INTEGRATION OF SOLAR WITH ELECTRIC VEHICLES
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SOLAR POWER

Integration of Solar with Electric Vehicles

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Integration of renewable energy will make EVs truly cleaner than conventional fuel vehicles taking into account the lifetime CO_2 emissions. Distributed solar energy will help reduce transmission and distribution losses, thereby, reducing the lifetime CO_2 emissions as well as the operating cost of EVs further, and accelerate their commercial feasibility. Distributed solar will also help curtail the CAPEX requirement for upgradation of transmission and distribution infrastructure resulting from additional demand from EV charging.

Introduction

India targets to have 6 to 7 million hybrid / electric vehicles (EVs) on road by the year 2020 and go 100% electric by 2030. These goals are undoubtedly welcome, considering that India has 14 cities out of the world's 20 most polluted cities in terms of PM 2.5[1].

However, while adopting these steep targets, we must be cognizant of the fact that EVs will increase the overall demand for electricity and will require massive upgradation in power transmission & distribution infrastructure. Simultaneously, in order to make EVs 'green' in true sense, the demand for additional electricity required for charging of the EVscannot come from thermal power plants.Integration of renewable energy, especially in distributed format, accompanied with friendly policies will help alleviate these challenges. In this article, we will cover why EV adoption and increase in solar energy integration has to go hand-in-hand.

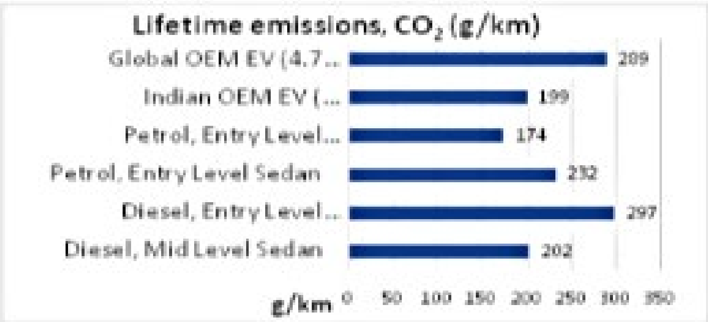
Green-house emissions

The main objective behind the push for electric vehicles is to have zero emissions on road. But, given our current power mix where almost 2/3rd of the electricity is generated from thermal power plants (using coal, oilorgas as fuel), if the trend persists, we will be just moving the emissions from onroad to remote locations of these power plants, and in fact increasing the global emissions.Altigreen Propulsion compared the lifetime emissions (the sum of emissions during manufacturing of the vehicle, direct emissions either on road or at the power generation plant for EVs, and indirect emissions emitted during transport and conversion of primary fuel to usable form) of vehicles by different fuel type[2].Electric vehicles from an Indian OEM (with ~8 km/kWh) as well as one of the global OEMs (with 4.7 km/kWh) were included in this study. As shown in Figure 1, lifetime CO_2 emissions from electric vehicles were found to be greater than those from an entry level petrol hatchback.

Today, EVs are more polluting than equivalent petrol vehicles largely because the energy generating plants emit average CO_2 emission of 0.721 kg/kWh of electricity used to charge the EVs. However, if we meet the renewable integration target of 175GW by the year 2022 and 275 GW by 2027,CO_2 emission by these plants is expected to reduce by 16% (to 0.604 kg/kWh) and 27% (to 0.524 kg/kWh) for the respective years,making electric vehicles truly less CO_2 emitting than petrol vehicles (ignoring the advancements in petrol vehicles).

Thus, it is important for all the stakeholders to strive towards the government settarget not only from the perspective of achieving renewable energy goals, butalso to make electric vehicles 'greener' than equivalent petrol vehicles.

