

Evaluating Methods to Encourage Plug-in Electric Vehicle Adoption

A review of reports on PEV incentive effectiveness for California Utilities



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1. Executive Summary

Plug-in electric vehicles (PEVs) offer enormous opportunities to electric utilities, along with a few potential challenges. This is in addition to the significant social benefits they offer to society at large and personal benefits they offer to owners. Sales are growing quickly, but due to a number of serious deficits in market support compared to gasoline vehicles, PEV market share is still below 1% in the US.

Planning for PEVs is a must for all utilities. Many have also determined that it would benefit them to encourage PEV adoption. To help utilities decide which methods of PEV encouragement are appropriate, this report reviews existing literature on the effectiveness of many different methods. Methods that seem effective and often suitable include:

- Raising awareness by mention in newsletters, social media, bill inserts, etc.
- Hosting events that offer test drives or rides in PEVs
- Installing and operating charging stations; focused on apartments, workplaces, metro and corridor
- Offering a financial incentive, like organizing a discounted group buy

More PEVs are coming; the only question is how fast they will arrive. Even utilities that aren't yet ready to encourage PEVs still need to monitor and plan for PEV growth. They can gain some control over PEV grid usage by offering PEV time-of-use (TOU) rates and load control programs that dynamically control PEV charging.

2. Plug-in Electric Vehicle Background

PEVs have several important social advantages over vehicles that obtain all of their energy from gasoline burned in an internal combustion engine (ICE). For example, PEVs are:

- Better for the economy (Roland-Holst, 2012; Stroo, 2015) as electricity is far cheaper and local
- Better for national security as electricity is domestically produced, and from multiple sources
- Better for air and water quality and CO₂ emissions given the CA generation mix (Nealer, 2015)

These benefits accrue to all citizens regardless of who buys the car, or what type of PEV they buy. The two main types are Battery-Electric Vehicles (BEVs) which are only propelled by grid electricity and Plug-in Hybrid Electric Vehicles (PHEVs) which drive first on electricity from the grid but have an ICE to take over for longer trips. They come in a variety of styles, sizes and prices; this variety is needed.

PEVs also offer several potential advantages to electric utilities, as well as a few possible challenges. Those will be briefly mentioned in the next section, but it is assumed that utilities reviewing this report have already determined that more PEVs in their service area would be beneficial.

In addition to being in the interest of most utilities and society at large, PEV owners are far more satisfied with their vehicles than gasoline owners are (Ayre, 2016; Linkov, 2015). In theory, this should make it easy for PEV adoption rates to skyrocket and for owners, utilities and society at large to reap the benefits.

In practice, there are many factors that limit adoption rates. PEVs are expensive up-front, public recharging infrastructure is sparse, manufacturers are limiting supply, and misconceptions abound. Meanwhile, PEV advantages and incentives are very poorly understood by the public (Carley, 2013).

This report will explore the efficacy of various tactics that utilities can employ to encourage PEV adoption. These tactics are collectively referred to as “incentives” even though not all are direct or financial. Incentives work – while US PEV share in 2014 was under 1%, California with better-than-average incentives (more cars available than other states, a rebate, HOV access, above-average infrastructure and multiple awareness programs) reached 3.3%, and Norway with a long list of diverse and generous incentives reached 14%.

2.1 Differences between PEV and ICE sales

While considering which methods of encouraging adoption will be most successful, it is helpful to understand some of the many ways in which selling a PEV is different from selling an ICE.

- Poor awareness. Most potential buyers can't name a single PEV (Singer, 2016a), haven't driven one, don't know where or how to charge a PEV, are more familiar with the high purchase price than the incentives or low operating costs, and aren't familiar with the personal advantages (Carley, 2013). They assume the worst – high costs, inconvenience, poor driving experience, etc. (Carley, 2013).
- Expensive new technology makes consumers nervous. A PEV may be a consumer's second-largest purchase ever after housing, so there may be fear of making a mistake - better-known ICE choices could feel safer. Consumers don't yet see large numbers of PEVs driving around, so if they consider them at all, they wonder what is wrong with them. PEV knowledge helps a great deal (Singer, 2016a) but it is far easier to skip the research required to become knowledgeable. Even when consumers do have all of their questions answered, like consumers of all products they consider what they may lose twice as much as what they may gain.
- There is a very small but extremely vocal group of PEV opponents that continuously harp on PEV downsides, including several imaginary ones like insufficient safety and performance, frequent battery replacements, no warning on excessive energy use, inability to use in cold weather, etc.
- Limited charging infrastructure. Most apartments and condos – where 34% of Californians reside - do not have charging available (CA PEVC, 2013). Public chargers are limited and often blocked or broken (Saxton, 2012). In many places there are no corridor Direct Current (DC) chargers so BEV road trips are impractical to make.
- Few models are available. There are dozens of types of ICEs available, from tiny compacts to sports cars, trucks, vans and SUVs. Yet most PEVs are fairly small hatchbacks. This keeps a significant portion of the market from considering a PEV (Berman, 2016; CA PEVC, 2016).
- Limited supply and advertising. Many manufacturers only make their PEVs available in the few states that require them (Stroo, 2015). Even there, they may only make limited numbers available and then stop building them. Even when they technically make them more widely available, dealers typically don't stock them and there is often no advertising (TEC, 2013 – footnote 35).
- Lack of dealer incentive. While some automakers are legally required to sell some PEVs in some places, most are also legally required to sell them through dealers, whom many consumers rely on (TEC, 2013 - footnote 35). However, there is no requirement for dealers to sell PEVs. In fact, they have some disincentives (Schwitters, 2015). They have to train staff, buy new equipment, and spend more time per sale explaining the new technology when new car sales are already barely break-even for most dealers. They make far more profit servicing ICE vehicles, but many PEVs require less service. With little incentive to sell PEVs, most dealers simply don't try (though some that do try have been very successful). A few are even openly antagonistic.
- Non-mainstream strategies. If automakers produce a mainstream PEV that cannibalizes sales of their ICE cars, dealers see the PEV as more work for less money and don't sell them. But non-cannibalizing (which often means slightly unattractive) conquest cars may interest some dealers because they pull in NEW customers to the brand (Schwitters, 2015). Attractive halo cars are fine too, because they are mostly to draw people in to showrooms. While the market will likely shift over time, many current BEVs and some PHEVs are still one of these two types, neither of which is meant to be sold in large volumes.

The normal factors that drive most ICE purchases – manufacturer large-scale production and advertising, dealer availability and sales effort, consumer familiarity and demand – are all greatly lessened for PEVs. This is why third parties like utilities getting involved can make a great difference in PEV adoption rates.

Consumers trust utilities more than government or auto industry sources for PEV information (EEI, 2014). At least one market researcher is confident that the involvement of some utilities is a key reason for California's high adoption rate in some areas (Navigant, 2016a).

While PEV sales are low so far, the environment for growth is very good – there are favorable policies, incentives, vehicles available, etc. However, some of these growth enhancers may disappear soon (Shepard, 2016b), so especially considering network effects based on market size that will continue selling cars after the incentives end (Li, 2015), the best time to act is now.

