Indo-German Energy Forum

Potential for Demand Side Management in Industry

Study by:

KPMG

On behalf of:

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Foreword

Recent national-level studies (both by POSOCO[1] and CEA[2]) for India highlight the benefits of flexible resources for integrating variable renewable energy onto India's electricity system. India's ambitious renewable energy targets (175 GW by 2022 and 450 GW by 2030), which are particularly focused on renewable resource/ RE rich states will face fewer challenges when combined with new planning and operational strategies and technologies. One such strategy i.e., demand response by which the system operator able to shift load throughout a day to minimize system wide production costs. It enables the utilities to reduce peak electricity demands there-by avoiding large investments in generation, transmission, and maintenance of grid security. On the part of consumers, it facilitates a reduction in electricity bills without necessarily reducing electricity consumption. Combined with the increasing intensity of electrification across various sectors and upcoming trends such as EV adoption, DR has emerged to be an integral part of almost all the state and central government missions to promote energy efficiency[3].

However, one must investigate the impacts of increasing demand response capacity under several renewable resource scenarios. Also, the addition of demand response may enable fuel shifting from high-marginal-cost and emissions-intensive subcritical coal and diesel generation to zero-marginal-cost and emissions-free renewable generation. Accordingly, the value that demand response provides to the system increases as the renewable penetration increases. In-addition to reducing production costs and emissions, demand response reduces the time that thermal generators spend at their minimum output levels, which typically represents a less efficient and costlier operational state.

In India, DR is at a nascent stage. It is impeded by factors such as limited consumer awareness and the apprehension of the utilities regarding revenues. With a huge variety of stakeholders involved and the varied responsiveness across different sectors, it becomes pertinent to identify the sector-wise potential of DR. In this context, the report aims to evaluate the applicability of dynamic pricing tariffs by identifying potential industries which could adapt their production processes (as well as large commercial consumers) to the variable energy supply increasingly generated by renewable energy sources such as sun or wind. Such dynamic tariffs could help to develop a new dynamic equilibrium to balance supply and demand, with sufficient flexibility in demand. The explores explore the existing and future potential of demand shift in India. Therefore, the main energy intensive industries are covered in the report, who might be interested in economic benefits from demand shift will be identified based upon how high technical ramping capacity is, up to which extend it would make sense for the consumer to ramp down or, up on demand, duration, notice time in advance and kind of incentives would be required.

The team acknowledges and appreciates the contributions of all industrial customers who shared their valuable inputs in shaping up the report.

1 https://posoco.in/wp-content/uploads/2017/06/National-Study-Full-report.pdf
2 https://cea.nic.in/old/reports/others/planning/irp/Optimal_mix_report_2029-30_FINAL.pdf
3 https://beeindia.gov.in/content/dsm

Abbreviations

TOD	Time of Day
TOU	Time of Use
DSM	Demand Side Management
DR	Demand Response
EC	Energy Charge
HT	High Tension
LT	Low Tension
YOI	Year of Implementation
APPC	Average Power Purchase Cost
CERC	Central Electricity Regulatory Commission
UT	Union Territory
EV	Electric Vehicles
PURPA	Public Utility Regulatory Policies Act
PLEC	Peak Load Exemption Charge

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1. Key Findings

1. A total of 8.7 GW could be shifted by 5 sectors (Iron and steel, Chemical, Aluminium, Textiles and Cement) for up to 2 hours during the peak. The DSR potential of all firms across all sectors is roughly 13 GW (using 2018-19 figures).

   DSR Potential of 5 Key Sectors:

Iron and Steel	Chemical	Textile	Cement	Aluminium	Total DSR Potential of the above sectors
5.2 GW	0.80 GW	0.85 GW	0.82 GW	1.1 GW	8.77 GW[1]

2. For these 5 sectors, roughly 80-90% of the load is expected to operate at a uniform rate with minimum disruptions. Most Iron and steel plants operate at 95% of their peak load during the day, followed by Aluminum and Textiles (at around 85%).
3. All sectors can reduce their consumption for at least 2 hours during the peak. Cement can reduce its demand for up to 4-6 hours (by halting finish grinding), Textiles can reduce its demand for up to 3-6 hours (by switching off some of the weaving units).
4. In terms of DSR incentives, cement can reduce its peak consumption at lower consumption as compared to textiles, iron & steel and aluminum. The latter sectors are very capital intensive and hence are expected to demand higher compensations for load-shifting etc.
5. It was observed across sectors that big firms that serve large market share (such as tata steel, hindalco) have their plants operating at 90% of their peak load during the entire day. Such firms are unwilling to shift load as the opportunity costs (in terms of the risk of production losses) are much higher due to large market size, contractual obligations, brand equity etc. On the other hand, smaller firms in all sectors were found to be much more sensitive to changes in peak and off-peak prices are more willing to shift their processes.
6. An approximate merit-order curve for industrial sectors DR with respect to per-unit incentive of demand reduction is as follows:
7. With regards to the sale of power on the Exchange, most firms are willing to sell their surplus profitably, however, not at the cost of sacrificing their self-consumption. These is because these firms have invested in building generation capacities for the sake of their production. Making profits from the sale of power is not the primary motto of these companies.

Incentive (Rs/Unit)	DR Potential (GW)
Rs 3.5 - Rs 5	3
Rs 5 - Rs 7	4.2
Rs 7- Rs 10	5.6
Rs 10 - Rs 14	7.1
Rs 14 and onwards	8.7

Source: KPMG Analysis, Stakeholder Consultations from 5 key sectors

[1] * The above numbers have been computed using the dataset of 6051 industrial units covered in the CEA dataset. For Iron and Steel, only 62% of the total industrial consumption was captured by the CEA data. Hence the above-reported DSR potential was adjusted/inflated to also incorporate the firms that were not covered in the CEA dataset/firms that do not have captive generation. For Chemical sector, the reported DSR potential is an approximate number for Chlor Alkali as well as Pharmaceutical sector and is subject to minor changes, if required, as per the review of other stakeholders
*For Aluminium sector, the reported DSR potential has been estimated basis the flexibility reported by the KPMG Consultants working in the Aluminium sector. The same is subject to minor changes, if required, as we speak to more stakeholders

2. Executive Summary

In India, power utilities typically respond to demand supply mismatch by adjusting the supply, however increasingly the solution to demand supply mismatch is being looked on the demand side as well, through **Demand response (DR) or Demand-side Response (DSR)**. DR or DSR is broadly defined as a measure for reducing energy load in response to supply constraints, generally during periods of peak demand and in exchange for economic incentives. DR is gaining a lot of attention lately also due to **increasing shares of the Variable Renewable Energy Sources**, **advances in the communication technologies and advent of smart meters** and **increasing electrification of various sectors** such as industry and transport.

In reference to this, the objective of the study was to estimate the DR potential of 5 keys sectors in India: Iron & Steel, Textiles, Aluminium, Cement and Chemicals. The study quantitatively assessed the flexibility in overall production processes of these sectors through stakeholder consultations as well as extensive literature survey. It was found during the course of study that most power intensive firms have started setting up their own captive power plants, either to supplement the electricity purchased from the Utilities, or for emergency use to protect against unreliable grid power such as power restriction/failure/cut. In fact, some big private players in such industries like Tata Steel rely entirely on their captive generation for their electricity needs. Many of such players in power intensive sectors also sell their surplus power, if any, to the Grid or on the Exchange. Also, some of these players such as Shree Cement etc. also have un-utilized stranded capacity in many states. Thus, the players in the industrial sector can participate in DR either by reducing their consumption of grid-power during peak hours (and move it to off-peak hours) or by injecting power into the grid during peak times.

The study found that a total of 8.7 GW could be shifted currently by 5 sectors (Iron and steel, Chemical, Aluminium, Textiles and Cement) for upto 2 hours during the peak whereas the DSR potential of all firms across all sectors is roughly 13 GW for 2021. For all sectors, roughly 80-90% of the load is expected to operate at a uniform rate with minimum disruptions. In case of Iron and steel and Aluminium, major proportion of the production processes is continuous and hence inflexible. Thus, a relatively higher DSR potential for these sectors can be attributed to their higher electricity consumption with regards to other sectors. From a purely technical standpoint, textile sector has a huge potential for demand response as all processes are batch processes. However, due to the high capital intensive natureof the sectors, firms lose out on their overall profitability if processes are halted for a long time. All sectors can reduce their consumption for atleast 2 hours during the peak. Cement can reduce its demand for upto 4-6 hours (by halting finish grinding), textiles can reduce its demand for upto 3-6 hours (by switching off some of the weaving units) whereas aluminium and iron steel can reduce them for upto 2 hours only (since most of their processes are continuous). Firms that serve large market share (such as tata steel, hindalco) have their plants operating at 90% of their peak load during the entire day. Such firms are unwilling to shift load as the opportunity costs (in terms of the risk of production losses) are much higher due to large market size, contractual obligations, brand equity etc. On the other hand, smaller firms in all sectors were found to be much more sensitive to changes in peak and off-peak prices are were more willing to shift their processes. Since these firms do not always operate at their full capacity, the opportunity costs are relatively lower.

In terms of DSR incentives, cement can reduce its peak consumption at the relatively lower consumption as compared to textiles, iron & steel and aluminium. The latter sectors are very capital intensive and hence are expected to demand higher compensations for load-shifting etc. With regards to the sale of power on the Exchange, most firms were willing to sell their surplus profitably, however, not at the cost of sacrificing their self-consumption.

The study found that DSR can accrue 2 kinds of savings:

1. Savings in terms of the investment obviated for building additional capacity in the future to serve peak load, amounting to Rs 1,55,808 Cr between 2021-2030
2. Current and Future Savings from not having to run expensive gas-peakers during peak hours, amounting to Rs 792 Cr and Rs 1284 Cr in 2021 and 2030 respectively.

The study also explores global best practices for implementing Real time pricing (RTP). Currently, none of the states in India have yet implemented RTP tariff due to the absence of operational, technical, and legal/regulatory framework. The study found that while it is technically feasible to introduce a DMP program where the tariffs for industrial consumers can be made equal to or linked to the prices of Day-ahead market or Real-time market on IEX, the industrial sector is unwilling to move to a dynamic tariff regime due to lack of understanding and associated price volatility.

One of the ways of promoting the RTP adoption in states, the fixed charge currently levied on the industrial players must be revised to ensure that switching away from a flat-tariff regime is incentive compatible for the players. Also, since the prices of electricity in the wholesale market fluctuate in different seasons, the fixed cost charged from these players in the dynamic/RTP tariff regime must change (seasonally or quarterly) according from profitability standpoint.

Since the success of RTP tariff is hugely contingent on its design (time-blocks, price setting, price update frequency etc.), proper quantitative simulations must be performed before introducing such a tariff-regime. There is a need for regulators and policy makers to design tariff structures that reflect market conditions, to develop pilot programs, to conduct proof-of-concept in various states etc. to help the industrial players understand the benefits of such a regime, along with its associated technology costs of making real-time adjustments in their power consumption.

3. Introduction with Reasoning for Demand Response

The power sector utilities need to balance supply and demand of the electricity in real time due to lack of economically viable electricity storage technology for large scale power systems. This challenge is compounded by the fact that both demand of the electricity and cost of producing it vary with time in the short interval and in the long run.

Earlier the utilities used to respond to demand supply mismatch by adjusting the supply, however increasingly the solution to demand supply mismatch is being looked on the demand side as well, through **Demand response (DR) or Demand-side Response (DSR)**. DR or DSR is broadly defined as a measure for reducing energy load in response to supply constraints, generally during periods of peak demand and in exchange for economic incentives. In other words, DR is the change in electricity usage pattern of the consumers in response to price signals or other incentives given by the utilities to lower consumption at the times of higher cost of power supply or when system is stressed or imbalanced.

While DR entails reduction in temporary energy consumption during peak hours in short term, other measures such as improvement in energy efficiency etc. that lead to a permanent reduction in demand of electricity are also envisaged as measures to bridge demand supply mismatch. DR and energy efficiency measures collectively help in managing the demand and are hence known as **demand side management (DSM)** measures.

DR is gaining a lot of attention lately also due to following recent changes in the electricity market:

Increasing shares of the Variable Renewable Energy Sources
such as Solar energy and Wind Energy in the electricity generation has led to need for more flexibility requirement in the power system to deal with fluctuations in the marginal cost curve of the electricity generation due to variable and unpredictable nature of the electricity generation from the renewable electricity generation sources. In this regard, the increased power system flexibility from the demand response can be extremely beneficial.

Advances in the communication technologies and advent of smart meters
have enabled two-way communication between the load/consumers and the utilities and real time price signalling to the consumers. This can be used by the utilities to incentivize consumers to participate in demand response to ensure system stability and improve economic efficiency of the electricity market.

The increasing electrification of various sectors
e.g., advent of electric vehicles had led to electrification of automobiles or electrification of heating systems, has opened new possibilities of demand response e.g., utilities can use electric vehicles as decentralized electricity storage devices by incentivizing electric vehicles owners to charge their vehicle during non-peak hours and supply electricity to the grid during peak hours.

An appropriately designed and executed DSR and DSM programmes have short-term and long-term advantages for the consumers, utilities, and the society at large, some of which are listed in Table 1.

Table 1: Short term and long-term benefits of DSR1

	Short Term Benefits	Long Term Benefits
Consumers	• **Lower Prices** during non-peak hours • **More freedom** for consumers to express their preferences by responding to the price signals resulting in **increased consumer surplus** • **Reduced Price volatility** in the Dynamic Price System • **Less load shedding** and outages at peak hours	• **Decrease in the average electricity tariff** due to efficiency gain in the sector • **Better opportunity for long-term planning** about the power usage scheduling to bring the power cost down
Producer/ Investor	• **Increase in producer surplus** as power production shifts from high marginal cost production at peak hours to lower marginal cost production at non-peak hours. • **Access to larger market for renewable energy producers** as consumers can shift their demand according to the variable production characteristics of renewables	• **Less fixed cost** in the long run due the decrease in capacity requirements due to tapering of the peak load demand • **Increase in long term profit** due to access to more demand and lower fixed and marginal cost
Distribution/ Transmission System Operator	• System operators have access to **additional tools to maintain grid stability** as they can also respond from the demand side along with supply side interventions to maintain real time balance between power demand and supply • **Reduction in peak load demand** due to shifting of demand from peak load hours to non-peak hours.	• Lower fixed cost due **to lesser investment requirements in the energy storage systems** for maintaining grid stability • More robustness and flexibility in the grid to respond to unforeseen supply shock in the power production
Society	• **Increase in social welfare** due to increase in producer and consumer surplus due to increased efficiency in the market due to response of market participants to the price signals based on demand and supply situation in the market • **Mitigation of the market power** of the producers and discoms	• **Reduction in the negative externality** of the electricity market due to **reduction in carbon emission** by shift of the electricity demand towards the time when there is good supply of renewable energy • Long term increase in the power systems stability and security

1 "Analyses of Demand Response in Denmark", Risø National Laboratory Ea Energy Analyses RAM, Denmark October 2006

4. Flexibility Options for Power Sectors

Having understood the long- and short-term benefits of DR, this section aims to first explore various power flexibility options and then will focuses on electricity demand flexibility by analysing various kinds of the Demand Response programs that utilities can have for different sections of consumers.

The power system flexibility is the ability of the power system to adapt to rapid and large swings in the electricity generation and consumption in a cost-effective manner to maintain power system stability. Thus, power system flexibility is an integral part of the power system design and operations which ensure temporal balance (balance between electricity demand and supply in the real time) and spatial balance (balance between electricity demand and supply between various regions of the grid) of the electricity network.

The flexibility options in the power systems can be characterised into 4 categories, as discussed in the table below. Among the 4 mentioned categories we will discuss the flexibility options in the electricity demand in details in the next sub-section.

4.1 Demand Side Management

The DSM initiatives can be divided into two major categories:

- **Energy Efficiency -** Initiatives that bridge energy supply demand gap through energy efficiency programmes
- **Demand Side Response -** Initiatives which call for voluntary response of customers to curtail their demand when asked by participating in demand response measures.

This report mainly focuses on Demand Side Response measures for Industrial processes that include turning off non-essential equipment during peak hours without affecting business operations or quality.

4.2.1 Demand Response Strategies

Demand Response is done through inducing following strategies to change the daily demand curve

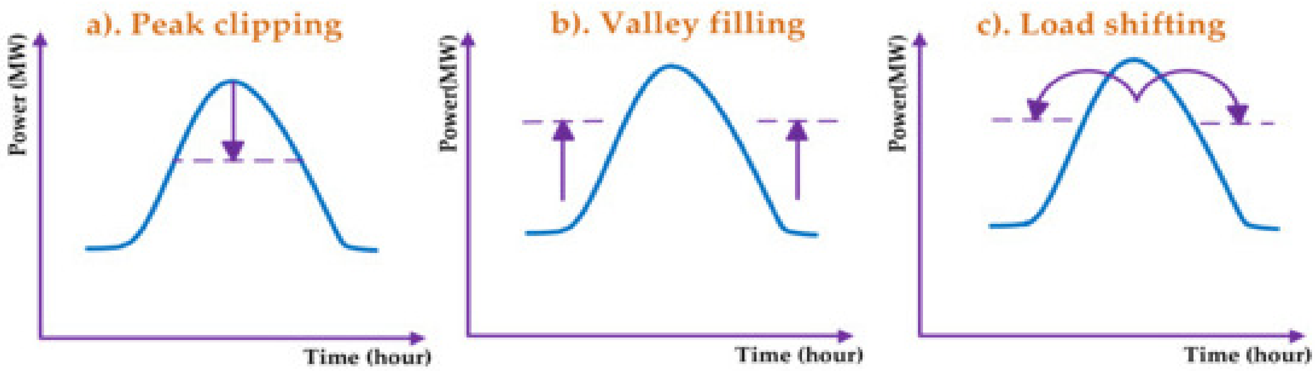
- **Peak Clipping -** Reduction in the peak load demand/ maximum demand of an electrical utility through reduction in peak load demand.
- **Valley Filling –** Increase in the off-peak load to prevent extreme lows in energy demand curve. It is a desirable strategy in the demand management when the utility has excess capacity in the off-peak hours. If this strategy is combined with time-of-day rates, the average rate for electricity can be lowered.
- **Load shifting -** It is a demand management strategy in which electricity consumption is shifted from one time (generally peak demand period) to other time periods (non-peak load period). E.g., postponing an industrial process from peak demand period to non-peak demand period

Table 2: Flexibility options in the power system

S. No	Flexibility Options	Explanations
1.	Flexibility in Electricity Demand	Flexibility provided by Demand Response through load reduction or load shifting by the consumer through two-way communication with the utility
2.	Flexibility in Electricity Supply	Flexibility options provided by both conventional generation systems and Renewables
3.	Flexibility due to Electricity Storage	Enabling time shifting of energy usage from over supply to under supply periods
4.	Flexibility due to Power System and Network	Offsetting fluctuations in electricity generation and load demand over larger geographical area

Figure 1 below illustrates the above-mentioned strategies to change the daily demand curve through demand response

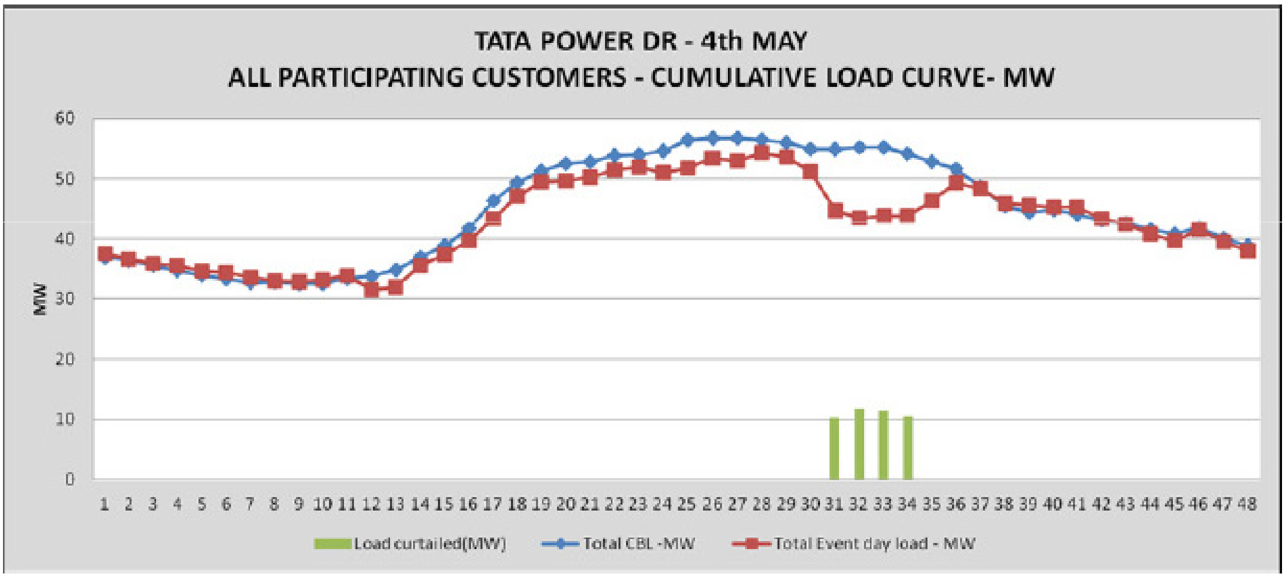
Figure 1: Strategies to change daily demand curve through demand response



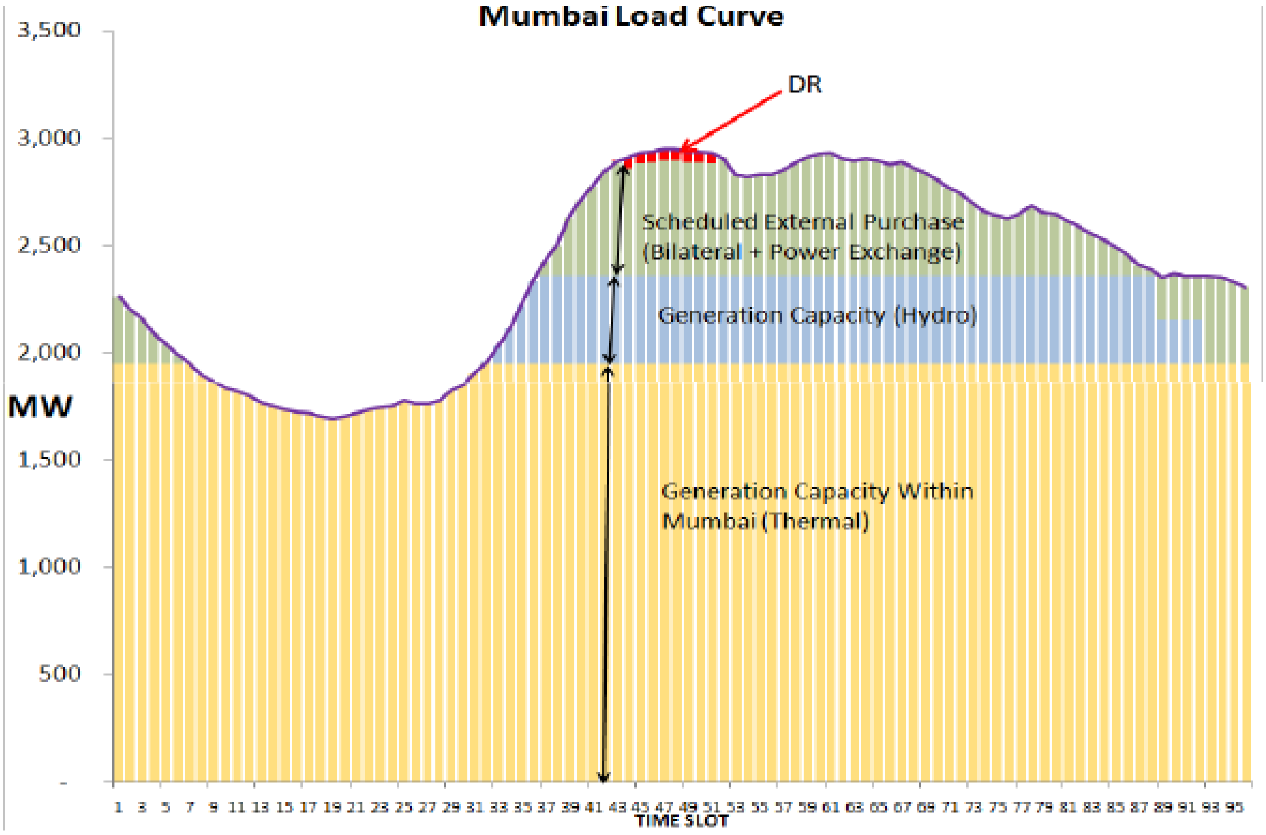
Source: Jabir, H.J.; Teh, J.; Ishak, D.; Abunima, H. Impact of Demand-Side Management on the Reliability of Generation Systems. Energies 2018, 11, 2155. https://doi.org/10.3390/en11082155

Figure 2 below illustrates the practical application of the above-mentioned DR strategies by Tata Power in Mumbai. In the first graph of the Figure 2, we can see that after the DR, the load curve (red curve)) had shown a dip compared to the normal load curve (blue curve) due to the load curtailment (shown in the green bar-graphs). The second graph of Figure 2 shows that implementation of DR programs during the peak hours (highlighted in the red) led to reduction in the peak load requirement and therefore less power purchases on the Exchange.

Figure 2: Illustrative load curve after application of DR2



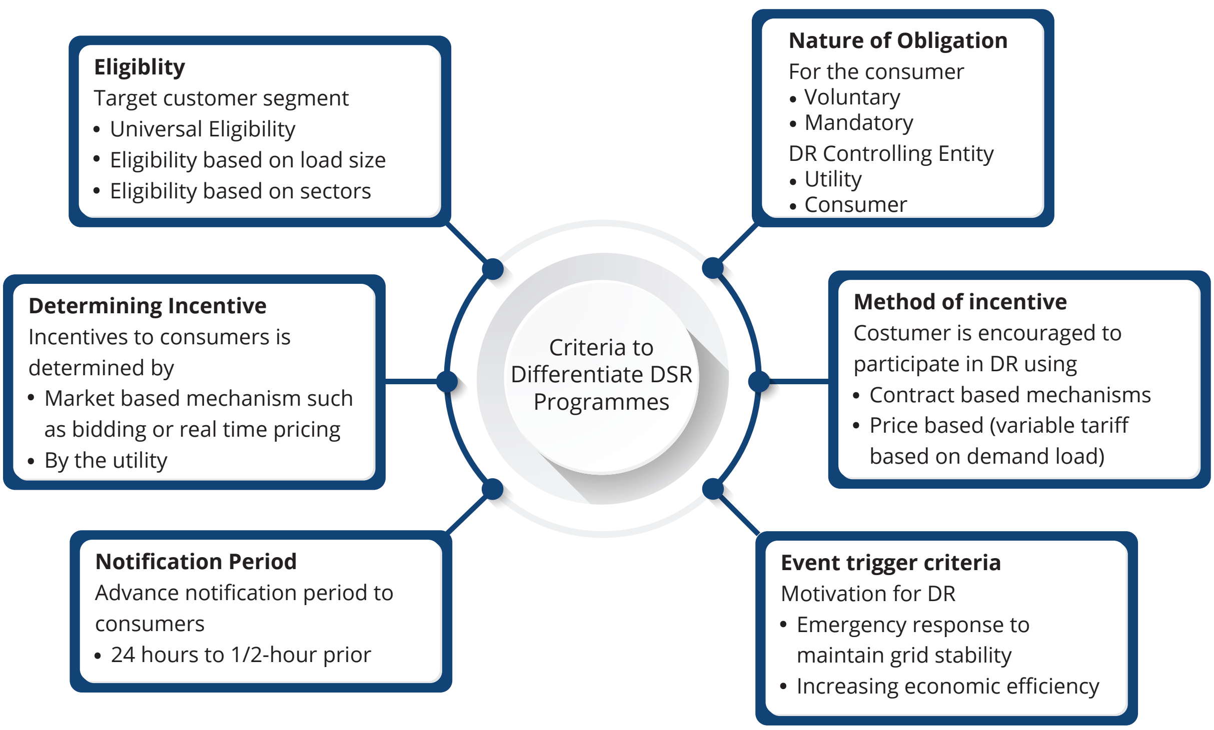
2 Source: "Demand Side Management", DSM Cell TATA Power Mumbai



4.2 Types of Demand Response

There are multiple types of Demand Response programmes which can be differentiated based on various criteria explained in the figure below3

Figure 3: Differentiation of demand response programs



3 "Demand Response – An Introduction Overview of Programs, Technologies and Lessons Learned", Mountain Institute Boulder Colorado, April 2006

Based on the above parameters, one can categorise various DR Programs4. For example, one can classify DR programs as **Incentive based or Price based programs.** The Incentive based DR Programs are called Demand Market Participation Programs.

Demand Market Participation (DMP) – It is a commercial arrangement between the utility and power consumer in which the consumer assists the utility in peak load management by reducing the load in peak demand hours as required by the utility in managing the balance between the demand and supply and the consumer is compensated by the utility for the assistance. The incentive structure for the consumers in the arrangement can be determined by the utility or it could be market based through bidding.

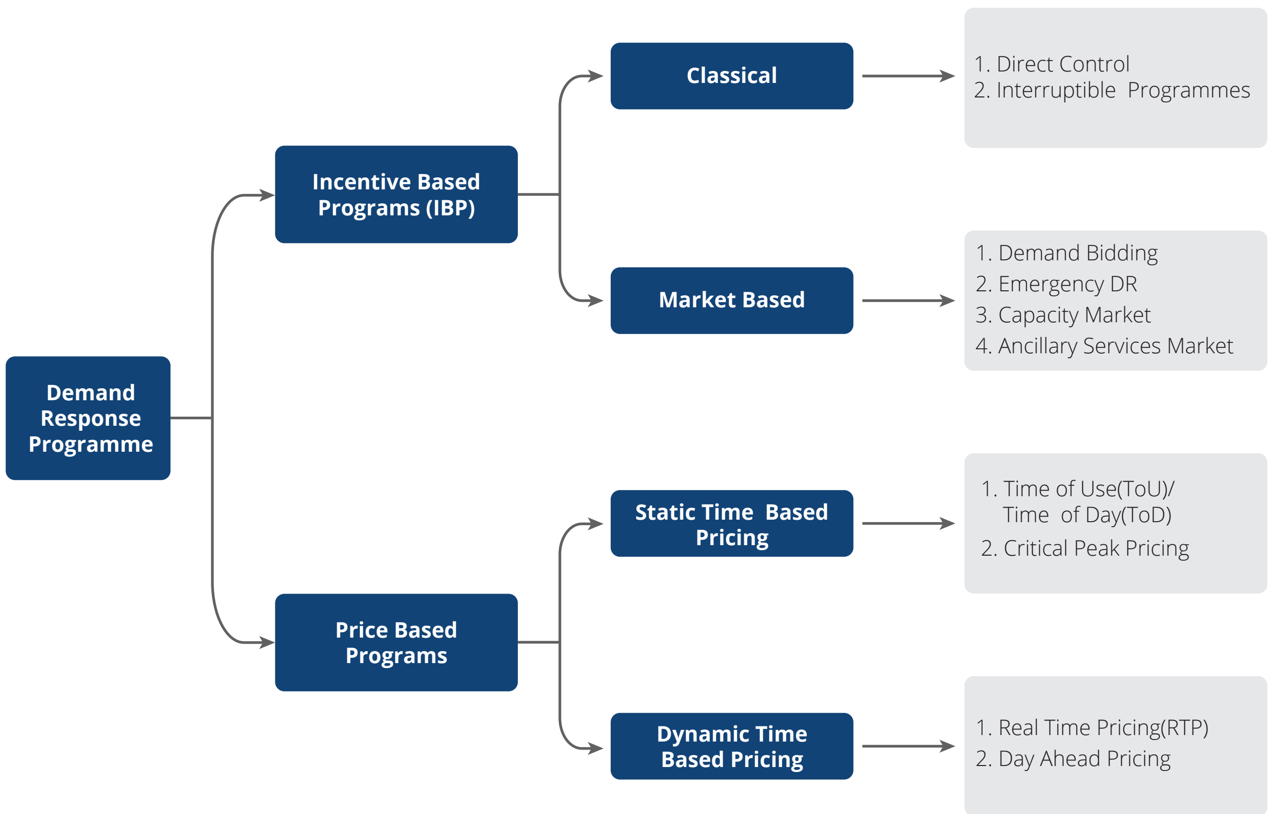
The commercial arrangement can be various types. Some of the possible commercial arrangements possible under demand market participation are following

- **Arrangement 1** – The consumer agrees in advance the amount of electricity that be reduced at a 30-minute prior notice. The consumer may or may not have the right to reject the request depending on the commercial arrangement. Similarly, according to the commercial arrangement, the consumer can vary the amount of electricity to be reduced from the prior agreed amount.
- **Arrangement 2** – Similar to the arrangement 1 the consumer agrees in advance the amount of electricity that be reduced at a 30-minute prior notice. However, in this case the consumer cannot reject the request by the utility to reduce electricity demand. However, may option to resort to using pollution emitting fuels such as paraffin and diesel to run its operations
- **Arrangement 3** – The consumer makes a commitment to reduce a fixed amount of load at the fixed pre-determined times. The load reduction happens without notification.

As shown in the above figure, the incentive-based DR programs/ Demand Market Participation programs are divided further into **Classical DR programs** and **Market Based DR programs.** In the Classical DR programs, the consumers receive participation payment in form of discount rate in tariff or bill of credit while in Market based mechanism the consumers are rewarded based on their performance in terms of amount of load reduction during critical conditions.

The Classical DR programs are further divided into **Direct Load DR Programs** and **Interruptible or Curtailable DR programs**. In Direct Load Programs utilities can shut down participants load remotely at a short notice. These kind of DR programs are more suited for residential and small commercial consumers and typical remotely controlled

Figure 4: Types of Demand response programs



4 "A summary of demand response in electricity markets"; M.H. Albadi and E.F. El-Saadany ; Department of Electrical and Computer Engineering, University of Waterloo, 200 University Ave. W, Waterloo, ON N2L3G1, Canada

equipment could be air conditioners and water heaters. In Interruptible/Curtailable Programs consumers receive upfront incentive payments or rate discounts and are required to reduce their load to predefined values when utilities require them to reduce their load and can face penalties in case of not responding to the utilities' request.

The Market based DR programs are further divided into Demand Bidding, Emergency DR programs, Capacity Market programs and Ancillary Services Market programs.

In **Demand Bidding DR program** consumers bid for specific load reduction in the wholesale markets. On the other hand, in the **Emergency DR programs** the consumers are paid for their measured load reduction during the emergency conditions. Furthermore, in the **Capacity Market DR Program**, costumers commit to pre specified load reduction during system contingencies and usually they receive a day ahead notice of the DR events.

The Ancillary Service Market programs in which customers bid for load curtailment in the spot market as operation reserves for the utilities. Thus, the Ancillary Services Market Programs are like Emergency DR Programs but with faster response. The Ancillary Services Market Programs are two types – **Synchronized Reserves/Spinning Reserves and Frequency Regulation programs.** Synchronized Reserves programs are designed for fulfilling unexpected need for power by the utility at a short notice (generally 5-20 minutes). The Frequency Regulation programs are designed to maintain quality of power supply in the grid by balancing generation and load to keep the grid frequency at the rated level.

The subsequent subsections covers few details about **Price/ Tariff Based DR programs** in which consumers are incentivized in the DR Programs through tariff structure based on marginal cost of power supply and thus having differential tariff for peak and non-peak hours or peak and non-peak seasons. They are unlike **Flat tariff structures** in which the electricity tariff to a consumer remains flat/unchanged throughout day and year. The Price based DR programs are divided between the **Static Time-based Pricing Tariffs** and **Dynamic Time-based Pricing Tariffs**

4.2.1 Static Time-based Pricing Tariffs

Static Time-based Pricing Tariffs are the tariff structures that are pre-determined. Although the tariffs can vary according to the time of the day or year, but the variation is fixed earlier and does not vary according to the current market demand and supply. The various Static Time-based Pricing Tariff structures are following

Flat Tariff – It is a tariff structure in which the per unit electricity tariff remains constant for a consumer even though underlying demand and supply conditions may vary. However, in the flat tariff structure the utilities can charge different flat tariffs for different consumers e.g. Having different tariffs for agricultural and industrial consumers.

