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ELECTRIC VEHICLE CHARGING CONTROL STRATEGIES

By Katherine Dayem, Catherine Mercier, and Peter May-Ostendorp, Xergy Consulting

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NRECA
America's Electric Cooperatives

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SUBJECT MATTER EXPERT ON THIS TOPIC

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ARTICLE SNAPSHOT

WHAT HAS CHANGED IN THE INDUSTRY?

Americans are embracing electric vehicles (EVs) and adopting them at an ever-increasing rate. In July of 2018, EVs comprised 2 percent of U.S. passenger car sales (InsideEVs 2018). EV sales are projected to continue growing to 20 to 30 percent of sales in the next ten years (BNEF 2017, Forbes 2017). Increasing battery size and range, with EVs with 200 to 300 miles of range like the Chevy Bolt and Tesla Models coming to market in recent years, equates to growing electricity demand to charge them.

WHAT IS THE IMPACT ON COOPERATIVES?

Although cooperatives and utilities are likely to see load growth from EVs as a positive development to offset recent load stagnation or declines, uncontrolled charging can have a negative impact if it occurs during times of day when electricity is in high demand and expensive. If well controlled, however, EV charging is a flexible load that can be aligned with supply, reduce peak demand and related charges, and increase the load factor of the grid. Providing EV information and charging services also helps the co-op establish itself as its members' trusted energy and EV advisor. In fact, failing to provide this information erodes consumer trust in their electricity provider and makes them more likely to use a third party for EV charging services (Utility Dive 2018). Finally, EVs and EV charging align with the goals of beneficial electrification.[1] They have lower emissions than gasoline or diesel vehicles (UCS 2018), and some models now have lower cost-of-ownership than their fossil fuel equivalents (Palmer et al. 2018).

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1 Beneficial electrification strategies substitute electricity for direct fossil fuel use where it yields cost savings to the consumer and/or reduces atmospheric emissions. In addition, beneficial electrification can provide flexible and controllable resources to the grid, offer local economic development, and increase product quality. For more information on beneficial electrification, visit NRECA's content on **www.cooperative.com**.

WHAT DO COOPERATIVES NEED TO KNOW OR DO ABOUT IT?

Co-ops have many options for controlling how EVs are charged in their service territories. These strategies range from simple behavior nudges to communicating with and controlling the charging equipment. How a co-op controls EV charging depends on factors such as the co-op's goals, their staff and financial resources, and member demographics. In general, while EV penetration is low in a co-op's service territory, indirect control via behavior nudges for the member, such as time-of-use (TOU) rates or other incentive programs that encourage charging at optimal times, can be effective (EPRI 2018, Nelder et al. 2016). At a high EV penetration, more complex control strategies may be necessary to match charging demand to available supply throughout the course of the day (Hodge 2017). These strategies require direct control of charging, usually through Level 2 electric vehicle supply equipment (EVSE), by the co-op or a third party. This report outlines the control strategies available to co-ops, and the situations in which the co-ops may employ them.

Why Control EV Charging?

Controlling EV charging can take many forms, and how a co-op decides to control charging depends on its goals. In the near term, these goals may include increasing EV sales and adoption, growing managed load, and establishing the co-op as the members' trusted source for EV information and EV charging services. As the aggregate load of EVs increases, however, co-ops will need to address imFOGIRE pacts in two areas:

1. **Distribution grid infrastructure**: EV drivers on flat electricity rates tend to plug in to charge their cars upon returning home (EPRI 2018, Figure 1). If a large number of drivers in a neighborhood return home and commence charging at the same time, demand may exceed the capacity of the distribution transformer or other local infrastructure. Rather than increasing the hosting capacity of the distribution grid, shifting load to times of day when the grid is underutilized is an effective means of providing additional electricity without investing in grid upgrades (see Figure 1 for example).
2. **Power procurement**: One of the benefits of EVs is increased electricity sales,[2] but co-ops will want to strategically procure cheaper off-peak power over expensive peak power, and shift demand to times of day when electricity rates are lower. In addition, as variable renewables increase their share of the power supply, co-ops may need to match flexible loads like EVs to the available supply.

