



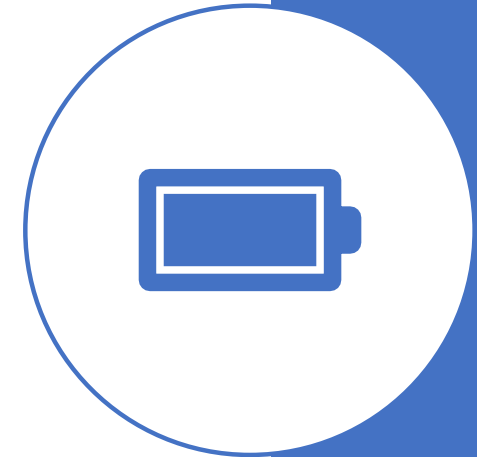
Ashok Jhunjunwala & Prabhjot Kaur


Electrifying Growth - Adoption of Electric Vehicles in Corporate Fleets

MoveinSynch and Centre for Battery Engineering and Electric Vehicles (C-BEEV)

Conventional fueling option for EVs

- **Charge batteries**
 - Fast charge in 45 minutes to preserve life, for inexpensive batteries
 - Waiting will be a problem
 - Slow charging at lower temperature makes the battery last longer
- One can use larger batteries (say 300 km range), but increases costs
 - higher weight batteries implies lower energy-efficiency of vehicle (Wh/km)





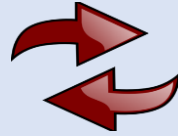
An alternative
rarely used in
West as
affordability is not
a serious issue

- Use smaller battery providing limited range: reduction in weight implies higher energy-efficiency
- Swap the battery when it runs-out in less than 5 minutes (time to fill a tank)
 - Swapping station keeps inventory of charged batteries
- Batteries no longer purchased with vehicle: reduces capital costs
 - Purchased by an Energy Operator (EO): Charges, Swaps and leases battery
 - Discharged battery charged slowly in conditioned environment ensuring maximum life
 - Lease-charges based on actual energy consumed: covers depreciation, finance cost and charging-cum-swapping costs

Indian Options



EV with Fast-CHARGE



EV with battery-SWAP



EV with Range Extension (RE) battery

- Vehicle has built in Fixed battery, say for 100 kms for a car
- Most days car driven for less than 100 kms, so slow-night charging is sufficient
- On 5% to 10% of days, when vehicle needs to drive longer, ADD a 100 kms RE battery at petrol pumps / convenient location (in a second empty slot in car)
 - If one drives longer than 200 kms, swap the RE battery

Paper compares
three options
of 5-seater
semi-luxury
cars

Assumptions



Battery: 100 kms range, costs ₹250,000, battery cycle-life of 2000

Vehicle : without battery costs ₹650,000



Petrol vehicles

Capital cost = ₹700,000; Operation cost per km = ₹7



EV with SWAP

Capital cost = ₹650,000; Operation per km = ₹4



EV with RE (100km fixed+100km swap)

Capital cost = ₹900,000;

Operation per km = ₹1.30 (90% operation at ₹1 and 10% at ₹4 per km)

Comparisons of different Options

- EV without battery best for taxi
- EV with RE-battery best for personal vehicles

	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 freq for personal vehicle	Rarely	Every day	Rarely
Operation costs per km when charged / swapped	₹1.25 at home ₹2.25 at charging stn	₹4 at swapping station	₹1.25 for Fixed and ₹4 for RE-SWAP

*Conventional vehicle fueling costs ₹7 per km

Capital and Operational costs in petrol, EV-SWAP and EVs with RE-battery

	Depreciation + Interest in ₹	Total Operation costs (₹ per year)		
Travel distance in km/ year		10000	20000	40000
Petrol	210,000	70,000	140,000	280,000
Swappable	195000	40,000	80,000	160,000
Range Ext.	270000	15250	30500	61000

