Use of tariff to modify demand: the concept of Green ToD

Introduction

Demand shifting is one of the three options of load management, the other two being valley filling and peak clipping. For better or for worse, shifting of demand comes down to economics. As a consumer, behaviours like turning the furnace down at night or altering the production process and increasing loads during peak solar generation hours will be driven by a comparison of costs incurred from the shifting and benefits derived from cheaper power during solar generation hours, if that is provided by the DISCOM.

Consider the case of India. The following diagram represents the demand curve of the country (2018-19). The demand curve reflects the activity of a population with respect to electrical power consumption of a typical day over the year, in this case 2019. Apart from the daily variation, the curve varies over different seasons and across geographies. Demand for power is the lowest in the early morning hours and it gradually increases as the day progresses, stabilising in the 140 to 145 GW range during the day. As one approaches early evening it falls a little and then again picks up to reach its peak at around 7.45 pm. The day time demand falls within the solar generation hours - 8 am to 4 pm, to which some of the evening loads can potentially be shifted. A reduced tariff in the form of a Green Time of the Day (ToD) can encourage this shift.

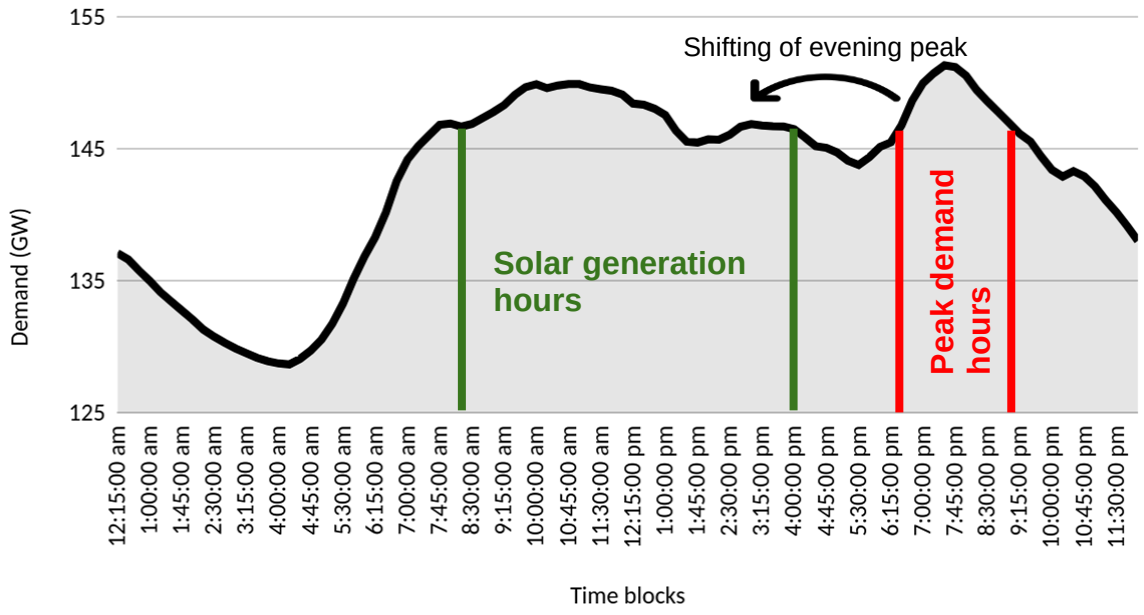

Figure 1: Shifting of demand to solar generation hours

Price elasticity of demand of electricity in India

With 175 GW of RE getting into the grid in the near future, DISCOMs need to work out their tariff structures in such a manner that consumers are encouraged to shift their demand to high RE generation hours. This encouragement can be in the form of a Green ToD in which discounted tariffs are offered during the high RE hours, maybe coupled with higher tariffs for low RE generation hours. The response to such a tariff structure will depend on the price elasticity of demand of the various consumer categories - higher elasticity being positively correlated with higher chances of adoption. Once there is substantial adoption of this tariff structure and demand shift happens within the target consumers, the DISCOM can then deepen this mechanism to cover other consumer categories as well.