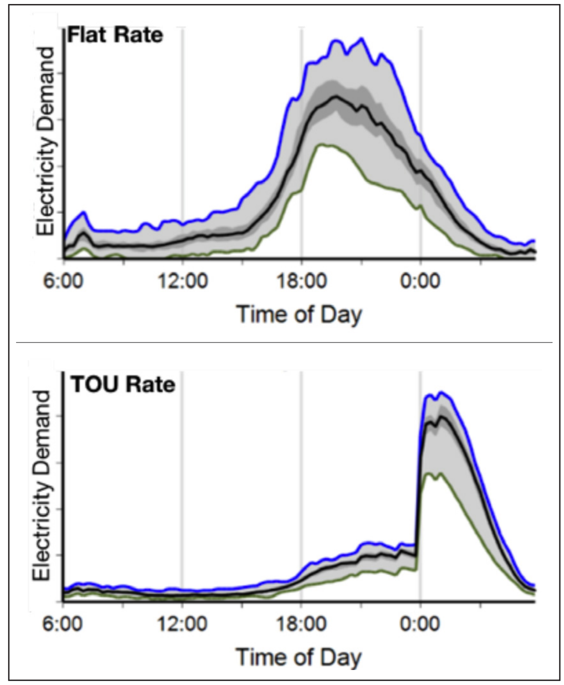

FIGURE 1: Examples of load profiles for uncontrolled EV charging (top) and indirectly controlled charging through TOU rates with off-peak hours from midnight to 6 am (bottom). Figure modified from The EV Project (2013).

Co-ops will need control solutions to address these impacts, increase load factor to avoid the need for expanded infrastructure, and align EV charging load with supply.

Where to address and control charging is a key consideration. More than 70 percent of EV charging occurs at home (ERPI 2018, INL 2015). EVs are generally at home overnight and for long periods of time, allowing flexibility in when the vehicle is charged. Consequently, we focus on residential charge control opportunities here, and briefly discuss the special considerations related to commercial and workplace charging in the **sidebar** on page 9.

Where to address and control charging is a key consideration.

CHARGING EQUIPMENT

EVs can be charged at home in two main ways. In both cases, EVSE regulates and safely supplies AC power to the on-board charger of the EV. The main difference is the amount of current that is delivered to the EV. The simpler, lower

[2] A cooperative with one thousand EVs in its territory may see a load increase of 9 MWh per day, assuming the average EV drives 30 miles per day and consumes 300 Wh per mile.

The advantage of Level 2 EVSE is two-way communication that allows the co-op (or a third party) to control charging and collect charging data.

While simple Level 1 EVSE control strategies offer benefits, the more advanced Level 2 EVSE strategies may be required for addressing future infrastructure and power procurement issues.

cost option is Level 1 charging, in which the EV is plugged into an outlet—often 120 V—with the cord provided with the vehicle. Some EVs such as the Nissan Leaf and the Tesla Model 3 also come with a 240 V option on the charge cord (see Figure 2). With Level 1 charging at 120 or 240 V, the EV can draw 8 to 20 amps of AC current, providing anywhere from 3 to 16 miles of charge per hour.[3] The member controls and schedules charging through the vehicle or the vehicle's app, but the co-op has no insight into the charge behavior. The second, more expensive, but more controllable type of charging uses Level 2 EVSE, which deliver up to 80 amps, provides 10 to 60 miles of charge per hour, and can communicate with both the member and the co-op (see Figure 3). Level 2 EVSE cost about $500 to $1,000, and depending on any necessary service and wiring upgrades, can cost a few hundred to one or two thousand dollars for installation by an electrician (Dayem et al. 2018). The advantage of Level 2 EVSE is two-way communication that allows the co-op (or a third party) to control charging and collect charging data. Without Level 2 EVSE, the co-op cannot directly control charging, and must rely on members to charge during beneficial times.[4]

FIGURE 2: Example of Level 1 EVSE. Some EVs are sold with a Level 1 EVSE that can use either 240V or 120V.

FIGURE 3: Example of Level 2 EVSE and phone app (image provided by eMotorWerks).

As we discuss below, simple control strategies can help co-ops gain experience and become their members' trusted advisor for EVs and charging in the near term. However, addressing future infrastructure and power procurement issues will require more advanced control strategies based on communication between the co-op and the EVs, which is provided by Level 2 (but not Level 1) EVSE. Although many EV drivers may not yet need the faster charging capacity or be able to justify the cost of Level 2 EVSE, and although co-ops may not yet need to directly control EV charging, it takes time to deploy the right equipment. Co-ops should not only plan their near term EV strategy, but look ahead to ensure that they can deploy the equipment required for direct control when it becomes necessary.