2.2 PEV potential for electric utilities

Utilities are not a particularly homogenous lot, so not all of these will apply to every utility. But PEVs present enormous opportunities to many utilities (Shepard, 2016a). Some of the possible advantages of having a number of PEVs in a utility's service area can include:

- More off-peak energy sold. The average PEV consumes roughly 1 kWh for every 3 miles of travel after charging overhead. At 12,000 miles per year, that is 4,000 kWh more electricity sold. Many of the PEVs in California are leveraging time-of-use rates that encourage customers to charge off-peak, mitigating the need to build more capacity. This can help counter and possibly even reverse declining utility sales due to energy efficiency programs and departing load due to distributed generation.
- Additional load from PEVs makes more efficient use of existing utility assets, which – especially through off-peak charging – puts downward pressure on electricity rates.
- Light-duty PEVs could drop GHG emissions up to 64% by 2050, result in consistent and widespread reduction of air pollutants such as VOC, NO_x, SO₂ and PM, and reduce petroleum use by nearly 100% (EPRI, 2015). Doing the right thing to help enable this transition will put utilities in a positive light with respect to their customers, regulators and community stakeholders.
- Easier integration of renewables. PEV loads are generally during low demand times (and can be moved around with TOU rates and other tools), making it easier to justify the addition of renewable power sources that cannot be ramped (INL, 2013; INL, 2015a; Baumhefner, 2016). PEV buyers are also more likely to be interested in the source of their electricity, support renewable integration, and pay for programs like Green Power (Axsen, 2012).
- Possible savings in CO₂ compliance programs. While it depends heavily on your regulatory environment, generation mix and costs, in some cases it is more cost effective to offer incentives for PEVs rather than to pursue other CO₂ reduction strategies (Thomas, 2014). This can be true even before considering other PEV benefits to the utility.

- Potential load control. Many PEV owners are open to load control programs, such as letting the utility or a third party turn PEV charging on and off as needed as long as it does not prevent the charge from finishing by a specified time (Tal, 2016).
- Going a step farther than load control is pulling energy from idle PEVs at peak load times via “vehicle-to-grid” (V2G). This is technically possible now, but automakers need a business case to cover the cycle wear on the batteries they warranty. Perhaps automakers could price V2G-capable cars higher, and interested utilities could offer a rebate to consumers that buy V2G-capable cars and enroll in a utility V2G program.
- Studying early PEV adoption in your service area is a must for growth planning. PEVs are coming, only the time scale is really in question. Utilities that communicate with early adopters and provide some incentive for them to allow their vehicle charging to be monitored can learn more about PEV charging behavior (which varies by demographics, geography, climate and infrastructure) in their service area and better plan for growth.
- Potential income other than standard kWh sales. While it may require regulatory changes at least to allow for a pilot program, utilities that install public charging infrastructure have an opportunity to experiment with some new business models. Charging infrastructure is typically more of a scarce resource than electricity, so many PEV owner groups encourage fees to be set by connection time rather than kWh sold, typically resulting in higher income (WA UTC, 2016). There are also opportunities to bundle public charging with home consumption, and pre-sell “packages” of energy paid for periodically whether they are consumed or not. California investor and publicly owned utilities are already demonstrating several different and new business models for accelerating EV adoption through providing charging infrastructure.
- More customer interaction with utility. PEV buyers rely on their utility daily and greatly appreciate electricity’s price advantage over petroleum products. Many early PEV adopters are eager to participate in experimental programs (Tal, 2016), and some are happy to put utility-provided “advertising” stickers on their PEV (see cover photo). PEV customers are larger, stickier, and offer potential for new business models and a more interactive customer relationship.

Supporting PEVs is a non-trivial new task for many utilities, and especially given regulatory changes that may be required, there is understandable temptation to put it off and see how things develop. However, many utilities have come to realize that not only will they have to do the work anyway - Oregon recently passed a law requiring the large utilities to have a plan to encourage transportation electrification (Drive Oregon, 2016) and California has considered such a law - but there are significant advantages to them if they move early and take a hand in growing, monitoring, and becoming part of the market. There is generally great support from government, PEV owners, NGOs and industry organizations for them to do so.

Several large utilities in California have been leaders in the area and at least one researcher believes that is one key reason for California’s exceptionally high PEV adoption rate (Navigant, 2016a).

2.3 PEV challenges for electric utilities

As with anything new, large and complicated, the story is not all good news. PEV adoption can cause some challenges for utilities. Fortunately these are usually minor issues with straightforward methods to deal with them. Note also that these issues are only encountered in relation to PEV adoption rates, which means the utility will simultaneously realize PEV benefits that will likely more than compensate for addressing these challenges.

- PEV charging could increase peak load. Fortunately PEVs don't usually charge at peak demand times, and TOU rates have proven quite successful in moving most charging to times when the utility has more power available than demand (INL, 2015a). Setting appropriate public charger use fees, monitoring and communicating with PEV owners, load control programs, encouraging home or workplace charging as appropriate, and depending on demand curves encouraging either Level 1 (L1, which is low-power 120V AC, but charging much of the time a PEV is parked) or Level 2 (L2, higher power 240V AC, but can set a timer to only charge during off-peak hours) can also help.
- More long-range BEVs in the future *might* mean that DC charging during peak hours will rise. This is not a given because much current DC use is for daily use for short-range BEVs, which may decline in favor of more charging at home overnight as BEV ranges increase. It also depends on geography and DC station locations. Even if daytime DC charging does increase because of long-range BEV road trips, road trips account for a small percentage of the energy consumed and it is easier to work with a few DC station owners rather than all PEV owners (which would include non-customers passing through). Local storage or generation can help, as can rates to discourage peak use or charging "bundles" that include more-profitable off-peak energy with expensive peak energy. Worst case, demand charges can be set to help with buildout to cover additional load.
- PEV clustering can overload some neighborhood transformers. PEV adoption may not be uniform in your service area, so sometimes local transformers can be overloaded from on-peak charging, multiple high-amp off-peak chargers, or from transformers in hot areas being designed with the assumption that they would be underused at night. TOU rates, monitoring and education can help quite a bit, but at some point some transformers may have to be upgraded just as they would for other types of load growth (INL, 2015c). Alternatively, utilities can modify their design standards for when transformers reach their normal end-of-life to require larger replacement transformers.
- Utilities operating under regulations to reduce electric energy used, without getting credit for displacing gasoline, may be penalized when their PEV customers use more electricity. Fortunately in most areas it is easy to make an economic, environmental and practical fairness case for changing these regulations. While some education may be required, there are many organizations and PEV owners willing to help. This can open up some great possibilities for profitable growth for the utility.

PEV adoption rates are rising so utilities will have to address these challenges whether they encourage PEVs or not; just at a different pace. Understanding PEV charging habits in your service area, communicating with PEV customers and planning for more PEVs is critical for all utilities.

3. Methods to Encourage PEV Adoption

It is important to note that no single action or incentive controls a majority of the PEV adoption rate (Zhou, 2015; Lutsey, 2015; Clark-Sutton, 2016). BEV purchases seem to rise with the number of incentives almost regardless of incentive type (Jin, 2014). Just like the rest of the automotive market, different consumers prioritize different things. And as noted earlier, the PEV market is missing several key elements that typically drive sales in the ICE market, so there is much to be done to make up for that.

Nissan claims that states with an incentive (in addition to the federal tax credit) adopt twice as many cars as states without an incentive; and states with two incentives sell three times as many (Frades, 2014). That claim is strongly supported by an A-B test among US states showing a base adoption rate of 0.27%; it rises to 0.56% with “PEV readiness” (infrastructure, awareness programs, etc.), 0.78% with a financial incentive, and 0.89% with both (Zhou, 2015). A different A-B comparison among US states noted that the four states with the highest total incentive value - including monetized non-financial incentives, total value \$2-6k (Jin, 2014) - sold 2-4 times the average, and were the only states to pass a 1% adoption rate (Stroo, 2015). Another way to look at it: states with above-average total incentives had adoption rates nearly 7 times higher than states with below-average incentives (Jin, 2014).

Another important consideration is that extremely few consumers will buy any new car – let alone an expensive one with unfamiliar technology and new limitations – based on a single action, incentive or piece of information. What many buyers need is several nudges to consider the PEV market over time, where the time to adjust to the idea may be as important as the nudges themselves. This is another reason why a multi-pronged approach may work best, and why starting soon is important.

Not all of the methods will make sense for your organization; one obvious example is that a utility clearly can't provide a state income tax credit. However, incentives not provided by utilities are by definition extremely cost-effective to utilities. It may be worthwhile to work with government, industry and owner groups to advocate for other organizations to provide incentives in addition to yours, especially given the combined effects of multiple incentives noted above.

