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Charging Behavior of American EV Drivers

Driver Segments

- **Geographic (Urban vs. Suburban vs. Rural):** EV charging patterns vary by location. Urban drivers often have less access to private home charging (especially those in apartments) and rely more on public stations or workplace charging. Suburban EV owners typically have garages and use home charging for the bulk of their needs, turning to public chargers mainly for long trips. Rural EV drivers face sparse charging infrastructure – some rural areas are "charging deserts" with few or no public stations [1]. Those in rural regions tend to depend heavily on home charging and may plan routes carefully due to longer distances between chargers. Urban public stations also see different usage patterns than rural ones: urban chargers are used more on weekdays with longer session durations, whereas rural public charging sessions are shorter on average (since rural EV owners often charge just enough to reach the next stop) [2] [3]. Overall, drivers in densely populated areas have more charging options but also contend with station congestion, while rural drivers enjoy less congestion but must plan around limited infrastructure.

- **Vehicle Types (Tesla vs. Non-Tesla):** Tesla owners have unique charging behavior thanks to the extensive Supercharger network. Many Tesla drivers rely on Superchargers for long-distance travel or quick top-ups, benefiting from high reliability and plentiful locations. Surveys show the Tesla Supercharger network scores much higher in user satisfaction and reliability than other public fast-charging networks [4] [5]. Non-Tesla EV owners must use a patchwork of public charging providers (e.g. Electrify America, ChargePoint, EVgo), and historically they faced more issues with broken chargers or compatibility. As a result, non-Tesla drivers may be more cautious in trip planning and often utilize a mix of Level 2 and DC fast chargers. (Notably, a recent move to open some Superchargers to non-Tesla EVs may start blurring this distinction.) Tesla drivers are also slightly more likely to do road trips due to confidence in the Supercharger network, whereas some non-Tesla drivers avoid very long trips unless they map out charging stops carefully. Both groups predominantly charge at home when they can, but Tesla owners have had an edge in seamless long-range charging away from home.

- **Ownership (Private Owners vs. Fleet/Commercial):** Private EV owners (personal vehicles) typically charge at home overnight if possible, and occasionally at public stations for longer trips. Fleet and commercial drivers – such as rideshare (Uber/Lyft) or delivery drivers – have higher daily mileage and different charging patterns. Many ride-share EV drivers take advantage of any available charging during downtime: for example, they might top-up at DC fast chargers during breaks or utilize workplace or public chargers in between rides. If a company fleet has a depot, those EVs often charge overnight at a depot facility (Level 2 or faster) to start each day full. Commercial drivers who don't have a depot or home charger must rely on public infrastructure, which can be challenging in areas where it's not plentiful [6]. A recent survey of EV drivers using their cars for ridesharing or delivery found that most are satisfied with the vehicle's viability for that purpose, but they are less satisfied with the public charging available – only about 56% reported being satisfied with public charging options for work needs [7]. This suggests that high-mileage drivers often need more

frequent charging and would benefit from more reliable, faster chargers strategically placed along their routes. In summary, private owners optimize for convenience (home charging), whereas commercial EV drivers incorporate more opportunistic charging into their work routines and often charge more frequently.

- **Demographics (Age, Income, Early Adopters vs. Mainstream):** Early adopters of EVs (often higher-income, tech-savvy individuals) have been willing to put up with limited infrastructure, typically installing home chargers and planning around charging limitations. These early adopters often skew younger to middle-age and have above-average incomes (able to afford home installation and higher upfront vehicle costs). As EVs go mainstream (a broader demographic including middle-income and older drivers), charging behavior is evolving. Mainstream adopters place a higher premium on convenience – if charging isn't as easy as pumping gas, they get frustrated [8] [9]. Surveys indicate that new EV buyers initially worry about range and charging, but after firsthand experience, their concerns drop significantly [10]. Older drivers or those less tech-oriented may be less inclined to fiddle with multiple charging apps and instead stick to one network or locations they trust. Income level impacts charging behavior primarily through housing: higher-income EV owners more often live in single-family homes (with garages for charging), whereas lower-income owners or those in multi-unit housing might lack home charging and thus rely on public infrastructure. This dynamic is expected to shift as EV adoption broadens – early waves of EV drivers mostly had home charging access, but more recent buyers include a growing share of apartment dwellers or those without private driveways. In fact, the National Renewable Energy Lab estimates that as EVs spread, up to 25% of drivers will not be able to charge at home in the future (vs. the vast majority who could in early years) [11]. This broader demographic mix is pushing the charging ecosystem to expand public options and simplify the user experience (e.g. plug-and-charge, integrated navigation to chargers) to accommodate drivers who are not "EV enthusiasts" but everyday consumers.

- **Housing (Single-Family Homes vs. Apartments):** Housing type is one of the strongest determinants of charging behavior. **Single-family home** owners overwhelmingly charge at home: as of 2023, roughly *90%* of battery EV drivers in single-family houses have access to home charging [12]. They typically install Level 2 chargers (240V) in their garage or driveway. Indeed, survey data shows about 74% of EV owners use Level 2 home charging, while ~20% still rely on a standard Level 1 wall outlet at home (120V) for overnight charging [13]. Homeowners with Level 2 can replenish 200-300+ miles of range overnight, so they rarely need public stations except on long trips. In contrast, **apartment and condo dwellers** face limited home charging access – only an estimated 55% of EV drivers living in multi-family housing had any home charging in 2023 [14]. Many apartment EV owners must use public chargers regularly since they can't simply plug in at home. They might charge at work if offered, or visit nearby public chargers a few times a week. A 2024 North American survey found ~29% of EV owners did **not** have a charger at home, underscoring the reliance on public infrastructure among those without dedicated parking [15]. Apartment dwellers often strategize their charging by combining it with other activities (e.g. charging at a shopping center or public garage overnight). They may also rely more on DC fast charging for a quick fill-up, since they can't slow-charge for many hours at home. Single-family drivers, by contrast, do **the majority** of their charging at home overnight – commonly known statistics say **around 80%** of all EV charging happens at home [16]. Going forward, increasing installation of chargers in multi-unit dwellings (and public "curbside" chargers in cities) will be critical to serve the growing segment of EV owners without a private garage. Housing situation thus heavily influences whether an EV driver's behavior centers on nightly home charging versus frequent public charging sessions.

Timeframe Trends (2018–2024)

- **Current (2022–2024):** In recent years, American EV charging behavior reflects the expansion of both EV range and charging infrastructure. Modern EVs (2020+ model years) often have 200–300+ mile ranges, allowing drivers to go multiple days between charges if needed. However, many drivers still top-up daily out of habit or convenience, especially if they can plug in at home each night. The period 2022–2024 has seen rapid growth in public charging: the number of publicly available charging ports in the U.S. grew by about **70%** from 2021 to 2023, now exceeding 170,000 public chargers nationwide [17]. This improved infrastructure has made en-route and opportunity charging easier and has begun to accommodate drivers without home chargers. Surveys in 2023 show that while over 90% of EV owners have home charging access, a **majority** still use public chargers at least occasionally [18]. Fast charging in particular is becoming a regular part of EV life – 42% of North American EV drivers report using DC fast chargers at least once a month, largely for travel purposes [19]. Another trend in 2022–2024 is the increasing normalization of EV charging routines: drivers are learning the "rhythm" of charging and incorporating it into daily life, much like smartphone charging. For instance, many have schedules to charge overnight or during off-peak hours (to take advantage of cheaper electricity), and public charging stops are planned around meal breaks or shopping. Overall, the current state is one where home charging remains dominant for day-to-day needs, but public charging is no longer a rarity – it's an important supplement for long trips, drivers with no home unit, or for those seeking a quick charge boost during busy days.

- **Historical Trends (2018–2021):** Looking back a few years, EV charging behavior has evolved significantly. In 2018, the EV market was still in early adopter phase (with vehicles like the Nissan Leaf, Chevy Bolt, Tesla Model S/3 leading the market). Ranges were shorter on average (many EVs ~150 miles or less), which meant drivers charged more frequently and often planned trips very conservatively to avoid running out of charge. Public charging infrastructure was also more sparse – for example, non-Tesla drivers in 2018 had limited DC fast charger availability outside certain corridors or metro areas. As a result, early EV drivers overwhelmingly charged at home or work. Studies from that period indicated **about 70–80%** of all charging was done either at home or at workplace parking, with relatively little done on public networks [20]. Many early EV owners charged **daily**, partly due to smaller batteries and range anxiety. Between 2018 and 2021, two key changes occurred: battery ranges increased and public chargers slowly spread. By 2020, an average EV might have ~250 miles of range (thanks to models like Tesla Model 3, newer Bolts, etc.), reducing the need for daily full charges – drivers could go a couple of days between plug-ins if they wanted. At the same time, initiatives like Electrify America (launched in 2018) began deploying more fast-charge stations, and Tesla's Supercharger network roughly doubled from 2018 to 2021. This enabled more confident long-distance travel and a shift in behavior: EV road trips became more common by 2021, whereas in 2018 many EV owners seldom ventured far from home charging comfort. Also, around 2019–2021 we see more *early majority* adopters coming in, not just tech enthusiasts. These newer owners demanded more convenience – prompting utilities to roll out EV-specific rate plans and governments to invest in public chargers. In summary, from 2018 to 2021 the trend was moving from a nearly home-only charging paradigm toward a more balanced approach with slowly improving public charging use. The groundwork laid in those years (more chargers, better range) set the stage for the 2022–2024 behavior where using a mix of charging options is increasingly typical.

