level. When you do that, some small markets generate some eye-popping data that dwarf the U.S. national average of 2.85 permits per 1,000 residents. Five small counties with less than 250,000 residents produced a permit-per-1,000-residents number of more than 20, led by Sumter County, Fla. (26.28) — home to The Villages mega-senior citizen development, and Walton County (26) on Florida's panhandle in the Crestview-Fort Walton Beach-Destin, Fla.

Analyzing market data will also help you see that it's not just the biggest metropolitan areas that provide the most construction or renovation opportunities. Of the 50 counties that *EC&M*'s editors selected for this article, only 12 had more than 1 million residents. Ten counties had less than 250,000 residents, proving that the small can indeed be mighty when it comes to electrical construction market potential. EC&M

If you need the local market data discussed in this article, Electrical Marketing newsletter (www.electricalmarketing.com) offers it at the county, metropolitan area, state and national level for a $99 annual subscription.

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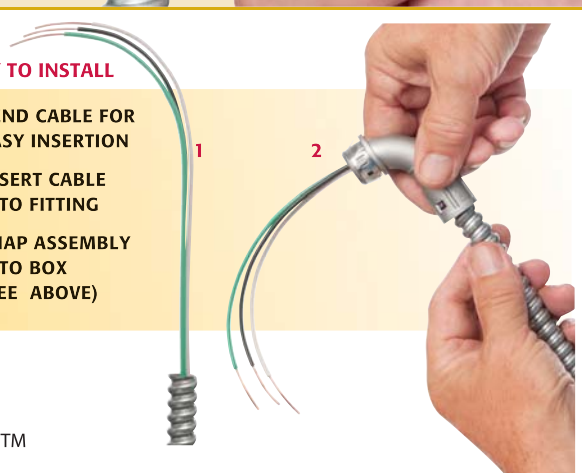

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Tap, Tap, Tap

Understanding the NEC rules for tapping feeders that permit overload protection at the termination of the tap.

By David Humphrey, County of Henrico, Va.

Often used and frequently misapplied, the rules for tapping feeders (NEC Sec. 240.21) continue to confuse many installers. First and foremost, it's important to recognize these rules do not apply to service conductors and other conductors that do not meet the definition of a feeder as outlined in Art. 100.

Section 240.21 requires that overcurrent protection shall be provided in each ungrounded conductor at the point the conductor receives its supply or generally at the starting point of the circuit. The exception to this general rule of overcurrent protection at the point of supply is found in Sec. 240.21(A) through (H). This Section is where we find our tap rules that permit overload protection at the termination of the tap.

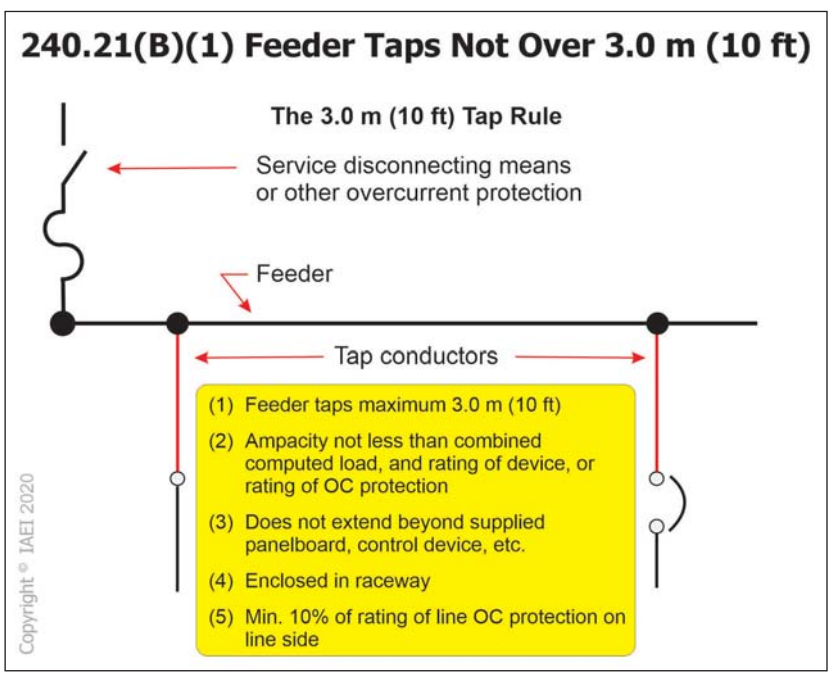

Fig. 1. The 10-ft rule. See Sec. 240.21(B)(1) for specific requirements.

TAP RULES IN GENERAL

Electrical installers are typically involved with taps that are 10 ft or less in length or more than 10 ft but not exceeding 25 ft in length. In some cases, such as outdoor settings, taps are permitted in longer lengths. So, what's the deal with the distance limitation, and why is the distance important?

The length of the tap, along with the size of the tap conductor, are major factors in determining the overall impedance of the tap conductor. Why? The tap conductor is generally smaller than the feeder conductor from which it is tapped. When applying the 10-ft tap rule (**Fig. 1**), the tap conductor may be as small as one-tenth the size of the overcurrent device protecting the feeder from which the tap is made [Sec. 240.21(B)(1)(4)]. When applying the 25-ft tap rule (**Fig. 2** on page 16), the tap conductor may be as small as one-third the size of the overcurrent device protecting the feeder from which the tap is made [Sec. 240.21(B)(2)(1)].

The length of the tap, along with the size of the tap conductor, are major factors in determining the overall impedance of the tap conductor.

OVERCURRENT AND OVERLOAD PROTECTION

Where is the ground-fault/short-circuit protection for the tap? The OCPD is protecting the feeder ahead of the tap. If the impedance of the feeder (and the potentially much smaller tap conductor) is too great, the feeder and its tap will not carry enough current with a fault on the tap conductors to open the overcurrent device upstream that protects both the feeder and the tap conductors. In short, the reason for the size — one-tenth on the 10-ft tap rule and one-third on the 25-ft tap rule — is that these limitations have been demonstrated as sufficient conductor size and length to carry enough current to open the upstream feeder overcurrent device providing the necessary ground-fault/short-circuit

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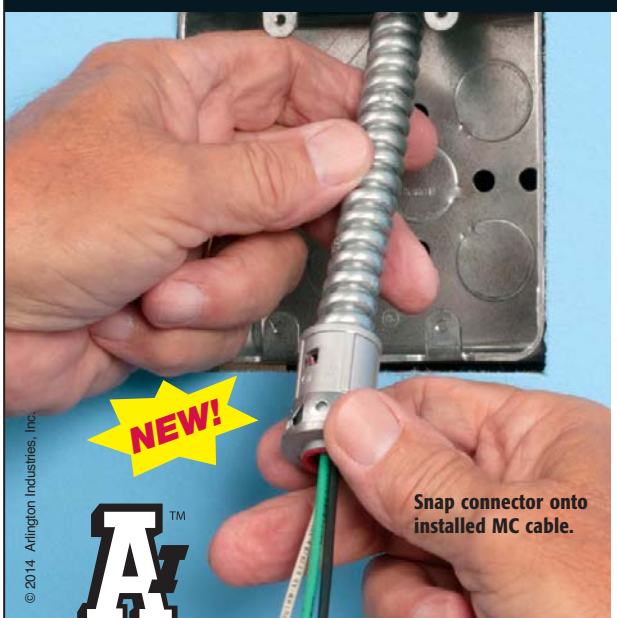

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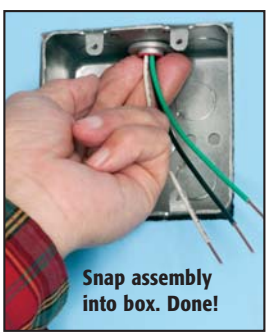

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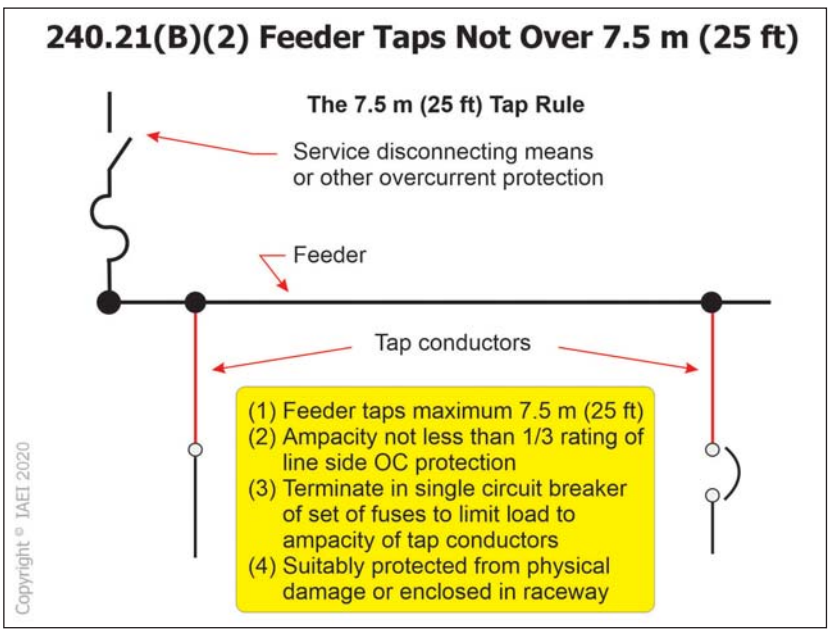

Fig. 2. The 25-ft rule. See Sec. 240.21(B)(2) for specific requirements.

protection of the circuit in the event of a fault on the tap conductor.

Now that we've addressed ground-fault and short-circuit protection, we are left with the final component of overload protection for the tap conductor. Overload protection is provided at the termination of the tap, which is often a fusible switch in a main breaker-type panelboard that is not greater than the ampacity of the tap conductor.

Section 240.4 generally permits the overcurrent device protecting a conductor to be rounded up to the next higher standard overcurrent device, up to 800A, in the event the conductor does not correspond to a standard size as noted in Sec. 240.6. With tap rules and transformer secondaries, DO NOT round up. Section 240.21(B) and (C) clearly state the rules of Sec. 240.4(B) do not apply. If we were to ignore the rule and round up anyway, our tap conductor may be smaller than the minimum size necessary to trip the overcurrent device in the event of a fault.

SIZING THE EQUIPMENT GROUNDING CONDUCTOR

The last element to address is probably the most often missed: sizing a wire-type equipment grounding conductor (EGC) or supply-side bonding jumper installed with the taps. This sizing is often done incorrectly, resulting in an undersized conductor. The EGC for tap conductors is sized based on the upstream overcurrent device, protecting the feeder from which the tap is made. Remember: If there is a fault on the tap conductor, the overcurrent device protecting the upstream feeder is the device that must trip. An example might be that if you tap a feeder protected at 1,000A, the EGC installed with the taps must be sized from Table 250.122 based on a 1,000A overcurrent device. Keep in mind the EGC per Sec. 250.122 is not required to be larger than the ungrounded tap conductors.

The EGC for tap conductors is sized based on the upstream overcurrent device, protecting the feeder from which the tap is made.

When addressing the transformer secondary conductors as found in Sec. 240.21(C), you generally do not have a wire-type EGC routed with the secondary taps — instead, there's a supply-side bonding jumper. This conductor performs many of the same functions as an EGC; however, it is sized based on Table 250.102(C). Using Table 250.102(C) based on the size of the transformer secondary conductors will nearly always result in the need for a larger size supply-side bonding jumper than an EGC sized per Table 250.122.

Although this article does not address every possible scenario that may arise with tap conductors or transformer secondary conductors, a clearer understanding of this information will keep designers, inspectors, and installers on the right track.

For more information on this topic, read "Why Tap a Feeder in the First Place" at https://bit.ly/3t1mGEY. EC&M

David Humphrey is certified as a 1&2 Family, General Electrical Inspector, Electrical Plans Examiner, and he holds a Virginia Master Electrician's certification. He currently serves as an electrical plan review engineer. He can be reached at hum@henrico.us.

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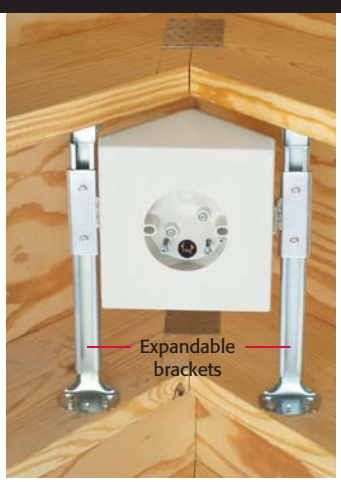

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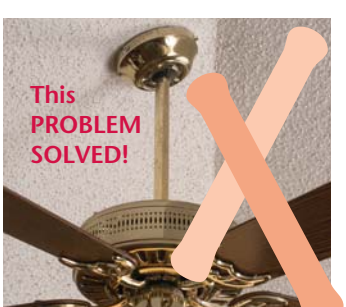

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Home Energy Predictions for 2022

Smart building trends create opportunities for electrical contractors in the residential space.

By Brad Wills, Schneider Electric

The world no longer operates the way it did two years ago, and yesterday's solutions won't solve today's problems. The meaning of home has shifted. As more companies adopt permanent remote working policies — with a quarter of professional jobs expected to be remote by the end of 2022 — it will continue to act as both an office and living space for many people. On top of that, extreme weather continues to intensify and hit new areas of the country with conditions some people have never experienced before. Southern areas are seeing plunging temperatures and harsher winter storms, while the northern regions are experiencing more intense heat waves.

Homeowners need to adapt their spaces for this new reality, where they face increasingly harsh weather that can lead to power disruptions, all while spending more time than ever before at home. For those working from home, they'll need to ensure they have the same reliable power supply and connection they'd have in the office.

There will be a rise in investments in home energy systems this year as homeowners look for long-term solutions that offer greater resiliency and safety measures. This presents an opportunity for electrical contractors, who can advise their customers on the investments and power systems that will make the biggest impact on these goals.

INCREASING DEMAND AROUND HOME RESILIENCY

Having reliable power at home has never been more important, a fact that the pandemic and rising instances of extreme weather — like last year's Texas winter storm — have exposed. The power grids

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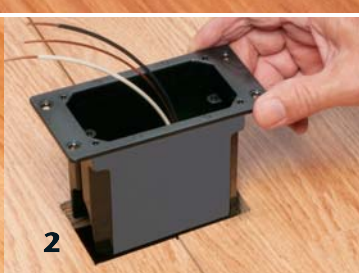

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are old and becoming less reliable, as residents in places like California, who face regular shutoffs during peak wildfire season, can attest. Homeowners across the country are realizing they can't rely on the grid for consistent power and need to take measures to protect their families and livelihoods into their own hands.

The path to adding backup power sources to homes isn't always straightforward. Homeowners must navigate a myriad of options — including solar, generators, and backup batteries — to determine what system best fits their needs. Traditional methods of adding multiple power sources to a home have often used several panels with complex connections that sometimes require a manual switch to move from one source to another. This can be inhibitive to homeowners who aren't well-versed in home power systems.

With the introduction of new technology options over the past couple of years that can condense backup power sources and offer homeowners more control over which system is in use, there will likely be a rise in power management system upgrades in the coming year. Homeowners in 2022 are going to look for solutions that will help maintain energy resiliency in their homes by installing multiple backup power sources that can be easily switched (depending on power needs). Having the ability to decide what circuits to power on the fly and having control over which power source is being used will also become more important.

Photo courtesy of Schneider Electric

An electrician installing an energy center system

CONNECTED DEVICES WILL BE IN HIGH DEMAND

The rise in home Internet of Things (IoT) device adoption has been steady for years, but we've reached a point where homeowners are looking beyond voice assistants and smart light bulbs toward connected devices that help them increase their home's resiliency and save money. For home energy systems, this includes connected thermostats, outlets, and switches that can help regulate energy use for heating and cooling systems and monitor power consumption down to the plug level. These connected devices provide a deeper insight into how energy is being consumed and can show which appliances and devices in a home are contributing the most to energy bills and inefficiencies.

There's a shift taking place in the home energy space that will continue throughout 2022, where energy management systems are viewed through a more modern mindset. Consumers are beginning to demand their power systems be as "smart" as other technology they regularly use, such as smartphones, voice assistants, etc. Electrical contractors should look to tap into this trend by understanding the technology and tools available in the market, so they're able to advise customers on the best power management systems and connected devices for their needs.

SAFETY TO BECOME A TOP PRIORITY FOR HOME TECHNOLOGY

Having a reliable power supply is imperative to safety, especially during colder months when a loss in power can create dangerous conditions by shutting off the heat and making it difficult to store and prepare food safely. This is why easy-to-control backup power sources are essential not only to maintain home resiliency, but also to provide an extra layer of safety.

Connected energy devices play a key role in safety. The same devices that can monitor appliance efficiency and power use from a cost-savings perspective can also give homeowners added peace of mind. Even when they're not at home, a connected outlet and energy monitoring system could allow a homeowner to see which appliances are using energy and identify if they left an appliance such as an oven on or a curling iron plugged in (both of these examples would be major fire hazards). Some connected energy management systems even give the homeowner the ability to cut power to that outlet remotely through a smart relay in the panel or through the smart outlet itself — without needing to go home and manually unplug the device.

LOOKING TO THE FUTURE

This year will likely be a time when homeowners look for long-term solutions to new challenges they face. For electrical contractors, this means customers will be looking to equip their homes with the right energy management technology that will allow them to increase the resiliency and safety of their homes. Luckily, there have been advances in home energy management technology over the last couple of years, which will provide contractors with solutions to meet these ever-changing needs. EC&M

Brad Wills is the director of strategic customers and programs at Schneider Electric. He can be reached at brad.wills@se.com.

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505010AST	Duplex Snap in, 3/4" KO w insulated throat	(2) .590 to .820
4110ST	Snap in, 1/2" KO	.525 to .705
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SHOW ME THE MONEY

The $1.2-trillion Infrastructure Investment and Jobs Act will drive an enormous amount of business to just about every corner of the electrical industry. Here's a rundown of where, when, and what stands in the way.