Residential Charge Control Strategies

Charge control strategies fall into two main approaches: indirect and direct control. Indirect control provides nudges via financial or other incentives that influence member charge behavior. Under these strategies members can use either Level 1 or Level 2 EVSE to charge their vehicles. Direct control is managed by the co-op or a third party, often through a Level 2 EVSE, and includes auto demand response (DR) and flexible charging services.

3 Assuming the EV consumes 300 Wh/mile on average.

4 Other methods of charge control that do not require a Level 2 EVSE are in development and may become available in the future. EPRI, for example, is developing an EV central server that allows utilities to control charging through direct communication with the EV.

Time-varying rates that provide financial incentive and flexibility are an effective means of shifting load.

INDIRECT CONTROL STRATEGIES

Indirect control strategies are carried out by members using the EV's onboard controls, a Level 2 EVSE, or an app for the vehicle or the EVSE. Members change their charge behaviors in response to financial or other nudges from the co-op. These nudges can be in the form of price signals, rewards programs, and green power mix options. The following describes these strategies and discusses the benefits and challenges related to each.

Rate Structures

Price signaling through time-dependent rates gives members financial incentive to charge their EVs during low-cost periods. Price signal strategies include time-of-use (TOU) rates, off-peak charging for a reduced rate or monthly fee, and peak demand charges.

TOU rates include at least on-peak and off-peak rates, but can include more granularity. Typically, off-peak rates occur overnight and on-peak rates in the morning and evening hours. Co-ops that have photovoltaic (PV) or other distributed generation may set off-peak hours to include the hours of distributed generation, such as the afternoon PV generation, as well.[5] The rates and peak hours may vary with season, and may apply to the whole home or only to the EV. If the rate applies to only the EV, the EV must be metered separately from the house. Often co-ops and utilities install a second AMI meter on the EV circuit, but many EVSE manufacturers are now developing Level 2 EVSE models that include this metering capability.[6] TOU rates are by far the most prominent EV charging control strategy employed by utilities and co-ops. A sampling of co-op whole-home and EV TOU rates is included in Table 1.

Although co-ops and utilities most often use peak demand charges for commercial and industrial customers, they may also be used in residential rate structures. Peak demand

TABLE 1: A Sampling of Co-op TOU Rates.

Cooperative	Rate Type	On-peak ($/kWh)	Off-peak ($/kWh)	Rate Ratio (on-peak:off-peak)
Berkeley Electric Cooperative	Whole-house	0.239	0.059	4.1
Connexus Energy	EV	0.455 (summer) 0.345 (winter)	0.073	6.2 (summer) 4.7 (winter)
Dakota Electric Cooperative	EV (pilot)	0.4414	0.0674	6.5
Illinois Electric Cooperative	EV	0.085	0.05	1.7
Lake Region Electric Cooperative	EV	0.4734	0.0707	6.7
Minnesota Valley Electric Cooperative	EV	0.397	0.065 (summer) 0.049 (otherwise)	6.1 (summer) 8.1 (otherwise)
New Hampshire Electric Cooperative	EV	0.23608	0.10468	2.3
Randolph Electric Membership Corporation	Whole-house	0.4641	0.0546	8.5
	EV	0.3642	0.0843	4.3
Sawnee Electric Membership Corporation	Whole-house	0.28	0.0415	6.7
	EV	0.28	0.0415	6.7
Sioux Valley Energy	Whole-house	0.1535	0.0544	2.8
	EV	0.1535	0.0544	2.8
Wake Electric Membership Corporation	EV	0.10944	0.0894	1.2
Wright-Hennepin Cooperative Electric Association	EV	0.1945	0.0521	3.7

5 Because EVs are often away from home during peak PV generation, co-ops with excess daytime generation should also consider workplace and public EV charging opportunities (see **Sidebar**, page 9).

6 EVSE models with on-board revenue-grade metering have the potential to reduce installation and equipment costs, and are therefore assumed to be the preferred solution, if available.

At high EV penetration levels, a rebound peak may occur If members schedule charging to begin at the start of off-peak periods.

