

Anderson Economic Group EV Transition Series: Report No. 1

Comparison: Real World Cost of Fueling EVs and ICE Vehicles

Electric vehicles can be more expensive to fuel than their internal combustion engine counterparts

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Purpose

A MAJOR TRANSITION, WITH SIGNIFICANT RISKS

The automobile industry is on the cusp of the biggest transition in fundamental technology since the earliest days of the industry. A century ago, gasoline-powered vehicles won the technology race of the era against competitors that included electric, steam, and horse-powered carriages. Today, electric vehicles are ascendant.

This transition poses significant risks and uncertainties. For consumers, one of the biggest is the cost to drive electric vehicles (EV) compared to their familiar internal combustion engine (ICE) counterparts. If customers find the true cost of EVs to be lower than for ICE vehicles, we can expect rapid adoption. On the other hand, if EVs cost *more* to drive and to own, that transition is likely to be much slower.

COMPARING THE TRUE COST OF FUELING EV AND ICE VEHICLES

The cost to fuel a vehicle, ICE or electric, is a substantial part of the total cost of ownership. Thus, a realistic examination of these costs is a critical question for consumers who are considering the move to EV.

To address this question, Anderson Economic Group conducted a rigorous analysis of the real-world costs to fuel both types of vehicles. We included all categories of costs, including several that are commonly omitted in other EV studies.

Multiple Categories of Costs

EVs are often presumed to be less expensive to fuel than their ICE counterparts. There is a rationale in physics for this: due to greater thermal efficiency, electric motors convert energy more efficiently than combustion engines. However, this cost is only one of five. For a complete picture, we must consider:

1. Commercial and residential electric power/fuel costs.
2. Registration taxes.
3. Equipment (e.g., chargers) and installation costs.
4. Deadhead miles incurred driving to a charger or fueling station.
5. The cost of time spent refueling.

Our analysis compares these costs for EVs and ICE vehicles, noting that some ICE vehicle expenses are bundled into the retail price of gasoline. We

provide a separate accounting of the direct monetary costs and time burdens for both sets of vehicles to generate a true apples-to-apples comparison.

Multiple Sources and Original Research

Anderson Economic Group has over two decades of experience in the automotive industry, including work for manufacturers and distributors, suppliers, trade associations, and automobile dealers. We make use of that expertise in the careful methodology we have followed in this analysis. Hallmarks of that methodology include separating vehicles into specific segments depending on cost and use, as well as recognizing the difference between rural and metropolitan geographic areas.

Unlike many other analyses on this topic, we make use of data sources that cover the range of consumer experiences and cost burdens for drivers. These extend well beyond government data on fuel economy and electricity prices, and include:

- Stopwatch measurements of the time required to refuel EVs and ICE vehicles.
- Recorded customer experiences regarding charger reliability, actual charging time, and actual costs.
- Consumer reports from EV drivers, including those posted on forums for Taycan and Tesla drivers; Reddit; and applications serving EV drivers such as PlugShare and ChargePoint.
- Tax laws that impose registration taxes on EV owners to fund road construction and maintenance.
- Auto industry data including segments, purchase prices, and other metrics.
- Actual driving and fueling experience in an EV covering multiple states, and a range of commercial charging as well as residential charging experiences.

In this publication, readers are presented with original research, data sources, and calculations that represent costs as of mid-2021. Because the industry and associated technologies are changing, these estimates should be viewed as a snapshot of comparable expenses at the time of this writing.

OUTLINE OF THE REPORT

This report proceeds as follows:

- Section one presents findings from our analysis,
- Section two describes additional costs associated with charging EVs, and
- Section three presents our methodology, along with direct monetary and time cost calculations.

THE ANDERSON ECONOMIC GROUP EV TRANSITION SERIES

This is Anderson Economic Group's first report in a series of analyses on the EV transition. Future reports will cover:

- Likely migration to EVs by consumer cohort, based on model, actual costs, and consumer preferences.
- Detailed, segment-specific projections.
- Comparisons of specific makes and models.
- Key target consumers.
- Factors affecting consumer adoption of EVs, and how these may change over time.
- Geographical analyses of charging infrastructure and costs in different areas.
- State and federal policy, including subsidies and restrictions regarding ICE and EVs.

For more information about Anderson Economic Group, please see "About Anderson Economic Group" on page 34.

Subscribing to the EV Transition Series

Anderson Economic Group is making this first installment available to the public at no charge. Certain analyses and detailed projections will be available by subscription only. For further information, contact Alston D'Souza at adsouza@andersoneconomicgroup.com or (517) 333-6984.

1. Key Findings

Our analysis of the refueling costs of vehicles indicate the following:

1. MULTIPLE CATEGORIES OF COSTS

1. *Fueling comparisons between EVs and ICE vehicles must account for all costs.* The cost of fueling EVs and ICE vehicles include the cost of fuel (or electricity), as well as the cost of pump or charger, and road taxes levied on drivers. Most of these are bundled into the retail price of gasoline for ICE vehicles. The comparable cost of fueling an EV include the following five categories:

1. *Commercial and residential electric power costs:* Commercial chargers often impose per kWh fees that are double or triple that of residential electric power costs.¹
2. *EV registration taxes:* In many states, EV drivers need to pay additional auto registration taxes for the construction and maintenance of roads.
3. *Cost of chargers and their installation:* EV buyers typically receive a Level 1 (L1) charger along with their auto purchase. These typically use a standard home electrical outlet and provide only a trickle charge for an EV. Sellers of EVs typically encourage the purchase of an optional Level 2 (L2) charger. Many owners that rely primarily on home-charging, purchase and install an L2 charger that uses a special electrical circuit.²
4. *Deadhead miles:* EV drivers incur costs of driving miles to a commercial charger for the sole purpose of charging. By comparison, there are over 100,000 gas stations in the US.
5. *Time costs of charging:* EV drivers also spend significant time finding and driving to a commercial charger, setting up the charger, and waiting for the charging process to complete. By comparison, finding a gas station and refueling the vehicle is relatively quick.

Typically, studies that compare the costs of driving EVs and ICE cars

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1. These costs also include session fee, network subscription costs and charging efficiency losses (defined as a fraction of power delivered to the EV battery to the power transmitted by the charger).
 2. Installation of an L2 charger often necessitates a home-renovation project. We estimate that installing a 240V power outlet with circuit breaker, and purchasing a home L2 charger costs about \$1600. See “Step 2: Calculating direct fuel cost per year” on page 24.

systematically underestimate the costs of driving EVs. For details, see “Comparison With Other Reports on EV Fueling Costs” on page 20.

We compare the categories of fueling costs for ICE and EV cars in Table 1.

TABLE 1. Comparison of EV and ICE Fueling Costs

EV	ICE
Direct Monetary Costs	
Commercial kWh rate, session charges, charging efficiency loss	Included in the retail price of gasoline/diesel fuel
EV highway registration taxes	
Cost of charger and installation	
Deadhead miles	Deadhead miles (very small)
Time Costs	
Time to connect and disconnect a charger, sync mobile app with charger and make payment, and wait for the charging process to complete (a)	Time to connect and disconnect a gas pump, sync mobile app (for some users), make payment, and wait for the gas to fill
Frequent trips to a commercial charger	Less frequent trips to a gas station
Additional time required due to charger breakdowns, and software and mobile app sync issues, which are common with EV chargers	Small number of interruptions at gas stations, which are very reliable

Source: Anderson Economic Group (2021) research.

Note: (a) We included a time cost for the charging process to complete only at commercial chargers. There was no additional time included beyond a short set-up and disconnection for residential chargers.