Consumption of electricity in the country has been steadily increasing - from 5,53,995 GWh in 2008-09 to 11,30,244 GWh in 2017-18, showing a CAGR of 7.39%. Of the total consumption in 2017-18,

the industry sector accounted for the largest share (41.48%), followed by domestic (24.20%), agriculture (18.08%) and commercial sectors (8.51%)[i]. This is illustrated in the following table.

Table 1: Sector-wise electricity consumption in India

Sectors	**Consumption (GWh)**	**% share**
Industry	468,825	41.48%
Agriculture	204,348	18.08%
Domestic	273,519	24.20%
Commercial	96,184	8.51%
Traction & Railways	14,354	1.27%
Others	73,014	6.46%
Total	**1,130,244**	**100.00%**

The extent to which loads would shift due to the introduction of a Green ToD will depend on the price elasticity of demand of that category of load. In India, the long-term price elasticity at the all-India level is 0.06% which is three times the short-term elasticity at 0.02%. This means that a 1% increase in real electricity price will result in about 0.06% decrease in electricity consumption in the long-run and 0.02% in the short-run. The opposite can also happen i.e., a 1% decrease in electricity price will result in a 0.06% and 0.02% increase in electricity consumption in the long and short term, respectively. Thus, a 1% reduction in tariff during the solar generation hours, in the form of Green ToD, can potentially shift more than 670 GWh in the long term and more than 220 GWh in the short term.

Table 2: Change in demand due to 1% change in tariff

Duration	**Elasticity**	**Potential shift in consumption (GWh)**
Short term	0.02%	226.05
Long term	0.06%	678.15

As the demand for agriculture and domestic, the major consumers apart from industry, is inelastic in nature, it can be assumed that there will be little change in their consumption pattern with small changes in tariff. On the other hand, electricity consumption for industrial loads is highly elastic in nature. The elasticity is higher in the long term as compared to the short term because industry needs to make investments, either capital investments in equipment or into processes, to alter their consumption patterns. Also, changes in demand curves will kick-in only after a tariff change of say 5%, below which the demand will be inelastic. Considering these, with the overall change in consumption within a range of +/- 10% is shown in Figure 2. From the figure one can observe that a reduction of tariff of 10% will increase the overall consumption by 2,260 GWh in the short term and 6,781 GWh in the long term. Similarly, an increase in tariff of 10% will reduce the consumption by the same amount. Considering the price elasticity of demand for the industrial sector double that of the overall price elasticity of the power sector, a reduction of tariff of 10% will increase the consumption by 1,875 GWh in the short term and 5,626 GWh in the long term.

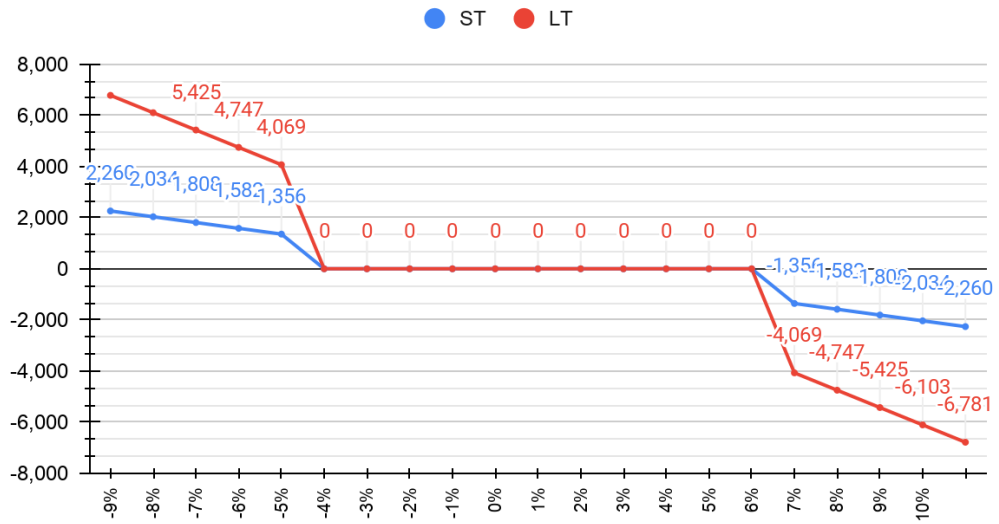

Figure 3: Change in overall electricity consumption with different levels of tariff change