By Tim Kridel, Freelance Writer

After a long gestation and difficult birth, the Infrastructure Investment and Jobs Act (IIJA) became law on Nov. 15, 2021. Partisan wrangling is the obvious reason it took nearly eight months to go from conception to reality, but another is its unprecedented scope. The IIJA provides funding for just about every type of infrastructure, including water and wastewater treatment plants, transportation (such as rail and buses, roads, bridges, ports, and airports) as well as grid upgrades, renewables, and more. That means plenty of new business for electrical design firms and electrical contractors over the next several years.

"The infrastructure work we'd expect to see at Cupertino Electric would be related to our energy business, especially utility-scale renewable and battery storage projects," says Tom Schott, president and CEO of the San Jose, Calif.-based firm. "On the public infrastructure side, we'd also be likely to see aviation, water treatment, and transit projects."

The states and a variety of federal agencies — such as the Department of Energy and the Department of Transportation — oversee disbursing the money, with timelines varying by project type. In some cases, such as Federal Aviation Administration (FAA) facilities, the money will be "available until expended." In others, it must be used by 2026 or 2028.

"It's going to be a bit of a bell curve," says Phil Squair, vice president of government relations at the Arlington, Va.-based National Electrical Manufacturers Association (NEMA). "Some money is flowing now. Then it'll grow and grow. Most of the funding is probably going to go in years two, three, and four and then start to taper in years four and five."

Ozone Park, N.Y.-based Five Star Electric has a similar outlook.

"I think a small portion of it [will be] in 2022, but I think it's going to have a larger impact over the following years — 2023, 2024, 2025 — especially with the magnitude and the size of the projects," says Russ Lancey, president and CEO.

The White House's "Building a Better America" guidebook, available at https://www.whitehouse.gov/build, spends 465 pages describing how, where, and when each dollar must be spent. (For perspective, that's roughly half the length of the 2020 National Electrical Code.)

"A little over half of the money is going to flow to the states," says Sarah Mathias, government relations director of the Arlington, Va.-based American Public Power Association (APPA), which represents community-owned utilities. "I've been trying to direct them to think about what projects they might have in the queue that could fit into these [IIJA-funded programs]."

$11 BILLION FOR GRID MODERNIZATION

One of the IIJA's goals is grid modernization, which includes making it more resilient against natural disasters, demand spikes, and hackers.

"We expect significant investment in transmission, energy storage to enhance reliability, substations and distribution assets to support multi-direction energy flows, funds for system hardening in the face of aging infrastructure and climate change, and more," says Marty Travers, executive director at Overland Park, Kan.-based Black & Veatch. "Additional opportunities will also exist for electrical engineering firms and electrical contractors who can support vehicle electrification infrastructure deployment funded by the IIJA." (For more information about IIJA funding for EV charging infrastructure, read the articles in our special EV section, starting on page 29.) The $11 billion earmarked for grid modernization has three programs. One is "Preventing Outages and Enhancing the Resiliency of the Electric Grid," which is funded at $5 billion and has some restrictions about how that money can be used.

"The list of what you can do with that is much longer than what you can't do," says the APPA's Mathias. "You can really do anything with that funding except construct new generation or large battery storage if it doesn't have sort of a disruptive event next to it. So, you can't do batteries for something else, or you can't do solar plus storage. But I think you could see a lot of folks obviously making an argument that they want to build battery storage for a resiliency purpose."

Some contractors specializing in solar say that the IIJA doesn't do much in terms of creating additional incentives. Instead, it will spur that market by, for example, funding transmission line expansions.

"That's a big one," says Mike Seger, vice president for renewable energy at Fenton, Mo.-based Aschinger Electric, now part of Guarantee Electrical. "There are a lot of big, utility-scale solar and smaller community solar [projects] in rural areas that are held up because of transmission issues."

Grid modernization also is an example of how the IIJA earmarks money for certain organizations.

"They set aside about 30% of the money for small utilities," Mathias says, referring to the $5 billion outage prevention and resiliency enhancement program. "There's a lot of layers to this program. States can apply and have kind of a plan for their whole state-wide resiliency, which I think could be some bigger infrastructure."

OLD UTILITIES (SUCH AS WATER) AND NEW ONES (SUCH AS BROADBAND)

The IIJA also aims to upgrade drinking water and wastewater infrastructure. A lot of that work falls outside electrical, such as replacing lead pipes, but that still leaves ample opportunities, such as new pumping plants.

"Within the IIJA, the majority of the money coming into the water sector is through the existing clean water and drinking water state revolving funds (SRFs)," says Francesca McCann, business management director of the infraManagement Group, a wholly owned Black & Veatch subsidiary. "There's $12 billion going each to clean water and drinking water SRFs."

The IIJA also earmarks $65 billion for broadband. A big chunk is subscriber subsidies, but $42 billion is for the infrastructure itself. That's an opportunity for electrical contractors who have expanded into the telecom market.

"That will be divided among states based on a formula, and those will be issued as subgrants that ultimately will be the path for that funding going to the contractors," says Steve Truebner, a Black

Photo courtesy of Five Star Electric

Ozone Park, N.Y.-based Five Star Electric specializes in transportation infrastructure, such as subways. President and CEO Russ Lancey thinks IIJA funding for those and other projects will kick into high gear starting in 2023.


Photo courtesy of Five Star Electric

Some electrical contractors have expanded their portfolio to include audio-video (AV) systems. That expertise could enable them to pursue IIJA-funded AV projects, such as digital signage and video surveillance in airport terminals and train stations.

Photo courtesy of Five Star Electric

Work on Newark Liberty International Airport's Terminal A, shown here, started before the IIJA. But it's still an example of the types of large-scale transportation projects that the IIJA will fund over the next several years.

& Veatch director who oversees broadband projects. "NTIA, a sister agency to the FCC, will create parameters. Each state submits a five-year action plan and selects the right broadband deployment projects and partners.

"For electrical contractors, the funding that's going to elevate their business is coming through the states. It's anticipated that most of the infrastructure investment would ultimately be going to internet service providers, and they typically use internal and external contractors to perform the work. Because this is such a massive influx of capital, there's an increased need for external contractors and partnerships to meet the expectations and the demand associated."

NOT SO FAST

It will take electrical engineers and contractors, as well as their clients, a while to navigate the IIJA's myriad programs, funding formulas, timelines, and other nuances. That's not necessarily a bad thing because it's also going to take a lot of time — probably the better part of this year — to line up everything necessary to start work on IIJA projects.

"A lot of this information is still kind of coming out," says the APPA's Mathias. "How much of it flows out this year is a little bit of a question mark, at least in my mind."

There are at least three major hurdles, starting with funding. President Biden signed a bill, not a check. That's why on January 18 — two full months after the IIJA became law — the American Public Works Association (APWA) sent a letter to Congressional leaders urging them to fully fund the IIJA for the 2022 fiscal year. At press time in early March, Congress had not voted on IIJA funding.

"We had a [member] meeting last month in Texas, and one of the issues raised is that they're being confronted by mayors, councils, and county commissioners who say, 'Let's get the money and start building,'" says APWA CEO Scott Grayson. "There is this misnomer out there that the money is all there and accessible, and it's not."

So, for at least the next few months, the electrical industry will have to wait for disbursements to ramp up the bell curve that NEMA's Squair referred to (see **Infographic** on page 26 for more information).

"Expect the full ramp-up of annual appropriations to take several years as new programs will have to be established to direct funding in several areas," says Black & Veatch's Travers. "In others, such as highway funding and certain transit elements, existing formulas determine the flow of money to the states.

"It's also important to note that in many cases, the IIJA and the American Rescue Plan Act (ARPA) — passed in March 2021 — can be used in tandem to allow states and municipalities to pursue infrastructure projects without having to raise matching funds, historically a major barrier to project development at the state and local level. This opportunity could accelerate and expand the range of projects likely to move forward in 2022 and beyond."

E-J Electric Installation Co. expects projects to start quickly once the money starts flowing.

"We see rapid deployment that will be required on many of these projects once fully funded," says Anthony E. Mann, president and CEO of the Long Island City, N.Y.-based firm. "Our roads, bridges, and tunnels desperately need these upgrades and projects to improve our crumbling infrastructure. This tells us that safe, fast-track project delivery will be key. We are gearing up for many of these projects to be delivered utilizing alternative delivery methods including design-build and progressive design-build."

DEMAND CURVE

Even if all the IIJA funds were disbursed today, a second major hurdle would stand in the way of many projects: a supply chain that's already struggling to keep up with booming residential construction and a robust commercial sector.

"Challenges related to supply chain could be exacerbated by the 'Buy America' provision in the infrastructure bill," says the infraManagement Group's McCann. "Many of the components and equipment needed for water projects are not manufactured in the United States. Carveouts and waivers have yet to be determined. All of the issues that we're facing could be heightened with this provision."

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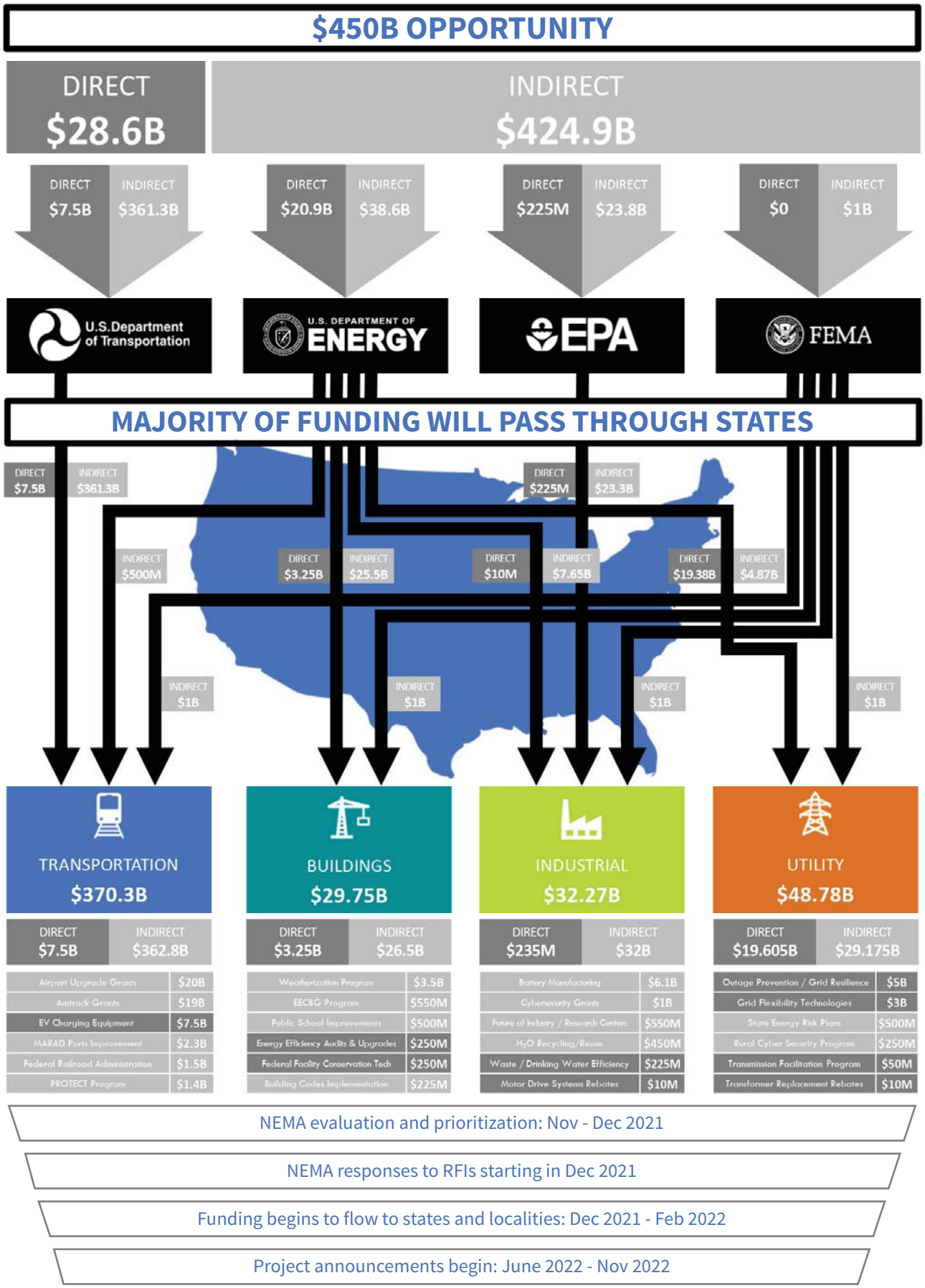
Infographic provided by NEMA

INFRASTRUCTURE INVESTMENT AND JOBS ACT



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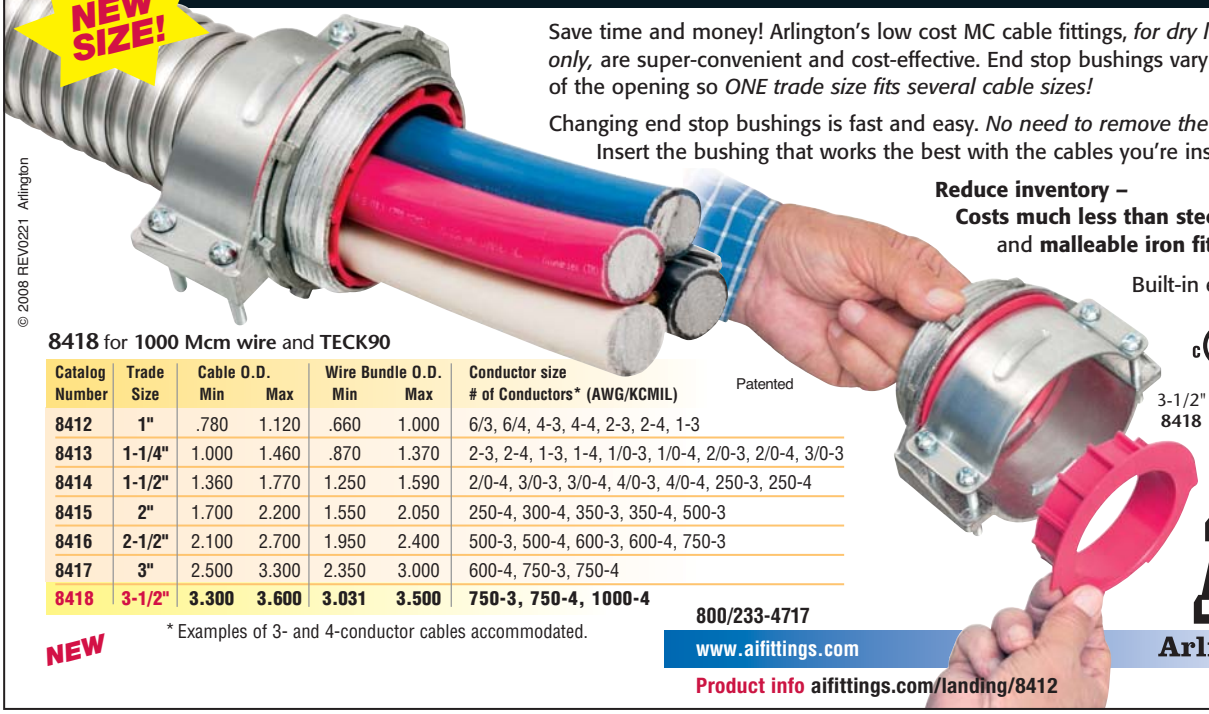

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8413	1-1/4"	1.000	1.460	.870	1.370	2-3, 2-4, 1-3, 1-4, 1/0-3, 1/0-4, 2/0-3, 2/0-4, 3/0-3
8414	1-1/2"	1.360	1.770	1.250	1.590	2/0-4, 3/0-3, 3/0-4, 4/0-3, 4/0-4, 250-3, 250-4
8415	2"	1.700	2.200	1.550	2.050	250-4, 300-4, 350-3, 350-4, 500-3
8416	2-1/2"	2.100	2.700	1.950	2.400	500-3, 500-4, 600-3, 600-4, 750-3
8417	3"	2.500	3.300	2.350	3.000	600-4, 750-3, 750-4
8418	**3-1/2"**	**3.300**	**3.600**	**3.031**	**3.500**	**750-3, 750-4, 1000-4**

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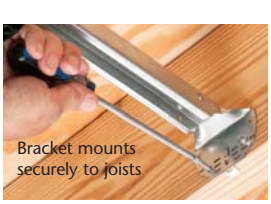

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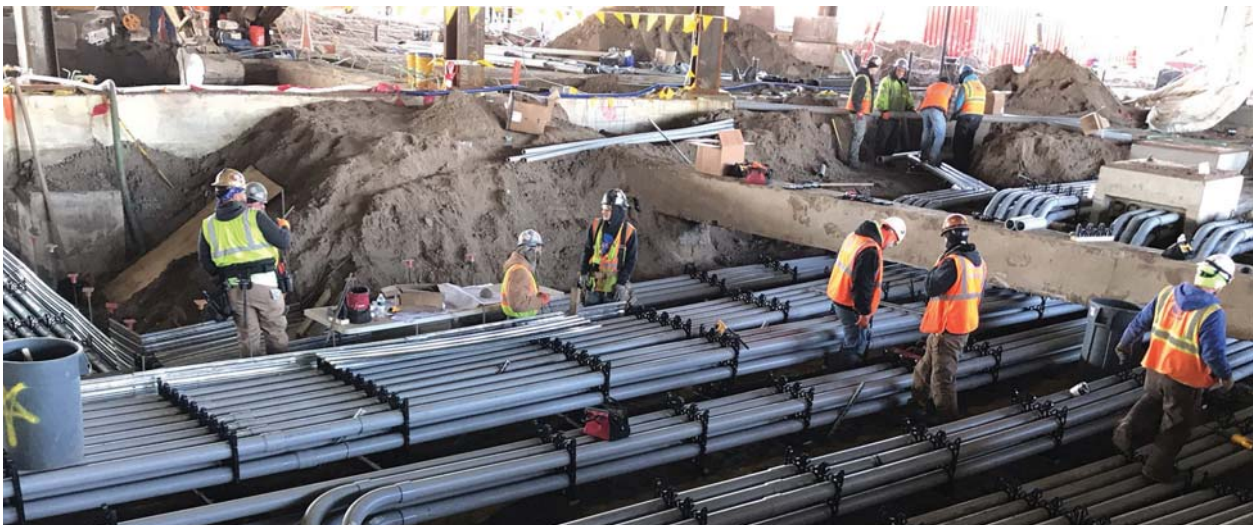


Photo courtesy of Five Star Electric

The states and a variety of federal agencies oversee disbursing the money, with timelines varying by project type. In some cases, such as Federal Aviation Administration (FAA) facilities, the money will be "available until expended."