2. EVS OFTEN COST MORE TO FUEL

2. *The direct monetary costs of fueling EVs is often higher than for comparable ICE vehicles.* We analyzed the direct monetary costs of fueling for six categories of representative vehicles. We included all the direct monetary costs listed in Table 1 for both ICE and EVs. Our analysis included the following steps:

- Our representative vehicles included EV and ICE cars in the entry-level, mid-priced and luxury segments.³
- We recognize that EV drivers choose between home and commercial chargers depending on their driving patterns, infrastructure availability and other individual circumstances. Therefore, we assumed some EV owners primarily use home chargers while others rely primarily on commercial chargers.
- We used the retail price of gasoline, which is inclusive of road taxes and the cost of operating the pump. We compared this with the cost of electricity at commercial and residential chargers, and the additional registration taxes levied in lieu of gas taxes on EVs. This is as close as possible to an apples-to-apples comparison.
- We also accounted for the burden of deadhead miles for EVs, which is significantly higher than for ICE cars.

Once these costs were included, we calculate that EVs often cost more to fuel than similar ICE vehicles.

For the example set in Michigan, the direct monetary costs to drive 100 miles in an ICE vehicle is between \$8 and \$12, and in an EV is between \$12 and \$15. A summary of this direct monetary cost comparison is in Table 2 on page 9.

3. For segment information, please refer to “Methodology” on page 22 of this report.

TABLE 2. Direct Monetary Costs of Fueling EVs and ICE Cars

	Entry ICE <i>Commercial fueling</i>	Mid-Priced ICE <i>Commercial fueling</i>	Luxury ICE <i>Commercial fueling</i>	Mid-Priced EV <i>Mostly Commercial Charging</i>	Luxury EV <i>Mostly Commercial Charging</i>	Luxury EV <i>Mostly Home Charging</i>
Per Year for 12,000 miles	\$1,030	\$1,030	\$1,512	\$1,554	\$1,862	\$1,698
Per 100 Miles	\$8.58	\$8.58	\$12.60	\$12.95	\$15.52	\$14.15

Note: (a) Direct Monetary Costs for ICE and EV vehicles refer to the first four categories of costs in Table 1, “Comparison of EV and ICE Fueling Costs,” on page 7. This includes the cost of fuel/electricity, cost of charger, registration or gasoline taxes, and deadhead miles.

(b) Costs are estimated for mid-year 2021.

For calculations and assumptions, refer to Table 5, “Direct Monetary Costs of Fueling ICE and EVs as of Mid 2021,” on page 27.

3. EV FUELING COSTS VARY WIDELY

3. *Fueling costs vary much more for EVs than for ICE vehicles.* Our analysis, which takes into account commercial and residential rates, produces another surprising result: fueling costs for EVs vary much more than ICE vehicles. This is caused by multiple factors.
- Hugely varying electric power costs. Commercial charger rates are often double or triple that of residential rates. Even residential rates often change 50% or more due to Time-of-Use (ToU) rates. By comparison, gas prices vary by about 10% or less.
 - Charging speed that varies with the type of charger, level of charge in the battery, temperature, and working status of the charger.
 - Pricing at commercial chargers that include a combination of per kWh, per unit time, and per session costs. This produces charging costs that vary considerably when calculated on a per kWh basis.

TABLE 3. Varying Costs of EV Commercial Chargers

Residential costs	15¢ - 25¢ per kWh “time of use” rates and charging efficiency loss can cause this to vary significantly
Commercial costs (a)	30¢ - 43¢ per kWh 33¢ - 66¢ per kWh with session time charges (b)
Charging efficiency (c)	85-95%

Sources: AEG market research (2021) at ChargePoint, Electrify America, Greenlots, and EVgo stations; rates shown on PlugShare, ChargePoint, and Greenlots apps as of Jan-Aug 2021.

Notes: (a) These prices are from a sample in the Midwest region, and are setup by a local entity (often the owner of the charging station) that is different from the charging network.

(b) “Session time” refers to a fixed fee for every charging session at a commercial charger that is separate from the kWh rate. Our calculations presume that each “session fee” is associated with one charging session. This implies, a short charging session can cost over \$1.00 per kWh.

(c) Charging efficiency refers to the fraction of power delivered to the EV battery from the power transmitted by the charger.

4. EVS IMPOSE CONSIDERABLE TIME BURDENS

4. *Finding reliable commercial fast chargers, and waiting for EVs to charge, impose significant time costs on drivers.* Even under ideal conditions, it takes substantially longer to fuel EVs than for comparable ICE cars. Real world conditions often impose additional burdens, including these two:

1. *Driving and charging time:* We estimate that for a typical EV driver in a non-rural area, it often takes about 20 minutes to drive to a reliable DC fast charger. It often takes another 20 to 30 minutes for the charging process to complete.

Of course, this is for fast DC chargers. Slower L2 chargers are much more common, but charging at these can take multiple hours. Of course, this will vary considerably depending on the resident location of the driver, and their use of the vehicle.

2. *Recurrent reliability problems:* EV drivers face recurring problems at chargers such as breakdowns, software bugs, delays in syncing the mobile application with the charger, charger output being significantly lower than advertised, and outright failures.⁴ This is in addition to the problem of vehicles blocking (or “icing”) EV charging spots.⁵

Online forums are full of comments from drivers expressing frustration about these problems.⁶ Moreover, our first-hand experience confirms the existence of these problems.⁷

For the infrastructure available as of the mid-2021 in metropolitan areas of the US, we estimate that typical time costs for EV drivers are about five to ten times that of comparable ICE drivers.

4. As indicated in the detailed calculations below, we include a modest allowance of time for a charging problem about once every twenty visits to a commercial charger. See “Step 1: Calculating hours spent on fueling per month” on page 28.

As for the driving time costs, for some drivers, this will be a substantial underestimate; for others, it will be an overestimate.

5. While the “iced” verb for this action is obviously related to drivers of ICE vehicles that block EV chargers, another common problem is the blocking of EV charger spaces by EVs that are no longer charging.

ESTIMATING IMPLICIT TIME COSTS

Estimating implicit time costs is an inherently subjective process. We include it only as a reference to quantify the time spent on refueling. For more details, please see “Implicit Pricing of Time Cost” on page 20 and “Separating Direct Monetary Costs from Implicit Time Costs” on page 21.

Implicit Time Costs at Two Reference Rates

Using relatively modest assumptions, we can estimate an implicit time cost for both EVs and ICE vehicles. We provide two reference cost per hour rates to calculate the time cost:

1. *Minimum hourly wage*: At this rate, the time cost for an EV driver can be equivalent to about \$50 a month or more, but less than \$10 for an ICE driver.
2. *Hourly wage at a \$70,000 annual salary*: The commensurate hourly wage for an individual making \$70,000 annually is about \$33. This implies a time cost of around \$200 per month for an EV driver, but \$33 for an ICE driver.

A summary of this implicit time cost comparison in Table 4 on page 13. For motivation on these rates, sources, and description of calculations, please see “Implicit Pricing of Time Cost” on page 20.

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6. For example, *PlugShare* (an online EV charging map) includes a “reliability rating” for each charging station that highlights the recent working condition of the charger, and asks users to click an icon that indicates that the charger did or did not work, as well as report the highest charging speed achieved. A review of these confirms the recurring reliability issues with commercial chargers, as well as differences in the consumer-reported reliability of different applications and different networks.

Recently, Ford Motor Company announced they would pay for “charging angels” who would drive around to check on EV chargers and fix non-working chargers. This is an implicit confirmation of the reliability problem. See Ramsey (2021).

7. Motivated readers with access to these forums can find numerous entries from the authors on charging speed, whether the charger was blocked, whether it was working, and in some cases whether it took multiple attempts to get a charger to work.

TABLE 4. Implicit Time Cost Comparison

	Entry ICE <i>Commercial fueling</i>	Mid-Priced ICE <i>Commercial fueling</i>	Luxury ICE <i>Commercial fueling</i>	Mid-Priced EV <i>Mostly Commercial Charging</i>	Luxury EV <i>Mostly Commercial Charging</i>	Luxury EV <i>Mostly Home Charging</i>
Typical hours spent on fuel- ing per month	1 or less	1 or less	1 or less	7	5.75	4.5
Implied time costs per month (at minimum wage)	\$9.65 or less	\$9.65 or less	\$9.65 or less	\$67.55	\$55.49	\$43.43
<i>Memo: Implied time costs per month (at hourly wage rate of \$33)</i>	<i>\$33 or less</i>	<i>\$33 or less</i>	<i>\$33 or less</i>	<i>\$231.00</i>	<i>\$189.75</i>	<i>\$148.50</i>

Source: Anderson Economic Group (2021) Research.