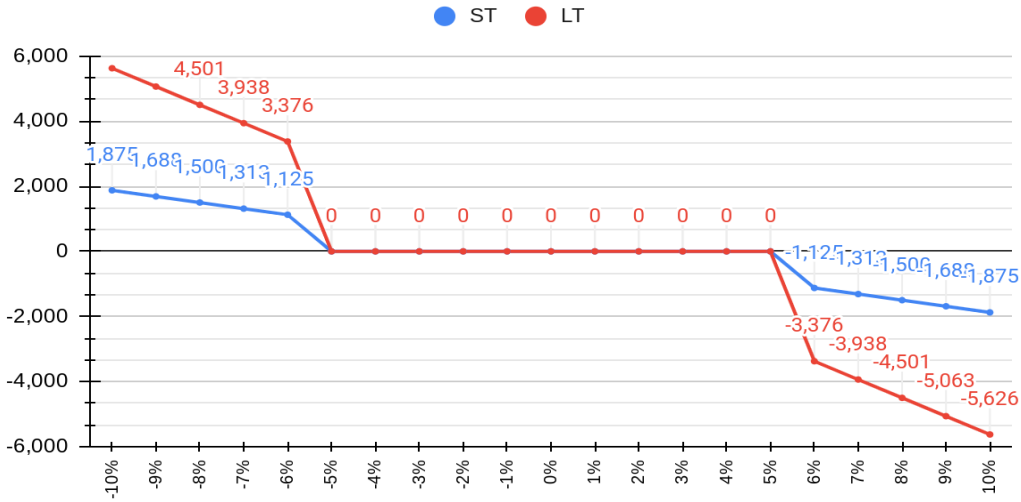

Figure 2: Change in industrial electricity consumption with different levels of tariff change

Which loads can be shifted?

The loads that can contribute to this shift could be of three types as given below – regulated loads, deferrable loads and adaptable loads.

Regulated loads

These are loads power supply for which is regulated by the DISCOMs to certain times of the day when supply is surplus. Such loads can be easily shifted by the DISCOMs to the hours when it gets cheap electricity, in this case solar. Consumers of these loads are accustomed to regulated supply of electricity and changing their practices is expected to be smooth.

Agricultural load

Agricultural load (for irrigation) is one such load. DISCOMs supply power to them during low demand or off-peak periods which are typically at night. Although this helps the DISCOMs to smoothen the demand curve it creates a lot of problems for farmers who have to brave the night for irrigating their fields leading to safety and security concerns and chances of animal attacks. As a response, many farmers keep their pumpset connections on and so that whenever power comes, water gets pumped out leading to over-irrigation. This is not only wasteful from the groundwater point of view but also

leads to a lot of electricity wastage. In many areas, this practice leads to water-logging of fields necessitating their drainage prior to cultivation of subsequent crops. From the DISCOM point of view, these loads are non-remunerative too. With solar generation coinciding with farm activities, DISCOMs can supply cheaper solar power to these consumers which will be welcomed by them.

Karnataka is one such state that has shifted 2,000 MW from night time to solar generation hours. The total power demand for the state is around 15,000 MW of which the share of agriculture is 34% i.e. 5,100 MW and the State intends to shift all of this to the solar generation hours [ii]. With separation of agricultural feeders being undertaken across the country shifting of these loads to solar generation hours can be an option that the DISCOMs may explore with comparative ease. Power supply to agriculture across the country is either free or is nominally priced leading to below cost revenue realisation for the DISCOMs in meeting these loads. Shifting these loads to solar generation hours can reduce the losses that the DISCOMs encounter from this consumer category.