Rewards programs may be easier to implement and more flexible because the co-op avoids a rate setting process.

charges are calculated on the highest demand interval (often 15 minutes or 1 hour) during a billing period. Peak demand charges can encourage members to charge EVs at lower current, reducing the magnitude of the load but increasing charge time. Alternatively, peak demand charges can be used to reduce system peaks if demand charges apply to a peak window. Mid-Carolina Electric Cooperative, for example, has this rate in place for all accounts.[7] Like TOU rates, peak demand charges can apply to the whole home or, if it is metered separately, only the EV.

Required equipment: If the price signal applies to the EV separately from the rest of the home, a second meter and/or a Level 2 EVSE is necessary for metering. If the rate applies to the whole home, no additional equipment is required.

Benefits: Time varying rates have proven to be effective at shifting load, provided that the financial incentive is appreciable and there is flexibility to charge during on-peak hours if necessary. If rates are set so they reflect the cost of power, the co-op does not gain or lose financially; the costs and savings are passed to the member.

Challenges: If the price signal applies to the EV, installing a separate meter and/or Level 2 EVSE adds significant cost to the implementation of this strategy. The co-op must decide how much of the equipment and installation cost it will cover, which depends on the co-op's goals for cost recovery versus goals for deploying equipment that will be required for future direct control programs.

When the rate applies to the whole home, the member may have little to no incentive to install a Level 2 EVSE, and the co-op misses out on an opportunity to install the equipment necessary for future direct control. EV owners who are worried about higher bills due to on-peak usage of other products in their homes may be discouraged from signing up a whole-home rate.

Finally, at high EV penetration, the co-op may experience a rebound peak if members schedule charging to begin at the start of off-peak periods (as seen in **Figure 1**, this is common behavior for consumers on TOU rates). If a rebound peak is large enough, it may negatively impact a distribution transformer by exceeding its capacity and reducing lifespan. This issue is transformer-specific and depends on the number and charge behavior of EVs served by the transformer, the non-EV load, and the transformer capacity. Co-ops should monitor rebound peaks for negative impacts. If rebound peak mitigation becomes necessary, co-ops can employ more advanced direct control methods that reduce the peak to a manageable maximum, and spread charging load across the off-peak interval.

For more about rate options to support EV programs, see **NRECA resources on www.cooperative.com**.

Rewards Programs

Rather than changing or adding rate structures, the co-op can reward off-peak charging and voluntary charging load reduction (sometimes called *voluntary demand response* (DR)) through bill credits or other rewards programs. Similar to price signal strategies, the co-op nudges members to charge during daily off-peak hours or to curtail charging during system peaks. The former requires that the co-op articulates off-peak hours to their members, whereas the latter requires announcing the curtailment request via email, text, or phone. EV charging must be monitored, so that the co-op can reward appropriately.

Required equipment: A couple of approaches are available to monitor EV charging for rewards programs. The information can be gathered directly from the EV using products like FleetCarma,[8] which collect location, charge behavior, and other data from the EV through a small piece of equipment that connects to the vehicle's onboard computer. The data is transmitted wirelessly to the co-op for its use. Alternatively, the information is collected at the house through a Level 2 EVSE and/or a separate meter.

Benefits: Rewards programs can be easier to implement and more flexible than special rates, because the co-op avoids the rate setting

[7] https://www.fleetcarma.com/smartcharge-rewards

[8] https://www.fleetcarma.com/smartcharge-rewards

process. They also provide greater flexibility in monitoring equipment. Co-ops can use on-vehicle monitoring like FleetCarma to collect EV data (including vehicle location, trip distances, and charge behaviors away from home), or revenue-grade metering like Level 2 EVSE to collect data on at-home charging, as well as use the opportunity to deploy equipment that can be used for direct control.

Offering green power is a non-financial incentive that may be appealing to early EV adopters.

Challenges: Although it avoids formal rate setting, the co-op must still determine appropriate levels for bill credits or rewards, factoring in costs related to monitoring equipment. Similar to using price signals, rebound peaks are possible at high reward program participation rates.

Green power mix options

The co-op can encourage a behavior change through non-financial incentives, especially for the generally less cost-sensitive early EV adopters. One example is providing green power (i.e., retiring renewable energy certificates on a member's behalf) to EV owners to enhance the green attributes of EV ownership and encourage charging during periods of excess renewable generation, offered by co-ops such as Great River Energy and Connexus Energy. These incentives are combined with TOU rates that incentivize off-peak charging on renewable energy.