There are many factors that affect how appropriate an incentive may be for a given utility. Some incentives (like installing infrastructure) require payment of full costs up front, with no way to measure impact until after the money is spent. Some (like a mail-in rebate) only require payment after the fact, and in exact proportion to PEVs sold. Some require funds to be allocated in advance; some result in lowered revenue; some only require a small administrative cost. Some simply sell more PEVs and provide the normal advantages of any PEV purchase; some can additionally give the utility an agreement with the PEV owner allowing them to monitor and perhaps even control some of how they charge their PEV. A short program can be easy to sell as a pilot and have funds and other resources allocated towards it; but a long-term program can get more help from outsiders, especially entities like automakers.

Different utilities have different needs and constraints, so there is no recipe for success that makes sense everywhere.

3.1 Programs that reduce adoption friction

There are a number of actions that are not direct incentives like a monetary rebate, but rather indirect incentives that compensate for some of the issues listed earlier that make consumers less likely to consider a PEV. Some of the negative effects are very significant, so despite being indirect these can be very effective incentives – and often at very low cost.

- *Raising awareness.* Most consumers are not aware of the range of PEVs that are available - 52% can't name a single PEV (Singer, 2016a). Few know their personal advantages (TEC 2013 – footnote 32) or the available incentives (Kurani, 2016) - sometimes as little as 5.5% (Collantes, 2014 - Krause). This applies to any incentive program you implement as well: if nobody knows about it, the effectiveness rate will be zero. Raising awareness is *required* for any incentive to be effective, and the cost can be quite low relative to the results. The reviewed literature was short on specifics for best practice, but it seems likely that a large variety of small pointers is best: billing inserts, newsletter blurbs, social media mentions, customer-facing employee pins, service vehicle wraps (especially on company-owned PEVs!), web pages, event brochures, letters to PEV owners if you can obtain a list, outreach to PEV owner groups, handouts for local dealers, etc.
- *Test rides and drives.* While unaware of the personal benefits of PEVs, most people are somewhat aware of their social benefits. Even if they feel they *should* buy one, they usually don't *want* to because they don't want to suffer the imagined downsides: high cost, anemic performance, inconvenience - all the opposite of favorite features noted by PEV owners. A test drive is the fastest way to switch many ICE drivers from arguing about why a PEV won't work for them to considering how to make it work; PEV conversion rates are far higher than typical ICE conversion rates (Brown, 2015) for similar events. Ride and drive events are typically inexpensive to put on, especially if you can use idle fleet PEVs or find local dealers or owner groups to supply the cars.
- *Model availability.* Automakers are acutely aware of their requirement to sell a certain number of PEVs (at least in states that have adopted the California Air Resource Board's Zero Emission Vehicle "ZEV" regulation – utilities outside ZEV states may consider asking a legislator to sponsor a bill adopting it), and well aware that locations with high awareness and multiple incentives are where it is easiest to sell cars. Greater vehicle availability (perhaps including models not previously sold in your area), automaker advertising, and dealer participation are more likely if you approach an automaker and let them know that you are working on raising PEV awareness and offering a new long-term incentive in your area. Just like with ICE sales, different consumers want different things and the larger the variety of models offered, the greater the sales.
- *Dealer incentives.* Even if an auto manufacturer makes their PEVs technically available in your area, your local dealer may not stock them and may make no effort to sell them. Selling a PEV is more work than selling an ICE, and the dealers are typically given no incentive to do so. Can you offer them anything? Payments for sales will not always be approved by regulators, but you might be able

to pay for dealers to hand out information and collect contacts, you can invite them as the exclusive dealer from their brand to test drive events (this can be a good enough incentive that over time some organizations have been able to charge dealers for this) or a group buy, and you can list them as “participating” dealers on your web site. You may be able to work out a deal with charging infrastructure installed at their site, or elsewhere with their name on it.

- *Home EVSE installation streamlining.* Over 85% of all charging is at home. The most important infrastructure for PEV adoption is in your customer’s garage; many prospective customers will not buy without it, and for many it is sufficient (INL, 2015d). It must be easy, quick and inexpensive to get charging ready at home. There are often regulatory issues that keep utilities from doing everything, but do what you can to make home EVSE installation a quick, high-value, one-stop shopping trip for consumers. If L1 is helpful for your utility, just advertising about the ease of 120V charging can help.
- *Utility approval of and information about PEVs.* While few consumers go looking for PEV info without some prompting, those that do search for PEV information often say they trust their utility to provide information on PEVs, and they need information from the utility on charging rates anyway. You may not get many hits until you start doing other things to raise awareness, but a clear, easy-to-find web page giving consumers the information they need – most notably, the cost of charging in your service area - before a PEV purchase can help make consumers comfortable with their decision even if they have already seen the same information elsewhere.

3.1.1 Evidence of effectiveness

- *Raising awareness*
 - In a pre survey, people that knew more about PEVs were significantly more likely to consider buying one (Singer, 2016a).
 - In another pre survey, 50% of potential mid-adopters cited a lack of knowledge as the reason they were not more favorable towards PEVs (Dubin, 2011). Only 37% claimed any knowledge of PEVs, and only 29% knew of any incentives.
 - Raising awareness of PEVs somewhat reduces the need to provide other incentives (Kurani, 2016) as fear of the unknown turns in to desire to obtain advantages.
- *Test rides and drives*
 - For three years measured, the month after National Drive Electric Week PEV sales went up 13%, 21% and 24% despite the overall auto market being flat (1 or 2 points down) or dropping 9% (Brown, 2014). In later months PEV sales continued to stay at higher rates than the previous year, though this effect is difficult to separate from other factors.
 - A post survey asked owners if people that rode in their cars loved it; 94% agreed and less than 1% disagreed (Shahan, 2015).
 - After a series of test drive events, a pre/post survey pair indicated that BEV purchase interest went from 23% to 55% (TEC, 2013).
 - Another test drive pre/post survey pair (second annual at the location; 22% had driven a PEV before) indicated that those “likely” or “very likely” to purchase a PEV went from 42% to 57%, and local dealerships confirmed that sales rose after the event (Russo, 2015).

- Yet another pre/post pair found 76% “more likely” to consider buying one after the test drive; “very” positive PEV perceptions went from 78% to 95% (CA PEVC, 2016). A few months later 15% had actually purchased one (55% saying the test drive was a “very important” part of the decision) and 94% had spread the word.
- *Model availability*
 - California is the only state where all PEVs are available. While there are other factors, they have significantly oversized adoption with over 1/3 of all PEVs sold there (TEC, 2013 – footnote 12).
 - An early pre survey in L.A. found that 56% said that greater vehicle availability was important for them to buy a PEV (Dubin, 2011) .
 - A series of test drives in California found that more test drives were taken where more models were offered, and the majority of questions were about differences between models (CA PEVC, 2016).
 - 5 of the top 7 metro areas for PEV adoption (which have 2-7 times the adoption rates of other areas) are in ZEV states (Lutsey, 2015); whereas several of the areas with poor adoption appear to be prepared with infrastructure and incentives, but are not in ZEV areas.
- *Dealer incentives*
 - A few states have tried public dealer recognition programs for selling PEVs, and while numbers are scarce it is assumed that there was success as the Multi-State ZEV Task Force is encouraging more (MSZTF, 2016).
 - Vermont tried a \$250 dealer incentive in 2014, and while results do not appear to be public (perhaps in part because the program launched in conjunction with other efforts) Vermont expanded the program in 2015 (Wagner, 2016).
 - After trying a dealer recognition program in 2014, Connecticut in 2015 added a dealer bonus equal to 10% of their “CHEAPR” consumer incentive (Edelstein, 2015). Results are not yet public.