Note: Time Costs for ICE and EV vehicles refer to the three categories of time costs in Table 1, “Comparison of EV and ICE Fueling Costs,” on page 7. These include charging time at a commercial charger, or to set up and disconnect a residential charger; trips to a commercial charger or a gas station, and additional time required due to occasional unreliability of EV chargers. The charging time at residential chargers is not included.

For calculations and assumptions, refer to Table 6, “Estimation of Implicit Time Burden as of Mid-2021,” on page 30 and “Estimation of Implicit Time Cost as of Mid-2021” on page 31.

See also “Implicit Pricing of Time Cost” on page 20, and “Separating Direct Monetary Costs from Implicit Time Costs” on page 21 on the inherently subjective nature of calculating time costs.

2. Unpacking the Cost of EV Charging

Vehicle owners are quite familiar with the cost of driving an ICE car. Organizations such as the American Automobile Association (AAA) have calculated costs of ICE vehicle operation for decades, and the IRS annually revises a safe-harbor figure on reimbursement for driving expenses.⁸ Fueling is a major component of these costs.

Fueling charges for ICE vehicles include the cost of refined gasoline or diesel fuel, state and federal excise taxes that fund road maintenance, and state sales taxes. All are bundled into the retail price of gasoline (or diesel fuel) at commercial gasoline stations in the United States.

To calculate the true cost of fueling EVs, we must include the same expense categories. Because they are not bundled as they are for ICE vehicles, we must account for each separately based on the four categories of direct monetary costs (below).

Direct Monetary Costs of Charging Electric Vehicles:

1. *Commercial and residential electric power costs.* Consumers can charge their vehicles at both residential and commercial chargers. As we describe further below, fueling time and fueling costs vary considerably among commercial and residential chargers. They also vary based on different charging speeds, and for different types of chargers.

8. AAA figures are intended to approximate the total cost of owning a vehicle, expressed as a per-mile figure, for automobiles that are regularly driven and maintained. IRS figures are intended to limit driver deductions for business and charitable purposes. As such, they should not be considered estimates of the total cost of car ownership.

AAA-published ownership costs for 2021:

- 83¢ for 10,000 annual miles.
- 64¢ for 15,000 annual miles.
- 55¢ for 20,000 annual miles.

IRS-issued standard mileage rates for 2021:

- 56¢ for business driven vehicles.
- 16¢ for medical driven vehicles.
- 14¢ for charitable organization driven vehicles.

See AAA (2021) and Internal Revenue Service (2021). These and other sources are listed in “References” on page 32.

Our analysis estimates the costs of residential and commercial charging separately. For home charging, we assume residential rates (including “time of use” rates for some homes). For commercial charging, we calculate a cost that represents the sum of per-kWh charges, subscription fees, per unit time, and per session costs.

Charging and discharging a battery involves energy losses in the form of heat. These are captured in the “charging efficiency” fraction, which we apply to both residential and commercial charging.⁹

In general, commercial charging costs are much higher than residential, although the cost of the charger itself must be added to the total cost of residential charging. We include this expense as a separate category for those who rely upon home charging. We assume the cost of a home charger is spread over multiple years.

2. *EV registration taxes.* The retail price of gasoline includes excise taxes to build and maintain roads. The retail cost of electricity does not. As a result, some states have imposed additional registration taxes on EVs to ensure that EV drivers pay a road tax burden that is (at least roughly) similar to that of ICE vehicle drivers.

Michigan, for example, levies an additional registration cost between \$135 and \$235 for most electric vehicles. California levies about \$100, while Texas is considering a fee between \$190 to \$400. Some states are considering a fee up to \$1,000.¹⁰ As EV sales increase, we expect every state to impose some kind of road usage fee or charge for EV drivers.

3. *Cost of chargers and their installation.* The retail gasoline price includes the cost of operating a commercial gas pump. Similarly, the retail electricity charge levied by commercial EV chargers includes the cost of the commercial charger. However, the cost of installing and operating a home charger must be added to the residential cost of electricity.
4. *Deadhead miles.* Poor EV charging infrastructure in the United States means drivers typically expend “deadhead miles” to get to a fast DC charger.¹¹ By comparison, most metropolitan-area ICE vehicle drivers (and many rural drivers) have ready access to one or more convenient gasoline stations.

9. See the discussion and references related to charging efficiency under “Calculating Direct Monetary Costs of Refueling” on page 24

10. See also “Calculating Direct Monetary Costs of Refueling” on page 24.

For our real-world cost comparison, we looked at geographic analysis of fast DC charger locations, utilized EV driver reports on forums, and relied upon the authors' EV driving experience to estimate the additional driving required to refuel an EV.

Note on “Free” Chargers. Some municipalities, colleges, and businesses offer “free” charging for a limited amount of time in specific places. These services are often combined with parking, offered as a convenience to shoppers, or provided as a benefit to employees or visitors. We recognize that these involve a cost that must be paid, and which may be embedded in property taxes, tuition, consumer prices, or investor burdens. We price them here using commercial rates.

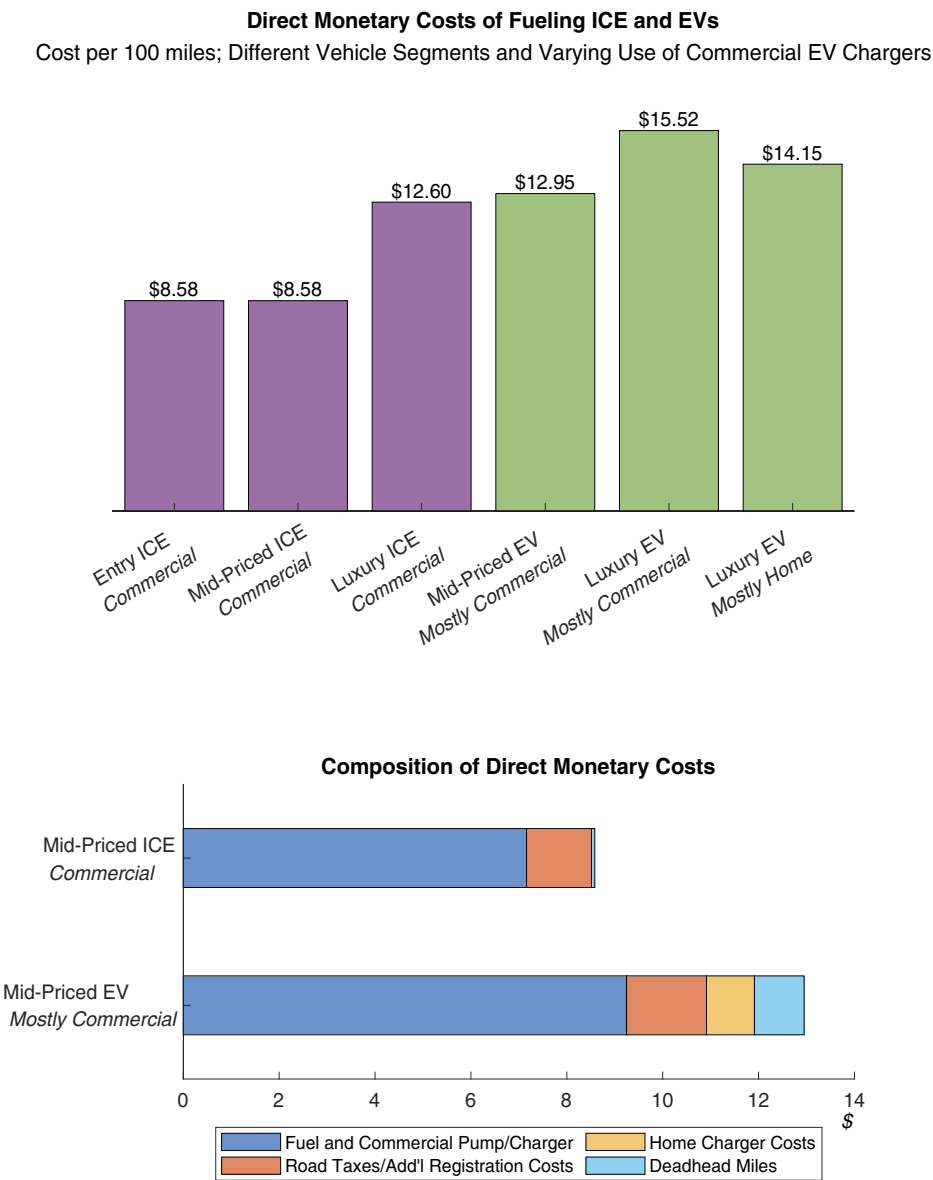
Note on Bundled Charging Services. A common practice in the current market is to bundle a specific charging service with the price of a new EV, often for the first two or three years. For example, vehicles sold by dealers representing Volkswagen Group companies (including VW, Audi, and Porsche in the United States) typically have a bundled service with Electrify America. Vehicles sold by Tesla have access to the Tesla network of chargers, within a certain allowance.

