Electrifying Growth - Adoption of Electric Vehicle in Corporate Fleet

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As vehicles get electrified, the conventionally followed fuelling option is to charge the batteries. Vehicle batteries are best slow-charged overnight in six to seven hours. Lower temperature and lower charging rates make the battery last longer. However, if a vehicle is driven in a day longer than the range provided by the battery (say 100 kms), the batteries are Fast-Charged. This can be done in 45 minutes to an hour as long as battery is cooled during charging to keep battery temperature as close to 25°C, as possible. Waiting for 45 minutes to an hour[1] for charging can be very often problematic. There are batteries which can be fully charged faster than this, but they are expensive. Of course, one can use larger batteries, which would give longer range (say for example, 300 kms), so that vehicle rarely requires more than one charge on a day. This, however, also significantly increases the cost of the batteries and therefore that of the vehicles. Also higher weight of the battery implies lower energy-efficiency of the vehicles and therefore lower range.

An alternative, not considered in nations where affordability is not a serious issue, is to use smaller battery providing limited range. The vehicle weight is also reduced, enhancing the overall vehicle energy-efficiency. When the battery runs out, one does not go to a charging station; instead, one goes to a Swapping Outlet, which keeps an inventory of charged batteries and swaps the discharged battery with a charged one. This can be done in less than five minutes, time that a petrol/diesel vehicle takes to fill the tank. Further, the batteries may be no longer purchased with the electric vehicle, reducing the capital costs of the vehicle. Instead, the battery is purchased by an “Energy Operator (EO),” which carries out charging and swapping and leases out the battery to the user. Once a discharged battery is swapped at Swapping Outlet, the discharged battery is taken to a conditioned environment, where the battery is cooled and charged in about two hours, ensuring that the life of the battery is maximised. The battery-lease charges depend upon the energy actually consumed and the battery-leasing rates are based on the depreciation and the interest-cost of the battery plus the charging-cum-swapping costs.

With Battery Swapping emerging as an option, a taxi-fleet may have two options:

EV with RE-battery

This option may be more meaningful for a private vehicle rather than a taxi. The vehicle is sold with a small fixed battery (say with a 100 km range). But the vehicle has a slot for a second battery, called Range-extension battery (RE-battery), which may be added or swapped at a swapping station, as and when needed. The fixed battery is slow-charged overnight and the vehicle can have 100 kms range in a day[2]. Most private vehicles travel less than this range for 90% to 95% of days. On the days the vehicle needs to travel longer distance, it just drives to a Swapping Outlet and gets RE-battery mounted, doubling the range. This is just like getting petrol filled, as it happens only once in 10 to 15 days. If one needs even longer-range, the RE battery is swapped. The RE-battery is returned to any swapping outlet, once used. So the vehicle does not require any fast charging; slow-charging of fixed battery during night-time is adequate, maximizing the life of the battery.

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[1] Fast charging may adversely impact the life-cycle of the vehicle battery

[2] Here the battery may also have a fast charging option, which can be utilised if needed

EV purchased without a battery

In this case, the taxi is purchased without a battery[3]. The capital costs of the vehicle is even lower as compared to the vehicle with RE battery. Battery is just leased in, when required. Only a single battery would normally be used, but a taxi-driver, going on a long-route, where the Swapping Outlet is unlikely to be available, may choose to get both the batteries mounted. Only disadvantage is that a person may have to go to a swapping outlet every day, but for a taxi it may be a better option.

Comparisons between different approaches

The table below compares the two approaches discussed here and the conventional approach of charging a vehicle for a taxi. It is assumed that swappable battery has 100 kms range and costs about ₹250,000 and has a cycle-life of 2000. The vehicle without battery is assumed to cost about ₹650,000 and that with RE-battery of 100 km range may cost about ₹900,000. The conventional EV is assumed to have a large battery with 300 km range[4].

	Conventional EV (battery range 300km)	EV without battery	EV with RE-battery (battery range 100 km)
EV Costs	₹1,400,000	₹650,000	₹900,000
Fast-charging / swapping time	60 minutes	5 minutes	5 minutes
Charging/swapping Frequency for taxi	Rarely	2 to 3 times a day	1 or 2 times a day
Charging/swapping Frequency for personal vehicle	Rarely	Every day	Rarely

From the above table, one may conclude that EV with RE-battery may be the best for personal vehicles, EV without battery may be best for taxi-fleet.