3.2 Incentives that reduce purchase cost

Aside from the arguable exception of concern about range, the up-front cost of PEVs is the single biggest factor holding back PEV adoption – in some surveys it has been listed as the greatest barrier over twice as often as any other obstacle (Lascrain, 2012). PEVs still cost more than the ICE vehicles they are typically (though often mistakenly due to misperceptions) compared to, and few consumers have done the math to determine how much they can save on operating costs. The few that do the math discount future savings. There are existing incentives like the federal tax credit, but less than half of consumers are even aware of the credit (Kurani, 2016), and ones that are aware often don’t have sufficient tax liability or can’t tell in advance if they will qualify. Consumers highly discount the delayed payback even when sure they will get it. And even those sure they will save money are still afraid of the risks of early adoption, and are not only unwilling to pay a premium but hope to pay far less for a PEV (Helveston, 2015). More needs to be done, but discounts can greatly help this factor.

There is little question that reducing the purchase cost is a very effective incentive – “the major mover” of PEV sales (Navigant, 2016a). Cost effectiveness can be a larger question; it is worth looking at local demographics, types of PEVs available and adoption rates to ensure you will not simply be handing money to people that would have made a purchase anyway. One key is to choose the incentive size carefully. It also helps to look at your funding source and how it is easiest for you to distribute the money; significant savings can sometimes be had by reducing overhead with an incentive that is easy for your utility to handle.

As far as consumers are concerned, cash at the time of purchase is by far the best financial incentive – over twice the value of a tax credit (Gallagher, 2008). Having to wait for a rebate discounts its value; having to wait to make sure they qualify is far worse. But for a utility, a mail-in rebate can provide other benefits as it ensures a quality channel to communicate with a new PEV owner, and there may be less coordination required with third parties. If allocating funds for a rebate program is difficult, and regulations allow, can you instead take the amount off future bills? The cost is the same and effectiveness lower, but the funds do not have to be allocated in advance.

The most cost-effective financial incentive (unless lost benefits and third-party coordination are very significant) is one you don’t pay. In addition to approaching local governments, NGOs and employers and asking them to help encourage PEV adoption, you can look into group buys.

- *Group buys.* If you select a willing dealer to be exclusive for a group buy and you offer to do some of the marketing, and especially if you can guarantee a minimum number (perhaps your utility could do a fleet purchase? Perhaps with help from a grant from a local NGO?) the automaker and dealer can sometimes provide strong financial incentives that can help move a lot of cars. Some of these programs have had fantastic results at extremely low cost to the organizers (Berman, 2016). There is some fear that sales may drop after a group buy as people wait in hopes of another one; but network effects in a nascent market help counteract that effect.
- *Grants.* Great for fleets in your service area, grants can be an effective cost reduction that both sides can know about in advance, and can include other conditions on charging and/or monitoring that could be advantageous to the utility.
- *Point-of-sale rebate.* A clear consumer favorite, but requires very careful coordination with dealers. Funds must be available in advance.
- *Mail-in rebate.* While the amount will be discounted by consumers, the utility can avoid working with dealers, do better verification, and best of all is guaranteed an introduction to the PEV owner. Like a grant, the rebate terms could include conditions advantageous to the utility.
- *Income tax credit or deduction.* This is not obviously a direct possibility for a utility, but it is certainly something a utility can advocate for. Lawmakers often appreciate that money does not have to be appropriated for this type of program. Consumers, however, still have to pay for/finance the whole amount, and will discount the amount because of uncertainty about eligibility and the distance of the payment.

- *Sales (or other purchase-time) tax waiver.* From a consumer point of view, this is very much like their favorite point-of-sale rebate. Utilities can't implement it directly and so would have to advocate for it, but like an income tax credit/deduction, lawmakers may appreciate that the money doesn't have to be appropriated. They may also appreciate that most PEV buyers lease, so the per-PEV waived sales tax amount is generally significantly less than on a purchase (Stroo, 2015). Plus such an incentive can attract upgraders that would not have otherwise purchased an ICE - up to 42% in some cases (Berman, 2016) - which can greatly reduce the sales tax income that is "lost".
- *Reduced lease/loans rates.* Regulations may make this difficult, but without spending money (at least not immediately) utilities could work with a financing provider to provide lower interest rates or higher residuals. The utility could offer some estimate of fuel payments via a special TOU rate that helps the financing provider feel confident that the buyer can afford the payment. While possibly getting deeper into regulatory issues, the utility could also guarantee either residual values, customer payments (linked to their utility bill?), or even used battery resale values, and take over end-of-lease or abandoned vehicles for fleet/study/resale/promotion/battery re-use.

3.2.1 Evidence of effectiveness

- *General financial incentives*
 - The top reason (by a significant margin) for not considering a PEV is price (Singer, 2016a).
 - 83% say price is an important factor, and 71% think EVs cost too much for what they offer (Dubin, 2011).
 - In one study, 40% will not pay any premium for a PEV, and another 46% say the premium must be under \$5k (Singer, 2016a).
 - In another study, only 20% indicated willingness to pay *any* premium for a cleaner car (Dubin, 2011).
 - 82% of potential buyers would be more likely to buy if state and local incentives were added to the federal incentive (Collantes, 2014 - Krause).
 - Hybrid Electric Vehicle (HEV) sales increased 4.5% per \$1,000 of incentive (Collantes, 2014 - Jenn).
 - A post survey of test drivers that did not purchase a PEV found that 50% may be persuaded to buy if the price was lower – and 30% said they may be persuaded if there were "more incentives" (CA PEVC, 2016).
 - When asked to pick the best incentive in a pre survey, the top choice at 44% was a \$3k rebate (Shahan, 2015) - and the second choice, at 28%, was also a financial incentive, just not an up-front one. All other incentives were far behind.
 - In a post survey, 38% said saving money was their primary decision factor in their PEV purchase (Powers, 2014).
 - A worldwide study found Norway offers the largest BEV incentive but no PHEV incentive; they have the largest PEV share in the world at 6.1%, and one BEV or another has topped the monthly sales charts multiple times. Meanwhile the Netherlands' BEV subsidy does not cover the price premium but they have the most generous PHEV subsidy; they have the second-highest PEV share (5.6%) and the highest PHEV share (Mock, 2014). Most other

- countries did not provide enough incentive to cover the cost premium, and PEV shares were all under 1% except the US at 1.3%.
- When Norway offered the largest BEV incentive but no PHEV incentive, only 1/8 of their PEVs were PHEVs (Wikipedia, 2016a). Norway's PHEV share jumped 5x from 2013-2015 as PHEV weight taxes were partially waived (Wikipedia, 2016a).
 - *Group buys*
 - In late 2015, while LEAF sales declined 56% nationwide (Salisbury, 2016) due to an anticipated 2016 battery improvement, one Boulder dealer's sales rose 477% due to a group buy program.
 - A similar program in Fort Collins had a 650% increase despite temporarily running short of cars (Salisbury, 2016).
 - A six-week group buy in Salt Lake City sold twice as many cars as were sold in the entire state the previous year. 72% of buyers had not even been *considering* an EV before hearing of the program, so the effectiveness rate was at least 72% (Berman, 2016).
 - *Grants*
 - 49% of fleet managers, when asked to pick a most effective incentive, chose grants (Lascrain, 2012). The next 3 choices were all financial, and everything non-financial trailed far behind.
 - *Tax credits*
 - A study found that a \$1k tax credit resulted in HEV sales increasing 3% - it noted that a same-sized sales tax rebate could have increased sales 45% (Collantes, 2014 - Gallagher).
 - A government study estimated that the HEV tax credit was 25% effective, and assumed the PEV tax credit would be more effective – perhaps 30% - because it is a larger percentage of the sales price (Gecan, 2012). A later study noted that network effects had not been included, and raised that estimate to 45% - but even that study still assumed every buyer qualified for the full amount which is clearly not true, so the effectiveness rate should be higher than that (Li, 2015).
 - An early L.A. pre survey found that 77% considered the federal tax credit important to the buying decision (Dubin, 2011).
 - One California post survey found that 44% said the federal tax credit was “extremely important” and 25% said it was “very important” in making the purchase *possible* (CSE, 2015); without that word the former number may have been higher.
 - The California CVRP was “extremely important” to 45% and “very important” to 28% (CSE, 2015); these are slightly higher numbers for a smaller rebate than the federal tax credit, but perhaps more knew they were eligible for it.
 - An older post survey with different wording found that 95% said that the California CVRP was “an important motivating factor” (CSE, 2014).
 - A recent multi-state post survey indicated that 96% of buyers were eligible for at least part of the federal tax credit; 49% to 71% of buyers (depending on vehicle) indicated the tax credit was necessary for the purchase (it was not applicable to 4-26%, so the effectiveness rates were higher). A state rebate was necessary for 9-33% of buyers; that rebate did not