For the past few years, some contractors have turned to reconditioned equipment as a way to keep projects on schedule. That could be an option for some IIJA-funded projects, too.

Equipment shortages also could drive up project costs, to the point that they exceed IIJA funding. The APWA warned the White House about that possibility in a meeting right before the bill was signed.

"I said, 'We're excited about the passage of this bill and will help in any way, but we realize that the infrastructure is going to be a lot more expensive than was envisioned when this bill was being written,'" Grayson says.

Some are optimistic that supply will start to catch up with demand around the time when funding really starts flowing.

"From all the studies and the research I've done and what I can see, I think it starts to unclog toward the back end of this year and then hopefully gets back to some normalcy following that point," says Five Star Electric's Lancey.

THE SEARCH FOR STAFF AT EVERY LEVEL

The third major hurdle might be the toughest: the chronic shortage of skilled labor. One potential option is using workforce service providers to quickly add people and support a major new project. Another is leveraging unions.

"There has definitely been a skilled labor shortage for field and also operations-type roles, such as project managers and engineers," says Cupertino Electric's Schott. "As a union contractor, we're able to tap into the national labor force of the IBEW when we go into different areas, but not all areas have the same workforce capacity. Fortunately, we have a proven model to address these challenges that allow us to stand up and deliver large-scale projects on a national scale."

Shortages also vary by region.

"The workforce shortage hasn't really been as large of a problem for us in this [Northeast] region when it was at its peak, before the pandemic," Lancey says. "There was a bit of a shortage. As a union contractor, what they do is call in neighboring locals or neighboring geographic areas to bring in people. All in all, the labor workforce is okay at the moment."

Some contractors see the IIJA as yet another reason to cast a wide recruiting net.

"I look holistically at what our industry can be doing to increase funding to help train and bring more women into the field," says E-J Electric's Mann, who is also a board member for Nontraditional Employment for Women (NEW). "I believe this is one of the many solutions to help with labor shortages. NEW actively prepares, trains, and places women in careers in the skilled construction, utility, and maintenance trades. This organization helps provide a pipeline of qualified workers to industries like ours that build, move, power, and maintain New York."

Meanwhile, other sectors have their share of labor shortages, which affects how much money and people they can devote to IIJA projects.

"Public works [has a] real shortage," Grayson says. "Whether it's public agencies, municipal and engineering firms, or contractors, [they all] have to raise salaries because there is this unusual market right now. When salaries are raised, the cost of goods and services go up exponentially. I'm still extremely positive about it, but we need to have our eyes wide open."

The states also must staff up to assess IIJA projects and then disburse funding. Hiring those people will take time.

"Some deem the overall process of SRF funding as cumbersome and slow anyway, and the additional funding will not speed up the process," says the infra-Management Group's McCann. "Some state SRF offices have their own labor challenges, too. If anything, because there's potentially more demand for the money, it could end up creating a backlog for the states processing this."

Federal agencies also have to add staff so they can help states and other entities.

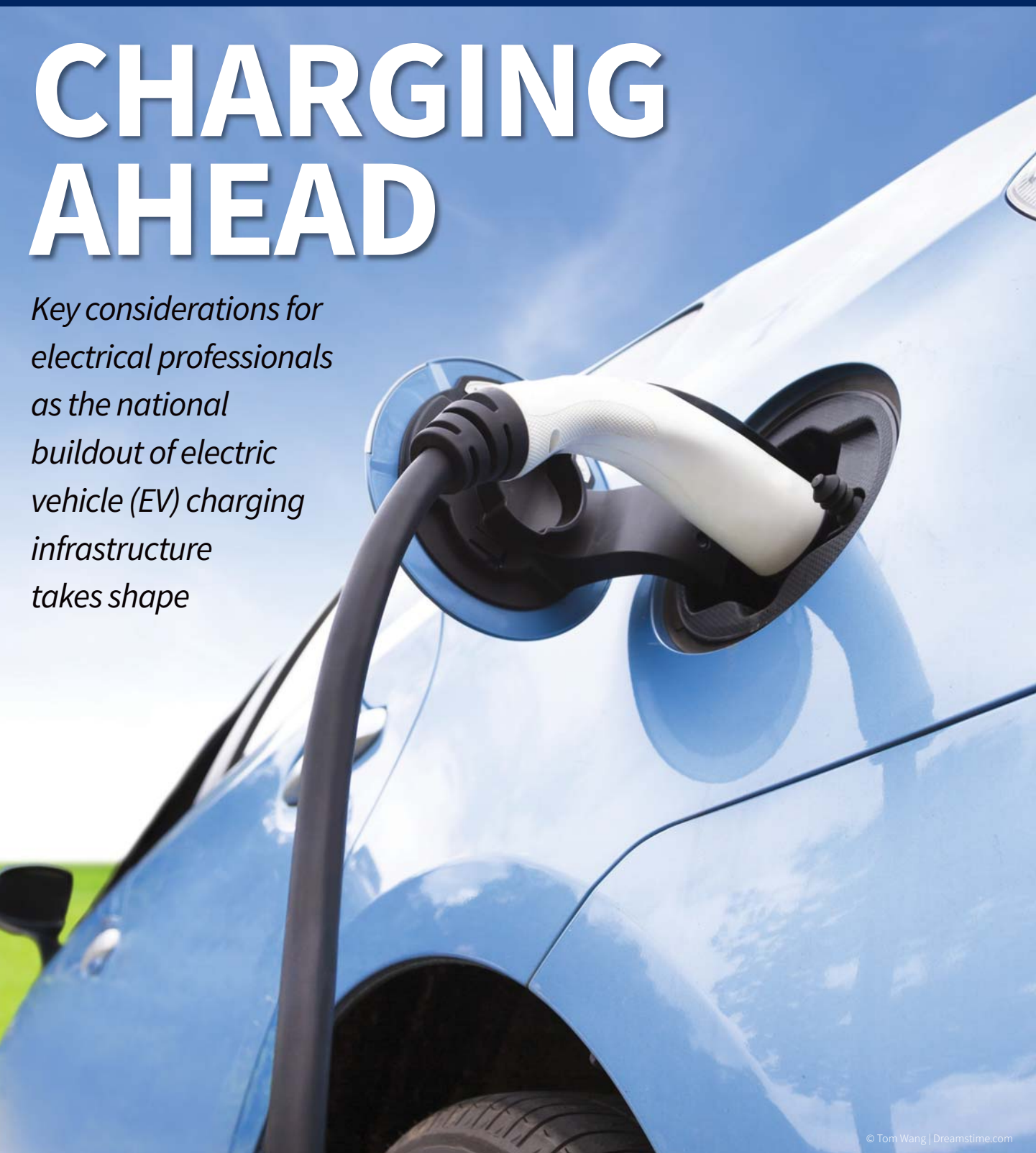
"The Department of Energy is ramping up their guidance, but they're also hiring," says the APPA's Mathias. "I think they're going to try to hire a thousand people. They're [also] going to change some internal structure and create an office dedicated just to infrastructure. That is going to have a leader that is going to have to be confirmed by the Senate. I don't know if that slows things down or maybe slows things down in the short term, but ultimately speeds things up. There's just a massive amount of implementation that's going to have to happen." EC&M

Tim Kridel is an independent analyst and freelance writer. He can be reached at tim@timkridel.com.

SPECIAL SECTION

CHARGING AHEAD

Key considerations for electrical professionals as the national buildout of electric vehicle (EV) charging infrastructure takes shape



Answering the Call

Challenging the electrical industry to build the nation's electric vehicle (EV) infrastructure

Whether you are an engineer, utility, manufacturer, contractor, electrician, or inspector, the nation is calling on the electrical industry to shoulder the huge task of creating a nationwide EV infrastructure in a short timeframe.

By Corey Hannahs, NFPA

There is no denying that electric vehicles (EVs) are the topic of many a conversation these days. A quick internet browser search of "electric vehicles" will turn up articles from manufacturers, automakers, associations, and more. The focal point of many of these conversations revolves around the $1.2-trillion infrastructure bill that President Biden signed into law in November 2021. Specifically impacting the electrical industry is $7.5 billion of the bill that has been earmarked toward building a nationwide network of EV chargers. With auto manufacturers making sizable investments to convert a large portion of their production to EVs, some having ambitious goals to be producing most or all vehicles as EVs in the next 10 to 15 years, the creation of a charging infrastructure is going to be critical to keep Americans on-the-go.

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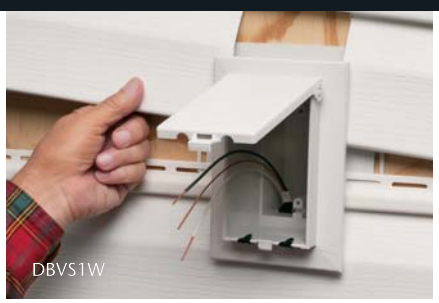

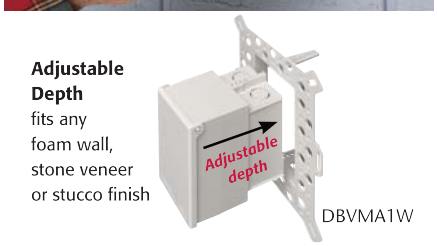

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Type	Input Voltage	Charging Time and Range	Notes
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Level 2 Charging	208V or 240V Single-phase	10 to 20 miles of range per 1 hour of charging	Level 2 chargers are commonly installed within homes as well as in public locations. As of 2020, more than 80% of public chargers were Level 2.
Level 3 DC Fast Charging (DCFC)	208V or480V 3-phase	60 to 80 miles of range per 20 minutes of charging	DCFC chargers are commonly installed at stations located along heavy traffic corridors. As of 2020, more than 15% of public chargers were DCFC.

A breakdown of the three main types of EV chargers in the market.

CALL TO ACTION

It is hard to imagine a time when there wasn't a gas station on nearly every corner in the United States. From the first gas station in the United States being established in St. Louis in 1905, we have grown to the present day with a gas station almost everywhere you look. With the rapid-moving shift in auto manufacturers' production to EVs, we don't have 100 years to build the infrastructure that will be needed to support them.

As an electrical industry, we are being called upon to build an EV charging infrastructure that is functional, sustainable, and installed based on current codes to produce the safest possible installation that protects all consumers. The backbone behind this infrastructure will be based upon the installation of the EV chargers themselves. While electric utilities will play a large role by providing power to the chargers, a heavy lift will be placed on the electrical contractors who will install the projected 500,000 chargers needed by 2030.

TYPES OF CHARGERS

Currently, EV chargers can be broken down into three categories: Level 1, Level 2, and DC Fast Charging (DCFC), which can also be referred to as Level 3 (see **Table**).

Level 1 chargers operate at 120V and are commonly provided with the EV itself. These chargers often remain onboard the vehicle and can serve almost like a "portable gas can" that provides the ability to charge the vehicle in a pinch. While Level 1 chargers certainly can be utilized within the home, it is more common for EV owners to have a Level 2 charger installed at their residence, often within the garage. Level 2 chargers operate seven to eight times faster than Level 1 chargers and can supply a full charge to an EV overnight.

Aside from being installed in homes, Level 2 chargers are also regularly installed within public areas. Based on 2020 data, 85% of the chargers installed within the United States were Level 2. Based on our fast-moving nation, the speed of DCFC chargers will likely drive a large amount of them to be used within the EV infrastructure. Since DCFC chargers use 3-phase power (commonly 480V), they are going to be found in public charging areas that have an electrical service capable and designed to meet that need. Regardless of the type of charger being installed, it is important that it is done in a manner that meets the current requirements of NFPA 70®, *National Electrical Code®* (NEC®).

As an electrical industry, we are being called upon to build an EV charging infrastructure that is functional, sustainable, and installed based on current codes to produce the safest possible installation that protects all consumers.

EVS AND THE NEC

Within the NEC, EVs are no stranger to change. The pages of the 1996 NEC first brought us Art. 625, then known as "Electric Vehicle Charging System Equipment." While the submission to create Art. 625 acknowledged that there were random areas throughout the NEC containing information that would assist with installing equipment that was EV -related in nature, the goal was to have a dedicated Article that would put much of the necessary information in one place. The substantiation for the submission stated, in part, that "The intent of this proposed Article for electric vehicle charging, therefore, is to provide necessary safety requirements for electric vehicle charging in one convenient location within the 1996 National Electrical Code." The derivation of Art. 625 in its roots is what needs to be utilized when creating the present-day EV infrastructure.

Technology and knowledge are constantly moving targets, and with that movement comes change. As can be expected, the past 25 years have brought about change to Art. 625. Post-1996, the next several cycles of the NEC saw changes to Art. 625 that helped shape how we see it today. Many changes were

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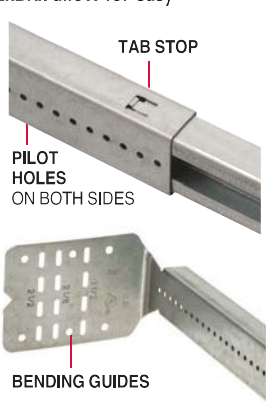

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SL2B18 KIT	**SL18** SLIDERBAR, TWO GANG Plastic Box
SL1B24 KIT	**SL24** SLIDERBAR, SINGLE GANG Plastic Box
SL2B24 KIT	**SL24** SLIDERBAR, TWO GANG Plastic Box

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structural and editorial in nature, as well as creating definitions that aligned with EV installations.

As part of the 2005 NEC, a new Section was added (at that time Sec. 625.26), which first mentioned EVs being utilized as a part of an interactive system using bidirectional power feeds. This change acknowledged the fact that not only do EVs consume power, but they also have the ability to supply power back to an interactive system. Therefore, from a technology and EV usability standpoint, this change was very impactful.

The 2017 NEC saw another technology-based change within Art. 625 that is likely to be utilized more in the coming years. In this cycle, wireless power transfer (WPT) was introduced as a new Part IV Wireless Power Transfer Equipment. These changes gave direction on how wireless charging of EVs was to be done per the NEC.

During 2020 revisions to the NEC, Art. 625 was renamed "Electric Vehicle Power Transfer System" in part to recognize the addition of power export equipment and bidirectional current flow equipment. Article 625 was no longer just about *charging* — as it had grown through the years to become more about *power transfer*, in both directions.

Change and the NEC are inevitable, yet necessary, components. Constant evaluation of the available technologies and best practices is necessary to ensure the safest installations possible.

As this article is being written, the 2023 NEC is making its way through the standards development process an (currently in the second draft stage). Some of the proposed changes being considered address how branch circuits and disconnects for electric vehicle supply equipment (EVSE) are to be installed. Branch circuits and disconnects are foundational pieces to the 500,000 EV chargers that will be installed as part of the new infrastructure. Yet, therein lies a dilemma.

The most recent changes within the NEC are only enforceable when current codes are being used. As of Jan. 1, 2022, there were 14 states enforcing the 2020 NEC, which is the most current version, and another 10 states that have the updating process to the 2020 NEC underway. Even with the states working through the process being included, less than half of the United States is using the most current version of the NEC. How do we build a functional, sustainable, and safe nationwide EV infrastructure possible if everyone involved isn't using the same requirements? With $7.5 billion in taxpayer funds being utilized (and the critical time line for getting the EV infrastructure in place), alignment is crucial. That calls on legislators to expedite the use of the most current codes in their areas, governmental agencies that write the EV infrastructure contracts to require the use of the most current codes, regardless of area, or both.

MOVING FORWARD

Building the nation's EV infrastructure requires alignment; however, at the same time we remain nimble on our toes and adaptable to further change. Another developing means of EV charging that may find its way into the EV infrastructure is being explored in Michigan.

Circa 1909 in Detroit, also known as the "Motor City" due to being the automotive capital of the world, Woodward Avenue became the first paved road in the United States. Now, Michigan is looking to incorporate the first-ever electrified road capable of wirelessly charging EVs — yet another example of developing technology that could become a component of building the EV infrastructure. Read the full story at https://bit.ly/3pNUflj.

Whether you are an engineer, utility, manufacturer, contractor, electrician, or inspector, the nation is calling on the electrical industry to shoulder the huge task of creating a nationwide EV infrastructure in a short time frame — and with ever-changing technology. But this is what we do every day. Through knowledge, ingenuity, drive, and lacing up our boots daily, we turn enormous asks into lasting realities. Our time is now — let's answer the call. EC&M

Important Notice: Any opinion expressed in this article is the opinion of the author and does not necessarily represent the official position of NFPA or its Technical Committees. In addition, this piece is neither intended (nor should it be relied upon) to provide professional consultation or services.

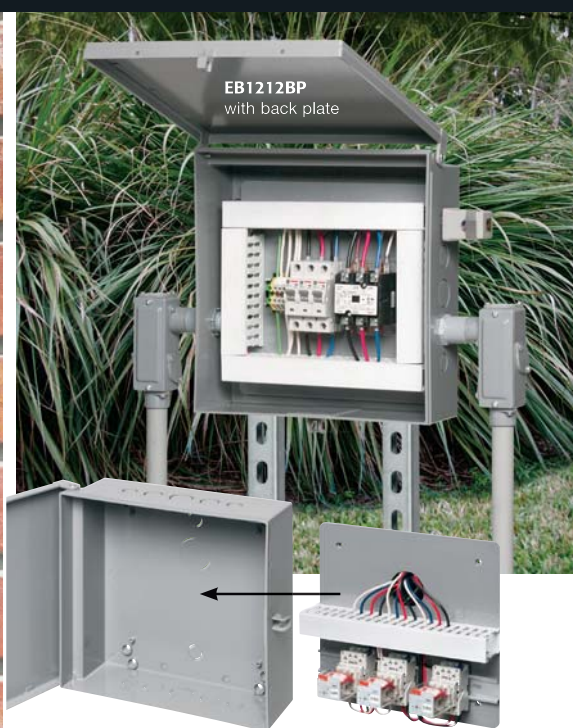
Corey Hannahs is a senior electrical content specialist at the National Fire Protection Association (NFPA). He can be reached at channahs@nfpa.org.