In this case, the consumer ultimately pays for the bundled service with the price of the vehicle. To recognize this, we price the costs of bundled commercial charging services at commercial rates.

11. Driver reports on EV forums are full of comments related to the problem of finding a reliable charger, and laments regarding the lack of fast DC chargers.

The burden of finding chargers on trips can be acute. Some charging applications (e.g., *PlugShare* 2021) offer trip planning with user-adjustable parameters regarding how many miles a driver is willing to go off their intended route to find a charger. Electric vehicles themselves typically have sophisticated applications to estimate the range available on the current charge, as well as assistance in finding chargers to use on a trip.

FIGURE 1. Direct Monetary Costs of Fueling ICE Vehicles and EVs



Source: Anderson Economic Group (2021) research; base data from consumer logbooks (prices and charging modalities); EIA (gasoline prices); road and additional registration taxes as levied in the state of Michigan.

Time Costs for Charging EVs. We estimate a time burden, and an implicit cost for that time, required to charge an EV.

5. *Time required to drive to a charger and refuel.* The time burden imposed by fueling at a commercial EV charger is significantly higher than fueling a comparable ICE car at a gas station. EV charging involves the following time costs:
- **Driving to a working charger.** These miles are sometimes known as “deadhead” miles, since their primary purpose does not get the driver to the desired destination.
 - **Time to set up and start the charger.** This often involves syncing a smartphone app with the charger, making payment or account arrangements, and waiting for the charger to activate and begin charging. (In some cases, it also involves setting up an application for a new charging network).
 - **Waiting for the charging process to complete.** Fast DC chargers typically enable the driver to complete a charge in 20 to 30 minutes. Slow L2 chargers, however, may take hours. It is worth noting that even after 30 minutes of use at a fast DC charger (and four hours of charging at an L2 charger), an EV battery is not likely to be completely charged.¹²

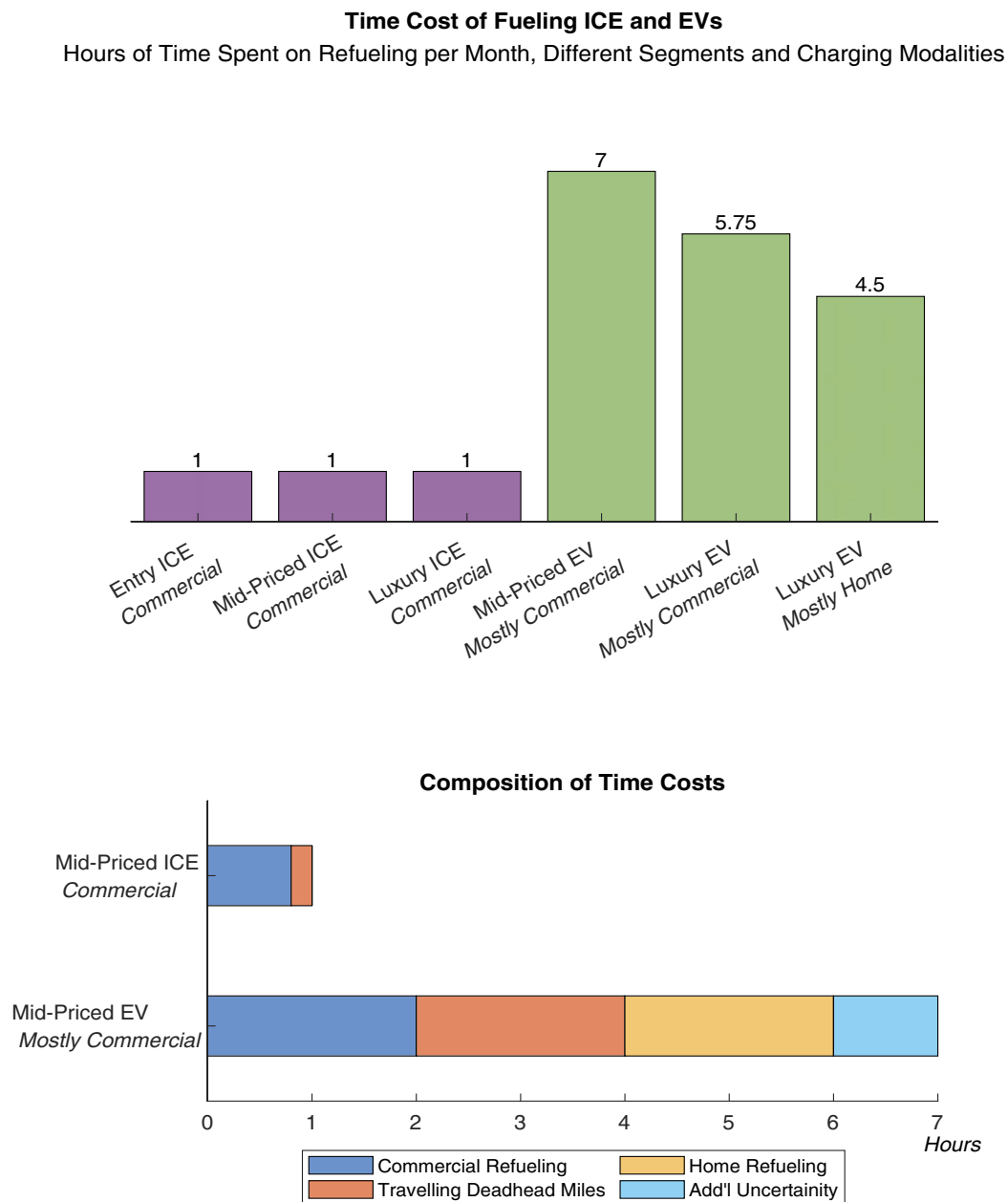
In addition to these time-intensive tasks, EV drivers bear the burden of finding an available *working* charger. The recurring phenomenon of unreliable, non-working, or blocked (“iced”) chargers adds significantly to a driver’s time burden, but is commonly ignored in other analyses.

Time Cost Analysis. For a description of the method and sources we use to calculate the time burden and estimate the implicit costs, please see “Calculating Implicit Time Costs of Refueling” on page 28.

12. This presumes that a vehicle has more than 15% but less than 50% charge at the start of the session. For an L2 delivering 6 kW, charging for 4 hours may add 24 kWh to the battery. This is about one third of the capacity of some current EVs. Charging for 30 minutes at a 50 kWh fast DC charger might add a similar amount of charge.

The actual charge will vary as discussed below under “Separating Direct Monetary Costs from Implicit Time Costs” on page 21.

FIGURE 2. Time Cost of Fueling ICE Vehicles and EVs



Source: Anderson Economic Group (2021) research; base data from consumer logbooks (prices and charging modalities); stopwatch measurements of time.