- apply to 52-79% so its effectiveness rate was also good. A local rebate was necessary for 2-8% of buyers, with 84-90% ineligible (Jin, 2014).
- A model based on surrounding states (Wescott, 2015) – that was later shown to be quite accurate by a time-based A-B examination (Shahan, 2016) – showed that the loss of a \$5k state tax credit would drop PEV sales in Georgia by 90%. Before dropping the tax credit, Atlanta’s BEV adoption rate was 8 times the average of other metro areas (Lutsey, 2015).
 - In a Colorado post survey 64% said the tax credit influenced their decision “very much”; 28% said “a little” (Russo, 2015).
 - An A-B study determined that each \$1k of tax credit increased BEV sales by 2 to 10% (Clinton, 2015).
 - *Point-of-sale rebates*
 - An early pre survey (describing hypothetical cars that were not available yet, but should be starting in 2016) said that a \$5k rebate in the US could raise future PEV market share from 14 to 61.8% (Tanaka, 2014). Shares for both BEVs and PHEVs went up well over 4x with the rebate.
 - Another study confirmed that while the federal tax incentive worked for HEVs, it would have been notably more effective as a point-of-sale rebate (Collantes, 2014 - Berensteanu).
 - The DOE claims that reducing a vehicle’s price by 10% will result in a 50-80% increase in market share (Federspiel, 2013).
 - A model based on surrounding states indicated that a \$3k BEV/\$1.5k PHEV rebate could have increased PEV sales in Oregon by 140% (Wescott, 2015).
 - In a pre survey of fleet managers, 46% said the most effective incentive would be a purchase rebate (Lascurain, 2012), the second choice behind a similar choice for grants. It was noted that of neighboring states, the only one with a POS rebate had the highest PEV rate.
 - 58% of fleet purchasers in a post survey did so because of lower costs after-rebate (TEC, 2013); an additional 16% because of expected lower costs when gas costs rise.
 - *Mail-in rebates*
 - An early simulation estimated the California PEV elasticity rate to be 3.6 (JFA, 2015), meaning that sales should increase 3.6% for every 1% reduction in price. The \$2,500 California mail-in rebate (far less effective than a point-of-sale rebate) reduced the average PEV price after federal tax credit by about 9%, so it supposedly increased sales about 32%.
 - A Massachusetts \$2500 BEV/1500 PHEV program post survey found that 80% said the rebate was “extremely” or “very” important in the purchase decision (Powers, 2014).
 - *Sales-tax waiver*
 - A review of studies in three states with sales tax waivers found that 52%, 63% and 68% of sales were likely due to the waivers (McCoy, 2015).
 - A study found that a \$1k sales tax rebate could have increased sales 45% (Collantes, 2014 - Gallagher).

3.3 Incentives that reduce operating costs

Consumers value incentives that lower their PEV purchase cost more than similar-sized incentives that lower operating costs. However, incentives that reduce operating costs by being paid over time are often preferred by the funding organization, especially since it can ensure that the PEV stays in the area rather than being flipped.

Given that PEV owners require charging, there are also more ways for a utility to interact with a recurring cost savings that may fit better into the utility's business model. Reduced rates can also come with conditions on charging, monitoring or load control that may be in the utility's interest.

- *Special TOU rates for PEVs.* In addition to being an incentive for the PEV buyer (and an obvious place they would expect to see their utility step in), it can encourage off-peak charging which is highly beneficial to most utilities. It could also include a monitoring provision to help with growth planning, and even load control though the utility would likely have to provide the equipment. PEV owners have to sign up for the TOU plan, so you can plan and communicate better.
- *Reduced recurring car fees.* This could be registration, weight or VMT taxes, safety or emissions inspection fees, and the like. These are more likely benefits that a utility would advocate for than offer directly; the utility can argue that all electric customers gain from PEVs continuously over their lifetime (more electricity sold off-peak can reduce rates, depending on regulations) so it is in the general interest to incent them.
- *Reduced cost parking/ferry/tolls/charging.* Only charging is likely to have a utility connection, but the others can be advocated for similar to reduced recurring car fees. A reduced-cost (though ideally not free, as that can encourage abuse) public charging incentive could be very similar to a TOU rate, allowing the utility to monitor, plan, encourage off-peak charging, and communicate better with PEV customers.
- *Home EVSE subsidy.* While many PEVs can make do with low-power 120V L1 charging, 240V L2 EVSE owners are far more likely to set a timer to charge overnight, so it is beneficial for some utilities (not all; some prefer the lower L1 power draw) to encourage EVSE purchases. While it could be a rebate at sale, it might be easier to give a rebate over time on the utility bill, or lease the equipment to the customer if regulations allow. Monitoring provisions and even load control could be part of the agreement.

3.3.1 Evidence of effectiveness

- *Special TOU rates*
 - 40% of owners surveyed would like a special PEV rate plan (Tal, 2016).
 - Early adopters weren't so picky, but 85% of mid adopters considered electricity rates as part of their buying decision (Dubin, 2011).

- 57% of owners in a post survey opted for a PEV-specific TOU plan, despite another 3-13% not knowing about it and others noting that there were no savings (INL, 2013).
- 78 to 85% (depending on the size of the rate difference) of owners on a special TOU rate plan programmed their car to charge during super-off-peak hours (INL, 2015a).
- *Reduced cost charging*
 - A pre survey found that when prospective buyers were asked to pick a single incentive, their second favorite (after a \$3k rebate) was free charging (Shahan, 2015).
- *Home EVSE subsidy*
 - A multi-state post survey found that 22% would not have purchased their PEV without a home EVSE subsidy, and another 39% said it was a very important part of the decision (INL, 2015a).
 - Another recent multi-state post survey found that 5-17% of buyers (depending on vehicle model) would not have purchased without an EVSE subsidy; in this study an additional 55-73% were not eligible for such an incentive (Tal, 2016) so the effectiveness rate is far higher.
 - In a workplace study, it was found that 94% of workplace chargers were in states that had an EVSE incentive in place (US DOE, 2015). Curiously, the paperwork to obtain a rebate was most often not filled out; while the reason for that is unknown, if the incentive affected the purchase decision this greatly increases the cost-effectiveness of the incentive.
 - An early L.A. pre survey found 73% said that a \$2k EVSE rebate would be important to their decision to buy a PEV, despite including many people that did not select the option because they were not interested in a PEV (Dubin, 2011).

3.4 Incentives that increase convenience

“Time is money,” so incentives that save time can be important to some PEV buyers.

While not as effective as financial incentives, they may be more cost effective – in fact some of them may be nearly free to provide. Unfortunately this type of incentive is unlikely to be provided directly by a utility, so advocating for these incentives would be the approach to take. Lawmakers may appreciate the low cost; although in places with high PEV adoption or crowded HOV lanes they may be loath to add to a problem in another area.