It had advantage that consumer has certainty in the tariff structure and can plan his/her electricity consumption accordingly. In addition, the consumers do not have to face very high electricity bills in case of unavoidable and unplanned consumption. However, it has disadvantage that it does provide any financial incentives for the consumers for the demand response.

Seasonal Tariff – It is tariff scheme in there is variations in the tariff with variations in seasons.

The differences in the tariff for different seasons is done to respond to season variations in the underlying demand and supply conditions. E.g., Peak season and lean season in the agriculture or agro-processing industries can lead to variations in the electricity demand. Thus, then there can be higher tariff in the peak season due to higher demand and lower tariff in the lean season due to lower demand.

Time of Day (TOD) - It is a tariff structure in which there are different pre-determined tariffs for different time of the day. E.g., there will be higher tariff during peak hours and lower tariff during the off-peak hours.

The advantage of this tariff structure is that it financially incentivizes the consumer to shift electricity consumption from peak hours to non-peak hours along with providing certainty in the tariff structure to the allow long term planning of the electricity consumption.

Time of Use (TOU) – TOU is similar to the TOD tariff structure in which the peak window hour is shorter in the duration to create stronger financial incentives for the consumers to shift their consumption from peak hours to non-peak hours.

Critical peak pricing (CPP) - It is a kind of Time of Use tariff structure which gives a very strong price signal to incentivize the reduction of excessive peak load. In the pricing consumers are charged a high fixed rate during a few peak hours of the day and a discounted rate during the rest of the day.

4.2.2 Dynamic Time-based Pricing Tariffs

The dynamic pricing is also called **surge pricing, or time-based pricing and demand pricing**. It is a pricing strategy in which the utility set the flexible tariff which is determined by the current market demand. In other words, the tariff rate varies at short time intervals based on the current electricity demand and supply conditions in the market. The various types of Dynamic Time-based Pricing Tariffs are following

- **Day ahead pricing –** It is a type of dynamic pricing in which the market/ power exchange lets buyers and sellers commit to buy and sell wholesale electricity a day before the operating day. It is done to avoid the price volatility and uncertainty of demand and supply of the real time pricing. Hence, it is a kind of forward trading and is different from spot market trading where the buyers and sellers transact in buy and sell electricity in the real time

- **Real time pricing (RTP)-** It is a type of dynamic pricing in which prices of the electricity change at very short interval of one hour or less based on current demand and supply situation.

It involves maximum uncertainty and risk for the consumers. However, it has maximum potential for efficiency gain in the market as the prices will reflect the actual demand and supply scenario, but it requires advance technologies such as smart meters to ensure price signaling in the real time to consumers.

The Table 3 lists the difference between the static time-based pricing and dynamic time-based pricing[5].

Thus, from the perspective of the consumer the quantum of incentive for the demand response must be proportionate to associated price risk. Hence, the dynamic price mechanism due to higher associated price risk must give larger compensation than the static price mechanism. The figure below plots the various DR programs based on their price risk and the proportionate incentive mechanism required[6].

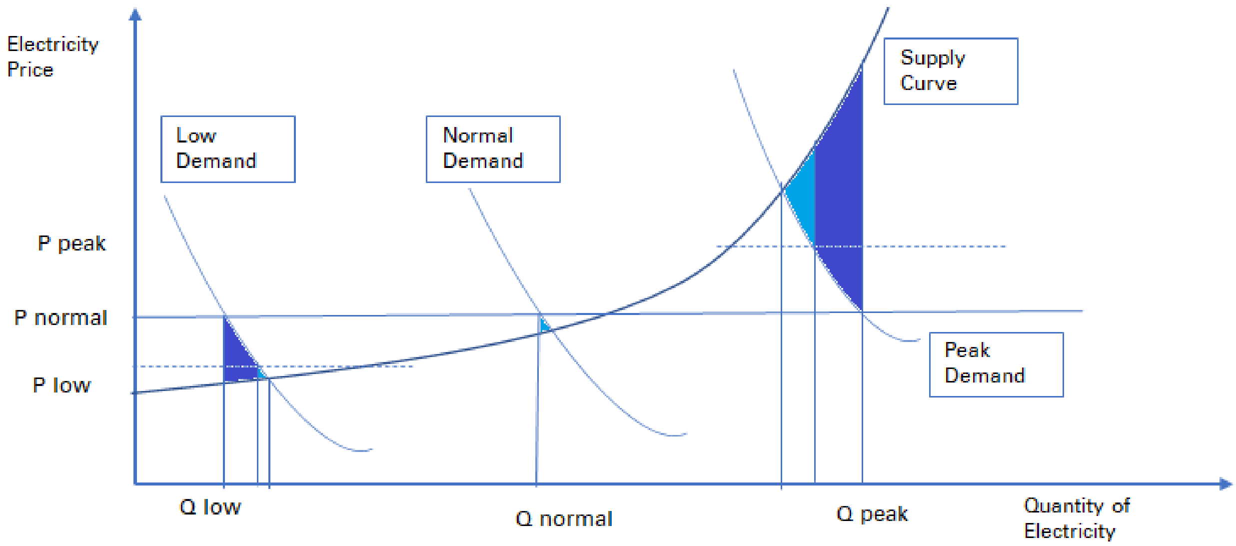
Table 3: Differences between static time-based pricing and dynamic time-based pricing

Static Time-based Pricing	Dynamic Time-based Pricing
Tariff structure is pre-determined and does not vary according to the current market demand and supply.	**Tariff structure** is not pre-determined and **varies according to the current market demand and supply conditions.**
The tariff structure can be **flat or vary according to seasons or time of day** based on peak load estimations of the utility	The tariff structure is **always variable** based on the demand and supply dynamics.
Less price volatility	**High price volatility** especially when supply and demand are inelastic
Lesser potential for the efficiency gain as price signals does not reflect the current market supply and demand. (As shown in the figure below)	**Higher potential for the efficiency gain** as price signals reflects the current market demand and supply. (As shown in the figure below)
Less price volatility leads to **lesser uncertainty** in the market and thus **lower price risk** for the consumer	Higher price volatility can lead to **higher uncertainty** in the market and thus **high price risk** for consumers especially in the electricity markets where there is lack of real time price signalling mechanism e.g., Lack of smart meters and IT infrastructure and high inelasticity of the demand and supply
More suitable for under-developed markets which lack good real price signalling mechanism such as smart meters and markets with inelastic demand and supply.	**More suitable for developed markets** with good real time price signalling infrastructure and elastic demand and supply to respond to the varying price signals.

5 "Analyses of Demand Response in Denmark ", Risø National Laboratory Ea Energy Analyses RAM, Denmark October 2006

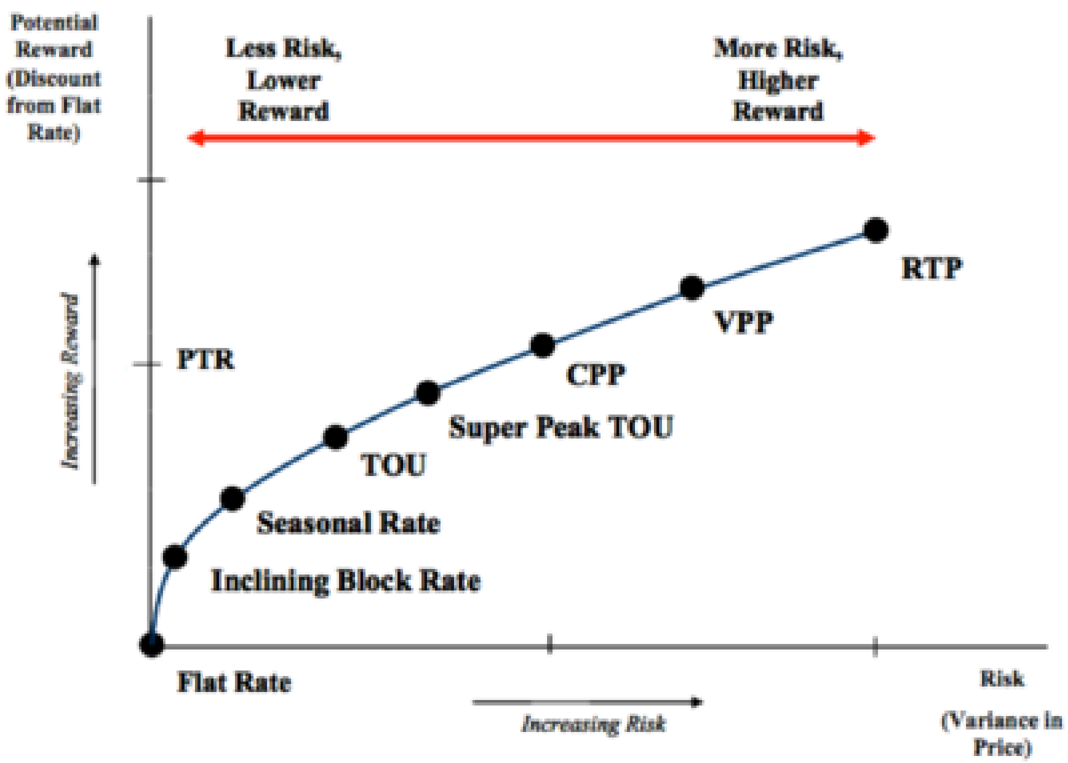
6 "Dynamic Pricing of Electricity: A Survey of Related Research", Goutam Dutta and Krishnendranath Mitra, Indian Institute of Management, Ahmedabad, August 2015

Figure 5: The welfare gains and loss in various tariff structures



Source: KPMG Analysis

Figure 6: Risk-Reward Relationship between various tariff structure



Source: "Dynamic Pricing of Electricity: A Survey of Related Research", Goutam Dutta and Krishnendranath Mitra, Indian Institute of Management, Ahmedabad, August 2015

4.3 Relationship between elasticity of demand and supply and electricity prices Dynamic Pricing

A supply shock of same magnitude leads to higher price adjustment and lesser quantity adjustment in case of inelastic demand and lower price adjustment and higher quantity arrangement in the case of elastic demand. **Thus, higher elasticity of demand and supply in the market leads to lower price fluctuation in Dynamic pricing.** Hence, higher elasticity of demand and supply lowers the uncertainty in the market due to lower price volatility and reduces the price risks for the market participants.

In, addition **the long run elasticity of the demand is higher than short run demand**7 because in the short run consumers respond to the price signals with current infrastructure and equipment but in the long run, they can alter their consumption pattern in response to the price signals by new investments in equipment, storage capacities, etc. E.g., a textile unit cannot respond to higher peak prices in the short run due to higher number of orders but can respond to the higher peak prices in the long run by creating extra storage and production capacity to produce more in the non-peak hours.

Some policy steps taken in India in the recent years to increase the elasticity of electricity demand include:

1. Push for installation of **Smart Meters** to improve real time price signalling mechanism.
2. **Separation of feeders** for the agricultural and non-agricultural consumers in the rural areas to enable demand response in agricultural load which can be shifted to non-peak hours.
3. Improvement in the **digital infrastructure** of the country through Digital India
4. Strengthening and upgradation of Transmission and Distribution infrastructure to create **Smart Grids**

7 "Dynamic Pricing of Electricity: A Survey of Related Research", Goutam Dutta and Krishnendranath Mitra, Indian Institute of Management, Ahmedabad, August 2015

5. Global Best Practices for implementation of real time pricing

In this section, we cover various Global Best Practices of real time pricing to understand the applicability of RTP in the Indian context.

In real time pricing programs, the prices vary on an hourly basis in par with wholesale electricity prices. The prices are announced a day or an hour ahead to allow consumers to manage their electric consumption within a short period of time. RTP enables the prices to reflect marginal costs of energy generation thus contributing to efficiency.

The RTP programs can take various forms. These include one part, two-part, day-type based, temperature based, and block-based programs (as discussed below):

- **One-part RTP program**: The hourly prices are applied to the whole electricity consumption.
- **Two-part RTP program**: The customers are charged for hourly prices only if they deviate from the baseline usage that is defined using their historical electricity usage.
- **Block based programs:** The real-time prices are transferred to TOU block prices, which are calculated by taking the average of the real-time prices of that period
- **Other types:** Some adopt a more detailed scheme for determining the supply charge. These might depend on **season, time of day, and the prior day's temperature**, whether it is a weekday or a weekend, whether it is winter or summer or the daily maximum temperature

5.1 Characteristics of the RTP programs[8]

Some of the characteristics of RTP programs, from literature, are listed below:

- Most of the RTP programs were **voluntary** and not mandatory for the consumers.
- Offering additional **value-added services** such as Load Guard and Central Air Conditioning Cycling etc. increase the customers' willingness to participate in the RTP programs.
- While TOU programs mainly benefits the highly flexible customers (with shorter production), the RTP programs **benefit a wider range of customers** and not just highly flexible ones.
- Two-parts programs **protects inflexible customers** from financial losses, but they limit the potential savings of these customers. These programs can incentivise the consumers to reduce their electricity usage (and thus increase their savings) instead of shifting to off peak periods.
- The day-type based, and temperature based RTP programs are more understandable for customers since they are designed with pre-defined prices. However, these may lead to financial loses of the utilities if the market prices deviate a lot.

5.2 Barriers to RTP adoption[8]

The adoption of real time pricing was hindered until the 90s primarily due to technological limitations. Many RTP programs and pilots were initiated thereafter but widespread prevalence of real time pricing is not yet observed. Some of the barriers relating to RTP implementation include:

- Technological requirements like real time metering equipment adds complexity and expense to metering hardware and administration.
- Communication requirements may limit the types of consumers for whom RTP is suitable, depending on what form of communication is chosen9.
- Some utilities are reluctant to adopt such programs due to speculations of revenue loss following load curtailment during peak periods without load shifting to off peak periods. This can be mitigated by targeting proper customers who can shift their electricity consumption.
- The intrinsic complexity of RTP pricing compared to other tariff modes contributes to lesser adoption.

8 Real-time electricity pricing for industrial customers: Survey and case studies in the United States - ScienceDirect
9 https://link.springer.com/article/10.1057/s41274-016-0149-4

- Consumers are also sometimes reluctant to participate in RTP programs given the choice due to the risk of paying higher bills during price volatility. Consumers with their own generating units and discrete production processes are more responsive to RTP.
- Lack of awareness among consumers and lack of assistance and transparency from the utilities also serves as a major barrier.

To evaluate the potential of dynamic tariffs, the examples of global best practices of the implementation of dynamic tariffs as well as requirements for implementation are demonstrated in Table 4.

Table 4: Global best practices of implementation of RTP tariffs

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Industrial and commercial sector					
• **Southern California Edison** • **Pacific Gas & Electric (PG&E)** • **San Diego Gas & Electric (SDG&E)** • **Los Angeles Department of Water and Power (LADWP)** • **Sacramento Municipal Utility District (SMUD)** • **Southern California Public Power Authority (SCPPA)** • **Northern California Power Agency (NCPA)**	Real time Energy Metering[10] (RTEM Program) (2001 – Present)	California installed 23,000 real-time meters for large customers at a cost of $35 million. One of the objectives of the project was to provide consumers with timely access to their usage data. The utilities designed systems by which the meters were polled each night, and data for the previous day was made available each day on a website[11].	All customers with peak demands greater than 200 kw in the state	In response, summer peak demand by those customers dropped by 500 MW under time-of-use pricing, which would allow the utility to avoid $250 million to $300 million in capacity additions[12].	Discrol (2020), Real-time pricing that integrates more solar power is proven to work in California Beck & Martinot (2004), Renewable energy policies and barriers Christensen Associates eEnergy Consulting, LLC (2005), Evaluation of California's Real-Time Energy Metering (RTEM) Program)

10 https://pv-magazine-usa.com/2020/06/30/real-time-pricing-that-integrates-more-solar-power-is-proven-to-work-in-california/
11 https://www.sciencedirect.com/topics/engineering/real-time-pricing
12 https://www.smartgrid.gov/files/documents/Evaluation_California_RealTime_Energy_Metering_RTEM_Progra_200512.pdf

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Georgia Power Company (GPC)	RTP-DA-213 (1992 - Present)	The tariff has two parts. Firstly, there are standard embedded tariffs and secondly tariffs are imposed on hourly load deviations from the customer baseline load (CBL) which is based upon consumers historical load before going on RTP. The hourly RTP prices are determined by GPC's hourly forecasted marginal cost plus a risk adder. The marginal costs are computed a day ahead (DA), and 24-hourly prices are transmitted to customers around 4 a.m. the prior day. Deviations below the CBL are credited to the customer at the hourly RTP price.	Commercial and industrial customers with a minimum peak demand of 250 KW	Along with other RTP programs of GPC like RTP-HA, the demand response can reach as high as 800-1,000 MW, or 5% of GPC's system peak	Borenstein, Jaske, Rosenfeld (2002), Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets.

13 Dynamic Pricing, Advanced Metering, and Demand Response in Electricity Markets (regulationbodyofknowledge.org)

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Duke Power	Hourly Pricing for incremental load14 (1994-Present)	In each billing period, the customer is charged for the energy usage and billing demand of their CBL at the rates of their otherwise applicable tariff. Energy consumption above/below the CBL in any hour is then charged/credited at the prevailing hourly price for that hour. Customers enrolled receive a monthly credit based on the difference between their CBL and their Firm Contract Demand.	Customers with a contract demand of at least 1 MW	Analysis of price response during summer months indicated that participants reduced their load by 150 MW to 200 MW (or 25% – 33% of their peak demand) at prices of \$0.25/kWh and higher. After the hot summer it was found that about half are price responsive. The greatest price response was exhibited by customers with large batch processes that can be rescheduled relatively easily (e.g., steel manufacturers with arc furnaces) and those with onsite generation. Overall, it was successful in reducing nearly 1% of the utility's peak15.	Barbose, Goldman (2004), A survey of utility experience with Real time pricing Hirst and Kirby (2001), Retail-load participation in competitive wholesale electricity markets

14 Microsoft Word - LBNL-54238_EMP website-1.doc (lbl.gov)
15 (PDF) Retail-Load Participation in Competitive Wholesale Electricity Markets (researchgate.net)

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Kansas City power and light	Schedule RTP and Schedule RTP-Plus 16(1995 - Present)	The price is equal to a weighted average of the "effective energy charge" of the otherwise applicable tariff and the projected hourly marginal costs. The effective energy charge in a particular hour incorporates both the energy charge of the standard tariff and any incremental billing demand charge that would be accrued if the customer were taking service under the standard tariff. Customers are notified of hourly prices by 4 PM, the day prior.	Available to customers with a maximum annual demand of at least 500 kW	The maximum load reduction is estimated to have been 16.2 MW when the hourly price reached $0.94/kWh. This occurred when fourteen customers were on the tariff, with an aggregate peak demand of approximately 30 MW. The maximum load reduction was 54% of the participant's peak and 0.4% of the utility's peak.	Barbose, Goldman (2004), A survey of utility experience with Real time pricing

16 https://eta-publications.lbl.gov/sites/default/files/report-lbnl-54238.pdf

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Southern Company (Gulf Power)	Rate Schedule RTP[9] 1995-Present	Hourly energy prices are based on the day-ahead hourly forecast of Southern Company System. Embedded generation and transmission costs are recovered through a multiplier (derived from the class average load profile). Fuel costs and embedded distribution costs are recovered through a fixed adder. Hourly energy prices are communicated to customers by 4 PM for the next weekday17	Customers with an annual peak load not less than 500 kilowatts (kW) for the previous 12 months	An analysis of participants' price response during summer 1998 was conducted as part of the pilot tariff evaluation (Gulf Power Company, 1999). This analysis revealed that the maximum load reduction achieved was 23 MW, when prices reached $0.70/kWh. This represents a reduction of about 15% relative to participants' aggregate peak demand of 140-150 MW. At more moderate prices of $0.15-30/kWh, load reductions were in the range of 5-10 MW, or 3-4% of peak demand. It constitutes 1% reduction of peak demand of the utility.	Wang & Nezamoddini (2017), Real time electricity pricing for industrial customers: Survey and case studies in the United States Gulf Power (2019), Rate Schedule RTP Limited availability real time pricing

17 https://www.gulfpower.com/content/dam/gulfpower/us/en/pdf/rates/business/rtp2.pdf

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Residential customers					
Commonwealth Edison (ComEd)	Hourly pricing (2007 – Present)	The day ahead prices are provided to the consumers each evening these serve as advisory prices. The consumers are billed based on the actual real time prices on the next day. The participants are provided with information and general tips for reducing electricity costs, access to electricity price updates online and by phone, real-time and predicted day-ahead price alerts, and online analysis tools for managing electricity usage18.	All residential customers under ComEd	The pilot carried on prior implementation showed that a price increase of one standard deviation (1.5 cents per kWh) led to a reduction in electricity use equivalent to one in four households turning off a 75-kWh lightbulb. Additionally, having a Pricelight reduced households' electricity use at prices above 10 cents/kWh, suggesting that making it easier for households to learn electricity prices may lead to conservation. At the highest priced hours during the evaluation, having a Pricelight reduced consumption by 200W, the equivalent of one in five households shutting off a window air conditioning unit19.	Power Advisory-Ontario Energy Board (2014), Jurisdictional Review of Dynamic Pricing of Electricity Allcott, Hunt. (2011), Rethinking Real-Time Electricity Pricing.

18 https://www.oeb.ca/oeb/_Documents/EB-2004-0205/Power_Advisory_Report_RPP_Jurisdictional_Review.pdf
19 https://www.povertyactionlab.org/evaluation/real-time-pricing-reduce-electricity-use-united-states

Discom	Name of tariff program (Date)	Characteristics of specific dynamic RTP	Participating entities	Key findings/ demand response achieved	Source
Ameren Illinois	Power Smart Pricing20, 21 (2007 - Present)	Power Smart Pricing is an hourly electricity pricing program for residential customers served by Ameren Illinois. The price paid for electricity varies hour by hour based on actual market prices. Power Smart Pricing uses "day-ahead" prices, meaning the price for each hour of the day is set the night before. The bill is calculated using the hourly, day-ahead market prices and the corresponding hourly usage.	All residential customers under Ameren Illinois	The program has been successful in reducing peak demand in the 15% range and achieving bill savings that averaged in the 10 to 15% range.	Star, Isaacson, Haeg, Kotewa (2010), The Dynamic Pricing Mousetrap: Why isn't the world beating down our door?

5.3 Special role of demand response providers

As seen in the earlier section, garnering customer interest away from traditional DR programs towards sophisticated initiatives like RTP would require the mitigation of costs and risks the customers must bear. Although costs of metering and load control equipment can be borne by the utility, the consumers' exposure to performance penalties remains a constant. This can be taken care by an aggregator between the customers and utilities to guarantee load responses thereby relieving the utilities from penalizing customers for their failure to curtail loads.

Load aggregators or demand response providers have been successful in removing many of the traditional barriers to demand response participation. They typically also pay all the costs for installation of metering and load control equipment thereby making participation for the customer a no-cost proposition. Furthermore, since load aggregators are measured on the total load reduction their entire portfolio of sites provides, and not on a site-by-site basis, they are able to pool resources in a way that ensures that contract performance requirements can be met. If performance penalties are assessed on the aggregator, many would still refrain from passing these onto the customers[22].

Demand response providers, also known as aggregators, enter contracts with many companies in a certain utility territory. They aggregate these companies into a large block of curtailable demand which increases the impact of their contract portfolios[23].

20 https://www.aceee.org/files/proceedings/2010/data/papers/1967.pdf
21 https://energynews.us/2016/05/04/in-illinois-real-time-pricing-saving-utility-customers-millions/
22 https://www.osti.gov/servlets/purl/1212423
23 https://news.energysage.com/demand-response-programs-explained/

Some of the major demand response solution providers for grid reliability have been provided in Table 5.

Table 5: Demand response providers worldwide

Demand response provider	Capabilities
EnerNOC24	It is a Boston Based company. It has 6.3 GW global demand response capacity with more than 8000 customers worldwide. EnerNOC also provides energy intelligence software that allows businesses to enhance efficiency of the facility. EnerNOC had forayed into Japan in December 2013 by forming a joint venture with trading firm Marubeni, named as EnerNOC Japan, KK to provide demand response service in the country. In late January, EnerNOC won a contract to deliver 217MW of demand response resources in Ireland.
Honeywell 25,26	It provides demand response solution to residential, small businesses and large industrial and commercial customers. It is one of the major providers of automated demand response (ADR) which offers a two-way communication solution to utilities for managing energy demand effectively. In May 2015, Honeywell, and Tata Power Delhi Distribution (TPDDL) deployed an automated demand response project for commercial and industrial plants in India.
Eaton[18]	Headquartered in Dublin, it is a power management company which offers hardware, software, and service to provide energy consumers with a portfolio of demand response alternatives. Their demand response management software supports two-way load control switches and smart thermostat solutions.
Siemens[18], 27	It provides a software platform for demand response management system (DRMS). It enables the utilities to manage their DR programs through a unified open standards-based system. They have deployed DRMS at several utilities.
Itron[18], 28	It integrates services to electric utilities which implements demand response and energy efficiency programs with 'Openway Riva' solution to help the utilities to connect with homes to improve distribution and operational & energy efficiency.

24 https://www.enelx.com/n-a/en/for-businesses/products/demand-response; https://www.greentechmedia.com/articles/read/top-5-demand-response
25 https://www.nsenergybusiness.com/news/major-demand-response-solution-providers-grid-reliability/
26 https://www.eaton.com/us/en-us/products/utility-grid-solutions/demand-response.html
27 https://www.businesswire.com/news/home/20161103005090/en/Siemens-and-AutoGrid-Rank-as-Top-Providers-of-Demand-Response-Management-Systems-in-Navigant-Research-Assessment
28 https://www.itron.com/na/solutions/what-we-enable/dem

6. Current Initiatives and Legal Framework for DSM in India

In this section we investigate the existing legal situation in India regarding DSM and steps taken by various Discoms in this regard.

The current legal framework for the power sector in India is the **Electricity Act 2003.** The features of the Act relevant for DR is given the flowchart in the next page.

In addition to the Act, some relevant sections regarding DR and RTP in the key policies related to the power sector are listed below29.

National Tariff Policy: The relevant provision of the National Tariff Policy, that defines the two-part tariff components and their applicability in DR as under:

"8.4: Definition of tariff components and their applicability
Two-part tariffs featuring separate fixed and variable charges and Time differentiated tariff shall be introduced on priority for large consumers (say, consumers with demand exceeding 1 MW) within one year. This would also help in flattening the peak and implementing various energy conservation measures."

National Electricity Policy: The relevant section of the National Electricity Policy with respect to promoting metering for TOD is following:

"5.4.9: The Act required all consumers to be metered within two years. The SERCs may obtain from the Distribution Licenses their metering plans, approve these, and monitor the same. The SERCs should encourage use of pre-paid meters. In the first instance, TOD meters for large consumers with a minimum load of one MVA are also to be encouraged. The SERCs should also put in place independent third-party meter testing arrangements".

FOR recommendations: FOR has also given the following recommendations in its Working Group Report on "Metering Issues" which is relevant for DR:

"Time of the day metering is important while propagating and implementing Demand Side Management (DSM) and achieving energy efficiency. Hence, TOD metering and automatic meter reading system should be introduced wherever it has not already been done. High-end consumers with the connected load of 25kW and above should be covered under TOD metering."

CEA regulations: Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 have stated the following with respect to TOD metering:

"Adoption of new technologies - The distribution licensee shall make out a plan for introduction and adoption of new technologies such as pre-paid meters, time of the day meters (TOD), automatic remote meter reading system through appropriate communication system with the approval of the Appropriate Commission or as per the regulations or directions of the Appropriate Commission or pursuant to the reforms programme of the Appropriate Government."

29 "Assignment on Implementation & Impact Analysis of Time of Day (TOD) tariff in India", PricewaterhouseCoopers India Private Limited Regulatory Economics Advisory

Table 6 characterises the electricity act, 2003 and Table 7 lists the initiatives taken at the State level by the state regulators and Discoms to enable DSM.

Table 6: The Electricity Act, 2003

Generation and Transmission	Distribution	Consumer Protection	Tariffs and Market Development	Institutional Reforms
Generation delicensed **Captive Generation** • Captive Generation is free from control • Open Access to Captive Generating Plants subject to availability of transmission facility **Generation from Non-Conventional Sources** To be promoted through **a Prescribed minimum amount of Power purchased from Renewables Sources** **Transmission Utility** At Centre and States for development of Transmission system **Load Dispatch Centres (LDC)** To be in the hands of PSU or Gov. organizations due to their critical role in maintaining Grid stability and neutrality between various stakeholders **Transmission Companies licensing** To be licensed by an Appropriate Commission **Open Access to Transmission Lines** To be provided to distribution licensees and generators companies	**Distribution Licensing** by SERC **Freedom to choose** Generating companies by the Distribution Licensee and vice versa to enable private sector participation without government guarantee **Retail Tariff** to be determined by the Regulatory Commission **Open Access in distribution** to be allowed by SERC **Metering** made mandatory In addition to wheeling charges, **provision for surcharge** in Open Access is allowed but encouraged to be phased out slowly **Distribution Licensee** can undertake generation and Generation companies can take distribution licenses **Segregation of Retail Supply from Distribution** and bringing in multiple supply licenses in the 2014 Amendment Endeavor to ensure **electrification of all villages** through **National Electricity Policy** notified by the Central Government	**Connection** must be given **to consumer within stipulated time** and penalty in case of failure **Redressal Forum** to be constituted by every distribution licensee for consumer grievance redressal under **Ombudsman Scheme** Constitution of **District level Committee** to **coordinate and review** quality of power supplied, consumer satisfaction and progress in electrification in the district **Measures against Electricity theft** • Shifting focus criminal proceeding to **revenue realization** • Provision for **compounding of offence** • Theft **punishable by imprisonment** • **Special courts** Provision for **suspension/ revocation of licenses by the Regulatory Commission in case of non-performance** on the performance standards set by Regulatory Commissions	**Regulatory Commission will determine** the **electricity supply tariff** for generating companies on long/ medium term contract **No tariff fixation by Regulatory Commissions** if **tariff is determined through bidding** or when consumers enter open access agreement with generators/traders **Cross subsidy to be progressively reduced** and tariffs should move towards actual cost of supply **State government can provide targeted subsidy support** through budget **Power trading** is **permitted with licensing** **Regulatory Commission may fix ceiling on trading margins** to avoid price volatility **LDCs and Transmission Utilities cannot participate in trading** to facilitate genuine competition	**Mandatory Constitution of State Electricity Regulatory Commission (SERC) for** State level regulation and continuation of **Central Electricity Regulatory Commission (CERC)** established under 1998 Act for central level regulation Provision of **Joint Commission** by more than one state/UT Creation of **Appellate Tribunal** to **hear appeals against SERC orders** and general supervision over them. **Appeals against Appellate Tribunals** to lie before Supreme Court **Central Electricity Authority** to continue as **technical advisor** for Gov. of India and State Gov. It is responsible for **setting technical and safety standards and overall planning** of the sector. **Restructuring of State Electricity Boards (SEBs)** • **Flexibility to States** to adopt model reform paths • Provision of **transfer scheme** to create **one or more companies from SEBs**

Table 7: **DSM Initiatives by the States30**

S. No.	States	Initiatives
1	**West Bengal**	**Initiatives of WBSEDCL (West Bengal State Electricity Distribution Company Limited)** • Mandatory TOD tariff for new industries with contract demand of 50KVA and above. • Additional rebate to consumers on load factor • Rebate to industrial consumers peak load shifting • Retrofitting of streetlights to LED Lights • Village awareness campaign for LED Lights • Investment Grade Energy Audit Implementation Programme • Segregation of Agricultural Feeders • Peak Load Management (PLM) **Installation of Advanced Metering Infrastructure through Smart Grid Pilot Project** • Initiatives of CESC Power Utility Company • Small scale pilot project on DSM • Lighting Load Plan • Scheduling of curtailable loads of target sectors according to system demands
3	**Jammu and Kashmir**	**J&K Energy Conservation Act** • A ban on use of incandescent lamps in all new buildings constructed in Public sector. • A Memorandum of Understanding (MOU) between J & K Gov. and Bureau of Energy Efficiency (BEE) for DSM and Energy Conservation and DSM activities • Funds allocated to Energy Efficiency Services Limited (EESL) for providing consultancy support to the Utility for Load Survey, Load Research, Load Strategies and Development of DSM action plan. • Financial support to JKPDD for engaging training agency and organizing workshops for capacity buildings for its officials. • National Level Workshop for dissemination of DSM measures • Awareness campaigns • Replacement of all non-functional Sodium Vapour Street Lighting Lamps to LEDs.
4	**Madhya Pradesh**	**Creation of DSM Cell** • A study to implement Agricultural DSM project in 11 KV feeders which are supplying predominantly to Agricultural consumers of 2 districts of Narsingpur and Rewa. • Awareness Programmes • Replacement of conventional bulbs with LED for households and street lighting
5	**Jharkhand**	The Discoms have been submitting the DSM reports to SERC

30 "Report of the Working Group on Demand Side Management", Forum of Regulators, October 2017

S. No.	States	Initiatives
6	**Assam**	• Distribution of over 19 lakh CFL lamps to rural consumers • Installation of 3 star rated (energy efficient) transformers • Monitoring consumption of high value consumers • Central HVCMS project (High Value Consumer Management System) • Proposed Smart grid pilot project includes DSM initiatives such as segregating consumer load under essential/non-essential etc. • Installation of 2 kW LT rooftop solar PV at Rajiv Bhawan, Guwahati under a net metering arrangement • Phase-wise Installation of Pre-paid meters • Three-tier Time of day (ToD) tariff for four categories of High value consumers namely HT-I Industries, HT-II Industries, Tea, Coffee and Rubber and Coal categories • Power Factor (PF) incentives and penalties for the HT industries to incentivize reduction in the reactive power requirement to increase the efficiency of generation plants. • Enrolment of Assam Power distribution Company Limited (APDCL) under BEE funded DSM programme. • APDCL has appointed Energy Efficiency Services Ltd (EESL) to provide consultancy service to prepare DSM master plan. • The DSM plan may have the following components: - • Domestic Sector - DELP (Domestic Efficient Lighting Programme) and Energy Efficient Fans • Municipalities and Commercial Sector- Energy Efficient Street Lightening Programme and Energy efficient pumps Programme • Government Buildings - ECBC Plan
8.	**Manipur and Mizoram**	• Partial Adoption of the FOR Regulations. • Surcharge for failure to maintain Power factor within the limits is specified in the Tariff Order. • Banning of use of incandescent lamps and conventional chokes in Govt. buildings of Mizoram • Mandatory use of solar energy for heating water in the Hospitals, schools, guest houses etc. in Mizoram.
9.	**Tamil nadu**	• Discom, Tamil nadu Generation and Distribution Corporation Limited (TANGEDCO) formed the Demand Side Management cell in 2003. • Demand Side Management Regulations 2013 by the SERC • Formation of sub-cells at Regional and Circle levels by the Discoms to coordinate with the cell at their Headquarter office. • Load Research study conducted by TERI for the Discoms • Distribution of CFLs to all hut services • Replacement of florescent tube lights with LEDs • Awareness activities such as energy conservation day/weeks • Capacity building of DISCOMS by BEE.