GRAY & BLACK NON-METALLIC • UV RATED

Made in USA

ENCLOSURE BOXES

PROTECT DEVICES, POWER BACKUPS and MORE!



Back plate with electronics mounted *(not included)*

All available with or without Back Plate

Outdoor Rated
Meets NEMA 3R
with Hinge on TOP

SIDE hinge for indoor use

Never Lose Another Cover *with a FACTORY-INSTALLED Cover!*

Shipped with *factory-installed* hinged covers, Arlington's non-metallic enclosure boxes **meet NEMA 3R requirements for outdoor use** *when mounted with the hinge on top.*

Perfect for protecting and securing power backups, security devices and other valuable equipment indoors *or outside,* our heavy-duty, UV rated boxes come *with or without a back plate*. Get easy access to components, even after the enclosure box is installed.

Gray and black, in a variety of convenient sizes, including the **new 6" depth**.

'Lockable' with a knockout for a cam lock *(**EBL1** sold separately)* or a padlock latch.

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GRAY Enclosure Boxes *Add suffix BL to order in Black

Cat #	UPC	Dimensions
EB0708	12672	7" x 8" x 3.5"
EB0708BP	23170	7" x 8" x 3.5" with Back Plate
EB1111	12670	11" x 11" x 3.5"
EB1111BP	23171	11" x 11" x 3.5" with Back Plate
EB1212	12671	12" x 12" x 4"
EB1212BP	23155	12" x 12" x 4" with Back Plate
EB12126	23172	12" x 12" x 6"
EB12126BP	23173	12" x 12" x 6" with Back Plate
EBL1	11400	Cam Lock

www.aifittings.com • Scranton, PA 18517 • 800/233-4717

Product info http://www.aifittings.com/landing/non-metallic-enclosure-boxes/

How to Support Safe EV Charging

Key considerations for building a safe electric vehicle charging infrastructure

By Lawrence Conner and Jaska Tarkka, Eaton

The global energy transition is being driven by the progressive replacement of carbon-based fuels with renewables and the direct/indirect electrification of more applications, including transportation. It's important to understand that electric vehicle charging infrastructure (EVCI) involves much more than just adding the physical charging device. There are wide-ranging demands on a building's electrical infrastructure to handle the incremental energy load of the chargers. This increased energy consumption can impact incoming electric utility service and power distribution system design as well as necessitate distributed energy resources like solar and battery storage to offset electricity demand and time-of-use rates.

Electric vehicle (EV) adoption is obviously on the rise in the United States. In August, President Joe Biden signed an executive order setting a target of 50% of passenger vehicles sold by 2030 to be electric. Additionally, the governor of New York recently set goals for all passenger cars and light-duty trucks sold in the state to be zero-emission vehicles by 2035; California has similar requirements for light-duty autonomous vehicles to emit zero emissions starting in 2030.

WHITE BUTTON® • NON-METALLIC

Made in USA

NEW

CABLE CONNECTORS

EASY PUSH-IN INSTALLATION OF ONE OR TWO CABLES

from ***OUTSIDE*** *a* ***New Work Box...***

Save money with Arlington's non-metallic NM cable connectors – the *lowest cost* NM cable connectors on the market – and the fastest to install! Easy push-in installation...

Listed for single or multiple cables, Arlington's new **White Button**® 1/2" NM94X and the ***NEW 3/4" NM95X*** offers smooth, easy cable insertion of one *or two* cables into a single opening from inside or outside the box.

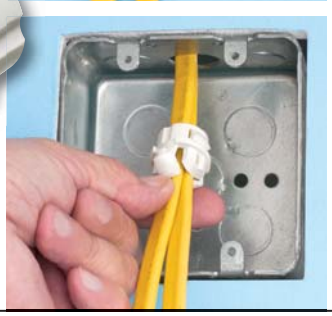
NM94X... BETTER than our popular NM94 AT THE SAME PRICE!

- 1/2" trade size NM94X holds:
  (1) 14/2 to 6/2, (1) 14/2/2, (1) 12/4,
  (1) 12/2/2, (1) 14/3 to 10/3,
  (2) 14/2 to 10/2, (2) 14/3,
  (2) 12/3,
  (1) 14/2 and (1) 12/2,
  (1) 14/2 and (1) 10/2,
  (1) 12/2 and (1) 10/2

NM94X

- **Easy** removal with pliers or screwdriver
- **Listed.** Exceeds UL/CSA pullout requirements

or ***INSIDE*** *an* ***Existing Box.***



c UL us

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Product info aifittings.com/landing/NM94X

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ONE-PIECE • NON-METALLIC

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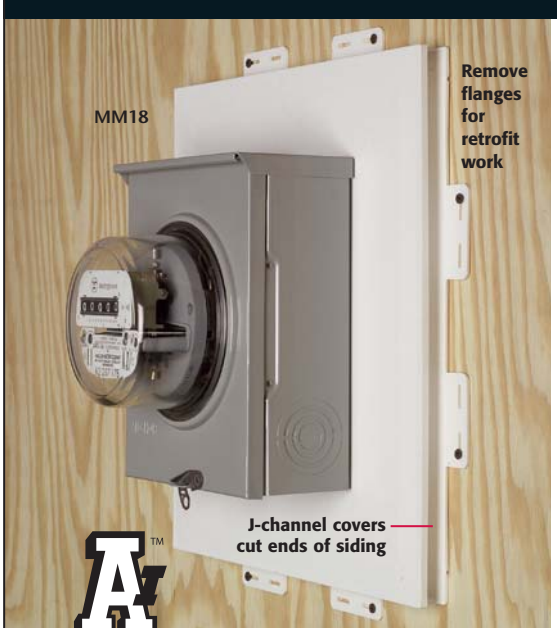
METER MOUNTING BASE

INSTALLS ON SIDING – AND OTHER SURFACES



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Arlington's one-piece, non-metallic Mounting Bases provide a smooth, flat mounting surface for most electric meters, *including the largest sizes* – as well as a variety of other products such as timers, disconnects, inlet boxes and more.

UV rated, paintable plastic for long outdoor life.

Available with squared-off corners, they're *gangable* so you can create the mounting base you need for the product you're installing.

NEW 5x7

NEW

MM7 5" X 7"	MM18 15-7/8" X 17-5/8"
MM10 7" X 10"	MM23 17-5/8" X 23"

MM7 info aifittings.com/landing/mm7
Other aifittings.com/landing/meter-mounting-bases

Circle 23 on Reader Service Card

Especially in commercial applications, it's important to understand that electric vehicle charging infrastructure (EVCI) involves much more than just adding the physical charging device.

To accommodate this growth, many states are challenging building owners to develop "EV-ready" power distribution systems that have electrical infrastructure capacity, dedicated branch circuits, and other equipment to distribute power to EV parking spots and support the future installation of charging stations.

Today, more than ever, the electrical infrastructure supporting commercial buildings must be able to adapt to change. In our opinion, that means designing buildings to safely support the EV charging needs of the future. In this article, we'll summarize various considerations for safe EVCI, including:

- Code compliance for EV charging systems.
- Strategies to increase electrical capacity in buildings.
- How to safely manage growing electrical demand.

CODES AND STANDARDS FOR SAFE EVCI SYSTEM INSTALLATION

When it comes to National Electrical Code (NEC) requirements for EVCI installation, there are several rules that affect EV charging systems. Some of these, per the 2020 edition of the NEC, include the following:

- Chapters 1 to 4 apply generally to all electrical installations. These chapters include requirements for load calculations that impact branch circuit, feeder and service sizes (or even a separate service), metering for fee-for-charging applications, and more.
- Section 625.40 mandates each outlet installed for the purpose of supplying EVCI shall be supplied by an individual branch circuit.
- Section 625.48 requires overcurrent protection with a rating sufficient for the receptacle it protects. The overcurrent protection device must also be rated for the maximum available fault current at the receptacle and included in the interactive equipment evaluation.
- Section 625.41 states overcurrent protection for feeders and branch circuits supplying EVCI shall be sized for continuous duty with a current rating of not less than 125% of the maximum load of the equipment.
- Section 625.5 requires third-party testing and relevant listing of all electrical materials, devices, fittings, and associated equipment.

In addition to the NEC, there are relevant product safety certifications specific to AC charging (UL 2594[2]), DC charging (UL 2202 and UL 2231), and bidirectional charging (UL 9741) that should be adhered to.

CHARGING OPTIONS

Both AC and DC charging options have their place, each of which comes with business and installation considerations.

AC charging is typically used in situations where a vehicle will spend the most time parked (e.g., work, school, shopping, entertainment, or hotels). Level 1 charging can also be used in locations where vehicles are parked overnight but can take up to 12 hours to fully charge; Level 2 charging typically takes approximately four hours to charge.

DC-type charging is preferred in some applications and for specific needs, depending on vehicle routes and dwelling time. This type of charging involves more power and can deliver a required charge in as little as 30 minutes.

It's expected that AC charging will represent the largest global public installs through 2025, and DC charging will provide critical network support on long travel routes like interstate highways as well as support for fleet operations and charging at popular destinations. Further, EV charging systems can be optimized with charge management software, battery energy storage, and the integration of renewables (like solar) to meet cost, resilience, and sustainability goals.

STRATEGIES TO INCREASE ELECTRICAL CAPACITY

When upgrading or designing building systems, planning for future EVCI capacity needs to avoid significant changes and costs later is important. In other words, you need to future-proof and provide the electrical architecture for what's to come. How many chargers will be required? How much additional power (kVA) do you need to accommodate for growth? It is critical that incoming utility electrical service and power distribution feeders are sized appropriately to be able to power EV charging safely and reliably.

For example, EVs are expected to make up 10% of the new car market in America by 2025 — meaning a typical local distribution center could reasonably expect to convert 10% or more of its parking capacity to bays with chargers. Most of these chargers (90%) could be Level 2 chargers for employees, but several would need to be DC fast chargers

STEEL BOX WITH BRASS COVER

LISTED SINGLE GANG FLOOR BOX KITS

CONVENIENT, FLUSH-TO-THE-FLOOR RECEPTACLE INSTALLATION

FLB5331NL
Single gang
steel box kit
w nickel-plated brass cover

FLB5331MB
Single gang Kit
w brass cover

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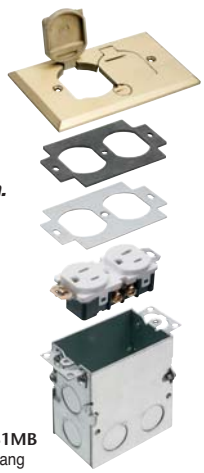
Arlington's **STEEL FLOOR BOX KITS** give installers a low cost, *convenient* way to install a receptacle *in a new or existing floor*.

Our Listed Single Gang Steel Floor Boxes deliver easy, flush-to-the-floor installation.

- Brass covers hide miscut flooring; gaskets prevent water intrusion; flip lids protect the box when it's not in use.
- Single gang brass and nickel-plated **Brass Covers** fit our boxes *and other manufacturers' single gang boxes.*

Covers also sold separately.



FLB5331MB
Single gang
steel box kit w brass cover

for NEW or existing floors

c UL us

Product info aifittings.com/landing/flb5331-flb5551-kits

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IN BOX® RECESSED COVER KITS

INSTALLS INSIDE 4.5" CONCRETE BOXES

NEW!

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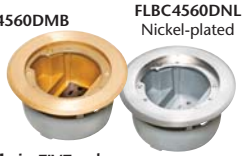
Arlington's **IN BOX® Recessed Cover Kits** are the neat way to install a receptacle in an installed 4.5" concrete floor box, *including our FLBC4500 or FLBC4502 boxes.*

Fast installation, *inside the can* reduces trip hazards caused by plugs sticking out of the box. They look great and you get power and low voltage in the *same* box.

Assembled. Comes with matching in-use slotted cover and cover blank for unused boxes in **brass** or **nickel-plated brass...**

FLBC4560DMB
Brass

FLBC4560DNL
Nickel-plated



...and **plastic** in FIVE colors.

FLBC4560DGY
Gray

FLBC4560DCA
Caramel

FLBC4560DBL
Black

FLBC4560DLA
Light almond

Product info aifittings.com/landing/inbox-cover-kits/

Circle 25 on Reader Service Card

for local delivery trucks, which need much more power. Even if only half of the chargers at the facility are used at any one time, the site's power demand can easily increase by a megawatt, effectively doubling the power requirements.

Building owners should consider this vastly increased power requirement before adding EVCI because sufficient electrical capacity may not be available. Current versions of DC rapid chargers typically have a power demand of 20kW to 350kW. However, more powerful chargers are becoming available. Careful planning and system design are essential to maximizing the return on investment for costly site upgrades associated with pulling more power from the electric grid.

Optimizing EVCI with load management technology will enable more installed chargers that deliver the optimal amount of power chargers need. When available capacity is reached, load management software limits energy consumption and reduces the available power. This integral approach to load management enables load shedding and avoids exceeding the incoming service capacity. However, if current electrical capacity simply cannot meet expected demand, electrical capacity must be increased at the electric utility service point.

An alternative to increasing service entrance upgrades is to incorporate onsite renewables and energy storage. This strategy enables owners and building managers to avoid expensive electrical capacity additions while supporting a more sustainable, low-carbon future.

SAFE, FLEXIBLE EVCI WILL POWER THE 21ST CENTURY

Now and in the future, electrical infrastructure needs to do much more than just receive power from the grid for distribution to building loads and equipment. With the significant growth of EVs on the horizon, it is important to start thinking about what steps are required to build safe EVCI for commercial buildings.

There is an enormous opportunity to manage power far more effectively, taking advantage of a new power paradigm that is decentralized, electrified, and decarbonized. If completed with safety and reliability in mind, the critical task of adding EVCI can be accomplished without unnecessary costs or complications down the road. That being said, there is no doubt that EVCI design and NEC requirements will continue to evolve, so energy infrastructure can work in new ways to ensure the power is always on and optimized for efficiency and safety. EC&M

Lawrence T. Conner is a senior application specialist in renewable energy at Eaton. Jaska Tarkka is a solar application engineer at Eaton. They can be reached at EVCharging@eaton.com.

ADJUSTABLE • NON-METALLIC

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IN/OUT™ BOX for Fans & Fixtures

EASY TO INSTALL... IN NEW CONSTRUCTION

Arlington's IN/OUT BOX ***for fans and fixtures*** adjusts up to 1-1/2" to accommodate varying ceiling thicknesses, like single or double drywall.

- Pre-set for 1/2" ceiling...use depth adjustment screw *after the ceiling's in place* to position the box flush with the ceiling
- Complies with 2020 NEC, 314.20 for set back boxes
- (4) screws attach box securely to joist in new work
- **2-Hour Fire Rating** ***Listed for fans up to 70 lbs; fixtures up to 100 lbs***

Product info aifittings.com/landing/fba426

1 Cutaway: Box set back in double drywall

2 After ceiling's installed, (if necessary) use the depth adjustment screw to position box flush with ceiling.

Patented

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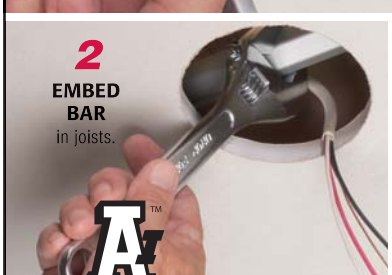
ADJUSTABLE BRACKET • EASY INSTALLATION IN EXISTING CEILING

FAN/FIXTURE BOX

HIGHER WEIGHT RATINGS



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Arlington's extra heavy-duty, plated steel fan/fixture box with adjustable bracket has ***higher UL Weight Ratings***:
at 24" on-center: **70 lb Fan, 90 lb fixture**
at 16" on-center: **70 lb Fan, 150 lb fixture**

The 20.0 cu. inch FBRS4200R installs *between* rafters with 16" to 24" on-center spacing, holding a fan or fixture securely in place. It's easy...

REMOVE BOX from bar.
INSERT BAR in opening. Embed bracket ends in joist. Tighten hex, first by hand then with a wrench. Pull wire.
REATTACH BOX to bar.

No parts to lose. Installation screws ship captive, along with a mud cover and installed NM cable connector.

FBRS4200R
Patented

CSA Rated: at 16" or 24" oc 50 lb fan or fixture

Product info aifittings.com/landing/fbrs4200r

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All About EV Charger (EVSE) Rebates

Currently, 51% of the United States has a rebate for the installation of a commercial EV charger.

Retailers are one of the prime candidates for EV charger installations.

By Randy Young, BriteSwitch

Electric vehicle (EV) sales are projected to grow dramatically, with millions more cars coming to the roads in the next few years. But where will these cars charge up? At the time of this writing, the United States has roughly 168,000 gas stations but only 44,417 publicly available EV charging stations. That means the infrastructure has a long way to go to catch up.

This trend presents a unique opportunity for electrical distributors and contractors. Both homeowners and businesses will be installing EV charging stations in the coming years to accommodate their new electric cars. Homeowners may seek the convenience of rapidly charging their car at home. Businesses will need a way to keep their electric fleet or their employees' cars charged up. Places like hotels, restaurants, and retail stores might need to add EV chargers to increase traffic and keep customers happy.