Figure 1: Comparison of lifetime emissions between petrol and electric vehicles



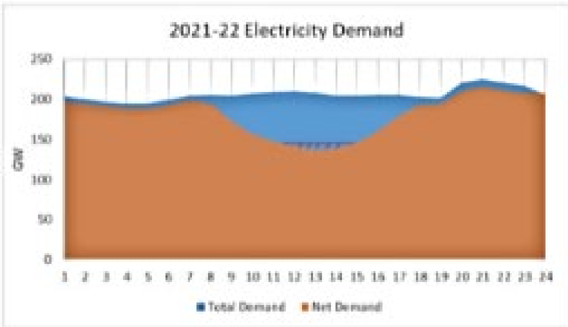
Duck Curve challenges

Though integrating more and more renewables into the power mix is good from the standpoint of reduction in greenhouse gas emissions, it introduces practical challenges in supply-demand matching. Figure 2 shows the projected total electricity demand in India as per the time of the dayon a typical day in the year 2021-22[3]. Typically, electricity demand rises at around 7 AM, stays relatively flat and then increases again at around 8 PM to reach peak at around 9 PM. As we integrate more solar PV into the overall power mix, sincesolar generates electricity only between sunrise and sunset, the power demand from conventional sources (thermal, nuclear and hydro) goes down during daytime hours. This 'net demand' curve, as shown in Figure 2, is called the 'Duck Curve' and is a challenge forintegration of renewable energy into the grid. The main problemlies inrapid ramping up of energy generating plants in the evening hours to maintain supply-demand balance. Base load providing plants will be operational throughout the day, but intermediate and peak load providing plants will be running only during part of the day.The rapid ramping and stop-starting of energy generating plants leads to inefficiencies and is expensive. Thus, any kind of solution for softening of peaks and valleys and flattening of the 'net demand' curve will help integration of more and more renewable energy into the grid. While efforts are underway to make base load power plants more flexible and while the advancement in'energy storage' solutions will be a game changer for flattening of the net demand curve; adoption of electric vehicles will also provide an opportunity to flatten this curve.

Electric vehicle owners must be incentivized through ToD(Time of Day) tariffs to charge their electric vehicles during intervals of low demand (night hours) and intervals of peak generation through renewable sources (9 AM to 3 PM). By year 2021-22, it is estimated that demand from electric vehicles will account for ~1% of the total electricity demand. Now imagine a theoretical situation when all the EVs are charged only during 4 to 5 hours around noon (as shaded in Figure 2). By doing so minimum load throughout the day will rise and peak load will reduce by less than a percent. Though not a significant impact in 2021-22; KPMG estimates[4] that demand from electric vehicles' charging will constitute as much as 8% of the total electricity demand by the year 2030 and will increase the peak load from 380 GW to 402 GW assuming the EV charging happens uniformly all throughout the day (Figure 3). However, by applying ToD tariffs and encouraging charging during off-peak hours, this peak load requirement can be restricted to 385 GW[4] (Figure 4) saving considerable capital expenditure otherwise required for power transmission upgradation.

Few states including Andhra Pradesh, Karnataka, Maharashtra and Telangana have already implemented ToD tariffs for industrial and commercial consumers. These states have also rolled out Electric vehicle policies; however, are yet to design a dynamic tariff structure for EV charging[4].

Figure 2: Projected 'Total Demand' and 'Net Demand' in 2021-22*.



* The shaded area is for representation purpose and not exactly as per the scale

Figure 3: 'Total Demand' profile on a typical day in 2030 with uniform EV load

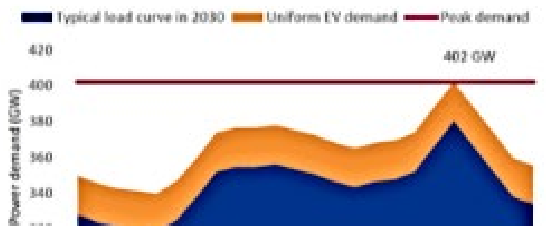
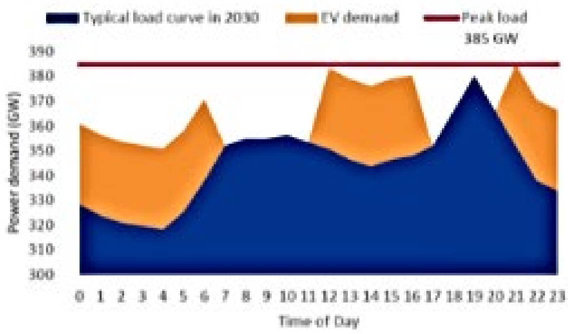


Figure 4: 'Total Demand' profile on a typical day in 2030 through ToD tariff policy for EV charging



Benefits of Distributed Solar for EV adoption:

Distributed solar has significant advantages on top of integrating more and more renewables into India's power generation mix to make EVs greener and economically viable.