- **Seasonal Variations (Winter vs. Summer):** EV charging behavior also changes with the seasons. **Winter** can dramatically affect EV range and charging needs. Cold temperatures not only reduce

battery range (by ~30% on average in freezing conditions) but also slow down charging speeds if the battery isn't warm [21]. To cope, EV drivers adjust their habits in winter: about *60%* of EV owners say they charge more often or keep a higher state-of-charge in cold weather [22]. In practice, this means drivers might plug in every night (even if they wouldn't normally) and are less likely to let the battery run down very low in winter. Many will charge to a higher level (for example, some drivers who normally stop at 80% might charge to 90-100% before a cold commute) [23] [24]. Preconditioning (warming the car/battery while plugged in) is another winter strategy to preserve range. Additionally, in extremely cold regions, EV drivers plan more carefully for long trips – they may identify all available fast chargers along the route, since range can drop faster and unexpected detours to charge are more likely. In **summer** or warmer months, range is better and drivers are generally more relaxed about charging. Many EV owners find they rarely need public charging in summer except for travel, whereas in winter even routine drives can require an extra charge stop ("somewhat frequently," as one EV owner noted about winter vs. summer [24]). Hot weather (e.g. in Arizona or Texas summers) has a smaller effect on range than cold, but running air conditioning does consume some extra energy. In hot climates, drivers may still charge primarily at night – partly to avoid peak electricity rates and partly because charging during the cooler night is easier on the battery and the grid. Some behaviors in hot regions include using timers to charge in early morning (when both temperature and rates are lower) and ensuring the car is shaded or garaged while charging to keep the battery cooler. Overall, winter prompts a noticeable uptick in charging frequency and caution (to mitigate "winter range anxiety"), whereas summer charging is closer to the ideal scenario – less frequent and more flexibility. Seasonal utility rate differences also play a role: for example, in California, summer electricity peaks can be costlier, encouraging EV owners to **always** charge off-peak at night during summer months to save money. In summary, American EV drivers adapt to seasons by charging more proactively in winter (and often aiming for a higher state of charge), while taking advantage of the relative ease of summer driving to charge a bit less often or less urgently.

Charging Behavior Types

- **Location Preferences – Home, Work, and Public:** Most U.S. EV drivers strongly prefer charging at home if they have the option. Home charging is convenient and typically cheapest, and indeed **around 80%** of total charging for the average EV owner occurs at home (or occasionally at a workplace) [20]. Surveys consistently show that over 90% of EV owners have access to some form of home charging [18], and this is where they do the bulk of "fueling" – usually overnight in their garage or driveway. Many early adopters installed a Level 2 home charger, which provides ~20-30 miles of range per hour of charging and easily meets daily needs. **Workplace** charging is the next most favored location when available. Employers that offer EV charging (usually Level 2 stations) find they are well utilized: over a quarter of EV owners with workplace charging use it *weekly*, and nearly another quarter use it *daily* during the work week [25]. Workplace charging effectively supplements home charging by adding range while the car sits parked at the office. It's especially valuable for those with longer commutes or who cannot charge at home (e.g. apartment dwellers may rely on charging at work). **Public charging** (outside home/work) is generally used on an as-needed basis. The majority of EV owners do use public chargers, but usually infrequently – for example, in one 2023 survey, roughly 47% of owners said they "rarely" use public Level 2 stations and 37% "rarely" use DC fast chargers, whereas only a small minority use public chargers daily [26] [27]. Public charging tends to be utilized for **road trips, errands, or emergency top-ups**. DC Fast Chargers (typically 50 kW up to 350 kW stations) are the go-to for long-distance travel or when a quick charge

is needed away from home. Many drivers plan road trips around fast charger stops every 2–3 hours of driving. In contrast, public Level 2 chargers (slower, ~6-7 kW) are used when the car will be parked for longer anyway – for instance, downtown parking garages, shopping centers, hotels, or parks where a 2-hour stay can add 40+ miles. Importantly, drivers without home charging depend heavily on public infrastructure: they might develop a routine like using a nearby DC fast charger once or twice a week to refill, or plugging into a public Level 2 at a grocery store or gym regularly. In such cases, public chargers become part of their normal life (akin to weekly gas station visits for gas car owners). In summary, **home is king** for EV charging, with workplace charging a strong secondary option, and public charging serving more specialized or occasional needs – except for those who lack other options and make public charging part of their regular routine.

- **Charging Frequency (Daily vs. Opportunistic vs. "Range Anxiety"-Driven):** Charging frequency among EV drivers can range from plugging in every single day to only charging a couple times per week, depending on driving patterns and personality. Many EV owners adopt a **"top-off daily"** habit – especially if they have a home charger – simply because it's easy and ensures they start each day with a full (or nearly full) battery. These drivers charge nightly regardless of remaining charge (similar to cell phone charging behavior). In fact, EV drivers on average tend to recharge **either daily or every two days**, typically overnight [20]. On the other hand, some drivers are more **opportunistic**, charging only when convenient or when they feel it's needed. For instance, an owner might not bother plugging in at home every night if they drove only 10 miles that day; they might wait until the battery gets down to, say, 30% and then charge. Studies have identified a subset of drivers who plan their charging strategically – one analysis described drivers who charge about 4–5 times per week (not necessarily every day) and try to keep the battery in an optimal mid-range (around 30–80% state-of-charge) [28]. These drivers avoid both very low and very high battery levels except when necessary, balancing convenience and battery health. **"Range anxiety"-driven** charging refers to plugging in out of fear of the battery getting too low. Early EV adopters often exhibited this behavior: not letting the charge drop below, say, 50% before recharging, just for peace of mind. As experience with EVs has grown, range anxiety is diminishing – seasoned EV owners become comfortable running down to 10-20% knowing their vehicle's true range and nearby charging locations. In a global survey, 61% of EV drivers said they worry less about running out of charge now than they initially did [29]. Nonetheless, new or anxious drivers may still recharge at every opportunity ("topping off" whenever a charger is available) to avoid ever seeing a low battery. We see this especially in cold weather (drivers charge more often to offset range loss) [22] and in areas with sparse chargers (drivers top-up whenever they find one). **Typical behavior for most American EV drivers** lands somewhere in the middle: if they have routine daily drives, they'll plug in overnight almost every day; if they have a light driving day or forget, it's no big deal because the range can cover multi-day use. And when planning long trips, even formerly anxious drivers charge strategically rather than constantly – for example, charging fully *before* a trip (pre-trip charging at home) and then using big fast-charge sessions every few hours on the highway. In summary, daily charging is common but not universal, and opportunistic charging happens when beneficial (like using a free charger during a shopping trip). As confidence in range grows, fewer drivers charge purely out of anxiety, focusing instead on when and where it's genuinely needed.

- **Charging Duration (Full Charges vs. Top-Offs vs. "Just Enough"):** The length of EV charging sessions varies widely based on context. **At home**, many drivers plug in for long durations (overnight, typically 8+ hours) but the car often finishes charging before they unplug – for instance, it might reach the desired charge in 3-4 hours but remain plugged in until morning. Home charging is

usually about **full or near-full charges**: drivers often aim to recharge the battery to 80% or 90% (or 100% if they need maximum range the next day). Because it's slow and overnight, they can easily charge from, say, 30% back to 90% at home. **In public, especially at fast chargers**, charging sessions are often shorter and more tactical. DC fast charging usually tapers speed as the battery fills, so drivers tend to do **"just enough"** charging to reach a comfortable level to continue their trip. For example, on a road trip a driver might plug into a 150 kW fast charger for 20 minutes and gain ~150 miles of range, which is "just enough" to reach the next planned stop or destination. Many will unplug once the battery hits around 80% during fast charging, since the charging speed drops off markedly after 80% and it's less time-efficient to wait for a full 100% charge. This is why you'll often see EV road-trippers stopping more briefly, multiple times, rather than doing one super long charge – it optimizes travel time. By contrast, **top-off sessions** happen at Level 2 public chargers in places where the car is parked for a while. If an EV driver goes to see a movie or do a two-hour grocery run and there's a Level 2 charger, they may plug in and take whatever charge they can get during that time (perhaps it's a top-off of 40-50 miles worth of energy). In such cases, the driver isn't necessarily aiming for a full charge; they're opportunistically extending their range buffer. Survey data show that *plug-in EV consumers expect to spend about 30 minutes to an hour at public chargers* if they plan a session [30]. Some indicate they'd **prefer** even shorter stops (15 minutes or less) if fast charging were quick enough [31] – highlighting that many public charging sessions are seen as a minor pit stop, not an hours-long stay. The average DC fast charge might indeed be on the order of 30 minutes, which usually brings most EVs from a low state up to ~80%. **In summary**, home charging often involves charging to a high state of charge over many hours (for a full or near-full battery), whereas public charging is more often about partial charges – either quick bursts at a fast charger to get enough range, or moderate top-offs while the car is parked. Drivers have learned not to always chase 100% at public stations if 70-80% will comfortably get them to the next stop, as that saves time. And with battery longevity in mind, some also intentionally avoid full 100% charges in daily use unless needed, sticking to quicker top-offs that keep the battery in a healthy mid-range.