Deferrable loads

A deferrable load is an electrical load that requires a certain amount of energy within a given time period, but the exact timing is not important; it can wait until power is available. Such loads just need to maintain their operating cycle and their starting time can be changed. A Green ToD regime can encourage shifting of the following loads to the solar generation hours. One such example is municipal pumping systems.

Municipal pumping systems

Urban local bodies (ULBs) are entrusted with supply of potable water to citizens. Pumping systems for water supply are generally run in the early morning and/or evening hours. Water supply is the largest expenditure item among all municipal services of ULBs in India. These can be shifted to the solar generation hours tapping the Green ToD tariff which will reduce the electricity bills of the ULBs. The money saved can be channelized for other municipal services like health, infrastructure development, and education. At the same time, it can be used for upgrading the quality of life in urban systems with improved access to basic services like water supply, drainage, and public lighting.

Adaptable loads

Certain consumers, especially large industrial ones, can change their operations to shift some of their loads to hours when electricity prices are lower. Such loads are called adaptable loads. Large industrial consumers are already under existing ToD regimes and changing of operations to take the benefits of lower tariffs under a Green ToD tariff regime might be easy.

Industrial loads

Electricity tariffs for industrial consumers in India, compared on a purchasing power parity (PPP) basis, is among the highest in the world [iii]. The overall demand of this sector is also the highest in the

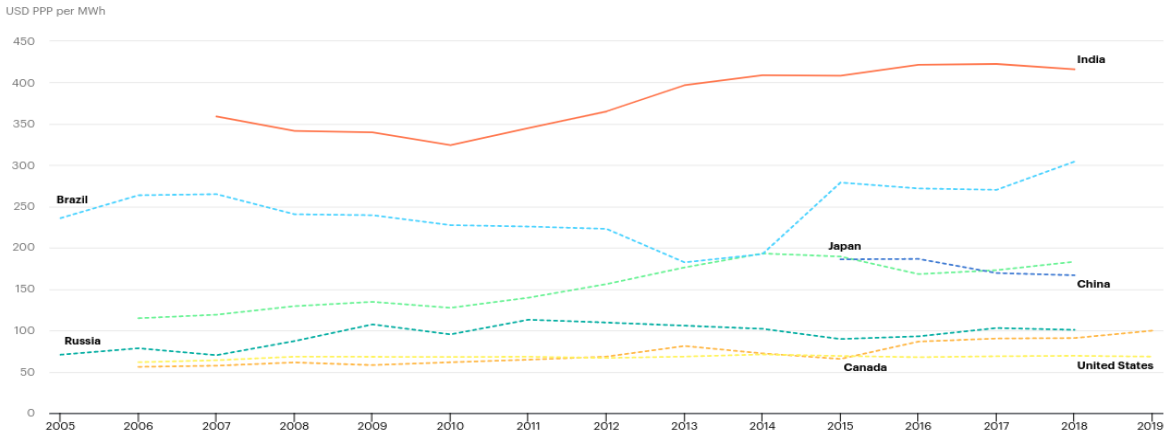

Figure 4: Electricity price across countries on PPP basis

country. Various studies have highlighted that large industrial consumers are the most sensitive to price electricity price changes and hence can be a potential target for Green ToD tariffs. **Industrial washing machines** and **dryers** are such examples. Other such loads are **water filtration**, **reverse osmosis** and **desalination plants** which are modular in nature and can operate at different levels of capacity without compromising on their overall efficiency. These loads can take the advantage of a Green ToD tariff structure to reduce their electricity expense and can be shifted to solar generation hours where the DISCOM offers lower tariffs leading to cost savings of the industry.