Required equipment: None.

Benefits: Provides additional, non-financial incentive to encourage members to charge off-peak that plays to first adopters' environmental motivations for getting an EV. Supports decarbonization and boosts demand for renewable energy.

Managed charging allows the co-op to match load with supply, minimize electricity costs, and avoid rebound peaks.

Challenges: Unless combined with an EV TOU rate, this strategy does not provide incentive for the member to install Level 2 EVSE.

DIRECT CONTROL STRATEGIES

Direct control strategies are those in which a system administrator, either the utility or a third party, controls when and how EVs charge, rather than relying on the member to respond to behavior nudges. These strategies include the familiar, such as auto (nonvoluntary) demand response (DR), and newer techniques that are tailored to management of EVs and other flexible loads.

Automated Demand Response

To reduce EV charging demand during system peaks, co-ops can use a familiar control strategy: auto DR. The co-op cuts power to the EV during DR events to curtail load and reduce expensive system demand peaks. Curtailment events may be initiated using a load control switch or a Level 2 EVSE. Unless the member contacts the co-op and is allowed to opt-out, charging is not allowed during the event.

Co-ops can use a similar approach to limit charging to off-peak hours. Instead of curtailing load during system peaks, it is curtailed on a daily basis, limiting charging to nighttime hours. The EV charging circuit is controlled separately from the rest of the house, using a load control switch or a Level 2 EVSE. Co-ops can offer the charging for reduced rates or a fixed monthly fee. Many co-ops offer such a program, frequently called an "EV Storage" program.

Required equipment: Load control switch or Level 2 EVSE.

Benefits: Co-op familiarity and experience with DR programs reduces the learning curve, and auto DR yields more curtailment than voluntary DR. An auto DR program presents the opportunity to incentivize installation of Level 2 EVSE for managed charging. Level 2 EVSE provides two-way communication to confirm curtailment and collect charging data.

Challenges: Load control switches do not communicate with EVSE, and therefore, do not facilitate managed charging control strategies.

Managed charging

Managed charging leverages the long, often overnight, periods that EVs are parked at home to coordinate charging at the system level. When an EV driver returns home and plugs in the vehicle, it does not matter when and how the EV is charged, as long as it is ready with the required amount of charge when the driver needs it. Managed charging allows the co-op to match load with supply, minimize electricity costs, and avoid rebound peaks. As supply

< PREVIOUS VIEW >

becomes more variable due to a growing share of renewable generation, the ability to manage flexible loads in real-time will become an essential tool for electricity providers.

As opposed to auto DR, which requires members to conform to the needs of the grid, managed charging relies on member inputs to determine how to charge the vehicle in a way that works for them as well as the utility. These inputs, gathered through Level 2 EVSE, include the vehicle's state of charge (SOC) before charging,[9] the amount of charge needed, and the time the EV needs to be available with that charge (for example, "I need 75 percent charge by 7:30am."). With this information, the charge control platform—be it the EVSE control platform, a Distributed Energy Resource Management System (DERMS) platform such as Virtual Peaker, or a smart home platform such as Google Home—automatically decides when and how to charge each EV based on aggregate demand. This creates a seamless charging service for the member. Using a DERMS or smart home platform further expands the co-op's load control capabilities by adding the capacity to control other flexible loads. Managed control platforms could also eventually enable co-ops to provide vehicle-to-grid (V2G) services by aggregating their EV resource for use when the grid calls for additional supply.

Required equipment: Level 2 EVSE

Benefits: Allows the co-op to match demand to supply in real-time, avoid rebound peaks associated with tiered rate structures, and provide charging-as-a-service to members. Opens the potential to aggregate EV resources for V2G services.

Challenges: By providing charging-as-a-service, the co-op takes on the responsibility of providing EV charge to member expectations. Until a solution is developed, the member must input SOC information in addition to charge preferences.

Controlling Commercial and Workplace Charging

EV charging locations other than residential present control opportunities and special considerations. Here we consider two main categories: commercial (or public) charging, and workplace charging.

When a driver pulls up to a commercial charger, chances are he or she is expecting a gas station-type of experience: charge the EV immediately, as quickly as possible. In this situation, the main strategy available is indirect control through price signals. During high demand, charging rates may increase significantly, signaling EV drivers to wait to charge if they can, but still allowing those who cannot wait to charge.