S. No.	States	Initiatives
10.	**Delhi**	• Creation of dedicated Demand Side Management and Energy Efficiency (DSM & EE) Group by Discoms take up DSM related programs which will include following components – To manage electricity demand – Encouraging change consumer electricity consumption pattern with respect to both timing and level of electricity demand – Complementing supply side strategies with DSM – Reduction of the environmental damage – Supplement national level efforts regarding DSM programmes – Enabling lasting structural or behavioural changes in the market for the adoption of energy efficient technologies, services, and practices – Load Research and potential DSM studies to understand the consumer Load Pattern and the peak occurring intervals and then identification of various schemes based on them • Summary of major DSM projects implemented - – **Bachat Lamp Yojana (BLY)-** Aimed at large scale replacement of incandescent bulbs in households by offering residential consumers CFLS at Rs 15 in exchange of working incandescent bulbs. The project is implemented in 6 districts and over 8 lakhs CFLs had been distributed. – **Appliance Replacement program** for old Refrigerators and Air conditioners. Under the scheme energy efficient star rated refrigerators and ACs were offered at the discounted rates from the market price in exchange for existing appliances – Pilot for Discount based scheme for Sun reflect paints conducted on one of the TPDDL building. A decrease of 5 °C in room temperature and 8 % energy savings was observed. – A discount-based scheme by Discom in association with LED manufacturers in which 7 W LED bulbs were offered at Rs 250 with 3 years warranty. Over 7200 bulbs were distributed under the scheme. – **Delhi Jal Board (DJB) Peak shifting-** Discom after load profiles analysis suggested DJB to shift its morning operation hours for water pumping station by 2 hours. This has helped in peak load reduction of 2 MW. – Policy advocacy for Bank ATMs – Dialogues with Ministry of Environment and Forest (MoEF) resulted in MoEF issuing guidelines to all the major banks in Delhi to ensure optimal temperature setting of the ACs in their ATMs. • Public information campaign and customer outreach programs at various forums such as RWAs, Consumer meets. • Preparation and distribution of energy conservation booklets and leaflets amongst internal and external stakeholders. • Organization of Renewable Energy Fair in association with State Designated Agency (SDA)
11.	**Haryana**	• Constitution of the DSM cell by the Discoms • Appointment of consultants by Discoms for conducting Load and Market Research studies. • Discoms to implement best practices like DSM based efficient lighting programme (DELP), Mu-DSM for street lighting etc.

S. No.	States	Initiatives
12.	**Maharashtra**	• The Cost-Effective Assessment Regulations 2010 to assess the cost effectiveness and prudence of the government expenditure had specified the criteria for the various DSM programmes and schemes. • DSM schemes under DSM regulations are as follows: - – Energy Efficient Lightening Programme – Thermal Energy Storage Programme – Five Star rated Ceiling fan Programme – Five Star Split AC programme – Five star rated Refrigerator Programme – Demand Response Programme – Energy Audit Programme – Standard Offer Programme – Agricultural DSM Programme – Domestic Efficient Lighting Programme (DELP)
13.	**Gujarat**	• Establishment of DSM cells by all Discoms. • Appointment of TERI as a consultant by all Discoms for preparation of DSM plan. The plan includes following DSM programmes – – LED Lamps – EE Plan – Solar Plans – Automated Switches for Capacitors – Energy Audits – Energy Efficient Pump set • Direction by SERC to each State owned DISCOM to contribute Rs 50 Crores in next 2 years towards DSM implementation. Similarly, It had also directed TPL (Private Discom) to contribute Rs 20 Crores for DSM implementation in each of its 3 license areas, within next 2 years.

Source: *"Report of the Working Group on Demand Side Management", Forum of Regulators, October 2017*

7. Implementation Status of TOD/TOU Tariffs in India

Time of day (TOD)/Time of Use (TOU) tariff structures were first implemented in Europe in the 1960s. From static tariffs for day and night hours, it slowly evolved into more complex and dynamic tariffs. USA followed the trend and in 1978, the PURPA (Public Utility Regulatory Policies Act) legislation was passed which opened the way for the TOD/TOU tariffs. As the concept gained more popularity in India, TOD tariff mechanism was launched by Ahmedabad Electricity company in 1999 with the objective of developing load research data, testing alternate energy efficiency measures and implementing them. Slowly other states joined the league and various TOD tariff structures started to roll out.

7.1. Need for ToD Tariff Regime

The load requirement of consumers keeps on varying at different times of the day. At any time of the day, the system as a whole experiences a load, which is arithmetic sum of individual loads of all the consumers at that time. But the system peak load during the day is not equal to the sum of individual peak of each of the consumers but is less than this sum. This is so because the individual peaks occur at different points of time, and hence cannot be added directly. This phenomenon is called diversity in usage and is measured by diversity factor. It is well known that by controlling the price of electricity, it is possible to motivate individual consumers to either reduce/increase or shift their consumption from one point of time to another during the day, i.e., the consumer can be motivated to change his consumption pattern during the day. It is desirable from the system point of view to reduce peak demand and encourage consumption/enhance load during off peak hours. This can be done by the following methods:

- Providing incentives to consumers for shifting their consumption to off-peak hours
- Providing dis-incentives to consumers for consumption during peak hours, and
- A combination of the above two.[31]

With this, the objective of ToD tariff regime is to shift the time of peak demand, thereby flattening the load curve and making the diversity factor closer to unity. Currently, in India, among a total of 36 states and Union territories, 28 of them have TOD tariffs in place. Please refer to appendix 1 for the TOD implementation details for states and UTs of India.

7.2. TOD implementation status of Indian states[32]

Different states have adopted TOD tariff regime at different times and are hence very different to each other in terms of its adoption and execution. Gujarat was the first state to implement TOD in India in 1999-00 while others such as Haryana had implemented it much later in 2016-17. The reason it took so long for some states to switch to TOD tariff regime was because of **number of barriers such as unawareness of consumer benefits, insufficient savings or loss of revenue as perceived by utilities, preference for fixed contracts, complex cost recording and billing and need for installation of smart meters**.

Moreover, the state regulators held a very different opinion about TOD tariff structure. The Gujarat State Electricity Regulatory Commission stated that **"The TOU charges are necessary so that the high consumption during peak hours is discouraged. This will go to reduce the total cost of supply."** On the other hand, Punjab State Electricity Regulatory Commission stated that "**TOD would be advantageous only if change of consumption takes place from day to night"**. The Commission was not in favour of extending TOD to three shift industries as it could lead to loss of revenue for the state electricity board.

Also, earlier in Punjab, a Peak Load Exemption Charge (PLEC) was introduced to control the maximum demand during peak hours. Prior to the TOD tariff implementation, consumers were paying PLEC, where they were charged higher tariffs on the units consumed

31 http://www.derc.gov.in/sites/default/files/BYPL_0.pdf

32 These observations are based on preliminary analysis and key inferences will be updated as per the stakeholder interactions with discoms, industries and regulators over the next 2.5 months

above the permissible amount during the peak hours. From 2016-17 the PLEC has been replaced with TOD to not only shift demand, but also encourage the consumption of more power. It is expected that large and medium industries will shift their consumption from peak hours and may even consume more during these off-peak hours due to cheaper tariffs. Additionally, it was envisaged that the Punjab Distribution Utility i.e., PSPCL would be able to release additional connections by switching to ToD regime which in turn could result in higher revenues to the utility and/or the state government as well as increase employment opportunities.[33]

Now TOD is implemented in full swing in Punjab and in a recent (2020-21) tariff order, Punjab State Electricity Regulatory Commission stated that "**A distribution licensee generally plans for long term power procurement to meet its base load/demand and goes for short term power procurement to cater to its peak demand. Thus, to achieve optimum power procurement, the load curve throughout the day needs to be as flat as possible. To achieve this objective, Time of Day (ToD) tariff is an accepted tool for DSM, wherein an additional charge is levied for consumption of electricity during peak-hours and rebate is allowed for consumption during off-peak hours, in order to incentivize consumers to shift their consumption from peak to off-peak hours, for achieving flattening of the load curve and minimizing the cost of power procurement to the distribution licensee.**"

Also, ToD scheme got varied responses from the stakeholder's side. For instance, in Assam, the stakeholders had argued that the TOD tariff is unfair for the tea, coffee and rubber industries which do not get government subsidies, unlike the oil and coal sectors. Similarly, in Maharashtra, M/s Haranai Sahakari Soot Girni Ltd. and other textile industries requested the Commission not to increase the overall ToD tariff as it will put additional burden on the textile industries. Also, Shri U. N. Nagane (another textile mill owner) stated that, the textile industry is already suffering from higher losses due to increased electricity tariff rates and variable rates of raw material. Increase in ToD charges will further aid in making the textile business unviable to operate. Hence, it is requested not to levy ToD charges but instead, incentives should be provided.34

Implementation of TOD in a phased manner: The TOD tariff has been introduced in many states in a phased manner. In the first phase, a state usually imposes the TOD tariff on HT consumers who contribute to a significant proportion of the peak demand. For instance, in Maharashtra, the TOD tariff scheme was introduced in the year 2000 only for the HT industrial category of consumers. Over time as this scheme helped shift the peak load in the state, it was extended to other consumer categories. Similarly, in Jammu & Kashmir it was declared in 2013-14 tariff order that TOD tariffs would be implemented in a phased manner. In phase 1 (current phase) TOD tariffs are mandatory for all HT consumers, in phase 2 it would include even LT consumers consuming more than 25 KW, and then in phase 3 that it would include even LT consumers consuming more than 10 KW.

Due to the phased implementation, some states have more industries being covered in the TOD regime than others. For example, apart from HT industries, some states such as Goa, Madhya Pradesh, Andhra Pradesh, etc. have made TOD mandatory for commercial customers (such as cold storages, shopping malls and hotels, etc.) while others like Maharashtra, Kerala, Daman and Diu, Punjab, Assam, and Uttarakhand have made TOD tariffs mandatory for even LT industries. In Assam, until now TOD tariff was mandatory only for HT industries such as HT tea, coffee, and rubber production, HT oil and coal. But from the year 2021-22, it has been extended to include even LT small industries and HT small industries. Similarly, for instance, in Chandigarh, TOD tariff is mandatory for HT and EHT industrial consumers but is optional for all other consumers. Similarly, in Goa, ToD tariff is still optional for LT industrial and commercial consumers.

This differentiation in the extent of industries covered by various states seems reasonable as it is important to identify consumers with higher quantum of energy and select industries where TOD tariff could be effectively implemented to the benefit of the utilities and the consumers. Before extending the TOD tariff to any industry, the DISCOM needs to carry out a detailed feasibility study, collect data on consumption patterns, metering facilities and expected incentives to be given for achieving a given demand response.

For some states, peak hours and off-peak hours have been defined differently across seasons. For example, the off-peak hours in Uttar Pradesh for the summer months April to September, are from 05:00 hrs to 11:00 hrs, while the off-peak hours for the winter months October to March are from 17:00 hrs to 23:00 hrs. On the other hand, in the case of Delhi, the TOD tariffs are only implemented during May to September. Further, Madhya Pradesh and Uttar Pradesh are the only states where the energy charge varies for seasonal industries/consumers. For example, in Madhya Pradesh, the season energy

33 http://pserc.gov.in/pages/PSPCL-TO-FY-2016-17-VOL-2.pdf
34 https://www.mahadiscom.in/consumer/wp-content/uploads/2020/03/Order-322-of-2019.pdf

charge is Rs. 5.60 to 6.80 per unit while the off-season energy charge is Rs. 7.92 to 8.16 per unit for the consumer category HV-4.

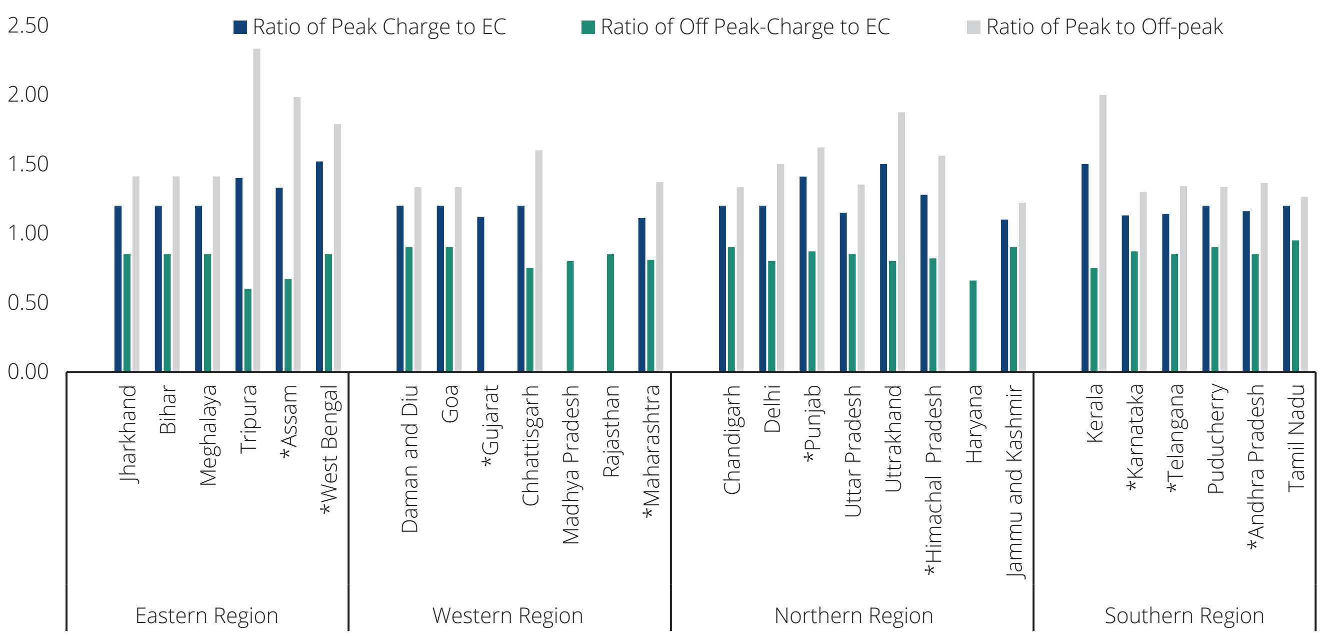
Variations in TOD components over time: Tariff orders are issued once every year, however, in some states (e.g., Madhya Pradesh and Tamil Nadu) tariff orders are issued once in three years. In Maharashtra, the electricity commission increased the differential between peak and off-peak electricity tariffs as well as the differential between the peak and off-peak hours after the successful implementation of ToD for the HT industrial consumers between the years 2000 and 2007. In Haryana, the TOD tariff was introduced in 2017 as an optional scheme. At the time, it was optional for H.T Industries, L.T. Industry, H.T. Non-Domestic, Bulk Supply consumers, Public Water Works, and Lift Irrigation. At that time, the off-peak rebate was 10% and the peak surcharge was 19%. In 2020, the commission found that the cost of power during the peaks was more expensive than was incorporated into these charges and thus, the charges changed to a 15% rebate and a 22% premium. The peak hours and off-peak hours also shifted slightly. In the latest tariff order, the commission has accepted the request by DISCOMs to merge the TOD tariff with the night-time concession and for 2021-22 only an off-peak rebate is being used.

Within the TOD framework, the energy charges (EC), peak charges and off-peak charges vary hugely across states. Within the 28 states, the peak charge ranges from 111% to 152%* of the energy charge and the off-peak charge ranges from 60% to 95% of the energy charge. West Bengal has the highest ratio of peak charge to EC and Tamil Nadu has the highest ratio of off-peak charge to EC. The energy charges in Maharashtra are relatively higher as compared to other states. For the consumer category LT-2(C) and HT-C, the energy charge are Rs. 12.95/unit and Rs. 11.2/unit respectively. However, the ratio of peak charge to EC is 1.11, which is relatively much lower than other states. On other hand, some states like Kerala have implemented the TOD tariff more effectively by maintaining the peak charge to energy charge ratio as high as 1.5. For all other states that have a peak tariff, this ratio is between 1.11 and 1.52.

A higher peak surcharge might generate additional revenue for the DISCOM, over and above what is required to compensate for the off-peak rebates. This can happen when the peak surcharge is higher than the off-peak rebate. In this regard, regulatory commissions in some states have recommended to maintain same deviations above and below the EC for peak charge and off-peak rebate respectively. This would ensure that TOD tariff is not being misused as a source of revenue for the utility and is being used solely to flatten the load curve. For example, Jammu & Kashmir maintains the level of peak charge and the off-peak charge at the same level (i.e., the peak charge and the off-peak charge are 10% above/ below the EC), and Uttar Pradesh maintains the peak charge at 15% above the EC and off-peak rebate at 15% below the EC. However, other states levy peak charges that deviate more from the EC than their off-peak charges.

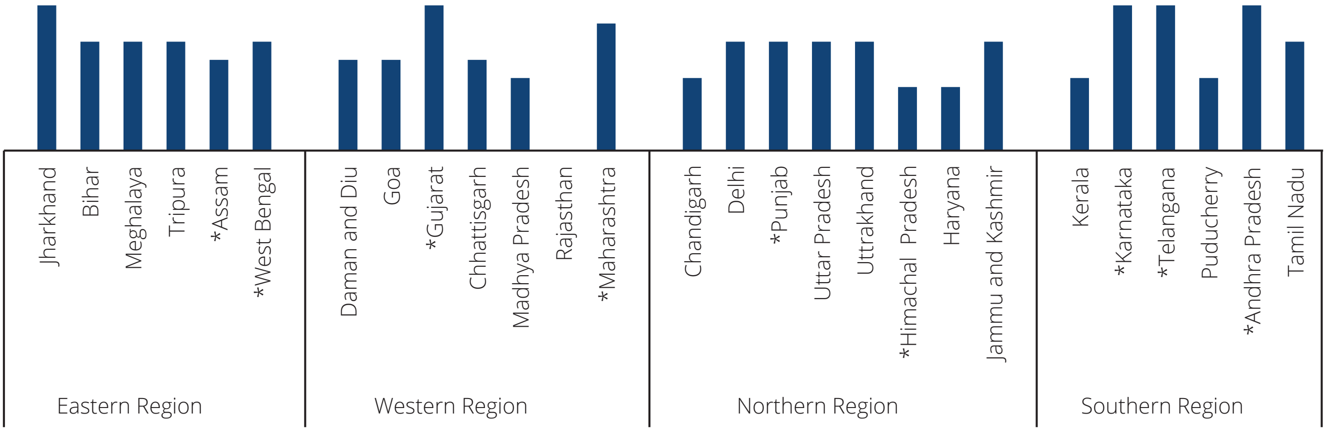
The following graph represents the ratios of peak charge, off-peak charge, and EC in different states:

Figure 7: **Ratios of peak charge, off-peak charge, and EC**



*Note: *These states do not have a standard peak and off-peak charge across consumer categories and thus an average has been calculated.*

Figure 8: **Duration of peak hours across states and UTs**

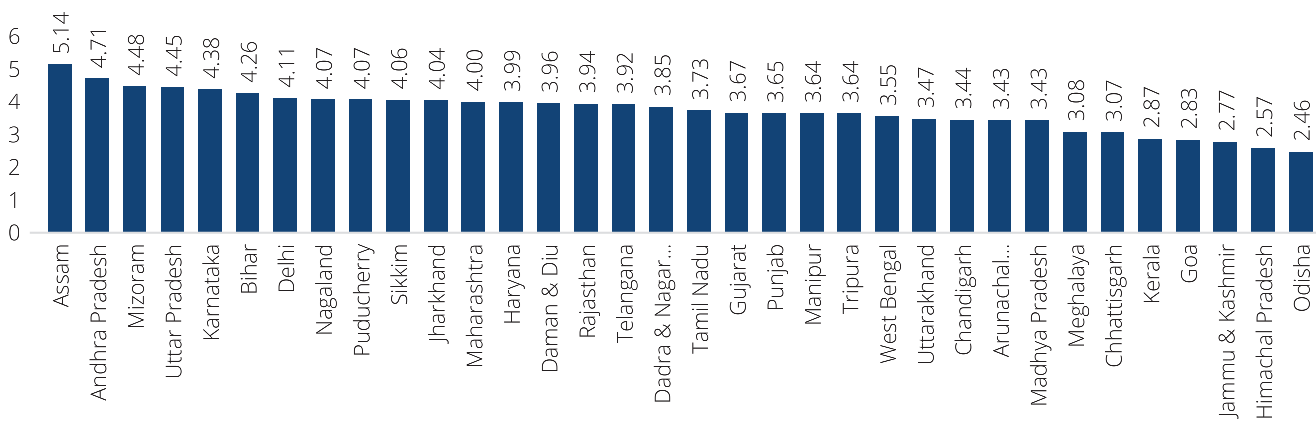


Also, some states do not have a peak charge but provide an off-peak rebate such as Madhya Pradesh, Rajasthan, and Odisha. These states only offer rebates during off peak hours but don't penalize high consumption during the peak times. This is because approval of the state regulator is required for levying a surcharge for peak periods, which, However, states that have both peak charges and off-peak rebates may have a greater potential of reducing the peak load or flattening the overall load curve.

With regards to **Duration of peak hours, typically,** Indian states, the peak period duration ranges from 3.5 hrs. to 8 hrs, with states like Himachal Pradesh and Haryana having lower durations (3.5 hrs). The industrialized states such as Gujarat, Jharkhand, Maharashtra, Tamil Nadu, and Karnataka have longer peak durations (between 6 to 8 hrs), as they have electricity-intensive industries in the state.

The main factors determining the ToD nuances such as number of peak periods, peak-period surcharge, off-peak rebate etc. in the state are its load curve, overall power purchase cost, access to resources for power generation and overarching political and regulatory framework. In India, rising costs of power procurement in the state may or may not be passed onto the consumers due to political reasons. In states like Maharashtra, especially in Mumbai, these rising costs have been passed on to the consumers, which has contributed to higher tariffs. Other states like Delhi, Haryana, Uttar Pradesh, and Tamil Nadu still offer subsidized power to its consumers. In addition, states like Gujarat rely on imported coal for producing power and thus resort to charging higher tariffs. On the other hand, some states like HP have access to inexpensive hydel[35] resources and others like Jharkhand, and Chhattisgarh have access to relatively inexpensive coal-fired thermal plants with lower marginal costs and tariffs.

Figure 9: **APPC across Indian States and Union Territories***



**APPC = [Cost of Power procured from Non-RE Sources (in Crores)] * 10 / [Volume of Power procured from NonRE Sources (in MUs)]. The total cost of power purchase considered excludes cost of generation or procurement from renewable energy sources. Transmission charges have been excluded from these calculations. In case of multiple utilities operating in a State, average of power purchase cost weighted by power quantum of respective utilities was computed to derive APPC for the entire State.*

35 https://economictimes.indiatimes.com/industry/energy/power/maharastra-madhya-pradesh-and-bengal-pay-most-for-power/articleshow/73053162.cms?from=mdr

The Central Electricity Regulatory Commission (CERC) has provided the average power purchase cost (APPC) for the states and at the national level 2020-21.36 At the national level, the APPC has been given as Rs. 3.85 per unit, while in 2019-20 it was Rs. 3.60 per unit. It was seen to be lowest in Odisha at Rs. 2.46 per unit, while it is very high in states/UTs like Andaman & Nicobar Islands (Rs. 16.13 per unit), Assam (Rs 5.14 per unit), Andhra Pradesh (Rs 4.71 per unit), Mizoram (Rs 4.48 per unit), Uttar Pradesh (Rs 4.45 per unit), Karnataka (Rs 4.38 per unit), Bihar (Rs. 4.26 per unit), Delhi (Rs 4.11 per unit), Jharkhand (Rs 4.11 per unit), etc. Figure 9 shows the APPC for 34 states and Union Territories in India, excluding Andaman & Nicobar Islands and Lakshadweep.

Keeping these costs in mind, the **tariffs in a state are determined by estimating the annual revenue requirement (ARR).** This exercise is done by calculating the forecasted cost of energy, allowed losses and wheeling charges. Usually, around 70-80% of the tariff charged to the consumer is made of the DISCOM's power purchase cost. This is made up of two-part tariffs where fixed or demand charges, and these are to be paid by a consumer irrespective of the actual energy consumption. The utility recovers its ARR largely through the per unit energy charges, while a small portion is recovered through the fixed or demand charge in the overall tariff design.

ToD tariff design is very crucial to its overall success in shifting demand from the peak to off-peak hours. For this, the ratio between peak to off peak price is also an indicator of the extent that peak load reduction can take place.[37] Higher ratios send clear price signals to consumers thereby allowing them to shift their load from the peak hours to normal or off-peak hours. We see that states such as Tripura and Kerala have the highest peak to off-peak price ratios of 2.3 and 2.0 respectively. On the other side, states like Jammu and Kashmir and Tamil Nadu have the lowest ratios of 1.22 and 1.26 respectively. When the ratios are lower, it offers a lower incentive to consumers to shift consumption to off-peak times.

While some states have tariffs designed in a way that they reflect the cost of peaking power while for others some others a progressive peaking power supply price signal is needed to appropriately reward flexible supply such as fast ramping of coal power, gas peakers, distributed as well as utility scale batteries, hydroelectricity, pumped hydro storage, and demand response management.38

For a TOD scheme to be successful and beneficial, all considerations like duration of peak charge, **ratio of peak to off-peak charge**, **the nature and extent of industries covered, RE generation curve, the variation in tariffs across seasons** etc. are important. To support this, Maharashtra Distribution Utility i.e., MSEDCL stated that the existing TOD tariff concept, rebate, or penalty is same in all months irrespective of load pattern, surplus & shortfall in availability. Further, due to various Govt. of India policies to promote RE generation and as per the RPO Targets set for Utilities by Commission, tremendous rise in RE generation particularly in solar is expected during daytime. The solar generation has typical shape of inverted hyperbola. There is no or very less generation during specific time of a day; particularly during 06:00 to 09:00 and during 15:00 to 19:00 Hrs. It is thus necessary to incentivize consumers to shift the demand pattern by relooking the TOD tariffs.39

Keeping these nuances in mind, and India's future plan of increasing the installed capacity of non-fossil-based power to 450 GW by 2030, the tariff prices should be revised – 1) to make it incentive compatible for industries to shift their consumption to off-peak hours and 2) include the costs of RE integration such as storage costs, to ensure uninterrupted supply of power to the growing needs of the nation.

36 https://cercind.gov.in/2021/orders/01-SM-2021.pdf
37 https://rmi.org/wp-content/uploads/2017/04/A-Review-of-Alternative-Rate-Designs-2016.pdf
38 https://ieefa.org/wp-content/uploads/2019/01/India_Time-of-Day-Pricing_January-2019.pdf
39 https://www.mahadiscom.in/consumer/wp-content/uploads/2020/03/Order-322-of-2019.pdf

8. Evaluation of the Applicability of RTP Tariff in India

This section explores the existing challenges associated with the implementation of the RTP Tariff in India

8.1 Overview of RTP Tariff Implementation in India by States

None of the states in India have yet implemented RTP tariff due to the absence of operational, technical, and legal/ regulatory framework. Even though India has day-ahead and real-time markets on the power Exchange(s), introducing RTP tariffs would involve joint efforts between the Centre and the states in setting up the adequate infrastructure. Some of the challenges pertaining to RTP implementation are discussed in the following section.

8.2 Current Challenges in the Implementation of RTP Tariff in India

There are 3 kinds of challenges pertaining to RTP implementation:

1. Economic/Financial
2. Technical/Infrastructural and
3. Operational/Institutional

Apart from this, lack of a proper regulatory framework to execute RTP implementation is another challenge since the existing regulations would need to be amended to allow for implementation of real-time tariffs.

Technical	Economic	Institutional
• **Lack of Real Time Price Signalling** mechanism i.e., lack installation Smart Meters • Lack of robust distribution and transmission infrastructure to enable RTP mechanism • Requirement of sophisticated communication and electricity **devices hinders the reach of RTP to small consumers** • **Industries with continuous processing** lack flexibility in shifting production based on dynamic movements in the electricity prices	• **Inelastic electricity demand** leading to **high fluctuation in electricity prices** leading to high uncertainty in market leading to thinning of markets • **High wheeling charge** by the Discoms • The **intrinsic complexity of the RTP tariff** in comparison to the flat tariff structure • For industrial consumers, electricity demand depends on factors other than electricity prices such as deadlines for fulfilment of client orders.	• **Lack of Revenue Realisation** at the distribution level • **Lack of customer engagement** and customer awareness about DSM • **Lack of competition** b/w utilities at the distribution level • **Reluctance** of the stakeholders such as consumers and Discoms to switch to a new tariff regime • **Energy inefficiency in** various sectors of economy like agriculture, housing, transport, MSMEs, etc

8.3 Applicability of RTP for Industrial sector in India

Could a demand market participation (DMP) program be introduced, based on IEX spot market prices or similar?

It is technically feasible to introduce a DMP program where the tariffs for industrial consumers can be made equal to or linked to the prices of Day-ahead market or Real-time market on IEX. The tariffs in case of DMP program can even be linked to the renewable energy production.

The flat tariffs currently levied for industrial consumers in all Indian states are very high (due to the cross-subsidization for residential and agricultural sectors). Therefore, the prices offered through such a DMP program would be less than (in expectation) to the existing flat tariffs making it incentive compatible for some large industrial customers to switch to dynamic tariffs. Thus, from an economic standpoint, DMP programs are feasible.

However, the way in which dynamic tariffs are designed is expected to impact the behaviour of industrial players, such a proof-of-concept for such a program must be simulated using what-if scenarios to quantitatively assess the expected benefits/welfare gains for industrial/ commercial customers as well as state utilities.

9. Flexibility in major industries

9.1 Introduction

In keeping with the objective of estimating the demand-side response (DSR) potential of major industrial customers in India, the industries to be incorporated in the study have been selected on the basis of quantum of electricity that they import from the grid. Even the industries that rely on captive generation can participate in DSR by injecting the power into the grid during peak hours. All such industries can play a significant role in peak demand management, by reducing or shifting their electricity usage during peak periods. This could be incentivized by appropriate time-based rates or other forms of financial compensations.

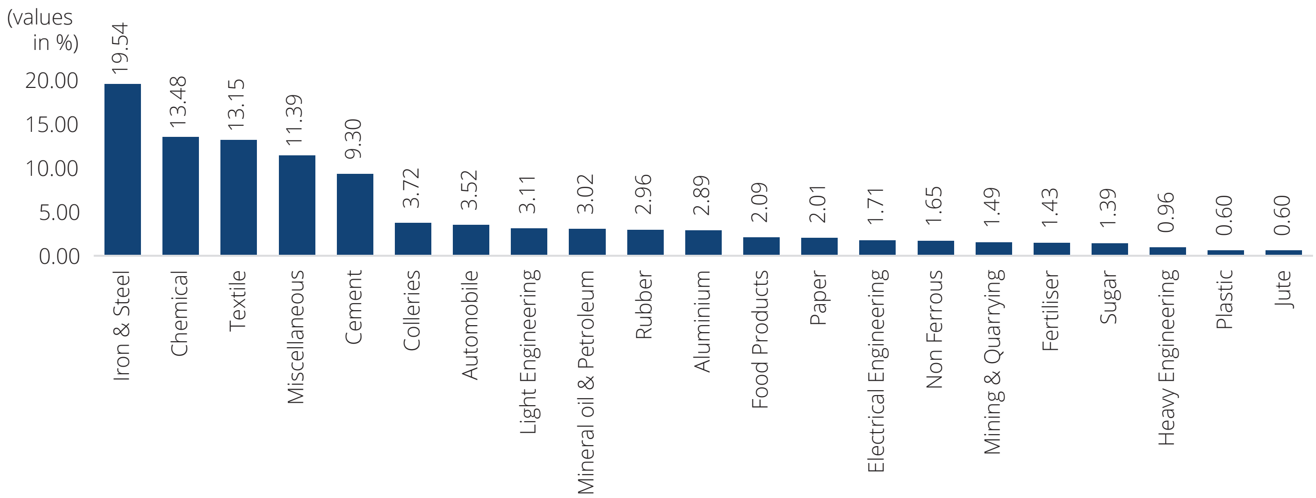
9.2 Selection of energy-intensive industries

The data on grid and captive power consumption by various industries is published by Central Electricity Authority in its publication titled *All India Electricity Consumption Statistics, General Review.* The data published in General Review 2020 has been used in this study. It pertains to 6051 industries in India that had a demand greater than 1 MW and also had captive generation. The parameters that were available in the data included **annual captive generation, electricity consumed, electricity import from grid, captive generation capacity, and export to grid**.

Below are the key insights obtained by studying this data:

- It was seen that Iron and steel industry leads in almost all the parameters, with the highest power consumption, highest captive generation capacity and highest power import from utilities. Its high export to utilities is second only to the textile industry.
- Aluminum industry has the second highest annual captive generation and a low dependence on grid. However, in demand side management scenario, it may have the potential to act as a supplier during peak hours.
- Iron and steel, chemicals, textiles, and cement industries dominate the consumption of energy from the utilities, accounting for more than 55% of the energy import from the grid.
- Iron and steel (26.6%), and aluminum (16.2%) industry have the highest share of energy import from the grid in total energy consumption (see Figure 11). The other two important industries are cement (9.5%) and chemical industries (8.7%).
- While considering electricity exported to grid, textiles industry, and iron and steel industry have the maximum amount of exports, followed by electrical engineering industry, which has a relatively lower annual production.

Figure 10: Share of energy imported of various industries from the grid



In view of the insights so gathered, the following industries have been shortlisted for estimating their DSR potential at a pan-India level:

1. Cement
2. Textiles
3. Iron and Steel
4. Aluminum
5. Chemical (Chlor-alkali)

In the following sections, these industries have been studied in detail with respect to their manufacturing processes, power consumption, and demand response potential. Stakeholder discussions with big players from these industries were conducted to better understand these aspects. In section 2, 3 and 4, we cover the analysis of the Indian cement industry, textile industry and Indian iron and steel industry respectively. The data collected from the stakeholder discussions is included in the Appendix but the insights pertaining to DSR from these discussions have been covered in the following sections.

9.3 A study of DSR potential in the Indian Cement Industry

India is the second largest cement producer in the world, with a production of 329 million tons (MT) in FY20. India has nearly **545 million tons** of cement production capacity with 210 large cement plants that have a combined installed capacity of 410 MT, and 350 mini cement plants with combined installed capacity of 135 MT.[40] In terms of energy consumption, the cement manufacturing process is highly energy intensive with the Indian cement industry's annual energy consumption being around 15 million tons of oil equivalent. The typical electricity use in a cement plant is between 90 to 150kWh/ton of cement depending on the technology, raw material properties, etc.[41]. But it has been observed that cement manufacturers are mostly coming up with captive generation plants in order to be self-sufficient. The total installed captive generation capacity in cement plants is around 6052 MW, which is around 8% of the total industrial captive generation capacity in India.[42] Table 8 and Table 9 shows the top five captive generation plants in the Indian cement industry in terms of capacity and energy purchased respectively.

Table 8: Top 5 captive generation plants in the Indian cement industry in terms of capacity

State/UT	Name of Industry	Fuel Used	Installed Capacity(kW)
Madhya Pradesh	Ultratech cement Ltd, (Vikram cement works, Khor)	Steam	506000
Madhya Pradesh	Ultratech cement Ltd, (Vikram cement works, Khor)	Diesel	270000
Madhya Pradesh	Jaypee Sidhi Cement Plant, Baghwar,	Steam	220000
Rajasthan	Shree Ram Cement Works	Steam	125300
Karnataka	ACC Limited Wadi Cement Works, Gulbarga	Steam	125000

Table 9: Top 5 captive generation plants in the Indian cement industry in terms of electricity imported from grid

State/UT	Name of Industry	Fuel Used	Energy Purchased (GWH)
D & N Haveli	Reliance industries limited, Silvassa	Diesel	517.0
Andhra Pradesh	Zuari Cement Ltd	Diesel	279.3
Himachal Pradesh	ACC Limited	Diesel	267.5
Telangana	Zuari Cement Limited	Diesel	259.1
Chhattisgarh	The Associated Cement Co's Ltd. (ACC), Jamul Cement Works Ltd., JamulDurg.	Steam	254.0

40 https://www.ibef.org/industry/cement-india.aspx
41 https://www.globalefficiencyintel.com/new-blog/2017/utilities-demand-response-manufacturing
42 All India Electricity Consumption Statistics, General Review 2020.