COMPARISON WITH OTHER REPORTS ON EV FUELING COSTS

Many commonly-cited studies of the cost of driving EVs include only the cost of electric power for EVs, but compare this with the total cost of fueling an ICE vehicle. Moreover, many presume drivers can routinely charge at favorable residential rates, ignoring the much higher costs of the commercial chargers EV drivers must use when they are away from a residential charger (if they have one).

Three such analyses are:

1. Electric Car Report (2020): Estimates fueling cost savings of 40 euros per month for EVs using residential electricity rates. *Ignores commercial charging costs, highway taxes, charger installation costs, and deadhead miles.*
2. Consumer Reports (2020): Includes the cost of commercial charging and estimates an annual EV savings of about \$1,000. *Excludes the cost of additional taxes, charger installation, and deadhead miles.*
3. Model3 Guru (2021): Estimates that a base Tesla Model 3 costs less than half the cost to fuel a comparable BMW 3-series sedan per year (\$481 versus \$1,029, based on Ohio costs and default values for gasoline and electricity). *Ignores commercial charging costs, additional taxes, charger installation costs, and deadhead miles.*

A more sophisticated analysis by Borlaug (2019), includes the amortized costs of a residential charger, and also recognizes charging efficiency losses that are borne by residential charger users.

IMPLICIT PRICING OF TIME COST

Every driver will value his or her time spent charging a vehicle differently. To provide an estimate for the time loss, we follow a long tradition in economics of using a wage rate to implicitly value lost time.

The concept of the cost of time is incorporated in the economic principle of opportunity cost, which recognizes that being required to do one thing means you cannot do others. It is also evident in the ubiquitous practice of charging more for convenience or immediate service. Examples include valet and short-term parking, express delivery, certain toll roads, and priority boarding on airlines.

For this report, we reference two implicit time prices:

1. A state minimum wage, and
2. A typical wage for a worker with sufficient income to qualify for a luxury segment vehicle loan.

These are intended as broad reference points readers can use to assess a personal additional time burden for driving an electric vehicle.

**SEPARATING DIRECT
MONETARY COSTS
FROM IMPLICIT TIME
COSTS**

This report separates implicit time costs from direct monetary costs. Direct monetary costs are explicit, and can be objectively measured. Time costs are inherently subjective, and can only be implicitly estimated. We include the latter as a gauge for the reader, but do not add time cost estimates to the direct monetary costs.

**FUELING COSTS NOT
ITEMIZED IN THIS
REPORT**

While this analysis properly accounts for four categories of direct monetary costs, and does so for both EVs and ICE vehicles, there are a handful of known costs that we do not itemize or include, such as:

1. *Phantom Drain.* Electric vehicles and ICE vehicles require a certain amount of electric power while they are not being actively driven. We ignore this in our analysis.
2. *Electrical Power Usage While Charging.* It is common for EV drivers to use vehicle features while at a commercial charger. This use includes lights, heater or air conditioner, electric seats (including any heating or cooling), and music or an infotainment system. In addition, EVs typically use internal systems to monitor the charging process.

For EV drivers, the cost of use while fueling is much higher than for ICE vehicles. For safety reasons, gasoline-powered cars must be turned off while refueling, and many stations require a person to be outside the vehicle in view of the pump while it is operating. Moreover, the very short time required to fill a gasoline tank means that any usage during that time is small.

We ignore this category of costs.

3. *Battery Degradation.* All vehicles degrade over time. Battery-electric vehicles have a primary system that predictably degrades, namely the battery.

Methodology

VEHICLE SEGMENTS

The automotive industry often classifies vehicles by categories or segments. We categorize EV and ICE vehicles into six segments: entry level ICE, mid-priced ICE (including trucks and crossovers), luxury ICE, mid-priced EV (mostly commercial charging), luxury EV (mostly home charging), and luxury EV (mostly commercial charging).¹³

An *entry level EV* costs almost as much as a new Lexus ICE car (from the *luxury ICE* segment). We therefore exclude this category and limit our analysis to purchase and driving decisions made by new EV owners in the *mid-priced* and *luxury* car segments.

Some *mid-priced* cars in the EV cohort are the:

- Mini Cooper Electric
- Nissan Leaf
- Kia Niro
- Chevrolet Bolt EV
- Tesla Model 3

Some *luxury* cars in the EV cohort are the:

- Porsche Taycan
- Tesla Model S and Model X
- Jaguar I-Pace
- Polestar 2

DATA ON DIRECT MONETARY COST OF FUELING

This analysis uses prices for gasoline and electricity from the state of Michigan. Because ICE cars are almost always fueled at commercial gas stations, we use standard gasoline prices for ICE car fueling costs. However, EV drivers must choose between home/work or a commercial charger. We therefore weigh EV refueling costs using both residential and commercial charging prices.

To illustrate the range of costs facing drivers, we create three scenarios for both ICE vehicles and EVs. These vary by auto segment, and by charging modality.

13. These segments are further defined in the Anderson Economic Group's *Automotive Dashboard* (<http://www.andersoneconomicgroup.com/automotive-dashboard/>).

- We presume all ICE vehicle drivers refuel at commercial gasoline stations.
- We presume some EV drivers rely primarily on commercial chargers, and some on residential chargers.
- We estimate charging costs for these representative drivers using a weighted sum of the residential and commercial charging costs (including, when applicable, the cost of a home L2 charger).

CONSUMER BEHAVIOR AND ACTUAL RELIABILITY

We collected information on consumer behavior and real-world EV and EV charger reliability from multiple sources, including:

1. *Driver Forums.* We collected numerous first-hand reports on EV owners' driving and charging habits, along with the costs of EV ownership, from forums such as Reddit and from brand-focused forums for drivers of Teslas and Porsche Taycans.
2. *Charging Applications.* Data on the extent and reliability of charging infrastructure was collected from charger-aggregation websites, such as *PlugShare.com* and *ChargePoint.com*.
3. *Driving Experience of the Authors.* The authors have collectively driven in multiple states and have charged/attempted to charge at multiple commercial stations, and have maintained personal logs that track actual costs, charging time, and user experience.

RESIDENTIAL ELECTRICITY RATES AND TOU

Our analysis presumes that a fraction of US consumers are subject to residential Time of Use (ToU) rates. ToU rates, intended to discourage electricity use during peak demand hours, make the per-kWh rate substantially higher during the day (often at a 2:1 ratio). This can be an advantage for EV owners who charge at home, as they are able to make use of lower overnight rates. It can also be a disadvantage to drivers who cannot, or do not, shift their charging to advantageous rate periods.

Evidence from Ontario and areas where ToU rates have been imposed in the US suggest they do affect behavior. Moreover, both anecdotal and limited empirical evidence confirm what common sense suggests: "early adopters" of EVs are often interested in ToU rates. Thus, we expect the expansion of ToU rates will affect future charging behavior, especially among those who primarily rely upon residential chargers.¹⁴

14. See Faruqui, Sergici, and Warner (2017), and Lessem, Faruqui, Sergici, and Mountain (2017).

CALCULATING DIRECT MONETARY COSTS OF REFUELING

The direct monetary costs of fueling are calculated in Table 5 on page 27. Italicized words match the names of rows in Table 5. We calculated these costs as follows:

Step 1: Calculating *total miles driven per year*

1. We assume both ICE and EVs drive 12,000 *purposeful miles per year*.
2. We assume ICE vehicles make four trips per month to a gas station, and EVs, depending on their charging preference and size of battery, make between 4-8 trips per month to a commercial charger. “Mid-priced” EVs have a smaller battery (shorter range) and need more frequent trips.
3. We assume two *deadhead miles per refueling trip* for ICE vehicles, and ten for EVs. This difference is due to the relative abundance of gas stations across the US.
4. We calculate *deadhead miles per year* for each category of vehicles using *deadhead miles per refueling trip*.
5. We calculate *total miles driven per year* by summing *purposeful miles per year* and *deadhead miles per year*.