More flexibility is available for controlling workplace charging, because the EVs are generally on-site for the work day and charging need not be immediate nor be carried out as quickly as possible. Especially when there is one charger for every EV, charging can be managed to occur during periods of low demand charges, excess on-site or utility scale PV generation, or other times when electricity rates are favorable. This type of control can be carried out with facility management software that receives EV driver input, such as initial SOC, and the amount of charge needed by a certain time (Hodge 2017). The software then schedules the charging to take place during beneficial periods throughout the work day. Workplace charging becomes more complicated if there is fewer than one charger available for each EV. In this case, there is less flexibility to charge at beneficial times, and more focus on providing charge to all EVs requesting the service. On the variable generation grid of the future, workplace and residential charge control will need to be a coordinated effort to charge EV batteries when generation, such as daytime PV or nighttime wind, is readily available, and provide V2G services during peak demand.

[9] At least one EVSE manufacturer (eMotorWerks) is coordinating with EV manufacturers to develop the ability for the EV to communicate SOC information to the EVSE. This functionality would eliminate the need for the user to provide SOC information.

Today's Charge Control Programs at Co-Ops and Other Utilities

TOU rates are the most common type of charge control employed by co-ops and utilities today.

RATE STRUCTURES

By far the most common charge control program used by co-ops and other utilities is TOU rates, either whole-home or EV-specific. **Table 1** is a sampling of co-op TOU rates. Given the wide range of rates, one pressing question is: what are the right rates? What TOU rates will encourage members to modify their behavior and save them money on their electricity bill? This has less to do with the absolute value of the rate, which largely depends on the co-op's cost to deliver electricity, and more to do with the ratio between on and off-peak rates. The difference between on and off-peak rates must be large enough for the member to see value in altering their behavior to off-peak charging. If on and off-peak rates are similar, then the member may not see value in altering behavior to charge during off-peak hours. A study by San Diego Gas & Electric (SDG&E) found that customers on EV rates with higher ratios between on and off-peak hours[10] shifted more of their charging to off-peak (Cook et al. 2014). On-peak rates of about 2, 4, and 6 times greater than off-peak rates resulted in 78 percent, 83 percent, and 85 percent of total charging during off-peak hours, respectively. Researchers estimate that on-peak rates greater than 6 times off-peak yield minimal additional shifting (Cook et al. 2014). Most of the rate ratios shown in **Table 1** are more than 2, although several co-ops offer rate ratios greater than 6.

The difference between on and off-peak rates must be large enough for the member to see value in altering their behavior to off-peak charging.

More recently, Salt River Project (SRP) studied load shifting with TOU and EV rates. They found that customers on a basic flat rate plan tend to begin charging their vehicles when they arrive at home, often in the late afternoon. Customers on whole home (on to off-peak ratio ~ 3) and EV TOU (on to off-peak ratio ~ 3.5) rates shifted most of their charging to off-peak hours (EPRI 2018).

AUTO DR

Delaware Electric Cooperative (DEC) conducted an auto DR pilot in 2018, and expanded it to a program in January 2019. Members who participated in the pilot received a ChargePoint Level 2 EVSE from DEC, then paid for its installation, and agreed to share their data with DEC. DEC integrated with the ChargePoint platform to send interrupt signals during peak reduction periods. DEC noted that two pilot participants used the EVSE to schedule all charging to be overnight, effectively taking their load out of the peak time, and shifting to off-peak. For the 2019 program, DEC offers a one-time credit of $100 for installing the approved EVSE and $5 per month bill credit for participating in the program.

Green Mountain Power (GMP), is an investor-owned utility in Vermont. GMP offers unlimited charging outside of peak events for a fixed monthly fee of $29.99. Power to the EV charging circuit is cut during peak events with a load control switch, but customers can contact GMP to opt-out of the event and charge for $0.60 per kWh. For an average EV driver, the monthly fee is equivalent to an electricity rate of $0.10/kWh, assuming the EV is driven 1,000 miles a month and uses on average 300 Wh per mile. Although fixed fee structures can lead to increased usage, such as increased cell phone data usage when data is unlimited, this risk for EV charging seems low since EV consumption is tied to the distance driven, and drivers are not likely to drive extra miles simply because they are free.[11] GMP's program has been very popular and successful, with 300 customers enrolled and very few complaints, according to Graham Turk, Innovation Strategist.