Electric vehicles

India has been thinking seriously on electric mobility since the past decade with GoI launching the National Electric Mobility Mission Plan 2020 in 2012 targeted to achieve six to seven million sales of hybrid and electric vehicles year on year from 2020 onwards. In 2016, Piyush Goyal, the then Minister of Ministry of Coal, Power, New and Renewable Energy, announced an aspirational goal of converting all vehicle sales in India to battery electric vehicles (BEVs) by 2030 [iv]. Thereafter, in 2019, GoI outlined its vision "... that 70% of all commercial cars, 30% of private cars, 40% of buses, and 80% of two-wheeler (2W) and three-wheeler (3W) sales in 2030 would be electric"[v]. Considering India's Nationally Determined Contributions (NDC) commitment and 175 GW of solar and wind by 2022 extrapolated till 2030, studies have been conducted to project the demand from EVs for charging till 2030 [vi]. From Figure 5 one can observe that the charging load from EVs can go up to 32 GW on weekdays and up to 25 GW on weekends, both in the evening. This additional evening load will be about 6% of the total peak load by 2030 (480 GW), which though is not substantial, the problem is the timing of the load - it will add onto the existing evening peak demand curve. As EV charging rates are commercial (Rs 8-9 per unit), this will be an additional revenue stream for the DISCOMs, but juxtaposed with solar surplus during the day will present a unique situation to the DISCOMs whereby

it has to balance the demand-supply curves at the cost of foregoing some of this additional potential revenue. Using Green ToD tariffs can be a tool to shift part of this load to the solar generation hours.

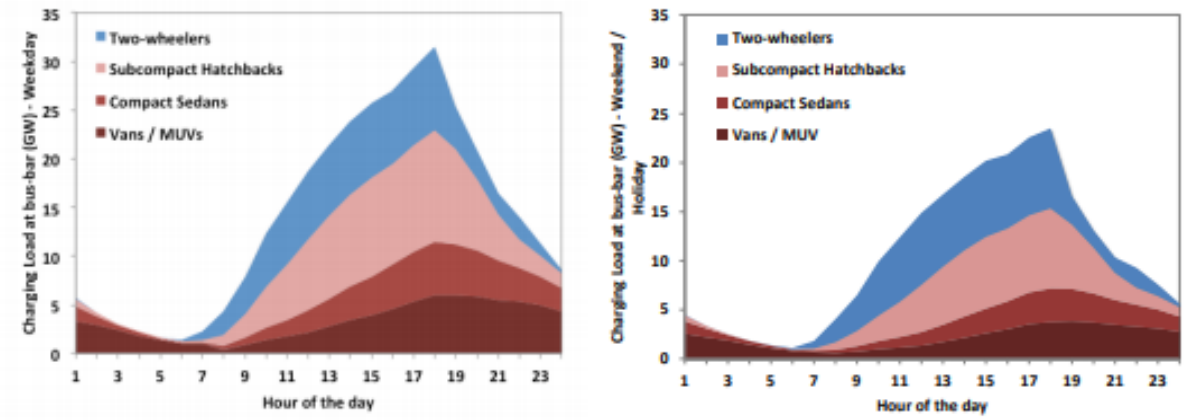

Figure 5: Electricity demands for different vehicles on typical weekdays and weekends
Source: Abhyankar et al.

Conclusion

With higher injection of RE into the grid, the issue of matching the demand and supply curves is becoming increasingly important. While on the one hand innovative procurement solutions like round the clock (RTC) power for RE is being tried out, one also needs to smoothen the demand curves and/or make them more responsive. Use of tariff is one of the tools that can be used by DISCOMs and regulators to modify the demand curves. Green ToD is one such tool. What is needed now is to design such a tariff structure and implement it in a DISCOM area to generate information on price elasticity of various categories of consumers, based on which fine tuning of the structure can be undertaken for wider adoption.

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[i] 'Energy Statistics India 2021 | Ministry of Statistics and Program Implementation | Government of India'.
[ii] 'PM-KUSUM - The Solar Saviour?'
[iii] 'Industrial Electricity Prices in India and Selected Countries, 2005–2019 – Charts – Data & Statistics'.
[iv] www.ETAuto.com, 'Aiming All-Electric Car Fleet in Country by 2030'.
[v] 'Investment of ₹12.5 Lakh Crore Needed to Realise India's 2030 EV Target'.
[vi] Abhyankar et al., 'All Electric Passenger Vehicle Sales in India by 2030'.