Operation costs

In case of conventional EV, the battery is purchased by customer and the operating costs are electricity costs and overall maintenance of vehicle. When charged at home, the costs will be close to ₹1.25 per km. This compares well with the operation costs of the petrol vehicle, which is closer to ₹7 per km. When the EV is charged with a fast charger, the operator of charger will

[3] Note that the leased battery is Locked-Smart battery [http://electric-vehicles-in-india.blogspot.com/2017/12/locked-smart-ls-batteries-and.html], which is not chargeable by the vehicle owner or anyone else and can only be charged by a EO. Fast charging may adversely impact the life-cycle of the vehicle battery

[4] The higher weight of the battery, however will limit the range to about 250 kms (not considered in the table)

charge a premium over the electricity costs. The costs may be closer to ₹2.25 per km.

When vehicle is purchased without battery, the leasing costs of battery plus vehicle maintenance may amount to ₹4 per km. This is still much less than the operational cost for petrol vehicles.

For a EV with RE-battery, the costs per km is different based on whether Fixed battery or RE-battery is used. Along with maintenance costs, the operation costs with Fixed battery is ₹1.25 per km, and with RE-battery is ₹4 per km. Since RE-battery is used only in about once in ten days, this will be highly acceptable.

Conclusion

Four-wheelers EVs in India need to be different from what is used in other countries, to match the affordability in India. Vehicles with large battery and Fast-charging does not make economic sense. An option, as discussed here is to purchase EV without battery and lease battery as required, swapping batteries when needed. This approach implies that the capital costs of the vehicle is similar to that of petrol vehicle and operational costs are much lower than the petrol-vehicles. This is an excellent approach for taxi-fleets. For personal vehicle, one may use EV with RE batteries. Capital costs will be slightly higher as compared to petrol-vehicles as well as EVs without batteries, but the operational costs will be much lower. RE battery swapping ensures no range limitation. This may be ideal for personal vehicles.

The capital as well as operation costs for petrol vehicles, EV without batteries and EV with RE-batteries is carried out in the box ***"Comparing capital and operations costs in petrol vehicles, EV with only swappable batteries and in EVs with RE-battery."*** Besides, a box on ***"A Case Study by MoveInSync to establish commercial viability of Electric Vehicles in Corporate Employee Transportation Segment"*** compares the number of vehicles required to service requirement of a specific large customer in the three options. Both the case studies clearly point out that EVs with RE option turns out to be slightly better than SWAP option, and much better than Charge option.

Comparing Capital and Operational costs in petrol vehicles, EV with only swappable batteries and in EVs with RE-battery

Assumptions for 5-seater, semi luxury vehicles

a. Petrol vehicles: Capital cost = ₹700,000; Operation cost per km = ₹7

b. EV with Swappable battery: Capital cost = ₹650,000; Operation cost per km = ₹4

c. EV with Range extension battery (100km fixed with 100km swappable):

Capital cost = ₹900,000; Operational cost per km = ₹1.30 (operation cost per km 90% of time at ₹1 and 10% time at ₹4)

Comparing total cost of operation for 10000km, 20000km, 40000km per year

We assume a total depreciation and interest cost to be 30% of capital cost. Though depreciation of petrol vehicle should be higher than that of EV with fixed battery which should still be higher than EV with only swappable battery, however here we assume everything as same. The total cost of operation for different km usage per year, works out to be as follows:

Depreciation, interest and operational costs for different travel distance per year

	Depreciation and Interest costs in ₹	Operation costs (₹ per year)		
Travel distance (km/year)		10000	20000	40000
Petrol	210000	70000	140000	280000
Swappable	195000	40000	80000	160000
Range Ext.	270000	15250	30500	61000

Total cost per year for different travel distance

	Total Cost per year in ‘000 Rs		
Yearly travel (kms)	10000	20000	40000
Petrol	280	350	490
Swappable	235	275	355
Range Ext.	285.25	300.5	331

A Case Study by MoveInSync to establish commercial viability of Electric Vehicles in Corporate Employee Transportation Segment

Background

The case computes the number of Electric Vehicles that may be required for a typical client on a typical day using (i) Range extension battery, (ii) Swapping and (iii) Charging (including fast charging) options. This is used to establish commercial viability of Electric Vehicles in Corporate Employee Transportation Segment.

Client details

A Bangalore based client with operations across two office locations. Client has a large employee base with 5000 employees using our platform across 47 shifts. This meant about 1500 trips being carried out in 24-hour cycle. On an average, the trip-time is 98 mins and the average trip-length is 35kms.