Though cement plants are spread out across the country, they are concentrated heavily in states such as Rajasthan, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, and Odisha. States in South India such as Tamil Nadu, Andhra Pradesh and Karnataka together have a capacity of around 161 MTPA. Northern states such as Rajasthan, Haryana, etc. together have a capacity of around 107 MTPA.[43]

9.3.1 Processes in the Cement Industry

There are mainly two kinds of cement produced, namely Ordinary Portland Cement (OPC) and Portland Pozzolona Cement (PPC). In general, the consumption of energy is greater in the production of OPC as compared to that of PPC. Table 10 shows the typical energy usage in production of clinker (an intermediate product), OPC and PPC.

Table 10: Average energy use by type of cement[44]

Product	Energy Use
Clinker	3600-4000 MJ/ton
OPC	3800-4000 MJ/ton
PPC	2700-3100 MJ/ton

The basic processes of cement manufacturing include **raw material grinding, kiln process, and finish grinding processes**. In general, about 60-70% of the electricity use in a cement plant is for raw material grinding, and finish grinding processes. A detailed sequence of processes is given below.

Raw material grinding: In this process, raw materials (mainly limestone) are transferred to the raw mill for grinding into a fine powder.

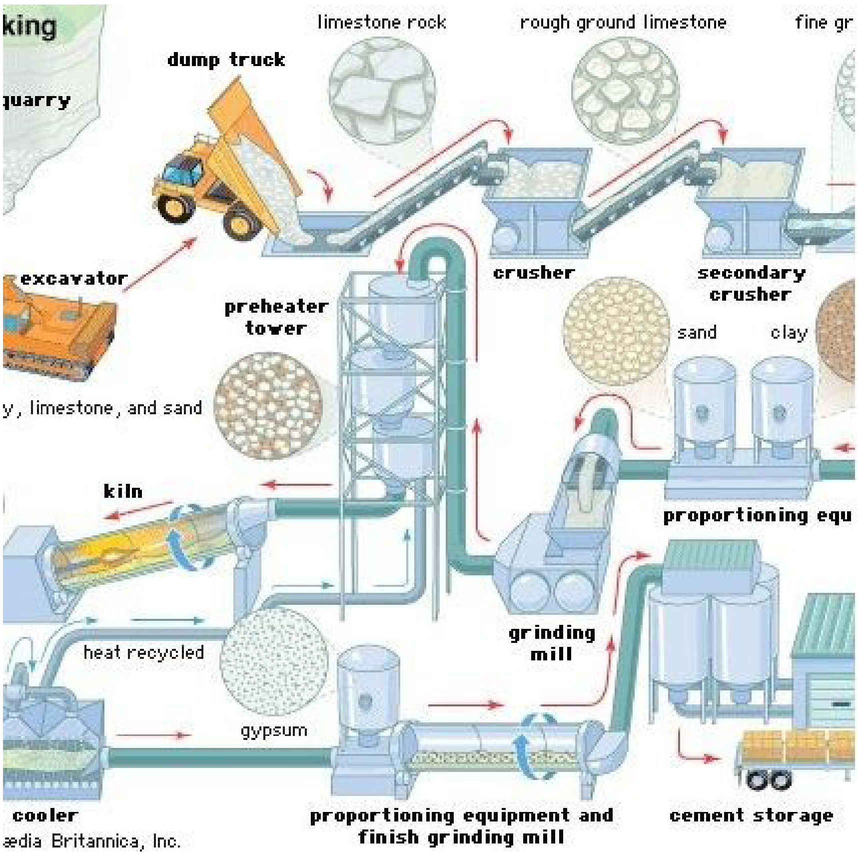
Kiln process

Clinkerization: This fine powder of limestone is then heated at a very high temperature of 1450 degrees centigrade. To heat this fine powder at such high-temperature, coal is used in this process of clinkerization.

This clinkerized raw material is then fed into electrostatic precipitator to store it in the form of the concrete silo. This is called as kiln feed.

Kiln feed is fed into preheater for pyro processing. The pyro processing of kiln feed produces cement clinkers. The hot clinkers are then cooled down and bucketed to store in clinker stockpiles.

Figure 11: Depiction of cement manufacturing process



Source: https://www.cmaindia.org/blogs/the-cement-manufacturing-process/

43 https://www.ibef.org/industry/cement-india/infographic
44 Study of Energy Use and CO2 Emissions in the Manufacturing of Clinker and Cement

Finish grinding: After the kiln process, clinker, and gypsum (or Pozzolana in case of PPC) are mixed and sent to the mill inlet for the further grinding process to form a fine grey powder. This fine grey powder is cement which is then packed and dispatched in the market for sale.

Table 11: **Embodied energy use (MJ/ton) across the world in clinker, OPC, and PPC**[45]

Product	US		Canada		Europe without Switzerland		Switzerland		Rest of the world	
	Electricity (MJ/ton)	Energy (MJ/ton)	Electricity (MJ/ton)	Energy (MJ/ton)	Electricity (MJ/ton)	Energy (MJ/ton)	Electricity (MJ/ton)	Energy (MJ/ton)	Electricity (MJ/ton)	Energy (MJ/ton)
Clinker	652	3760	450	3720	643	3810	1230	2970	663	3710
OPC	627	4110	228	3730	417	3940	444	3190	420	3860
PPC	534	3210	-	-	365	3220	334	2570	368	3160

9.3.2 DSR Potential in the Cement industry (from Literature)

The raw material grinding process has the following **three DSR-friendly** characteristics:[46]

1. It is a batch process
2. It has large storage capacity for its output (ground raw material) which last for hours and often for days
3. The following process (which is kiln) can be considered a bottleneck of the production. This combined with large storage capacity before the bottleneck process (#2) provides a perfect condition for DSR.

The finish grinding process has the following **three DSR-friendly** characteristics:

1. It is a batch process
2. There is a large storage capacity after kiln for ground clinker (and before finish grinding), which last for hours if not days.
3. If production scheduling is flexible, the operation of finish grinding to produce the final cement product can be delayed for a few hours while the previous process can continue their operation.

9.3.3. Stakeholder Consultations in the Cement Industry

Currently, stakeholder consultations in the cement industry have been **Shree Cement and Ultratech** in Rajasthan.

9.3.4. Key Insights from the stakeholder discussion (Shree Cement, Rajasthan)

- There is a general trend of cement plants coming up with their own captive plants to be self-sufficient for at least 90 to 95 % of their electricity demand, thus minimizing the import from the grid. The plant load factor (PLF) for the industry is around 60 to 70%, thereby creating some room for DSR.
- The Shree Cement plant at Beawar in Rajasthan has a captive generation capacity of 300 MW (out of which 150 MW is stranded). Plant's own requirement is around 125 MW and the contracted demand with discom is around 2 MW. The surplus generation from captive plant is being sold to the DISCOMS, private consumers, and even to Nepal (from Rs. 3.75 to Rs. 18 per unit). But nowadays power sale is not as lucrative, and the viable price for power sale considering the high input cost, needs to be at least Rs. 5 per kWh (without bearing transmission losses).
  - Input costs are high due to the cost of importing coal and railway freight costs.
  - Also, sale on the market is unattractive due to high taxes and the requirement of bearing transmission charges and losses.
- The relevant manufacturing processes that consume high electricity include the **kiln process and finish grinding process**. Among these two processes, the typical electricity consumption accounts for around 60-70% and 30-40% respectively of the total electricity consumption.
  - **DSR potential in kiln process:** This is a continuous process that runs 24 hours, for over 9 months in a year. The process runs at full capacity always, and it is very difficult and expensive to stop the kiln processes. Hence there

45 Prakasan, S., Palaniappan, S., & Gettu, R. (2020). Study of Energy Use and CO 2 Emissions in the Manufacturing of Clinker and Cement. Journal of The Institution of Engineers (India): Series A, 101(1), 221-232.

46 https://www.globalefficiencyintel.com/new-blog/2017/utilities-demand-response-manufacturing

is no flexibility at this stage of manufacturing in the cement industry. Also starting and stopping a boiler cost around Rs. 6 to 7 lakhs, which is very expensive.

 - **DSR potential in finish grinding process:** This is a batch process, that runs typically for 6 to 8 hours at a stretch. There is flexibility in this process in terms of stopping and starting the grinding, for which an hour's notice would suffice for the plant.

- In terms of DSR potential, Shree cement can inject a surplus of 50-60 MW into grid by switching off all their grinding units in Rajasthan. The entire cement industry in Rajasthan would be able to inject 100 – 150 MW in the grid. At an all-India level cement industry will have the capacity to inject 400 – 500 MW in the grid.
  - Up to a certain extent they can push their contract deadlines if the revenue from power market is attractive enough, but this is a complex decision-making process.
- In addition, the expectations, and limitations for engaging in demand response are as follows:
  - Profits from power market should be higher than opportunity cost of reduced cement production. For active participation in DSR, a price incentive of Rs 4 per unit on the minimum side would be expected.
  - A price schedule at least 1 – 2 days prior is necessary so that cement production operations can also be planned accordingly.
  - In the off-peak period, they are restricted by their contract demand with utilities as the penalties are high and signing a bigger contract has a higher cost which makes it infeasible.
  - Hence if a consumer is allowed a flexible contract demand or minimal penalties for exceeding contract demand of 2 MW, then the DSM model can be a more attractive proposition.

9.4 A study of DSR potential in the Indian Textile Industry

The textile industry is one of India's oldest and one of its most important manufacturing industries. The size of the industry in the year 2020 was approximately 103.41 billion dollars. It constitutes 2 percent of India's GDP, and 12 percent of the overall exports from India. In addition, as a labour-intensive sector, it employs 45 million people which makes it the second largest provider of employment after agriculture India.[47] In terms of production, the Indian textile sector has produced 35.4 million bales of raw cotton, 1.60 million tons of fibre and 4,762 million kgs of yarn in FY 2020. Textile manufacturing is an energy intensive process which requires on an average 7-8 units of electricity per kg of yarn production. Thus, considering the size and energy intensity of the textile industry in India, it is crucial to study the DSR potential in the industry.

The sector is extremely diverse in India in terms of technology, size, and centralization. Indian textile industries can be broadly classified into organized and unorganized/decentralised sectors. The organized sector includes spinning mills and composite mills. On the other hand, the unorganised sector consists of a large variety of industries such as handloom sectors, power loom sector, hosiery, fabric recycling sector etc.

Regionally it is organised in terms of clusters. In the northern part of India, the notable clusters are Panipat for blankets and quilts, Kashmir, and Ludhiana for woollen textiles. In the southern part of India, the notable clusters are Tirupur, Coimbatore and Madurai for hosiery and Bengaluru, Mysore, and Chennai for silk. In the west, Ahmedabad, Mumbai, Surat, Rajkot, Indore, and Vadodara are notable clusters for cotton textile manufacturing due to nearby raw material availability. In the east, there are clusters in Bengal for jute production.

47 Source: https://www.investindia.gov.in/sector/textiles-apparel

In Table 12 below, the textile units in India with the highest captive power generation capacity are listed and in Table 13 below the textile units in India with the highest amount of electricity purchase are listed. The tables are based on the data provided by CEA on the captive power generation units in India.

Table 12: Textile units in India with the largest captive generation capacity.

S.No.	State/UT	Name of Industry	Fuel Used	Installed Capacity (kW)	Gross Generation (GWH)	Total Consumption (GWH)	Energy Purchased (GWH)
1.	Chhattisgarh	Lanco Amarkantak Power Ltd.	Steam	600000	4285	25	0
2.	Gujarat	Gujarat State Energy Generation Ltd.	Gas	326430	235	225.7	0
3.	Madhya Pradesh	Birla Corporation Ltd.	Steam	191500	230.232	209.642	0
4.	Gujarat	Gujarat State Energy Generation Ltd.	Steam	181100	140	131.1	0
5.	Gujarat	Essar Steel Ltd.	Steam	108000	0	6.9	6.9

Table 13: Textile units in India with the highest amount of Energy Purchased.

S. No.	State/UT	Name of Industry	Fuel Used	Installed Capacity (KW)	Gross Generation (GWH)	Total Consumption (GWH)	Energy Purchased (GWH)
1.	Jammu & Kashmir	Chenab Textile Mills	Diesel	19712	1.074	226.86	225.78
2.	D & N Haveli	JBF Industries Ltd.	Diesel	4000	0.106	163.61	163.50
3.	Maharashtra	Mumbai International Airport Pvt. Ltd.	Diesel	29838	0	163.00	163.00
4.	Gujarat	The Arvind Mills Ltd.	Gas	27000	34.97	180.36	149.52
5.	Rajasthan	Sangam India Ltd.	Steam	16000	83.378	204.72	136.16

9.4.1 Processes in the Textile Industry

The production process can be broadly classified into 3 manufacturing steps which are as follows:

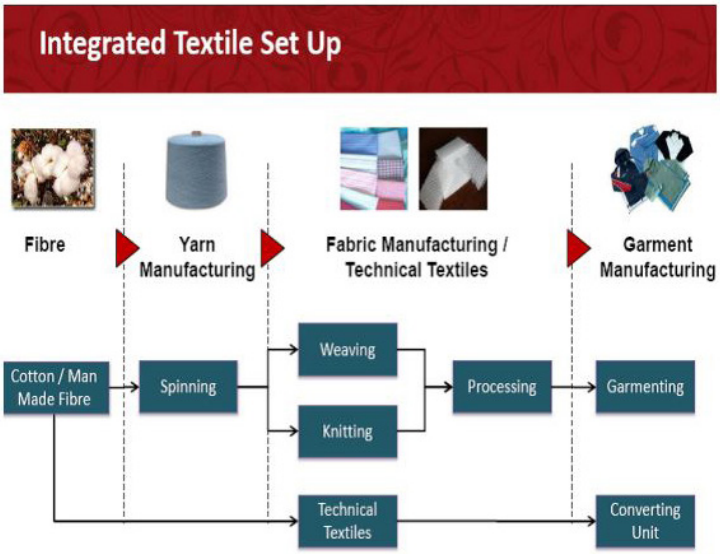
Spinning: This is the first step in which the raw material (Cotton, wool, silk etc.) is converted into yarn.

Weaving: The second step in the manufacturing process is weaving which is the process of making fabric/cloth from the yarn. Looms (Power looms or handlooms) are used in this process.

Processing: The third step in the production is processing. It includes all types of the processes like Preparation, Dyeing and Finishing that involve chemical or wet treatment given to the weaved cloth. In the dying process, different dying technologies are used depending upon material to be dyed. After dying finishing is done. It involves Drying, Calendaring (gives a glossy appearance), Softening (of stiff fabric), etc.

The mills which have all the 3 steps of the production under one mill are called composite mills. The process flow of textile manufacturing is explained in the Figure 13 depicting the stages of the production and the sub-processes involved in each stage.

Figure 12: **Process flow of textile manufacturing**



Source: http://www.sdcmsmzn.com/notes/deepak/14_chapter4(1).pdf

9.4.2 Power consumption in the Textile production process

The textile manufacturing process consumes both thermal and electrical energy. Spinning and weaving are the electricity intensive processes while thermal energy is used more extensively in processing. Electricity consumption in spinning and weaving is on the account of utilities such as compressors, humidification plants, pneumatic automation as well as ring spinning and power-loom motors. These two processes, together, comprise of roughly 60-70% of electricity consumption in a textile mill.

There have been several studies on the Energy consumption by the different processes in the Indian textile industry. In terms of energy use in per unit production in the Indian textile industry, it was estimated that for producing 1 kg of yarn, on an average 8.45 units of electricity are consumed during the year of 2010[48].

In addition, an Energy audit conducted in one of the leading textile mills located in South Tamil Nadu gave the total installed load capacity of the different sub processes and their percentage contribution in the total installed load capacity for the mill.[49] This is shown in Table 14 below. We can see from the table that it is the ring fence spinning stage that is the most energy intensive process as it constitutes almost half of the total load of the mill. Also, carding and humidification constitute a significant part of the connected load.

Table 14: **Power distribution in textile mills including productive and non-productive machines[50]**

Processes	Installed Load (kW)	Total Load %
Blow room	58.78	2.39
Carding	327.6	13.32
Draw frame	61	2.48
Comber	59.23	2.41
Speed frame	68.32	2.78
Ring frame	1158.88	47.12
Autoconer	196.35	7.98
Winder	26.4	1.07
Humidification plant	284.3	11.56
Waste collection	45.48	1.85
Buffing	7	0.28
Compressor	93	3.78
Lighting	35.15	1.43
Sewage plant	7.25	0.29
Water pump–hostel	18.7	0.76
Admin office, QC, hostel	11.84	0.48
Total power	2459.28	100

48 Dhayaneswaran, Y., Ashok Kumar, L. A Study on Energy Conservation in Textile Industry. J. Inst. Eng. India Ser. B 94, 53–60 (2013). https://doi.org/10.1007/s40031-013-0040-5

49 Dhayaneswaran, Y., Ashok Kumar, L. A Study on Energy Conservation in Textile Industry. J. Inst. Eng. India Ser. B 94, 53–60 (2013). https://doi.org/10.1007/s40031-013-0040-5

50 Dhayaneswaran, Y., Ashok Kumar, L. A Study on Energy Conservation in Textile Industry. J. Inst. Eng. India Ser. B 94, 53–60 (2013). https://doi.org/10.1007/s40031-013-0040-5

Similarly, another study by GIZ and BEE in 2018[51] had estimated the thermal and electrical energy consumption in different processes and sub processes of the textile manufacturing for different kinds of fibers in India for the assessment year 2014-15. The findings of this study are presented in the Table 15 The study indicates that winding is the most energy intensive stage as it has the highest consumption of electrical power (units per kg) among all the sub processes listed in the Table 13

Table 15: Energy consumption by different sub processes of Indian textile industry[52].

Process	Unit	Assessment Year 2014-15	
		Lowest	Average
Electrical UKG* up to winding (Yarn-40s count)	kWh/kg	3.385	5.375
Electrical UKG (Open end Yarn)	kWh/kg	0.392	1.349
Electrical UKG (Fibre Dyeing)	kWh/kg	0.122	0.461
Electrical UKG (Weaving)@ 60 PPI	kWh/kg	1.313	3.429
Thermal SEC (Weaving)@ 60 PPI	kcal/kg	89.93	1231.11
Electrical UKG (Knitting)	kWh/kg	0.204	2.126
Electrical UKG (Cotton based fabric)	kWh/kg	0.637	1.499
Thermal SEC (Cotton based fabric)	kcal/kg	1818	7170.67
Electrical UKG (Polyester cotton-based fabric)	kWh/kg	0.616	1.714
Thermal SEC (Polyester cotton-based fabric)	kcal/kg	1908.3	8654.53
Electrical UKG (Lycra Fabric)	kWh/kg	1.144	1.211
Thermal SEC (Lycra Fabric)	kcal/kg	1619.8	4517.77
Electrical UKG (Wool based fabric)	kWh/kg	1.007	1,007
Thermal SEC (Wood based fabric)	kcal/kg	3630.4	3630.36

*Note: *UKG stands for Units per kg and SEC stands for Specific energy consumption*

9.4.3 DSR Potential in the Textile industry (from Literature)

There is a substantial potential of DSR in textile industry because all the 3 stages of textile manufacturing processes spinning, weaving, and processing have DSR friendly technical characteristics.

The spinning stage, which consumes a significant proportion of the total electricity consumption in the textile industry, has a good DSR potential as spinning process is a batch process and offers scheduling flexibility.

Just like spinning, weaving is also a batch process and is conducted through different power-looms, some of which can be switched off during peak periods.

Similarly, in the wet processing plants, there are many batch processes and flexible processes such as drying, stenting, dyeing etc. Thus, there is good DSR potential through proper production scheduling through good coordination between various departments and good storage capacity.

While most processes in textile industry are batch processes, the industry is very capital as well as labor intensive. Thus, machines and labor cannot be left idle for a long time to ensure adequate returns on the capital investment. Due to these nuances, we invested in more in-depth understanding of the Indian textile industry along with stakeholder discussions to estimate the actual DSR potential.

9.4.4 Stakeholder Consultations in the Textile Industry

We have done stakeholder consultations with the following players in the textile industry. The details of the consultations are given below:

1. Arvind Textiles Ltd, Saltej, Gujarat
2. Sachdeva Textiles, Panipat, Haryana
3. BSL Limited, Bhilwara, Rajasthan

The data collected from these stakeholders has been presented in the Appendix, while insights from the discussions have been presented in the following sections.

51 BEE, GIZ. Improving Energy Efficiency in Textile Sector (Achievement and Way Forward), PAT September 2018
52 BEE, GIZ. Improving Energy Efficiency in Textile Sector (Achievement and Way Forward), PAT September 2018

9.4.5 Key Insights from Stakeholder Consultation: Arvind Textiles, Saltej

- Arvind is one of the top 5 composite textile mills in India comprising of separate spinning, weaving, and processing units at multiple locations in India, with average electricity consumption of 52 MW. One of its biggest plant is in Saltej, having contract demand of 34 MW with UGVCL (Uttar Gujarat Vij Company Limited).
- Saltej unit has captive generation of about 16.2 MW of rooftop solar which is available only during daytime (8 hours in a day). Hence the mill has complete reliance on grid electricity despite its captive generation
- The overall load curve of the Saltej plant is fairly constant (around 29 MW) with additional demand of only 1-1.5 MW during peak hours.
- TOD Ex**perience:**

The surcharge during peak hours is 30 paisa more than the average tariff rate (Rs 4.3 per KVA) while night-time rebate is 40 paisa lower than the average tariff.

Total monthly bill of the mill is in the range of Rs 8 Cr for a month (Jul 2021).

The plant has a power trading cell that also buys power on the Exchange in case its available at a price cheaper than its contract tariff.

The electricity consumption by various processes is presented below:

Weaving is the most electricity intensive process at Saltej plant comprising of about 700-800 looms operating 24*7 in a day. For weaving, major electricity consumption is on the account of air compressor, followed by power looms and humidification plant. Air compressor is common across all processes but roughly 70% of the total compressor load can be attributed to weaving.

Both spinning and weaving are batch processes and can be technically halted for few hours on the prior notice of 15-20 minutes. If weaving (which is most electricity intensive) is completely halted, a relief of about 40% in total consumption (~12 MW) can be achieved during peak hours by switching off the compressor as well all power looms. However, if weaving is stopped for 1-2 hours in a day, additional power looms and other equipment may be required to be able to achieve the same level of production in the day.

Currently, 800 looms run for 24 hours. This accounts for 19,200 working hours. If 800 looms run for 22 hours during the day and are stopped during peak hours, it accounts for 17,600 hours. To meet the original level of production (with 19,200 hours), 8% of additional equipment is required, which would be a huge cost (roughly 50 Cr).

Figure 13: Total monthly bill of Arvind Textiles, Satlej

CALCULATION OF CHARGES									
Demand Charges	DMD in KVA	Rate per KVA	Amount Rs						
1st 500 KVA	500	150	75000	Electricity Duty	KWH	Consumption Charges	ED Rate	Amount	Exempted Amount
2nd 500 KVA	500	260	130000		20322610	139601939.03	.15	20940290.85	0
Next	31438	475	14933050		0	0	.2	0	0
Excess DMD									
Tot Demand	32438		15138050	SET OFF DETAILS					
	KHW	Rate	Amount	Total->		Wind Energy	CPP	Open Access	
Energy Charges	20322610	4.3	87387223.00	Units		0			
Night Rebate	7105280	.43	3055270.4	Amount					
				Adj (Credit)		0			
Fuel charge	20322610	1.80	36580698.00	Adj (Debit)					
PF Rebate	87387223	-1.75%	-1529276.40						
EHV Rebate	87387223.00	0.75	-655404.17	AMG Charges					
TOU	6748140	0.85	5735919.00	CGST:			SGST:		
Tot Consumption Charge			139601939.03						

SUMMARY OF CHARGES									
Demand Charge	Energy Charge	Fuel Surcharge	PF Adj/Rebate	Night Rebate	EHV Rebate		Time Of Use Charges	Tot Consumption Charge	
15138050.00	87387223.00	36580698.00	-1529276.40	3055270.40	-655404.17		5735919.00	139601939.03	
Electricity Duty	Meter Charges	Cross Subsidy	Wheeling Charges		Parallel Operation Charges		Current MOnth's Bill	Outstanding Arrears	
20940290.85	0.00						160542229.88	0.00	
Delayed Payment Charges	Adv.Payment / Adjust.	Net Payable	TCS	Total Payable	PREV.BILL TCS Cr	Reading Date	Bill Date	Due Date	Freeze Amount
0.00	-70556832.38	89985397.50	0.00	89985397.50	0.00	01-08-2021	02-08-2021	12-08-2021	0.00

Amount in Words: Eight Crores Ninety Nine Lakhs Eighty Five Thousand Three Hundred And Ninety Seven And Fifty Paise Only

- Further, if weaving is stopped, it will have direct impact of various processing procedures which are conducted sequentially in the plant. Halting at any stage will cause lingering delays for other processes.
- Thus, even with batch processes, it is not able to execute DSR profitably due to its complex sequential processes as well as high capital intensity.

9.4.6 Key Insights from Stakeholder Consultation: Sachdeva Textile mill, Panipat

- There are two types of textile industries in Panipat: recycled clothes spinning industry and Fresh cotton spinning industry. Most of the technology in the manufacturing is imported from China.
- Recycling is the first and the most energy intensive part in the whole manufacturing process for the recycled cloths spinning industry. The reason for the high energy intensity is that during recycling, old cloths need to be opened to convert them into fiber which requires good amount of energy. For the process the Fabric recycling machine is used which consumes nearly half unit of electricity/kg of yarn.
- The next steps in the manufacturing process are Blow room line, Cotton card, Draw frame, Spinning, TFO doubling machine.
- The total power requirement in the whole process is around 1 unit/kg of yarn. In addition, the production of finer yarn requires more electricity.
- Some processes can be stopped at the time of peak load while others cannot be stopped e.g., Processes like Recycling which consumes 50% of the total energy consumption of the unit can be adjusted if multiple machines are in place and while in processes where certain operational climate has to be maintained can't be adjusted.
- The textile industry in Panipat uses open end spinning plant in recycling with 750 KW connected load while the spinning plant with Ring Spinning unit with 2500 kW connected load operate mostly in Punjab.

9.4.7 Key Insights from Stakeholder Consultation: BSL Limited, Bhilwara

- There are around 3 composite textile mills, 10 spinning units, 30-40 weaving units and 50-100 power looms in Bhilwara, Rajasthan.
- Connected load of textile mills in the same region/ cluster varies a lot with the size of the mill. e.g., Nitin Spinners' connected load is 25 MW compared to BSL Limited textile mill's connected load of 5 MW due to the former's higher production capacity.
- The BSL Limited textile mill is a composite unit. The yarn is produced in the mill for sale and as raw material for weaving.
- In terms of the energy consumption (in unit per kg) in the spinning process, wool consumes the highest amount of electricity, cotton, and polyester-viscose blend (PV) spinning consumes lesser electricity than wool, and viscose spinning consumes the least amount of electricity.
- There are various kinds of spinning technologies such as vortex spinning, open spinning, ring spinning and compact spinning. Among them, ring spinning is the most power intensive spinning process.
- The unit makes textiles with diverse set of fibers such as viscose, polyester, and wool blend.
- The spinning of double yarn consumes more unit per kg than single yarn because double yarn production additionally requires use of Two-for-one (TFO) doubling machine.

TOD Experience:

- The manufacturing at the mill is a 24X7 processes. Thus, the load throughout the day is almost constant within the range of 4.8 to 5 MW. Hence, there is only around 5% change in the load from peak to off peak. This 5 % variation in load is due to various factors like material changeovers, morning to night variations due to various possible factors such as fatigue of workers, management issues, efficiency reduction, etc. in the night shift. However, there is no load variations during the shift changes.
- There is also 5% variation in load due to change in seasons because humidification plant requires less power in winter and more power in summer/ rainy season.
- However, this continuous and almost constant load curve of the mill is due to contractual obligations to fulfil the order requirements, but it is technically feasible to shift a large part of load requirement of the mill.
- It is technically feasible to shift 90% of the load in the spinning and weaving stage as only 10 % of the load requirement in these stages (which are for lighting, air regulation, etc.) is fixed and cannot shifted be to other times. Most of the other loads in these stages can be shifted due to batch processing nature of the stages. In the processing stage, 40-50 % of load cannot be shifted as boilers required for steaming (which consume 40-50 % of load of the processing stage) and cooling plants are not flexible processes and batch processing is not possible and hence can't be shifted to other times. Rest of the load in the processing stage is mostly flexible and can be shifted.

Sale of power:

- The power cost from IEX has a very high variance, with prices rising to Rs 10/kWh to Rs 12/ kWh and sometimes as low as Rs 1/kWh to Rs 2/kWh and there are very high transmission charges and losses for participating in the market. These characteristics make power purchase from IEX not very beneficial.
- Due to existing solar capacity, exchange power is not required now.
- There is a lack of clarity regarding RTP implementation and possible lack of proper understanding of its working among manufacturing unit.

9.4.8 Broad inferences pertaining to DSR for the Textile Industry

Based on the literature survey and stakeholder consultations we can draw the following broad inferences about the sector and its DSR potential:

- The Indian textile sector is extremely diverse in terms of size of units, technology, fiber used, final products etc. Thus, there is also a great diversity terms of energy intensity of the units and their DSR potential based on their products, size, region, technology etc.
- Broadly, textile manufacturing is a 3 stage-process. The first stage is spinning in which the fibers are converted to yarns. The second stage is weaving in which yarns are weaved into cloth. The last stage is processing in which the weaved cloths are processed as required.
- Spinning and weaving are the most electricity intensive processes in a textile mill. Among all the spinning technologies, the ring frame spinning is the most energy intensive. In terms of types of fiber, wools weaving is the most energy intensive. Also, the energy intensity of the spinning and weaving increases with fineness of the fabric or the thread count.
- From a purely technical standpoint the sector has a huge potential for demand response as it is technically possible for most of the composite units to adjust 70-80 percent of the load according to the time of day because except for some processes in the processing stage, all stages in the production are technically highly flexible. Thus, by creating good storage space and advanced production scheduling, management, and inter-departmental coordination a very high ToD demand response can be achieved in the sector.
- Thera are some operational constraints that make DSR execution tough. For example, if weaving is stopped, it will have direct impact of various processing procedures which are conducted sequentially in the plant. Halting at any stage will cause lingering delays for other processes.
- Thus, even with batch processes, it is not able to execute DSR profitably due to its complex sequential processes as well as high capital intensity. The actual demand response by the sector will depend on a lot on a diverse range of factors such as production structure of the unit, TOD tariff structure, awareness, government policy, contractual obligations, market demand etc.
- Through stakeholders' interactions, we have found that it is essential to give strong monetary incentives in the ToD tariff structure to incentivize units to go for ToD demand response. According to the rough estimates of the industry stakeholders, a 5 percent reduction in the demand during peak hours will require a ToD tariff difference between peak and non-peak hours to be Rs. 1-1.5/kWh, 10 percent demand reduction will require the tariff difference to be Rs. 2/kWh and 12 percent reduction will require a tariff difference of Rs.2.5-Rs.3/kWh. The interactions also revealed that in addition to monetary incentive in the form of tariff structure, it is essential to give prior information about the peak load tariffs to the units in advance so that they can schedule various stages of their production accordingly.
- The stakeholder consultations have shown that the textile manufacturing units are not very enthusiastic about RTP and buying power from exchange. The major reasons quoted by them was very high variance in the tariff rates and lack of understanding of price movements in the case of RTP and very high entry costs and high wheeling charges levied by the discoms in the case of buying power from exchange. Hence, most of the manufacturing units rely on discoms for their power supply.

9.5 A study of DSR potential in the Indian Iron and Steel Industry

Iron and Steel industry is one of the highly energy intensive industries. India is the second largest producer of steel in the world with a total capacity of over 111 million tons per annum.[53] India has also envisioned a goal of expanding this capacity to nearly 3 times that is over 300 million tons in the present decade. Amongst all the industries steel industry has the highest installed captive capacity and ranks at the top in exporting electricity to the grid as well as importing from the grid. Total Electricity consumption of this industry in India is

53 https://www.ibef.org/industry/steel-presentation

67875.66 Gwh/year whereas the total installed captive generation capacity is 14237.66 MW (Figures given for units having captive power plants and connected load of more than 1 MW).[54]

Steel industry is divided into two parts, the primary producers, and the secondary producers. Primary producers consist of integrated steel plants which are large producers involved in processing iron ore to manufacture steel. There are around 15 such plants operating in India which account for nearly half of India's total steel production. They are located in the states of Chhattisgarh, Jharkhand, West Bengal, Odisha, Karnataka, and Andhra Pradesh as proximity to source of iron ore is an important factor. The secondary producers consist of mini steel mills which recycle the scrap steel to make it reusable. They are located across the country with high density in Gujarat and Maharashtra.

In Table 16 below, the iron and steel units in India with the highest captive power generation capacity are listed and in Table 17 below the iron and steel units in India with the highest electricity purchase are listed. The tables are based on the data provided by CEA on the captive power generation units in India.

Steel making can be done broadly by 3 routes which are conventional Blast Furnace – Basic Oxygen Furnace (BF – BOF), Electric Arc furnace (EAF) and Direct reduction - Induction Furnace (DRI - IF). BF – BOF route is used in the integrated steel plants whereas mini steel mills use electric or induction furnaces. The production process as depicted in fig. 4.2 can be divided into 2 broad parts. First part involves production of molten steel from any of the above-mentioned techniques whereas the second part involves casting of molten steel followed by different shaping techniques like hot rolling, cold rolling etc.

Figure 14: Share of each process in Indian Iron and Steel Industry

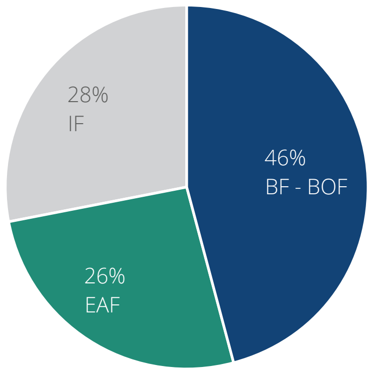


Table 16: Iron and Steel units in India with the largest captive generation capacity.