Step 2: Calculating *direct fuel cost per year*

1. We collect measures for ICE and EV *fuel economy* from data reported to the EPA.
2. We assume an EV *charging efficiency* of 88%. Energy is lost in the form of heat at the time of charging a battery. These heat losses occur within the chargers (including the transformers and inverters that convert the AC current in the grid to the DC current used by the vehicle) and in the vehicle itself during the charging process, such as for cooling and running the vehicle’s charging system. Charging efficiency is approximately the ratio of power delivered into the EV battery to the power consumed by the charger. Charging efficiency varies with the type of charger, charging cable, age of the battery, external temperature, vehicle system, and other factors. Some analyses estimate this efficiency to be between 80% to 84%; others place the figure closer to 90%. A straightforward explanation was presented by Voelcker (2021) in *Car & Driver*. Experimental results are shown in Kostopoulos (2020). See SpeakEV (2019), Kane (2018), Battery University (2017) and Borlaug (2019).

The consumer unambiguously bears the charging efficiency losses at residential chargers, as the metered use of energy is partially lost to heat. We were unable to determine the manner in which multiple commercial charging services, with varying equipment, meter the energy that is lost to heat within their chargers. As an estimate of these losses,

we use the same charging efficiency ratio as for residential chargers.

3. We assume *fractions* for “home share” and “commercial share” depending on the amount of fuel obtained from these sources. For ICE cars, 100% of fuel is from a gas station. EV drivers who rely primarily on commercial chargers and use an L1 charger at home may get only 10% of their total charge from residential charging.
4. We collect *prices* for gasoline from EIA; for residential charging from Consumers Energy and DTE Electric; for commercial charging from ChargePoint, Electrify America, Greenlots, and EVgo stations.
5. We calculate the *weighted cost of fuel* (“weighted average cost per kWh” and “weighted average cost per gallon”) using *fractions* and *prices*.
6. Finally, we calculate *direct fuel cost per year* using *total miles driven per year*, *fuel economy*, *charging efficiency*, and *weighted cost of fuel*.

Step 3: Calculating *additional charger cost per year*

1. We assume drivers who rely on mostly commercial charging have only an L1 charger for home-charging, and those who rely mostly on residential charging have an L2 charger.
2. We collect the *cost of chargers* and installation from Edmunds (2020), Graham (2021), HomeServe.com (2021), and advertising from utilities such as DTE Energy (n.d.). We then calculate an average.
3. We calculate the *additional charger cost per year* by amortizing the *cost of chargers* over five years.

Step 4: Calculating *additional registration taxes per year*

1. We collect the additional EV registration taxes per year from the Michigan Secretary of State’s website. This additional registration fee varies between \$135 to \$235 per year. We use \$200 to be a representative of this fee. This figure makes an allowance for the variance of fees across states, and any increase over time.

Step 5: Calculating *direct monetary costs of fueling*

1. We calculate the *fueling cost per year* by summing the costs calculated in Steps 2 to 4.

Step 6: Calculating *excise taxes on fuel per year*

1. We calculate *excise taxes on fuel per year* using *fuel units used*, and state and federal fuel taxes. Fuel taxes are:
 - 26.3¢ per gallon levied by the State of Michigan.
 - 18.4¢ per gallon levied by the federal government.

Step 7: Calculating *cost of deadhead miles per 100 purposeful miles*

1. We calculate *cost of deadhead miles per 100 purposeful miles* using *deadhead miles per year* and *cost of fueling 100 purposeful miles*.

SENSITIVITY ANALYSIS

We provide six scenarios that vary by type of vehicle, vehicle segment, and among the EVs, charging modalities. These represent a broad range of potential drivers. We also make reasonable assumptions for the costs and efficiencies involved, in order to make directly comparable cost estimates for ICE and EVs represented by these scenarios.

We performed a set of sensitivity analyses to assess the effect on our findings of these assumptions and of the scenarios we present, which we summarize here:

1. Varying residential charging and ToU rates: Consumers that are able to rely more on residential charging will, in general, incur lower costs. This is especially the case if the consumer takes advantage of ToU rates. On the other hand, many consumers will find that their reliance on commercial chargers is larger than we present in these scenarios, or will be hit harder by expensive ToU rates.
2. Different charging efficiency: We make an allowance for heat losses during charging, and note that the consumer unambiguously bears the full cost of such losses in residential charging. To the extent commercial charging is either more efficient, or that heat losses are not part of the metered energy cost to the consumers, that fraction of the efficiency losses will be lower.

However, our literature review indicates that charging efficiency losses are often higher with high-current charging, and therefore the consumer costs could be higher.

3. Driving behavior: For both gasoline and electric cars, driver behavior affects fuel economy.
4. Changing tax laws: We make an allowance for state registration taxes on EVs. Individual states will, of course, vary in these taxes. Furthermore, at least for some time EV drivers in some states may avoid the direct road tax burden that is borne by other drivers.

On the whole, these sensitivity analyses confirm the general findings stated in the report, and demonstrate how individual costs will vary by driver, by state, and by vehicle, as well as by driving and charging behavior that varies during the year.

TABLE 5. Direct Monetary Costs of Fueling ICE and EVs as of Mid 2021

	Entry ICE Commercial Fueling	Mid-Priced ICE Commercial Fueling	Luxury ICE Commercial Fueling	Mid-Priced EV Mostly Commercial Charging	Luxury EV Mostly Commercial Charging	Luxury EV Mostly Home Charging
Purposeful miles per year	12,000	12,000	12,000	12,000	12,000	12,000
Deadhead miles per year	96	96	96	960	720	480
Total miles per year	12,096	12,096	12,096	12,960	12,720	12,480
Fuel economy: miles per gallon (a), (c)	33	33	26	-	-	-
Fuel economy: miles per kWh (b), (c)	-	-	-	4.2	3.3	3.3
Fueling efficiency ratio (d)	1	1	1	0.88	0.88	0.88
Fuel units used	366.5	366.5	465.2	3,506.5	4,380.2	4,297.5
fractions: commercial share per unit of fuel	1	1	1	0.7	0.7	0.4
fractions: home share per unit of fuel	0	0	0	0.3	0.3	0.6
Commercial unit cost of fuel (per gallon or per kWh) (e)	\$ 2.81	\$ 2.81	\$ 3.25	\$ 0.43	\$ 0.43	\$ 0.43
Residential unit cost of fuel (per gallon or per kWh)	\$ -	\$ -	\$ -	\$ 0.17	\$ 0.17	\$ 0.17
weighted average cost per unit fuel (per gallon or per kWh)	\$ 2.81	\$ 2.81	\$ 3.25	\$ 0.35	\$ 0.35	\$ 0.27
Fueling cost per year	\$ 1,030	\$ 1,030	\$ 1,512	\$ 1,234	\$ 1,542	\$ 1,178
Home charger cost per year (f)	\$ -	\$ -	\$ -	\$ 120	\$ 120	\$ 320
Additional registration tax per year (g)	-	\$ -	\$ -	\$ 200	\$ 200	\$ 200
Total fueling cost per year	\$ 1,030	\$ 1,030	\$ 1,512	\$ 1,554	\$ 1,862	\$ 1,698
Cost per purposeful mile	\$ 0.09	\$ 0.09	\$ 0.13	\$ 0.13	\$ 0.16	\$ 0.14
Fueling cost per 100 purposeful miles	\$ 8.58	\$ 8.58	\$ 12.60	\$ 12.95	\$ 15.52	\$ 14.15
<i>Memo: Excise taxes on fuel per year (h)</i>	\$ 163.85	\$ 163.85	\$ 207.96	-	-	-
<i>Memo: Cost of deadhead miles per 100 purposeful miles</i>	\$ 0.07	\$ 0.07	\$ 0.10	\$ 1.04	\$ 0.93	\$ 0.57
Assumptions for each scenario:						
Deadhead miles per refueling trip	2	2	2	10	10	10
No. home charging sessions per month	-	-	-	25	25	25
Number of commercial charger/gas station trips per month	4	4	4	8	6	4

Sources: Anderson Economic Group (2021) research using assumptions listed; base data from consumer logbooks (prices and charging modalities); EIA (gasoline prices); excise taxes and additional registration taxes as levied by the State of Michigan.