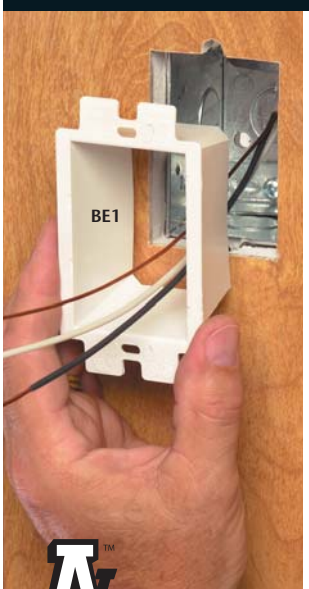
As contractors and distributors start to focus on opportunities in the EV charging market, rebates will likely be a key to their success. The cost of installing an EV charger can add up for a homeowner or a business, making it harder to get

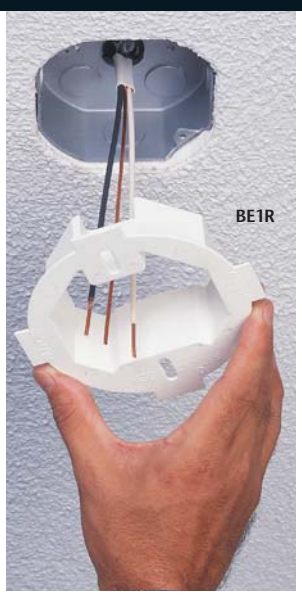
UL LISTED

Made in USA

BOX EXTENDERS

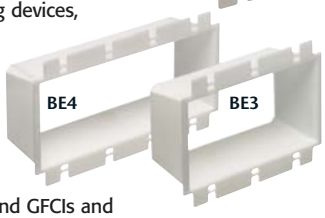
EXTENDS SET BACK BOXES UP TO 1-1/2 INCHES





Arlington's **UL/CSA Listed** Box Extenders extend set back electrical boxes up to 1-1/2".

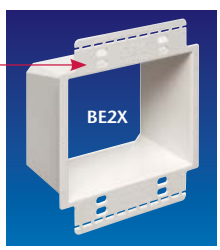
Made of heavy-duty, non-conductive plastic, they level and support wiring devices, protecting wires against damage and stripping.



BE1R for round or octagonal boxes, the single-gang (BE1), two-gang (BE2) for all standard devices, switches and GFCIs and **three- and four-gang box extenders for multiple gang boxes!**

*Try them all, including our **'Larger Flange' one-, two-, three- and four-gang styles**, for the safe, easy way to obtain Listed installations in set back boxes!*

Larger Flanges



Product info http://www.aifittings.com/landing/box-extenders/

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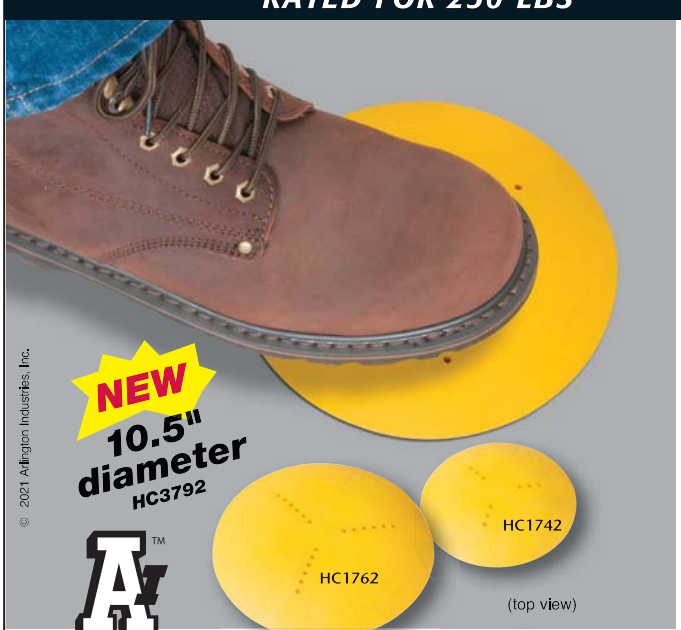
NON-METALLIC HOLE COVER KITS

RATED FOR 250 LBS ***ENSURES COMPLIANCE WITH OSHA***



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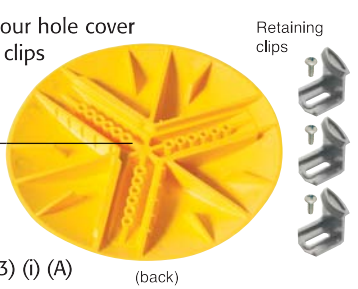
Arlington's non-metallic hole cover kits offer the *fastest way* to cover a hole – and ensure compliance with OSHA safety standards on a multi-story building site.

Available in ***three*** sizes, our hole cover kits come with retaining clips that adjust to fit a range of hole sizes.



- Reference scale for precise sizing to hole diameter
- Complies with OSHA Standard 1910.28 (b) (3) (i) (A)
- Rated for 250 lb load

***HC1742** fits 1-3/4" to 4-1/4" opening,*
***HC1762** a 1-3/4" to 6-1/4" hole*
***HC3792** 3-3/4" to 9-1/4" hole*

HC1742 w/ clips set for 1-3/4" hole

HC1762 set for a 6" hole

Patent pending

Product info aifittings.com/landing/hole-cover-kits

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customers to install these stations. As a result, many organizations across the country are providing rebates, incentives, and tax credits for installing EV chargers. While many in the industry may be familiar with rebates for equipment such as lighting or HVAC that have been around for years, EV charger rebates can work a little differently.

UNDERSTANDING THE TYPES OF EV CHARGERS AVAILABLE

To fully understand rebates and incentives for EV chargers, it's essential to review the terminology often used. Technically, what most people call "EV chargers" are actually "Electric Vehicle Supply Equipment" (EVSE). These stations convert power to a format that the electric vehicle can accept; the charger itself is built into the car. That being said, the most popular term for these units is "EV chargers." Broadly speaking, EV chargers fall into three categories:

Level 1 Charger

LEVEL 1 CHARGER: 120V

A Level 1 EV charger plugs into a standard outlet and is usually the type of charger that comes with most EVs. Usually, a Level 1 charger can add two to three miles to a car for each hour they're connected. These units are primarily used in residential applications.

LEVEL 2 CHARGER: 240V

A Level 2 EV charger lets users charge up their electric vehicle around five times faster. These chargers use 240V and can be hardwired or use a NEMA 14-50 plug. They add between 12 to 60 miles

Level 2 Charger

to a battery each hour. These chargers are the most popular in both residential and commercial applications.

LEVEL 3 CHARGER: 400V OR MORE

A Level 3 EV charger is the fastest type of EV charger. They're also called fast chargers, DCFC chargers, or DC fast

Level 3 Charger

chargers. These units typically use 400V or more and add 150 miles to a battery in an hour. These are limited to commercial applications.

SOURCES OF EV CHARGER INCENTIVES

Rebates and incentives for EV chargers can come from a variety of sources. The most widely known program, the Federal 30C Tax Credit, expired at the end of 2021, but more opportunities are available. Approximately 57% of the country is also covered by an additional rebate, incentive, or grant for EV chargers (See **Map** on page 46).

REBATES FOR COMMERCIAL EV CHARGERS

Currently, 51% of the United States has a rebate for the installation of a commercial EV charger, but eligibility can vary depending on the type.

Level 2 EV chargers are the most commonly incentivized. Almost half of the United States (49%) has a rebate available for this type of equipment. While there is quite a range of dollar amounts, the average rebate for a Level 2 charger is $1,731.

Level 3 commercial EV charger rebates are less popular, with only 38% of the country having an additional incentive available. However, because these charging stations are much more expensive than Level 2 chargers, the incentive can be significantly higher. On average, the rebate for a Level 3/DC fast charger is $37,878.

REBATES FOR RESIDENTIAL EV CHARGERS

When it comes to EV chargers for home/private use, approximately 30% of the country has a rebate or incentive available. Most of these incentives are for Level 2 chargers. That makes sense because most EVs come with Level 1 chargers when purchased. On average, the rebate is $473 for this type of charger, but it can vary anywhere from $50 to $2,000.

IMPORTANT FACTORS TO CONSIDER

Make sure the charger you purchase meets the program's requirements. For example, some rebate programs require

THE SPACER™

Made in USA

CABLE SPACER

FOR POWER and LOW VOLTAGE CABLE

The SPACER™, Arlington's versatile cable spacer holds up to eight individual cables *centered* on a 2x4.

Quick, easy installation. *Just nail or screw The SPACER to a wood or metal stud!*

- Holds single or double row of power or low voltage cables:
  -One to eight 14/2
  -One to four 14/3, 12/2, 10/2
  -One or two 12/3
- Positions, fastens, routes power or datacom cable
- Complies with article 300.4(d) of NEC

Also available...
Screw-on CS14SC

Product info
aifittings.com/landing/spacer

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PRESS-ON INSTALLATION

EMT BUSHINGS

ECONOMICAL CABLE PROTECTION

- Fast & easy press-on installation
- Holds tight as cables are pulled
- Protects cable from abrasion
- Less expensive alternative to costly fittings when used just for wire
- Meets NEC requirements (2020) for 300.15 protection. Listed for use in environmental air handling per NEC 300.22(c)

Product info aifittings.com/landing/emt-bushings

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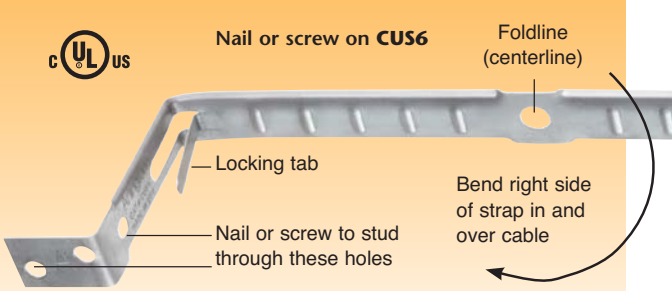
GALVANIZED STEEL

Made in USA

NEW

CABLE SUPPORT

ECONOMICAL...HOLDS UP TO FOUR MC CABLES • EASY TO INSTALL



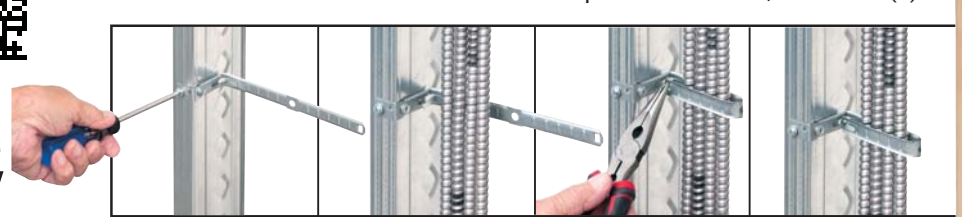
Holds up to four MC cables centered on a 2x4!

Arlington's economical CUS6 galvanized steel Cable Support holds cable secure and centered on a metal or wood stud.

It's perfect for fastening and positioning *up to four* individual metal clad cables – or six NM cables on a 2x4.

Installation is quick and easy. Nail or screw ***CUS6*** to a wood or metal stud, and position the cables. Next bend the strap at the foldline (centerline). Fold the strap over the cables and insert the locking tab in the opening as shown to hold them securely in place.

- Complies with 2020 NEC, article 300.4(D)



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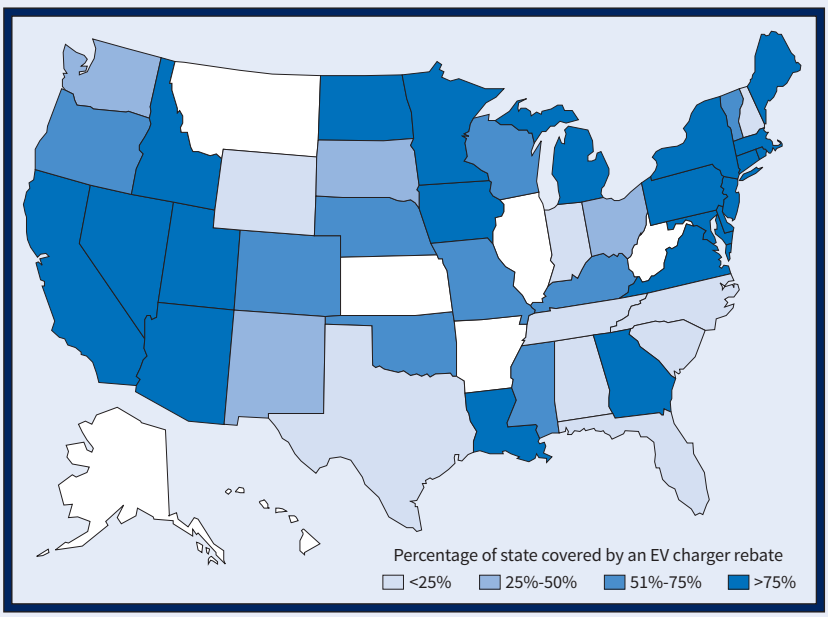
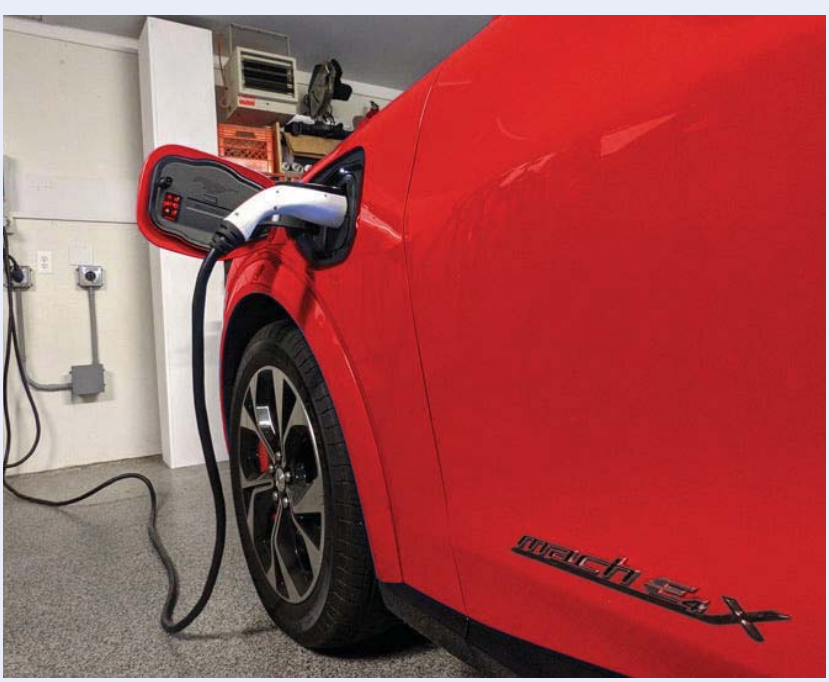


Map of EV charger rebates in the United States



When it comes to EV chargers for home/private use, approximately 30% of the country has a rebate or incentive available. Most of these incentives are for Level 2 chargers. That makes sense because most EVs come with Level 1 chargers when purchased. On average, the rebate is $473 for this type of charger, but it can vary anywhere from $50 to $2,000.

that the charger is networked (usually with Wi-Fi) to report data back. Other programs require that the charger uses a specific rate code or billing plan.

The specific make and model of an EV charger can also matter. Some programs will require a particular brand of charger. Others may have a list of approved equipment. These types of programs are in the minority, with only around 5% of all rebates specifying certain models or brands.

When installing multiple chargers, it's important to look for any rebate caps per site. For example, some programs will only allow a certain number of chargers; others will cap the incentive at a specific dollar amount per site.

When installing multiple chargers, it's important to look for any rebate caps per site.

Some EV charger rebate programs have limited funding that goes very quickly. This issue will likely be exacerbated in the future as EVs grow in popularity. Pay attention to deadlines, and make sure to adhere to them. Research the options early on to see if a program currently has a waitlist or will be re-opening in the future.

HOW LONG WILL EV CHARGER REBATES LAST?

It's hard to tell how long incentives for EV chargers will last. Historically, rebates for other technologies like lighting, HVAC, and other efficient equipment have been around for many years. But EV chargers are different; they don't provide energy efficiency benefits. Instead, they offer the utility a new way to make revenue. In theory, there will eventually be enough chargers to meet the demand, and these rebates may no longer be needed. Therefore, it's very likely that early adopters of EV charging will be the only ones to benefit from rebates. EC&M

Randy Young is the operations manager at BriteSwitch, a company that specializes in finding and capturing rebates for businesses. He can be reached at randy.young@briteswitch.com.

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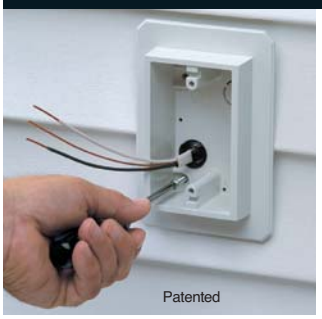

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Is the Rise in EVs Cause for Electrical Safety Concern?

An inside look at the electrical hazards associated with rechargeable energy storage systems and how to ensure safe installation, troubleshooting, and maintenance.

By Tommy Northcott, Jacobs Technology, Inc.

Electric vehicles (EVs) are becoming a regular player in road transportation systems, whether you're talking about privately owned vehicles, public transportation, or vehicles used in the corporate setting. Constantly evolving technologies are proving to make EVs more appealing and cost-effective for both public and private consumers.

As history has shown us before, a step-change in technology often provides the safety standards associated with the new technology. However, they will lag as we learn how to safely approach the development and maintenance of the new technological trend. Is that the case for the new rechargeable energy storage system (RESS)? A basic overview of typical RESS components may help electrical professionals understand how these components may impact approaches to mitigating the hazards and help answer the question: Are current safety and design standards sufficient to address the electrical hazards associated with RESSs?

First, it's important to point out that there are other hazards associated with RESSs, but for this article, we are singling out potential electrical hazards. The battery packs used for RESSs in EVs, hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) are large and complex. These systems provide electrical power to the drive train and other components in the vehicle through the controlled release of current at a design voltage. However, due to their high stored electric energy capacity, any uncontrolled release creates a dangerous situation.

