ELECTRIC VEHICLE ADOPTION, WHILE ENVIRONMENT FRIENDLY, FACES MANY BARRIERS

Electric vehicles (EVs) have multiple advantages, including reductions in global air pollution, local air pollution, oil imports, etc. In particular, EVs are likely to play a key role in the decarbonization of transportation. The transportation sector currently accounts for 15% of global emissions worldwide, and 40% in California.

Given this, many countries are pursuing aggressive EV targets—including Australia, Germany, India, and China—with the developing countries taking a lead. For example, China has set a target that EVs account for 25% of new car sales by 2025. India has a similarly ambitious target: that 30% of all vehicles are EVs by 2030.

In this context, it is pertinent to examine the key barriers to large-scale EV adoption. These include: aspirational value, range anxiety, and—eventually—finance. The aspirational value relates to whether, based on preferences, a decision maker views a vehicle as desirable to own. This is been largely addressed by companies such as Tesla. The range anxiety relates to whether the user would need to worry about running out of charge at inconvenient times. This is starting to be addressed by fast chargers and charging networks.

2 See https://www.sciencedirect.com/science/article/pii/S0306261919307834
3 See https://www.c2es.org/content/international-emissions/
4 See https://www.biologicaldiversity.org/programs/climate_law_institute/transportation_and_global_warming/index.html
6 See https://www.forbes.com/sites/scottcarpenter/2019/12/05/can-india-turn-nearly-200-million-vehicles-electric-in-six-years/#2e736b3e15db
7 See https://www.forbes.com/sites/jeffmcmahon/2019/01/27/the-4-lingering-obstacles-to-electric-vehicle-adoption-and-what-might-overcome-them/#22666a45c54
9 See https://www.consumerreports.org/hybrids-evs/electric-car-charging-network-is-expanding/
UPFRONT COSTS (AND FINANCING) OF EVS IS A KEY BARRIER DESPITE COMPARABLE LIFETIME COSTS

In this thought piece, we explore the last barrier (i.e., finance\(^{10}\)) and how it could be overcome using innovative approaches. Simply put, the capital expenditure (CAPEX i.e., initial cost) of EVs is higher than comparable regular vehicles using an internal combustion engine (ICE).\(^{11}\) This is primarily due to the battery costs,\(^{12}\) even though the rest of the vehicle may actually be cheaper given reduced mechanical complexity.\(^{13}\)

The key insight here is that, while the capital expenditure of EVs tends to be higher compared to comparable ICE vehicles (ICEVs), the operating expenditure (i.e., yearly cost, or OPEX) tends to be much lower. This is due to cheaper fuel—electricity vs fossil fuel—and maintenance costs.\(^{14}\)

That is, over the lifetime of a vehicle, accounting for both capital and operating expenditures using a metric called the total cost of ownership (TCO), many EVs are now less expensive than comparable ICEVs.\(^{15}\) This is true even after appropriately discounting operating expenditures, and using the well-known concept of net present value (NPV).\(^{16}\)

This brings up the obvious question: If EVs have cheaper total cost of ownership than comparable ICEVs, why does cost—in particular, higher capital expenditure – remain a barrier?

Note that this barrier manifests itself only in some situations and, in fact, has been addressed in other contexts. The key element is whether the buying decision is based on total cost of ownership or on capital expenditure. This creates a dichotomy between business vs. individual buying decisions.

In particular, this barrier does not manifest in situations where the buying decision is based on total cost of ownership and not just on capital expenditure. This is more likely to happen when businesses make the buying decisions; examples of this include public transportation as well as fleet operators. For example, in public transportation, many municipalities request proposals from private operators to bid on levelized cost of transportation (LCOT) in $/Km. This is another form of total cost of ownership, and the lowest bidders win.\(^{17}\) Under this model, the private operators essentially consider the forecasted fuel costs and bear associated risks.

However, this barrier still manifests in situations where buying decisions are based on capital expenditure and not total cost of ownership. This is more prevalent in private purchases,\(^{18}\) despite the fact that individuals still need to not only pay fuel costs but also bear associated risks of fuel price volatility.