- *HOV lane access with a single driver.* While a clear favorite of this type among PEV buyers, it only works in areas with bad traffic but clear HOV lanes. If it works too well and PEV adoption spikes, the HOV lanes may no longer meet federal flow requirements and lose funding.
- *Inspection waivers.* This could be for VMT, emissions inspections, or the like. This is the least visible and least likely to cause other problems; though usually the fees are small so it is not typically a strong incentive.
- *Preferred parking/ferry line position.* Like HOV lane access, this only works in areas of high demand – but those same areas are where a successful program can’t last forever, because it can cause other

problems. One difference with this incentive is that it can be affected by the placement of charging stations, which means the benefit could in some cases be gained “by default”, making it easier to obtain permission.

3.4.1 Evidence of effectiveness

- *HOV access*
 - A 2014 post survey found access to California HOV lanes being cited as a “primary purchasing motivation” to range from 0% for a LEAF far from any HOV lanes to 64% for a Plug-in Prius in Los Angeles (Tal, 2014) - 17% overall (CSE, 2013). Even when not selected as “primary”, it is often selected as one of several reasons that were necessary to purchase the car – 32% call it “extremely important” and 27% “somewhat important” (CSE, 2013).
 - A study (CSE, 2014) pointed out that while an HOV incentive was less effective for BEVs, it was more cost-effective as BEVs drove 4 times as many e-miles per HOV mile.
 - A more recent multi-state survey found that HOV access was necessary for 7-11% of buyers; with many non-CA buyers in the study, an additional 63-70% were not eligible for HOV access (Tal, 2016).
 - A pre survey asked prospective buyers which single incentive was most likely to incent them to buy; the first two were financial, but the third was HOV access (Shahan, 2015).
 - An early study in L.A. showed that 55% said HOV access would be important to the PEV buying decision (Dubin, 2011).
- *Dedicated parking*
 - A multi-state post survey indicated that 6-11% of buyers would not have purchased the car without a dedicated parking incentive; 55-68% additional buyers were not eligible for such an incentive so the effectiveness rate was far higher (Tal, 2016).
 - An early L.A. pre survey found that 55% said free parking was important to their PEV buying decision (Dubin, 2011).

3.5 Charging infrastructure

Charging infrastructure is an area where utilities have several clear advantages over other potential players in the space (Tal, 2016). Utilities already have a billing relationship with the customer, are expected to be in this space by most PEV owners, have wholesale access to energy, already have a fleet of experts that can monitor and repair equipment in the field, and gain some strategic benefits (an important advantage in a very-low-margin space of commodity access like charging stations) by being able to encourage PEVs, monitor electrical usage, plan for growth, set pricing to discourage on-peak charging, and even experiment with load control on customer equipment.

Of course, a utility may be in a regulatory environment that makes some of these advantages difficult to leverage. But to the extent possible, it makes sense for utilities to get involved in charging infrastructure as they are the only entities with a strategic interest aside from automakers – and most automakers

have several reasons to be dragging their feet. One is that standardized infrastructure installed by one automaker benefits all, so laggards are rewarded. Utilities' defined geographical territories make being involved with charging in their service area a much more obvious benefit.

Charging is what is most different about PEVs, so more available charging makes ICE drivers more willing to switch to a PEV. All PEV drivers should have a way to charge at home or at work; PEV ownership is very inconvenient without it. BEV drivers fear an emergency might leave them in need of a charge, so access to a network of workplace and/or public charging eases their concerns even when rarely used. PHEV drivers don't require a public charge, but get more benefit from their PHEV when they are able to charge more often away from home. After purchase cost reductions, available charging infrastructure is likely the largest driver of PEV sales – yet 71% of California owners are dissatisfied with existing infrastructure (CSE, 2015). According to a simulation, installing infrastructure could be 3 times as cost effective as providing financial incentives for PEV purchases (Li, 2015).

- *Home.* A PEV owner could rely on 120V charging, have an electrician install a NEMA 14-50 outlet, or install one of many L2 EVSEs on the market. But few understand the options, capacity requirements for each, permits required, or the costs. The first place many look is their utility, who if regulations allow is in a perfect position to ensure they have sufficient capacity, explain special TOU rates, offer to install, operate and maintain charging infrastructure and/or provide charging station rebates, navigate the permit process, and have the customer pay for it over time on their utility bill so they do not have the up-front expense at the same time they buy a car. The utility at this point knows who their PEV customers are, has enabled and encouraged them to charge during times of higher supply than demand, and can include monitoring provisions.
- *Apartments, condos, etc.* (Multiunit dwellings, or MUDs). From the utility and customer perspective, this is very similar to the home charging situation, and utility programs and investments can be the same. However, there is now a landlord, HOA, or other entity to contend with. Often these entities are small and unfamiliar with PEV charging requirements; sometimes they would prefer to just deny the request to save time; although in California it is illegal to disallow a “reasonable” request if the resident pays for installation (CA LAW, 2014). At the very least, they often want to consult with the utility before proceeding; having a program designed for this can facilitate the process. The PEV owner not owning the installation site may encourage equipment leasing. There are also often concerns about carefully monitoring usage and billing the PEV owner, another area the utility is uniquely qualified to handle. There can be some extra effort; but it can pay off when a second customer at the site signs up, and this sort of work can expand the addressable market of PEVs rather than just give incentives to people that could get one anyway if they really want it.
- *Workplace.* While utilities with peak daytime use may want to discourage this in the afternoon, utilities with excess solar may like that it encourages daytime charging. Dwell times are long enough that 120V L1 charging can be sufficient, which helps to keep infrastructure costs and power requirements low. However, 240V L2 charging could be increasingly be important for utilities that want to leverage workplace charging to absorb excess generation created by increased renewable energy production during smaller time windows. Workplace charging allows short-range BEVs to be

used in many more situations and for PHEVs to earn their position over ICEs. It can enable a PEV purchase for some people that can't get reliable charging (usually related to unassigned parking) where they live. Workplace charging also creates a "showroom effect" helping drive adoption of PEVs (Chargepoint, 2015; US DOE, 2014). Similar to charging at homes, fleets and MUDs, utility programs for workplaces can provide a turnkey solution with charging infrastructure, rebates, and trusted advice on charging options and rates.

- *Public charging.* This includes L2 EVSEs and DC charging. Some cities have found that when they change streetlights to LEDs, they free up enough power to put an EVSE in the base of the light posts. As most PEVs are currently PHEVs or short-range BEVs, L2 EVSEs in many locations (ideally ones with long dwell times that are not typically close to home) can be quite useful; but as ranges increase it is likely that DC chargers in metro areas and along popular travel corridors may be a better incentive for PEV purchases.
- *Fleet.* A single fleet program can affect a very large number of electric miles. Fleets may require either overnight charging, daytime DC charging or a combination; through equipment and rates the utility can encourage the fleet to charge at the best times for the grid. Fleets are also great candidates for load control programs and even V2G if supported by the vehicles.

3.5.1 Evidence of effectiveness

- *Home charging*
 - A post survey of owners said that 40% would like for utilities to install home EVSEs. The same survey said that 59% would participate in, and another 25% would consider, a demand-response program from their utility. (Only 41% would participate if offered by another entity). (Tal, 2016).
- *Apartments, condos, etc.*
 - A 2013 post survey of California PEV drivers found that 93% of them own their own home (CSE, 2013). MUD dwellers are therefore highly underrepresented; implying a lack of MUD charging.
 - In an early L.A. pre survey, 61% lived in MUDs where they can't charge; 56% said that would prevent them from buying a PEV (Dubin, 2011). They simulated an estimate that 50% MUD coverage would increase adoption 10%.
- *Workplace charging*
 - A multi-state post survey said that a workplace charger was necessary for 7-19% of buyers; 49-68% more buyers were not eligible for that incentive (Tal, 2016) so effectiveness was high.
 - Employees of Workplace Charging Challenge participants are 6 times as likely to drive PEVs as the general population (US DOE, 2015).
- *Public charging*
 - A post survey of PEV owners said that utilities tied with local governments as the entities most expected to install public charging (Tal, 2016).
 - A study in Japan showed a 92% correlation between DC stations and PEV registrations (Patterson, 2014).