The possible release of smoke, toxic fumes, fire, explosion, and/or hazardous electrical forces poses risk for exposure to personnel. Manufacturers have invested time and resources in designing physical barriers, mechanical safety systems, and other control measures to mitigate the potential for severe physical abuse, such as puncturing,

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crushing, or excessive heating, which can cause uncontrolled energy release. EV battery pack manufacturers design their products to deliver specified performance characteristics safely under anticipated usage conditions. Given the ever-changing chemistry of battery cell designs, understanding potential failure modes are still developing to ensure RESSs are reliably safe in the various environments to which they will potentially be exposed.

EV BATTERY PACK BASICS

While EV battery packs can vary significantly by manufacturer and application, some characteristics are common to many applications. The basic function of the EV battery pack is centered around several mechanical and electrical component systems. All EV battery packs include a collection of battery cells. These can have different sizes, shapes, and chemical make-up, depending on the application and preference of the battery pack manufacturer. One common trait is that the battery pack will always incorporate many individual battery cells connected in series and parallel to achieve the desired voltage and current output rating needed for the specific application. Depending on the requirements of the application, this can vary from a few cells to several hundred individual cells.

Another common feature in EV, HEV, and PHEV battery packs is the main fuse, which limits the current of the battery pack under short-circuit fault conditions. A "service disconnect" or a "service plug," which provides a means to split the battery stack into multiple electrically isolated sections, is another way to limit the potential release of the full capacity of the battery pack. When performing service or maintenance on or around the battery pack, the service disconnect reduces the electrical hazard potential while the main terminals of the battery pack are exposed.

In addition, battery packs typically include contactors used to control the distribution of electrical energy to the output terminals. Typically, two or more contactors are included to control the connection of the high current supply to the electrical drive motor(s). A battery

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management system (BMS) is used to regulate the performance and safety of the battery pack during operational discharging and charging. The BMS controls all of the power distribution and includes sensors to monitor temperature, voltage, current, and many other characteristics the manufacturer deems important to the performance and safety of the battery pack and vehicle operation.

When it comes to the design of RESSs used in EVs, HEVs, and PHEVs, development and testing have gone into methods to ensure the systems are safe for general public use while delivering specified performance characteristics under anticipated usage conditions. Much like general permanently installed electrical systems, the RESS is designed according to industry standards to prevent the general public from being exposed to electrical hazards under normal circumstances. An example of one of these standards is ANSI/CAN/UL/ULC 2580:2021, *Standard for Safety, Batteries for Use In Electric Vehicles*. However, there are scenarios when interaction with the batteries may fall outside these normal circumstances, such as maintenance, repair, replacement, or accidental damage. Therefore, we must consider how to protect personnel from the electric energy stored within these systems.

EVALUATING THE HAZARD

When I am asked to provide an opinion on how to protect personnel from unique or unusual scenarios, the first thing I do is break down the hazards into their most basic forms. Electrical energy is very diverse and can present itself in unusual and novel ways, such as new large energy storage devices. However, at the end of the day, it is still just "electrons and holes," as one of my mentors used to tell me.

As we have covered, RESSs have batteries that store electrical energy in battery cell arrays. The available electrical energy in a cell is limited by its chemistry. Specifically for lithium cells, their electromechanical material properties limit available electrical potential to 3V to 4V per cell. EVs, HEVs, and PHEVs typically have requirements that range from a few hundred volts to more than 1,000V in the battery arrays as technology continues to evolve. These individual cells must be arranged in series to reach the required voltage and then connected in parallel to achieve the electrical current and power requirements. The RESS delivers high voltage to the drive system and a range of lower voltages to other vehicle systems.

For the sake of this discussion, let's assume we have exposure to a maximum direct-current (DC) voltage of 1,000V. Voltage is the more straightforward variable of the electrical hazard. Regardless of the scenarios we evaluate, the voltage will remain constant for the connected circuit. The amount of current a person could be exposed to may vary depending on the scenario in which they're interacting with the batteries, various subsystems, and associated charging systems. There are several safety features built into the battery pack that will effectively limit the amount of current being released. However, if maintenance or repair requires dismantling the battery pack or some of its subsystems, each task needs to be evaluated to determine how these activities will expose personnel to electrical hazards as part of an overall risk assessment.

Another variable that comes into play is the use of charging systems. General-use systems are designed to be safe for the operator to plug in, charge, and unplug. A more complex scenario comes into play when a manufacturer is

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performing research and development tasks that may pose an elevated risk to employees working around these test environments. Every scenario needs to be evaluated on a case-by-case basis.

ADDRESSING THE ELECTRICAL HAZARD

Often when a scenario falls outside of what we are accustomed to, it will look foreign, complicated, or intimidating. When it comes to electrical safety, that is not necessarily a bad thing. That reaction is a great excuse to pause and think through the task at hand. Whether the hazard is in the form of a storage system or a distribution system, from the context of electrical hazard safety, it is still just a DC voltage source.

We protect ourselves from the RESS' DC voltage sources just like we would any other DC voltage source. Our first consideration, using the hierarchy of risk control method, is to create an electrically safe work condition (NFPA 70E-2021, Sec. 110.3). The challenge of working directly with the storage system is that in many scenarios, it's simply infeasible (NFPA 70E-2021, Sec. 110.4) to create an electrically safe work condition. The next option would be to perform a shock risk assessment and an arc flash risk assessment (NFPA 70E-2021, Sec. 130.4 and Sec. 130.5) to determine the extent of the electrical hazards and ways to be protected from such hazards. This will likely result in establishing shock boundaries, utilizing insulating gloves and/or other materials, and considering other mitigating techniques. The point is, once the scenario is broken down into fundamental hazards, mitigating measures start to become more apparent for how personnel can be protected from specific hazards.

RESEARCH AND DEVELOPMENT SCENARIOS

One common question is related to research and development (R&D) facilities. Due to unique aspects of an R&D facility's tasks, there seems to be a common perception that there are hazards too complex to be mitigated. Unfortunately, there are no "one-size-fits-all" solutions to be offered. Each scenario needs to be evaluated on a case-by-case basis using methods of determining the basic hazards, going through the hierarchy of risk control methods to determine appropriate means of protection, and implementing protective measures.

When carefully thought through, a scenario has yet to be presented that prevents developing methods to ensure personnel can execute necessary tasks safely. Don't let unique aspects of any given scenario intimidate you from breaking it down to the hazards that are very common and sometimes easily able to be mitigated. One word of caution: Just because it is a DC system, do not overlook the potential for an arc flash hazard. Have a knowledgeable professional look at the scenario to determine if a potential for enough energy to sustain an arc is present. If so, perform an arc flash evaluation to determine the level of protection necessary to protect personnel inside the arc flash boundary.

THERMAL RUNAWAY

While many safety features are put into place to limit the probability and severity of a battery fire or thermal runaway event, the hazards are still present. Let's address the basics of the fire and thermal runaway hazards in EV battery packs. Thermal runaway (in layman's terms) is an abnormal event that causes a battery cell to no longer dissipate heat as quickly as it's being generated.

The most common battery for consumer vehicles is the lithium-ion battery, which contains a flammable electrolyte that serves as the liquid membrane through which chemical ions pass between electrodes. If a cell short circuits, the flammable electrolyte may catch fire and burst through battery cell walls. As this has been known for quite some time, manufacturers design barriers to insulate the battery as well as portions of the battery pack to prevent thermal runaway and minimize the spread if it does occur.

Applying the same principles discussed earlier, the goal of the manufacturer is to develop mitigating techniques that enable the battery back as a whole and individual cells to dissipate heat faster than is generated. While thermal runaway events tend to make headlines fairly frequently, several studies indicate when compared to the flammability of gasoline, Li-ion batteries pose a far lower risk of fire or explosion during or after a vehicle accident involving an EV.

TYING IT ALL TOGETHER

Continuous technological advancements in the performance, efficiency, and affordability of EVs have helped get hundreds of thousands of EVs, HEVs, and PHEVs into the hands of public and private consumers over the last decade. Various styles of EVs are now available from several manufacturers, offering drivers a wide variety of body styles, performance specs, and price points. While the capabilities of RESSs have been rapidly evolving, the safety testing required to ensure EVs, HEVs, and PHEVs are safe for use by the public is, for the most part, very similar to testing techniques used for safety testing of traditional combustion engines.

New standards are emerging, which are regularly reviewed and revised, as the industry continues to learn and understand the evolving technology. There is no reason for any elevated concern related to operating these vehicles. Maintenance and R&D personnel should evaluate specific scenarios by thinking about the basic hazards to which they are exposed, consider the risk of each hazard, and take the appropriate precautions to mitigate the hazards as required by the NFPA 70E. EVs and their electrically dense battery packs are an exciting technological trend that continues to advance and provide different and efficient transportation means but has yet to pose an electrical hazard risk that exceeds our ability to be protected. EC&M

Tommy Northcott is a professional engineer licensed in the state of Tennessee and a senior power engineer with Jacobs Technology, Inc., in Tullahoma, Tenn. He is also an NFPA 70E compliance subject matter expert, a principal member of the NFPA 70B Committee, electrical safety trainer, certified maintenance and reliability professional, and certified reliability leader. He can be reached at Thomas.Northcott@Jacobs.com.

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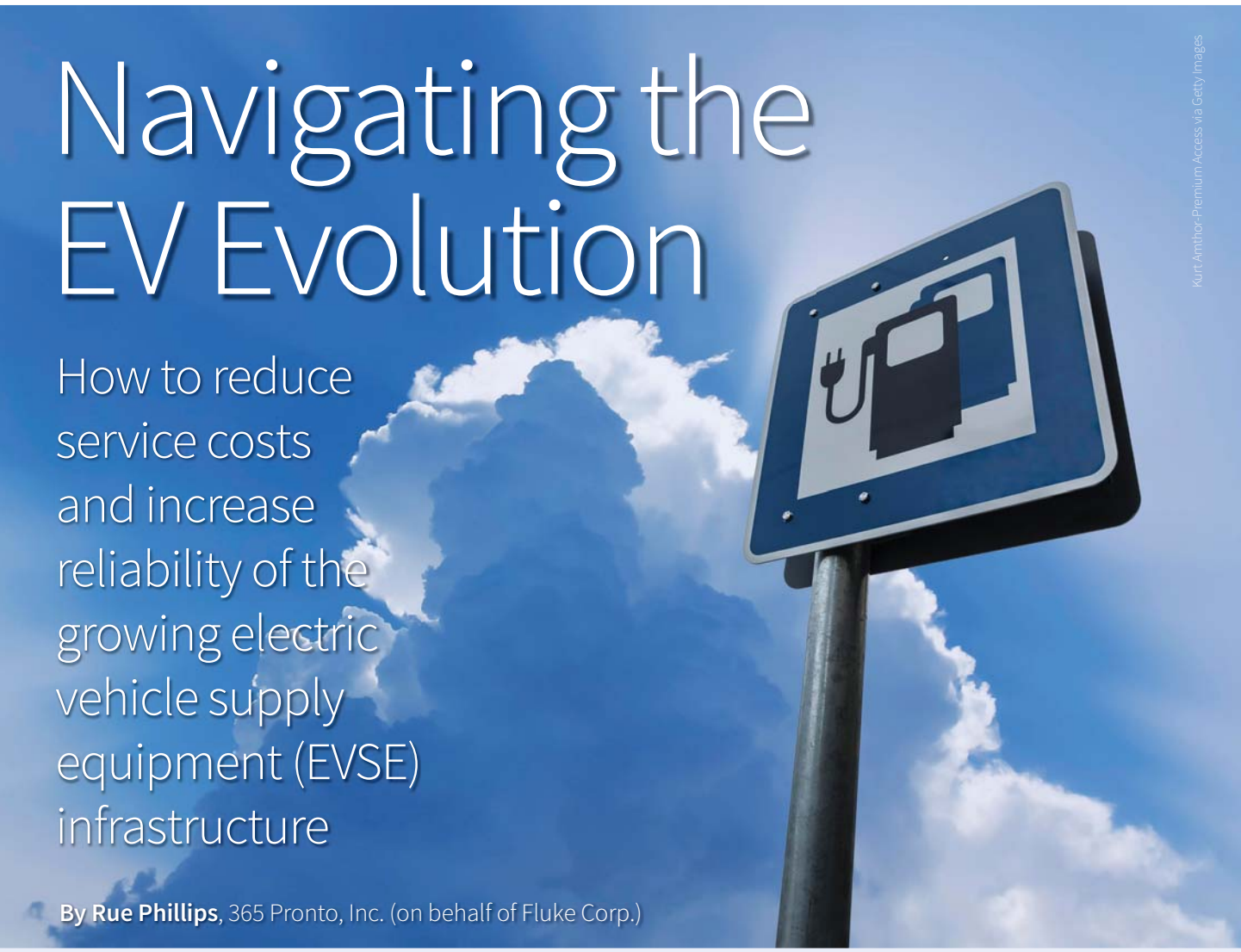

Kurt Amthor–Premium Access via Getty Images

How to reduce service costs and increase reliability of the growing electric vehicle supply equipment (EVSE) infrastructure

By Rue Phillips, 365 Pronto, Inc. (on behalf of Fluke Corp.)

The projected growth of electric vehicles (EVs) on U.S. roads is expected to reach 22 million by 2030. With that dramatic increase in the number of vehicles comes an equally dramatic increase in demand for reliable EV supply equipment (EVSE) infrastructure.

Already, EV charging stations are cropping up around shopping malls, big-box retailers, and grocery stores, allowing EV owners to charge their cars while shopping. Yet, once you get out of urban areas and onto interstate highways, the availability of EV charging stations declines sharply. There aren't nearly enough charging stations to serve the wave of demand that's about to break over the next decade — and the stations that exist may or may not be fully functional when you drive up (**Photo 1** on page 56). This creates "range anxiety" for EV drivers, who worry about keeping their vehicles charged on long-distance trips.

Availability and reliability are key to building a successful EV infrastructure, and reducing servicing costs is critical to increasing both (**Photo 2** on page 58). EVSE station owners and operators need to be able to build, operate, and maintain EV charging stations cost effectively. Meanwhile, drivers need confidence that when they drive into an EV station, they'll find working chargers. Charging station reliability has been a big issue since the early days of EVs, largely due to a lack of preventive maintenance and slow response time for fixing outages.

REDUCE COSTS AND INCREASE RELIABILITY

One way to reduce EVSE service costs — and increase reliability — is to streamline inspections so that EVSE manufacturers and station owners can commit to a regular, proactive program of preventive maintenance. Proper maintenance helps minimize downtime, which reduces lost revenue from non-functional chargers. Regular maintenance can also help reduce replacement costs by maximizing the useful life of charging equipment.

Some EVSE manufacturers already offer total care plans that guarantee a certain level of uptime for their equipment; this will likely become a wider standard as time goes on. A big challenge to implementing those plans is the shortage of labor trained to troubleshoot and maintain EVSE installations. That challenge creates new opportunities and revenue streams for local electrical professionals to install, certify, and maintain the equipment.

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Photo 1. More EVs need more charging stations, which means more technicians are needed to keep those stations functioning safely.

STREAMLINE EVSE MAINTENANCE AND TROUBLESHOOTING

To make EVSE preventive maintenance more cost-effective and efficient, new tools are available that streamline the inspection process, thus reducing the time and labor required for maintenance and troubleshooting.

A typical preventive maintenance protocol for an EV charger includes cleaning the cables, connectors, and filters and then checking operability. In the past, the charger operability testing required connecting an actual EV to the charger to see whether the unit was working. This required moving the EV from charger to charger. If the charging sequence didn't start, there was no easy way to tell whether the problem was with the charger or with the vehicle.

Now a handheld tool called an EV adapter can simulate the control pilot charging state of an electric vehicle and automate several safety and functionality tests — with no EV required. The technician simply connects the adapter to a charging port and runs a protective earth pre-test grounding safety check to make sure the station is wired correctly and that the protective earth is functioning. Some simulators also include a ground-fault circuit interrupter (GFCI) function test to ensure the GFCI will trip when necessary. With a simulator, the average testing would take 10 to 15 minutes per charger.

With this type of tool in their arsenal, electricians can delegate monthly preventive maintenance inspections to a technician who has completed 5 to 10 hours of EVSE training. If everything checks out, the charger is good for another month. If technicians find a problem that needs more extensive evaluation, they can call in a licensed electrician to diagnose and fix the problem. This reduces average servicing costs,

making it more practical for EVSE station owners and operators to commit to a regular preventive maintenance program. It also frees up electricians to address problems that require more expertise and produce more revenue.

EXPAND OPPORTUNITIES FOR LICENSED ELECTRICIANS

An EV adapter gives electricians a troubleshooting head start by quickly identifying the most common problems (**Photo 3**). Once the problem is identified, electricians can connect more advanced tools to get to the root cause. For example, they can simulate multiple charging states with the EV adapter and connect a digital multimeter to verify voltage transfer from the charger to the EV in each charging state. They can also simulate PE and CP ground fault errors and verify on the digital multimeter that the voltage from the charging station to the EV cuts off when those occur.

For more advanced testing, electricians can connect other test tools (such as portable oscilloscopes and power quality testers) to an EV adapter to assess insulation resistance, power quality, waveform, and loop impedance analyses, among other measures.

EFFICIENT USE OF PROFESSIONAL RESOURCES

The ability to delegate EVSE preventive maintenance to skilled technicians can create a predictable revenue stream for electrical contractors while also extending the capacity of licensed electricians to handle more complex projects. At the same time, this approach can significantly reduce inspection costs, thus committing to preventive maintenance programs more financially attractive to EVSE operators and owners. The result is a more reliable EVSE infrastructure that gives EV drivers confidence they'll be able to charge their vehicles wherever they drive.

The accelerating growth of the EV market is creating many interesting opportunities for electrical professionals to expand into EVSE support. I encourage anyone interested in getting into EVSE installation, troubleshooting, and/or maintenance to do some research.