Assuming 30% interest plus depreciation costs per year

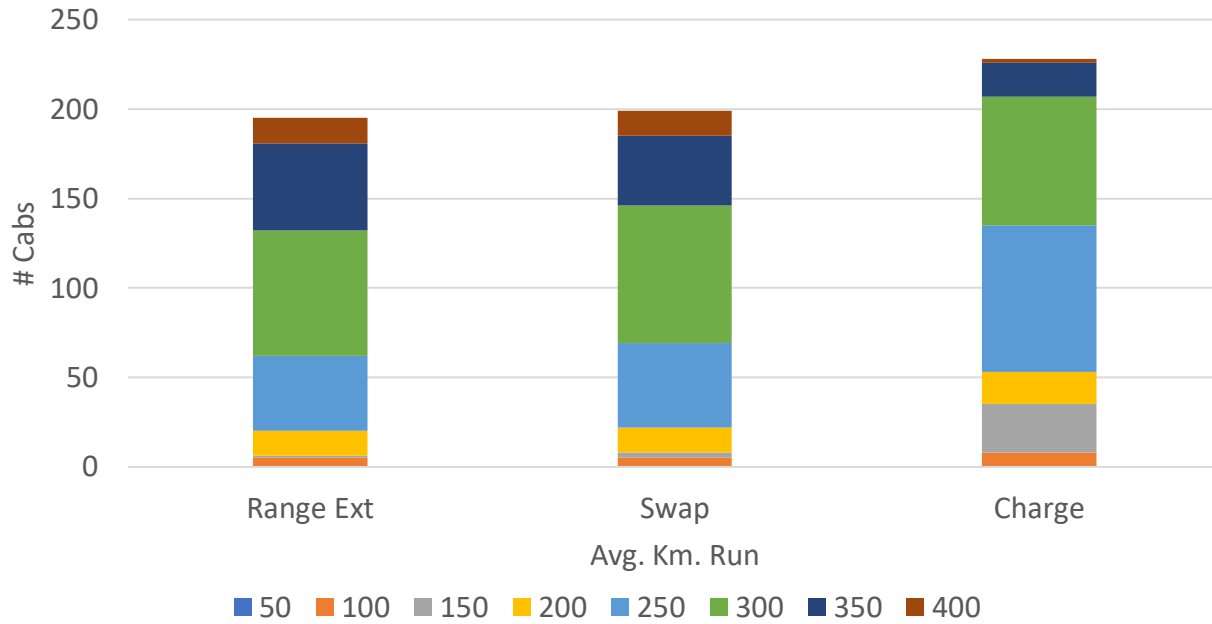
	Capital (depreciation + interest) + Operation costs ('000 ₹ per year)		
yearly travel (kms)	10000	20000	40000
Petrol	280	350	490
Swappable	235	275	355
Range Ext.	285.25	300.5	331

EVs in Corporate-employee Transportation

- Bangalore client with two office locations
 - 5000 employees across 47 shifts; 1500 trips in 24-hour cycle
 - Average trip-time: 98 mins; average trip-length: 35km
- Analyzed the real time data for 24 hours with assumptions
 - Battery-swapping for 100 kms range in 7 mins
 - Charging: Three Fast (60 min) followed by one slow (6 hours) charge
 - Impact on battery life ignored
 - Simulation for a typical weekday, assigning a vehicle when needed
 - A new vehicle added when existing vehicle not available for a trip