Several co-ops offer charging for a reduced rate, restricted to off-peak times using load control switches. These co-ops include Berkeley Electric Cooperative, Cass County Electric Cooperative, Connexus Energy, Minnesota

10 Note that the study had three rates: on-peak (most expensive), off-peak (intermediate rate), and super off-peak (least expensive) hours. Findings showed that customers charged during super off-peak hours a large majority of the time. For simplicity in this discussion, we compare the most expensive rates to the least expensive rates and ignore the intermediate rate, which is optional. We refer to the most expensive rate as the "on-peak" rate, and the least expensive as "off-peak."

11 In some situations, however, unlimited charging could increase usage. Unlimited charging could, for example, lead to additional trips by the EV that had previously been made in an internal combustion engine vehicle, or more aggressive driving behavior that decreases the EV's efficiency.

Valley Electric Cooperative, and Wright-Hennepin Cooperative Electric Association.

MANAGED CHARGING REWARDS PROGRAM

The investor-owned utility (IOU) American Electric Power (AEP) is working with eMotorWerks to provide charge control options to their customers. The program uses Level 2 EVSE to automatically shift charging to off-peak hours for a $5/month bill credit with five opt-outs per month. Customers can also allow AEP to reduce charge current from 4 to 7 p.m. for a $3 credit per month with 2 opt-outs per month, or participate in day ahead peak demand events for $5 credit per event.[12]

Opt-out programs generally produce higher participation rates, as people tend toward inaction; but opt-in programs can yield greater savings and behavior changes.

OPT-IN VS OPT-OUT PROGRAMS

One decision a co-op will need to make about its EV control programs is whether the member will automatically be enrolled in the program and given the chance to opt out, or if the member will voluntarily opt into the program. Generally, opt-out programs yield higher participation rates than opt-in programs, because people tend towards the path of inaction. However, opt-out program designs may suffer due to perception problems if EV owners feel targeted or otherwise inconvenienced by their co-op. On the other hand, opt-in programs can yield greater savings or behavior changes because the member actively buys into the program, but marketing and recruitment efforts are critical to their success.

Because it will take time to deploy Level 2 EVSE into the field in significant numbers, co-ops should begin planning for direct control strategies in the near-term.

To create an opt-out EV control program, the co-op would need to identify members that have EVs. This could be accomplished, for example, by using information from dealers or registration records, or perhaps disaggregating AMI data to identify EV loads. Going through registration records is a resource intensive process. Disaggregating the AMI data, however, could be done simply and easily. On the other hand, with opt-in programs the co-op relies on the member to identify their EVs. Co-ops may market EV control programs via dealers or using registration records, or offer an incentive like Salt River Project (SRP).[13]

If the co-op is offering an incentive, such as a discounted Level 2 EVSE, then it can require the member to participate in a control program, such as a EV TOU rate or an auto DR program. In this case, the financial incentive may encourage members to join the program. Often, these programs offer flexibility to change rate structures or to opt-out of a control event. Providing this flexibility is important, so the member is not deterred from signing up for the program for fear of being locked into an undesirable situation.

Developing an EV Charge Control Strategy

The EV and power supply markets are rapidly and simultaneously transforming, and the well-prepared co-op will be able to respond to and capitalize on this changing landscape. Many co-ops already control EV charging to some extent by offering rate structures and other incentives that encourage members to charge when most beneficial. At low EV penetration, these indirect strategies have proven to be effective (EPRI 2018, Nelder 2016). In the longer term, however, direct and especially real-time control of EV charging may be necessary to better match EV load with a more variable supply and increase distribution grid load factor.

Although some direct control strategies can be carried out using a load control switch, Level 2 EVSE offers a broader range of control strategies, including managed control that allows the co-op to respond to real-time pricing, supply fluctuations, and grid conditions. Because it will take time to deploy Level 2 EVSE into the field in significant numbers, co-ops should begin planning for direct control strategies in the near-term, deciding which Level 2 EVSE (and perhaps the associated charge control

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12 **http://aepinnovation.com/ev**

13 SRP has a webpage for EV drivers to register. In exchange, they get a $50 gift card, information on EV rates and other educational material (**https://www.srpnet.com/electric/home/cars/secure/EVsignup.aspx**).

platform) best suits their needs, and deploying that equipment.

