Electric Vehicle as a Flexible Load

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***Abstract*— India is keen to attempt to work towards a low carbon emission pathway. As per goal set up for Intended Nationally Determined Contribution (INDC) by India, India has to reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level and to create an additional carbon sink of 2.5 to 3 billion tones of CO2 equivalent through additional forest and tree cover by 2030. Harnessing Renewable energy (RE) sources is one of the attempt to work towards a low carbon pathway. Sustainable green transportation network is another measure for achieving this goal.**

To accelerate development and deployment of renewable energy in the country, the Government is taking a number of initiatives like, up-scaling of targets for renewable energy capacity addition from 30GW by 2016-17 to 175 GW (out of total 479 GW Installed Capacity(IC)) by 2021-22 and further up to 275 GW (out of total 619 GW IC) by 2026-27. Government of India has also taken multiple initiatives to promote manufacturing and adoption of electric vehicles in India. However, in India, Electric vehicles (EVs) still have a long way to go for making a significant change.

Due to variable, intermittent and non-dispatchable generation from RE sources, the safe and reliable grid operation is the next step towards the readiness for integration of such huge capacity of RE into the grid. Presently the balancing of grid for variability and intermittency of RE generation is done by ancillary services, already in place and by increasing/decreasing of generation from conventional sources. In the year 2021-22, when the capacity of RE is expected to be 175 GW (37 % of the total IC) and further upto 275 GW (44% if the IC) in the year 2026-27, some other measures needs to be identified for balancing the grid.

As the % of RE generation into the grid increases, the difference in maximum and minimum load to be met from coal generation during the day will also increase. This leads to increase in ramp up & down capacity and its change in rate, reserve capacity, residual capacity, spinning reserve and balancing capacity in the grid. In order to reduce the said difference, some measures like operation of some pre identified units of coal and gas and hydro plants in the form of flexible generation may be made operational into the grid. The temporal shifting of Renewable energy generation with the help of energy storage like battery storage and pump storage may also be helpful to achieve this. Further, the flexible load in the form of flexible loads in buildings, Electric vehicle charging, may also be effective in providing flexibility to net load curve.

Also, since, EVs needs charging stations to charge the batteries, the impact of EVs on power system cannot be ignored. The impact of EV charging will be felt first at local hotspots on distribution grids before the other levels i.e. generation, transmission and grid are affected.

As the EV load penetration increases, their potential to contribute to flexibility services via Demand Side Response (DSR) will also increase. It can play an active role in increasing the flexibility of power systems. Electricity markets should also facilitate the EV load to participate for grid balancing. The policy and regulatory frame works are also required to be modified suitably.

Keywords-Electric vehicle, Flexibility, Renewable Energy, EVs,. Flexible Load

I. INTRODUCTION

India is keen to attempt to work towards a low carbon emission pathway, while simultaneously endeavoring to meet all the developmental challenges that the country faces today. As per goal set up for Intended Nationally Determined Contribution (INDC) by India, India has to reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level and to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030 [3]. Thrust on renewable energy, promotion of clean energy, enhancing energy efficiency, developing climate resilient urban centres and sustainable green transportation network are some of the measures for achieving this goal. To accelerate development and deployment of renewable energy in the country, the Government is taking a number of initiatives like up-scaling of targets for renewable energy capacity addition from 30GW by 2016-17 to 175 GW by 2021-22 and further upto 275 GW (out of total 619 GW) by 2026-27. As per 19th Electricity Power Survey report the peak electricity demand of the country will also increase to 226 GW in the year 2021-22 to 298 GW in the year 2026- 27[3].

Due to large deployments of renewable energy generating plants, some significant changes in the physical supply-demand dynamics of the future Indian electricity system can be anticipated. This would be more prominent with the increased penetration of RE generation (30-40% of the total consumption) into the grid. With the help of improved sensing, and simple control functionality, we can reduce its effect on system including peak electricity demand and accommodate increased renewables penetration, creating a more sustainable electricity grid.

II. THE PRESENT & FUTURE SCENARIO OF ELECTRICITY SUPPLY-DEMAND DYNAMICS

At present most of the generation is dispatch able and load is almost passive. The status for the RE generation is a must run status. Balancing in the grid due to variability of RE generation is being fulfilled by conventional Generating Stations. The ancillary services are introduced to take care of ramp up and ramp down and balancing requirement of the grid. At the end of the year 2021-22, it is expected that, out of total 479 GW of All India installed capacity, 175 GW (37 % of the total IC) would be from RE sources. The RE generation capacity will be non-dispatchable and the load is expected to be almost passive load. The all India expected load curve for a typical day during the year 2021-22, is as shown in Fig 1.