- **Time-of-Day Patterns (Overnight vs. Peak Hours vs. Off-Peak Rates):** When EV drivers choose to charge is heavily influenced by electricity pricing and convenience. A large share of American EV owners are on **time-of-use (TOU)** electric rates that incentivize nighttime charging. For instance, utilities in California offer EV rate plans with cheap off-peak power (often after 9 p.m. until morning). This has led to a pronounced pattern: **most home charging happens overnight**. Data from California shows that EV owners on TOU plans charge **over 80–90% of their EV energy during off-peak hours** (typically between 11 p.m. and 7 a.m.) [32] [33]. Charging late at night not only saves money but also aligns with when the car is idle for long periods. As a result, it's now common for drivers to plug in their car in the evening and let it charge automatically in the wee hours. Many EVs and chargers allow scheduling, so owners might set a timer for charging to start at, say, midnight when rates drop – they wake up to a full battery by morning. **Peak-hour charging** (late afternoon/early evening) is generally avoided by cost-conscious drivers because electricity is expensive and grids are stressed. However, some drivers without home charging might end up using public chargers during the day as needed, even if that's during peak times – for example, a commuter using a fast charger at 5 p.m. on the way home. Utilities and charging networks are exploring pricing strategies to shift more of this public charging to off-peak too (some public stations have higher rates during peak demand hours). In places with demand charges or congested grids, there's a push to move EV load to nights. **Workplace charging** often occurs during daytime (obviously), but many workplaces offset this by using solar panels or encouraging lunchtime charging when solar generation is high. Overall, **overnight charging dominates** schedules for those who have home or

workplace options. One exception is for road trips – drivers charge whenever they reach the next charging stop, which could be any time of day. But even here, many long-distance travelers prefer early morning or late-night charging to avoid crowds at popular stations. It's worth noting that as EV adoption grows, there's concern that if everyone charges exactly at 11 p.m. when off-peak starts, it could create a new spike – but currently the load is still reasonably spread through the night. In summary, American EV drivers predominantly charge during **off-peak, overnight hours** for routine charging, taking advantage of lower electricity prices and the convenience of idle nighttime hours. Only when necessary (or when relying on public infrastructure) do they routinely charge during daytime peak periods, and even then there's a trend toward shifting to times when power is cheaper or greener (some drivers intentionally charge when solar or wind power is abundant, for environmental reasons). Time-of-day considerations have become ingrained enough that many EV owners schedule charging just like they schedule an alarm clock – it's a set nightly routine.

- **Trip Planning: Pre-Trip Charging vs. En-Route Strategies:** EV drivers have developed distinct charging strategies for road trips or longer drives. **Pre-trip charging** is a common behavior: before embarking on a long trip, EV owners will ensure their car is as charged as possible (often 100% if the trip is at the edge of their range). This might mean timing an overnight charge to finish right at departure, or topping up in the morning before leaving. Many EVs allow one to override daily charging limits (like if you normally only charge to 80%, you might do 100% before a big trip). Once on the journey, **en-route charging** comes into play. Experienced EV travelers plan their stops ahead of time, usually via mapping apps or the car's navigation that shows charger locations. A typical strategy is to drive from charger to charger, aiming to arrive at each with ~10-20% battery, charge up to ~60-80%, then continue. This minimizes time spent charging while providing a buffer. Indeed, drivers have learned that two or three shorter fast-charge stops can be quicker overall than one long stop to go from near-empty to full. Tesla drivers have long used the built-in Trip Planner which optimizes such stops; non-Tesla drivers often use apps like PlugShare, Chargeway, or ABRP (A Better Routeplanner) to map out charging along a route. An interesting behavior is **destination charging** as part of trip planning: if an EV driver is going to stay at a hotel or visit someone, they often plan to charge at the destination (many hotels now have Level 2 chargers for guests). That way, the car charges while the driver is doing something else (sleeping at the hotel, for example) and they can start the next segment of the trip full without an extra stop. Also, **en-route charging preferences** can depend on amenities – drivers will often choose charging stops that coincide with meal times or rest breaks. A survey of fast charger usage found that **60% of drivers use charging time to eat or get refreshments, and ~19% use the time to shop** at nearby stores [34]. This reflects deliberate trip planning: people choose charging locations that have restaurants, restrooms, or shops, turning the charging pause into a useful break. For the most part, American EV drivers plan trips around the charging network's capabilities; this is a new mindset compared to gasoline where one might not plan stops in advance. But as networks expand, spontaneous travel is getting easier – drivers in 2024 can often find a charger almost anywhere along interstate routes. Still, *planning ahead* remains a hallmark of EV road trips. Pre-trip, that means charging fully and maybe bringing along adapters; en-route, it means knowing where to charge, how long to charge, and possibly having a backup station in mind in case one is out of order (since unfortunately public charger reliability ~78% means occasional backups are wise [35] [36]). In everyday (non-road-trip) contexts, "trip planning" might simply mean budgeting enough charge for the day's errands. For example, if a driver plans a long day of driving around town, they might ensure they leave home with a high state of charge or identify a convenient charger near one of their stops (like planning to charge at the mall while shopping). In essence, EV drivers incorporate charging into trip planning far more than gasoline

drivers ever had to, but it has become second nature for many – a part of route planning like checking traffic or deciding when to take a coffee break.

- **State of Charge (SoC) Management:** EV owners pay close attention to their vehicle's state of charge – essentially the "fuel gauge" expressed as a percentage. Different drivers have different comfort levels for how low they let the battery go and how high they charge it on a routine basis. A common guideline (for battery longevity) is the "20–80 rule": try to keep the battery between about 20% and 80% for regular use, charging to 100% only when needed [37]. In real life, many drivers do exactly this. They might arrive home with, say, 30% charge, then charge up to 80% overnight, which covers the next day's driving. If a longer trip is planned, they'll break the rule and charge to 100%. According to one survey, **most EV owners don't begin charging until the battery is below 50%** – they're comfortable using the first half of the battery without anxiety [38]. Only a very small minority (around **4%**) said they always try to keep the car "nearly fully charged" at all times [38]. This indicates that most drivers are fine with the battery dropping well under full before they feel a need to charge. In practice, many drivers set a **minimum SoC threshold** for themselves. For example, some will always charge once they hit 20% (not letting it go lower), as 20% might equate to 50-60 miles range which is a safe buffer. Others are comfortable going to 10% or even single digits if they know a charger is available. On the upper end, lots of EV drivers intentionally stop short of 100% on daily charging – perhaps charging to 80-90% – both to preserve battery health and because they simply don't need the full range every day. Tesla vehicles even let you set a max charge limit in the software, and many owners use that feature (e.g. set daily charge to 80%). However, drivers also adapt their SoC targets to conditions: in winter, as noted, people often keep a higher buffer, charging to higher percentages because range is lower and you don't want to run too low in the cold. Conversely, on a mild day with minimal driving expected, a driver might only charge to 70% to avoid unnecessary battery wear. We also see "SoC management" come into play during **charging sessions**: e.g., a driver deciding "I'll charge until 60% and that's enough to get home." Drivers think in terms of percentages, and with experience they know approximately how many percent they need for a given trip. Many EVs' navigation systems will even tell you "you will arrive with 15%" and drivers plan accordingly, charging en route until they have slightly above the amount needed. In summary, American EV drivers have become adept at managing state of charge: they typically don't panic as the battery dips to 30% or 20% (that might just be a normal point at which they'll charge later in the day or that night). They also often avoid keeping the car at 100% for long, unless necessary. The **minimum comfortable SoC** varies by person and context – some might say 10% is their "zero" in practice, while others get antsy below 50% – but on average, it appears many will charge once under about 30-40%. This is a balance between efficiency (using the battery's range) and caution (not pushing it to absolute zero). As EV familiarity grows, the trend is that drivers are letting batteries run lower than they used to (indicating reduced range anxiety) and charging to slightly lower maximums in daily use (for battery care), except when they truly need every mile.