- In the US, Nissan claims a 75% correlation between BEV sales and DC infrastructure (Woodward, 2015). 2/3 of their owners use public charging, ¼ at least once per week; charging speed is the primary consideration (except at work) so DC charging is strongly preferred.
- In Japan only 2% of the stations are DC, but they deliver 19% of the energy (Patterson, 2014).
- A post survey of test drivers that did NOT purchase a PEV found that 54% might be persuaded to buy if infrastructure was increased (CA PEVC, 2016).
- Oregon has no financial incentives; but with the best DC infrastructure, Portland's BEV adoption is 3 times the metro area average (Lutsey, 2015).
- A simulation projected that a 10% increase in public charging increases PEV sales about 8% - and a 10% increase in PEV sales results in 6% more public charging, so there is a virtuous network effect (Li, 2015).
- A geographic A-B study on financial incentives claimed that installing infrastructure was not a significant factor in PEV sales (Clinton 2015); but infrastructure was not the study subject and they did not provide enough detail to determine why their results were different from other studies.

4. Best Practice Recommendations

Prospective buyers and owners have slightly different takes on the relative importance of various incentives to encourage PEV adoption, but in companion pre and post surveys, the same four factors are ranked by both groups above all other choices: financial incentives, infrastructure, test drives, and more media coverage (Shahan, 2015; Powers, 2014). These factors have also been long encouraged by owner and advocacy groups such as Plug In America, and show up repeatedly as salient factors in the literature (TEC, 2013; Lutsey, 2015; Sierzchula, 2012).

Utilities vary greatly in their regulatory environment, goals, resources, constraints, customer demographics, generation mix, spare capacity, load variance, daily load profile, traffic patterns and other relevant factors so a single “recipe” for success is not possible. A wide variety of methods have been mentioned in this report, but if you are looking for a combination of several factors that are likely to have a significant effect on PEV adoption rates at reasonable cost, a simple way to start is by considering the following options that were discussed in the previous section:

- *Install more charging stations.* There are many options, but AC charging for multi-unit dwellings and DC stations in metro areas and along major travel corridors are likely to have an outsized effect on BEV adoption in the next few years. PHEV adoption will be more likely tied to AC charging stations at frequent long-dwell locations (i.e. at or very near multi-unit dwellings or the workplace).
- *Reduce the purchase cost.* The ideal method would cut a significant amount off at the time of purchase. If you can organize a “group buy” with a local dealer, your utility may not have to pay anything at all other than some administrative and marketing costs. Failing that, rebates – whether provided by the utility or a local government or employer - are excellent, especially if they can apply at the time of sale.
- *Host test drive or ride events.* Once local contacts are assembled, it can be simple and inexpensive to host a series of test drive events. Trying one of the cars is the fastest way to convert a holdout to a buyer; without first-hand experience most consumers assume the worst about PEVs.
- *Raise awareness.* Awareness of PEVs, their advantages and incentives are extremely low. Show or mention PEVs – briefly is fine – every place you can. Most people are aware of the social benefits but don’t base car buying decisions on them, so focus on the personal benefits: fun to drive, convenient, inexpensive to own.

If none of these work for your utility, look over other ideas from the previous section. Almost any incentive can help; the most important thing is to find ones that make sense for your utility and get started soon.

Regardless of whether your utility actively encourages PEVs, offering a PEV-specific TOU rate - even with no overall savings to the customer - is an easy way to exert some control over when the majority of charging happens. PEVs are coming even without encouragement, so it is important for all utilities to be prepared.

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5.3 Studies in progress

These studies may be relevant, and as of April 2016 appear to be underway:

UC Berkeley: The Effectiveness of State and Local Incentives on Household Ownership of Alternative Fuel Vehicles – a SEM Analysis <http://www.ucconnect.berkeley.edu/effectiveness-state-and-local-incentives-hosehold-ownership-alternative-fuel-vehicles-sem-analysis-0>

UC Davis: a job posting seeks somebody to evaluate the effectiveness of incentives

Securing America's Future Energy (SAFE) is helping to evaluate the EV programs as part of the DOE's Smart Cities contest; they are looking for things that are efficient and replicable so one element of the applications may be incentive effectiveness

Clean Cities and EEI agreed in June 2015 to study effectiveness of utility investments in EVs.
<http://energy.gov/eere/articles/driving-progress-through-ev-everywhere-utility-partnership>

Urban Foresight: Electric Vehicles – Local Incentives: <http://urbanforesight.org/wp-content/uploads/2015/08/11th-E-cosse-Forum-Presentations-Merged.compressed.pdf>

Rand Corporation: Factors Affecting the Wider Adoption of Electric Vehicles:
<http://www.rand.org/randeuropa/research/projects/electric-vehicles.html>

UC Davis and Multi-State ZEV Task Force are doing a consumer survey on customer knowledge and attitudes. Measuring incentive effectiveness is part of their Priority Actions http://altfueltoolkit.org/wp-content/uploads/2015/09/Portland_EV_Workshop_Summary_Report.pdf

6. Appendix A - How Incentive Effectiveness is Determined

Here are some of the ways research on the topic of incentive effectiveness is performed and analyzed for those that wish to understand the meaning of the numbers in detail.

A utility looking for the best method to encourage PEV adoption in their service area would ideally obtain a list of methods, each with the cost to deploy and its effectiveness rate. Then they could choose how many additional PEVs they would like to see, or if the budget is limited, how much they want to spend on PEV adoption. Either way, they could know exactly how many additional PEVs they will get in their service area for their efforts, and know that they are getting it at the lowest cost.

While this report is trying to move in that general direction, several complications keep the ideal well out of reach. Difficulties measuring effectiveness rates will be expanded upon below. Even if a precise effectiveness number is determined for one program, and it was re-implemented in exactly the same fashion elsewhere, the effectiveness rate would not likely be the same due to the large number of interacting factors, many of them relating to zeitgeist and motivations which aren't entirely understood and therefore unable to be measured or modeled with precision.

Costs can also vary widely by implementation details, including some caused by the widely differing regulatory environments that utilities operate under. Because of cost variances, this report focuses mainly on effectiveness and leaves cost-effectiveness as an exercise for the reader. Similarly, PEV benefit values vary among utilities depending on many variables including the regulatory environment.

Cost-effectiveness is an extremely important consideration for choosing between alternate methods, but minimizing cost of a single program is not the goal by itself - a point that was missed in a couple of studies. Minimum cost for any program is achieved by doing nothing, but can be an enormous mistake if benefits that arise from the program are ignored. Designing a set of programs *with the most favorable cost/benefit ratio* should be the goal, though it requires a more thorough accounting to establish.

6.1 Types of studies

There are several ways to attempt to determine the effectiveness rate of an incentive – that is, how many people purchased due to the incentive that would not have purchased without it. It is useful to understand some of the strengths and limitations of some of the measurement methods that were observed in the literature. Pointing out study limitations is not intended as criticism; it simply speaks to the immense difficulty of the task of determining effectiveness rates.

No single study, or even method, produces results that can be relied on as accurate to a significant degree, especially when the purpose is to apply the number to other situations. However, when studies using a number of disparate methods form reasonably well-established bounds, a general assessment of

the effectiveness of the incentive can be considered established - at least to a degree sufficient to use in a complex cost/benefit equation that will contain a number of other difficult-to-enumerate factors.

It is best to read an entire study rather than a summary – especially a summary by a third party. Studies are often misinterpreted in articles that discuss them, for example saying the study concludes that a particular incentive is “the most effective method” or “not worth it” for PEV adoption. Indeed, the study’s analysis may include those very words. But sometimes that conclusion is because PEV adoption was a means rather than the goal of the study. For example, one study focused on CO2 reduction rather than PEV adoption, and because they purposely didn’t consider other PEV benefits (and stated so), they found a more cost-effective method to achieve their narrow CO2 goal that did not involve PEVs at all.