Analysis

We analyzed the real time data, the trip pattern and cab requirement shift-wise for 24 hours across the two office locations. We assumed that for battery-swapping the time required to swap would be 5 - 7 mins (7 mins assumed in computation) and each swap would give a range of 100 kms. We assumed in the charging-option that the vehicle will go through three Fast charges[5] followed by one slow charge. Every fast charge takes 60 mins and slow charge takes 6 hours.

Summary of analysis

Our analysis shows that a total of 199 electric vehicles will be required to service this demand pattern, when the vehicles are refueled using battery swapping mechanism. Using the Range Extension strategy, only 195 electric vehicles would meet the same demand. If the same uses Electric Vehicles which with fast and slow-charge, then the number of vehicles required increases to 228.

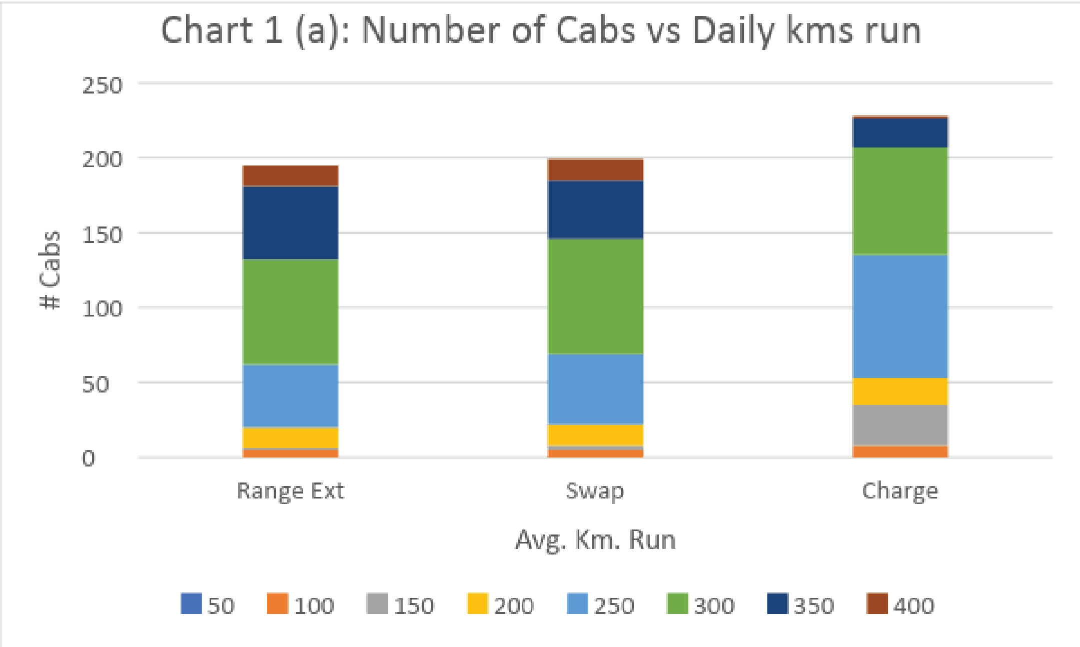
Details of Simulation Results

Simulation was carried out for a typical weekday, assigning a vehicle as and when needed. Vehicles were rotated as much as possible and when existing vehicles were not available for a trip, a new vehicle was added.