Regional Focus

- **High EV Adoption States (California, Pacific Northwest, Northeast):** States like **California, Washington, Oregon, New York, New Jersey** have led in EV adoption and thus exhibit some of the most developed charging behaviors. **California** in particular, with by far the largest EV population, has a robust home charging culture supplemented by an extensive public network. Over 50% of all EVs in the U.S. are in California, and the state's drivers benefit from many incentives: nearly all major utilities offer time-of-use EV rates (encouraging off-peak home charging), there are rebates for

installing home chargers, and workplaces have been early to add EV spots. California EV owners typically charge at home overnight (often on solar-powered homes or using TOU rates) and use public chargers for longer trips to places like Los Angeles to San Francisco drives or road trips to neighboring states. California also has the most public charging stations; even so, urban areas like the Bay Area and Los Angeles can see high usage at popular stations (and occasional lines for fast chargers on holiday travel days). Driver behavior in California has also been influenced by HOV lane access for EVs – some drivers consider charging at times that avoid traffic to maximize that benefit. The **Pacific Northwest (Washington, Oregon)** also has high EV uptake. Washington and Oregon drivers similarly have high home charging rates, and both states have built out fast-charger corridors (e.g., along I-5 and I-90). A lot of PNW EV owners participate in utility programs for smart charging. For instance, Seattle-area utilities have encouraged charging after 9 p.m., and many drivers comply to save money. These states, with a greener grid, also have drivers motivated by environmental concerns – some drivers choose public chargers that are solar-powered or try to charge when renewable energy is abundant. **Northeast states (NY, NJ, etc.)** present a mix: high population density means more apartments/condos, so a significant number of EV owners in metro NYC or New Jersey might not have home charging. These drivers rely on a growing network of curbside or public chargers – behaviors include overnight parking at public chargers or using fast chargers on the New Jersey Turnpike for regional travel. New York City EV drivers, for example, often charge at public garages or use one of the city's street chargers, planning their charging around alternate-side parking rules and availability. In all high-adoption states, one trend is clear: **home charging dominates where available**, but public infrastructure usage increases as EV adoption broadens. These states also have more **Tesla** vehicles (especially CA) so the Supercharger network is heavily utilized for intercity travel; a trip from Seattle to Portland or NYC to Boston is routine for EV drivers now because fast chargers exist along those routes. Another aspect in these regions is **policy-driven behavior**: for example, California's peak demand charges sometimes discourage commercial fast charging during the day, but state programs are trying to mitigate that. So drivers in these areas might see more "off-peak charging discounts" or even coordinated charging via apps, affecting when they plug in. Overall, the early-adopter states show what more widespread EV use looks like: mostly charging at home at night, with a reliable web of public chargers for travel and those without home access, and evolving habits in response to incentives and infrastructure availability.

- **Emerging EV Markets (Texas, Florida, Colorado, etc.):** States like **Texas, Florida, Colorado, Arizona, Georgia** are rapidly growing their EV fleets. **Texas** and **Florida** rank among the top EV sales states now. Charging behavior in these emerging markets can differ slightly from California's pattern due to infrastructure still catching up. In Texas, for instance, home charging is common (Texans often live in suburban homes with garages), but the state's vast distances mean that inter-city EV travel is still an adventure. EV drivers in Texas metro areas (Dallas, Austin, Houston) primarily charge at home or work, but when traveling between cities, they rely on key fast charger locations (like along I-35 or I-10). As a result, Texas EV drivers often plan routes diligently, and it's becoming easier each year as more stations are added (the Texas government has been investing in corridors). We see more **pickup truck EVs** (Ford F-150 Lightning, etc.) in places like Texas and Colorado – these drivers might tow or haul, which can cut range, so they exhibit behaviors like charging to 100% when towing and stopping more frequently. **Florida** EV drivers don't worry about cold weather, but they contend with a still-maturing network outside big cities. Many Floridian EV owners charge at home overnight (air conditioning load leads many to adopt TOU rates to save money at night). For road trips (e.g., Miami to Orlando), EV drivers use fast chargers along the Turnpike; there's also a trend of

using EVs for evacuation during hurricanes, which has led some Floridians to install home backup power or ensure their EV is charged whenever a storm is looming. **Colorado** has high EV adoption in the Denver area, and unique to Colorado, many EV drivers are concerned with altitude and mountain travel – they often plan charging in mountain towns and use regenerative braking on descents to extend range. Colorado's cold winters also mean behavior similar to northern states (charging more in winter). In **Georgia (Atlanta)**, EV adoption spiked early due to state incentives. Many Atlanta EV drivers charge at home and take advantage of HOV lane incentives; a notable behavior was the popularity of free public charging stations in the early 2010s which led some drivers to go out of their way to use them. Now in 2024, free stations are rarer, but drivers still love a deal – if a retailer or parking deck offers free charging, you'll see it used heavily. Across emerging markets, one consistent theme is **fast-growing public charging usage**: these states are catching up on infrastructure, and new EV owners in 2022-2024 are testing out public chargers often. A large survey by a charging company in 2024 reflected a North America-wide pattern: about **35%** of EV drivers primarily use public Level 2 stations and **27%** mainly use DC fast chargers as their usual charging method (with the remainder mixing both) [39]. Those numbers hint that outside the traditional EV enclaves, a significant chunk of drivers are depending on public chargers. The emerging markets are effectively transitioning from the early adopter norm (mostly home charging) to a more mixed model of charging out of necessity and convenience. Education efforts in these states also shape behavior – utilities and car dealers are informing new owners about optimal charging times (to avoid straining the grid). As a result, even new EV drivers in places like Texas or Florida are increasingly aware of off-peak charging and may emulate the patterns established in California. In summary, emerging EV regions see mostly home charging in day-to-day use, but with a quickly rising importance of public charging for those new adopters who don't have home setups or who travel long distances within these large states.

- **Urban vs. Rural Infrastructure Differences:** There is a pronounced urban-rural divide in EV charging access, which in turn affects driver behavior. **Urban areas** tend to have more public charging stations, often spurred by higher EV ownership and supportive policies. In cities, you'll find more Level 2 chargers at shopping centers, parking garages, and public lots, as well as a growing number of DC fast hubs. Urban EV drivers can often rely on an "ecosystem" of chargers around the city for opportunity charging. For example, an EV owner in Los Angeles or San Francisco might seldom need public charging for daily use but will still find many options if needed; meanwhile an EV driver in a smaller city or town might have just one public station in town. One consequence is that **small urban centers and rural towns attract far fewer charging stations** per capita, and some rural regions have virtually none [1]. **Rural EV drivers** therefore overwhelmingly depend on home charging. If they venture outside their home area, they must plan around the limited chargers (often located only on major highways). Rural charging stations that do exist might see different use patterns: studies show rural fast chargers often have shorter average sessions (perhaps because locals just need a quick top-off to get home, or travelers are just passing through briefly) [3]. Urban stations, conversely, get heavier usage during business hours and sometimes serve as a substitute for home charging for apartment residents – those urban chargers might have EVs plugged in for hours (leading to initiatives like idle fees to encourage unplugging when done). **Charging deserts** are a reality in some rural parts of America [1]. EV drivers in such areas have adapted by possibly carrying portable chargers or even avoiding EV use for very long rural trips if infrastructure is lacking. On the flip side, rural EV owners often have more predictable routines (e.g., daily commute within range), so they might charge at home and not need public options except on rare occasions. **Urban drivers** also face challenges like ICEing (gas cars blocking charging spots) due to crowded

parking, which rural drivers less frequently encounter. Another difference: electricity pricing. Rural co-ops might have flat electricity rates (so no strong time-of-day signals to the driver), whereas urban utilities often have TOU pricing that shapes behavior. Thus, some rural EV owners may charge whenever convenient (since power cost doesn't vary) while urban owners carefully avoid peak times. In summary, urban EV drivers benefit from abundant chargers but also navigate more competition for those resources, whereas rural drivers operate in a sparse charging environment, leading them to be more self-reliant on home charging and careful route planning when leaving their home base. Bridging this urban-rural gap is a focus of current policy, but until more stations are deployed in less-populated areas, EV driving experiences will remain very different depending on where one lives.