Some places to start include the Electric Vehicle Infrastructure Training Program (EVITP) and regional programs like Clean Tech Institute. Talk to EVSE manufacturers and local electric utilities about EVSE certification training resources. Find out about the variety of EVs available, and drive a few. Start now, and become part of the growing EVSE infrastructure where you are — you never know where it will take you. EC&M

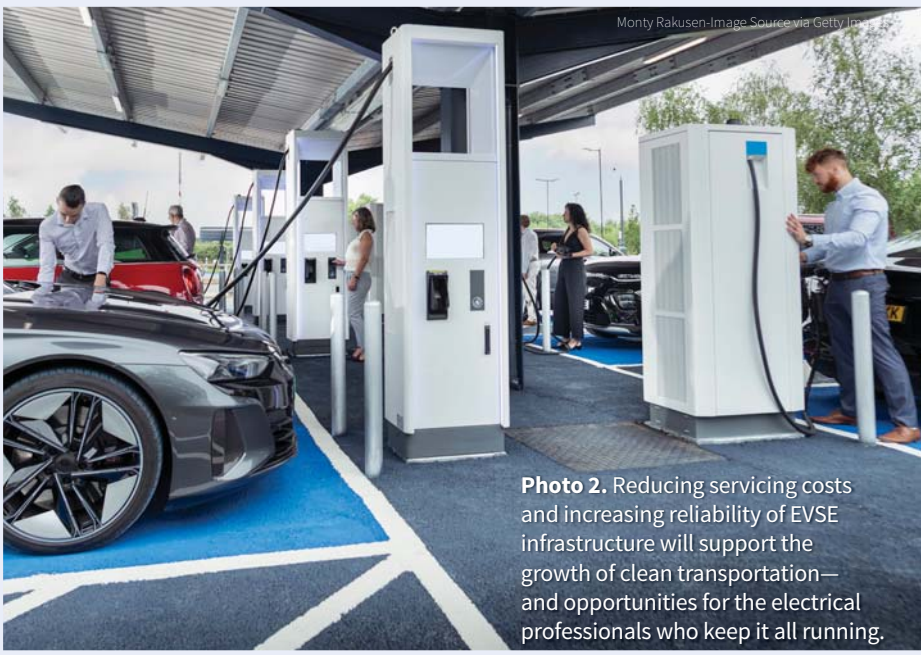

Photo 2. Reducing servicing costs and increasing reliability of EVSE infrastructure will support the growth of clean transportation—and opportunities for the electrical professionals who keep it all running.

Photo 3. A technician can use an EV charging station adapter with other tools to check out EV equipment and identify common issues as part of a preventive maintenance program.

Rue Phillips is a recognized leader and veteran in solar, electric vehicle (EV), and renewable technologies who has created and run numerous companies in the cleantech space. As a sought-after industry expert, Rue is a frequent event keynote and technical speaker, and he serves on expert advisory committees for the development of codes and standards for the U.S. renewable energy industry. He's also the host of the popular podcast "EV Chat," as well as the community founder and director for the LinkedIn group EV Infrastructure Forum. This article was written on behalf of Fluke Corp.

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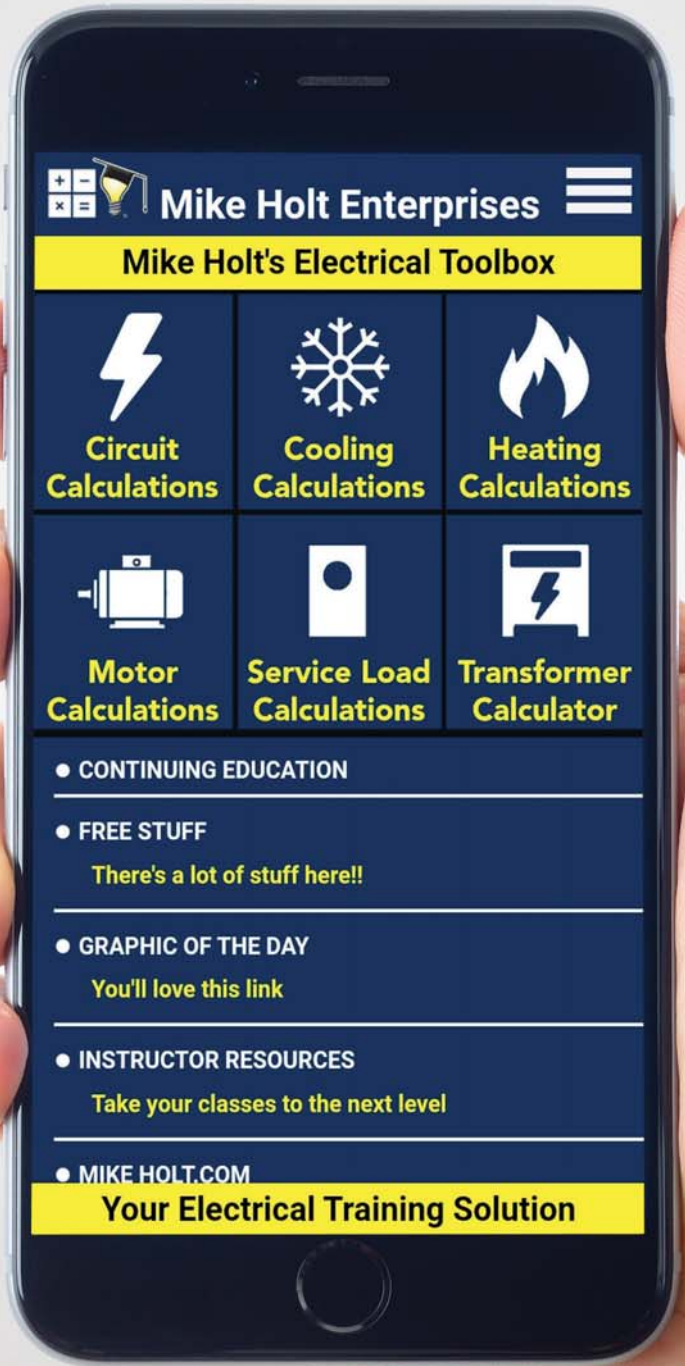

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"…as for me and my house, we will serve the Lord." [Joshua 24:15]

New Semiconductor & EV Plants Expected to Fuel $130-Billion Construction Surge

The construction of chip plants, EV factories, and battery plants could dominate industrial construction in the near future.

By Jim Lucy, Editor-in-Chief, *Electrical Wholesaling* and *Electrical Marketing*

Intel Corporation

Intel will be spending $20 billion to expand an existing semiconductor facility in Chandler, Ariz.

The announcement on Feb. 21, 2022, that Tritium, an Australian electric vehicle (EV) charging company, plans to build a factory in Lebanon, Tenn., that will eventually be capable of manufacturing up to 30,000 DC chargers annually, is the latest example of an EV or semiconductor manufacturer with plans to build a massive factory in the United States.

According to *Electrical Marketing* research, these companies have announced plans for no less than $130.7 billion in facility construction in the coming years to produce electric vehicles, EV charging stations, and semiconductors in the United States (**Table**). When you consider that electrical construction materials typically account for 10% of a construction job, these plants will provide electrical manufacturers, contractors, distributors, reps, design firms, and other channel partners with a $13 billion-plus market opportunity.

EV & Semiconductor Plants On the Drawing Boards or Underway						
Contract Value ($ Millions)	**Project**	**City**	**State**	**Project Type**	**Status**	**Source**
30,000	Texas Instruments fab plants	Sherman	TX	Semiconductor	Plans announced	www.ti.com
20,000	Intel Ohio semiconductor plants	Licking County	OH	Semiconductor	Plans announced	www.intel.com
20,000	Intel Ocotillo campus semiconductor plant expansion	Chandler	AZ	Semiconductor	Plans announced	www.intel.com
17,000	Samsung semiconductor plant	Taylor	TX	Semiconductor	Plans announced	www.npr.org
12,000	Taiwan semiconductor plant	Phoenix	AZ	Semiconductor	Plans announced	www.cnbc.com
11,000	Ford electric vehicle & battery plants	Multiple	KY & TN	Electric vehicle or EV battery	Plans announced	www.ford.com
7,000	GM EV plants	Multiple	MI	Electric vehicle or EV battery	Plans	www.gm.com
6,000	First phase of Taiwan semiconductor plant	Phoenix	AZ	Semiconductor	Broke ground Oct. 21	construction.com
5,000	Rivian electric vehicle plant	Morgan and Walton Counties	GA	Electric vehicle or EV battery	Plans announced	www.rivian.com
1,300	Toyota EV battery plant	Greensboro	NC	Electric vehicle or EV battery	Plans announced	www.toyota.com
1,006	Tesla gigafactory	Austin	TX	Electric vehicle or EV battery	Nearing completion	www.kvue.com
470	Nikola Motors' hydrogen-electric truck plant	Eloy	AZ	Electric vehicle or EV battery	Broke ground Jan. 21	construction.com
NA	Tritium battery plant	Lebanon	TN	Electric vehicle or EV battery	Plans announced	tritiumcharging.com

This table highlights some of the largest semiconductor, EV, and battery plants underway or on the drawing boards.

The ground is yet to be broken on most of these facilities, but Tesla is reportedly nearly finished with its $1-billion gigafactory in Austin, Texas, that will produce its Model Y, Model 3 EVs, and eventually its Cybertruck. Tesla's rivals, Ford and GM, are all in on electric vehicles and, over the past year, announced plans for new plants or expansion of existing facilities. Ford plans to spend $11 billion on new battery plants in Kentucky and Tennessee, and last month, GM announced its intentions to invest $7 billion in a new battery plant in Michigan and retrofit an existing facility in the state to produce electric pickup trucks by 2024.

While the scale of the expected investment in facilities for electric vehicles or battery construction is indeed mammoth, it pales in comparison to what's going on in the semiconductor market, where Intel, Samsung, Taiwan Semiconductor, and Texas Instruments plan to spend $105 billion on new chip manufacturing plants. The biggest of them all is a $30-billion manufacturing campus Texas Instruments says it will build in Sherman, Texas. Intel made headlines last month when it announced that it would be spending $20 billion on greenfield semiconductor plants in Licking County, Ohio. The company is also spending $20 billion on an existing facility in Chandler, Ariz.

The EV and semiconductor industries will be able to tap into several financial and government incentives to fuel some of this growth. The Infrastructure Investment and Jobs Act (IIJA) passed late last year includes $7.5 billion to assist in the construction of a national EV charging network; a surprising number of electric utilities are offering a robust mix of rebates for the installation of commercial and residential EV chargers; and both the Senate and House of Representatives have passed bills with federal subsidies for domestic semiconductor production.

The House of Representatives passed the America Creating Opportunities for Manufacturing Pre-Eminence in Technology and Economic Strength (America COMPETES) Act of 2022 on Feb. 4, 2022, which will provide $52 billion in federal subsidies. On June 8, 2021, the Senate passed the U.S. Innovation and Competition Act of 2021, which includes the same level of funding for that goal. Once the Senate and House hammer out their differences on the legislation, it's expected to gain enough bipartisan support to be signed into law. EC&M

Electric Vehicle Equipment

DC Wall Box

The Terra DC wall box offers fast charging in an ultra-compact footprint. Fully compatible with current and future electric vehicles, the product features a built-in connection to the company's Ability platform to ensure reliable payments and asset management. The product is compatible with residential, commercial, office, and public assets spaces. It also offers smart charging; setup for external energy meter integration for dynamic load management; connectivity options of GSM/3G/4G, Ethernet, or RFID; charging voltage of 150VDC to 920VDC; outdoor and indoor installation options; and more. It includes built-in safety features, such as overcurrent, overvoltage, undervoltage, ground-fault protection, and more.

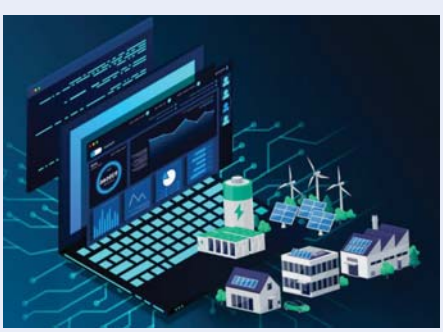
ABB

Battery-Integrated EV Charger

According to the company, the Boost Charger is the first battery-integrated ultra-fast charging system to achieve UL certification. It is designed to boost power at the grid edge instead of relying on utility upgrades. It uses existing low-voltage power (coupled with an integrated battery buffer) to enable ultrafast charging speeds while reducing installation costs and complexity. By eliminating grid upgrades, the charger makes ultra-fast charging feasible at 10 times as many locations compared to traditional chargers, according to the company. In addition, it is compatible with both 3-phase and split-phase inputs, using low-voltage infrastructure readily available at most commercial locations, including public charging, workplace, or fleet applications. Additionally, it features the company's proprietary lithium-ion battery pack (certified to UL 1973).

FreeWire

EV Charging Services



The plug-and-play FlexGen EV charging services utilize the company's updated HybridOS 9.3 energy management system platform. It provides a containerized energy storage system (ESS) that guarantees efficient and economical charging, optimizes energy consumption to ensure maximum value to the charging network operator, ensures charging stations never exceed physical limits, and minimizes demand charge rates. According to the company, the platform integrates seamlessly with on-site energy resources, reducing charging site demand costs within the constraints of customers' existing interconnect. The software also supports both greenfield and brownfield EV charging needs.

FlexGen

Solar-Powered EV Charger

The SolarFirst EV Quick Charger utilizes the Enteligent NMax RSD to deliver the highest possible amount of electricity from the solar panel to the inverter (shade or no shade), according to the company. It is designed to reduce costs and easily install with plug-and-play SunSpec RSD certification. The charger allows charging powered directly by existing solar panels and can also be powered simultaneously by the AC grid to provide peace-of-mind charge continuity, and it is designed for use at homes, work, stores, and more. According to the company, the SolarFirst EV charger is up to three times faster than AC Level 2 EV chargers at a reduced cost compared to dedicated DC chargers.

Enteligent

Vehicle Charging Station Test Adapter

The FEV100 electric vehicle charging station test adapter tests the safety and performance of Level 1 or Level 2 electric vehicle AC charging stations (EVSEs) with Type 1 connectors. The product is designed to simulate the presence of an EV, allowing technicians to test the charging station in combination with appropriate test instruments. Features include protective earth (PE) pre-test to test for dangerous voltage in the earth; control pilot (CP) for vehicle simulation; PE and CP error notification; and GFCI testing to ensure user safety, voltage, waveform, loop impedance, and resistance testing. It offers connectivity with the company's other test and measurement tools, allowing users to run additional tests, such as viewing the maximum available current, performing CP signal analysis, and more.

Fluke

Customized EV Charger

The companies partnered to create the Ford Charge Station Pro, a custom EV charger for the Ford F-150 Lightning. This charger is the first bidirectional-ready EV solution set for release at retail customer scale to receive certification under the newly expanded UL 9741, according to the company. The new charge station also features a peak power of 19.2kW, the maximum power rating currently available for a Level 2 charge station. The charging station is needed to enable Ford Intelligent Backup Power, a system that allows the Ford-150 Lightning to become an interactive part of the home and be used as a power generation source during outages. The company expects future firmware updates to the charger that will help customers interact even further with the grid.

Siemens and Ford

Smart Home EV Charger

The company has announced two new features, which come standard with its Pulsar Plus smart home EV charger: Eco-Smart and Power Boost. Eco-Smart uses a power meter to measure the energy from a home's rooftop solar system to charge an EV in an efficient and sustainable way, allowing homeowners to determine the source and mix of power to be delivered to the EV. It has two modes: Full-Green and Eco. Power Boost is designed to allow installation of a more powerful charger where the home's electrical capacity might otherwise require limiting the power available for EV charging. It's able to measure the real-time energy usage of a household and dynamically adjust EV charging power. Both features are embedded within Pulsar Plus and are activated through the myWallbox app and with the professional installation of a power meter kit.

Wallbox

Electric Vehicle Supply Equipment

The company's Smart Charging Solutions include open-standard protocol software and broad selection of hardware configurations, designed to create a flexible system, providing unlimited use-case scenarios for the same hardware asset. With the product, property owners can create separate charging rates, access privileges, and operating parameters for a variety of different users, such as employees, customers, tenants, fleet drivers, and the public.

Zevtron

Taking the Mystery Out of Sizing Pull Boxes and Junction Boxes

Make sure you know the proper sizing requirements for pull boxes, junction boxes, and conduit bodies to avoid damaging the conductor insulation when installing conductors 4 AWG and larger.

By Mike Holt, NEC Consultant

Pull boxes, junction boxes, and conduit bodies must be sized to allow conductors 4 AWG and larger to be installed without damage to the conductor insulation. The NEC provides sizing requirements in Sec. 314.28.

Keep in mind these requirements address conductors used for general wiring, such as those identified in Table 310.16. The requirements do not apply to other types of wiring or cabling. A specialty signal cable might have a bend radius of 24 in., which would require a significantly larger pull box than what you'd use for a general wiring conductor of a similar-sized outer jacket.

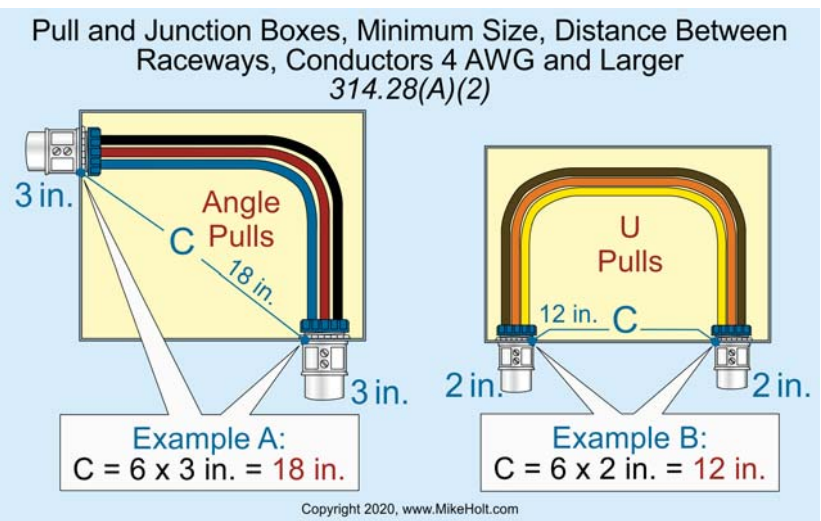


Fig. 1. The distance between raceway entries enclosing the same conductor must be at least six times the trade size of the largest raceway.