Notes:

(a) EPA-reported luxury segment fuel economy included model year 2021 BMW 530i xdrive at 27 mpg; Cadillac CTS at 26 mpg; and Mercedes-Benz A220 4matic at 28 mpg. Reported fuel economy for "family sedans" included Honda Insight (hybrid) at 52 mpg; Toyota Prius (hybrid) at 52 mpg; Honda Accord at 33 mpg; Toyota Camry XLE/XSE at 31 mpg; and Chevrolet Malibu at 32 mpg. Reported fuel economy for "entry level" included Nissan Versa at 35 mpg; Hyundai Accent at 33 mpg; Kia Rio Sedan at 36 mpg; Kia Forte at 31 mpg; Subaru Impreza at 32 mpg; Chevrolet Spark at 33 mpg; and Mitsubishi Mirage at 36 mpg.

(b) Using EPA-reported efficiency in kWh/100 miles, translated into miles per kWh for comparison with MPG. The highest reported efficiency figure for the 2021 model year was 2.9 miles/kWh for the Tesla Model S, Porsche Taycan 4S, and Polestar 2.

(c) Comparison of fuel efficiency is for combined city/highway as reported to the EPA.

(d) Adjusts for energy lost as heat from the battery and charger at the time of charging. It is approximately the fraction of power delivered to the EV battery from the power transmitted by the charger. See "Step 2: Calculating direct fuel cost per year" on page 25.

(e) EIA data for 2019 shows per gallon prices for "all grades" averaged \$2.81 in 2018 and \$2.69 in 2019. "Premium" averaged \$3.25 and \$2.83. 2020 prices were affected by the pandemic recession and were lower. Commercial charging rates at ChargePoint, Electrify America, Greenlots, and EVgo stations; rates shown on PlugShare, ChargePoint, and Greenlots apps for Jan-Aug 2021.

(f) Applies only to EVs. We assume an L1 charger costs \$600 and L2 charger (with installation) costs \$1,600. This cost is amortized over 5 years.

(g) Estimated based on tax levied by the State of Michigan. We selected \$200 to be a representative figure. These fees will vary across states and are expected to increase over time.

(h) Included in the retail price of gas. Calculated at 26.3 cents per gallon Michigan state gas tax, and 18.4 cents per gallon federal fuel tax.

CALCULATING IMPLICIT TIME COSTS OF REFUELING

The time costs for fueling are calculated in Table 6 on page 30 and Table 7 on page 31. Italicized words match names of rows in Table 6 and Table 7. We calculated these costs as follows:

Step 1: Calculating *hours spent on fueling per month*

1. Consistent with our previous calculations for *direct monetary cost of fueling*, we assume ICE vehicles make four trips per month to a gas station, and EVs, depending on their charging preference and size of battery, make between 4 to 8 trips per month to a commercial charger. We further assume that all EVs conduct 25 home-charging sessions per month.
2. We use stopwatches and applications to collect *time measurements* for refueling at gas stations, residential chargers, and commercial chargers. For ICE vehicles, we included the following observations.
 - A typical refueling session at a commercial gas pump takes approximately 2.5 minutes, including the time for a credit card payment. If we add this to the time required to pull into and out of the gas station, we arrive at a full time burden of approximately 5 minutes.
 - A relatively burdensome trip might involve: two miles of driving, crossing a traffic light during a busy traffic period, visiting a busy commercial gas station that requires a short wait, filling the vehicle's tank, paying for the purchase, then driving another two miles for the return trip. This scenario produced a full time burden of approximately 12 minutes.

For electric vehicles:

- For residential charging, we measured set-up and disconnect times for already placed chargers at approximately 1 ½ minutes to set up and less than 1 minute to disconnect. Additional time is needed to use the mobile app to prepare the car for charging, ensure the charger is delivering power to the car, and diagnose any problems. We allotted a total of 5 minutes for this process.
- We assume residential charging does not impose an additional time burden.
- For commercial chargers, we included the time needed to drive to and from the charger (deadhead miles), plus time to initiate the charger (which involves syncing a mobile-phone based application with the charger). We then added time to hook up the charger, wait for it to start, and the charging time itself.
- We estimated the time burden for deadhead miles using a mix of secondary roads and highways.
- We used actual time measurements from numerous commercial charging sessions. Because actual charging power varies during most commercial charging sessions, these variations are included in the actual time measurement. Typical charging sessions at fast DC chargers ranged from about 20 minutes to 40 minutes. Charging sessions at L2 chargers, like those for residential chargers, were often much longer.

- We included an additional time burden (*penalty*) for the occasional unreliability of commercial EV chargers. We assume a *penalty* of 0.25 hours for every 1 in 20 commercial charging sessions.
- 3. We calculate *hours spent fueling per month* using *time measurements*, *number of monthly trips*, and *penalty* for non-functional chargers.
- 4. We calculate *total monthly hours spent refueling* by summing *hours spent driving deadhead miles* and *hours spent fueling per month*.

Step 2: Calculating *time costs of refueling*

1. We calculate the *time costs of refueling* using *Michigan's minimum wage* and *total monthly hours spent fueling per month*.

TABLE 6. Estimation of Implicit Time Burden as of Mid-2021

	Entry ICE Commercial Fueling	Mid-Priced ICE Commercial Fueling	Luxury ICE Commercial Fueling	Mid-Priced EV Mostly Commercial Charging	Luxury EV Mostly Commercial Charging	Luxury EV Mostly Home Charging
Purposeful miles per year	12,000	12,000	12,000	12,000	12,000	12,000
Deadhead miles per year	96	96	96	960	720	480
<i>Total miles driven per year</i>	<i>12,096</i>	<i>12,096</i>	<i>12,096</i>	<i>12,960</i>	<i>12,720</i>	<i>12,480</i>
Hours spent driving deadhead miles per month (a)	0.2	0.2	0.2	2	1.5	1
Hours spent refueling	0.4	0.4	0.4	5	4.25	3.5
Total monthly hours spent on the refueling process (b)	1	1	1	7	5.75	4.5
Assumptions for each scenario:						
Number of home charging sessions per month	-	-	-	25	25	25
Number of commercial charger/ gas station trips per month	4	4	4	8	6	4
Refueling time: Commercial <i>(includes deadhead miles)</i>	0.15	0.15	0.15	0.50	0.50	0.50
Refueling time: Residential	-	-	-	0.08	0.08	0.08
Assumptions:						
Non-functional EV charger penalty time (c)		0.25				
Non-functional EV charger frequency (d)		1 in 20				

Sources: Anderson Economic Group (2021) research using assumptions listed; base data from consumer logbooks (prices and charging modalities).

Notes:

- (a) Time spent on deadhead miles is calculated assuming the vehicle covers deadhead miles at an average of 40mph.
- (b) Although the total monthly hours spent refueling ICE vehicles sums to 0.6 hours (about 35 minutes), we make an allowance for the variance in consumer driving patterns and round the monthly time burden to one hour.
- (c) Time spent driving to an EV charger to find it not-working, not working properly, or ICE'd.
- (d) Frequency of finding an EV charger that is non-functional.

TABLE 7. Estimation of Implicit Time Cost as of Mid-2021

	Entry ICE Commercial Fueling			Mid-Priced ICE Commercial Fueling			Luxury ICE Commercial Fueling			Mid-Priced EV Mostly Commercial Charging			Luxury EV Mostly Commercial Charging			Luxury EV Mostly Home Charging		
Total monthly hours spent on the refueling process	1			1			1			7			5.75			4.5		
Time cost per 100 miles at minimum wage	\$	0.97		\$	0.97		\$	0.97		\$	6.76		\$	5.55		\$	4.34	
Time cost per month at minimum wage	\$	9.65		\$	9.65		\$	9.65		\$	67.55		\$	55.49		\$	43.43	
<i>Memo: Time-cost per 100 miles at a \$33/hour wage rate</i>	\$	3.27		\$	3.27		\$	3.27		\$	21.39		\$	17.90		\$	14.28	
<i>Time-cost per month at a \$33/hour wage rate</i>	\$	33.00		\$	33.00		\$	33.00		\$	231.00		\$	189.75		\$	148.50	
Assumptions:																		
Michigan minimum wage per hour (a)				\$	9.65													
Hourly wage rate at \$70,000/year				\$	33.00													

Sources: Anderson Economic Group (2021) research using assumptions listed; base data from consumer logbooks (prices and charging modalities).