- **Climate Impact by Region (Cold vs. Hot Weather States):** Climate influences how drivers charge in different parts of the country. In **cold-weather states** like Minnesota, Michigan, upstate New York – and extreme cases like Alaska – EV owners have adapted to harsh winters. As noted earlier, winter behavior includes more frequent charging and keeping the battery at higher charge levels. For example, a Minnesota EV driver in January might top-off every night and whenever possible, because range can drop substantially in subzero temperatures. Some northern-state EV owners also invest in heated garages or battery warmers; they often leave the car plugged in so that the battery conditioning system can run to keep the pack warm (many EVs will draw power from the outlet to maintain battery temperature in very cold conditions). Public fast charging can also be slower when it's very cold, so drivers in these areas plan for longer stops or try to arrive with a warmer battery (e.g., by using battery preheat features en route to a charger). On the other hand, **hot-weather states** like Arizona, Nevada, Texas (in summer) present a different set of behaviors. Extreme heat doesn't reduce range as dramatically as cold, but it can lead to drivers being mindful of battery cooling. Many EV owners in hot climates will charge late at night or early morning to avoid adding heat to an already hot battery, and to ensure the car isn't sitting fully charged in 110°F heat for too long. They also take advantage of climate control scheduling – cooling the cabin/battery while plugged in, so that the car is comfortable and the battery is at optimal temperature before driving off. In places like Arizona, some EV drivers avoid using DC fast chargers in the hottest part of the day if they can (both because the car might throttle charging speed to manage battery temperature, and because standing outside in scorching heat is unpleasant – though that's more a comfort issue!). **Snowbelt vs. Sunbelt differences** also extend to electricity rates and grid considerations: Northern states sometimes have cheaper winter off-peak power (since overall demand is lower at night in winter), whereas hot states have very high summer peak prices (due to AC load). So, in hot states, EV drivers are strongly incentivized to charge at night – and indeed many do, as reflected in utility data that EV load in places like California, Arizona, Texas spikes after midnight. In cold states, some utilities have "winter peak" considerations too (heating load), but many EV owners simply plug in when they can due to the priority of keeping the car functional in cold mornings. Interestingly, driver *psychology* in cold vs. hot differs: cold weather induces "range anxiety" more, so northern drivers are often more conservative (charging sooner, not pushing the battery too low in winter). In hot climates, range isn't as much of a worry but battery longevity might be – so some Southern EV owners keep their battery at moderate charge to avoid stressing it in heat (for example, not leaving it at 100% in hot weather). **Regional examples:** A Colorado EV driver might charge to 90% overnight and also plug in at a ski resort parking lot just to ensure a warm battery and sufficient charge to get home (cold mountain scenario). A Phoenix EV driver might do most charging at home at night but also might seek out shaded or covered public chargers (some locations provide canopy or solar panel shade for EV parking). In sum, drivers in cold climates charge more frequently and deliberately to combat range loss, while drivers in extremely hot climates schedule charging to cooler times and

pay attention to not overstressing the battery. Both extremes require slight adjustments in routine, but nothing that prevents EV usage – it's just about being aware of how weather impacts the car's performance and adjusting charging habits accordingly.

Behavioral Insights

- **Motivations: Convenience, Cost, Speed, Environment:** The motivations behind how and where EV drivers charge boil down largely to convenience and cost, with speed of charging also a major factor, and an underlying environmental ethos for many. **Convenience** is king – EV owners often choose the charging option that interferes least with their daily life. This is why home charging is so popular: it's extremely convenient to plug in at home and not have to make a special trip to fuel up. In surveys, drivers frequently cite convenience as a top reason for charging at home or at work (the car charges while they do other things). **Cost** is another key motivator. Electricity is cheaper than gasoline on a per-mile basis, but EV drivers still care about minimizing cost. Access to low-cost home electricity was found to be the **most significant economic factor** encouraging EV adoption in one 2022 survey – more so even than purchase incentives [40]. Many drivers time their charging to off-peak hours specifically to save money, and they take advantage of free charging where available. For example, if a workplace or shopping center offers free EV charging, drivers will prefer those locations to save a few dollars (sometimes going a bit out of their way for it). That said, drivers balance cost against convenience: interestingly, about **57%** of EV drivers said they're willing to pay a premium over home electricity rates to use a public Level 2 charger for convenience's sake [41], and similarly over half are willing to pay more for DC fast charging when they need a quick charge [41]. This shows that while they appreciate cheap charging, they won't shy away from paying if it means getting back on the road faster or avoiding a hassle. **Speed** of charging is closely tied to convenience – it's essentially the time cost. Many EV owners plan their charging around how fast they can get energy. If they're in a hurry or on a trip, they'll seek out the fastest available DC charger to minimize downtime. At home, speed is less critical (any Level 2 overnight is fine), but at public stops, faster is better. Some drivers are even willing to pay extra for a higher-power charger to save 10-15 minutes. Automakers and charging providers have noticed this motivation: for instance, Tesla's Superchargers (up to 250 kW) and new 350 kW stations from networks appeal to drivers who value time. Meanwhile, **environmental motivations** do play a role but more so in the decision to drive an EV rather than the day-to-day charging choices. Early adopters who were environmentally driven might be more willing to put up with inconvenience (like slower charging or using renewable energy sources) because it aligns with their values. As EVs go mainstream, environmental concerns remain a positive factor but convenience and cost tend to dominate immediate charging behavior. One example of environment affecting behavior: some eco-conscious drivers enroll in utility programs to charge when renewable energy percentage on the grid is highest, or they might use solar at home to charge during sunny midday hours even if that's not the cheapest time, because it's clean energy. Overall, the typical EV driver is motivated to charge in ways that are **easy, cheap, and fast**, roughly in that order, with the knowledge that any electric charging is still cleaner than gasoline fueling as a satisfying bonus.

- **Barriers and Pain Points: Range Anxiety, Infrastructure Gaps, Time Constraints:** Several barriers have shaped (and continue to shape) EV charging behavior. **Range anxiety** – the fear of running out of charge – was very common in early EV days and drove ultra-cautious behavior (frequent charging, never letting the battery get low). As mentioned, this anxiety is easing with experience and better infrastructure (most seasoned owners trust their range and the network more now), but for new or

prospective EV drivers it's still a hurdle. Drivers mitigate range anxiety by planning redundancy: e.g., knowing where backup chargers are or charging more often than strictly necessary "just in case." **Infrastructure gaps** remain in certain regions and along some routes. When drivers know an area has few chargers, they adapt by charging to 100% beforehand or avoiding that route. A notable pain point is arriving at a needed charger and finding it broken or occupied – something many drivers have experienced. In fact, broken or non-functional chargers were cited as a **major concern or deal-breaker by 46%** of public fast charger users in one EV owner survey [42]. This leads drivers to often have *Plan B* chargers and to share info via apps (like PlugShare comments) about station reliability. The inconsistency of public charging reliability has made some drivers stick to one network they trust or even avoid long trips after a bad experience (though this is improving as reliability becomes a focus under programs like NEVI). **Time constraints** are another barrier that shapes behavior: charging simply takes longer than a gas fill-up, so drivers with very tight schedules find it challenging. For example, ride-share drivers on a clock can't afford long charging breaks – some Uber/Lyft EV drivers have noted that finding time to charge between rides is tough, which in turn means they might not accept EV trips far from known charging hubs. For the average commuter, time constraints might mean not wanting to stop during a busy day; thus they ensure charging is done overnight or at work. The **lack of charging at convenient times/places** can be a barrier too – e.g., apartment dwellers who work nights might find their nearest charger is in use or a sketchy location late at night. Survey data highlight concerns like chargers being too far apart, stations feeling unsafe at night, or chargers being occupied (so you have to wait) [43] [44]. These issues cause behavioral adaptations: some drivers charge at non-peak times to avoid waiting (like going to a 24-hour station at 10 p.m. when it's empty), or they may choose a slightly out-of-the-way charger if it's more reliable/safer. **Pricing and payment hassles** are also barriers that affect usage – confusion over different networks' pricing models has left some drivers frustrated [45]. For instance, a driver might avoid a particular public charger known to be very expensive or one that only accepts a certain app/RFID they find annoying. On the flip side, some barriers like having to use multiple apps or RFID cards are gradually being addressed by initiatives like Plug-and-Charge (automatic authentication), but until that's widespread, drivers often carry a "charging wallet" of network cards and apps. To sum up, these barriers – fear of running low, insufficient or unreliable chargers, and the time it takes to charge – all influence driver behavior by making them plan more, charge earlier or more often, and gravitate towards reliable, convenient charging solutions. As infrastructure improves (both in coverage and reliability), we expect drivers will become even more confident and perhaps less conservative in their charging habits (e.g., willing to run down to low battery knowing a charger *will* be there and *will* work).

- **Price Sensitivity and Incentives:** EV drivers are generally quite cost-conscious about charging, since one of the touted benefits of EVs is cheaper fuel per mile. **Electricity pricing** thus influences behavior strongly. As discussed, time-of-use rates steer many to charge at night when electricity might cost, say, \$0.10/kWh instead of \$0.30/kWh during peak. Many utilities also offer special EV charging plans, and uptake is high – for example, in some California utilities a significant majority of EV owners have already moved to EV-specific TOU plans [32]. When on these plans, drivers exhibit *load shifting*: some studies note EV owners on TOU plans charge **83–92% off-peak** [33], which shows high compliance to the price signal. Drivers also respond to other incentives: **free charging** is a big one. If a workplace or mall offers free EV charging, lots of drivers will make use of it even if they don't strictly need a charge at that moment, because it's free. We see this at locations like some supermarkets or hotels that offer complimentary charging – EV drivers often plug in "because why not, it's free" and get a few extra kWh. There are also **utility demand-response programs** emerging,

where drivers get a small rebate for allowing the utility to manage their charging (throttle or delay it during peak events). Early participation is limited, but those in it will let their car charging pause for an hour or two if the grid is stressed, in exchange for a discount. **Public charging pricing** sensitivity also exists: many drivers will compare the cost of different stations (some networks charge per kWh, others per minute, etc.). They might favor a station that charges \$0.30/kWh over one that effectively costs \$0.50/kWh. However, convenience can trump this – a driver in need will pay the higher price if it's the only option. Still, the general sentiment as revealed in driver reviews is frustration with the "Wild West" of public charging pricing [46] [45]. The lack of consistent pricing or clear signage means some drivers feel "burned" by an expensive session and avoid that station later. On the positive side, **off-peak discounts** and special programs do alter behavior: for example, some public networks have lower prices at night or free charging sponsored by advertisers at certain times; drivers who know this might schedule their charge stop accordingly. A concrete data point: drivers are indeed willing to pay more for faster charging when in a hurry – over **50%** say they'd pay a premium for DC fast versus Level 2 if it saves time [41]. But they also appreciate **incentives** like discounted overnight rates or credits. Many states offer reduced tolls or HOV access for EVs, which indirectly saves drivers money/time and encourages EV use, but not directly charging behavior. One could say EV drivers have become *amateur energy economists*, timing and locating their charging to maximize value. They'll charge at home at \$0.10/kWh rather than pay \$0.35 at a public charger, unless they have to. And if their utility offers a super off-peak window (like midnight to 5 a.m.), you can bet many EVs start charging right at midnight. In summary, price signals *do* work with EV owners: they respond by shifting charging times and places to save on cost, and they are motivated by programs that reward such behavior.