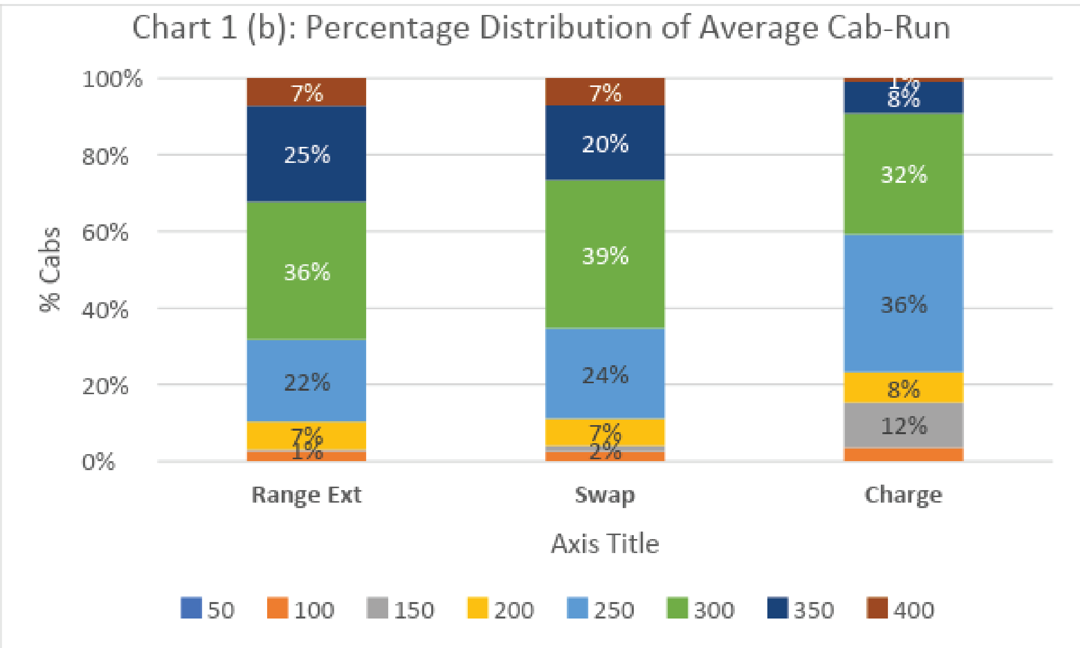
Chart 1(a) shows the number of cabs required in a day to serve the demand. It describes the number of vehicles required in each of the three cases viz. a) vehicles with charging (referred to as **CHARGE**), b) vehicles with swappable battery (referred to as **SWAP**) and c) vehicles with range extension swapping (referred to as **Range Ext** or simply **RE**). Further it gives average distance run in km for each of the three cases.

[5] Frequent fast charges can adversely affect the battery life. This has not been taken into account in analysis.

Thus, as shown in chart 1(a), RE can manage the operations with a total of 195 cabs, while for swapping the vehicles required are slightly higher at 199. But the vehicles required in charging scenario is significantly higher at 228.



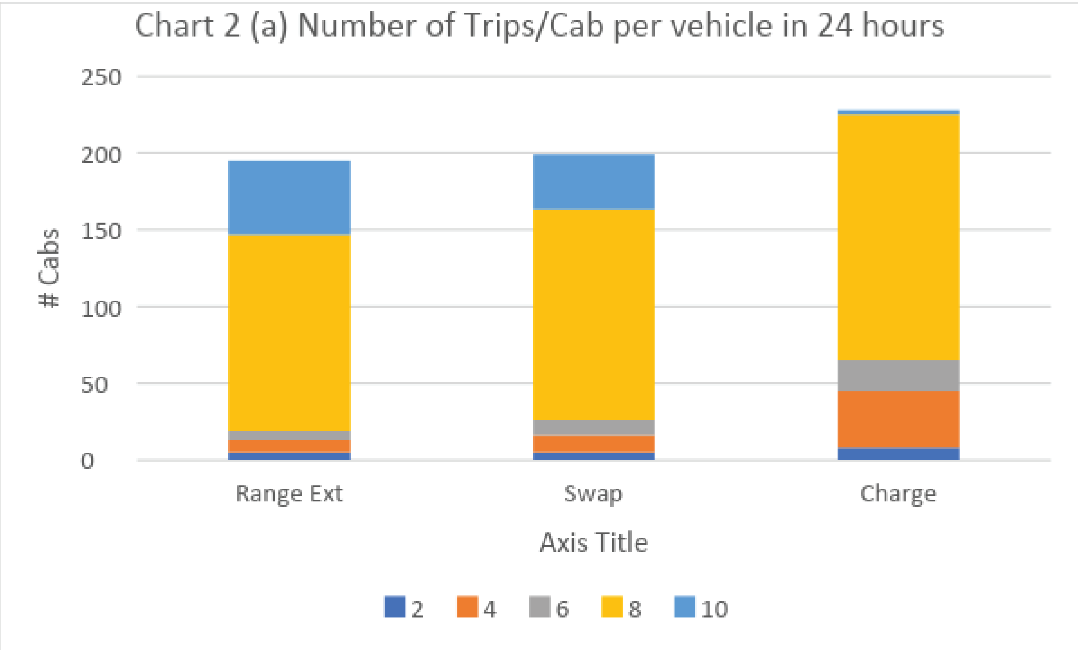
The results are shown in a different manner in chart 1(b). In case of RE, the utilization of the vehicle is higher as compared to SWAP and significantly higher as compared to Charging. For example, 7% of vehicles in RE run 400 km on average and 25% run 350 km on average. On the other hand, in SWAP case, 7% vehicles run 400 km on average, but only 20% of the vehicles run 350 km on average. Charge has much poorer vehicle-utilization with only 1% of the vehicles running 400 km only 8% running 350 km.