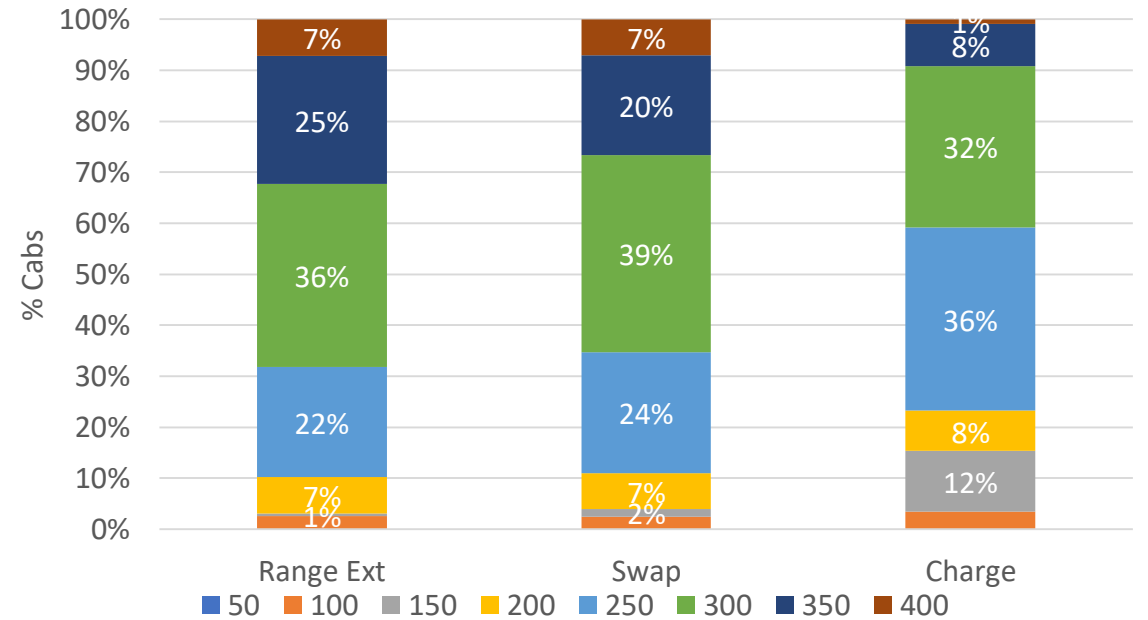
Number of Cabs vs Daily kms run



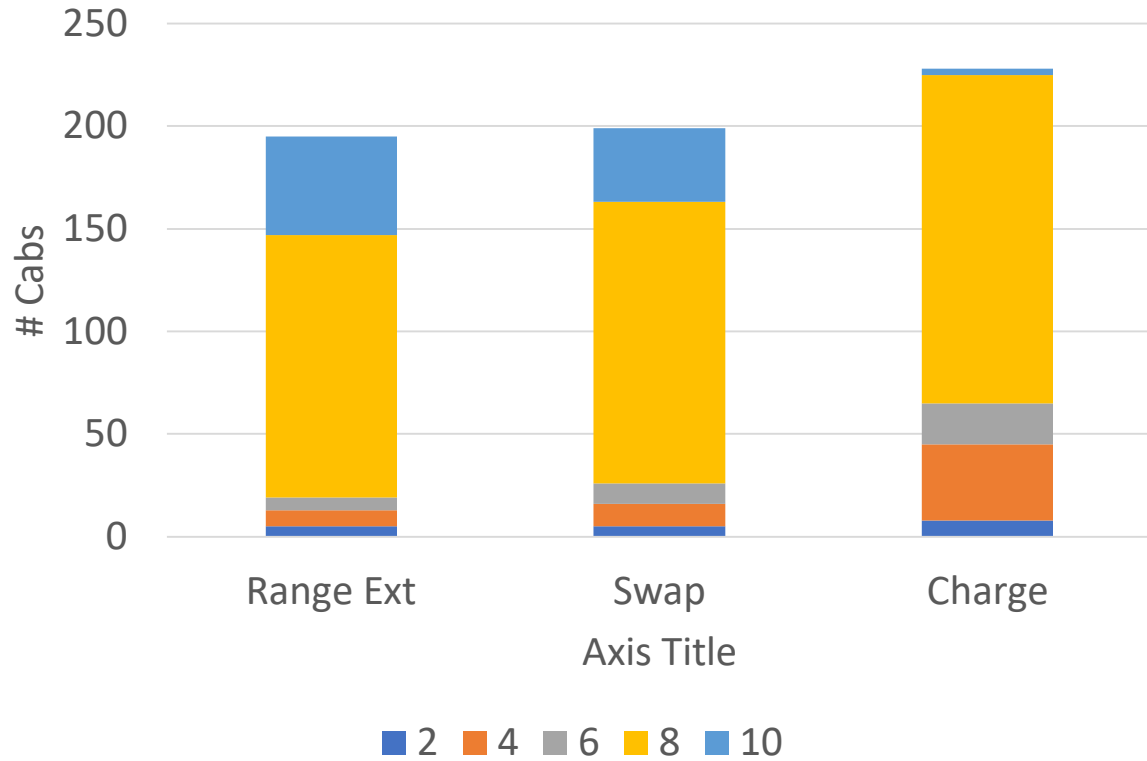
In RE, 7% vehicles run 400 km and 25% run 350 km; in SWAP, number is 7% and 20% and for Charge it is 1% and 8%