Figure 4 maps out near-term activities related to indirect charge control and preparation for future direct charge control. In the near-term, a co-op can develop strategies for identifying EVs in their service area, as well as begin indirect control strategies such as price signaling and rewards. Steps for preparing for future direct control include establishing the co-op as the members' trusted source for EV charging information, including how and when to charge, to prepare members for the charging-as-a-service future of direct control. The co-op can also decide how it will control EV charging and use indirect charge control programs as an opportunity to deploy the Level 2 EVSE that will make direct control possible. These activities will address current EV charging while building a solid foundation for future direct control. ■

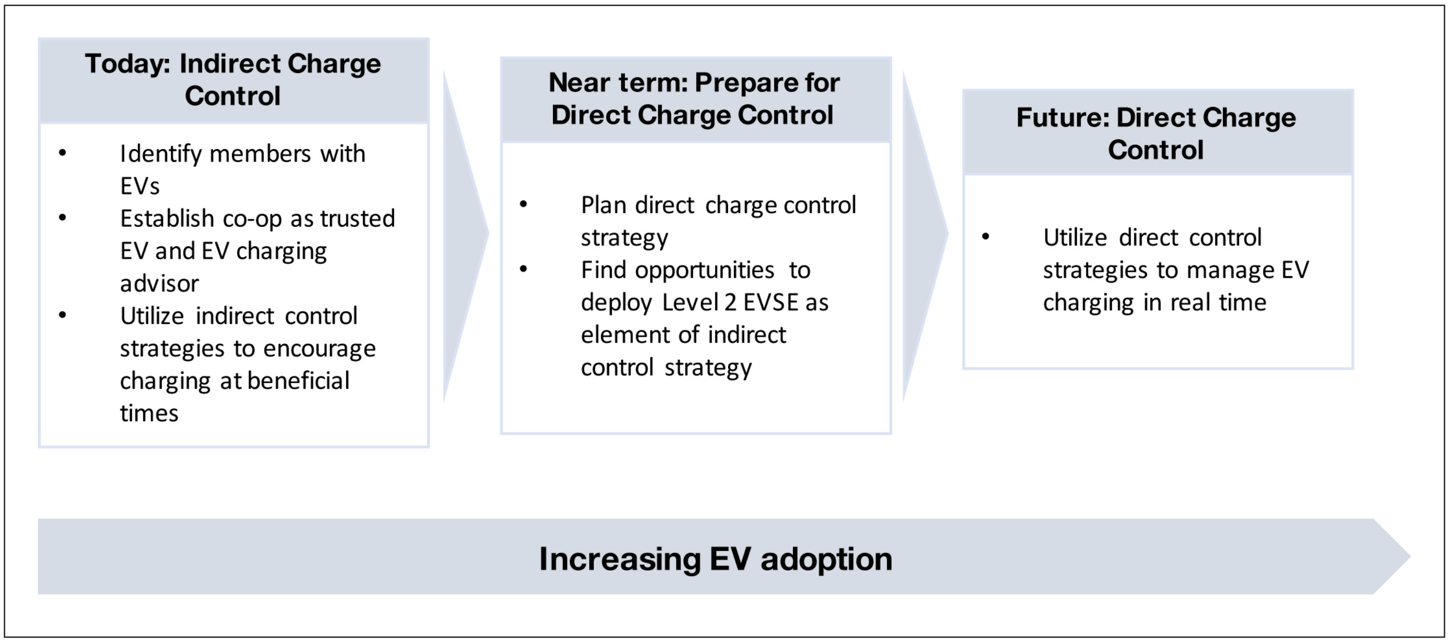

FIGURE 4: Residential EV charge control activities for near term control and preparation for future direct charge control.

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- To find more resources on business and technology issues for cooperatives, visit our **website**.

DISTRIBUTED ENERGY RESOURCES WORK GROUP

The Distributed Energy Resources (DER) Work Group, part of NRECA's Business and Technology Strategies department, is focused on identifying the opportunities and challenges presented by the continued evolution of distributed generation, energy storage, energy efficiency and demand response resources. For more information, please visit **www.cooperative.com**, and for the current work by the Business and Technology Strategies department of NRECA, please see our **Portfolio**.