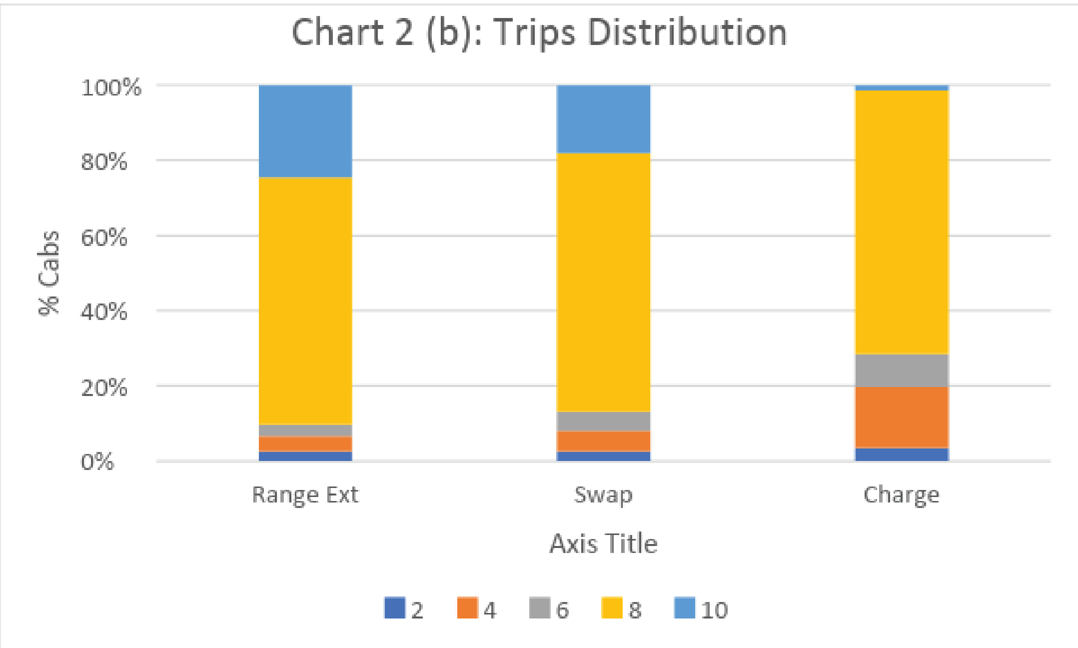


To conclude, if vehicles use battery swapping, more percentage of cabs are able to run for higher KMs on average, thus leading to better asset utilization.

- About 90% of the cabs run 250 kms or more using Range Extension or Swap strategies.
- About 75% of the cabs run 200 kms or more using only Charging strategies

Another way of comparing the three ways of utilization is shown in Chart 2 (a) and 2 (b). Chart 2(a) shows the number of trips that a vehicle does in 24 hrs in the different cases. The same data is shown in percentage terms in chart 2(b). In RE case about 25% of the vehicles are able to do on an average 10 trips per day and 66% do an average of 8 trips per day. The same numbers for swap are 18% and 62%.





To conclude, if vehicles use battery swapping, more percentage of cabs are able to run 7 trips or more on average, thus leading to better asset utilization.

- About 90% of the cabs run 7 trips or more using Range Extension or Swap strategies
- About 70% of the cabs run 7 trips or more using only Charging

We have finally computed the number of vehicles required when battery size is such, so as to give 100km, 90km and 80km range respectively. Chart 3 shows the number of vehicles required in each of the three cases. If the battery has a fixed range of 80 km then number of vehicles required in Charge goes up considerably from 228 to 266, while the numbers for RE and swap remains quite close. This proves that as the battery ages (reducing the range that they provide for the vehicles), Charge would require many more vehicles, whereas RE and SWAP will manage without it.

Chart 3: Number of vehicles required for battery range of 80kms, 90 kms and 100 kms.

	Battery Range (kms)		
# Cabs Required	**80**	**90**	**100**
Range Extension	200	198	195
Swap	203	201	199
Charge	266	251	228

To conclude, RE and SWAP strategy, is certainly better than then Charge.

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