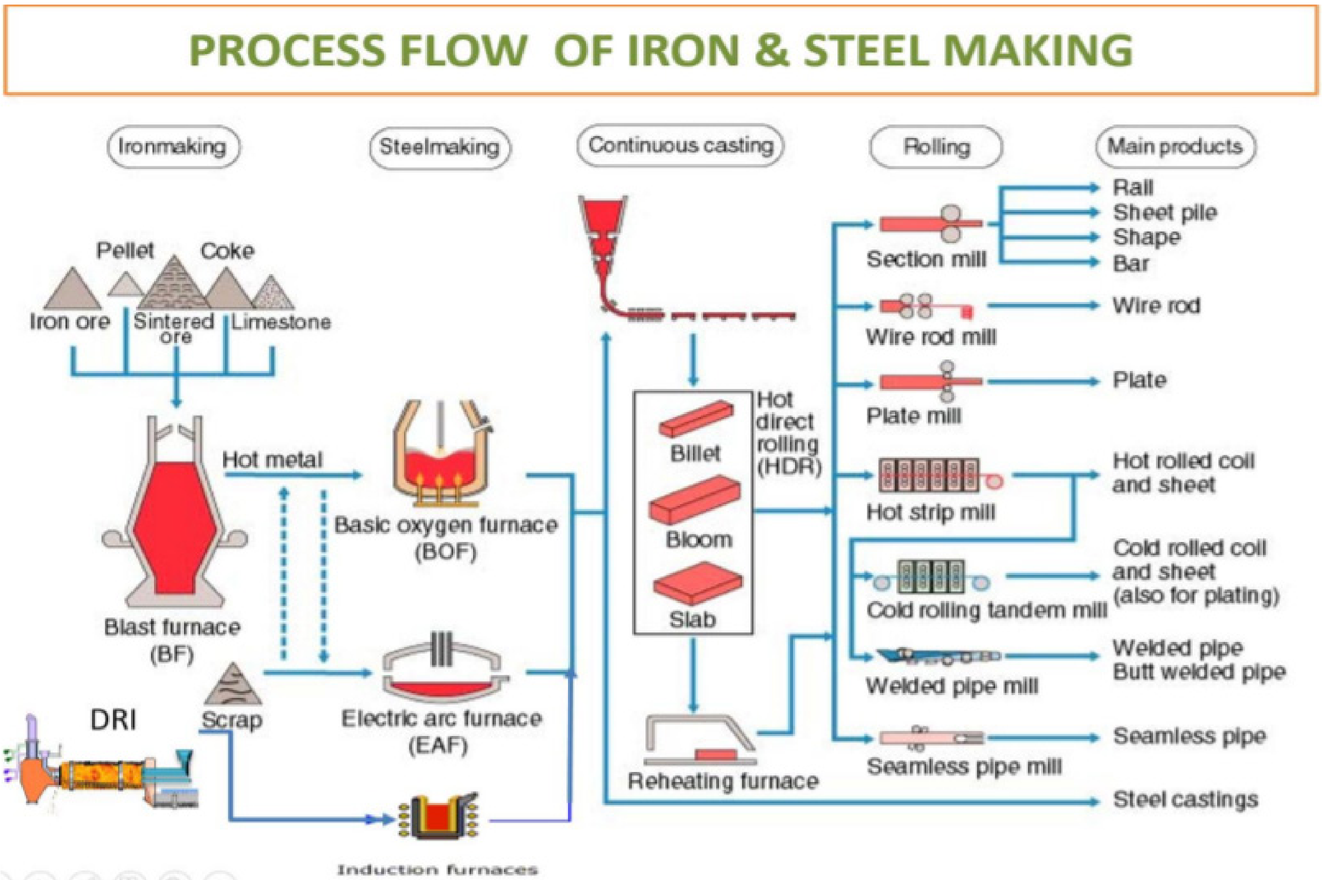
S. No.	State/UT	Name of Industry	Fuel Used	Installed Capacity (KW)	Gross Generation (GWH)	Energy Purchased (GWH)	Total Consumption (GWH)
1.	Chhattisgarh	Bharat Aluminium Co. Ltd	Steam	1440000	10179	0	9077
2.	Odisha	Jindal Steel and Power Limited	Steam	840500	2667.86	NA	2074.694
3.	Chhattisgarh	Jindal Steel & Power Ltd	Steam	824000	3232	0	2402
4.	Jharkhand	Tata Steel Limited	Steam	615000	4060.22	171.51	4045.7332
5.	Karnataka	JSW Steel Ltd	Steam	600000	4352.503593	0	3982.540788

Table 17: Iron and Steel units in India with the highest amount of Energy Purchased.

S. No.	State/UT	Name of Industry	Fuel Used	Installed Capacity (KW)	Gross Generation (GWH)	Energy Purchased (GWH)	Total Consumption (GWH)
1.	Andhra Pradesh	Rashtriya Ispat Nigham Limited,	Steam	522600	2765.388	3302.077018	5830.3482
2.	Maharashtra	JSW steel (Ispat Industries) Ltd.	Diesel	67500	267.8589	2182	2420.2089
3.	West Bengal	SAIL, IISCO Steel Plant, Burnpur Works (ISP)	Steam	76200	319	917	1169
4.	Haryana	Jindal Stainless (Hisar) Limited	Diesel	44000	1.1749	731.612	732.739904
5.	Karnataka	BMM ISPAT Ltd,	Steam	95000	427.137111	319.154983	566.7854396

54 "All India Electricity Statistics, General Review 2020"

Figure 15: **Process flow of Iron and Steel Making**[55]



9.5.1 Processes in Steel Plants

Integrated Steel Plants using BF – BOF process

1. Integrated Steel Plants are big plants which produce steel from Iron ore using Blast Furnace – Basic Oxygen Furnace (BF – BOF) pathway. The production process is as follows: -
2. **Sintering:** smaller fractions of iron ore sized below 25 mm cannot be put in BF, so they are agglomerated in sinter plants at a temperature of 1200 °C.
3. **Blast Furnace:** Iron ore (Sintered) and coke is mixed in appropriate proportions and put in blast furnace and heated to white hot temperature around 2200 °C. Molten iron flows out of the furnace.
4. **Basic oxygen furnace**, oxygen is supplied for removal of carbon, slag is also removed from the molten iron followed by refining. BOS vessels also contain scrap steel to regulate vessel temperature and steel quality. Oxygen is then blown through the vessel. Metals are added to ensure proper alloy composition (as per the need) and the molten metal is then removed from furnace.
5. **Oxygen production** is carried in house (mostly) and continuously without storing.
6. **Continuous Casting:** is done to give shape to the molten metal and allow it to solidify.
7. **Rolling:** hot rolling is done directly after casting while metal is still hot, whereas cold rolling can be done later.

55 https://steel.gov.in/sites/default/files/R%26D%20Chapter%20for%20MoS%20Website%20July%202019%20updated_0.pdf

Table 18: Electricity Consumption in BF – BOF plant[56]

Section	Process	Electricity Consumption (GCal/tonne of steel)
Material Preparation	Sintering	0.04
	Coking	0.02
Iron making	Blast Furnace	0.02
Steel making	Basic Oxygen Furnace	0.02
Casting	Refining	0.02
	Continuous Casting	0.006
Hot rolling	Hot rolling – Strip	0.08
	Hot rolling – Bar	0.06
	Hot rolling – wire	0.10
Sub-total Based on Hot rolling Bars		0.20
Cold Rolling		0.06
Finishing		0.02
Total		0.12
Casting and rolling	Replace continuous casting and rolling with thin slab casting	0.04
Total (Considering thin slab casting)		0.17

Mini Steel Plants

Mini Steel Plants are involved in recycling of scrap steel and operate using electric arc furnace or induction furnace. Such units are plenty in number and are spread across India, by production capacity they are comparable to ISPs, but capacity of individual plant is significantly low. Specific energy consumption per ton of steel produced ranges from 700 – 1200 units of electricity. The manufacturing process in these plants involves following steps:

1. **Pre-processing of scrap**: Scrap steel/ Secondary steel from factories is received. Cutting/pressing operations are done to reduce the size and increase the density which makes it suitable for induction furnace.
2. Melting (Induction furnace) consumes 90 – 95% of power used in plant. The furnace is filled with recycled steel scrap and three graphite electrodes are lowered into the melt. Current is passed and an arc is formed. Heat generated melts the steel; lime is added, and carbon and oxygen are blown to remove impurities.
3. Specific properties can be achieved by adding alloying metals.
4. This is followed by casting and rolling.
5. Sintering is a batch process and is done as per the requirement of the plant. Somewhat flexibility can be achieved if storage of sintered ore is done to ensure flexibility for Demand side response.

Electricity consumption in these plants is according to the following points.

1. Pre – processing consumes 0.01 MW.
2. Melting consumes 90 – 95% power. It is done in cycles with a cycle time of 2 – 2.5 hours
3. Connected load of melting depends up on capacity, can be around 10 MW.
4. Slowly the load of furnace is increased. Starting from less than 50% the load is gradually increased to 100% within an hour.
5. Rolling takes 2.5 – 3 MW and has different connection from melting.

56 https://www.keralaenergy.gov.in/files/Resources/Iron__Steel_Sector_Report_2018.pdf

Other Steel Plants

There are other steel plants which plants which are involved in not all these functions but some of these. Most of the times they buy raw steel or hot rolled steel from steel mills and perform further specialized tasks like cold rolling for precise dimensions, galvanization, tin coating, paint coating etc. They produce highly specific operations to customize raw steel into steel suited for different applications.

9.5.2 DSR Potential in the Iron and Steel industry (from Literature)

- Blast Furnace runs continuously for months, and power is sourced from coal and coke thus there is no scope for demand response there. It is only stopped for planned maintenance shutdowns.
- Basic oxygen furnace process is a batch process, with a cycle time of 40 minutes and 13 – 15 minutes of blowing time. Most of the power required is sourced from captive power plants. This process happens right after the molten metal comes out of the blast furnace. This is followed by casting of the molten metal into solid metal which is still at high temperature. Since that is a continuous process there cannot be any scope to delay it as a part of demand side response.
- Rolling is a batch process with some flexibility depending upon the product mix which needs to be formed in each rolling unit. It is done at various temperatures and various speeds. Some rolling operations are done directly after casting whereas some are done at later stages. Thus, a possibility of demand side response exists here.
- There are some other processes which consumer electricity like production of oxygen. Oxygen is produced as well as used in gaseous form. However, there are possibilities of storing Oxygen in liquid form to allow for Demand Side Response.
- In mini steel plants, most of the units operate at less than full capacity. Although plant load factor can be as high as 90% sometimes, yet during low demand season plant can be shut during peak hours. Melting and rolling are batch processes, after completion of one cycle, second cycle can be scheduled at a desired time following a schedule which takes into account the energy supply.

9.5.3 List of Stakeholder interactions[57]

The following stakeholders were consulted from the Iron and Steel Industry with integrated steel plants:

1. Steel Authority of India (5 integrated steel plants + 2 small steel plants)
2. Tata Steel (2 integrated steel plants)
3. JSW Maharashtra (Cold rolled and coated products)
4. Amba steel industry (mini steel plants)
5. Goa Ispat

9.5.4 Key Insights from Stakeholder Consultation: SAIL

- Processes that are most electricity intensive: Rolling mills>Oxygen Plant> Sintering Plant> Others
- SAIL has total consumption of electricity around 7000 – 8000 Million units of electricity out of which more than 90% are consumed at Integrated steel plants locations. Load curves are nearly constant with 20% difference between peak and valley with load coming down during shift change timings and high evening load from townships. SAIL has inhouse oxygen plants, SAIL can reduce load in oxygen plant by excess production in off peak hours and liquification, however compensation for the cost incurred will be expected.
- Sinter plants have capacity for DSM relief of 20 – 25 MW.
- In rolling when slab goes in load is around 75 – 80 MW, when it goes out it takes around 35 – 40 MW. it's the process with maximum fluctuations. Every 3 minutes one slab is rolled in Bokaro. Thrice a day roll changing takes place which takes around 1 – 1.5 hours. Given these flexibilities, rolling mills which consume 35% of electric load can shift 80% of the load for 2 hours.
- SAIL supplies electricity to nearby townships. Whenever overshoot is expected, load shedding is done in townships for few hours, saving 30 – 40 MW. Such emergencies only come during evening hours.
- Up to 50% reduction can be seen in total electricity consumption at a given Integrated steel plant of SAIL with different processes, but they have different notice periods and can operate for different durations of time. However, 10% of this comes by cutting supply to the townships, and it is not recommended to cut their supply to sell electricity in the market.
- SAIL has two alloy steel plants which operate using electric arc furnace. The load fluctuation in these plants is very high with average to peak load ratio being about 0.5
- EAF in SAIL plants takes 80% of the plant load and is a batch process and annual consumption is 500 – 700 Million units of electricity.

57 Refer to Appendix for the data from stakeholder consultations

9.5.5 Key Insights from Stakeholder Consultation: Tata Steel

- Tata steel has a supplier of oxygen which runs plants 24*7. The oxygen supplying company has the design of plant in such a manner that much liquification is not possible hence flexibility is not available. Installed captive generation capacity is 500MW in one and around 250 MW in another. Tata Steel consumes 90 – 95% power from captive generation. Sometimes power is surplus and then sent to standalone small units of Tata like ferro alloy plants in Odisha. Some other surplus power is sometimes sold on exchange. It is sold at a price higher than cost of generation.
- Tata Steel has the lowest cost of production thus they are always able to sell their produce, flexibility is low and capacity utilization is well above 90%
- As a result of high capital cost of steel production keeping plant idle for certain amount of time is not feasible. Decision and interests of investors as well as board members is important before making any such choice before making any compromise on steel production and participating in demand response activities.
- Large industries have set up captive power plants to decouple their operations from fluctuations in external grids. Participation in demand response won't be possible if it affects their own stability.
- Rolling mills can operate in batches but Tata Steel's inhouse rolling capacity is less than steel production capacity and a lot of produce is rolled by contractors specially meant for rolling. Thus, flexibility in rolling is not there.

9.5.6 Key Insights from Stakeholder Consultation: JSW

- JSW steel plant has a peak load of 95 MW whereas average load is 70 MW. 5 MW of load can be spared at a notice of 15 minutes. At the month end for 10 days, they run at full capacities always to meet the demands.
- Cold roll mills consume 42% of the electricity whereas galvanization consumes 35%. Rest of the electricity consumption comes is by coating (Color or tin) and other operations.
- JSW products have very high demand in the market. They are able to sell at low costs as the raw materials are sourced in house, hot rolled steel comes from another JSW plant, paints are sourced from JSW paints and electricity comes from captive power plants. This procurement policy gives them a competitive advantage over other producers. Thus, for them steel business becomes much more profitable then selling power.
- Currently the power plants have excess capacity which is being sold to Discoms or open access wherever the price is better. This will change as they are expanding steel production at one of the plants in Maharashtra. They will need more power and they will reach a power deficit state where they will be purchasing more power from Discoms. Green power is infirm power, which means solar power will only be available when the sun shines and depending upon the brightness of the sun. However thermal power is not infirm power a more stable supply which is required in such plants can be available from thermal plants as per the current technology. Thus, expansion into RE is difficult. Government should make clearances easy and offer benefits for using RE.

9.5.7 Key Insights from Stakeholder Consultation: Amba Steel

- They at times stop production during peak hours as it becomes less profitable depending upon price of steel.
- If a prior schedule is given to the industry, melting processes can be then planned according to that.
- They try to take maximum benefit of lower tariffs at night
- Factories annually operate at around 90% of the production capacities. (Stopping nearly 30 days in a year). Reducing production below that would make it too expensive as the fixed cost is high. So entire load cannot be shifted to night-time.
- During the rainy season (August, September, and October), demand of steel is less and more potential to free up peak period is available
- If peak hour rates even increase by 10% then many people would shut down their furnaces. Many would shift to open access in that case.
- If company reduces consumption, they will want reduction in fixed charges and compensation for labor costs as the labor must sit idle. If they must stop for 1 – 2 hours, then labor cost can be calculated.

9.5.8 Key Insights from Stakeholder Consultation: Goa Ispat

- In the production processes, electricity is consumed by Induction furnace followed by rolling machinery.
- Induction furnace uses electricity to melt the scrap and pig iron. This process requires heating at temperature close to 1500-1800 degree Celsius and is extremely electricity intensive. Also, the process is carried out almost through the day to keep the metal at a constant temperature. Induction furnaces consume about 50-60% of the total electricity consumption of the plant.

- The billets produced from induction furnace are extremely hot and cannot be put to rolling (due to lack of automation/machinery)
- After the billets are cooled down (in about 2-3 hours), they are put into rolling machines that run on electricity.
- Rolling is a batch process and accounts for 30-40% of the total electricity consumption. Before rolling, the billets are again heated to about 1200 to 1500 degree Celsius using coal.
- Rolling is completely flexible and can be scheduled/ altered within a notice of 1-2 hours.
- Complete shutting down of rolling can reduce the overall electricity consumption to 30-40%.
- To avoid the consumption of coal for rolling, the billets that come out of the induction furnace would directly be put into rolling (while they are hot). In such a case, rolling cannot be interrupted separately. However, if DSR compensations are good, both induction and rolling processes can be stopped together during peak hours.

9.5.9 Broad inferences pertaining to DSR for Iron and Steel Industry

Since all big plants rely on captive generation, the drawl from grid is very low. Thus, DSR potential exists only in terms of injecting captive power into the grid during peak hours. Plants that operate on full capacity through the year such as Tata Steel can’t participate much in either way (drawing less or injecting from captive generation) as most processes are continuous and run full time. The broad objective to such companies is to promote their steel-making business and not derive profits from sale of power

- Steel industry is highly capital intensive. Utilization of assets must be high. If utilization is low, plant will become uncompetitive. 95% of the load is expected to operate at a uniform rate with minimum disruptions.
- Captive power plants are set to isolate the manufacturing plant from external uncertainties. Moreover, trading power is not the main business thus they would ideally like to work for steel making purposes. Power plants were always set for steel manufacturing, they will not be keen on dealing in power, shareholders will not be happy about that.
- Oxygen is a major production requirement in integrated steel plant and industrial oxygen plants are setup for it. Oxygen is supplied in the form of gas from oxygen plant however demand side response potential can be developed with liquification of oxygen that allows for storage.
- Rolling and sintering plants also have flexibility to schedule operation, however it is subject to steel demand and rates of power in the market. Tata steel has high demand, JSW has competitive advantage as all raw materials are sourced in house; only SAIL has a significant flexibility to reschedule the operations.
- If user is reducing peak consumption on demand, benefit should also be provided in the demand charge. If around 1 MVA exemption happens in the demand charge (which is around 350/KVA), around Rs. 40 million per annum can be saved. Penalty of overshooting peaks are very high in case off-peak period overshooting happens.
- Regulations which allow real time decision making are essential for supporting demand side response in steel industry as power markets are dynamic, decision making is complex and time consuming.
- Easy NOC availability to expand electricity production capacity especially if RE is being used. Incentives for shifting to RE over conventional energy as RE being infirm power is less reliable for a large industrial consumer who needs constant power supply at a particular voltage.

Smaller firms that make Steel from scrap can offer some DSR potential

- Smaller firms which operate using scrap steel have lower investments, flexible processes and are spread out across country though in clusters, which can provide a significant demand response potential sufficient for surrounding regions.
- All the processes in small mills are flexible, scheduling can be done as per the power availability. It may not always be possible to lower the production, which is dependent on market demand, but rescheduling can be done with necessary compensations. Opportunity costs are less, and hence lower compensations will be required.
- Per ton of steel produced, more electricity is consumed in these mills as compared to integrated steel plants.
- These firms will also require that fixed charges be reduced as if demands will be reduced and rescheduled, they will at times be drawing less power for some time making fixed charge an extra burden.
- Stakeholders have mentioned that if the tariffs are reduced during off-peak charges, it can be made incentive compatible for such industries to shut/slow down their processes during peak hours.

9.6 A study of DSR potential in the Indian Aluminium Industry

Aluminium is one of the most used metal in the world. It's annual consumption worldwide including scraps is approximately 65 million tonnes. It has critical applications in a wide range of sectors such as electrical and electronics, automotive industry, construction industry, packaging, defence, aeronautical industry, consumer durable etc. It is the metal with very high potential in future as its consumption has grown by nearly 20 times in the last sixty years and is expected to grow at a good speed in the future.58

India is a major player in the aluminium manufacturing with a share of 5.3% of global aluminium output and a share of 10% in the global bauxite reserves.59 In terms of production, the aluminium production in India in the FY 2020 was 3.6 MT. The sector in India is growing rapidly by leveraging growth in demand and raw material availability. The aluminium industry in India is dominated by 3 large players – HINDALCO, NALCO and Sterlite (BALCO)60

The manufacturing process of Aluminium is an energy intensive process which consumes high amount of both thermal and electrical energy resulting in specific energy consumption around 13,500 -14,500 kWh/MT of molten aluminium in the smelting of aluminium.61

In Table 19 below, the aluminium industry units in India with the highest captive power generation capacity are listed and in Table 20 below the aluminium industry units in India with the highest amount of electricity purchase are listed. The tables are based on the data provided by CEA on the captive power generation units in India.

Table 19: Aluminium industry units in India with the largest captive generation capacity.

S. No.	State/UT	Name of Industry	Fuel Used	Installed Capacity (KW)	Gross Generation (GWH)	Energy Purchased (GWH)	Total Consumption (GWH)
1	Odisha	Vedanta Aluminium Ltd.	Steam	3015000	19365	408.3	17499.3367
2	Odisha	NALCO Ltd., Smelter & Power Plant,	Steam	1200000	7066.235	382.727	6500.452
3	Odisha	Aditya Aluminium Limited	Steam	900000	5605.27	NA	5050.923
4	Uttar Pradesh	Hindalco Industries Limited	Steam	840000	6619.478192	129.11	6231.049442
5	Odisha	Hindalco Industries	Steam	467500	2988.14	NA	2670.056

Table 20: Aluminium industry units in India with the highest amount of Energy Purchased.

S.No.	State/UT	Name of Industry	Fuel Used	Installed Capacity (KW)	Gross Generation (GWH)	Energy Purchased (GWH)	Total Consumption (GWH)
1	Madhya Pradesh	HIM Technoforge Limited	Diesel	602	0	709	709
2	Odisha	Vedanta Aluminium Ltd.	Steam	3015000	19365	408.3	17499.3367
3	Odisha	NALCO Ltd.,Smelter & Power Plant,	Steam	1200000	7066.235	382.727	6500.452
4	Gujarat	Rolex Rings Pvt.Ltd.	Wind	8750	22	250	272
5	Odisha	National Aluminium Co. Ltd. (NALCO), Alumina Refinery	Steam	94100	512.37	200.07	692.046

58 https://www.equitymaster.com/research-it/sector-info/aluminium/Aluminium-Sector-Analysis-Report.asp
59 https://www.equitymaster.com/research-it/sector-info/aluminium/Aluminium-Sector-Analysis-Report.asp
60 Source: "Improving Energy Efficiency in Aluminium Sectors (Achievement and Way Forward) ", September 2018, GIZ and BEE
61 Source: "Improving Energy Efficiency in Aluminium Sectors (Achievement and Way Forward) ", September 2018, GIZ and BEE

9.6.1 Processes in the Aluminium industry

The aluminium is made from the ore bauxite. Once the bauxite is extracted, there are 4 main steps in the process of manufacturing: alumina production, anode manufacture, smelting and ingot casting. The steps are concisely explained below

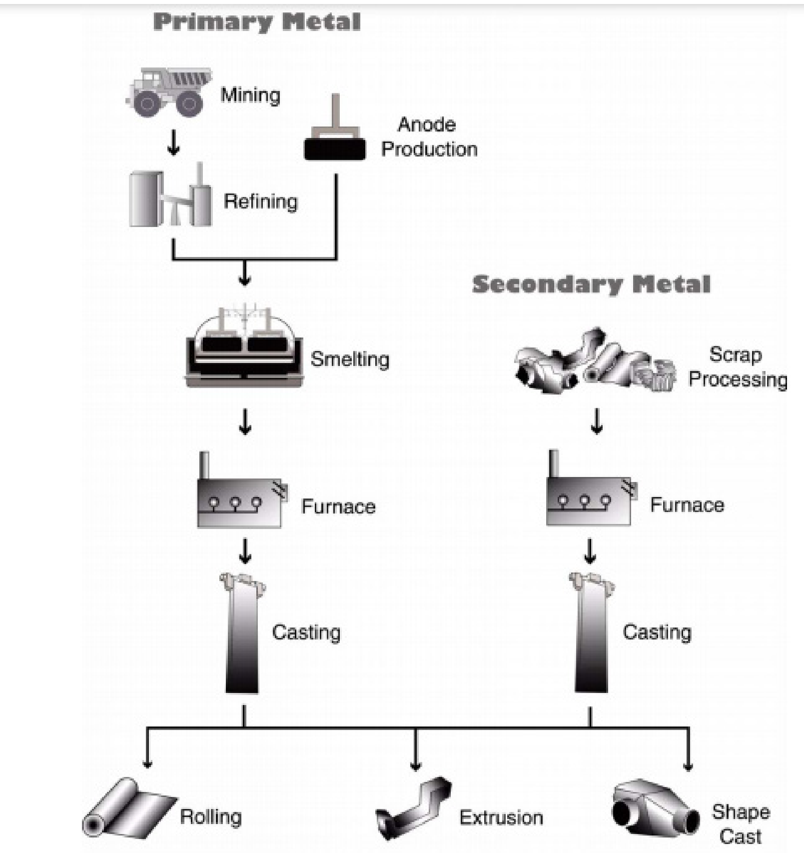
1. **Alumina Production (Refining):** In this step bauxite ore is converted to alumina using Bayer process. In the Bayer process the ore is dissolved in caustic soda solution. Many minerals remain insoluble and are extracted. Then Calcination is done to produce anhydrous alumina. This step is an energy intensive process. 85 percent of the energy is consumed in this step consumed in the form of fuel.
2. **Anode production:** In this step anode is produced in a furnace by heating which is then used in the smelting
3. **Smelting (Electrolysis):** In this step alumina is converted to molten aluminium using Hall Heroult process. In the process electrolysis is used in which direct current is passed through alumina dissolved in cryolite, molten aluminium gets collected at the bottom of the container which is collected using siphon. It is also an energy intensive process and consumes a large amount of electrical energy.
4. **Ingot Casting:** In this step the molten metal is poured into containers, alloys can be formed at this stage, and let to cool down. Various shapes can be formed depending upon the requirement of the end user. Then aluminium after cooling is sent to sheet roll mill for producing end products i.e., aluminium rolled products.

The manufacturing plants where both processes Refining and Smelting take place are called Integrated plants. In addition to manufacturing of aluminium from bauxite (primary metal), the aluminium products can also be manufactured from recycling the old aluminium products (secondary metal). The Figure 17 below gives the schematic view of the aluminium manufacturing process.[62]

Power consumption in the production process

The aluminium manufacturing is an energy intensive process which consumes huge amount of both thermal and electrical energy. The Table 21 and Table 22 below list the amount of electrical energy required by the different sub processes of the aluminium manufacturing industry in India and its comparison with global benchmark in terms of energy intensity based on the report by GIZ and BEE. The tables show that the energy intensity of the Indian manufacturing process is a bit higher compared to the global benchmarks.

Figure 16: Schematic view of the aluminium manufacturing process.



62 Source: U.S. Energy Requirements for Aluminium Production Historical Perspective, Theoretical Limits and Current Practices Prepared for Industrial Technologies Program Energy Efficiency and Renewable Energy U.S. Department of Energy February 2007

Table 21: **Energy intensity of different processes of Indian Aluminium Industry (Part I)**

Production Process	Global Best	Global Average	India Average	Indian Best Numbers	Unit
Alumina Refinery	0.2	0.267	0.33	0.23	TOE/Tonne of Alumina
Aluminium Smelting	13599	14145	14361	14558	KWh/Tonne of Molten Aluminium

Table 22: **Energy intensity of different processes of Indian Aluminium Industry (Part II)**

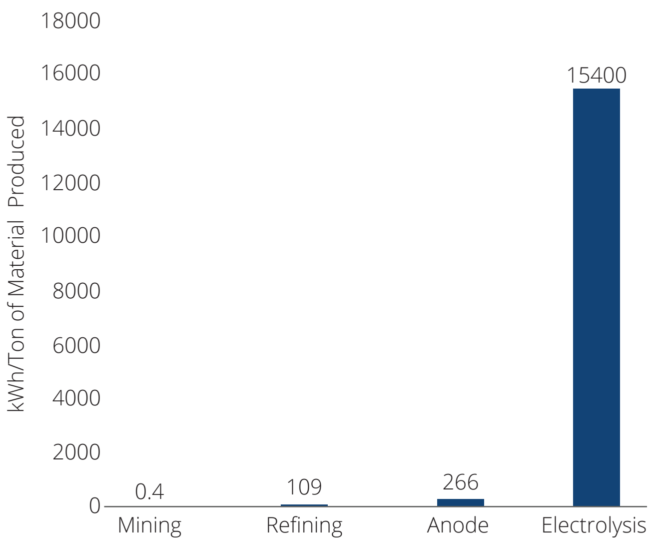
Process	Section wise	Unit	India Best Numbers (Gcal/t)	Average Numbers(GCal/t)
Anode Manufacture (Carbon)	Fuel	GCal/T	0.49	0.63
	Electricity	KWh/T	0.12	0.16
Ingot Casting	Electricity	KWh/T	0.09	0.15

The other important point to notice in the Table 21 and Table 22 is that it is the smelting that has much higher energy intensity in terms of the electrical energy consumption in comparison to the other subprocesses. This is because smelting is done using electrolysis is which consumes very high amount of electrical energy.

Another study on the US Aluminium industry also showed the disproportionate high electrical energy intensity of the smelting among all the sub processes. This can be seen in the Figure 18 which shows that electrical energy consumption of the different sub processes of the US aluminium industry. The study also, concludes that smelting consumes 46 % of the total electricity consumption by the US Aluminium industry and 30-40% of the total cost of production of primary aluminium are the electricity costs.

Thus, DR potential of the aluminium industry depends largely on DR potential of the smelting process.[63][64][65]

Figure 17: **The electricity requirement of sub processes of US Aluminium industry**



63 Source: "Improving Energy Efficiency in Aluminium Sectors (Achievement and Way Forward) ", September 2018, GIZ and BEE

64 Source: "Improving Energy Efficiency in Aluminium Sectors (Achievement and Way Forward) ", September 2018, GIZ and BEE

65 Shoreh, M. H. et al. "A survey of industrial applications of Demand Response." Electric Power Systems Research 141 (2016): 31-49.

9.6.2 DSR Potential in the Aluminium industry (from Literature)

As, discussed above that among all the sub processes in the aluminium manufacturing it is the smelting that consumes most of the connected load. Hence, for DSR potential for the aluminium manufacturing largely depends on the DSR potential of smelting and we need to have a deeper look into the smelting process to analyse its DSR potential.

In the smelting process, in pots DC current is passed through a cryolitic bath to remove oxygen from alumina and to get molten aluminium at the bottom of pot. In the process the alumina (aluminium oxide) and electric current are added continuously, and molten aluminium is extracted periodically. Generally, aluminium smelters work on very high DC current (in range of several hundred thousand amps) and very low voltage (below 10 V). A smelter consists of several potlines. Pot lines are combinations of hundreds of pots connected in a series load. Total power consumption of a potline can go up to hundreds of MWs. The smelting works on a very high temperature to ensure that aluminium is produced in the molten stage. This leads to a very high energy intensity of starting the smelting process, equal to 15MWh for every ton of aluminium to get the right high temperature. Thus, during the operation it is essential to maintain the thermal balance of the smelter and DSR should ensure that.

The power requirement of the smelter can be varied through two ways – by changing the output voltage of the rectifier that supplies DC current to the smelter or shutting down entire potline by switching breaker.

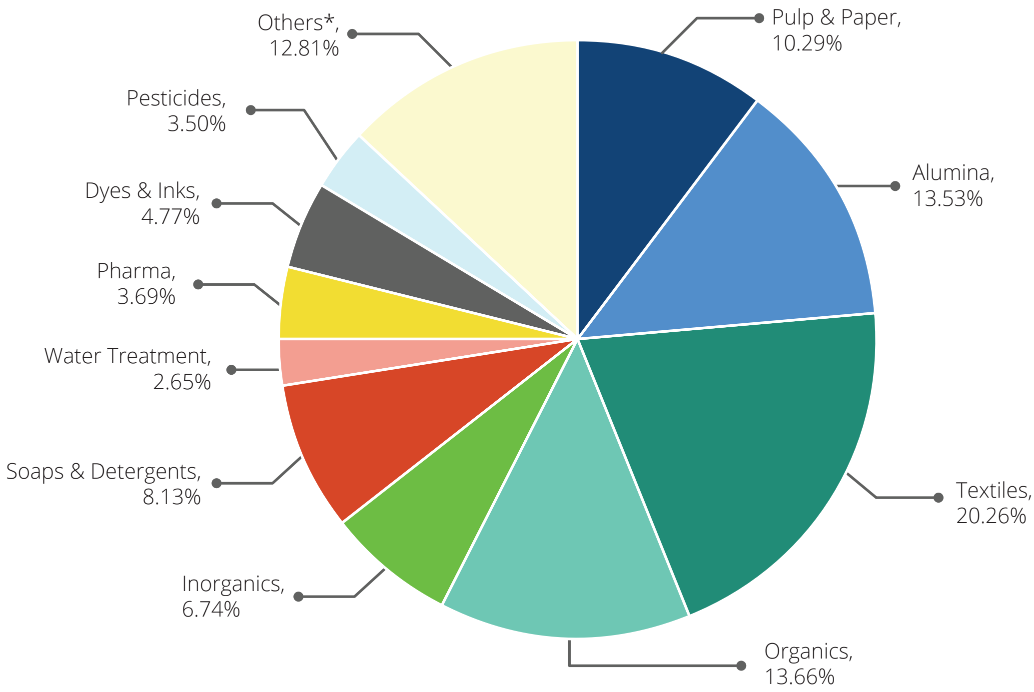
By changing voltage, the power consumption rate can be changed very quickly. As, the pots have high thermal mass (inertia to temperature change) with a multi-hour thermal time constant, they allow for instantaneous power variations that do not change the pot thermal balance. Hence, we can change the power requirement of the smelter for some time for DSR provided that the average power to the smelter over few hours remain constant.

In addition, we can achieve DSR by shutting down entire potline for short periods. The shutdown period can vary from few minutes to two hours depending on the plant characteristics that will allow for shut down of a potline without disturbing the thermal balance of the whole smelter. In the smelters with multiple potlines, we can even rotate the interruptions/ shut down of the potline to enable a longer total interruption[67].

According to a study by M.H. Soreh et.al. (2016), the capacity utilization of aluminium smelter is generally seen to be 95-98%, thus the potential demand response of the aluminium industry to the peak load pricing lies in the load shedding not in load shifting. The study had also estimated based on experiments that the electricity demand in the electrolysis process can be reduced up to 25 percent for 4 hours before any undesirable interruption[67].

The flexibility of 25 percent for aluminium sector was confirmed by stakeholders of Hindalco Industries Limited.

Figure 18: Sector-wise caustic soda consumption in India (2016-17)



9.7 A study of DSR potential in the Indian Chemical industry (chlor-alkali and Pharmaceutical sector)

The chlor-alkali industry is one of the oldest industries in the country, which indulges in the production of inorganic chemicals such as caustic soda (NaOH), Hydrogen (H_2), chlorine (Cl_2), soda ash (Na_2CO_3), etc. Chlor alkali sector has contributed significantly to the nation's economic growth through exports, supply to various downstream companies (textile, alumina, soaps, detergents, water treatment, etc.).