- **Technology Adoption (Apps, Navigation, Payment Methods):** EV charging behavior is facilitated by technology – smartphone apps, in-car navigation, RFID cards, etc. **Most EV drivers use apps or in-car systems** to find and monitor chargers, though perhaps surprisingly few rely on them for *daily* charging needs. One research report noted that fewer than 5% of EV owners rely on smartphone apps to find charging stations for daily use [47]. This makes sense: daily charging is typically at home or a familiar work charger, so no app needed. However, for trip planning or when in unfamiliar areas, apps are indispensable. Popular apps include PlugShare (for crowdsourced info on stations), Electrify America's app, ChargePoint's app, etc., and automakers often have integrated systems (e.g., FordPass, Tesla's in-car map) to locate chargers. Tesla's integration is noteworthy: Tesla drivers have essentially all Superchargers mapped in their car and even routing that includes them, so they rarely need a separate app. Other EV drivers might use their car's built-in navigation which increasingly includes public charger locations (with filters for connector type, availability, etc. on some newer models). Payment methods have been a bit of a pain point – juggling multiple RFID cards or accounts. Many drivers end up with a "collection" of RFID fobs (for ChargePoint, Blink, etc.) or apps on their phone. The trend is moving towards simplification: **Plug-and-Charge** capability (where you just plug in and the car communicates with the station to handle billing) is being adopted on newer EVs and networks, which will eliminate the need for apps/cards at the moment of charging. But as of 2023, only some combinations (like Ford at Electrify America, etc.) have this, so most drivers still have to manually activate a charger. **Apps also provide real-time info** – drivers use them to check if a station is in use or functioning. Many have gotten into the habit of looking at the station status before driving there. If an app shows all chargers in use or one is down, a driver might choose a different location, thus dynamically adjusting their plan. **Navigation systems** in EVs are a big help too: e.g., many EVs will show your current state-of-charge and the range to various chargers on the map, aiding decisions. Tesla's system even preconditions the battery when navigating to a

Supercharger to optimize charging speed – a tech feature that directly influences behavior by automating part of it. **Community and information sharing** via technology is also prevalent: EV drivers often check reviews or PlugShare comments for tips (e.g., "Charger #2 has a faulty connector" or "the parking lot is closed after 10pm"). This crowdsourced info guides behavior, such as avoiding a known unreliable charger or bringing a specific adapter. Payment-wise, aside from network apps, an increasing number of public chargers accept contactless credit card or Apple/Google Pay, which some drivers prefer for simplicity. The proliferation of apps has been a bit burdensome, but most drivers quickly learn which ones they need for their region/travel. Interestingly, **vehicle brand can influence app usage**: as noted, Tesla owners might rarely use third-party apps because the ecosystem is integrated, whereas a Nissan Leaf or Chevy Bolt owner might rely on PlugShare plus their charging network apps frequently. In summary, EV drivers have eagerly adopted tech tools to streamline charging – from planning apps to payment solutions – and these tools significantly shape the charging experience (often making it smoother by providing information). The end goal many are hoping for is more seamless technology (one app or no app needed), but for now, being tech-savvy is almost part of being an EV driver.

- **Lifestyle Integration:** Perhaps the biggest shift that comes with driving an EV is integrating "refueling" into one's lifestyle differently than with gas cars. EV charging is more **integrated into daily routines** rather than a separate chore. Many EV owners love that they "never have to go to a gas station" – instead, they just plug in at home like charging a phone. This means their routine might involve plugging in the car every evening when they get home or every few days when convenient, rather than detouring to a station. EV drivers often multi-task during charging. For example, while charging at home overnight is essentially out-of-sight/out-of-mind, charging away from home is usually combined with another activity. Surveys have found that more than half of EV drivers use the time spent at a public charger to do something productive or enjoyable: getting a meal, shopping, running an errand, or relaxing [34] [30]. This **dwell time** integration is key – unlike pumping gas, which is a 5-minute chore you stand around for, charging 30+ minutes means drivers plan it around a coffee break, a lunch stop, catching up on email, or letting kids play at a park. As a result, businesses are noticing this captive time: malls and restaurants hosting chargers find that EV drivers are good customers who stick around. One example: a retail study found that offering free charging increased the time (and money) EV drivers spent in the store during the charging session [48]. On a daily lifestyle note, EV owners often schedule charging around their sleep or work schedules (charging when it least interferes with other activities). Many say it's liberating to **start each day with a "full tank"** from home charging, making the rest of the day simpler. For those who cannot charge at home, their lifestyle integration might involve a routine like "Tuesday and Friday evenings I stop at the fast charger for 20 minutes on the way home from work" – effectively treating it like going to the gym or another errand. Some have compared it to how people charge smartphones: not a big deal, you plug it in when you can and it's usually fine. Another lifestyle aspect is **travel habits**: EV road trips require a bit more planning, but many families have turned charging stops into part of the journey (snack breaks or sightseeing near charger locations). EV clubs and communities sometimes even gather at charging locations (for example, "Tesla meet-ups" at Superchargers where owners chat while charging). In essence, charging is becoming a normalized part of life – it happens in the background or alongside other tasks. One could argue EV drivers have more **flexibility** in *when* they "fuel" (since if you have a charger at home, you choose when to plug in), but less flexibility in *where* compared to gas (since not every corner has a fast charger yet). Over time, as infrastructure grows, the hope is that charging will fit even more seamlessly into everyday life (with ubiquitous workplace chargers, wireless charging pads in parking spots, etc.). Already, early

adopters report that after adjusting, they find the routine convenient: for example, in a Plug In America survey, over 90% of current EV owners said they're happy with their charging experience overall (despite frustrations with public chargers, they love the convenience of home charging) [49]. This indicates that charging has successfully woven into their lifestyle in a mostly positive way. To a new EV driver, the idea of plugging in might seem like a hassle, but soon it simply becomes another minor daily habit, much like plugging in your phone or checking your email – part of the modern routine.

Specific Data Points and Averages

To ensure realistic profiles for an EV battery health simulation, here are **key quantitative data points** on charging behavior drawn from recent studies and surveys:

- **Average Charging Frequency:** Most American EV drivers charge their vehicles either *daily* or *every couple of days*. One comprehensive report noted that EV owners tend to recharge **daily or once every two days**, typically overnight [20]. This translates to roughly **3–7 charging sessions per week** at a home or primary location, depending on individual use. Drivers who commute long distances or lack a large battery are on the higher end (plugging in every day), whereas those with longer-range EVs or shorter commutes might only charge after two or three days. It's worth noting that **weekly** public charging is common for some: about **31%** of EV drivers with home charging still use a public charger at least once a week (often to supplement or during travel) [50]. Meanwhile, those without home charging may plug into public stations almost daily out of necessity. For modeling purposes, a safe general assumption is an EV gets charged *5 to 7 times per week* (mostly at home), but this can drop to ~2–3 times per week for a long-range EV with light usage, or increase to near-daily including public top-ups for a heavy-use case.