MINIMUM DIMENSIONS

For straight pulls when raceways contain conductors 4 AWG or larger, the minimum distance from where the raceway containing conductors enter to the opposite wall must be at least eight times the trade size of the largest raceway. A straight-pull calculation applies when raceways containing conductors enter one side of a box and leave through the opposite wall of the box [Sec. 314.28(A)(1)].

For other types of pulls where the raceways contain conductors 4 AWG or larger, these rules apply [Sec. 314.28(A)(2)]:

• **Angle pulls.** These occur when raceways containing conductors enter a wall and leave through one that's 90° from the entry wall. The distance from the raceway entry to the opposite wall must be at least six times the trade size of the largest raceway, plus the sum of the trade sizes of the remaining raceways on the same wall and row.

• **U pulls.** A raceway containing conductors that enters and leaves from the same wall is a U pull. The distance from where the raceways enter to the opposite wall must be at least six times the trade size of the largest raceway, plus the sum of the trade sizes of the remaining raceways on the same wall and row.

• **Splices.** When conductors are spliced, the distance from where the raceways enter to the opposite wall must be at least six times the trade size of the largest raceway, plus the sum of the trade sizes of the remaining raceways on the same wall and row.

• **Rows.** Where there's more than one row of raceway entries on the same wall, each row is calculated individually, and the row with the largest distance must be used.

• **Distance between raceway entries.** The distance between raceway entries enclosing the same conductor must be at least six times the trade size of the largest raceway, measured from the raceways' opening nearest edge to the nearest edge (**Fig. 1**).

The measurement between raceway entries is taken from the actual raceway entry, not the locknuts or bushings used to terminate the raceways.

When conductors enter an enclosure with a removable cover, such as a conduit body or wireway, the distance from where the conductors enter to the removable cover must be at least the bending distance listed in Table 312.6(A)

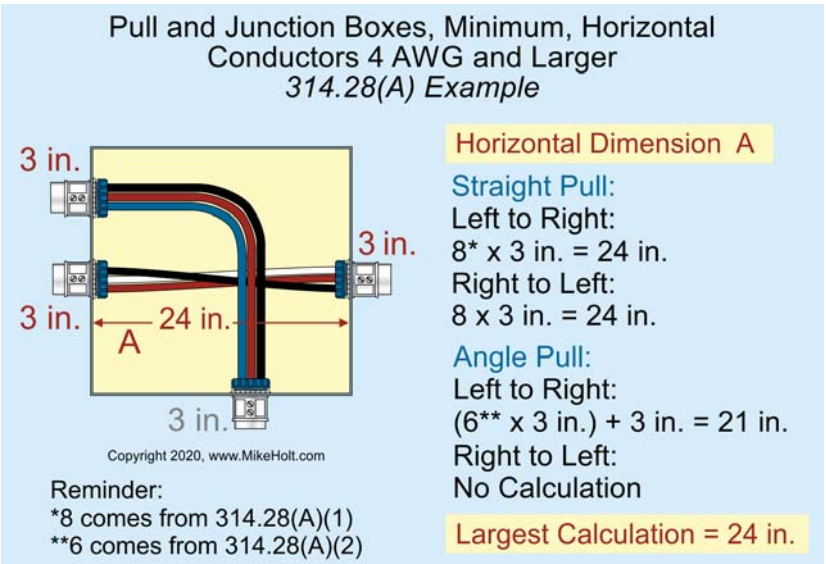


Fig. 2. As noted in this example, the minimum horizontal distance of the box is 24 in.

for one conductor per terminal [Sec. 314.28(A)(2) Exception].

PULL BOX EXAMPLE 1

A junction box contains four trade size 3 raceways: two on the left side, one on the right side, and one on the bottom. The conductors from one of the trade size 3 raceways on the left wall are pulled through the trade size 3 raceway on the right wall. The conductors from the other trade size 3 raceway on the left wall are pulled through a trade size 3 raceway at the bottom of the pull box.

What's the horizontal dimension of this box (**Fig. 2** on page 67)?

Quick Tips for Pull Box Sizing

TIPS FOR LEARNING:

- Pull box calculations become easier with more practice. Use practical field examples to practice calculations.
- Draw up some sample pull boxes and calculate them.
- Obtain drawings from a completed project and "reverse engineer" the box sizes by calculating them.

TIPS FOR DOING:

- Draw out the problem.
- To avoid simple mistakes, take your time, and be methodical.
- Do one wall at a time, and remember which wall you're working on.
- Calculate the horizontal distance(s):
  - Left to right straight calculation
  - Right to left straight calculation
  - Left to right angle or U pull calculation
  - Right to left angle or U pull calculation
- Calculate the vertical distance(s):
  - Top to bottom straight calculation
  - Bottom to top straight calculation
  - Top to bottom angle or U pull calculation
  - Bottom to top angle or U pull calculation
- Calculate the distance between raceways enclosing the same conductors.

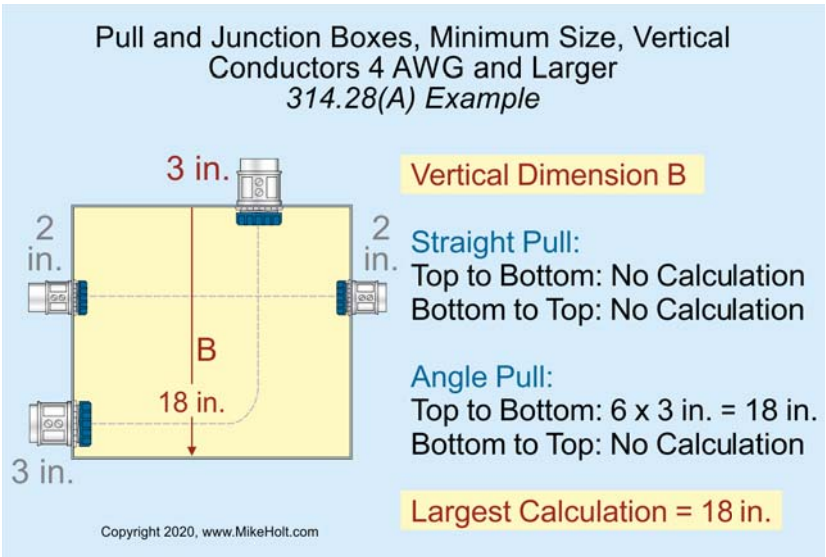


Fig. 3. As noted in this example, the minimum vertical distance of the box is 18 in.

Solution:

Left to right straight pull = 8 × 3 in. = 24 in.

Right to left straight pull = 8 × 3 in. = 24 in.

Left to right angle pull = (6 × 3 in.) + 3 in. = 21 in.

Right to left angle pull = no calculation

Answer: 24 in. [Sec. 314.28]

What's the vertical dimension of this box?

Solution:

Top to bottom straight pull = no calculation.

Bottom to top straight pull = no calculation.

Top to bottom angle pull = no calculation.

Bottom to top angle pull = 6 × 3 in. = 18 in.

Answer: (a) 18 in. [Sec. 314.28]

What's the minimum distance between the two trade size 3 raceways containing the same conductors?

Solution: 6 × 3 in. = 18 in.

Answer: (a) 18 in. [Sec. 314.28]

PULL BOX EXAMPLE 2

A pull box contains a trade size 2 and trade size 3 raceway on the left side, a trade size 3 raceway on the top, and a trade size 2 raceway on the right side. The trade size 2 raceways are a straight pull, and the trade size 3 raceways are an angle pull.

What's the horizontal dimension of this box?

Solution:

Left to right straight pull = 8 × 2 in. = 16 in.

Right to left straight pull = 8 × 2 in. = 16 in.

Left to right angle pull = (6 × 3 in.) + 2 in. = 20 in.

Right to left angle pull = no calculation.

Answer: (a) 20 in. [Sec. 314.28(A)(2)]

What's the vertical dimension of this box (**Fig. 3**)?

Solution:

Top to bottom straight pull= no calculation.

Bottom to top straight pull = no calculation.

Top to bottom angle pull = 6 × 3 in. = 18 in.

Bottom to top angle pull = no calculation.

Answer: (b) 18 in. [Sec. 314.28(A)(2)]

If the two trade size 3 raceways contain the same conductors, what's the minimum distance between these raceways?

Solution: 6 × 3 in. = 18 in.

Answer: (a) 18 in. [Sec. 314.28(A)(2)] EC&M

These materials are provided to us by Mike Holt Enterprises in Leesburg, Fla. To view Code training materials offered by this company, visit www.mikeholt.com/code.

Stumped by the Code?

By Mike Holt, NEC Consultant

All questions and answers are based on the 2020 NEC.

Q. What is the Code definition of "electronically protected" as related to motors?

A. The NEC defines an electronically protected motor as one that is provided with electronic control, which is an integral part of the motor and protects the motor against dangerous overheating due to failure of the electronic control, overload, and failure to start [Sec. 430.2 Definitions].

This type of motor will be identified by the words "electronically protected" or "E.P." on the nameplate, just like the motors with internal thermal protection have the words "thermally protected" on the nameplate.

A reference to this type of protection was added to Sec. 430.32(A)(2), which previously only covered thermal protection.

Q. What is the Code rule for sizing conductors that feed an adjustable-speed drive system?

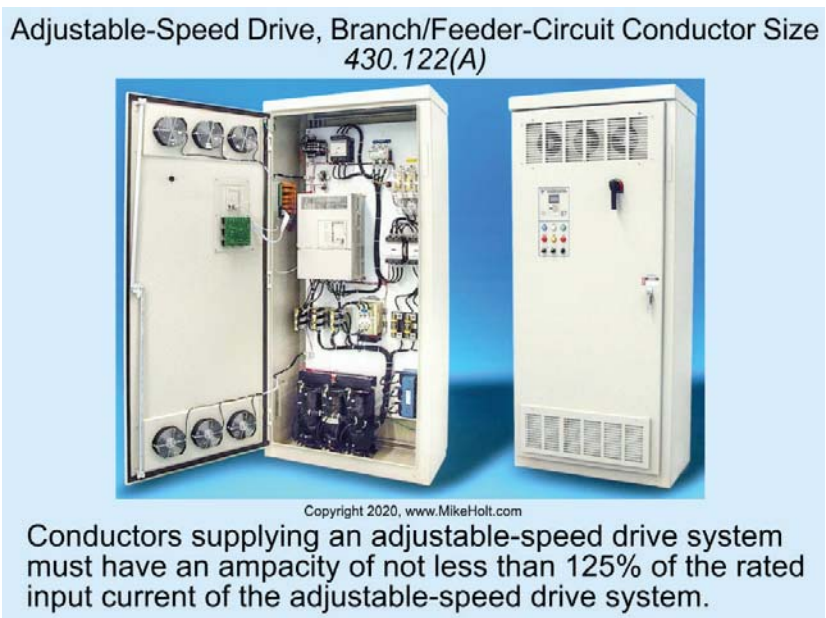
A. As per Sec. 430.122(A), circuit conductors for an adjustable-speed drive system must have an ampacity of not less than 125% of the rated input current to the power conversion equipment (See **Figure**).

Let's look at an example scenario to show you how this works.

What size branch-circuit conductors are required for an adjustable-speed drive system with a rated input of 25A and terminals rated 75°C?

Solution: Rated input from adjustable speed drive = 25A. Branch-circuit conductor = 25A × 125% = 31.25A

Use a 10 AWG conductor rated 35A at 75°C [Table 310.16 and Sec. 110.14(C)(1)(a)(3)].



Circuit conductors for an adjustable-speed drive system must have an ampacity of not less than 125% of the rated input current to the power conversion equipment.

Q. What is the Code rule for sizing branch-circuit short-circuit and ground-fault protection for circuits containing an adjustable-speed drive system?

A. Circuits containing an adjustable-speed drive system must be protected by a branch-circuit short-circuit and ground-fault protective device in accordance with all the following [Sec. 430.130(A)]:

(1) The rating and type of protection must be determined by Sec. 430.52(C)(1), (C)(3), (C)(5), or (C)(6), using the motor's full-load current (FLC) as listed in Tables 430.248 and 430.250.

Exception: The rating and type of protection is determined by Table 430.52 using the adjustable-speed drive system rated input current where the adjustable-speed drive system is listed and marked "Suitable for Output Motor Conductor Protection."

Note No. 1: Motor conductor branch-circuit short-circuit and ground-fault protection from the adjustable-speed drive system to the motor is provided by an adjustable-speed drive system that is listed and marked "Suitable for Output Motor Conductor Protection."

Note No. 2: A motor branch circuit using an adjustable-speed drive system, including equipment listed and marked "Suitable for Output Motor Conductor Protection," includes the input circuit to the power conversion equipment.

(2) The maximum branch-circuit short-circuit and ground-fault protective ratings must be in accordance with the manufacturer's instructions. EC&M

These materials are provided to us by Mike Holt Enterprises in Leesburg, Fla. To view Code training materials offered by this company, visit www.mikeholt.com/code.

Illustrated Catastrophes

By Russ LeBlanc, NEC Consultant

All references are based on the 2020 edition of the NEC.

ROGUE RV PARK WIRING

Thanks to Mike Allen from Erwin, Tenn., for sharing this photo with us. He discovered this mess when his company was asked by a local excavating contractor to "assess the electrical supply to an existing RV park in the mountains of Upper East Tennessee." Generally speaking, protecting 10/2 UF cables with a 200A overcurrent device would typically be a violation of Sec. 240.4(D)(7). These cables should be protected at 30A maximum unless otherwise permitted in Sec. 240.4(E) or (G). Section 240.4(E)(3) permits tap conductors to be protected per Sec. 240.21. If these wires are considered feeder taps, Sec. 240.21(B)(5)(2) permits them to terminate at a single circuit breaker or fuse that limits the load to the ampacity of these tap conductors. Mike did not mention whether each of these wires was connected to overcurrent devices in RV site equipment at the load end of the circuits, so we can't determine if these wires are considered properly protected against overcurrent. One thing I am certain about is the number of conductors landed in each terminal is a violation of Sec. 110.14(A). Terminating more than one conductor in a terminal is only permitted if the terminal is specifically identified for that purpose.

VINEYARD VIOLATIONS

EC&M reader Brian shared this photo with us. He says, "While walking along a vineyard road in Northern California, I noticed some conduit becoming exposed along a roadbed. The conduit looks to be 1½ in., and the conductors might be #10. Sure wasn't buried to the required depth even when installed!"

Direct buried conduits and raceways must be installed deep enough to meet the minimum coverage requirements outlined in Table 300.5. Column 3 of this table provides the minimum cover required for nonmetallic raceways, including rigid PVC conduit. Under streets, roads, alleys, parking lots, and driveways, the minimum depth of cover for rigid PVC conduit is 24 in. This raceway appears to have been buried only a few inches deep. The tire impressions in the dirt indicate a tractor or large truck travels along this roadway and has finally worn down the dirt enough to destroy the raceway and damage the enclosed conductors. This raceway will need serious repair work, and new conductors will probably need to be pulled through the raceway to make this safe again. Perhaps the raceway could be encased in concrete, buried deeper, or re-routed to provide some much-needed protection.

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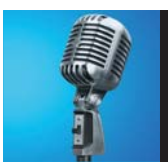

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What's Wrong Here?

By Russ LeBlanc, NEC Consultant

How well do you know the Code? Think you can spot violations the original installer either ignored or couldn't identify? Here's your chance to moonlight as an electrical inspector and second-guess someone else's work from the safety of your living room or office. Can you identify the specific Code violation(s) in this photo? Note: Submitted comments must include specific references from the 2020 NEC.

Hint: A suspicious supporting means

'TELL THEM WHAT THEY'VE WON...'

Using the 2020 NEC, correctly identify the Code violation(s) in this month's photo — in 200 words or less — and you could win an Arlington Industries 18" Slider Bar and plastic box for mounting between studs with non-standard spacing , which includes a stainless steel trap door cover and a 20A decorator-style, tamper-resistant receptacle. E-mail your response, including your name and mailing address, to russ@russleblanc.net, and Russ will select three winners (excluding manufacturers and prior winners) at random from the correct submissions. Note that submissions without an address will not be eligible to win.

JANUARY WINNERS

Our two winners this month were Al Caton, a reader from Kodak, Tenn., and John E. Skog, P.E., with Maintenance and Test Engineering LLC of Olympia, Wash. They both knew that receptacles installed in wet locations are required to have weatherproof enclosures.

For 15A and 20A, 125V and 250V receptacles, Sec. 406.9(B)(1) requires an enclosure that is weatherproof with an attachment plug inserted or removed. Outlet box hoods used for this purpose must be identified as "extra-duty." The large attachment plug installed here prevents the cover from being secured in a closed position. Extra deep covers and boxes are available to accommodate large attachment plugs like the one in the photo. Covers that are weatherproof only with the attachment plug removed are not permitted for these types of receptacles in wet locations. For areas subjected to routine high-pressure spray washing, the exception to Sec. 406.9(B)(1) permits the use of covers that are weatherproof when the attachment plug is removed. Weather-resistant receptacles must also be used in damp or wet locations.

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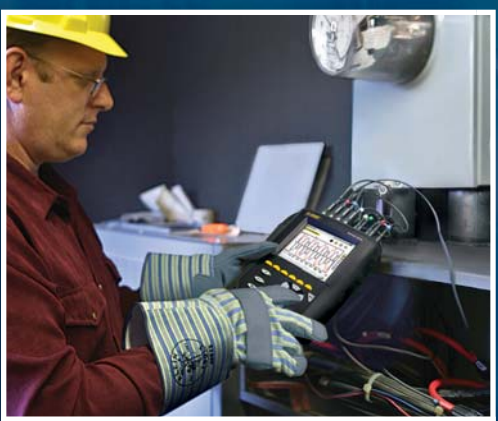

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