RE requires 195 cabs, SWAP needs 199, whereas CHARGE requires 228

Percentage Distribution of Average Cab-Run

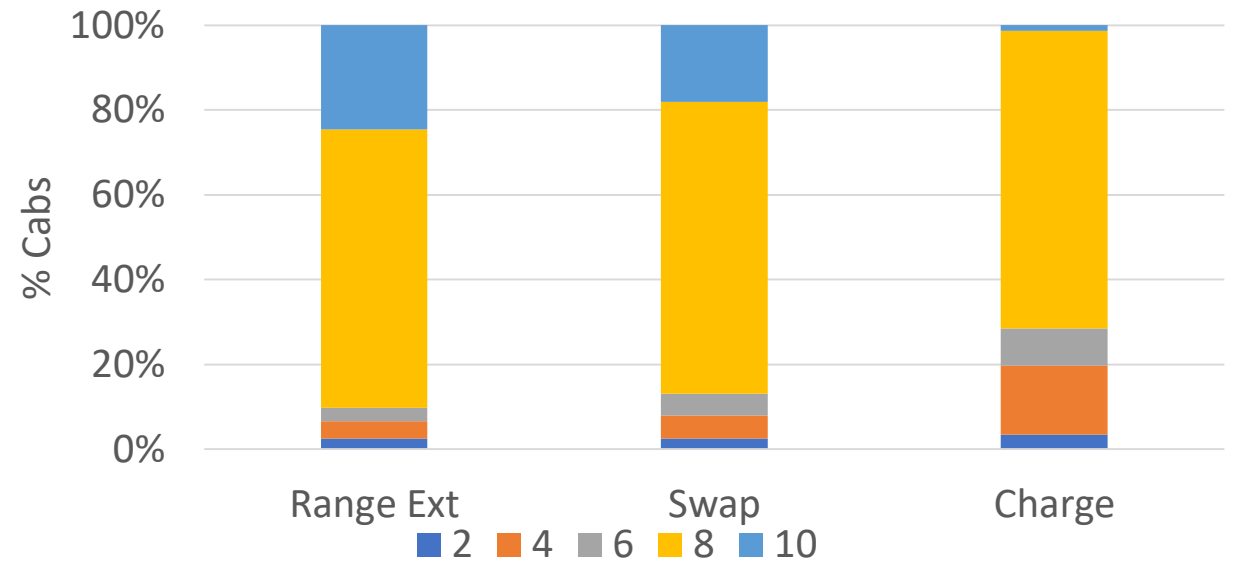


Number of Trips/Cab per vehicle in 24 hours



Asset utilisation: In 90% of cabs run 7 or more trips in RE and SWAP, whereas only 70% do so in CHARGE

Trips Distribution



Number of vehicles required for battery range of 80kms, 90 kms and 100 kms

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