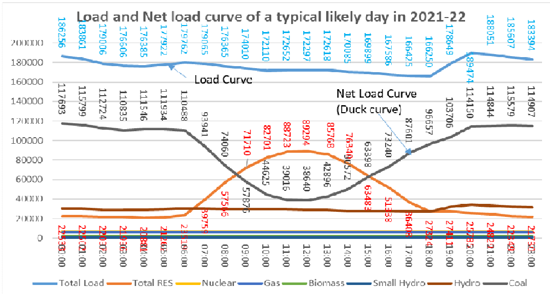

Fig.1

The expected all India Net load curve (Duck Curve) obtained from the All India Load curve after deducting the load met from must-run plants i.e. wind, solar and nuclear generations, and generation from hydro plants. The net load curve in Fig.1 would be met with coal generation. As the % RE generation into the grid would increase, the difference in maximum and minimum load to be met from coal generation during the day would also increase.

Considering the high variability and intermittency of generation from renewable, efficient and economical grid operation becomes one of the critical challenges in India‘s Power system. The CERC has taken several initiatives to ensure integration of variable RE generation. The framework for forecasting, scheduling and deviation settlement for wind and solar has been put in place. To enable thermal generators to provide balancing support, necessary regulatory framework has been provided defining technical minimum for such plants and commensurate compensation for flexing such (thermal) generation up to technical minimum. The CERC has issued Suo Motu order delineating the road map for operationalizing reserves[2]. The SERCs are also taking necessary steps in this regard in their respective states.

In order to reduce the difference in maximum and minimum load to be met from the coal during the day, some measures like operation of some pre identified units of coal and gas during morning peak and off peak hours and also some capacity of hydro plants (to stop generation from morning 6:00 hours to evening 18:00 hours and shall run from evening peak,18:00 hours to morning peak, 6:00 hours) in the form of flexible generation may be made operational in the grid. The temporal shifting of Renewable energy generation with the help of energy storage like battery storage and pump storage (consume power during off peak and generating power at peak hours of net load curve) may also be helpful in decreasing the difference in maximum and minimum load to be met from coal during the day[1]. As the capacity of RE generation into the grid increase, some additional measures are also to be identified to reduce the same. Flexible load has a large potential to solve the same. Flexible load in the form of flexible loads in buildings, Electric vehicle charging, and battery electric storage, may be effective in providing flexibility to the grid.

III. EFFECT OF EVs ON POWER SYSTEM

Since, EVs needs charging stations to charge the batteries, the impact of EVs on power system cannot be ignored.

With the rise in sizable number of EVs and its usage patterns, there may have an impact on power system at different levels, i.e generation, transmission, system operator & distribution. Some of the impacts, with the widespread use of EVs, are mentioned below:

Generation: There may have an increase in the energy requirement on all India basis due to charging of batteries of EVs. The increase in All India peak demand may depend upon the charging pattern of Electric Vehicle owners.

Transmission : There may be change of direction and quantum of power flow on Inter-state and Intra State transmission lines. Although this will depend on weather and behavioral aspects of citizen/people for charging of their EVs.

System operator : During peak times, the system may require more system services, such as frequency control ancillary services, and the need to maintain reserve power capacity, if EV loads coincides with peak times.

Distribution level: The DISCOMS may have to procure more power for charging requirement of EVs. The network augmentation may be required to cater the load of EVs and to avoid overloading of lines and transformers. The voltage drop below a statuary limits may also be felt at distribution level. There may have some assets which can experience thermal limits/overloads. The power quality may also be affected. In addition, EVs in contrast with other loads on distribution networks, are not stationary.

The impact of EV charging will be felt first on distribution grids before the other levels are affected. It is, therefore, DISCOMs would have to evaluate how these will be affected by different numbers of EVs. Further, the number of EVs simultaneously charging will depend on multiple factors, including the time of day (morning/afternoon/evening), type of day (weekday or weekend), weather conditions, EV owner’s requirement etc[4].

IV. EV LOAD AS A FLEXIBLE LOAD

As the EV load penetration increases, their potential to contribute to flexibility services via Demand Side Response (DSR) will also increase. It can play an active role in increasing the flexibility of power systems. By providing flexibility services, it can increase opportunities for integration of variable renewable energy resources into the generation mix, as well as reducing cost associated with the adaptation of power systems to increased EV uptake. The EV load as a flexible load can coincides with RE generation/off- peak time, can also lower the ramping requirements of the remaining generation fleet or can also reduce the peak load. Electricity markets should also facilitate the EV load to participate for grid balancing.