The primary product is the caustic soda, while others are generated as byproducts.66 Most of the plants manufacturing these chemicals are in Western India. The products from the chlor-alkali industry act as important inputs for other industries such as aluminium, textiles, paper, pharmaceuticals, etc.[67]

The installed capacity for caustic soda (and for chlorine which is a byproduct) has grown at a CAGR of 7.8% during the years FY16 to FY20, with the installed capacity increasing from 33.7 ltpa (lakh tonnes per annum) to 45.44-ltpa. About 60% of the total new additional capacity in the recent times has been done in Western India, as the region has a strong presence of chemical industries. Specifically, the state of Gujarat accounts for around 55% of the total installed capacity for caustic soda in India. Also, nearly 87% of the installed capacity for caustic soda in India is now based on captively produced power (CPP) due to the high costs of grid power. [68]

9.7.1 Processes in the chlor-alkali industry

The manufacturing of caustic soda can be done using three different electrochemical cell technologies, which are as follows:

- Diaphragm cell technology
- Mercury cell technology
- Membrane cell technology

Table 23: Top 5 captive generation plants in the Indian chemical industry in terms of capacity

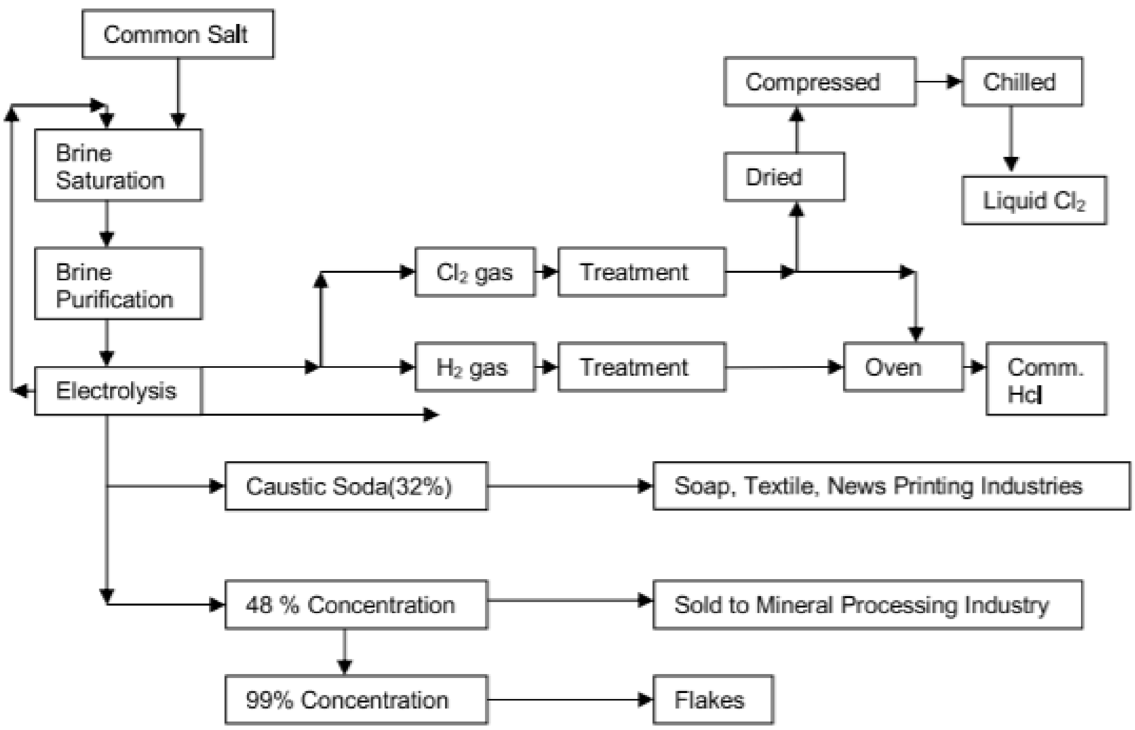
State/UT	Name of Industry	Fuel Used	Installed Capacity (kW)
Gujarat	Reliance Industries Ltd., Surat	Steam	564420
Gujarat	Reliance Industries Ltd., Surat	Gas	321640
Gujarat	Nirma Limited, Bhavnagar	Steam	166090
Madhya Pradesh	Godrej Consumers Products Ltd., Bhind	Steam	160000
Telangana	Nava Bharat Ventures Limited	Steam	150000

Table 24: Top 5 captive generation plants in the Indian chemical industry in terms of electricity imported from grid

State/UT	Name of Industry	Fuel Used	Energy Purchased (GWH)
Gujarat	Hindalco Industries Ltd., Bharuch	Steam	655
Gujarat	Gujarat Alkalis & Chemicals Ltd., Vadodara	Wind	495
Gujarat	Gujarat Alkalies & Chemicals Ltd., Bharuch	Gas	441
Maharashtra	Deepak Fertilisers and Petrochemicals Corpn. Ltd., Raigad	Diesel	419
Madhya Pradesh	Grasim Industries Ltd., Ujjain	Steam	416

66 https://www.keralaenergy.gov.in/files/Resources/Chlor_Alkali_Sector_Report_2018.pdf
67 Source – Alkali Manufacturers Association of India
68 http://ama-india.org/wp-content/uploads/2020/10/Chlor-alkali-industry-in-India-status.pdf

Figure 19: Process Flow Chart for Caustic Soda, Liq. Chlorine & HCl Production in Caustic soda

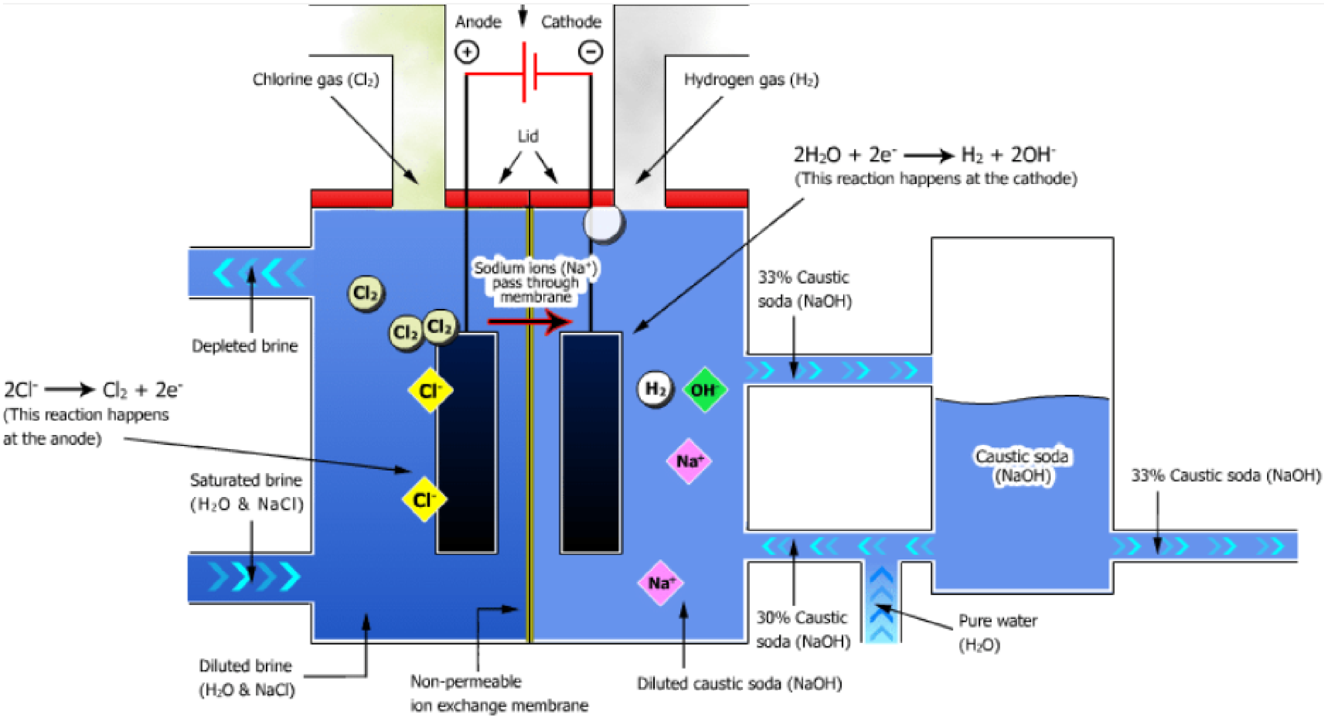


Manufacturing using diaphragm cell technology has become obsolete and is no longer in use in India. The mercury cell technology was also discontinued in the industry due to its high electricity consumption (3200 kWh/ MT of caustic soda) and environmental pollution. India had been using mercury cell technology for a long time which made Indian caustic soda costlier on the back of higher pollution control and power cost involved in manufacturing through this technology. India faced threat of heavy dumping from other countries wherein cost of production was considerably lower due to their early shift to membrane cell technology. However, mostly all the caustic soda plants in India are now based on membrane cell technology, which is relatively new and is a cleaner and energy efficient method of production of caustic soda (consumes 25% lesser energy than mercury cell technology. Hence, in terms of power and cost efficiency, India is now at par with other caustic soda producing countries. This, coupled with the gradual rise in the relatively cheaper renewable power capacity, has resulted in a declining trend in the per unit cost of power consumed, which would make the cost of power consumed for producing caustic soda in India largely at par with other countries in the medium term.

In the membrane cell technology, brine solution is fed into the anode half of the system, and chlorine is separated from the brine, wherein the electric current is passed through the anode. This helps in the production of chlorine gas. The caustic solution is then dispersed along the cathode through the permeable membrane, and 30-35% caustic soda and hydrogen is exited from the cathode shell. The power consumption of utilizing membrane cell technology is significantly lesser, i.e., 2400 – 2500 kWh/MT caustic soda, thereby implicating the increase in production for power consumed by mercury cell technology. The main disadvantage of this technology is the need to replace membranes at regular intervals, unless otherwise could increase the overall specific energy consumption of the production.69

69 https://www.keralaenergy.gov.in/files/Resources/Chlor_Alkali_Sector_Report_2018.pdf

Figure 20: **Process Flow of the membrane cell process**[70]

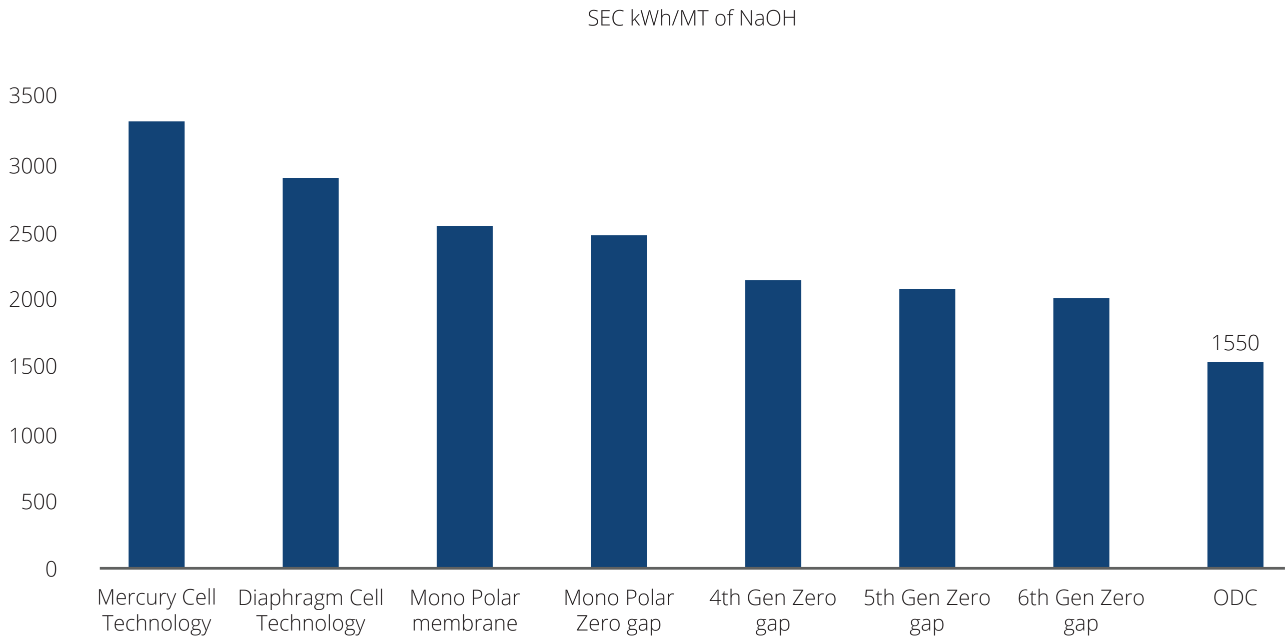


9.7.2 Power consumption in the industry

Earlier in general it was seen that the power consumption in the mercury cell technology was around 3200 kWh/ MT of caustic soda, while in the membrane cell technology it is significantly lesser, i.e., around 2400-2500 kWh/MT caustic soda.

It is possible to reduce the power consumption further by approximately 25%, using oxygen depolarised cathodes (ODC) technology, in which the estimated power consumption is around 1550 kWh/MT caustic soda. This is especially done in countries where the electricity is expensive.71

Figure 21: **Benchmark of various cell technologies for NaOH production**



70 https://www.eurochlor.org/about-chlor-alkali/how-are-chlorine-and-caustic-soda-made/membrane-cell-process/
71 https://ucpcdn.thyssenkrupp.com/_binary/UCPthyssenkruppBAISCountryWebsiteIndia/en/products-and-services/electrolysis/Article-on-Chlor-Alkalil.pdf

Energy savings under PAT cycle – I72

PAT is a regulatory instrument to reduce specific energy consumption (SEC) in energy intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy savings, which could be traded.

PAT Cycle – I started from 2012, with its baseline from FY 2007 – 08 to 2009 – 10. During the 1st cycle of PAT, the average value of specific energy consumption by the unit during baseline year i.e., 2007-08, 2008-09 & 2009-10 were taken into consideration and the specific targets were established for the plants. Under this

scheme, those industries with a minimum energy consumption of 12,000 MTOE and above were designated as a Designated Consumer (DC). A total of 22 chlor alkali plants were listed as DCs, mandated to reduce their energy consumption as per the target given to those DCs. The total reported energy consumption of these designated consumers (DCs) was about 0.88 million TOE. They were given target of 0.054 million TOE energy consumption reduction, which was only around 0.8% of the total national energy saving target assessed under PAT cycle - I.

Chlor Alkali sector has achieved energy savings of 0.09 million TOE in comparison to the target of 0.054 million TOE. This achievement has estimated GHG emission reduction of 0.62 million tonnes of CO2 equivalent.

9.7.3 DSR potential in the chemical industry

A study in the year 200873 estimated that a typical caustic-chlorine/ chlor alkali plant can reduce about 19% of its peak demand with a corresponding saving of about 3.9% in electricity costs, through optimal load scheduling under TOD tariffs.

On the other hand, DSR potential of pharmaceutical industryis slightly higher, about 40%, as per the discussions with sector expets within KPMG. Since the segregation of the electricity consumption by chlor-alkali and pharmaceutical sector is not available, we have assumed an average flexibility of 32% for the chemical sector.

Table 25: Achievements of Chlor Alkali sector in PAT Cycle - I

Particulars	Unit	Value
Number of plants in the sector	Nos.	22
Baseline Energy Consumption in PAT Cycle - I	million TOE	0.88
Energy reduction target for the sector	million TOE	0.054
Energy Savings achieved in PAT Cycle - I	million TOE	0.09
Reduction in GHG Emissions in Cycle - I	million T CO_2	0.62
Cumulative energy savings with impact of PAT till 2030 over BAU	million TOE	2.51

72 Improving efficiency in Chlor-Alkali sector – Perform, Achieve and Trade (September 2018)
73 https://ieeexplore.ieee.org/abstract/document/4484953

10. Potential Savings from Demand Side Response Potential of Industrial Consumers in India

10.1 Estimation of Demand Side Response Potential of key industrial sectors

The General Review of 2020 has reported the captive generation of key industrial sectors that covers the details received from 6051 industrial units with demand of 1 MW and above having Captive generation plants, for the year 2018-19.

It is to be noted that the total industrial consumption of power by 6051 industries comprises only around 50% of the total industrial consumption. This would mean that some additional sectors of the economy and some firms of the sectors already covered have not been included in the CEA dataset.

For the key 5 sectors except Iron and Steel, the CEA dataset seemingly covers almost all major firms of each sector. Using the data of sector-level electricity consumption and the flexibility quotient (% of the total electricity consumption that can be ramped down during peak hours) estimated by understanding the technical processes of each sector, we have calculated the demand side response (DSR) potential for these 5 sectors.

DSR Potential of 5 Key Sectors:

- Iron and Steel: 5.2 GW
- Chemical: 0.80 GW
- Textile: 0.85 GW
- Cement: 0.82 GW
- Aluminium: 1.1 GW
- Total DSR Potential of the above 5 sectors: 8.77 GW[74]

DSR Potential of all sectors included in the CEA database

While the study entails detailed analysis of the 5 key sectors only, an average flexibility quotient of 40 % for other sectors of the economy can be roughly estimated. Using this, one can compute an average DSR potential at the PAN-India level. This comes out to be 11.6 GW75 for the 6051 industrial units covered in CEA database.

Since the General Review data pertains to the year 2018-19, the DSR potential for 2021 can be extrapolated on pro-rata basis.

DSR Potential in 2021 (from the 5 Key Sectors): 11.7 GW

DSR Potential of all sectors included in the CEA database for 2021: 13 GW[76]

Since, the CEA dataset only incorporates a fraction of industries, the true DSR potential of industrial sector in India is more than 13 GW. An educated guess, basis the total industrial consumption, and a flexibility quotient of 30%, would give a number close to 15 GW for the entire industrial sector.

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74 * The above numbers have been computed using the dataset of 6051 industrial units covered in the CEA dataset. For Iron and Steel, only 62% of the total industrial consumption was captured by the CEA data. Hence the above-reported DSR potential was adjusted/inflated to also incorporate the firms that were not covered in the CEA dataset/firms that do not have captive generation. For Chemical sector, the reported DSR potential is an approximate number for Chlor Alkali as well as Pharmaceutical sector and is subject to minor changes, if required, as per the review of other stakeholders
*For Aluminium sector, the reported DSR potential has been estimated basis the flexibility reported by the KPMG Consultants working in the Aluminium sector. The same is subject to minor changes, if required, as we speak to more stakeholders

75 *The above number (11.6 GW) have been computed using 2018-19 data.

76 *The total industrial consumption of power by 6051 industries comprises only around 50% of the total industrial consumption. This would mean that some additional sectors of the economy and some firms of the sectors already covered (except iron and steel) have not been included while calculating the DSR potential

10.2 Key Insights/DSR Characteristics

Some of the key insights from the study are as follows:

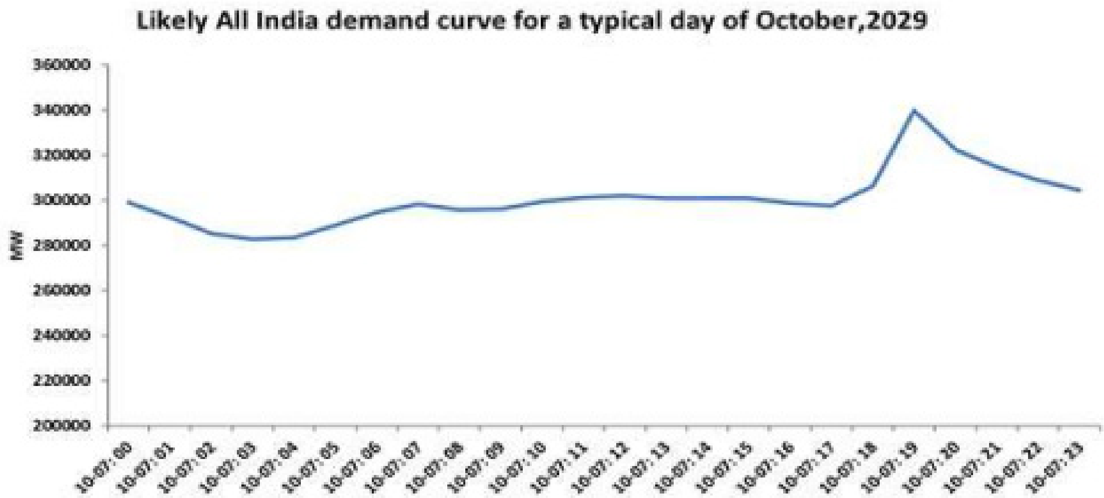
1. A total of 8.7 GW could be shifted by 5 sectors (Iron and steel, Chemical, Aluminium, Textiles and Cement) for upto 2 hours during the peak. The DSR potential of all firms across all sectors is roughly 13 GW.
2. The DSR potential of the 5 key sectors (Iron and Steel, Chemical, Textiles, Cement, Aluminium) is expected to be much more than the remaining other sectors due to their sheer size in the overall power consumption basket.
3. For all sectors, roughly 80-90% of the load is expected to operate at a uniform rate with minimum disruptions. Most Iron and steel plants operate at 95% of their peak load during the day, followed by Aluminium and textiles (at around 85%).
4. In case of Iron and steel and Aluminium, major proportion of the production processes is continuous and hence inflexible. Thus, a relatively higher DSR potential for these sectors can be attributed to their higher electricity consumption with regards to other sectors.
5. From a purely technical standpoint, textile sector has a huge potential for demand response as all processes are batch processes. However, due to the high capital intensive natureof the sectors, firms lose out on their overall profitability if processes are halted for a long time.
6. All sectors can reduce their consumption for atleast 2 hours during the peak. Cement can reduce its demand for upto 4-6 hours (by halting finish grinding), textiles can reduce its demand for upto 3-6 hours (by switching off some of the weaving units) whereas aluminium and iron steel can reduce them for upto 2 hours only (since most of their processes are continuous).
7. Firms that serve large market share (such as tata steel, hindalco) have their plants operating at 90% of their peak load during the entire day. Such firms are unwilling to shift load as the opportunity costs (in terms of the risk of production losses) are much higher due to large market size, contractual obligations, brand equity etc.
8. On the other hand, smaller firms in all sectors were found to be much more sensitive to changes in peak and off-peak prices are were more willing to shift their processes. Since these firms do not always operate at their full capacity, the opportunity costs are relatively lower.
9. In terms of DSR incentives, cement can reduce its peak consumption at the relatively lower consumption as compared to textiles, iron & steel and aluminium. The latter sectors are very capital intensive and hence are expected to demand higher compensations for load-shifting etc.
10. An approximate merit-order curve for industrial sectors DR with respect to per-unit incentive of demand reduction is as follows:

Incentive (Rs/Unit)	DR Potential (GW)
Rs 3.5 - Rs 5	3
Rs 5 - Rs 7	4.2
Rs 7- Rs 10	5.6
Rs 10 - Rs 14	7.1
Rs 14 and onwards	8.7

Source: KPMG Analysis, Stakeholder Consultations from 5 key sectors

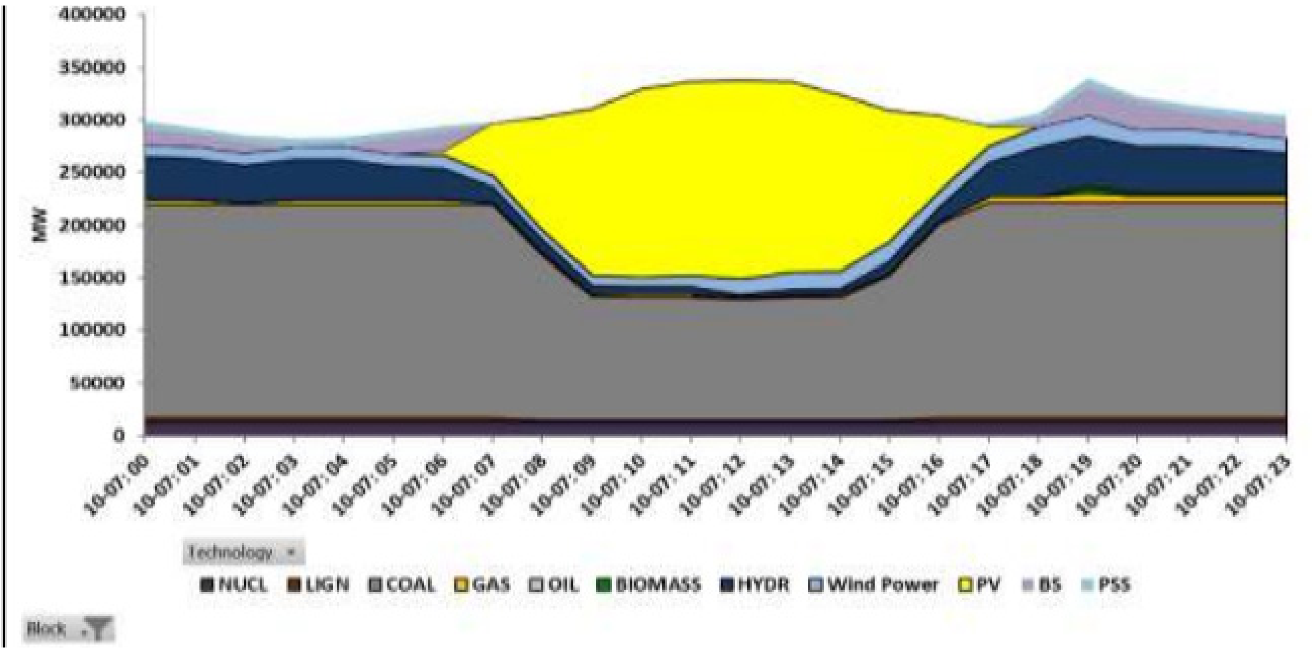
11. With regards to the sale of power on the Exchange, most firms were willing to sell their surplus profitably, however, not at the cost of sacrificing their self-consumption. These is because these firms have invested in building generation capacities for the sake of their production. Making profits from the sale of power is not the primary motto of these companies.
12. The actual demand response by the sector depends on a lot on a diverse range of factors such as production structure of the unit, TOD tariff structure, awareness, government policy, contractual obligations, market demand etc.

Figure 22: **Likely all India demand curve for a typical day of October, 2029**



Source: 'Report on Optimal Generation Capacity Mix for 2029-30'

Figure 23: **Generation Dispatch**



Source: CEA Report on Optimal Generation Mix for 2029-30

10.3 Potential Cost-Savings from effective Demand Side Management of Industrial Consumers

There are two kinds of savings that can be accrued from peak load management:

1. **Savings in terms of the investment obviated for building additional capacity in the future to serve peak load**

As per the Report on Optimal Generation Capacity Mix for 2029-30, published by CEA, the hourly demand profiles on all India basis of the years 2014-15, 2015-16 and 2016- 17 have been studied to arrive at the most probable demand profile and the same has been extrapolated considering the peak electricity demand and electrical energy requirement for the study in the year 2029-30. The likely hourly demand curve for a typical day in October 2029 is shown below:

Table 26: **Current Capacity Mix (in 2021)**

Technology	MW	Cost (Cr/MW)
Coal	196894	7.3
Battery	0	7
Hydro	45399	10
PSP	4000	3.5

Source: CEA Report on Optimal Generation Mix for 2029-30

Table 27: **Expected Capacity Mix (in 2030, in absence of DSR)**

Technology	MW	Cost (Cr/MW)
Coal	266911	7.3
Battery	27000	4.3
Hydro	60977	10
PSP	10151	3.5

Source: CEA Report on Optimal Generation Mix for 2029-30

Table 28: **Additional Capacities Required to serve the peak in 2020**

Technology	MW	Cost (Cr/MW)
Coal	70017	7.3
Battery	27000	5.65*
Hydro	15578	10
PSP	6151	3.5
Total	118746	

**Since the battery costs are expected to decline between 2021-30, we have assumed an average cost between 2021 and 2030*

Table 29: **Capacity investments that can be obviated with DSR**

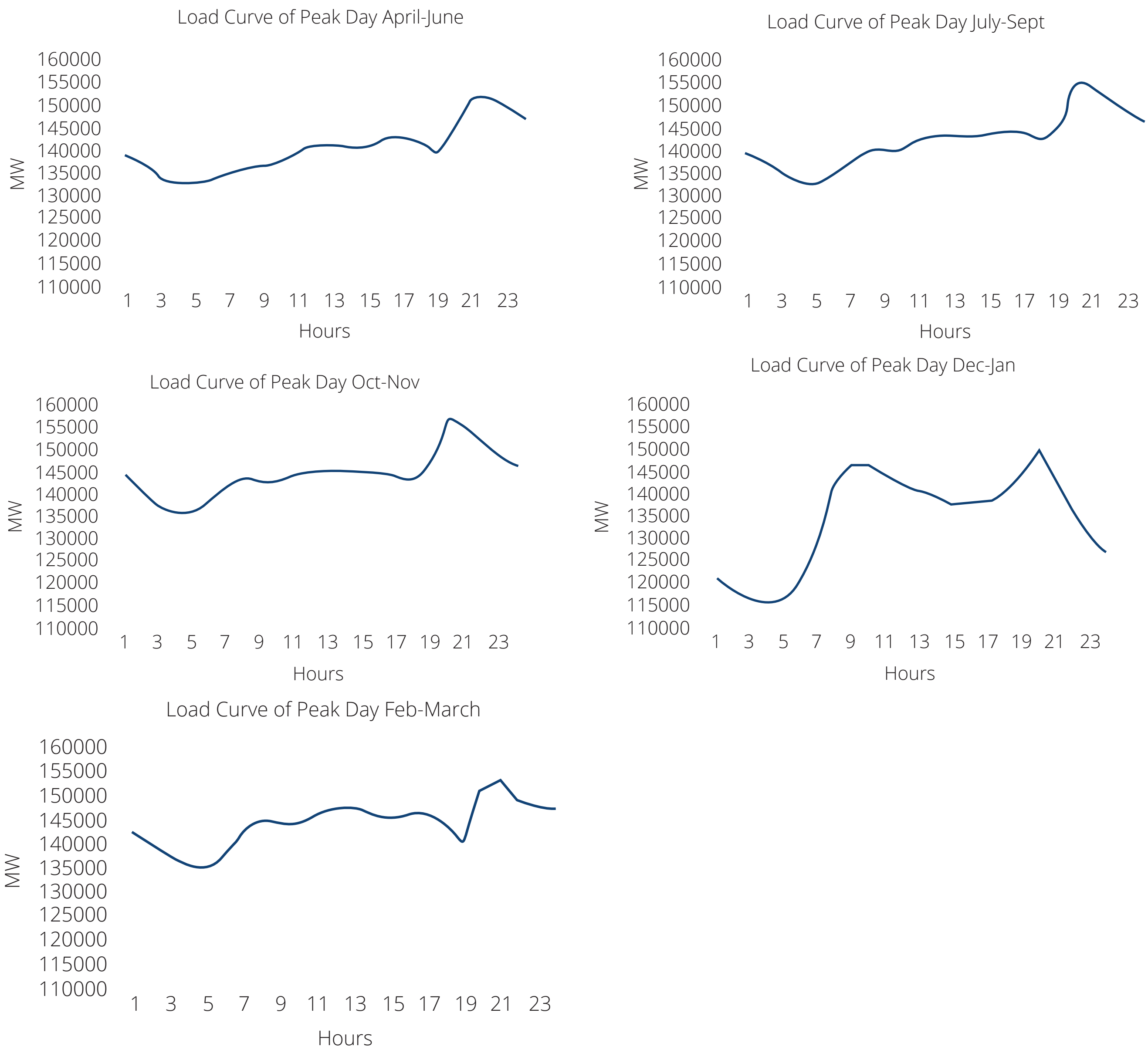
Technology	MW	Savings (in Rs crore)
Coal	12.97	94695.65
Battery	5.00	28262.85
Hydro	2.89	28861.27
PSP	1.14	3988.572
Total	**22.00**	**155808.3**

As seen from the above figure, even in 2030, evening peak is expected to last for around 2 hours. However, with the increase in the overall industrial demand, the DSR potential (at PAN India level) is also likely to grow to roughly 22.5 GW (calculated using pro-rata calculations, assuming similar percentage flexibility of peak demand.

In absence of any DSM intervention, additional capacities would be required to serve the peak and these capacities would include coal-fired plants, battery energy storage, hydro and pump storage capacities (as per CEA's report on Optimal Generation Capacity Mix for 2029-30), as depicted in the figure below:

Some of these capacities such as battery storage system are relatively more expensive currently, however, they're needed for purposes other than peak serving (for example battery storage systems are needed to absorb additional solar generation and facilitate system balancing in times of need). Since the need for a particular kind of capacity cannot be completely obviated, we can compute the savings by adjusting the quantum of each type of capacity that is required to serve the peak. The reduction is capacity requirement can be done on pro rata basis.

Figure 24: Load curve of the country across various season



Source: 'Report on Optimal Generation Capacity Mix for 2029-30'. The load curves shown above are average load curves for the year 2014-15, 2015- 16 and 2016-17.

Hence the total savings due to DSR from 2021-2030 would be close to Rs 1,55,808 Cr which amounts to Rs 15,580 Cr per year

2. **Current and Future Savings from not having to run expensive gas-peakers during peak hours**

India's current load profile indicates that peak load is generally observed during morning hours and evening hours. However, the evening peaks are higher than the morning peaks morning. The capacities that are expected to run during peak periods are expected to be relatively costlier than off-peak capacities

All India peak load is observed generally in the month of September/October (load curve of the year 2014-15, 2015- 16 and 2016-17). The load curve of the country varies significantly during different seasons and the same is shown in the following figure:

Though the load curves vary across seasons, the peak load was mainly observed during the 7.30 pm to 9.30 pm during evenings. During this time, the marginal capacities (usually gas based) are run to serve the peak demand and the marginal cost of generation is between Rs 3/KWh to Rs 6/KWh usually, except for few very expensive gas generators like Gandhar LNG, Anta liquid, RGPPL, Auraiya RLNG that have variable cost of over Rs 6/KWh. The marginal cost of each state varies across seasons but typically varies in this range of Rs 3/unit-Rs 6/unit. On the other hand, off-peak generators have variable cost that lie in the range of Rs prices lie between Rs 1.5/KWh to Rs 3/KWh. This data is publicly available on Merit India website: (https://meritindia.in/MarginalDetails)

While Merit India data gives a fair estimate of variable costs of marginal and non-marginal generators, the data on capacities run during peak and off-peak hours is not available. Thus, to get an estimate of the price differential between peak and off-peak times, one can refer to the prices during peak (evening) and off-peak times on the Day-ahead market on Indian Energy Exchange. This is because the true cost of power is determined close to the real-time when utilizes buy/sell their residual demand/excess generation.

Thus, for 2021, the savings accrued due to DSR can be computed using the exchange price differential during peak and off-peak times

Savings in 2021 through DSR

Weighted average cost of generation from marginal generators	**Rs 3.91/KWh**[77]
Weighted average cost of generation (during off-peak hours)	**Rs 3.08/KWh**[78]
DR Potential in 2021	**13 GW**
Annual Savings in 2021 (from load shifting from peak to off-peak hours)	**792 Cr INR**[79]

For 2030, expected variable costs for capacities run during peak and off-peak hours are borrowed from CEA's report on Optimal Generation Mix for 2029-30

Future Savings (in 2030) through DSR

Weighted average cost of generation during peak hours	**Rs 3.8/KWh**[80]
Weighted average cost of generation during off-peak hours	**Rs 3.0/KWh**[81]
DR Potential in 2030	**22 GW**
Annual Savings in 2020 (from load shifting from peak to off-peak hours)	**1284 Cr INR**[82]

It is to be noted that the savings number for both 2021 and 2030 represent approximate savings computed using data from merit Indi and CEA's report. It is to be noted that actual savings may be vary from day to day depending upon the duration of the peak as well the mix of generation capacities utilized in peak and off-peak hours and their variable costs in the future.

77 Approximate number calculated using DAM prices on IEX in 2021
78 Approximate number calculated using using DAM prices on IEX in 2021
79 Calculated assuming peak load shifting for 2 hours each day
80 Approximate number calculated using cost data shared in the appendix of CEA's report on Optimal generation Mix for 2029-30
81 Approximate number calculated using cost data shared in the appendix of CEA's report on Optimal generation Mix for 2029-30
82 Calculated assuming peak load shifting for 2 hours each day

11. Conclusion and future recommendations

The study found that there exists some untapped potential of Demand-side response by industrial customers which can help curtailing the existing peak demand by 10-13 GW. One of the ideal ways for creating incentives for consumers to reduce or shift their energy consumption is through introducing dynamic/real-time tariff regimes. However, to begin with, the dynamic/real-time tariffs should be made voluntary, just like how Time-of-day tariffs were scaled up gradually in various states.

Secondly, to promote the RTP adoption in states, the fixed charge currently levied on the industrial players must be revised to ensure that switching away from a flat-tariff regime is incentive compatible for the players.

Also, since the prices of electricity in the wholesale market fluctuate in different seasons, the fixed cost charged from these players in the dynamic/RTP tariff regime must change (seasonally or quarterly) according to the economic feasibility standpoint.

Thirdly, some of the states in India have levied very high intra-state open access charges which hinders market participation by industrial players. A larger market participation can indirectly promote RTP tariff adoption. This is because as these players get more aware of price-trends in the wholesale market, their risk appetite would increase eventually leading to a higher RTP tariff adoption.