- **Preferred Charging Speeds by Use Case:** Charging speed preference depends on context:

- **Home:** The majority of home charging is done on Level 2 (240V) units. About **74%** of surveyed EV owners use Level 2 home charging equipment, which delivers typically 7.2 kW (roughly 20–30 miles of range per hour) [13]. ~20% still use Level 1 (120V) at home [13], which is slow (~4–5 miles of range per hour) but can meet daily needs for lower-mileage drivers. Those using Level 1 are often drivers of shorter-range EVs or plug-in hybrids, or early adopters who haven't installed a 240V charger. Overall, EV owners *prefer* Level 2 at home for faster overnight replenishment – installing a Level 2 charger is one of the first upgrades many make after buying an EV.
- **Workplace:** Almost all workplace stations are Level 2, and this is generally sufficient since cars are parked for hours. Employees are content with ~6-7 kW charging at work which adds perhaps 40 miles during a typical stay. Workplace charging speed just needs to cover the commute distance; thus Level 2 is preferred (rarely would DC fast chargers be installed at workplaces, as it's overkill and costly – plus constant DC fast charging isn't ideal for battery longevity).
- **Public/Destination:** When out and about, if a driver is planning to do something for a while (dining, shopping, movie), they prefer **Level 2** chargers at those destinations so the car can *sip* charge during the stay. Preferred speed here is the standard 6-7 kW AC charger, which is common in public parking lots. As long as it's free or low-cost, drivers are happy to gain some range during their activity. They don't necessarily seek the fastest charger if they're going to be parked for a longer duration.
- **En-Route Fast Charging:** For highway stops or "in a hurry" scenarios, **DC Fast Charging** is the preference. Drivers generally look for the highest power available that their car can handle. Many

EVs today cap at 50–150 kW, while newer ones can take 250+ kW. A survey of North American EV drivers found that **27%** primarily use DC fast chargers for their charging needs (likely those without home charging or doing frequent long trips) [39] . Fast chargers (50 kW and above) are crucial for road trips – drivers will plan around getting to these. In practice, a 150 kW charger is considered a good baseline, and anything above that is a bonus (reducing session time). So for simulation, assume that for long-distance travel, drivers will seek ~100+ kW charging if possible; if not available, they'll use 50 kW but likely account for the longer wait.

- **Summary of Preferences:** *Level 1* is tolerated only at home (and only by a minority) due to its slowness. *Level 2* is the workhorse for home, work, and many public situations because it balances speed and battery friendliness. *DC Fast* is the choice for quick energy on the go – typically used when a driver needs a substantial charge in under an hour. There's also an emerging ultra-fast category (250–350 kW) which high-end EV drivers seek out to cut charging time to 15-20 minutes, but those stations are still rolling out. Overall, American EV drivers prefer the fastest practical option available *for the context*: slow-but-steady Level 2 when the car is parked for a while, and lightning-fast DC when they're trying to minimize downtime [19] .

- **Home Charging Adoption Rates and Equipment Types:** As mentioned, **approximately 90%** of current U.S. EV owners have access to home charging [18] , though this number is slowly declining as more apartment dwellers join the EV ranks. The breakdown of home charging equipment (from surveys of EV owners) is roughly:

- **Level 2 home charger:** ~70–75% (often a 240V wall-mounted unit or a portable EVSE plugged into a 240V outlet) [13] . These are typically 30–40 amp chargers delivering 7.2 to 9.6 kW. A few percent of these might be higher-power (e.g., Tesla Wall Connectors can do 11.5 kW if the circuit allows, but most home setups are 7.2 kW).
- **Level 1 home charging:** ~20–25% use regular 120V outlets exclusively at home [51] . This includes some who drive short ranges or initially try to avoid the expense of installing a charger. Interestingly, even some long-range EV owners rely on Level 1 if their daily driving is low – the Plug In America survey noted that not only plug-in hybrids, but also owners of Nissan Leaf, Chevy Bolt, Tesla Model 3, etc., were among those using only Level 1 at home [51] . (For example, ~28% of Leaf drivers in that survey managed with just Level 1 at home [52] .)
- **Both Level 1 and 2:** A small fraction (~6%) reported having access to both at home [13] – perhaps meaning they have a Level 2 charger but also use a 120V in another location or for a second EV.
- **Smart Chargers vs Dumb:** Many home Level 2 units are "smart" (WiFi connected, app-enabled) but some are basic. Drivers who want to schedule charging or track energy often get smart chargers or use the car's built-in scheduler. No precise percentage readily available, but anecdotal evidence suggests a large portion of newer EV buyers are installing internet-connected chargers that can respond to utility signals or at least be monitored.
- **Home Charging Usage:** On average, EV owners with home charging do about **70-80%** of all their charging at home [20] . They typically plug in at home for slow overnight charge and rarely completely fill up elsewhere unless needed. Home charging sessions often replenish 30-60% of the battery (for example, from 40% up to 90%) depending on daily usage.
- It's also noteworthy that home charging **adoption** is near 90% for single-family households, but only ~55% for multi-family as of 2023 [53] . So, in an overall EV population that still skews toward homeowners, we see the high overall home charging rate; but future scenarios expect that number to drop as more renters/apartment residents get EVs (projected maybe ~75-80% overall by late decade).

- For the simulation's purposes, assume a high likelihood the user has Level 2 at home if they are a homeowner (with ~7 kW typical power), whereas an apartment dweller profile might have zero home charging and rely on other methods.

- **Public Charging Session Duration and Frequency:** Public charging sessions vary by charger type:

- **DC Fast Charging Sessions:** Typically last around 20 to 40 minutes. Most EVs can get from ~20% to ~80% in about 30 minutes on a high-power fast charger. Indeed, EV drivers polled expect to spend **30 minutes to an hour** at a fast charger in general [30], with many aiming for the shorter end of that range. Real-world data: if a driver is on a road trip, they might stop for 25-30 minutes for a charge, which is often synced with a restroom break or snack (and as noted, 60% use that time to eat, etc. [34]). Some fast charge sessions are shorter "splash and dash" ones – e.g., a 10-minute charge to get an extra 50 miles to safely reach home. Others could be longer if the driver chooses to charge to 100%, but that's relatively inefficient and thus less common. For simulation, consider ~30 minutes as a typical DCFC session when needed, perhaps once in a while for a given driver (unless they rely on DC regularly).
- **Public Level 2 Sessions:** These can range from 1 to 4+ hours, depending on context. For example, workplace or park-and-ride chargers might have a car plugged in for 4-8 hours (entire workday), whereas a shopping center Level 2 might see usage for 1-2 hours during a customer visit. If someone without home charging uses a public Level 2 overnight (say at an apartment complex lot or public garage), they might be plugged in for 8+ hours. But effectively, the *charging* might finish earlier; it's the parking duration that defines session length. Many public L2 sessions in urban areas are around 2 hours (often there are time limits or fees that encourage moving after a couple hours).
- **Frequency of Public Charging:** The need for public charging ranges widely. Surveys indicate that among EV owners in general, **about half use public charging at least monthly** [19]. A subset uses it very frequently: one study (ChargeLab via GreenCarReports) found ~31% of EV drivers use a public charger a few times a week, and ~23% use one "most days" [54]. Those likely correspond to the group without home charging or doing commercial driving. On the other end, about 25-30% of EV owners said they *never* use public charging (likely those with reliable home charging and rarely taking long trips) [26].
- Given the mix, a realistic profile might be: a typical EV owner primarily charges at home but might use a public DC fast charger a couple of times per month (say on road trips or if they were low and out doing errands) and use a public Level 2 occasionally when conveniently available. Meanwhile, an EV owner with no home charger might fast-charge 1-2 times per week and supplement with some Level 2 at work or around town regularly.
- **Session Energy Dispensed:** A DCFC session (~30 min) usually gives on the order of 100 – 200 miles of range (depending on charger power and vehicle). A public Level 2 session of 2 hours might give ~40 miles. These figures align with what drivers seek: just enough to get where they're going next or to fill up while they themselves do something else.
- **Behavior during sessions:** As mentioned, people don't typically sit idle – they plan their time. If modeling driver behavior, one could incorporate that public charging often coincides with meal times (noon, dinner) or activities, which indirectly influences when they choose to charge.

- **Idle/Unplug behavior:** Many networks charge idle fees if you leave the car after it's done charging, so drivers try to return to the car when charge is complete. But sometimes people do leave cars at chargers longer than necessary (especially free chargers), which is a known issue. In any case, from the battery perspective, the charging stops when done, even if the car stays plugged physically.