Fundamentally, enabling EVs as a flexible load can happen in three main ways[5]:

• Direct load control, where the utility has the ability to directly control the electricity demand and has the right to discontinue it.
• Dynamic pricing arrangements that provide a price signal directly to customers so they can voluntarily react to the prices.
• Participation through an aggregator in electricity markets where price signals incentivize flexibile/DSR activity of EVs as load.

Direct control and Participation through an aggregator have more control and predictability in comparison to Dynamic pricing arrangements. Participation through aggregator take the responsibility for the DSR / flexible activity of EV loads and may have more predictability.

Vehicle to Grid (V2G): The widespread adoption of EVs and their evolving technologies also allows for envisioning a future in which EVs can feed electricity back into the grid, known as vehicle to- grid (V2G) integration. Electricity distribution companies in US, Japan and China are experimenting with utilization of EVs as grid assets, either by using them as a demand response resource or for providing ancillary services through Vehicle-to-Grid technologies[6]. Theoretically for V2G services, the life of battery can reduce in terms of years of service. However, many V2G trials have shown that if the Depth of Discharge (DOD) is kept above 50% of the battery capacity, the effect of V2G operations on battery life is minimal[7].

To enable EVs to participate as a flexible load in the grid, there is a need that, policy and regulatory frame works are modified suitably. The market must include the presence of ancillary services suitable for EV participation. Dynamic electricity pricing levels needed to incentivise charging behavior. The market may also allow the participation of small loads through aggregators. The direct load control, if implemented, also needs execution of contracts between utilities and consumers.

The changes and modifications in the policies and regulations, to enable EVs as flexible load, are required to be done in a phased manner with different level/size of integration of EVs into the grid. The phase wise implementation of Grid integration of EVs, and regulatory and market requirements may be as follows [5]:

a) Grid-compliant charging

   This is the phase where EVs are connected to the grid for their charging needs, EVs comply with the local requirements and regulations. The charging power is below the thresholds prescribed by grid operators.

b) Level 1 – Controlled charging

   The charging power and timing of charging can be shifted remotely. Dynamic electricity pricing levels needed to incentivise charging behaviour. Smart charging may be introduced.

c) Level 2 –Aggregated controlled charging

   The market may also allow the participation of small loads including EVs through aggregators.

d) Level 3 – Bidirectional charging

   EVs can also feed electricity back to the grid. This allows for the use of EVs as a distributed electricity storage mechanism, and enhances the attractiveness for EVs as a frequency response measure. Bidirectional charging requirements may be included in the standardisation of EVSE and EVs.

e) Level 4 –Aggregated bidirectional charging

   The enhanced flexibility capacities of EVs are managed by aggregators to be able to compete in the flexibility market with larger capacities. Aggregators need to be allowed as a market player, benefits from bidirectional flexibility should be rewarded through electricity market dynamics.

Eight Indian states namely, Andhra Pradesh, Delhi, Karnataka, Kerala, Maharashtra, Telangana Uttarakhand and Uttar Pradesh have issued their individual draft/final electric vehicle policies till June 2019 focusing mainly on manufacturing and deployment of electric vehicles in their respective states. Twelve State Electricity Regulatory Commissions (SERCs) have also issued tariffs for EV charging. These are Andhra Pradesh, Chhattisgarh, Delhi, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh Maharashtra, Punjab, Telangana and Uttar Pradesh. The Joint Electricity Regulatory Commission for Union Territories also issued electricity tariff for EVs in Chandigarh. While Delhi, Punjab, Andhra Pradesh, Uttar Pradesh, Telangana, Chhattisgarh and Madhya Pradesh have refrained from adding fixed charges component to their EV tariffs, Maharashtra, Jharkhand, Haryana, Karnataka, Gujarat and Chandigarh have kept fixed capacity charges. Delhi, Maharashtra, Uttar Pradesh and Telangana have applied “Time-of-Day” (ToD) rebate/surcharge as part of their EV tariffs as a means to influence EV charging behavior.

V. CONCLUSION

Exciting yet challenging times lie ahead. The future electricity systems, with the large capacity of RE generation, would be radically different from today’s systems. It may be dominated by non dispatchable & variable generation and technology enabled flexible load. Though the future electricity systems seems technically feasible, however, it requires identification of appropriate generation, storage (battery and pump storage) and flexible loads at suitable location.

Electric Vehicle as a Flexible load needs potential analysis as a pilot project for future implementation. Regulators may also have to strive to do required regulatory changes for successful implementation of the concept. All the measures well planned and well placed into the system, would certainly help safe, reliable, economic and flexible operation of the grid with different types of energy resources.

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