Fourthly, since the success of RTP tariff is hugely contingent on its design (time-blocks, price setting, price update frequency etc.), proper quantitative simulations must be performed and the results must be evaluated before execution. Also, the optimal price spread should be carefully determined. On the one hand, the spread should be sufficient to incentivize customers to change their consumption pattern. On the other hand, price differentials that are too large might hinder the adoption by customers as their financial risk is higher. A cap on the highest price zone, a sort of “best price guarantee”, could overcome this process.[83]

Lastly, to ensure maximum adoption and create awareness, insights from few large industrial customers must be considered while designing the tariff scheme. This can improve the acceptance of the dynamic pricing scheme as consumer preferences could be taken into consideration

To summarise, there is a need for regulators and policy makers to design tariff structures that reflect market conditions, to develop pilot programs, to conduct proof-of-concept in various states etc. to help the industrial players understand the benefits of such a regime, along with its associated technology costs of making real-time adjustments in their power consumption

83 https://www.smartgrid-engagement-toolkit.eu/fileadmin/s3ctoolkit/user/guidelines/GUIDELINE_DESIGNING_A_DYNAMIC_TARIFF.pdf

Some broad recommendations to overcome the existing barriers pertaining to RTP are discussed in the table below:

S.No.	Challenges	Recommendations
1.	**Lack of Real Time Price Signalling** mechanism i.e., lack installation Smart Meters	• Mission mode installation of **smart meters** to enable two-way communication between load and utility
2.	**Lack of** distribution and transmission **infrastructure** to enable RTP mechanism	• Investment in transmission lines E.g., **Green Energy Corridors** • Investment in electricity storage E.g., Investment in **advance battery technologies**
3.	Requirement of sophisticated communication and electricity devices **hinders the reach of RTP to small consumers**	• Packaging of DSM programs must address high fixed cost/ entry barrier for small consumers e.g., **EMI option** • **Government schemes targeting small consumers** entry to DSM programs
4.	**Industries with continuous processing** lack flexibility in shifting production based on dynamic movements in the electricity prices	• Focus on **DSM in the ancillary services** in the process e.g., Cooling plants, lighting, etc
5.	**Inelastic electricity demand** leading to **high fluctuation in electricity prices** leading to high uncertainty in market leading to thinning of markets	• **Feeder Separation** between agriculture and non-agriculture consumers • **Use of automation** to make certain load to automatically respond to price signals in the real time
6.	**High wheeling charge** by the Discoms	• Regulatory authorities SERCs and CERC must **determine a ceiling** on the wheeling charges
7.	The **intrinsic complexity of the RTP tariff** in comparison to the flat tariff structure	• RTP implementation on pilot basis in small areas and specific consumer segments like large industries and then a **gradual scale-up** • Regulatory institutions should **establish standards and codes** in the DSM for wider adoption
8.	Consumer's electricity demand depends on factors other than electricity prices such as deadlines for fulfilment of client orders. Hence, in these cases RTP can lead to high variability in the electricity cost	• Use of **advanced forecasting techniques** such Artificial Intelligence, Machine Learning, etc by the consumers and utilities • Financial incentives like **high discount rates in the initial implementation phase**
9.	**Lack of Revenue Realisation** at the distribution level	• Institutional **Reforms in Discoms** • Focus on **metering** at consumer and distribution transformer metering level
10.	**Lack of customer engagement** and customer awareness about DSM	• **Awareness campaigns** using various mediums such as social media, print media, etc
11.	**Lack of competition** b/w utilities at the distribution level	• **Delicensing of Distribution sector**
12.	**Reluctance** of the stakeholders such as consumers and Discoms to switch to a new tariff regime	• **Transaction cost evaluation** • Financial incentives like **EMI based payment mechanism** for installation of DSM related equipment
13.	**Energy inefficiency in** various sectors of economy like agriculture, housing, transport, MSMEs, etc	• Energy efficiency in buildings through widespread adoption **Green Building Codes** such as GRIHA Ratings in the building construction and usage • Energy efficiency in industry through schemes such as **PAT schemes** • Energy efficient transport through **investment in public transport**

Appendix

Appendix 1: TOD implementation details for states and UTs of India

<table>
<tr><th>TOD Implementation Details</th><th>TOD Timings</th><th>TOD Tariff details (industrial/ commercial)</th><th>TOD tariff details (others)</th><th>Remarks</th></tr>
<tr><td colspan="5">Eastern Region*</td></tr>
<tr><td colspan="5">1. Jharkhand:</td></tr>
<tr><td>YOI: 2003-04
Optional:
HTS: All the consumers drawing power at voltage level at 6.6 kV and above except Domestic-HT and HT-Institutional Consumers.
HTS institutional: Railway Traction, Military Engineering Services and Other Distribution Licensees.</td><td>Peak Period: 06:00hrs. to 10:00hrs and 18:00hrs to 22hrs.
Off Peak Period: 22:00hrs to 06:00hrs.
Normal period: 10:00hrs to 18:00hrs.</td><td>a) HTS:
Energy Charge: Rs. 5.5
Peak Charge: 120% of EC
Off peak Charge: 85% of EC</td><td>a) HT Institutional
Energy Charge: Rs. 5.25
Peak Charge: 120% of EC
Off peak Charge: 85% of EC</td><td>Jharkhand (JBVNC) 2020-21 tariff order</td></tr>
<tr><td colspan="5">2. Bihar:</td></tr>
<tr><td>YOI: 2008-09
Mandatory: HT-all categories: Installations with contract demands above 50 kvA
HTS-I: Installations that meet the contract demand 50kVA-1500kVA
HTS-II: Installations that meet the contract demand 500kVA-15,000kVA
HTS-III: Installations that meet the contract demand Minimum 7.5MVA
HTS-IV: Installations that meet the contract demand Minimum 10MVA
HTSS: Installations that meet the contract demand 300 kVA and above

HT EV charging stations
Optional:
LTIS-I: Installations that meet the contract demand Up to 19kW
LTIS-II: Installations that meet the contract demand 9kW-74kW
PWW (Public water works) Installations that meet the contract demand 50kVA-1500Kva</td><td>Peak Period: 17:00hrs to 23hrs.
Off Peak Period: 11:00hrs to 17:00hrs.
Normal period: 23:00hrs to 11:00hrs.</td><td>a) LTIS - I, LTIS - II
Energy Charge: Rs. 6.4
Peak Charge: 120% of EC
Off peak Charge: 85% of EC
b) HTS - I
Energy Charge: Rs. 6.55 Rs.
Peak Charge: 120% of EC
Off peak Charge: 85% of EC
c) HTS - II
Energy Charge: Rs. 6.5
Peak Charge: 120% of EC
Off peak Charge: 85% of EC
d) HTS - III, EV charging stations
Energy Charge: Rs. 6.45
Peak Charge: 120% of EC
Off peak Charge: 85% of EC
b) HTS - IV
Energy Charge: Rs. 6.4
Peak Charge: 120% of EC
Off peak Charge: 85% of EC
e) HTSS
Energy Charge: Rs. 7
Peak Charge: 120% of EC
Off peak Charge: 85% of EC</td><td>a) PWW
Energy Charge: Rs. 7.95
Peak Charge: 120% of EC
Off peak charge: 85% of EC</td><td>(NBPDCL, SBPDCL) 2021-22 tariff order</td></tr>
</table>

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
3. Meghalaya				
YOI: 2018-19 **Mandatory:** HT & EHT (only Industrial)	**Peak Period:** 17:00 hrs. to 23:00 hrs. **Off Peak Period**: 23:00 hrs to 06:00 hrs. **Normal period:** 06:00 hrs to 17:00 hrs.	**a) HT:** **Energy Charge:** Rs. 6.6 **Peak Charge:** 120% of EC **Off peak Charge:** 85% of EC **b) EHT** **Energy Charge**: Rs. 6.2 **Peak Charge**: 120% of EC **Off peak Charge:** 85% of EC	-	Meghalaya (MSERC) 2020-21 tariff order
4. Tripura				
YOI: 2005-06 **Optional:** Industrial, Tea/Coffee/ Rubber Gardens, Bulk Supply, Water Works, and Irrigation categories	**Peak Period:** 17:00 hrs. to 23:00 hrs. **Off Peak Period:** 23:00 hrs to 06:00 hrs. **Normal period:** 05:00 hrs to 17:00 hrs.	**a) Industrial:** **Energy Charge:** Rs. 5.93-7.25 **Peak Charge:** 140% of EC **Off Peak Charge:** 60% of EC **b) Bulk Supply:** **Energy Charge:** Rs. 7.33 **Peak Charge:** 140% of EC **Off Peak Charge:** 60% of EC	**a) Tea, Coffee, rubber** **Energy Charge:** Rs. 7.5 **Peak Charge:** 140% of EC **Off Peak Charge:** 60% of EC **b) Water Works** **Energy Charge:** Rs. 6.65 **Peak Charge:** 140% of EC **Off Peak Charge**: 60% of EC **a) Irrigation** **Energy Charge:** Rs.4.95 - 5.95 **Peak Charge:** 140% of EC **Off Peak Charge:** 60% of EC	Tripura (TERC) 2020-21 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
5. Assam				
YOI: 2004-05 **Mandatory:** **LTVIII:** Consumers having Contract Demand/Connected Load up to 25 kW. **HT Category V (A):** Consumers with Connected Load above 25 kW (or 30 kVA) and up to 50 kVA **HT Category V (B):** Contract Demand/Connected Load above 50 kVA and up to 150 kVA. **HT Category V (C):** Contract Demand/Connected Load above 150 kVA. **HT Category VI:** Applicable for tea, coffee, and rubber plantation/ production by utilisation of electrical power in factory, irrigation, lighting, etc., in the Estate. **HT Category VII:** Installations of Oil and Coal Sector.	**Peak Period:** 17:00hrs. to 22:00hrs. **Off peak hours:** 22:00hrs. to 06:00hrs **Normal period:** 06:00hrs to 17:00hrs.	**a) LTVIII** **Energy Charge:** Rs. 4.75-5.00 **Peak Charge:** Rs. 2.00 above EC. **Off peak Charge:** Rs. 2.00 below EC. **b) HT Category V (A)** **Energy Charge:** Rs.5.45 **Peak Charge:** Rs. 2.00 above EC. **Off peak Charge:** Rs. 2.00 below EC. **c) HT Category V (B)** **Energy Charge:** Rs.5.85 **Peak Charge:** Rs. 2.00 above EC. **Off peak Charge:** Rs. 2.00 below EC. **d) HT Category V (C)** **Energy Charge:** Rs.6.35 **Peak Charge:** Rs. 2.00 above EC. **Off peak Charge:** Rs. 2.00 below EC. **e) HT Category VI** **Energy Charge**: Rs.6.35 **Peak Charge:** Rs. 2.00 above EC. **Off peak Charge:** Rs. 2.00 below EC. **f) HT Category VII** **Energy Charge:** Rs 7.40 **Peak Charge:** Rs. 2.00 above EC. **Off peak Charge:** Rs. 2.00 below EC.	-	Assam (APDCL) 2020-21 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
		6. West Bengal		
YOI: 2001 - 02 **Mandatory:** Commercial plantation, Industries (above 220 kV) **Optional:** Commercial (Low Voltage), Industry optional, Industries optional (11 - 132 KV), Commercial optional (up to 132 KV), private educ. & hospitals, e) Commercial (50 - 125kVA), public utilities, cottage industry and poultry,	**Peak Period:** 1700 hrs. to 23:00 hrs **Off peak period:** 23:00 hrs to 0600 hrs **Normal period:** 0600 hrs to 1700 hrs	**Low and medium voltage consumers** **a) Commercial (Low Voltage) optional** **Energy Charge :** Rs.7.74 **Peak Charge :** Rs.9.28 **Off peak charge:** Rs.6.58 **b) Commercial plantation mandatory** **Energy Charge :** Rs.7.2 **Peak Charge :** Rs.8.75 - 9.23 **Off peak charge:** Rs.6.79 - 6.81 **c) Industry optional** **Energy Charge :** Rs.6.63 - 6.84 **Peak Charge :** Rs.7.98 - 8.21 **Off peak charge:** Rs.4.95 - 5.13 **d) private educ. & hospitals optional** **Energy Charge :** Rs.6.88 **Peak Charge :** Rs.7.51 **Off peak charge:** Rs.6.43 **e) Commercial (50 - 125kVA) optional** **Energy Charge :** Rs.7.04 **Peak Charge :** Rs.9.85 **Off peak charge:** Rs.4.65 **High and extra high voltage consumers** **f) Industries optional(11 - 132 KV):** **Energy charge:** Rs.6.87 - 7.08 **Peak charge:** Rs.8.23 - 8.5 **Off peak charge:** Rs.5.15 - 5.31 **g) Industries mandatory(220 KV):** **Energy charge:** Rs.6.27 - 6.31 **Peak charge:** Rs.7.51 - 7.57 **Off peak charge:** Rs.4.71 - 4.73 **h) Industries mandatory(400 KV):** **Energy charge:** Rs.6.07 - 6.11 **Peak charge:** Rs.7.27 - 7.33 **Off peak charge:** Rs.4.56 - 4.58 1 **i) Commercial optional (up to 132 KV)** **Energy charge:** Rs.6.64 - 6.76 **Peak charge:** Rs.9.99 - 10.14 **Off peak charge:** Rs.3.93 - 3.98 1	**Low and medium voltage consumers** **a) Public utilities optional** **Energy Charge:** Rs.6.63 **Peak Charge:** Rs.7.25 **Off peak charge:** Rs.6.2 **b) Cottage industry and poultry (optional)** **Energy charge:** Rs.6.69 - 7.66 **Peak charge:** Rs.7.31 - 8.37 **Off peak charge:** Rs.6.26 - 7.17 **High Voltage consumers** **c) Public Utilities (11kv -33kv) (optional)** **Energy charge:** Rs.6.11 - 6.28 **Peak charge:** Rs.9.17 - 9.48 **Off peak charge:** Rs.4.79 - 4.94	Source: West Bengal (WBEDCL) 2017-18 tariff order. West Bengal has three DISCOMS (WBEDCL, CESC Ltd., New Town Electric Supply Company Ltd.)

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
		Western Region		
		7. Daman & Diu		
YOI: 2013-2014 **Mandatory: All HT and LT supply** (Examples are: Private houses, Hostels, Hospitals, Religious Institutions, Government Schools, Shops, Offices, Restaurants, Bus Stations, Photo Studios, Laundries, Cinema, Theatres, Industrial Lighting, Clubs, Electricity for lighting external advertisements, external hoardings and displays at departments stores, malls, multiplexes, theatres, clubs, hotels, bus shelters, Railway Stations and EV charging stations.)	**Peak period:** 18:00hrs. to 22:00hrs. **Off peak period:** 22:00hrs to 06:00hrs. **Normal period:** 06:00hrs to 18:00hrs.	**a) LT and HT Commercial:** **Energy charge:** Rs. 3.00-4.20 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **f) LT, HT and EHT industrial:** **Energy charge:** Rs. 3.60-4.20 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC	**a) Domestic:** **Energy charge:** Rs. 1.40-3.00 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **b) Agriculture:** **Energy charge:** Rs. 0.75-1.05 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **c) Public lighting:** **Energy charge:** Rs. 4.50 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **d) LT PWW:** **Energy charge:** Rs. 4.10 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **e) Hoarding/ Signboards:** **Energy charge:** Rs. 6.70 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **f) EV Charging stations:** **Energy charge:** Rs. 4.50 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC	Electricity department of Daman and Diu 2021-22 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
8. Goa				
YOI: 2012-13 **Mandatory: All HT and EHT supply** (Examples are: Residential consumers of Bungalows, Villas or cottages whose contract demand falls within the threshold category for HT, Houses with rent back facilities, Government hospitals, Commercial complexes and business premises, Entertainment services, Offices, Marriage halls/ Hotels/ Restaurants, Automobile and repair centres, Banks/ ATM centres, Water pumping/ street lighting etc., Sports facilities, R&D units, Educational institutions, Airports/ train stations/ bus stations, Ice manufacturing, IT industries/parks, Sewage pumping stations, Steel rolling, Metal alloy, Steel melting, Ferro alloy, Irrigation pumping/water lifting/dewatering, Poultry/Livestock, Horticulture/ Greenhouses/plantations, Fisheries, Tissue culture/mushroom activities/ aquaculture/ sericulture etc.) **Optional: LT- Industrial and Commercial** (Examples are: Flour mills/Dal mills/ Rice mills/Poha mills/Masala mills/ Sawmills/power looms, Ice cream manufacturing units/Ice factories/ Plants and dairy testing process/Milk dairies/Milk processing and chilling plants, Engineering workshops/ Printing press/Tyre retreading units etc., Mining/Quarry/ Stone crushing units, Garment manufacturing, Sewage water treatment plants, IT industries/parks, LPG/CNG bottling plants)	**Peak period:** 18:00hrs. to 23:00hrs. **Off peak period:** 23:00hrs to 07:00hrs. **Normal period:** 07:00hrs to 18:00hrs.	a) **LT and HT Commercial:** **Energy charge:** Rs. 3.55-5.50 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **c) LT and HT Industrial:** **Energy charge:** Rs. 3.40 – 4.80 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC	**a) HT Domestic:** **Energy charge:** Rs. 3.65 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **d) HT-Ferro/SM/PI/ SR:** **Energy charge:** Rs. 4.80 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **e) HT-AG (Pump sets/ irrigation):** **Energy charge:** Rs. 1.60 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC **f) HT-AG (Allied activities):** **Energy charge:** Rs. 1.95 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC	Goa (EDG) 2021-22 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
9. Gujarat				
YOI: 1999-00 **Mandatory: WWSP, HTP-I, HTP-II and HTP-III** (Examples are: Water works and Sewerage pumping stations, consumers contracting 100kVA and above for regular power supply and consumers taking supply of electricity at high voltage, contracting for not less than 100kVA for temporary period)	**Peak period:** 07:00hrs. to 11:00hrs. and 18:00 to 22:00hrs. **Off peak period:** 11:00hrs to 18:00hrs. and 22:00hrs to 06:00hrs.	**a) HTP-I:** **Energy charge:** Rs. 4.00 – 4.30 **TOU peak charge:** Rs.0.45-0.85 higher than EC **b) HTP-III:** **Energy charge:** Rs. 6.60 **TOU peak charge:** Rs.0.85 higher than EC	**a) WWSP (Water pumping and sewage pumping):** **Energy charge:** Rs. 3.20-4.30 **TOU off peak charge:** Rs.0.40-0.85 lower than EC **b) HTP-II (HT WWSP):** **Energy charge:** Rs. 4.35 – 4.65 **TOU peak charge:** Rs.0.45-0.85 higher than EC	Gujrat Electricity Commission 2019-20 tariff order (DGVCL, MGVCL, PGVCL, UGVCL)
10. Chhattisgarh				
YOI:2005-06 **Mandatory: HV-2, HV-3, HV-4** (Examples are: mines, mines with stone crusher unit, coal mines, coal washery, etc., for power, lights, fans, cooling ventilation, all types of industries including cement industries, also applicable for bulk supply at one point to establishment such as Railways (other than traction), hospitals, offices, hotels, shopping malls, electric charging centres for Vehicles, power supplied to outside of State (border villages), educational institutions, mixture and/or stone crushers and other institutions, etc., having mixed load or non-industrial and/or non-residential load, steel industries, mini-steel plant, rolling mills, sponge iron plants, ferro alloy units, steel casting units, pipe rolling plant, iron ore pellet plant, iron beneficiation plant and combination thereof including wire drawing units with or without galvanizing unit, for power, lights, fans, cooling ventilation.	**Peak period:** 18:00hrs. to 23:00hrs. **Off peak period:** 23:00hrs to 05:00hrs. **Normal period:** 05:00hrs to 18:00hrs.	**a) HV-2 (Mining):** **Energy charge:** Rs. 6.00-6.70 **TOD peak charge:** 120% of EC **TOD off peak charge:** 75% of EC **b) HV-3 (Other Industrial and General Purpose Non-Industrial):** **Energy charge:** Rs. 5.91-6.91 **TOD peak charge:** 120% of EC **TOD off peak charge:** 75% of EC **c) HV-4 (Steel industries):** **Energy charge:** Rs. 5.30-6.75 **TOD peak charge:** 120% of EC **TOD off peak charge:** 75% of EC	-	Chhattisgarh (CSERC) 2020-21 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
11. Madhya Pradesh				
YOI:2005-06 Mandatory: All HV industries (For example: Coal Mines for power, ventilation, lights, fans, coolers, etc, regular mines, Banks, General purpose shops, Water supply, Sewage pumps, Police Stations etc. in the premises of the industrial units and Dairy units where milk is processed (other than chilling, pasteurization etc.) to produce other end products of milk, cold storages, Railway Stations, Offices, Hotels, Hospitals, Institutions, establishments of shopping malls, Mini Steel Plants (MSP), MSP with rolling mills/ sponge iron plants in the same premises, electro chemical/ electro thermal industry, Ferro alloy industry, lift irrigation schemes, group irrigation, Public Utility Water Supply schemes, sewage treatment plants /sewage pumping plants and for energy used in lighting pump house.)	**Peak period:** 18:00hrs. to 22:00hrs. **Off peak period:** 22:00hrs to 06:00hrs.	**a) HV-2 (Coal Mining industry):** **Energy charge:** Rs. 5.70-7.15/unit **TOD Peak Charge:** Same as normal **TOD off peak rebate:** 20% of EC **b) HV-3(Industrial, Non-industrial and Shopping malls):** **Energy charge:** Rs. 5.00-7.30/unit **TOD Peak Charge:** Same as normal **TOD off peak rebate:** 20% of EC **c) HV-4(Seasonal industries):** **Energy charge:** Rs. 5.60-8.16/unit **TOD Peak Charge:** Same as normal **TOD off peak rebate:** 20% of EC	**HV-5 (Irrigation, Public water works other than agricultural):** Energy **charge: Rs. 5.30-5.90/unit** **TOD Peak Charge:** Same as normal **TOD off peak rebate:** 20% of EC	Source: Madhya Pradesh (MPERC) 2019-20 tariff order
12. Rajasthan				
YOI: 2019-20 **Mandatory: LP/HT-5, EV/HT-6** (For example: Large Industrial Power Consumers, Printing Presses, Government Lift Irrigation Projects, IOC/HPC etc, Sewage treatment Plants and Reverse Osmosis (RO) plants, Metro Traction and all its related establishments, Pumping stations, Hatcheries, Flour mills, Water Supply by RIICO in RIICO Industrial Areas and Water works for Public supply\ and Water Supply by Trusts/Local Bodies, Pumping Back Seepage water by IGNP, Handicraft, Textile, Dyeing & Printing Industries, Cold Storage units, Software Units, Software, IT & IT enabled Service, public charging station for Electric Vehicles)	**Off Peak Period:** 22:00hrs to 06:00hrs.	**LP/HT-5 (Large Industrial Service):** **Energy charge:** Rs.6.30-7.30 **TOD Peak Charge:** Same as normal **TOD off peak rebate:** 15% of EC	**EV/HT-6 (EV charging stations):** **Energy charge:** Rs.6.00 **TOD off peak rebate:** 15% of EC	Rajasthan (Jaipur Vidyut Vitran Nigam Ltd.) 2020-21 tariff order.

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
		13. Maharashtra		
YOI:-2000-01 **Mandatory: HT, EHT, LT-2(B), LT-2(C), LT-2(B), LT-3(B), LT-3(C), LT-V>20kW, LT-VII(A)&(B)>20kW** (For example: Seasonal industries (cotton seed oil, salt etc.),Cold storage, Food processing, R&D units, Seed manufacturing, Telecommunication towers, Flour mills, rice mills etc. , Ice factories, Mining, quarrying, stone crushing, Garment manufacturing, Brick kiln, LPG/CNG bottling plants, Sewage treatment plants, Entertainment facilities, Offices, Marriage halls/ hotels, Tailoring shops, Bank and ATM centres, Sports club facilities, Milk collection, Sewage treatment plants, Advertisements, hoardings etc., Public water works and Sewage treatment plants, Healthcare facilities, sport facilities, Educational institutions, Educational institutions, Spiritual organizations, Airports, ports and jetties, Waste units, Courts, jails etc, EV charging stations) **Optional: LT-2(A), LT-3(A),LT-4(A) & LT-4(B)<20kW, LT-V<20kW, LT-VII(A)&(B)<20kW** (For example: Non-residential, business and commercial premises, Entertainment facilities, Tailoring shops, Bank and ATM centres, Sports club facilities, Public water works)	**Peak period:** 09:00hrs to 12:00hrs and 18:00hrs. to 22:00hrs. **Off peak period:** 22:00hrs to 06:00hrs. **Normal period:** 06:00hrs to 09:00hrs. and 12:00hrs. to 18:00hrs.	**a) LT-II (Non-residential or Commercial):** **Energy charge:** Rs. 7.18-12.95/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **b) LT-V (Industry)** **Energy charge:** Rs. 5.01-5.93/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **c) HT-I (Industry):** **Energy charge:** Rs.6.96-7.22/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **d) HT-C (Commercial):** **Energy charge:** Rs. 11.2/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC	**a) LT-III (PWW and Sewage treatment plants):** **Energy charge:** Rs. 2.46-5.12/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **b) LT-VII (Public services):** **Energy charge:** Rs. 3.12-7.49/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **c) LT-VIII (EV charging stations):** **Energy charge:** Rs. 4.12/ kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **d) HT-IV (PWW and Sewage treatment plants):** **Energy charge:** Rs. 6.17/ kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **e) HT-VIII (Public services):** **Energy charge:** Rs. 7.74-9.48/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC **f) HT-IX (EV charging stations):** **Energy charge:** Rs. 4.94/kW **TOD peak charge:** Rs. 0.8-1.1 higher than EC **TOD off peak charge:** Rs. 1.5 lower than EC	Maharashtra (MSEDCL) 2020-21. The tariffs mentioned are applicable for 2021-22. Maharashtra has four DISCOMS of which only one (MSEDCL) is public. Tariff orders for the private DISCOMS (BEST Undertaking, Tata Power ltd. And Reliance Energy Ltd.) are not available.

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
Northern Region				
14. Chandigarh				
YOI: 2012-13 (TOD tariff scheme was not implemented in the year 2017-18) **Mandatory:** HT & EHT (Industries) **Optional:** All others	**Peak Period:** 18:00hrs. to 22:00hrs **Off Peak Period:** 22:00hrs to 06:00hrs **Normal period:** 06:00hrs to 18:00hrs.	**a) LT-Commercial** **Energy Charge:** Rs.4.5 – 5 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC **b) HT-Commercial** **Energy Charge:** Rs.4.7 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC **c) Industrial** **Energy Charge:** Rs.4.3-4.5 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC **d) Bulk Supply** **Energy Charge:** Rs.4.4 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC **e)EV Charging** **Energy Charge:** Rs3.6 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC	**a) Domestic Supply** **Energy Charge:** Rs.2.5 – 4.3 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC **b) Agriculture** **Energy Charge:** Rs 2.6 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC **c) Public Lightings** **Energy Charge:** Rs. 4.80-6.40 **Peak Charge:** 120% over EC **Off peak Charge:**90% below EC	Chandigarh (EWEDC) 2021-22 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
15. Delhi				
YOI: 2009-10 **Mandatory:** All consumers (other than Domestic) whose sanctioned load/MDI (whichever is higher) is 10kW/11kVA and above.	**Peak Period:** 14:00 hrs. to 17:00 hrs. and 22:00hrs to 01:00 hrs **Off Peak Period:** 04:00 hrs to 10:00 hrs. **Normal:** 10:00 hrs to 14:00 hrs and 17: 00 hrs to 22 hrs and 1:00 hrs to 4:00 hrs	**a) Industrial** **Energy Charge:** Rs. 7.75 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **b) Non-Domestic** **Energy Charge:** Rs. 6 – 8.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **c) Delhi Int. Airport** **Energy Charge:** Rs. 7.75 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **d) Advertisements & Hoardings** **Energy Charge:** Rs. 8.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **e) EV charging** **Energy Charge:** Rs. 4 – 4.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC	**a) Individual connections** **Energy Charge:** Rs. 3 – 8.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **b) Single Point Delivery Supply for GHS** **Energy Charge:** Rs.4.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **c) Agriculture** **Energy Charge:** Rs. 1.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **d) Mushroom Cultivation** **Energy Charge:** Rs. 3.5 **Peak Charge:** 120% of EC **off peak charge:** 80 % of EC **e) Public utilities** **Energy Charge:** Rs. 6.25 **Peak Charge:** 120% of EC **Off peak charge:** 80 % of EC	Delhi (BRPL, BYPL, TPDDL & NDMC) 2020-21 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
16. Punjab				
YOI: 2013-14 **Mandatory:** LS (Large Industrial Supply), MS (Medium Industrial Supply), NRS (Non-residential supply) above 100 kVA, BS (Bulk supply)	**June – Sep:** **Peak:** 1800 hrs – 2200 hrs **Normal:** 2200 hrs – 1800 hrs **Sep – June:** **off Peak:** 2200 hrs – 0600 hrs **Normal:** 0600 hrs – 2200 hrs **Exclusive Night tariff timings:** 2200 hrs – 0600hrs	a) **LS – general** **Energy Charge:** Rs.5.98-6.19 **Peak Charge:** Rs. 1.25 over EC **Off peak Charge:** Rs. 2 below EC b) **LS – Energy Intensive** **Energy Charge:** 6.02 – 6.41 **Peak Charge: Rs.** 1.25 over EC **Off peak Charge:** Rs. 2 below EC **c) LS – Night exclusive** **Energy Charge:** Rs. 4.83 **d) MS – general** **Energy Charge:** Rs.5.8 **Peak Charge:** Rs. 1.25 over EC **Off peak Charge:** Rs. 2 below EC **e) MS – Night Exclusive** **Energy Charge:** Rs. 4.83 **f) NRS** **Energy Charge:** Rs. 6.35 – 7.29/ kVAh **Peak Charge:** Rs. 1.25 over EC **Off peak Charge:** Rs. 2 below EC **g) BS LT** **Energy Charge**: Rs. 6.46 Peak Charge: Rs. 1.25 over EC Off peak Charge: Rs. 2 below EC **h) BS HT** **Energy Charge:** Rs.6.05 **Peak Charge:** Rs. 1.25 over EC **Off peak Charge:** Rs. 2 below EC	**Energy Charge**: Rs.5.98-6.19 **Peak Charge**: 120% over EC **Off peak Charge**:90% below EC	PSERC – Tariff Order 2020-21 for PSPCL

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
17. Uttar Pradesh				
YOI: -2003-04 **Mandatory: LMV-3, LMV-6, LMV-11, HV-2** For example: Public lamps, Floriculture, mushroom, and farming units other industrial and agro industrial industries, EV charging stations, Arc/ induction furnaces, Rerolling mills, steel plants	**Summer (April to September):** **Peak period:** 17:00hrs to 23:00hrs **Off peak period:** 05:00hrs to 11:00hrs. **Normal period:** 11:00hrs to 17:00hrs. and 23:00hrs. to 05:00hrs. **Winter (October to March):** **Peak period:** 17:00hrs to 23:00hrs **Off peak period:** 23:00hrs to 05:00hrs. **Normal period:** 05:00hrs. to 17:00hrs.	**a) LMV-6 (Small and Medium power):** **Energy charge:** Rs.7.30-7.90/unit **TOD peak charge:** 115% of EC **TOD off peak charge:** 85% of EC **a) HV-2 (Large and Heavy power):** **Energy charge:** Rs.6.10-7.10fxf **TOD peak charge:** 115% of EC **TOD off peak charge:** 85% of EC	**a) LMV-3 (Public lamps):** **Energy charge:** Rs.7.50-8.50 **TOD peak charge:** 20% of EC **b) LMV-11 (EV charging stations):** **Energy charge:** Rs.7.30-7.700 **TOD peak charge:** 115% of EC **TOD off peak charge:** 85% of EC	Source: Uttar Pradesh (DVVNL, MVVNL, PVVNL, PuVVNL, KESCO) 2020-21 tariff order
18. Uttarakhand				
YOI: 2003-04 **Mandatory:** All HT industries (load>75kW) and LT industries (load > 25kW)	**Summer:** **Peak period:** 18:00hrs to 23:00hrs **Winter:** **Peak period:** 18:00hrs to 22:00hrs and 06:00hrs to 09:00hrs	**a) HT:** **Energy charge:** Rs. 4.45-4.85 **TOD peak charge:** 150% of EC **TOD off peak charge:** 80% of EC **b) LT** **Energy charge:** Rs. 4.3 **TOD peak charge:** 150% of EC **TOD off peak charge:** 80% of EC		**Source:** Uttarakhand (UERC) Tariff order April 2021

<table>
<tr><th>TOD Implementation Details</th><th>TOD Timings</th><th>TOD Tariff details (industrial/ commercial)</th><th>TOD tariff details (others)</th><th>Remarks</th></tr>
<tr><td colspan="5">19. Himachal Pradesh</td></tr>
<tr><td>YOI: 2001-02
Mandatory:

Small industrial power supply: Includes industries with contract demand between 20-50 kVA,

b) Medium industrial power supply: Includes industries with contract demand between contract demand between 50 – 100 kVA

c) Large industrial power supply; Includes industries with contract demand between contract demand exceeding 100 kVA

d) Irrigation and drinking water pumps (contract demand exceeding 20 kVA)</td><td>Peak Hours
6:30 pm – 10 pm
Night concession timings (10 pm – 6 am)</td><td>a) Small industrial power supply:
Energy Charge: Rs. 4.6 – 4.75
TOD peak charge: Rs. 5.9 – 6.41
TOD off peak charge: Rs. 1.1 below EC (June – Aug), Rs. 0.7 below EC (other months)
b) Medium industrial power supply:
Energy Charge: Rs. 4.6
TOD peak charge: Rs. 5.7
TOD off peak charge: Rs. 1.1 below EC (June – Aug), Rs. 0.7 below EC (other months).
c) Large industrial power supply;
Energy Charge: Rs. 4.2 – 4.6
TOD peak charge: Rs. 5.5 – 5.7
TOD off peak rebate: Rs. 1.1 below EC (June – Aug), Rs. 0.7 below EC (other months)</td><td>Irrigation and drinking water pumps
Energy Charge: Rs. 4.2 – 4.5
TOD peak charge: Rs. 5.5 – 5.9
TOD off peak charge: Rs. 0.7 below EC (June – Aug), Rs. 0.5 below EC (other months)</td><td>Source: HPSEBL tariff order dated 31st May 2021, applicable for FY22 to FY24.</td></tr>
<tr><td colspan="5">20. Haryana</td></tr>
<tr><td>YOI: 2016-17

Optional:

HT (11 & 33kV), HT (66kV and above)

b) EV</td><td>Peak hours:
5:30 pm – 9: pm
Off Peak hours:
9pm to 5:30 am
Normal hours:
5:30 am to 5:30pm

(applicable only for months November to March)</td><td>a) HT:
Energy Charge: Rs. 6.25 – 6.65
TOD Peak Charge: Same as normal
Off Peak Charge: Rs. 3.75(>66kV), Rs. 4.25(11&33kV)
(applied only on enhanced usage)
b) EV:
Energy Charge: Rs. 5.5
TOD Peak Charge: Same as normal
Off Peak Charge: Rs. 3.75(>66kV), Rs. 4.25(11&33kV)
(applicable only on total consumption and not incremental consumption)</td><td>-</td><td>Haryana (HERC) 2020-21 tariff order The structure of demand charge is such that it encourages industries to avoid peak consumption and tries to keep the load curve flat</td></tr>
</table>

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
21. Jammu & Kashmir				
YOI: -2016-17 **Mandatory:** HT consumers with load above 1MVA connected at 33KV levels For example: Public Water Works, HT industrial, HT PIU and Bulk supply	**Peak period:** 06:00-08:00hrs and 18:00-22:00 hrs. **Off peak period:** 23:00-05:00hrs	**a) HT Industrial:** **Energy charge:** Rs. 2.86/kWh **TOD peak charge:** 110% of EC **TOD off peak charge:** 90% of EC	**a) PWW:** **Energy charge:** Rs. 5.14/kWh **TOD peak charge:** 110% of EC **TOD off peak charge:** 90% of EC **b) HT PIU:** **Energy charge:** Rs. 3.34/kWh **TOD peak charge:** 110% of EC **TOD off peak charge:** 90% of EC	Jammu and Kashmir introduced the TOD tariff in the tariff order for 2016-17. This is also the most recent tariff order available.