6.2 Simulations

Before PEVs are widely available in an area, or before an incentive is added or removed, sometimes mathematical “simulations” are run to determine how PEV adoption rates might change based on economic models of behavior. Some of these simulations have extremely detailed input models and extremely long sections of elaborate mathematics, including allowing for feedback effects. The skill and dedication is often admirable.

However, in addition to concerns about sensitivity to input assumptions (often obtained from “analogous” situations, like HEVs that have significant differences from PEVs) and the applicability of each computation in the model, the simple fact is that buying a car is a complex emotional decision that psychologists do not understand fully so economists are unable to accurately model. A few studies made valiant efforts to account for this, but our abilities in this area still need some work. The simulations also often do not allow for supply-side issues unique to PEVs that were covered earlier.

These models are far better than nothing, which may be the alternative at the time they are run. And there are some cases where predictions proved out well. But once other data is available, it pays to compare results.

6.3 Counting incentive takers

Once an incentive is deployed, if the consumer has to take an action (i.e., fill out and mail in a rebate form) to get the incentive, it is possible to count the number of actions taken and compare them to the PEVs sold, assuming that people took the action if the incentive was a purchase driver and skipped the action if it was not.

Fortunately only two articles were found with this type of accounting, which seems fundamentally flawed. People might have not bought without the incentive but then forgot to take the action or found

out too late that they did not qualify; or they may have been planning to buy anyway, but took the action simply because the incentive was offered. No results from this method were cited in this report.

6.4 A-B tests

The standard method for studying incentive effectiveness in industry is an A-B test. Typically different offers (including a “base” offer where practical) are given to a large number of people in a set geographic area at the same time; which offer they get is random. Take rates for the different offers are then compared. This is an excellent method and a number of papers attempted something of this nature.

However, none of the observed studies actually had control over the incentive, so they were unable to randomize it in the same time and place. Instead, they varied the incentive over time or space – they compared the same place before and after an incentive, or compared different places with and without the incentive. Some of these studies were very carefully done, elaborate and they have some useful data.

However, it goes without saying that many things change over time. More PEVs may have become available - or perhaps fewer in a sense, if the top sellers are just about to be refreshed. Other incentives may have come or gone. An awareness campaign may have started or ended. The PEV sales rate typically goes up over time, so that should be controlled for...but is complicated by common PEV sales fluctuations, which are significantly different from ICE market fluctuations, in large part due to incentives.

Similarly, much can be different about another place. One place may have more charging infrastructure, or the infrastructure may be sited or maintained better. Or the demographics could be more aligned to PEV purchases. Geography could play a role – how far do people have to drive, along what routes – as well as traffic patterns and major housing and employment centers. Employers or a utility on one area may do more to encourage PEVs. Some studies worked hard to adjust for these factors, but there are just too many to deal with effectively.

A-B tests are a fantastic tool, but without the ability to randomize incentive offers in a single time and place, should be used in conjunction with other tools whenever possible.

6.5 Pre survey

The information in question is, what will it take to get new buyers to choose a PEV? A “pre survey” that is sent to a large number of random individuals that have not yet purchased a PEV can ask this question directly.

A couple of observed surveys had trouble finding sufficiently large or representative audiences. Not many, but this is really a key measure for this type of tool. With a sufficiently large and representative audience, asking this question directly should theoretically result in a perfect answer. But test design and psychological oddities of respondents often muddle the results.

Without extremely careful design, the survey questions may easily be unintentionally misleading, may not include answers that cover all situations, or may not properly correlate answers between related questions. And as with any survey, practical issues may arise – a too-long survey may result in rushed answers; fear of follow-up questions may point users away from certain options; slider boxes to choose a value may bounce to a previous value if the user doesn't get the cursor close enough to the end; wording and default settings can influence answers when respondents are not positive about an answer.

Interviewing respondents in person can result in new insights and explain more of the findings, but is far more costly. A good tactic is to interview a small group first to help design a better survey for a larger online audience.

Some survey takers don't take it seriously. Some try, but don't spend enough time to understand the questions. Some try to use it to "send a message" or please the survey takers rather than to describe their actual expected behavior. And even when they try to answer faithfully...it turns out that people answering surveys are usually disassociated from the question enough that they use more of their frontal cortex and less of their emotional circuits than they would if they were really considering a PEV. The "decision" is different.

Like most other tools, a pre survey is a great thing to have in the toolbox, but results are best compared to results from other tools.

6.6 Post survey

If survey respondents cannot be trusted to guess correctly what they might do in a hypothetical future, can they at least say which factors were critical to their decision after they have made a purchase?

Not reliably. First, they often forget, especially since there can be multiple related factors over a long period of time. Without an email two years ago from with a description of PEV benefits from a local clean-air organization, they may not have visited a test drive event a year ago; without going to the event they would not have learned about an incentive; without the incentive they would not have discussed it with their spouse; without the discussion their spouse would not have paid attention two months ago to information from a friend about operating costs that pushed them over the edge.

As decisions are emotional, a lot of the "reasoning" is subconscious, and unless people reflect and have decent understanding of their own motivations, they may not really know what drove them to make the

purchase. And even if they know, they may select an answer that “sounds better”. For example, in one survey 70% said environmental factors were the largest factor in their decision to buy a PEV; yet on another question 72% of those same respondents said they had not even considered a PEV until they heard of a significant discount as part of a group buy (Berman, 2016).

In addition to the regular worries about whether the surveyed group is representative of current buyers, there is also concern about how well they represent future buyers, which can change dramatically in the early days of a new market.

Study design is just as important with a post survey as a pre survey. In-person interviews can be even more helpful with post surveys because you can see people interact with the product.

Post surveys are another valuable tool best not used in isolation.

6.7 Industry and analyst projections

The best projections by industry analysts combine several of the above methods, add consultation with experts inside and outside the industry, interviews with consumers, offer many caveats and give ranges of possibilities. Adding the knowledge of industry veterans can be extremely valuable. Predicting the future is hard and they are not always correct, but sometimes these efforts are worth the money.

Other times, even when backed by the same data and methods used by others, industry insiders – or analysts with abundant access to them – inadvertently project wishful thinking about where industry would *like* to see the market go. Entire college courses are based on stories of large industry changes that were not seen (or at least dismissed in scope) by industry executives or analysts. Information from industry insiders must be viewed as critically as any other source. Without that, otherwise careful, expensive work can sometimes be very poor at predicting future events.

7. About CalETC and Plug In America



CalETC was created over 20 years ago with a charter to promote electric transportation as a means to reach the clean air goals in California. We have worked tirelessly to support all forms of electric transportation. Over the last 20 years electric off-road equipment has become commonplace with forklifts, airport equipment, lawn equipment and other types of off-road equipment transitioning to clean electricity. This transition has resulted in significantly lowering the use of petroleum in these various categories, paving the way for the next wave of on-road large-scale deployment of electric vehicles. With every major auto maker producing or announcing production of some manner of electric vehicle, California is poised to continue to lead the transition of the transportation sector away from petroleum and towards electricity. CalETC will continue to support all aspects of the transition to electric transportation, working closely with our government, environmental, and industry partners to ensure success.

www.caletc.com



As leader of the nation's plug-in vehicle movement, we work through grassroots activism, legislative advocacy, education and outreach to accelerate the global shift to all-electric and plug-in hybrid electric vehicles. We represent drivers and supporters of plug-ins, including motorcycles, passenger cars and trucks, shown to be cleaner than the cleanest gas or natural gas cars. We serve on behalf of all who want to wean America off its dependency on foreign oil and improve the global environment.

www.pluginamerica.org