Firstly, power transmission and distribution losses in 2016-17 were 20.65% and are estimated to be 16.96% and 14.87% in the year 2021-22 and 2026-27 respectively[3]. These losses not only increaselifetime g/km CO_2 emissions of EVs but also result in increasing the cost of electricity to charge the vehicles. Since distributed energy helps reduce the power loss during transmission and distribution (energy is generated close the point of consumption, hence lower losses), EVs will become greener and economically viable faster from the standpoint of total cost of ownership.

Secondly, distributed energy will contribute towards reduction ofCAPEXrequired for upgradation of transmission and distribution (T&D) infrastructure. This is important to the DISCOMs as well as to the end user. For a case study, we considered Fourth Partner Energy's office in Hyderabad. Our peak load is ~13 kW and we have around 60 employees working in this office. We have a step-down transformer of 25 kVA capacity. Now even if 10% of the employees convert to electric vehicles and if there comes a situation where all of themcharge their vehicles simultaneously, even a 3 kW charging load per vehicle will increase our peak load to 31 kW and our existing transformercannot withstand that. However, thanks to the 15 kWp solar plant installed on our office rooftop, we can easily sustain around 10% of our employees switching to EVs without upgrading the transformer. Note that, this problem will become much more severe when we think of the stress EV charging will cause on the higher capacity distribution transformers and capex required for upgradation of the same. This stress on the T&D network should also be tackled with technical advancements such as networked charging infrastructure so as to split available power equally among all the cars connected to the charging network.

Thirdly, some EV OEMs might adopt the technology of battery swapping for their vehicles. Battery swapping will be a faster way of charging the EVs and will reduce the upfront cost of purchasing an EV. It is possible to set up distributed solar farms on low cost lands for charging of the batteries and provide cleanlow-cost energy for electric vehicles. In addition, battery swapping provides a golden opportunity to use energy storage as a mechanism for flattening of the total electricity demand by charging the batteries during day-time hours and release the energy back into the grid during peak hours.

Lastly, globally nearly 80% of the EVsare charged overnight at homes, and office premises are the second most preferred option. Overnight charging is no doubt good for the grid, but, there is also significant opportunity to utilize the solar hours to charge your vehicles directly from a solar rooftop or a solar car port while you are in office. It will definitely be the most efficient and least emission generating method of charging electric vehicles.

A brief overview of government policies[5]:

In order to boost EV adoption,the central government and various state governments have already launched various policies. Here is a brief overview of them:

- FAME India scheme (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) launched with implementation in effect from April 2015 to support the market development and manufacturing eco-system. The scheme has four focus areas: technology development, demand creation, pilot projects and charging infrastructure.
- Karnataka Electric Vehicles and Energy Storage Policy for a period of 2017-2022 with the objective of attracting investment of Rs. 31,000 crores with special incentives for EV manufacturing and facilitating energy storage and charging equipment manufacturing.
- Maharashtra government approved Electric Vehicle policy 2018 for enabling manufacturing of 500,000 EVs in the next five years. The policy also provides various subsidies to EV owners as well as charging infrastructure owners for setting up charging stations across the state.
- Through Uttar Pradesh Electric Vehicles Manufacturing policy 2018, the state not only wants to promote EV battery and charging equipment manufacturing, butalso incentivize manufacturing of solar cells to generate clean energy.
- Andhra Pradesh, Telangana and Tamil Nadu governments have also rolled out similar policies to incentivize demand for EVs as well as attract manufacturing investments in the respective states.

Conclusion

India has all the right intentions and goals set up regarding adoption of Electric Vehicles and integration of renewable energy into the overall power mix. However, it is essential to understand that these goals go hand in hand and complement each other very well. Integration of renewable energy will make EVs truly cleaner than conventional fuel vehicles taking into account the lifetime CO_2 emissions. Distributed solar energy will help reduce transmission and distribution losses, thereby, reducing the lifetime CO_2 emissions as well as the operating cost of EVs further, and accelerate their commercial feasibility. Distributed solar will also help curtail the CAPEX requirement for upgradation of transmission and distribution infrastructure resulting from additional demand from EV charging. On the other hand, increased adoption of electric vehicles coupled with the right ToD tariff structure will provide an opportunity to flatten the load profile, even if partially, and help integration of more renewable energy into the overall power mix.

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