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\(^{10}\) See [https://qz.com/1701143/price-not-range-is-the-reason-people-will-buy-electric-cars/](https://qz.com/1701143/price-not-range-is-the-reason-people-will-buy-electric-cars/)

\(^{11}\) See [https://www.inc.com/minda-zetlin/electric-car-ev-battery-range-cost-less-than-gas.html](https://www.inc.com/minda-zetlin/electric-car-ev-battery-range-cost-less-than-gas.html): An electric Ford Focus is 62% more expensive than a comparable ICE car.

\(^{12}\) See [https://www.forbes.comsites/robday/2019/12/03/low-cost-batteries-are-about-to-transform-multiple-industries/#23365e0f1054](https://www.forbes.comsites/robday/2019/12/03/low-cost-batteries-are-about-to-transform-multiple-industries/#23365e0f1054)


\(^{16}\) See [https://www.academia.edu/29851431/Total_cost_of_ownership_of_electric_vehicles_compared_to_conventional_vehicles_A_probabilistic_analysis_and_projection_across_market_segments](https://www.academia.edu/29851431/Total_cost_of_ownership_of_electric_vehicles_compared_to_conventional_vehicles_A_probabilistic_analysis_and_projection_across_market_segments)


EVS CAN BE MADE MORE ATTRACTIVE BY FINANCIAL INNOVATION, IN PARTICULAR ANNUALIZATION

This dichotomy—between business and private buying decisions—suggests that there may be ways to make EVs appear more attractive to individuals. At a high level, these would require annualizing capital expenditures and even potentially assigning an appropriate fraction of the same into operating expenditures. Similar models—i.e., leases and power purchase agreements—helped the solar photovoltaic (PVs) gain traction with individuals.

For example, imagine that, when buying a vehicle, an individual would pay for both the vehicle and the fuel in equal annual installments over time. These equal installments would need to include an annualized version of the capital expenditure as well as average operating expenditure. Now, if the total cost of ownership for EVs is attractive compared to ICEVs, these installments are also likely to be cheaper. That is, there is clearly a case for EVs to be cost-effective compared to comparable ICEVs.

The trick is in how to make this work; the devil is in the details! To be able to compare these installments across EVs and comparable ICEVs at the buying date, we need the two constituent annual components: the annualized version of capital expenditure as well as average operating expenditure. Note that the former is already present in the form of mortgages and leases, so that should not be hard to either understand or justify.

However, an issue may arise in establishing the average (or expected) operating expenditures on the date of purchase. Typically—even though the consumer is responsible for the operating expenditures, and bears the risk around fuel cost volatility—while some consumers do think in terms of total cost of ownership, many consumers are not likely to be trained in thinking about expected operating expenditures and will focus only on capital expenditure.

AUTOMOBILE MANUFACTURERS CAN PLAY A KEY ROLE IN PROVIDING ANNUALIZATION OPPORTUNITIES

In these cases, a key question is: How to make this happen? Of course, there may be suitable roles for various stakeholders, including policymakers, electric utilities, and automakers. We start by discussing two approaches, potentially driven by automobile manufacturers, that may help to make a case for EVs being cheaper compared to ICEVs.

The first approach would be for automobile manufacturers that make both EVs and ICEVs (e.g., Ford, or for that matter, all traditional manufacturers) to start offering both vehicle types at annual installments that cover both capital and operating expenditures. As discussed above, the coverage of capital expenditure already happens today in the form of mortgages and leases. Covering operating expenditures may require automobile manufac-

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19 Annualizing, in the simplest form, would mean dividing the capital expenditure by the lifetime of the asset. For example, a $30,000 vehicle with a lifetime of 10 years would have annualized capital expenditure of $3,000. Now, if future is discounted using an appropriate discount rate, this annual capital expenditure would change so that the net present value of these annual installments would be equal to the original capital expenditure.