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
Southern Region				
22. Kerala				
YOI:2002-03 **Mandatory: EHT, HT, LT-IV (Industrial), LT-I (Domestic)** (For example: manufacturing units, grinding mills, flour mills, oil mills, rice mills, sawmills, units using electric hydraulic axe machines, ice factories, rubber smoke houses, tyre vulcanizing/ re-treading units, units manufacturing rubber sheets from latex, coconut drying units. workshops using power, mainly for production and/or repair, public water works, drinking water pumping for public by Kerala Water Authority, Corporations, Municipalities and Panchayats, telemetry stations of KWA, pumping water for non-agricultural purposes, sewage pumping units, power laundries, screen printing of glassware or ceramic, SSI units engaged in computerized colour printing excluding photo studios/ colour labs, audio/video cassette/CD manufacturing units, printing presses including presses engaged in printing dailies, bakeries (where manufacturing process and sales are carried out in the same premises), diamond-cutting units, stone crushing units, granite cutting units (where boulders are cut into sheets in the same premises), book binding units with allied activities, garment making units, seafood processing units, prawn peeling and processing units, plantations of cash crops, tea factories, cardamom drying and curing units, units carrying out extraction of oil in addition to the filtering and packing activities carrying out in the same premise and under the same service connection, dairy, processing of milk by pasteurization and its storage and packing, soda manufacturing units, bottling plants/ packaging drinking water, electric crematoria, Information Technology (IT) and IT enabled services including akshaya-e-centres, computer consultancy services units, call centres, software services, data processing activities, desktop publishing (DTP), software development units, charging stations of electric vehicles, illumination, exhibition, festivals, public meetings, fairs)	**Normal period:** 06:00hrs to 18:00hrs. **Peak Period:** 18:00hrs. to 22:00hrs. **Off Peak Period:** 22:00hrs to 06:00hrs.	**a) LT-IV (Industrial):** **Energy charge:** Rs. 5.65-6.25 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **b) HT-I (Industrial):** **Energy charge:** Rs. 5.75-6.05 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **c) HT-IV(Commercial):** **Energy charge:** Rs. 6.30-7.60 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **d) EHT Industrial:** **Energy charge:** Rs. 5.00-5.50 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **e) EHT Commercial:** **Energy charge:** Rs. 6.10-7.10 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC	**a) HT-II (General):** **Energy charge:** Rs. 5.60-7.20 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **b) HT-III (Agriculture):** **Energy charge:** Rs 3.10-3.60 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **c) HT-VI (EV charging stations):** **Energy charge:** Rs. 5.00 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **d) HT-VII (Temporary connections):** **Energy charge:** Rs. 11/ unit **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC **e) EHT General:** **Energy charge:** Rs. 5.30-6.80 **TOD peak charge:** 150% of EC **TOD off peak charge:** 75% of EC	Kerala State Electricity Commission, Thiruvanan thapuram, 2019-20 tariff order

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
23. Karnataka				
YOI: 2009-10 **Mandatory:** **HT- 2(a), HT-2(b), and HT-2(c) with 500 kVA contract and above** **Optional:** **1) HT-2(a), HT-2 (b), and HT-2 (c) consumers with contract demand less than 500 kVA:** (examples include industrial and commercial consumers with >500KVA contract demand, Government Hospitals & Hospitals run by Charitable Institutions & ESI Hospitals, Universities, Educational Institutions belonging to Government, Local Bodies and Aided Institutions and Hostels of all Educational Institutions. **2) LT-5:** (examples include BBMP and other Municipal Corporations 2. Other Industries and installations not specified) **3) HT-1:** (examples include Water Supply and Sewerage Installations)	**Peak Period:** 06:00hrs. to 10:00hrs. and 18:00hrs. to 22:00hrs. **Off Peak Period:** 22:00hrs to 06:00hrs. **Normal period:** 10:00hrs to 18:00hrs.	**1) HT-2(a):** **Energy Charge:** Rs. 7.25-7.65 **TOD Peak Charge:** Rs. 1 above EC **TOD off peak charge:** Rs. 1 below EC **2) HT-2(b):** **Energy Charge:** Rs. 8.95-9.25 **TOD Peak Charge:** Rs. 1 above EC **TOD off peak charge:** Rs. 1 below EC **3) HT-2(c):** **Energy Charge:** Rs. 7.10-8.50 **TOD Peak Charge:** Rs. 1 above EC **TOD off peak charge:** Rs. 1 below EC	**1) LT-5:** **Energy Charge:** Rs. 5.60-7.20 **TOD Peak Charge:** Rs. 1 above EC **TOD off peak charge:** Rs. 1 below EC **2) HT-1:** **Energy Charge:** Rs. 5.45 **TOD Peak Charge:** Rs. 1 above EC **TOD off peak charge:** Rs. 1 below EC	Karnataka electricity regulatory commission (2021-22) tariff order
24. Telangana				
YOI: 2014-15 (The state was earlier part of Andhra Pradesh which introduced TOD in 2010-11) **Mandatory:** **HT I, HT II, and HT III:** examples are airports, bus station, railway stations	**Peak hours:** 6 am - 10 am; 6 pm - 10 pm	a) **HT I:** **Energy Charge:** Rs 5.65 - 7.60 **TOD peak charge**: Rs. 6.65 - 7.65 **TOD off peak charge:** Rs. 4.65-5.65 (10pm -6 am) **b) HT II:** **Energy Charge:** Rs 6.80 - 7.80 **TOD peak charge**: Rs. 7.80 - 8.80 **TOD off peak charge:** 5.80 - 6.80 (10pm -6 am)	**a) HT III:** **Energy Charge:** Rs 6.45 - 7.50 **TOD peak charge**: Rs. 7.45 - 8.50 **TOD off peak charge:** Rs. 5.45 - 6.5 (10pm -6 am)	Telangana (TSSPDCL) 2018-19 tariff order
25. Puducherry				
YOI: 2012-13 **Mandatory:** **All HT industries:** (For Supply at 11 kV, 22 kV or 33 kV) **All EHT industries:** (For Supply at 11 kV, 22 kV or 33 kV)	**Peak hours:** 6pm – 10 pm **Off-peak hours**: 10pm – 6am **Normal hours:** 6am – 6pm hours	**All HT Industries:** **Energy Charge:** Rs. 5.5 **TOD peak charge:** 120% of EC **TOD off peak charge:** 90% of EC (10 pm – 6 am) **All EHT Industries:** Energy Charge: Rs. 5.2 TOD peak charge: 120% of EC TOD off peak charge: 90% of EC (10 pm – 6 am)	-	**Source:** Tariff Order-Electricity Department, Government of Puducherry, and Joint Electricity Regulatory Commission, for 2020-21

TOD Implementation Details	TOD Timings	TOD Tariff details (industrial/ commercial)	TOD tariff details (others)	Remarks
26. Andhra Pradesh				
YOI: 2010-11 **Mandatory:** **a) HT commercial:** (examples are Advertising hoardings, Function halls and auditoriums, Start-up power, EV charging stations, Green power) **b) HT industrial:** (examples are Seasonal industries, Cottage industries, Energy intensive industries, Industrial colonies, Poultry & Aquaculture)	**Peak hours**: 18:00hrs. to 22:00hrs. And 06:00hrs. to 10:00hrs. **Off peak hours:** 22:00hrs to 06:00hrs.	**a) HT – commercial:** **Energy Charge:** Rs. 6.70 to 7.65 **TOD peak charge:** Rs 1 above EC **b) HT-Industrial** **Energy Charge:** Rs 5.4 to 6.3 **TOD peak charge:** Rs 1 above EC **TOD off-peak charge:** Rs 1 below EC	-	**Source:** Andhra Pradesh regulatory commission 2021-22 tariff order
27. Tamil Nadu				
YOI: 2002-03 **Mandatory: HT IA industrial consumers:** Examples include all manufacturing and industrial establishments and registered factories including Tea Estates, Textiles, Fertilizer Plants, Steel Plants, Heavy Water Plants, Chemical plants. However, registered factories such as LPG bottling Units which are of non-manufacturing nature are not to be included in this tariff category. 2. Common effluent treatment plants, Industrial estate's water treatment/ supply works, 3. Cold storage units	**Peak hours:** 6 am - 9 am and 6 pm - 9 pm	**Energy Charge:** Rs 6.35 **TOD peak charge:** Rs 7.62 **TOD off-peak charge:** Rs 6.03 (95% of EC)	-	**Source:** Tamil Nadu electricity regulatory Commission tariff order 2017-18

**Note: Odisha implemented ToD tariff in 2005 (An off-peak rebate of Rs. 0.10/unit was offered to all three phase consumers then) and has since then continued to give only an off-peak rebate (In FY21, it is 20 paise/unit rebate to all three phase consumers excluding Public Lighting, emergency supply to CGP, LT Domestic, and LT General Purpose categories; the off-peak hours are from 10 pm to 6 am). There has been no peak hour tariff in the state. There is a frequency-based tariff (ABT: Availability Based Tariff) in place currently, and as a result the load curves of the industries are mostly flat. Thus, it has been argued that the TOD benefit may no longer be required.*[84]

84 https://www.tpwesternodisha.com/RST%20details/Final%20RST%20Order%202020-21.pdf

Appendix 2: Cement Industry

Data from Stakeholder consultation: Shree Cement, Rajasthan

	Annual Production Capacity	Electricity Consumption per unit produced	Grid Connection (MW)	% of grid connected load utilized	Captive Generation Capacity (MW)	% of captive generation utilized
1. Plant/Unit			125 MW		300 MW	
2. All Units in your state						
3. PAN-India	35 MT					

	% Consumption from DISCOM	% Consumption from Open Access	% Consumption from Captive	Plant Load Factor (%)
1 Plant/Unit	<5 to 10%	-	90 to 95%	60 to 70%
2. All Plants in your state				60-70%
3 PAN India			90%	60-70%

Process Specific Information

Process /Technology	Process Duration	% Electricity Consumption by the process	Not Flexible/ Somewhat flexible/ Very Flexible	Process halt /delay duration	Time needed for halting /delaying	Maximum possible reduction in electricity consumption (in kW/MW) by your plant
1. Raw material grinding	Continuous	Not significant				
2. Kiln Process	Continuous	60-70%	Not flexible	-	-	
3. Finish Grinding	Batch process (6 -8 hours each day)	30-40%	Flexible	-	1 hour	8-10 MW
Total						

Process /Technology	Maximum possible reduction in electricity consumption (in kW/MW) by all your plants (in your state)	Maximum possible reduction in electricity consumption (in kW/MW) by all your plants in other states	Maximum possible reduction in electricity consumption (in kW/MW) by all plants in India
1. Raw material grinding	-	-	-
2. Kiln Process			-
3. Finish Grinding	50-60 MW	50-60 MW	400 – 500 MW
Total			

Willingness to reduce peak hour consumption (Yes/No)	
Demand Reduction	**Compensation (in Rs/unit)**
Reduction by 5%	Rs 5/kwh for reduction of 10 MW
Reduction by 10%	-
Reduction by 12%	-
Reduction by 15%	-
	-
Reduction by 25%	

Computation of overall DSR Potential for Industry (by Extrapolation)

Total DSR Potential	DSR Reduction
Stakeholder 1	**50 MW**
Stakeholder 2	
Stakeholder 3	
Stakeholder 4	
Entire Industry (PAN India level)	**400-500 MW**

Appendix 3: Textile Industry

Data from Stakeholder consultation: Panipat Textile Mill

	Annual Production Capacity	Electricity Consumption per unit produced	Grid Connection (MW)	% of grid connected load utilized	Captive Generation Capacity (MW)	% of captive generation utilized
1 Plant/Unit	15 tonne/day (weight of yarn)		750 KW		0	NA
2. All Units in your state	15*3 tonne/day (3 units)		2 MW			
3. PAN-India	130*15 tonnes/day (around 130 units)		100 MW			

	% Consumption from Discom	% Consumption from Open Access	% Consumption from Captive	Plant Load Factor (%)
1 Plant/Unit	100	Very little due to high wheeling charge	None	
2. All Plants in your state				
3 PAN India				

	Tariff borne during peak hour (Rs/KWh)	Tariff borne during off peak hour (Rs/ KWh)	Normal Tariff (Rs/KWh)	Price of Captive Generation Capacity (Rs/KWh)
1 Plant/Unit	Rs 10/unit (6-10 pm peak hours)	Rs 8/unit		
2. All Plants	Same	Same		

ToD Experience

How many days in a year (out of 365 working days), you are able to halt/delay your flexible processes in response to ToD tariffs

Process / Technology	Maximum possible reduction in electricity consumption (in kW/MW) by your plants (in your state)	Maximum possible reduction in electricity consumption (in kW/MW) by all your plants in other states	Maximum possible reduction in electricity consumption (in kW/MW) by all plants in India
Open End Recycling Plant			
Total			

Load characteristics:

Load Curve on a typical curve, Base Load etc.

Time (according to state load curve), 4-5 blocks	Current load (MW)	By how much you can reduce their demand in this blook	To which time you will be able to shift	How much price to be reduced for enabling you to shift demand to this period
10 PM- 6PM Normal period	750 KW			
6 PM-10 PM **Peak load period**	750 KW	60-70% (Base load 30-40% for the recycling plant)	1 hour	

Data from Stakeholder consultation: BSL Limited, Bhilwara

	Annual Production Capacity	Electricity Consumption per unit produced	Grid Connection (MW)	% of grid connected load utilized	Captive Generation Capacity (MW)	% of captive generation utilized
1. Plant/Unit (composite unit)	Yarn: 15 ton per day Weaving (cloth): 10000 m per day Processed cloth: 10 ton per day	Spinning: 4.5 units per kg of double yarn and 2.6 -3 units per kg for single yarn. (In most of the cases double yarn is used) Weaving: 0.6 units per metre Processing: Varies a lot with the kind of fibre	5 MW (contract demand)		(rooftop solar of 4.3 MW)	
2. All Units in your state			Highly variable based on size/ production capacity of mill Nitin Spinners in Bhilwara, e.g.; 25 MW (has 1.5 lakh spindles per day production capacity)			
3. PAN-India						

	% Consumption from Discom	% Consumption from Open Access	% Consumption from Captive	Plant Load Factor (%)
1 Plant/Unit	100 (Discom - AVVNL)	Nil after installation of captive solar		
2. All Plants in your state				
3 PAN India				

	Tariff borne during peak hour (Rs/KWh)	Rebate off peak hour (Rs/KWh)	Normal Tariff (Rs/KWh)	Price of Captive Generation Capacity (Rs/KWh)
1 Plant/Unit		Rs 1 (11pm to 6am)	Rs 7.85	
2. All Plants				

Process Specific Information

Process /Technology	Process Duration	Electricity Consumption by the process	Not Flexible/ Somewhat flexible/Very Flexible	Process halt /delay duration	Time needed for halting /delaying	Maximum possible reduction in electricity consumption (in kW/ MW) by your plant
Spinning	continuous	85000 units consumption (3.3 MW)	flexible	4-6 hrs (as much required)	instant	3
Weaving	continuous	0.9 MW	flexible	4-6 hrs (as much required)	instant	0.8
Processing	continuous	0.8 MW	Not flexible	As much as required (depends on contract)	7 to 8 hours	0.4
Total		5 MW				4.2

Process /Technology	Maximum possible reduction in electricity consumption (in kW/MW) by your plants (in your state)	Maximum possible reduction in electricity consumption (in kW/MW) by all your plants in other states	Maximum possible reduction in electricity consumption (in kW/MW) by all plants in India
Spinning	90%	NA	90%
Weaving	90%	NA	90%
Processing	40-50%	NA	40-50%
Total			

Load characteristics:

Load Curve on a typical curve, Base Load etc.

Time (according to state load curve), 4-5 blocks	Current load (MW)	By how much you can reduce their demand in this block (MW)	To which time you will be able to shift	How much price to be reduced for enabling you to shift demand to this period
6 AM-9 AM Normal period	4.8-5	3.5-4	Anytime	
9 AM-12 pm **Peak period**	4.8-5	3.5-4	Anytime	
12:00hrs. to 18:00hrs. **Normal period:**	4.8-5	3.5-4	Anytime	
18:00hrs. to 22:00hrs. **Peak period**	4.8-5	3.5-4	Anytime	
22:00hrs to 06:00hrs. **Off peak period:**	4.8-5 (Mostly on the lower side)	3.5-4	Anytime	

When is your peak demand during a typical day, how much is the peak demand?

Compensation/Incentives

Willingness to reduce peak hour consumption (Yes/No)	
Demand Reduction	**Compensation (in Rs/unit)**
Reduction by 5%	**1-1.5 Rs/kwh**
Reduction by 10%	**2 Rs/kwh**
Reduction by 12%	**2.5 – 3 Rs/kwh**
Reduction by 15%	
Reduction by 25%	**Not Possible**

Reduction possible till 5-10%

Futuristic Questions

Would be you willing to sell power on the Exchange? (Yes/No)	
How much quantum can be sold during peak hours? (in kWh)	
Where would you sell the power? (Exchange/Discom/Grid Injections)	
Expected benefits to industry in RTP Tariff implementation	
Expected costs/current barriers with regards to RTP Tariff implementation	

Appendix 4: Iron and steel industry

	Annual Production Capacity	Electricity Consumption per unit produced	Grid Connection	% of grid connected load utilized*	Captive Generation Capacity	% of captive generation utilized
	Million Tonnes per annum (Crude Steel)	KWH	MVA	%	MW	
Bhilai Steel Plant (CG)	5.9	400	200	15%	390	
Durgapur (WB)	2.4	380	100	45%	140	
Rourkela (Odisha)	3.6	400	150	56%	204	
Bokaro (Jharkhand)	4.8	400	225	85%	338	
ISP Burnpur (WB)	2.5	380	160	75%	72	
Alloy Steel Plant	0.1	700	Power Requirement is met from Durgapur Steel Plant. Figures of DSP include requirement / supply to ASP			
Salem Steel Plant	0.350 (Saleable Steel)	800	80	48%	NIL	
*	Average Load in MW / (Contract Demand x Power Factor)					

Data from Stakeholder consultation: Steel Authority of India Limited (SAIL)

	% Consumption from Discom	% Consumption from Open Access	% Consumption from Captive	Plant Load Factor (%)
Bhilai Steel Plant (CG)	10%	NIL	90%	80%
Durgapur (WB)	11%	NIL	89%	87%
Rourkela (Odisha)	45%	NIL	55%	81%
Bokaro (Jharkhand)	60%	NIL	40%	40%
ISP Burnpur (WB)	62%	NIL	38%	55%
Salem Steel Plant	75%	25%	NIL	Not applicable

<table>
<tr><th></th><th>Tariff borne during peak hour (Rs/KWh)</th><th>Tariff borne during off peak hour (Rs/KWh)</th><th>Normal Tariff (Rs/KWh)</th><th>Price of Captive Generation Capacity (Rs/KWh)</th></tr>
<tr><td></td><td colspan="4">(The Values are for Energy Charge only; Demand Charge is billed separately on Rs /kVA / Month basis)</td></tr>
<tr><td>Bhilai Steel Plant (CG)</td><td colspan="3">Rs 5.25/KVAH
(Normal Energy Charge applicable from 5 AM to 6 PM)
125% of Normal Energy Charge applicable in Peak Hours (6 PM to 11 PM)
75% of the Normal Energy Charge applicable during off peak (11 Am to 5 AM)
No ToD tariff Slabs</td><td>Rs 9/kwh x approx. 170 MU(PP-1)
to Rs 5.5 / Kwh x 300 MU (PP-II)
RS 4 / kwh x 2100 MU (PP-3)
(There are three Power Plants)</td></tr>
<tr><td>Durgapur Steel Plant and Alloy Steel Plant, Durgapur (WB)</td><td colspan="3">Please refer to table Below</td><td>Rs 13/kwh x 65 MU (PP-I)
RS 5 /kwh x 900 MU (PP-II)
There are two power plants</td></tr>
<tr><td>Rourkela (Odisha)</td><td>Rs 5.95 / KVAH
No TOD Tariff</td><td colspan="3">Rs 6.5 / kwh x 180 MU (PP-I)
Rs 4.8 x 1000 MU (PP-II)
Rs 6 x 160 MW (PP-III)
(There are three power plants)</td></tr>
<tr><td>Bokaro (Jharkhand)</td><td>2.95/KVAH
(No TOD Tariff)</td><td colspan="3">Rs 4.0 /kwh</td></tr>
<tr><td>ISP Burnpur (WB)</td><td colspan="3">Please refer to table below</td><td>Rs 6 / kwh x 250 MU</td></tr>
<tr><td>Salem Steel Plant (Tamil nadu)</td><td>Rs 6.35 / Kwh</td><td colspan="3">20% extra on the energy charges for the energy recorded during peak hours.
(6.00 A.M to 9.00 A.M and 6.00 P.M to 9.00 P.M)
Reduction of 5% on the energy charges for the consumption recorded during 10.00 P.M to 5.00 A.M.</td></tr>
</table>

ToD Experience

How many days in a year (out of 365 working days), you are able to halt/delay your flexible processes in response to ToD tariffs?

In Salem Steel Plant effort is made to utilize only Open Access Power during Peak Hours (6.00 A.M to 9.00 A.M and 6.00 P.M to 9.00 P.M) when the Energy Charge is 20% extra over and above the Normal Energy Charge is Rs 6.35 / kwh)

DSP, ASP, ISP and BSP do not vary their production plan to match the ToD slabs

BSL and RSP do not have ToD

Process Specific Information

Process / Technology / Equipment	Process Duration	% Electricity Consumption by the process	Not Flexible/ Somewhat flexible/ Very Flexible	Process halt /delay duration	Time needed for halting /delaying	Maximum possible reduction in electricity consumption (in kW/MW) by your plant
Blast Furnace	Continuous	10%	Not Flexible	None	Not possible to halt	
BOF	Batch Process (Approx. 40 mins batch cycle)	15%	Not Flexible	None	Not possible to halt	
Oxygen Plant	Continuous	20%		Turndown up to 20% is possible	2 hrs	Turndown up to 20% is possible
Sintering	Continuous	15%	Somewhat Flexible	4 hrs	1 hr	70% if process is halted
Rolling	Approx. 22 hrs a day	35%	Somewhat flexible	2 hrs	10-15 mins	80% if process is halted
Townships	Residential Load	10%	Flexible	2-3 hrs	Less than 5 mins	100%
Others						
Total						

Process /Technology	Maximum possible reduction in electricity consumption (in kW/MW) by your plants (in your state)	Maximum possible reduction in electricity consumption (in kW/MW) by all your plants in other states	Maximum possible reduction in electricity consumption (in kW/MW) by all plants in India
Blast Furnace	NIL	NIL	NIL
BOF	NIL	NIL	NIL
Oxygen Plant**	100	100	100
Sintering**	600	600	600
Rolling**	400	400	400
Townships**	1000	1000	1000
Total			

**** Reduction in Consumption is resorted to in emergency situations only**

When is your peak demand during a typical day, how much is the peak demand?

1. Peak Demand in an Integrated Steel Plant occurs between 6 PM to 9:30 PM. The Peak is about 10% higher than the average load (in an integrated steel plant)
2. In a Plant based on EAF route of Steel making Peak demand occurs when the EAF is arcing. The Peak will be about 2 times the average.

Compensation/Incentives

Willingness to reduce peak hour consumption (Yes/No)	Yes
Demand Reduction	**Compensation (in Rs/unit)**
Reduction by 5%	SAIL Plants reduce their peak load only when Actual Demand (from grid) is likely to exceed Contract Demand (to avoid Penalties). The Penalties are generally double of the Normal Demand Charge for example if the Demand Charge is Rs 350 / KVA / Month. The Penal Demand Charge (For exceeding the Contract Demand) would be RS 700/KVA / Month. Even if the Peak Load is reduced by any other means the benefit to user will be Reduction in Demand Charge. For every 1 MVA reduction in Demand Charge the expected benefit is Rs 4 Crore per annum.
Reduction by 10%	
Reduction by 12%	
Reduction by 15%	
Reduction by 25%	

Futuristic Questions

Would be you willing to sell power on the Exchange? (Yes/No)	
How much quantum can be sold during peak hours? (in kWh)	**Presently SAIL does not have surplus power to be able to sell.** **One 250 MW Unit is likely to be operational by December 2021 at RSP after that it will be able to sell approx. 50-75 MW Power (depending on Time period of the day)** **Minimum compensation (net after deducting applicable charges should be Rs 4/kwh**
Where would you sell the power? (Exchange/Discom/ Grid Injections)	
Expected benefits to industry in RTP Tariff implementation	
Expected costs/current barriers with regards to RTP Tariff implementation	**Cross Subsidy Surcharge** **No compensation in Demand Charge**

Table: Tariff Applicable for Durgapur Steel Plant and IISCO Steel Plant (DVC – 220 KV HT Tariff of West Bengal)

Customer Category	Tariff scheme	Energy charge (P/kWh)			Demand Charge (Rs/ kVAh/month	Tariff Scheme	Time of Day	Energy Charge (P/ kWh)			Demand Charge (Rs/kVAh/ month
		Summer	Monsoon	Winter				Summer	Monsoon	Winter	
Industries 220 kV and above	Normal	404	402	400	384	TOD	6 00 hrs – 1700 473hrs	394	392	390	384
							1700 hrs – 23 00 hrs	473	470	468	
							23 00 hrs – 6 00 hrs	335	333	332	

Data from Stakeholder consultation: JSW

	Annual Production Capacity	Electricity Consumption per unit produced	Grid Connection (MW)	% of grid connected load utilized	Captive Generation Capacity (MW)	% of captive generation utilized
1 Plant/Unit			50 + 28.5 MW		300	
2. All Units in your state					1200	
3. PAN-India						

	% Consumption from Discom	% Consumption from Open Access	% Consumption from Captive	Plant Load Factor (%)
1 Plant/Unit	5%		95	
2. All Plants in your state				
3 PAN India				

	Tariff borne during peak hour (Rs/KWh)	Tariff borne during off peak hour (Rs/KWh)	Normal Tariff (Rs/KWh)	Price of Captive Generation Capacity (Rs/KWh)
1 Plant/Unit				
2. All Plants				

ToD Experience

How many days in a year (out of 300 working days), you are able to halt/delay your flexible processes in response to ToD tariffs

Process Specific Information

Process/ Technology	Process Duration	% Electricity Consumption by the process	Not Flexible/ Somewhat flexible/ Very Flexible	Process halt /delay duration	Time needed for halting /delaying	Maximum possible reduction in electricity consumption (in kW/MW) by your plant
Cold rolling	24 hours	42				
Galvanizing	24 hours	35				
Colour coating/ tin coating	24 hours	23				
Total						25 MW

Process /Technology	Maximum possible reduction in electricity consumption (in kW/MW) by your plants (in your state)	Maximum possible reduction in electricity consumption (in kW/MW) by all your plants in other states	Maximum possible reduction in electricity consumption (in kW/MW) by all plants in India
Total			

Load characteristics:

Load Curve on a typical curve, Base Load etc.

Time (according to state load curve), 4-5 blocks	Current load (MW)	By how much you can reduce their demand in this blook	To which time you will be able to shift	How much price to be reduced for enabling you to shift demand to this period
6 AM-9 AM Normal period				
9 AM-12 pm **Peak period**				
12:00hrs. to 18:00hrs. **Normal period:**				
18:00hrs. to 22:00hrs. **Peak period**				
22:00hrs to 06:00hrs. **Off peak period:**				

When is your peak demand during a typical day, how much is the peak demand?

Compensation/Incentives

Willingness to reduce peak hour consumption (Yes/No)	
Demand Reduction	**Compensation (in Rs/unit)**
Reduction by 5%	
Reduction by 10%	
Reduction by 12%	
Reduction by 15%	
Reduction by 25%	**Not Possible**

Futuristic Questions

Would be you willing to sell power on the Exchange? (Yes/No)	Yes
How much quantum can be sold during peak hours? (in kWh)	**Already having a 300 MW contract with MSEDCL**
Where would you sell the power? (Exchange/Discom/Grid Injections)	
Expected benefits to industry in RTP Tariff implementation	
Expected costs/current barriers with regards to RTP Tariff implementation	

	Annual Production Capacity	Electricity Consumption per unit produced	Grid Connection (MW)	% of grid connected load utilized
1 Plant/Unit	1 lakh ton	800 - 1200	8.5 – 10 MW + 2 -3 MW (rolling)	
2. All Units in your state	8 lakh ton	800 – 1200		
3. PAN-India		800 – 1200		

Data from Stakeholder consultation: Amba Steel

	% Consumption from Discom	% Consumption from Open Access	% Consumption from Captive	Plant Load Factor (%)
1 Plant/Unit				
2. All Plants in your state				
3 PAN India				

	Tariff borne during peak hour (Rs/KWh)	Tariff borne during off peak hour (Rs/KWh)	Normal Tariff (Rs/KWh)	Price of Captive Generation Capacity (Rs/KWh)
1 Plant/Unit				
2. All Plants				

ToD Experience

How many days in a year (out of 300 working days), you are able to halt/delay your flexible processes in response to ToD tariffs

Process Specific Information

Process /Technology	Process Duration	% Electricity Consumption by the process	Not Flexible/ Somewhat flexible/ Very Flexible	Process halt /delay duration	Time needed for halting /delaying	Maximum possible reduction in electricity consumption (in kW/MW) by your plant
Pre – processing		1%	flexible	flexible	2 – 3 hour	100%
Melting	2.5 hours	90 – 95%	Somewhat flexible	3 hours	2 hours	Up to 100%
Rolling		20 – 30% (from other load)	Somewhat flexible	3 hours	2 hours	100%

Process /Technology	**Maximum possible reduction in electricity consumption (in kW/MW) by your plants (in your state)**	**Maximum possible reduction in electricity consumption (in kW/MW) by all your plants in other states**	**Maximum possible reduction in electricity consumption (in kW/MW) by all plants in India**
Pre – processing			
Melting			
Rolling			
Total			

Load characteristics:

Load Curve on a typical curve, Base Load etc.

Time (according to state load curve), 4-5 blocks	Current load (MW)	By how much you can reduce their demand in this blook	To which time you will be able to shift	How much price to be reduced for enabling you to shift demand to this period
6 AM-5 pm Normal period	100%			
5 AM- 10 pm **Peak period**	80 – 90 %			
10 pm – 6 am **Off peak period:**	100%			

When is your peak demand during a typical day, how much is the peak demand?

Compensation/Incentives

Willingness to reduce peak hour consumption (Yes/No)	Yes
Demand Reduction	**Compensation (in Rs/unit)**
Reduction by 5%	**Equivalent to opportunity cost + labour cost**
Reduction by 10%	**Equivalent to opportunity cost+ labour cost**
Reduction by 12%	**Equivalent to opportunity cost+ labour cost**
Reduction by 15%	**Equivalent to opportunity cost + labour cost**
	Fixed charges need to be reduced if the industry is willing to reduce load during peak hours as this would imply sub-optimal usage of connected load.
Reduction by 25%	**Not willing to reduce to this level**

Futuristic Questions

Would be you willing to sell power on the Exchange? (Yes/No)	No captive generation
How much quantum can be sold during peak hours? (in kWh)	
Where would you sell the power? (Exchange/Discom/Grid Injections)	
Expected benefits to industry in RTP Tariff implementation	
Expected costs/current barriers with regards to RTP Tariff implementation	

Appendix 5: Potential savings:- Annexure A

Benefits Breakup:

The benefits observed from the tools accrue from multiple areas. Below table captures these benefits:

Use Case #	Use Case	Cost Saving (INR)	Exchange Sale increase (INR)	Comments
A	Improved power procurement planning for Rabi season	308.4 cr		Analysis based on comparing the total cost of power procurement based on AS-IS system vs the recommendations from the optimization engine
B	Shutting down marginal plants	5 cr		Analysis based on extrapolation of actual benefits observed for sample days
C	Availing URS power (Un-requisitioned Surplus)	1.4 cr		Analysis based on extrapolation of actual benefits observed for sample days
D	Improved clearance of sale bids on exchange		24 cr	Analysis based on extrapolation of actual benefits observed for sample days
E	Increased sale due to updated merit order		146 cr	Analysis based on extrapolation of actual benefits observed for sample days
	Cost Savings (A+B+C)	**315 cr**		
	Increment in Sale Revenue (A+B+C)		**170**	

Further component-wise details of the computation is provided in Annex B.

Appendix 6: Potential savings:- Annexure B

A - Improved power procurement planning for Rabi season

Estimated benefits [85]

Month	AS-IS System (A) Power Procurement cost per day (Full availability) (INR Lacs)	Proposed System (B) Power Procurement cost per day (Optimal Mix of sources based on tool recommendation) - (INR Lacs)	Per day Savings (A-B) (INR Lacs)
Nov 2018	5797	5738	59
Dec 2018	5949	5876	73
Jan 2019	6336	6120	216
Feb 2019	6689	6434	255
Mar 2019	6356	5948	408

Total estimated cost savings for Rabi season: 308.4 cr INR

B - Shutting down marginal plants

Date	AS-IS Scenario (A) Procurement Cost: Without shutdown of marginal unit - (INR Cr)	Actual implemented scenario (B) Procurement cost with shutdown of marginal unit based on recommendation from tool - (INR Cr)	Per day Savings (A-B) (INR Lacs)
21/12/2018	42.18	42.26	8
01/01/2019	42.84	42.96	12
01/05/2019	43.43	43.21	22

Total estimated savings (annual): 5.04 cr

Calculation:

Average Savings per day (INR Lacs)	14
Duration of each shutdown decision (days)	3
Number of decision instances in a month	2
Number of months in a year for such decisions	6
Total Savings (INR Lacs)	504
Total Savings (INR cr)	5.04

85 This analysis was done using the estimated load profile for the months of Nov 18 – Mar 19. Actual demand profile may have been different from estimated profile.
For the purpose of this analysis, units of the marginal plant have been considered at full availability for the AS-IS scenario. While this was largely the case during the Rabi season, there will be days which would have a different source mix.

C - Availing URS power (Un-requisitioned Surplus)

Instances when URS power was used

Date	Station	Landed Cost (in Rs/kWh)	Blocks	Quantum (MW)	Savings (INR Lacs)
4-Jul	Sasan	1.53	06:45-15:30	300	16.275
15-Aug	Singrauli	2.12	12:00-17:00	166	11.205
23-Sep	Sasan	1.51	08:00-11:00	225	8.7075

Average Savings per day (INR Lacs)	**12**
Number of decision instances in a month	2
Number of months in a year for such decisions	6
Total Savings (INR Lacs)	144
Total Savings (INR cr)	1.44

Total Savings = 1.44+ 5.04+ 308.4 = 315 Cr

D - Improved clearance of sale bids on exchange

Dates	Estimated Sales from earlier strategy (Rs lakh)	Actual Revenue from the tool (Rs lakh)	Revenue Increase (Rs lakh)
4/30/2019	155	163	66
5/8/2019	99	101	32
5/16/2019	140	141	34
5/24/2019	122	140	42
5/27/2019	108	123	73
6/4/2019	57	61	32
6/12/2019	47	54	24
6/20/2019	176	181	54
6/28/2019	149	157	94
7/1/2019	14	17	7
7/9/2019	205	214	45
7/17/2019	156	158	25
7/25/2019	101	103	26
8/2/2019	2	7	6
Total	**1529**	**1619**	**89.98**

Calculation

Average % increase in exchange sale per day (from April'19 to Aug'19)	**=89.98/1529 ~ 6%**
Total Sale Revenue in FY 18-19 (INR Cr)	999
Total Increment in Revenue (INR cr)	**=1.06*999-999**
	=~60 Cr

E – Increased Sale on Exchange due to accurate merit order

Dates	Estimated Sales from earlier strategy (Rs lakh)	Actual Revenue from the tool (Rs lakh)	Revenue Increase (Rs lakh)
4/30/2019	97	163	66
5/8/2019	69	101	32
5/16/2019	107	141	34
5/24/2019	98	140	42
5/27/2019	51	123	73
6/4/2019	29	61	32
6/12/2019	30	54	24
6/20/2019	127	181	54
6/28/2019	63	157	94
7/1/2019	9	17	7
7/9/2019	168	214	45
7/17/2019	134	158	25
7/25/2019	77	103	26
8/2/2019	1	7	6
Total	1059	1619	561

Calculation

Average % increase in exchange sale per day (from April'19 to Aug'19)	=561/1059 ~ 53%
Total Sale Revenue in FY 18-19 (INR Cr)	999
Total Increment in Revenue (INR cr)	=999-999/1.53
	=~346 Cr

Total Increase in Sale Revenue on Exchange = 346+ 60 = 406 Cr