- **Battery State-of-Charge Management Patterns:** EV drivers are developing consistent habits around how full to charge and how low they let the battery go:

- **Target Maximum SoC:** For daily use, many drivers target about 80% charge. This is often recommended by manufacturers to extend battery life (e.g., Tesla and others often default to ~80-90% unless you override for a trip). So a lot of drivers will routinely charge to 80% each night. Some go to 90% if they expect to use more range the next day. Only when needed do they charge to 100%. Therefore, a realistic pattern is: daily target ~80-90%, with occasional 100% (before a long trip or if they know they'll need the full range). In contrast, a few drivers, especially those with shorter-range EVs, might top to 100% more regularly to get every mile – but even they might not do so if it significantly slows their charging (since the last 10-20% takes longer).
- **Minimum SoC (Comfort Zone):** Most drivers have an informal "bottom threshold" they try not to go below. From anecdotal and survey data, common thresholds are 10-20%. For instance, a driver might say "I usually charge when I get down to about 20%." The New Zealand survey (likely indicative of general behavior) found *most* people charge when under 50%, but that means anywhere between 50 down to, say, 10% [38]. Only 4% always keep it nearly full (meaning 96% allow the battery to drop well below full) [38]. This suggests a lot of drivers are comfortable driving until the battery is half or less. However, relatively few push it to near-zero routinely; many will start feeling the need to charge as it approaches 15-20%. There are drivers who test their limits, but on average we don't often hear of people arriving at chargers with under 5% except perhaps on planned long trips.
- **Average SoC on Arrival at Charger:** A proxy from fast charger data is that drivers often arrive around 20% and charge up to ~80%. Recurrent (a battery analytics firm) in analyzing EV data noted that in cold weather drivers charged sooner (not letting it drop as low) [23]. In moderate conditions, some might take it down to 10%. It varies, but for modeling, you could assume an average driver plugs in around 20-30% remaining when they do a deliberate charge (not counting opportunistic top-offs).
- **SoC Cycling Frequency:** If someone charges daily to ~80% and uses, say, 30% of the battery per day, then they cycle between 80% and 50% daily. If they charge every two days and use 60% in that time, they might cycle 80% to 20%. Each driver's pattern might differ – a commuter might do 100% to 50% every day if they drive a lot; a light user might oscillate between 60% and 40% if they only charge once a week.
- **Range Buffer:** Many EV drivers like to keep a buffer of some miles "just in case." This often translates to that minimum SoC – e.g., keeping at least 30 miles (~10%) in the tank. As range anxiety eases, some shrink their buffer, but most still have something.
- So in practical terms: For **battery health**, the model could incorporate that many users habitually charge to ~80% and discharge to ~20% on a regular basis, which is actually a healthy cycling range. When needed (long trips), they will charge to 100% and maybe go down to 5-10%, but that's occasional. These patterns align with advice to avoid deep discharges and prolonged full charges.

- **Example Pattern:** A typical EV owner might say: "I charge to 90% for my daily driving, and I usually don't let it go below 20%. If I'm going on a road trip, I'll charge to 100% before I leave, and on the road I'll stop when I get down to about 15% and charge up to ~80% at each stop." This encapsulates what many do.

- **Response to Pricing Incentives:** EV drivers have shown significant responsiveness to pricing and incentives, which is important for realistic modeling:

- **Off-Peak Charging:** As noted, when offered lower rates at night, a large portion of EV owners shift their charging. For example, if off-peak is 9pm-7am, many will program their charger to start at 9 or 10pm. In California's analysis, assuming 75% on TOU with primarily off-peak charging is quite realistic [32]. So one can say a typical EV owner on a TOU plan charges ~80-90% of their energy off-peak. If not on TOU (flat rate), they might just plug in after getting home anyway, which could be early evening – but increasingly utilities are defaulting EV users into TOU.
- **Demand Response Programs:** Some utilities have pilot programs where they can pause charging for short intervals during peak grid times, or where EV owners get a lower rate but the utility controls the charging window. Participation rates aren't huge yet (these are new programs), but where available, many tech-savvy EV owners join to save money. For example, a utility might offer: "We'll give you \$50 at end of year if you allow us to occasionally stop your charging for up to 1 hour during peak events." Many EV owners find that acceptable because they usually charge with plenty of time overnight.
- **Free/Public Incentives:** When chargers are free (often subsidized by cities or businesses), they may become very popular. We have anecdotal evidence like free fast chargers in a city getting queues of users. Conversely, introducing a fee at previously free stations often dramatically reduces usage (people then only use it if they need). So EV drivers are quite price-sensitive in that sense: they prefer free or cheap options, and will adjust routines to take advantage of them within reason.
- **Time-of-Use Awareness:** Many drivers actively monitor utility rate schedules. For instance, in forums you'll see EV owners comparing how much they saved by charging at super off-peak. This indicates many treat it almost like "fuel points" to optimize.
- **Overall Impact:** The net effect is that pricing incentives are effective – drivers do respond by shifting time of charge and selecting charging locations based on cost. This is beneficial for grid load management and for the driver's wallet. As more dynamic pricing (like charging more during 4-9pm) comes into play, we can expect even stronger avoidance of those expensive times by EV users.
- **Statistics:** From the Synapse Energy report on California: EV customers on TOU plans charge **outside of peak hours 83%–92% of the time** [33]. That's a quantifiable response to incentive. Also, when given options, drivers show willingness to pay more for speed (thus not purely cost-minimizers) but if speed is equal, they'll choose the cheaper station or time.
- For simulation, one could incorporate that a certain percentage of users strictly charge off-peak (if they have control) and maybe a small percent don't bother (maybe they have flat rate or are less price-sensitive). Perhaps 75-80% off-peak, 20-25% mixed charging times (some of which might be forced by schedule).
- **Incentive Programs:** Also note things like "EV nights free" promotions (some utilities have tried giving free charging after midnight). Those cause spikes exactly at midnight as EVs plug in or start then. So incentives can lead to somewhat synchronized behavior patterns among drivers.

Each of these data-driven insights helps paint a comprehensive picture: American EV drivers predominantly charge at home (especially overnight), topping up frequently (daily or a few times a week) to keep their batteries in a comfortable range, while also utilizing faster public charging when convenience or travel needs dictate. They adjust their habits based on region, season, and personal circumstances, all with an eye toward balancing convenience, cost, and range confidence. The above figures and trends should enable a battery health simulation to use realistic charging profiles that mirror what real drivers are doing – rather than idealized assumptions – ensuring the simulation reflects true American EV usage patterns circa 2024.

Sources: Recent surveys and studies on U.S. EV owner charging behavior, including the Plug In America 2023 EV Driver Survey [18] [13], research by the International Council on Clean Transportation [12] [55], the Joint Office of Energy and Transportation's reports [16], the Transportation Energy Institute's consumer

behavior analysis [20] [41], and large-sample driver surveys by charging network providers (e.g., FLO's 2024 survey of 40,000 EV drivers [19] [56]). These sources provide quantitative backing for the patterns described above, from the predominance of home charging and overnight habits to the nuances of public charging usage and drivers' adaptive strategies in response to infrastructure and pricing.

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[1] [6] [8] [9] [35] [36] [43] [44] [45] [46] The state of EV charging in America: Harvard research shows chargers 78% reliable and pricing like the 'Wild West' | Institute for Business in Global Society
https://www.hbs.edu/bigs/the-state-of-ev-charging-in-america

[2] Rural vs. Urban: How Urbanicity Shapes Electric Vehicle Charging ...
https://doaj.org/article/c7bda99bc76c430c8f4069cf39b7a406

[3] Rural vs. Urban: How Urbanicity Shapes Electric Vehicle Charging ...
https://www.researchgate.net/publication/387693217_Rural_vs_Urban_How_Urbanicity_Shapes_Electric_Vehicle_Charging_Behavior_in_Rhode_Island

[4] [5] [7] [13] [18] [25] [26] [27] [40] [42] [51] [52] pluginamerica.org
https://pluginamerica.org/wp-content/uploads/2023/05/2023-EV-Survey-Final.pdf

[10] [29] 80% of US EV Drivers Say Public Charging Reliability Has Improved
https://evinfo.net/2025/06/80-of-us-ev-drivers-say-public-charging-reliability-has-improved-according-to-shell-survey/

[11] [16] [17] Community Charging: Emerging Multifamily, Curbside, and Multimodal Practices
https://driveelectric.gov/files/community-emobility-charging.pdf

[12] [14] [53] [55] theicct.org
https://theicct.org/wp-content/uploads/2024/03/ID-89-%E2%80%93-Chargers-2032_final-v2.pdf

[15] [19] [34] [39] [56] Survey Says: Most EV Drivers Rely on Fast Chargers for Long Trips | FLO
https://www.flo.com/news/survey-says-most-ev-drivers-rely-on-fast-chargers-for-long-trips-use-onsite-amenities-while-charging/

[20] [30] [31] [41] [47] [48] transportationenergy.org
https://www.transportationenergy.org/wp-content/uploads/2022/11/21FI_-EVC_ConsumerBehaviorReport_V07-FINAL.pdf

[21] [22] [23] [24] EV Drivers Adjust Behavior To Deal With Winter Range Issues: Study
https://insideevs.com/news/627510/electric-car-drivers-adjust-behavior-winter-range/

[28] Charging patterns and motives of electric vehicle drivers
https://www.sciencedirect.com/science/article/pii/S2214367X25001127

[32] [33] synapse-energy.com
https://www.synapse-energy.com/sites/default/files/EV%20Impacts%20December%202022.pdf

[37] EV battery charging best practices | FLO
https://www.flo.com/insights/ev-battery-charging-best-practices-the-20-80-rule-for-batteries/

[38] eeca.govt.nz
https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/Electric-Vehicle-Charging-Survey.pdf

[49] GM Says 90 Percent Of EV Users Charge At Home Or Work
https://gmauthority.com/blog/2022/09/gm-says-90-percent-of-ev-users-charge-at-home-or-work/

[50] [54] 3 of 5 EV drivers with home charging use public chargers weekly
https://www.greencarreports.com/news/1142479_ev-drivers-home-charging-use-public-chargers-weekly