21 See https://www.goodfinancialcents.com/is-it-better-to-lease-or-buy-a-car/


23 Of course, in this context, there may be suitable roles for other stakeholders, such as policymakers, electric utilities, etc. We discuss them subsequently.
turers to get into operating contracts (including fuel) with consumers and then hedge their fuel-related risks in commodity as well as financial markets.

While feasible, this approach could pose its own set of issues. The first one being that automobile manufacturers may not want to get involved in fuel contracts, given that this requires experience with commodity trading and financial markets. The second one being that, by doing so, automobile manufacturers may expedite the cannibalization of their own ICEV business. While both of these issues are surmountable, doing so may require strategic leadership from some manufacturers.

The second approach would be for automobile manufacturers that make only EVs to start offering EVs at annual installments while clearly specifying the annualized capital expenditure and expected operating expenditure components. In this context, they can also provide comparisons with corresponding annual installments for comparable ICEVs in the market. Separating the battery capital expenditures from the cost of rest of the vehicle will help further by allowing for annualized battery capital expenditures to be viewed more clearly as expected operating expenditures.24

**ELECTRIC UTILITIES CAN ALSO PLAY A KEY ROLE IN PROVIDING ANNUALIZATION OPPORTUNITIES**

On the other hand, electric utilities may also be well positioned to partner with automakers in providing annualization opportunities.25 This is due to the fact that they provide the main fuel—electricity—for the EVs. In fact, selling electricity to EVs may allow these utilities to overcome the utility death spiral catalyzed by flagging demand in face of increased distributed solar energy penetration.26 In this context, utilities have taken a keen interest not only in incentivizing more EV sales—they are in a unique position to influence individual consumers27—but also in providing charging infrastructures.28

In the context of annualization, it may be appropriate for utilities to partner with automakers, such that, while the automakers continue to sell EVs without batteries, the utilities own and sell batteries-plus-electricity as a combined fuel option. This would allow for the annualization of the vanilla EVs (without batteries) by the automakers while also allowing for annualization of the fuel (i.e. batteries plus electricity) by the utilities. The customer would then simply regularly pay the utility for the so-called fuel without really owning the battery, with the utility now being responsible for ensuring appropriate battery quality while meeting customer driving requirements.

This business model has many other advantages from the utilities’ perspective. Utilities are already using batteries for provision of flexibility services in the electricity grid.29 While utilities are highly interested in the vehicle to grid interactions, it has proven hard to scale given the distributed nature of interactions and limited vehicle owner buy in due to concerns around level of incentives and battery degradation.30 These concerns may go away if the utilities own the batteries. In fact, given that the utilities would own the batteries they can not only control battery quality better over the lifetime, thereby enabling optimal battery management including en-

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24 See [https://mobilebatterysquad.com/finance-your-new-car-battery](https://mobilebatterysquad.com/finance-your-new-car-battery) for battery financing options
abling second life, but also bring down battery costs via mass procurement.

Furthermore, given the essential nature of electricity, the utilities may be in a unique position to ensure that customers pay their so-called fuel bills on time. This may allow for utilities to raise low-cost finance for large-scale battery procurement via green bonds, similar to ones raised for rooftop solar installations under the on-bill financing as well as property assessed clean energy (PACE) models. This reduction in financing costs would allow the TCO of EVs come further down, making EVs even more attractive compared to ICEVs.

While these innovative approaches may require many details to be sorted out, thinking along these lines will help individuals overcome the capital expenditure barrier. This may allow widespread adoption of EVs in a much faster way, and help the world move towards its environmental goals, both local and global!

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31 See https://www.sciencedirect.com/science/article/abs/pii/S1364032118302491
32 E.g., see EESL’s success with LED bulbs in India: https://wbnpf.procurementinet.org/featured/unlocking-energy-efficiency-market-india-through-innovative-procurement-business-model
33 See http://www.greentechmedia.com/articles/read/pace-roundp-150m-securitization-by-ygrene-clean-fund-closes-60m