Notes:

(a) The Michigan minimum wage was scheduled to increase to \$9.87/hour in 2021. However, the rate did not increase as the unemployment rate for 2020 exceeded 8.5%. See MCL 408.934(2), Workforce Opportunity Wage Act 138 of 2014, as amended.

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About Anderson Economic Group

Founded in 1996, Anderson Economic Group is one of the most recognized boutique consulting firms in the United States. The company has offices in East Lansing, Michigan and Chicago, Illinois, and specializes in public policy, business strategy, and market analysis.

The firm's consultants have won five national awards for writing on business economics topics that include the value of businesses, business location decisions, economics and presidential elections, and consumer demand for alcoholic beverages and cannabis products.

Following are some representative examples of Anderson Economic Group's past clients:

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Automotive. Manufacturers including General Motors, Ford Motor Company, Honda Motor Company, and Lithia Motors; suppliers and trade associations including the Michigan Manufacturer's Association and Business Leaders for Michigan; and dealers and dealership groups representing Audi, Cadillac, Chevrolet, Chrysler, Ferrari, Ford, Genesis, Harley-Davidson, Hyundai, Kia, Lamborghini, Mercedes-Benz, MINI, Suzuki, and Toyota.

Financial, Sports, & Retail. ITC Holdings Corp., First Merit Bank, Bank of America Merrill Lynch, Meijer, Inc., and Relevant Sports.

Beverage. National Wine & Spirits, Nestle, Labatt USA, and InBev USA; wholesalers representing Anheuser-Busch, Molson, Coors, and Miller; and suppliers and distributors of numerous craft beers, wines, and spirits.

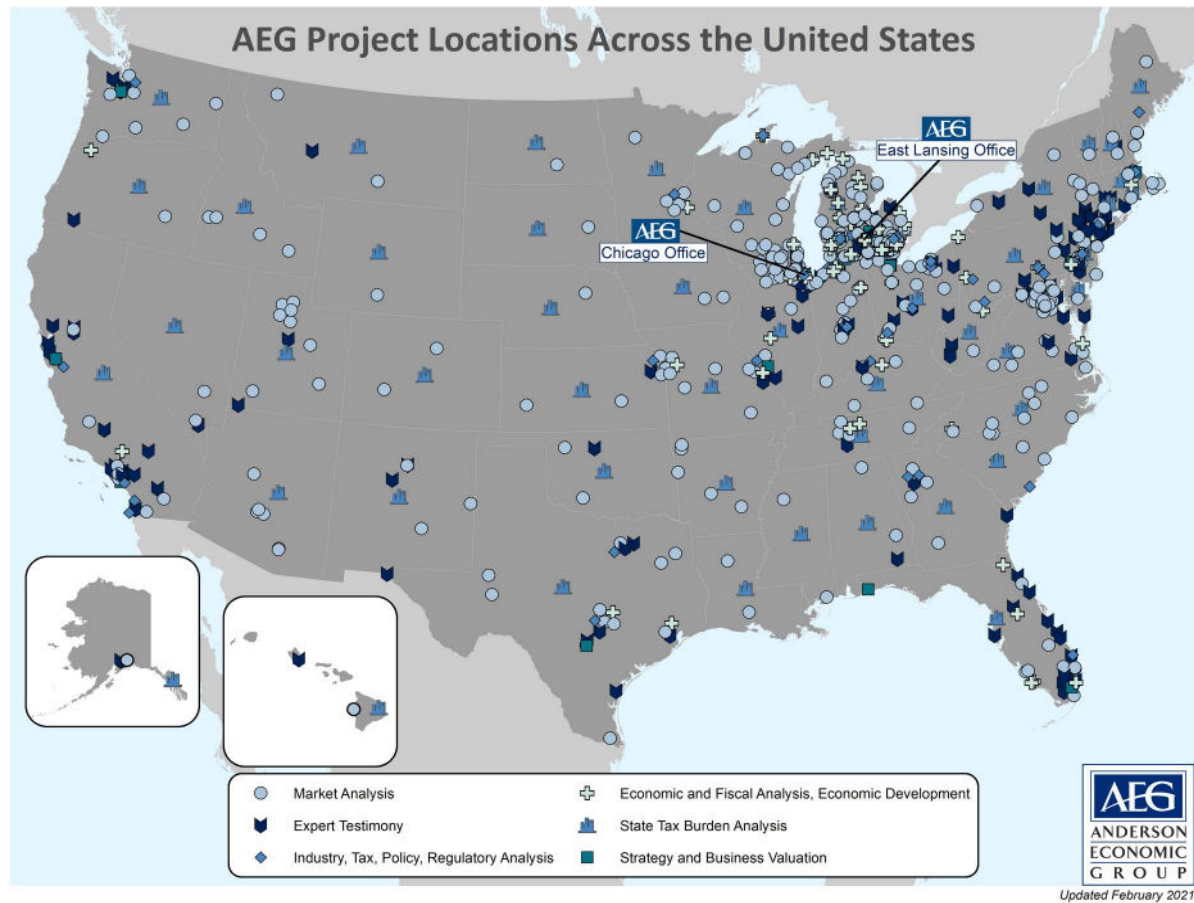
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The Canadian federal government; the States of Michigan, North Carolina, Kentucky and Wisconsin; the Cities of Detroit, Cincinnati, and Sandusky; Oakland County, Michigan, and Collier County, Florida; and authorities such as the Detroit-Wayne County Port Authority.

NON-PROFIT ORGANIZATIONS

Higher education institutions including Michigan State University, University of Chicago, Wayne State University, and University of Michigan; labor unions such as the National Education Association and Service Employees International Union; and trade associations that include the National Auto Dealers Association, Small Business Association of Michigan, and Michigan Chamber of Commerce.

Please visit AndersonEconomicGroup.com for more information.



Subscription Information

For information on subscriptions to the Anderson Economic Group EV Transition Service, or to receive detailed projections and up-to-date analyses, contact Alston D'Souza at adsouza@andersoneconomicgroup.com

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Patrick L. Anderson

Mr. Patrick Anderson founded Anderson Economic Group in 1996, and serves as the company's principal and CEO.

Mr. Anderson is one of the nation's foremost experts on the automotive industry. His knowledge extends to manufacturers, franchisors and franchisees, and suppliers. He is frequently called upon to serve as an expert witness in matters regarding industry disputes, and is often asked to provide media commentary regarding matters affecting the auto sector. He is also a sought-after presenter at industry conferences.

Beyond his automotive industry specialization, Mr. Anderson is a nationally-recognized expert in business economics. He has written over 100 published works, including *Economics of Business Valuation* from Stanford University Press. Five of his journal articles have received national awards from the National Association of Business Economics.

Mr. Anderson is a graduate of the University of Michigan, where he earned a Master of Public Policy degree and a Bachelor of Arts degree in political science.

Alston L. D'Souza

Mr. Alston D'Souza works in Anderson Economic Group's strategy and business valuation practice area, where he serves as a senior analyst and data scientist. While at Anderson Economic Group, Mr. D'Souza's work has focused on damages and market analysis. Most recently, he has conducted an extensive market analysis related to electric vehicle sales and consumer costs.

Mr. D'Souza holds a master's degree in econometrics and quantitative economics from the University of Wisconsin-Madison, and a Bachelor of Technology degree from the National Institute of Technology Karnataka (India).